Assembler Language Reference

Assembler Language Reference

Note

Before using this information and the product it supports, read the information in Appendix I, “Notices” on page 593.

Second Edition (April 2001)

Before using the information in this book, read the general information in Notices.

This edition applies to AIX 5L Version 5.2 and to all subsequent releases of this product until otherwise indicated in new editions.

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About This Book

This book provides information on the assembler language program as implemented by the AIX 5.2 assembler. Topics covered include assembler operation, instructions, pseudo-operations, and extended mnemonics for the POWER family and PowerPC architectures and their supported processors.

Who Should Use This Book

This book is intended for experienced assembler language programmers. To use this book effectively, you should be familiar with this operating system or UNIX System V commands, assembler instructions, pseudo-ops, and processor register usage.

Highlighting

The following highlighting conventions are used in this book:

Bold	Identifies commands, subroutines, keywords, files, structures, directories, and other items whose names are predefined by the system. Also identifies graphical objects such as buttons, labels, and icons that the user selects.
Italics	Identifies parameters whose actual names or values are to be supplied by the user.
`Monospace`	Identifies examples of specific data values, examples of text similar to what you might see displayed, examples of portions of program code similar to what you might write as a programmer, messages from the system, or information you should actually type.

Case-Sensitivity in AIX

Everything in the AIX operating system is case-sensitive, which means that it distinguishes between uppercase and lowercase letters. For example, you can use the **ls** command to list files. If you type `LS`, the system responds that the command is ″not found.″ Likewise, **FILEA**, **FiLea**, and **filea** are three distinct file names, even if they reside in the same directory. To avoid causing undesirable actions to be performed, always ensure that you use the correct case.

ISO 9000

ISO 9000 registered quality systems were used in the development and manufacturing of this product.

Related Publications

The following books contain information about or related to the assembler:

- *AIX 5L Version 5.2 Commands Reference* Volume 1: a through c
- *AIX 5L Version 5.2 Commands Reference* Volume 2: d through h
- *AIX 5L Version 5.2 Commands Reference* Volume 3: i through m
- *AIX 5L Version 5.2 Commands Reference* Volume 4: n through r
- *AIX 5L Version 5.2 Commands Reference* Volume 5: s through u
- *AIX 5L Version 5.2 Commands Reference* Volume 6: v through z
- *AIX 5L Version 5.2 General Programming Concepts: Writing and Debugging Programs*

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Chapter 1. Assembler Overview

The assembler is a program that operates within the operating system. The assembler takes machine-language instructions and translates them into machine object code. The following articles discuss the features of the assembler:

- "Features of the AIX Assembler"
- "Assembler Installation" on page 8

Features of the AIX Assembler

This section describes features of the AIX assembler.

Multiple Hardware Architecture and Implementation Platform Support

The assembler supports the following systems:

- Systems using the first-generation POWER family processors (POWER family architecture).
- Systems using the POWER2 processors (POWER family architecture).
- Systems using the PowerPC 601 RISC Microprocessor, PowerPC 604 RISC Microprocessor, or the PowerPC A35 RISC Microprocessor (PowerPC architecture).

The assembler also supports development of programs for the PowerPC 603 RISC Microprocessor (PowerPC architecture).

Attention: The PowerPC 601 RISC Microprocessor implements the PowerPC architecture plus most of the POWER family instructions that are not included in the PowerPC architecture. This implementation provides a POWER family-to-PowerPC bridge processor that runs existing POWER family applications without recompiling and also runs PowerPC applications. Future PowerPC systems might not provide this bridge. An application should not be coded using a mixture of POWER family and PowerPC architecture-unique instructions. Doing so can result in an application that will run only on a PowerPC 601 RISC Microprocessor-based system. Such an application will not run on an existing POWER family machine and is unlikely to run with acceptable performance on future PowerPC machines.

There are several categories of instructions. The following table lists the categories of instructions and shows which implementations support each instruction category. The ″X″ means the implementation supports the instruction category.

Implementations Supporting Each Category of Instructions						
Instruction Category	POWER family	POWER2	**601**	**603**	**604**	**A35**
POWER2-unique instructions		X				
POWER2 and PowerPC common instructions, not in POWER family		X	X	X	X	X
POWER family-unique instructions not supported by PowerPC 601 RISC Microprocessor	X	X				
POWER family-unique instructions supported by PowerPC 601 RISC Microprocessor	X	X	X			

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POWER family and PowerPC common instructions with same mnemonics	X	X	X	X	X	X
POWER family and PowerPC common instructions with different mnemonics	X	X	X	X	X	X
PowerPC instructions supported by PowerPC 601 RISC Microprocessor			X	X	X	
Instructions unique to PowerPC 601 RISC Microprocessor			X			
PowerPC instructions not supported by PowerPC 601 RISC Microprocessor				X	X	
PowerPC 32-bit optional instruction set 1			X	X	X	
PowerPC 32-bit optional instruction set 2				X	X	
Instructions unique to PowerPC 603 RISC Microprocessor				X		

The following abbreviations are used in the heading of the previous table:

601 PowerPC 601 RISC Microprocessor
603 PowerPC 603 RISC Microprocessor
604 PowerPC 604 RISC Microprocessor

Host Machine Independence and Target Environment Indicator Flag

The host machine is the hardware platform on which the assembler runs. The target machine is the platform on which the object code is run. The assembler can assemble a source program for any target machine, regardless of the host machine on which the assembler runs.

The target machine can be specified by using either the assembly mode option flag **-m** of the **as** command or the **.machine** pseudo-op. If neither the **-m** flag nor the **.machine** pseudo-op is used, the default assembly mode is used. If both the **-m** flag and a **.machine** pseudo-op are used, the **.machine** pseudo-op overrides the **-m** flag. Multiple **.machine** pseudo-ops are allowed in a source program. The value in a later **.machine** pseudo-op overrides a previous **.machine** pseudo-op.

The default assembly mode provided by the AIX assembler has the POWER family/PowerPC intersection as the target environment, but treats all POWER/PowerPC incompatibility errors (including instructions outside the POWER/PowerPC intersection and invalid form errors) as instructional warnings. The **-W** and **-w** assembler flags control whether these warnings are displayed. In addition to being closen by the absence of the **-m** flag of the **as** command or the **.machine** pseudo-op, the default assembly mode can also be explicitly specified with the **-m** flag of the **as** command or with the **.machine** pseudo-op.

To assemble a source program containing platform-unique instructions from more than one platform without errors or warnings, use one of the following methods:

- Use the **.machine** pseudo-op in the source program.
- Assemble the program with the assembly mode set to the **any** mode (with the **-m** flag of the **as** command).

For example, the source code cannot contain both POWER family-unique instructions and PowerPC 601 RISC Microprocessor-unique instructions. This is also true for each of the sub-source programs contained in a single source program. A sub-source program begins with a **.machine** pseudo-op and ends before the next **.machine** pseudo-op. Since a source program can contain multiple **.machine** pseudo-ops, it normally consists of several sub-source programs. For more information, see the **.machine** pseudo-op.

Mnemonics Cross-Reference

The assembler supports both PowerPC and POWER family mnemonics. The assembler listing has a cross-reference for both mnemonics. The cross-reference is restricted to instructions that have different mnemonics in the POWER family and PowerPC architectures, but which share the same op codes, functions, and operand input formats.

The assembler listing contains a column to display mnemonics cross-reference information. For more information on the assembler listing, see Interpreting an Assembler Listing.

The mnemonics cross-reference helps the user migrate a source program from one architecture to another. The **-s** flag for the **as** command provides a mnemonics cross-reference in the assembler listing to assist with migration. If the **-s** flag is not used, no mnemonics cross-reference is provided.

CPU ID Definition

During the assembly process the assembler determines which instruction set (from a list of several complete instruction sets defined in the architectures or processor implementations) is the smallest instruction set containing all the instructions used in the program. The program is given a CPU ID value indicating this instruction set. Therefore a CPU ID indicates the target environment on which the object code can be run. The CPU ID value for the program is an assembler output value included in the XCOFF object file generated by the assembler.

CPU ID can have the following values:

Value	Description
com	All instructions used in the program are in the PowerPC and POWER family architecture intersection. (The **com** instruction set is the smallest instruction set.)
ppc	All instructions used in the program are in the PowerPC architecture, 32-bit mode, but the program does not satisfy the conditions for CPU ID value **com**. (The **ppc** instruction set is a superset of the **com** instruction set.)
pwr	All instructions used in the program are in the POWER family architecture, POWER family implementation, but the program does not satisfy the conditions for CPU ID value **com**. (The **pwr** instruction set is a superset of the **com** instruction set.)
pwr2	All instructions used in the program are in the POWER family architecture, POWER2 implementation, but the program does not satisfy the conditions for CPU ID values **com, ppc**, or **pwr**. (The **pwr2** instruction set is a superset of the **pwr** instruction set.)
any	The program contains a mixture of instructions from the valid architectures or implementations, or contains implementation-unique instructions.The program does not satisfy the conditions for CPU ID values **com**, **ppc**, **pwr**, or **pwr2**. (The **any** instruction set is the largest instruction set.)

The assembler output value CPU ID is not the same thing as the assembly mode. The assembly mode (determined by the **-m** flag of the **as** command and by use of the **.machine** pseudo-op in the program) determines which instructions the assembler accepts without errors or warnings. The CPU ID is an output value indicating which instructions are actually used.

In the output XCOFF file, the CPU ID is stored in the low-order byte of the n_type field in a symbol table entry with the C_FILE storage class. The following list shows the low-order byte values and corresponding CPU IDs:

Low-Order Byte	CPU ID
0	Not a defined value. An invalid value or object was assembled prior to definition of the CPU-ID field.
1	**ppc**
3	**com**
4	**pwr**
5	**any**
224	**pwr2(pwrx)**

Source Language Type

For cascade compilers, the assembler records the source-language type. In the XCOFF file, the high-order byte of the n_type field of a symbol table entry with the C_FILE storage class holds the source language type information. The following language types are defined:

High-Order Byte	Language
0x00	C
0x01	FORTRAN
0x02	Pascal
0x03	Ada
0x04	PL/I
0x05	Basic
0x06	Lisp
0x07	Cobol
0x08	Modula2
0x09	C++
0x0A	RPG
0x0B	PL8, PLIX
0x0C	Assembler
0x0D-BxFF	Reserved

The source language type is indicated by the **.source** pseudo-op. By default, the source-language type is ″Assembler.″ For more information, see the **.source** pseudo-op.

Detection Error Conditions

Error number 149 is reported if the source program contains instructions that are not supported in the intended target environment.

An error is reported if the source program contains invalid instruction forms. This error occurs due to incompatibilities between the POWER family and PowerPC architectures. Some restrictions that apply in the PowerPC architecture do not apply in the POWER family architecture. According to the PowerPC architecture, the following invalid instruction forms are defined:

- If an Rc bit, LK bit, or OE bit is defined as / (slash) but coded as 1, or is defined as 1 but coded as 0, the form is invalid. Normally, the assembler ensures that these bits contain correct values.

  Some fields are defined with more than one / (slash) (for example, ″///″). If they are coded as nonzero, the form is invalid. If certain input operands are used for these fields, they must be checked. For this reason, the following instructions are checked:

  – For the PowerPC System Call instructions or the POWER family Supervisor Call instructions, if the POWER family **svca** mnemonic is used when the assembly mode is PowerPC type, the SV field must be 0. Otherwise, the instruction form is invalid and error number 165 is reported.

Note: The **svc** and **svcl** instructions are not supported in PowerPC target modes. The **svcla** instruction is supported only on the PowerPC 601 RISC Microprocessor.

– For the Move to Segment Register Indirect instruction, if the POWER family **mtsri** mnemonic is used in PowerPC target modes, the RA field must be 0. Otherwise, the instruction form is invalid and error number 154 is reported. If the PowerPC **mtsrin** mnemonic is used in PowerPC target modes, it requires only two input operands, so no check is needed.

- For all of the Branch Conditional instructions (including Branch Conditional, Branch Conditional to Link Register, and Branch Conditional to Count Register), bits 0-3 of the BO field are checked. If the bits that are required to contain 0 contain a nonzero value, error 150 is reported.

  The encoding for the BO field is defined in the section ″Branch Processor Instructions″ of PowerPC architecture. The following list gives brief descriptions of the possible values for this field:

BO	Description
0000y	Decrement the Count Register (CTR); then branch if the value of the decremented CTR is not equal to 0 and the condition is False.
0001y	Decrement the CTR; then branch if the value of the decremented CTR is not equal to 0 and the condition is False.
001zy	Branch if the condition is False.
0100y	Decrement the CTR; then branch if the value of the decremented CTR is not equal to 0 and the condition is True.
0101y	Decrement the CTR; then branch if the value of the decremented CTR is not equal to 0 and the condition is True.
011zy	Branch if the condition is True.
1z00y	Decrement the CTR; then branch if the value of the decremented CTR is not equal to 0.
1z01y	Decrement the CTR; then branch if the value of the decremented CTR is not equal to 0.
1z1zz	Branch always.
	The z bit denotes a bit that must be 0. If the bit is not 0, the instruction form is invalid.

  Note: The y bit provides a hint about whether a conditional branch is likely to be taken. The value of this bit can be either 0 or 1. The default value is 0. The extended mnemonics for Branch Prediction as defined in PowerPC architecture are used to set this bit to 0 or 1. (See Extended Mnemonics for Branch Prediction for more information.)

  Branch always instructions do not have a y bit in the BO field. Bit 4 of the BO field should contain 0. Otherwise, the instruction form is invalid.

  The third bit of the BO field is specified as the ″decrement and test CTR″ option. For Branch Conditional to Count Register instructions, the third bit of the BO field must not be 0. Otherwise, the instruction form is invalid and error 163 is reported.

- For the update form of fixed-point load instructions, the PowerPC architecture requires that the RA field not be equal to either 0 or the RT field value. Otherwise, the instruction form is invalid and error number 151 is reported.

  This restriction applies to the following instructions:

  – **lbzu**
  – **lbzux**
  – **lhzu**
  – **lhsux**
  – **lhau**
  – **lhaux**
  – **lwzu** (**lu** in POWER family)
  – **lwzux** (**lux** in POWER family)

- For the update form of fixed-point store instructions and floating-point load and store instructions, the following instructions require only that the RA field not be equal to 0. Otherwise, the instruction form is invalid and error number 166 is reported.
  - **lfsu**
  - **lfsux**
  - **lfdu**
  - **lfdux**
  - **stbu**
  - **stbux**
  - **sthu**
  - **sthux**
  - **stwu** (**stu** in POWER family)
  - **stwux** (**stux** in POWER family)
  - **stfsu**
  - **stfux**
  - **stfdu**
  - **stfdux**
- For multiple register load instructions, the PowerPC architecture requires that the RA field and the RB field, if present in the instruction format, not be in the range of registers to be loaded. Also, RA=RT=0 is not allowed. If RA=RT=0, the instruction form is invalid and error 164 is reported. This restriction applies to the following instructions:
  - **lmn** (**lm** in POWER family)
  - **lswi** (**lsi** in POWER family)
  - **lswx** (**lsx** in POWER family)

    Note: For the **lswx** instruction, the assembler only checks whether RA=RT=0, because the load register range is determined by the content of the XER register at run time.
- For fixed-point compare instructions, the PowerPC architecture requires that the L field be equal to 0. Otherwise, the instruction form is invalid and error number 154 is reported. This restriction applies to the following instructions:
  - **cmp**
  - **cmpi**
  - **cmpli**
  - **cmpl**

    Note: If the target mode is **com**, or **ppc**, the assembler checks the update form of fixed-point load instructions, update form of fixed-point store instructions, update form of floating-point load and store instructions, multiple-register load instructions, and fixed-point compare instructions, and reports any errors. If the target mode is **any**, **pwr**, **pwr2**, or **601**, no check is performed.

Warning Messages

Warning messages are listed when the **-w** flag is used with the **as** command. Some warning messages are related to instructions with the same op code for POWER family and PowerPC:

- Several instructions have the same op code in both POWER family and PowerPC architectures, but have different functional definitions. The assembler identifies these instructions and reports warning number 153 when the target mode is **com** and the **-w** flag of the **as** command is used. Because these mnemonics differ functionally, they are not listed in the mnemonics cross-reference of the assembler listing generated when the **-s** flag is used with the **as** command. The following table lists these instructions.

Table 1. Same Op Codes with Different Mnemonics

POWER family	PowerPC
dcs	**sync**
ics	**isync**
svca	**sc**
mtsri	**mtsrin**
lsx	**lswx**

- The following instructions have the same mnemonics and op code, but have different functional definitions in the POWER family and PowerPC architectures. The assembler cannot check for these, because the differences are not based on the machine the instructions execute on, but rather on what protection domain the instructions are running in.
  - **mfsr**
  - **mfmsr**
  - **mfdec**

Special-Purpose Register Changes and Special-Purpose Register Field Handling

TID, MQ, SDR0, RTCU, and RTCL are special-purpose registers (SPRs) defined in the POWER family architecture. They are not valid in the PowerPC architecture. However, MQ, RTCU, and RTCL are still available in the PowerPC 601 RISC Microprocessor.

DBATL, DBATU, IBATL, IBATU, TBL, and TBU are SPRs defined in the PowerPC architecture. They are not supported for the PowerPC 601 RISC Microprocessor. The PowerPC 601 RISC Microprocessor uses the BATL and BATU SPRs instead.

The assembler provides the extended mnemonics for ″move to or from SPR″ instructions. The extended mnemonics include all the SPRs defined in the POWER family and PowerPC architectures. An error is generated if an invalid extended mnemonic is used. The assembler does not support extended mnemonics for any of the following:

- POWER2-unique SPRs (IMR, DABR, DSAR, TSR, and ILCR)
- PowerPC 601 RISC Microprocessor-unique SPRs (HID0, HID1, HID2, HID5, PID, BATL, and BATU)
- PowerPC 603 RISC Microprocessor-unique SPRs (DMISS, DCMP, HASH1, HASH2, IMISS, ICMP, RPA, HID0, and IABR)
- PowerPC 604 RISC Microprocessor-unique SPRs (PIE, HID0, IABR, and DABR)

The assembler does not check the SPR field's encoding value for the **mtspr** and **mfspr** instructions, because the SPR encoding codes could be changed or reused. However, the assembler does check the SPR field's value range. If the target mode is **pwr**, **pwr2**, or **com**, the SPR field has a 5-bit length and a maximum value of 31. Otherwise, the SPR field has a 10-bit length and a maximum value of 1023.

To maintain source-code compatibility of the POWER family and PowerPC architectures, the assembler assumes that the low-order 5 bits and high-order 5 bits of the SPR number are reversed before they are used as the input operands to the **mfspr** or **mtspr** instruction.

Related Information

Chapter 1, “Assembler Overview” on page 1.

“Assembler Installation” on page 8.

Chapter 5, “Assembling and Linking a Program” on page 51.

“Pseudo-ops Overview” on page 459.

The **as** command.

“.machine Pseudo-op” on page 486, “.source Pseudo-op” on page 494.

Assembler Installation

The AIX assembler is installed with the base operating system, along with commands, files, and libraries for developing software applications.

Related Information

The **as** command.

“.machine Pseudo-op” on page 486, “.source Pseudo-op” on page 494.

Chapter 2. Processing and Storage

The characteristics of machine architecture and the implementation of processing and storage influence the processor's assembler language. The assembler supports the various processors that implement the POWER family and PowerPC architectures. The assembler can support both the POWER family and PowerPC architectures because the two architectures share a large number of instructions.

This chapter provides an overview and comparison of the POWER family and PowerPC architectures and tells how data is stored in main memory and in registers. It also discusses the basic functions for both the POWER family and PowerPC instruction sets.

All the instructions discussed in this chapter are nonprivileged. Therefore, all the registers discussed in this chapter are related to nonprivileged instructions. Privileged instructions and their related registers are defined in the PowerPC architecture.

The following processing and storage articles provide an overview of the system microprocessor and tells how data is stored both in main memory and in registers. This information provides some of the conceptual background necessary to understand the function of the system microprocessor's instruction set and pseudo-ops.

- "POWER family and PowerPC Architecture Overview"
- "Branch Processor" on page 17
- "Fixed-Point Processor" on page 19
- "Floating-Point Processor" on page 22

POWER family and PowerPC Architecture Overview

A POWER family or PowerPC microprocessor contains the sequencing and processing controls for instruction fetch, instruction execution, and interrupt action, and implements the instruction set, storage model, and other facilities defined in the POWER family and PowerPC architectures.

A POWER family or PowerPC microprocessor contains a branch processor, a fixed-point processor, and a floating-point processor. The microprocessor can execute the following classes of instructions:

- Branch instructions
- Fixed-point instructions
- Floating-point instructions

The following diagram illustrates a logical representation of instruction processing for the PowerPC microprocessor.

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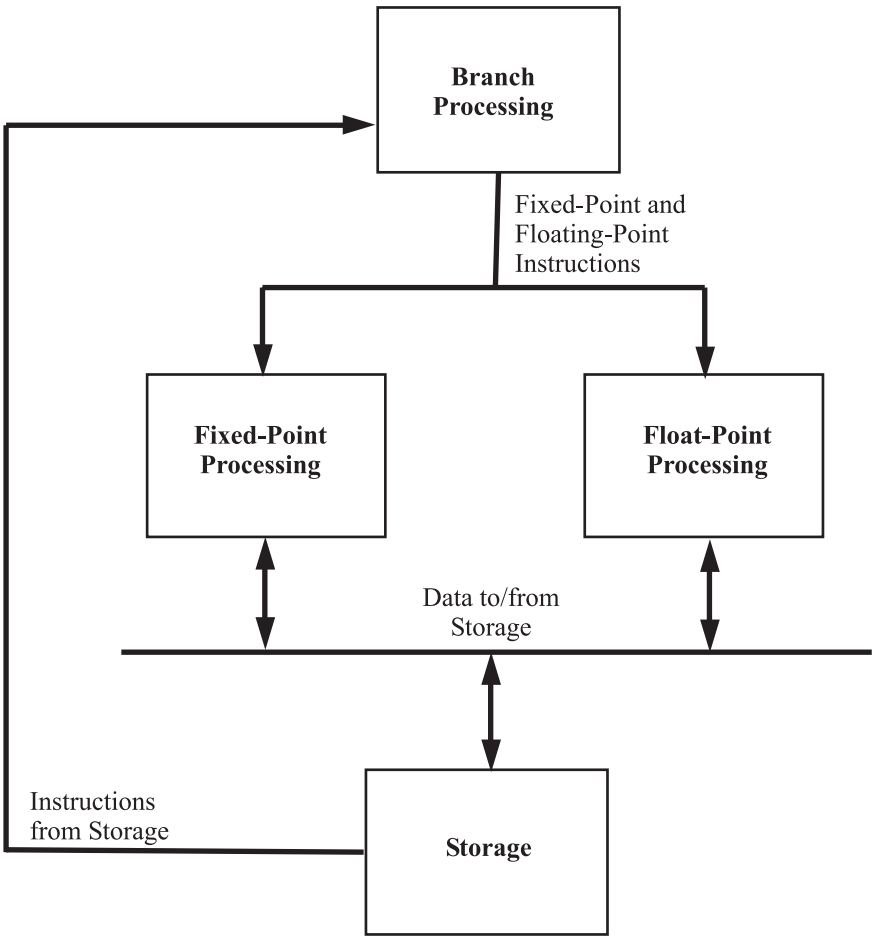

Figure 1. Logical Processing Model. The process begins at the top with Branch Processing, which branches to either fixed-point or float-point processing. These processes send and receive data from storage. Storage will also send more instructions to Branch Processing at the top of the diagram.

The following table shows the registers for the PowerPC user instruction set architecture. These registers are in the CPU that are used for 32-bit applications and are available to the user.

Register	Bits Available
Condition Register (CR)	0-31
Link Register (LR)	0-31
Count Register (CTR)	0-31
General Purpose Registers 00-31 (GPR)	0-31 for each register
Fixed-Point Exception Register (XER)	0-31
Floating-Point Registers 00-31 (FPR)	0-63 for each register
Floating Point Status and Control Register (FPSCR)	0-31

The following table shows the registers of the POWER family user instruction set architecture. These registers are in the CPU that are used for 32-bit applications and are available to the user.

Register	Bits Available
Condition Register (CR)	0-31
Link Register (LR)	0-31

Register	Bits Available
Count Register (CTR)	0-31
General Purpose Registers 00-31 (GPR)	0-31 for each register
Multiply-Quotient Register (MQ)	0-31
Fixed-Point Exception Register (XER)	0-31
Floating-Point Registers 00-31 (FPR)	0-63 for each register
Floating Point Status and Control Register (FPSCR)	0-31

The processing unit is a word-oriented, fixed-point processor functioning in tandem with a doubleword-oriented, floating-point processor. The microprocessor uses 32-bit word-aligned instructions. It provides for byte, halfword, and word operand fetches and stores for fixed point, and word and doubleword operand fetches and stores for floating point. These fetches and stores can occur between main storage and a set of 32 general-purpose registers, and between main storage and a set of 32 floating-point registers.

Instruction Forms

All instructions are four bytes long and are word-aligned. Therefore, when the processor fetches instructions (for example, branch instructions), the two low-order bits are ignored. Similarly, when the processor develops an instruction address, the two low-order bits of the address are 0.

Bits 0-5 always specify the op code. Many instructions also have an extended op code (for example, XO-form instructions). The remaining bits of the instruction contain one or more fields. The alternative fields for the various instruction forms are shown in the following:

- **I Form**

Bits	Value
0-5	OPCD
6-29	LI
30	AA
31	LK

- **B Form**

Bits	Value
0-5	OPCD
6-10	BO
11-15	BI
16-29	BD
30	AA
31	LK

- **SC Form**

Bits	Value
0-5	OPCD
6-10	///
11-15	///

Bits	Value
16-29	///
30	XO
31	/

- **D Form**

Bits	Value
0-5	OPCD
6-10	RT, RS, FRT, FRS, TO, or BF, /, and L
11-15	RA
16-31	D, SI, or UI

- **DS Form**

Bits	Value
0-5	OPCD
6-10	RT or RS
11-15	RA
16-29	DS
30-31	XO

- **X Instruction Format**

Bits	Value
0-5	OPCD
6-10	RT, FRT, RS, FRS, TO, BT, or BF, /, and L
11-15	RA, FRA, SR, SPR, or BFA and //
16-20	RB, FRB, SH, NB, or U and /
21-30	XO or EO
31	Rc

  - **XL Instruction Format**

Bits	Value
0-5	OPCD
6-10	RT or RS
11-20	spr or /, FXM and /
21-30	XO or EO
31	Rc

  - **XFX Instruction Format**

Bits	Value
0-5	OPCD
6-10	RT or RS
11-20	spr or /, FXM and /

Bits	Value
21-30	XO or EO
31	Rc

– **XFL Instruction Format**

Bits	Value
0-5	OPCD
6	/
7-14	FLM
15	/
16-20	FRB
21-30	XO or EO
31	Rc

– **XO Instruction Format**

Bits	Value
0-5	OPCD
6-10	RT
11-15	RA
16-20	RB
21	OE
22-30	XO or EO
31	Rc

- **A Form**

Bits	Value
0-5	OPCD
6-10	FRT
11-15	FRA
16-20	FRB
21-25	FRC
26-30	XO
31	Rc

- **M Form**

Bits	Value
0-5	OPCD
6-10	RS
`11-15	RA
16-20	RB or SH
21-25	MB
26-30	ME

Bits	Value
31	Rc

For some instructions, an instruction field is reserved or must contain a particular value. This is not indicated in the previous figures, but is shown in the syntax for instructions in which these conditions are required. If a reserved field does not have all bits set to 0, or if a field that must contain a particular value does not contain that value, the instruction form is invalid. See “Detection Error Conditions” on page 4 for more information on invalid instruction forms.

Split-Field Notation

In some cases an instruction field occupies more than one contiguous sequence of bits, or occupies a contiguous sequence of bits that are used in permuted order. Such a field is called a *split field*. In the previous figures and in the syntax for individual instructions, the name of a split field is shown in lowercase letters, once for each of the contiguous bit sequences. In the description of an instruction with a split field, and in certain other places where the individual bits of a split field are identified, the name of the field in lowercase letters represents the concatenation of the sequences from left to right. In all other cases, the name of the field is capitalized and represents the concatenation of the sequences in some order, which does not have to be left to right. The order is described for each affected instruction.

Instruction Fields

AA (30) Specifies an Absolute Address bit:

- **0** Indicates an immediate field that specifies an address relative to the current instruction address. For I-form branches, the effective address of the branch target is the sum of the `LI` field sign-extended to 64 bits (PowerPC) or 32 bits (POWER family) and the address of the branch instruction. For B-form branches, the effective address of the branch target is the sum of the `BD` field sign-extended to 64 bits (PowerPC) or 32 bits (POWER family) and the address of the branch instruction.
- **1** Indicates an immediate field that specifies an absolute address. For I-form branches, the effective address of the branch target is the `LI` field sign-extended to 64 bits (PowerPC) or 32 bits (POWER family). For B-form branches, the effective address of the branch target is the `BD` field sign-extended to 64 bits (PowerPC) or 32 bits (POWER family).

BA (11:15) Specifies a bit in the Condition Register (CR) to be used as a source.

BB (16:20) Specifies a bit in the CR to be used as a source.

BD (16:29) Specifies a 14-bit signed two’s-complement branch displacement that is concatenated on the right with `0b00` and sign-extended to 64 bits (PowerPC) or 32 bits (POWER family). This is an immediate field.

BF (6:8) Specifies one of the CR fields or one of the Floating-Point Status and Control Register (FPSCR) fields as a target. For POWER family, if i=BF(6:8), then the `i` field refers to bits i*4 to (i*4)+3 of the register.

BFA (11:13) Specifies one of the CR fields or one of the FPSCR fields as a source. For POWER family, if j=BFA(11:13), then the `j` field refers to bits j*4 to (j*4)+3 of the register.

BI (11:15) Specifies a bit in the CR to be used as the condition of a branch conditional instruction.

BO (6:10) Specifies options for the branch conditional instructions. The possible encodings for the BO field are:

BO	Description
0000*x*	Decrement Count Register (CTR). Branch if the decremented CTR value is not equal to 0 and the condition is false.
0001*x*	Decrement CTR. Branch if the decremented CTR value is 0 and the condition is false.
001*xx*	Branch if the condition is false.
0100*x*	Decrement CTR. Branch if the decremented CTR value is not equal to 0 and the condition is true.
0101*x*	Decrement CTR. Branch if the decremented CTR value is equal to 0 and the condition is true.
011*x*	Branch if the condition is true.
1*x***00***x*	Decrement CTR. Branch if the decremented CTR value is not equal to 0.
1*x***01***x*	Decrement CTR. Branch if bits 32-63 of the CTR are 0 (PowerPC) or branch if the decremented CTR value is equal to 0 (POWER family).
1*x***1***xx*	Branch always.

BT (6:10) Specifies a bit in the CR or in the FPSCR as the target for the result of an instruction.

D (16:31) Specifies a 16-bit signed two's-complement integer that is sign-extended to 64 bits (PowerPC) or 32 bits (POWER family). This is an immediate field.

EO (21:30) Specifies a10-bit extended op code used in X-form instructions.

EO' (22:30) Specifies a 9-bit extended op code used in XO-form instructions.

FL1 (16:19) Specifies a 4-bit field in the **svc** (Supervisor Call) instruction.

FL2 (27:29) Specifies a 3-bit field in the **svc** instruction.

FLM (7:14) Specifies a field mask that specifies the FPSCR fields which are to be updated by the **mtfsf** instruction:

Bit	Description
7	FPSCR field 0 (bits 00:03)
8	FPSCR field 1 (bits 04:07)
9	FPSCR field 2 (bits 08:11)
10	FPSCR field 3 (bits 12:15)
11	FPSCR field 4 (bits 16:19)
12	FPSCR field 5 (bits 20:23)
13	FPSCR field 6 (bits 24:27)
14	FPSCR field 7 (bits 28:31)

FRA (11:15) Specifies a floating-point register (FPR) as a source of an operation.

FRB (16:20) Specifies an FPR as a source of an operation.

FRC (21:25) Specifies an FPR as a source of an operation.

FRS (6:10) Specifies an FPR as a source of an operation.

FRT (6:10) Specifies an FPR as the target of an operation.

FXM (12:19) Specifies a field mask that specifies the CR fields that are to be updated by the **mtcrf** instruction:

Bit	Description
12	CR field 0 (bits 00:03)
13	CR field 1 (bits 04:07)
14	CR field 2 (bits 08:11)
15	CR field 3 (bits 12:15)
16	CR field 4 (bits 16:19)
17	CR field 5 (bits 20:23)
18	CR field 6 (bits 24:27)
19	CR field 7 (bits 28:31)

I (16:19) Specifies the data to be placed into a field in the FPSCR. This is an immediate field.

LEV (20:26) This is an immediate field in the **svc** instruction that addresses the **svc** routine by b'1' || LEV || b'00000 if the SA field is equal to 0.

LI (6:29) Specifies a 24-bit signed two's-complement integer that is concatenated on the right with 0b00 and sign-extended to 64 bits (PowerPC) or 32 bits (POWER family). This is an immediate field.

LK (31) Link bit:

0 Do not set the Link Register.

1 Set the Link Register. If the instruction is a branch instruction, the address of the instruction following the branch instruction is placed in the Link Register. If the instruction is an **svc** instruction, the address of the instruction following the **svc** instruction is placed into the Link Register.

MB (21:25) and ME (26:30) (POWER family) Specifies a 32-bit string. This string consists of a substring of ones surrounded by zeros, or a substring of zeros surrounded by ones. The encoding is:

MB (21:25)
Index to start bit of substring of ones.

ME (26:30)
Index to stop bit of substring of ones.

```
Let mstart=MB and mstop=ME:
If mstart < mstop + 1 then
          mask(mstart..mstop) = ones
          mask(all other) = zeros
If mstart = mstop + 1 then
          mask(0:31) = ones
If mstart > mstop + 1 then
          mask(mstop+1..mstart-1) = zeros
          mask(all other) = ones
```

NB (16:20) Specifies the number of bytes to move in an immediate string load or store.

OPCD (0:5) Primary op code field.

OE (21) Enables setting the OV and SO fields in the XER for extended arithmetic.

RA (11:15) Specifies a general-purpose register (GPR) to be used as a source or target.

RB (16:20) Specifies a GPR to be used as a source.

Rc (31) Record bit:

0 Do not set the CR.

1 Set the CR to reflect the result of the operation.

For fixed-point instructions, CR bits (0:3) are set to reflect the result as a signed quantity. Whether the result is an unsigned quantity or a bit string can be determined from the EQ bit.

For floating-point instructions, CR bits (4:7) are set to reflect Floating-Point Exception, Floating-Point Enabled Exception, Floating-Point Invalid Operation Exception, and Floating-Point Overflow Exception.

RS (6:10) Specifies a GPR to be used as a source.

RT (6:10) Specifies a GPR to be used as a target.

SA (30) SVC Absolute:

0	**svc** routine at address '1' || LEV || b'00000'
1	**svc** routine at address x'1FE0'

SH (16:20) Specifies a shift amount.

SI (16:31) Specifies a 16-bit signed integer. This is an immediate field.

SPR (11:20) Specifies an SPR for the **mtspr** and **mfspr** instructions. See the **mtspr** and **mfspr** instructions for information on the SPR encodings.

SR (11:15) Specifies one of the 16 Segment Registers. Bit 11 is ignored.

TO (6:10) Specifies the conditions on which to trap. See Fixed-Point Trap Instructions for more information on condition encodings.

TO Bit	ANDed with Condition
0	Compares less than.
1	Compares greater than.
2	Compares equal.
3	Compares logically less than.
4	Compares logically greater than.

U (16:19) Used as the data to be placed into the FPSCR. This is an immediate field.

UI (16:31) Specifies a 16-bit unsigned integer. This is an immediate field.

XO (21:30, 22:30, 26:30, or 30) Extended op code field.

Related Information

Chapter 2, "Processing and Storage" on page 9.

"Branch Processor".

"Fixed-Point Processor" on page 19.

"Floating-Point Processor" on page 22.

Branch Processor

The branch processor has three 32-bit registers that are related to nonprivileged instructions:

- Condition Register
- Link Register
- Count Register

These registers are 32-bit registers. The PowerPC architecture supports both 32- and 64-bit implementations.

For both POWER family and PowerPC, the branch processor instructions include the branch instructions, Condition Register field and logical instructions, and the system call instructions for PowerPC or the supervisor linkage instructions for POWER family.

Branch Instructions

Use branch instructions to change the sequence of instruction execution.

Since all branch instructions are on word boundaries, the processor performing the branch ignores bits 30 and 31 of the generated branch target address. All branch instructions can be used in unprivileged state.

A branch instruction computes the target address in one of four ways:

- Target address is the sum of a constant and the address of the branch instruction itself.
- Target address is the absolute address given as an operand to the instruction.
- Target address is the address found in the Link Register.
- Target address is the address found in the Count Register.

Using the first two of these methods, the target address can be computed sufficiently ahead of the branch instructions to prefetch instructions along the target path.

Using the third and fourth methods, prefetching instructions along the branch path is also possible provided the Link Register or the Count Register is loaded sufficiently ahead of the branch instruction.

The branch instructions include Branch Unconditional and Branch Conditional. In the various target forms, branch instructions generally either branch unconditionally only, branch unconditionally and provide a return address, branch conditionally only, or branch conditionally and provide a return address. If a branch instruction has the Link bit set to 1, then the Link Register is altered to store the return address for use by an invoked subroutine. The return address is the address of the instruction immediately following the branch instruction.

The assembler supports various extended mnemonics for branch instructions that incorporate the `BO` field only or the `BO` field and a partial `BI` field into the mnemonics. See “Extended Mnemonics of Branch Instructions” on page 87 for more information.

System Call Instruction

The PowerPC system call instructions are called supervisor call instructions in POWER family. Both types of instructions generate an interrupt for the system to perform a service. The system call and supervisor call instructions are:

- “sc (System Call) Instruction” on page 356 (PowerPC)
- “svc (Supervisor Call) Instruction” on page 443 (POWER family)

For more information about how these instructions are different, see “Functional Differences for POWER family and PowerPC Instructions” on page 112.

Condition Register Instructions

The condition register instructions copy one CR field to another CR field or perform logical operations on CR bits. The assembler supports several extended mnemonics for the Condition Register instructions. See “Extended Mnemonics of Condition Register Logical Instructions” on page 94 for information on extended mnemonics for condition register instructions.

Related Information

Chapter 2, “Processing and Storage” on page 9.

“POWER family and PowerPC Architecture Overview” on page 9.

“Fixed-Point Processor” on page 19.

“Floating-Point Processor” on page 22.

Fixed-Point Processor

The PowerPC fixed-point processor uses the following registers for nonprivileged instructions.

- Thirty-two 32-bit General-Purpose Registers (GPRs).
- One 32-bit Fixed-Point Exception Register.

The POWER family fixed-point processor uses the following registers for nonprivileged instructions. These registers are:

- Thirty-two 32-bit GPRs
- One 32-bit Fixed-Point Exception Register
- One 32-bit Multiply-Quotient (MQ) Register

The GPRs are the principal internal storage mechanism in the fixed-point processor.

Fixed-Point Load and Store Instructions

The fixed-point load instructions move information from a location addressed by the effective address (EA) into one of the GPRs. The load instructions compute the EA when moving data. If the storage access does not cause an alignment interrupt or a data storage interrupt, the byte, halfword, or word addressed by the EA is loaded into a target GPR. See “Extended Mnemonics of Fixed-Point Load Instructions” on page 97 for information on extended mnemonics for fixed-point load instructions.

The fixed-point store instructions perform the reverse function. If the storage access does not cause an alignment interrupt or a data storage interrupt, the contents of a source GPR are stored in the byte, halfword, or word in storage addressed by the EA.

In user programs, load and store instructions which access unaligned data locations (for example, an attempt to load a word which is not on a word boundary) will be executed, but may incur a performance penalty. Either the hardware performs the unaligned operation, or an alignment interrupt occurs and an operating system alignment interrupt handler is invoked to perform the unaligned operation.

Fixed-Point Load and Store with Update Instructions

Load and store instructions have an ″update″ form, in which the base GPR is updated with the EA in addition to the regular move of information from or to memory.

For POWER family load instructions, there are four conditions which result in the EA not being saved in the base GPR:

1. The GPR to be updated is the same as the target GPR. In this case, the updated register contains data loaded from memory.
2. The GPR to be updated is GPR 0.
3. The storage access causes an alignment interrupt.
4. The storage access causes a data storage interrupt.

For POWER family store instructions, conditions 2, 3, and 4 result in the EA not being saved into the base GPR.

For PowerPC load and store instructions, conditions 1 and 2 above result in an invalid instruction form.

In user programs, load and store with update instructions which access an unaligned data location will be performed by either the hardware or the alignment interrupt handler of the underlying operating system. An alignment interrupt will result in the EA not being in the base GPR.

Fixed-Point String Instructions

The Fixed-Point String instructions allow the movement of data from storage to registers or from registers to storage without concern for alignment. These instructions can be used for a short move between arbitrary storage locations or to initiate a long move between unaligned storage fields. Load String Indexed and Store String Indexed instructions of zero length do not alter the target register.

Fixed-Point Address Computation Instructions

There are several address computation instructions in POWER family. These are merged into the arithmetic instructions for PowerPC.

Fixed-Point Arithmetic Instructions

The fixed-point arithmetic instructions treat the contents of registers as 32-bit signed integers. Several subtract mnemonics are provided as extended mnemonics of addition mnemonics. See “Extended Mnemonics of Fixed-Point Arithmetic Instructions” on page 95 for information on these extended mnemonics.

There are differences between POWER family and PowerPC for all of the fixed-point divide instructions and for some of the fixed-point multiply instructions. To assemble a program that will run on both architectures, the milicode routines for division and multiplication should be used. See “Using Milicode Routines” on page 78 for information on the available milicode routines.

Fixed-Point Compare Instructions

The fixed-point compare instructions algebraically or logically compare the contents of register RA with one of the following:

- The sign-extended value of the `SI` field
- The `UI` field
- The contents of register RB

Algebraic comparison compares two signed integers. Logical comparison compares two unsigned integers.

There are different input operand formats for POWER family and PowerPC, for example, the `L` operand for PowerPC. There are also invalid instruction form restrictions for PowerPC. The assembler checks for invalid instruction forms in PowerPC assembly modes.

Extended mnemonics for fixed-point compare instructions are discussed in “Extended Mnemonics of Fixed-Point Compare Instructions” on page 96.

Fixed-Point Trap Instructions

Fixed-point trap instructions test for a specified set of conditions. Traps can be defined for events that should not occur during program execution, such as an index out of range or the use of an invalid character. If a defined trap condition occurs, the system trap handler is invoked to handle a program interruption. If the defined trap conditions do not occur, normal program execution continues.

The contents of register RA are compared with the sign-extended `SI` field or with the contents of register RB, depending on the particular trap instruction. In 32-bit implementations, only the contents of the low-order 32 bits of registers RA and RB are used in the comparison.

The comparison results in five conditions that are ANDed with the `TO` field. If the result is not 0, the system trap handler is invoked. The five resulting conditions are:

TO Field Bit	ANDed with Condition
0	Less than
1	Greater than

TO Field Bit	ANDed with Condition
2	Equal
3	Logically less than
4	Logically greater than

Extended mnemonics for the most useful TO field values are provided, and a standard set of codes is provided for the most common combinations of trap conditions. See “Extended Mnemonics of Fixed-Point Trap Instructions” on page 98 for information on these extended mnemonics and codes.

Fixed-Point Logical Instructions

Fixed-point logical instructions perform logical operations in a bit-wise fashion. The extended mnemonics for the no-op instruction and the OR and NOR instructions are discussed in “Extended Mnemonics of Fixed-Point Logical Instructions” on page 98.

Fixed-Point Rotate and Shift Instructions

The fixed-point processor performs rotate operations on data from a GPR. These instructions rotate the contents of a register in one of the following ways:

- The result of the rotation is inserted into the target register under the control of a mask. If the mask bit is 1, the associated bit of the rotated data is placed in the target register. If the mask bit is 0, the associated data bit in the target register is unchanged.
- The result of the rotation is ANDed with the mask before being placed into the target register.

The rotate left instructions allow (in concept) right-rotation of the contents of a register. For 32-bit implementations, an *n*-bit right-rotation can be performed by a left-rotation of 32-*n*.

The fixed-point shift instructions logically perform left and right shifts. The result of a shift instruction is placed in the target register under the control of a generated mask.

Some POWER family shift instructions involve the MQ register. This register is also updated.

Extended mnemonics are provided for extraction, insertion, rotation, shift, clear, and clear left and shift left operations. See “Extended Mnemonics of 32-bit Fixed-Point Rotate and Shift Instructions” on page 105 for information on these mnemonics.

Fixed-Point Move to or from Special-Purpose Registers Instructions

Several instructions move the contents of one Special-Purpose Register (SPR) into another SPR or into a General-Purpose Register (GPR). These instructions are supported by a set of extended mnemonics that have each SPR encoding incorporated into the extended mnemonic. These include both nonprivileged and privileged instructions.

> **Note:** The SPR field length is 10 bits for PowerPC and 5 bits for POWER family. To maintain source-code compatibility for POWER family and PowerPC, the low-order 5 bits and high-order 5 bits of the SPR number must be reversed prior to being used as the input operand to the **mfspr** instruction or the **mtspr** instruction. The numbers defined in the encoding tables for the **mfspr** and **mtspr** instructions have already had their low-order 5 bits and high-order 5 bits reversed. When using the **dbx** command to debug a program, remember that the low-order 5 bits and high-order 5 bits of the SPR number are reversed in the output from the **dbx** command.

There are different sets of SPRs for POWER family and PowerPC. Encodings for the same SPRs are identical for POWER family and PowerPC except for moving from the DEC (Decrement) SPR.

Moving from the DEC SPR is privileged in PowerPC, but nonprivileged in POWER family. One bit in the SPR field is 1 for privileged operations, but 0 for nonprivileged operations. Thus, the encoding number for the DEC SPR for the **mfdec** instruction has different values in PowerPC and POWER family. The DEC encoding number is 22 for PowerPC and 6 for POWER family. If the **mfdec** instruction is used, the assembler determines the DEC encoding based on the current assembly mode. The following list shows the assembler processing of the **mfdec** instruction for each assembly mode value:

- If the assembly mode is **pwr**, **pwr2**, or **601**, the DEC encoding is 6.
- If the assembly mode is **ppc**, **603**, or **604**, the DEC encoding is 22.
- If the default assembly mode, which treats POWER family/PowerPC incompatibility errors as instructional warnings, is used, the DEC encoding is 6. Instructional warning 158 reports that the DEC SPR encoding 6 is used to generate the object code. The warning can be suppressed with the **-W** flag.
- If the assembly mode is **any**, the DEC encoding is 6. If the **-w** flag is used, a warning message (158) reports that the DEC SPR encoding 6 is used to generate the object code.
- If the assembly mode is **com**, an error message reports that the **mfdec** instruction is not supported. No object code is generated. In this situation, the **mfspr** instruction must be used to encode the DEC number.

For more information on SPR encodings, see “Extended Mnemonics of Moving from or to Special-Purpose Registers” on page 100.

Related Information

Chapter 2, “Processing and Storage” on page 9.

“POWER family and PowerPC Architecture Overview” on page 9.

“Branch Processor” on page 17.

“Floating-Point Processor”.

Floating-Point Processor

The POWER family and PowerPC floating-point processors have the same register set for nonprivileged instructions. The registers are:

- Thirty-two 64-bit floating-point registers
- One 32-bit Floating-Point Status and Control Register (FPSCR)

The floating-point processor provides high-performance execution of floating-point operations. Instructions are provided to perform arithmetic, comparison, and other operations in floating-point registers, and to move floating-point data between storage and the floating-point registers.

PowerPC and POWER2 also support conversion operations in floating-point registers.

Floating-Point Numbers

A floating-point number consists of a signed exponent and a signed significand, and expresses a quantity that is the product of the signed fraction and the number **2****_exponent_. Encodings are provided in the data format to represent:

- Finite numeric values
- +- Infinity
- Values that are ″Not a Number″ (NaN)

Operations involving infinities produce results obeying traditional mathematical conventions. NaNs have no mathematical interpretation. Their encoding permits a variable diagnostic information field. They may be used to indicate uninitialized variables and can be produced by certain invalid operations.

Interpreting the Contents of a Floating-Point Register

There are thirty-two 64-bit floating-point registers, numbered from floating-point register 0-31. All floating-point instructions provide a 5-bit field that specifies which floating-point registers to use in the execution of the instruction. Every instruction that interprets the contents of a floating-point register as a floating-point value uses the double-precision floating-point format for this interpretation.

All floating-point instructions other than loads and stores are performed on operands located in floating-point registers and place the results in a floating-point register. The Floating-Point Status and Control Register and the Condition Register maintain status information about the outcome of some floating-point operations.

Load and store double instructions transfer 64 bits of data without conversion between storage and a floating-point register in the floating-point processor. Load single instructions convert a stored single floating-format value to the same value in double floating format and transfer that value into a floating-point register. Store single instructions do the opposite, converting valid single-precision values in a floating-point register into a single floating-format value, prior to storage.

Floating-Point Load and Store Instructions

Floating-point load instructions for single and double precision are provided. Double-precision data is loaded directly into a floating-point register. The processor converts single-precision data to double precision prior to loading the data into a floating-point register, since the floating-point registers support only floating-point double-precision operands.

Floating-point store instructions for single and double precision are provided. Single-precision stores convert floating-point register contents to single precision prior to storage.

POWER2 provides load and store floating-point quad instructions. These are primarily to improve the performance of arithmetic operations on large volumes of numbers, such as array operations. Data access is normally a performance bottleneck for these types of operations. These instructions transfer 128 bits of data, rather than 64 bits, in one load or store operation (that is, one storage reference). The 128 bits of data is treated as two doubleword operands, not as one quadword operand.

Floating-Point Move Instructions

Floating-point move instructions copy data from one FPR to another, with data modification as described for each particular instruction. These instructions do not modify the FPSCR.

Floating-Point Arithmetic Instructions

Floating-point arithmetic instructions perform arithmetic operations on floating-point data contained in floating-point registers.

Floating-Point Multiply-Add Instructions

Floating-point multiply-add instructions combine a multiply operation and an add operation without an intermediate rounding operation. The fractional part of the intermediate product is 106 bits wide, and all 106 bits are used in the add or subtract portion of the instruction.

Floating-Point Compare Instructions

Floating-point compare instructions perform ordered and unordered comparisons of the contents of two FPRs. The CR field specified by the BF field is set based on the result of the comparison. The comparison sets one bit of the designated CR field to 1, and sets all other bits to 0. The Floating-Point Condition Code (FPCC) (bits 16:19) is set in the same manner.

The CR field and the FPCC are interpreted as follows:

Condition-Register Field and Floating-Point Condition Code Interpretation		
Bit	**Name**	**Description**
0	FL	(FRA) < (FRB)
1	FG	(FRA) > (FRB)
2	FE	(FRA) = (FRB)
3	FU	(FRA) ? (FRB) (unordered)

Floating-Point Conversion Instructions

Floating-point conversion instructions are only provided for PowerPC and POWER2. These instructions convert a floating-point operand in an FPR into a 32-bit signed fixed-point integer. The CR1 field and the FPSCR are altered.

Floating-Point Status and Control Register Instructions

Floating-Point Status and Control Register Instructions manipulate data in the FPSCR.

Related Information

Chapter 2, “Processing and Storage” on page 9.

“POWER family and PowerPC Architecture Overview” on page 9.

“Branch Processor” on page 17.

“Fixed-Point Processor” on page 19.

Chapter 3. Syntax and Semantics

This overview explains the syntax and semantics of assembler language, including the following items:

- "Character Set"
- "Reserved Words" on page 26
- "Line Format" on page 26
- "Statements" on page 27
- "Symbols" on page 29
- "Constants" on page 33
- "Operators" on page 36
- "Expressions" on page 37

Character Set

All letters and numbers are allowed. The assembler discriminates between uppercase and lowercase letters. To the assembler, the variables *Name* and *name* identify distinct symbols.

Some blank spaces are required, while others are optional. The assembler allows you to substitute tabs for spaces.

The following characters have special meaning in the operating system assembler language:

, (comma)
Operand separator. Commas are allowed in statements only between operands, for example:

```
a 3,4,5
```

 # (pound sign)
Comments. All text following a # to the end of the line is ignored by the assembler. A # can be the first character in a line, or it can be preceded by any number of characters, blank spaces, or both. For example:

```
a 3,4,5 # Puts the sum of GPR4 and GPR5 into GPR3.
```

: (colon)
Defines a label. The **:** always appears immediately after the last character of the label name and defines a label equal to the value contained in the location counter at the time the assembler encounters the label. For example:

```
add: a 3,4,5    # Puts add equal to the address
                # where the a instruction is found.
```

; (semicolon)
Instruction separator. A semicolon separates two instructions that appear on the same line. Spaces around the semicolon are optional. A single instruction on one line does not have to end with a semicolon.

To keep the assembler listing clear and easily understandable, it is suggested that each line contain only one instruction. For example:

```
a 3,4,5                 # These two lines have
a 4,3,5                 # the same effect as...

a 3,4,5; a 4,3,5        # ...this line.
```

$ (dollar sign)
Refers to the current value in the assembler's current location counter. For example:

```
dino:   .long 1,2,3
size:   .long $ - dino
```

Related Information

"Reserved Words" on page 26

"Line Format" on page 26

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“Statements” on page 27

“Symbols” on page 29

“Constants” on page 33

“Operators” on page 36

“Expressions” on page 37

The **atof** subroutine.

“.comm Pseudo-op” on page 467, “.csect Pseudo-op” on page 469, “.double Pseudo-op” on page 471, “.dsect Pseudo-op” on page 473, “.float Pseudo-op” on page 479, “.lcomm Pseudo-op” on page 483, “.tc Pseudo-op” on page 499, “.toc Pseudo-op” on page 500, “.tocof Pseudo-op” on page 500.

Reserved Words

There are no reserved words in the operating system assembler language. The mnemonics for instructions and pseudo-ops are not reserved. They can be used in the same way as any other symbols.

There may be restrictions on the names of symbols that are passed to programs written in other languages.

Related Information

“Character Set” on page 25

“Line Format”

“Statements” on page 27

“Symbols” on page 29

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The **atof** subroutine.

“.comm Pseudo-op” on page 467, “.csect Pseudo-op” on page 469, “.double Pseudo-op” on page 471, “.dsect Pseudo-op” on page 473, “.float Pseudo-op” on page 479, “.lcomm Pseudo-op” on page 483, “.tc Pseudo-op” on page 499, “.toc Pseudo-op” on page 500, “.tocof Pseudo-op” on page 500.

Line Format

The assembler supports a free-line format for source lines, which does not require that items be in a particular column position.

For all instructions, a separator character (space or tab) is recommended between the mnemonic and operands of the statement for readability. With the AIX assembler, Branch Conditional instructions need a separator character (space or tab) between the mnemonic and operands for unambiguous processing by the assembler. (See “Migration of Branch Conditional Statements with No Separator after Mnemonic” on page 119 for more information.)

The assembler language puts no limit on the number of characters that can appear on a single input line. If a code line is longer than one line on a terminal, line wrapping will depend on the editor used. However, the listing will only display 512 ASCII characters per line.

Blank lines are allowed; the assembler ignores them.

Related Information

“Character Set” on page 25

“Reserved Words” on page 26

“Statements”

“Symbols” on page 29

“Constants” on page 33

“Operators” on page 36

“Expressions” on page 37

The **atof** subroutine.

The “.comm Pseudo-op” on page 467, “.csect Pseudo-op” on page 469, “.double Pseudo-op” on page 471, “.dsect Pseudo-op” on page 473, “.float Pseudo-op” on page 479, “.lcomm Pseudo-op” on page 483, “.tc Pseudo-op” on page 499, “.toc Pseudo-op” on page 500, “.tocof Pseudo-op” on page 500.

Statements

The assembler language has three kinds of statements: instruction statements, pseudo-operation statements, and null statements. The assembler also uses separator characters, labels, mnemonics, operands, and comments.

Instruction Statements and Pseudo-Operation Statements

An instruction or pseudo-op statement has the following syntax:

[*label***:**] *mnemonic* [*operand1*[**,***operand2*...]] [**#** *comment*]

The assembler recognizes the end of a statement when one of the following appears:

- An ASCII new-line character
- A # (pound sign) (comment character)
- A ; (semicolon)

Null Statements

A null statement does not have a mnemonic or any operands. It can contain a label, a comment, or both. Processing a null statement does not change the value of the location counter.

Null statements are useful primarily for making assembler source code easier for people to read.

A null statement has the following syntax:

[*label***:**] [**#** *comment*]

The spaces between the label and the comment are optional.

If the null statement has a label, the label receives the value of the next statement, even if the next statement is on a different line. The assembler gives the label the value contained in the current location counter. For example:

```
here:
       a 3,4,5
```

is synonymous with

```
here:  a 3,4,5
```

Note: Certain pseudo-ops (**.csect**, **.comm**, and **.lcomm**, for example) may prevent a null statement's label from receiving the value of the address of the next statement.

Separator Characters

The separator characters are spaces, tabs, and commas. Commas separate operands. Spaces or tabs separate the other parts of a statement. A tab can be used wherever a space is shown in this book.

The spaces shown in the syntax of an instruction or pseudo-op are required.

Branch Conditional instructions need a separator character (space or tab) between the mnemonic and operands for unambiguous processing by the assembler. (See "Migration of Branch Conditional Statements with No Separator after Mnemonic" on page 119 for more information.)

Optionally, you can put one or more spaces after a comma, before a pound sign (#), and after a #.

Labels

The label entry is optional. A line may have zero, one, or more labels. Moreover, a line may have a label but no other contents.

To define a label, place a symbol before the : (colon). The assembler gives the label the value contained in the assembler's current location counter. This value represents a relocatable address. For example:

```
subtr:   sf 3,4,5
# The label subtr: receives the value
# of the address of the sf instruction.
# You can now use subtr in subsequent statements
# to refer to this address.
```

If the label is in a statement with an instruction that causes data alignment, the label receives its value before the alignment occurs. For example:

```
# Assume that the location counter now
# contains the value of 98.
place:   .long expr
# When the assembler processes this statement, it
# sets place to address 98. But the .long is a pseudo-op that
# aligns expr on a fullword. Thus, the assembler puts
# expr at the next available fullword boundary, which is
# address 100. In this case, place is not actually the address
# at which expr is stored; referring to place will not put you
# at the location of expr.
```

Mnemonics

The mnemonic field identifies whether a statement is an instruction statement or a pseudo-op statement. Each mnemonic requires a certain number of operands in a certain format.

For an instruction statement, the mnemonic field contains an abbreviation like **ai** (Add Immediate) or **sf** (Subtract From). This mnemonic describes an operation where the system microprocessor processes a

single machine instruction that is associated with a numerical operation code (op code). All instructions are 4 bytes long. When the assembler encounters an instruction, the assembler increments the location counter by the required number of bytes.

For a pseudo-op statement, the mnemonic represents an instruction to the assembler program itself. There is no associated op code, and the mnemonic does not describe an operation to the processor. Some pseudo-ops increment the location counter; others do not. See the “Pseudo-ops Overview” on page 459 for a list of pseudo-ops that change the location counter.

Operands

The existence and meaning of the operands depends on the mnemonic used. Some mnemonics do not require any operands. Other mnemonics require one or more operands.

The assembler interprets each operand in context with the operand’s mnemonic. Many operands are expressions that refer to registers or symbols. For instruction statements, operands can be immediate data directly assembled into the instruction.

Comments

Comments are optional and are ignored by the assembler. Every line of a comment must be preceded by a # (pound sign); there is no other way to designate comments.

Related Information

“Character Set” on page 25

“Reserved Words” on page 26

“Line Format” on page 26

“Symbols”

“Constants” on page 33

“Operators” on page 36

“Expressions” on page 37

The **atof** subroutine.

“.comm Pseudo-op” on page 467, “.csect Pseudo-op” on page 469, “.double Pseudo-op” on page 471, “.dsect Pseudo-op” on page 473, “.float Pseudo-op” on page 479, “.lcomm Pseudo-op” on page 483, “.tc Pseudo-op” on page 499, “.toc Pseudo-op” on page 500, “.tocof Pseudo-op” on page 500.

Symbols

A symbol is a single character or combination of characters used as a label or operand.

Constructing Symbols

Symbols may consist of numeric digits, underscores, periods, uppercase or lowercase letters, or any combination of these. The symbol cannot contain any blanks or special characters, and cannot begin with a digit. Uppercase and lowercase letters are distinct.

If a symbol must contain blank or special characters because of external references, the **.rename** pseudo-op can be used to treat a local name as a synonym or alias for the external reference name.

From the assembler's and loader's perspective, the length of a symbol name is limited only by the amount of storage you have.

Note: Other routines linked to the assembler language files may have their own constraints on symbol length.

With the exception of control section (csect) or Table of Contents (TOC) entry names, symbols may be used to represent storage locations or arbitrary data. The value of a symbol is always a 32-bit quantity.

The following are valid examples of symbol names:

- `READER`
- `XC2345`
- `result.a`
- `resultA`
- `balance_old`
- `_label9`
- `.myspot`

The following are not valid symbol names:

`7_sum`	(Begins with a digit.)
#ofcredits	(The # makes this a comment.)
`aa*1`	(Contains `*`, a special character.)
IN AREA	(Contains a blank.)

You can define a symbol by using it in one of two ways:

- As a label for an instruction or pseudo-op
- As the name operand of a **.set**, **.comm**, **.lcomm**, **.dsect**, **.csect**, or **.rename** pseudo-op

Defining a Symbol with a Label

You can define a symbol by using it as a label. For example:

```
              .using          dataval[RW],5
loop:
              bgt             cont
  .
  .
              bdz             loop
cont:         l               3,dataval
              a               4,3,4
  .
  .
.csect dataval[RW]
dataval:        .short    10
```

The assembler gives the value of the location counter at the instruction or pseudo-op's leftmost byte. In the example here, the object code for the **l** instruction contains the location counter value for `dataval`.

At run time, an address is calculated from the *dataval* label, the offset, and GPR 5, which needs to contain the address of `csect dataval[RW]`. In the example, the **l** instruction uses the 16 bits of data stored at the `dataval` label's address.

The value referred to by the symbol actually occupies a memory location. A symbol defined by a label is a relocatable value.

The symbol itself does not exist at run time. However, you can change the value at the address represented by a symbol at run time if some code changes the contents of the location represented by the `dataval` label.

Defining a Symbol with a Pseudo-op

Use a symbol as the name operand of a **.set** pseudo-op to define the symbol. This pseudo-op has the format:

.set *name*,*exp*

The assembler evaluates the *exp* operand, then assigns the value and type of the *exp* operand to the symbol *name*. When the assembler encounters that symbol in an instruction, the assembler puts the symbol's value into the instruction's object code.

For example:

```
      .set              number,10
  .
  .
       ai         4,4,number
```

In the preceding example, the object code for the **ai** instruction contains the value assigned to `number`, that is, 10.

The value of the symbol is assembled directly into the instruction and does not occupy any storage space. A symbol defined with a **.set** pseudo-op can have an absolute or relocatable type, depending on the type of the *exp* operand. Also, because the symbol occupies no storage, you cannot change the value of the symbol at run time; reassembling the file will give the symbol a new value.

A symbol also can be defined by using it as the *name* operand of a **.comm**, **.lcomm**, **.csect**, **.dsect**, or **.rename** pseudo-op. Except in the case of the **.dsect** pseudo-op, the value assigned to the symbol describes storage space.

CSECT Entry Names

A symbol can also be defined when used as the *qualname* operand of the **.csect** pseudo-op. When used in this context, the symbol is defined as the name of a csect with the specified storage mapping class. Once defined, the symbol takes on a storage mapping class that corresponds to the name qualifier.

A *qualname* operand takes the form of:

symbol[*XX*]

OR

symbol{*XX*}

where *XX* is the storage mapping class.

For more information, see the ".csect Pseudo-op" on page 469.

The Special Symbol TOC

Provisions have been made for the special symbol TOC. In XCOFF format modules, this symbol is reserved for the TOC anchor, or the first entry in the TOC. The symbol TOC has been predefined in the assembler so that the symbol TOC can be referred to if its use is required. The **.toc** pseudo-op creates the TOC anchor entry. For example, the following data declaration declares a word that contains the address of the beginning of the TOC:

```
.long TOC[TC0]
```

This symbol is undefined unless a **.toc** pseudo-op is contained within the assembler file.

For more information, see the ".toc Pseudo-op" on page 500.

TOC Entry Names

A symbol can be defined when used as the *Name* operand of the **.tc** pseudo-op. When used in this manner, the symbol is defined as the name of a TOC entry with a storage mapping class of TC.

The *Name* operand takes the form of:

*symbol***[TC]**

For more information, see the ".tc Pseudo-op" on page 499.

Using a Symbol before Defining It

It is possible to use a symbol before you define it. Using a symbol and then defining it later in the same file is called *forward referencing*. For example, the following is acceptable:

```
# Assume that GPR 6 contains the address of .csect data[RW].
      l 5,ten(6)
       .
       .
  .csect data[RW]
  ten: .long 10
```

If the symbol is not defined in the file in which it occurs, it may be an external symbol or an undefined symbol. When the assembler finds undefined symbols, it gives an error message unless the **-u** flag of the **as** command is used to suppress this error message. External symbols may be declared in a statement using the ".extern Pseudo-op" on page 478.

Declaring an External Symbol

If a local symbol is used that is defined in another module, the **.extern** pseudo-op is used to declare that symbol in the local file as an external symbol. Any undefined symbols that do not appear in a statement with the **.extern** or **.globl** pseudo-op will be flagged with an error.

Related Information

"Character Set" on page 25

"Reserved Words" on page 26

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The **atof** subroutine.

".comm Pseudo-op" on page 467, ".csect Pseudo-op" on page 469, ".double Pseudo-op" on page 471, ".dsect Pseudo-op" on page 473, ".float Pseudo-op" on page 479, ".lcomm Pseudo-op" on page 483, ".tc Pseudo-op" on page 499, ".toc Pseudo-op" on page 500, ".tocof Pseudo-op" on page 500.

Constants

The assembler language provides four kinds of constants:

- Arithmetic constants
- "Character Constants" on page 35
- "Symbolic Constants" on page 35
- "String Constants" on page 35

When the assembler encounters an arithmetic or character constant being used as an instruction's operand, the value of that constant is assembled into the instruction. When the assembler encounters a symbol being used as a constant, the value of the symbol is assembled into the instruction.

Arithmetic Constants

The assembler language provides four kinds of arithmetic constants:

- Decimal
- Octal
- Hexadecimal
- Floating point

In 32-bit mode, the largest signed positive integer number that can be represented is the decimal value (2**31) - 1. The largest negative value is -(2**31). In 64-bit mode, the largest signed positive integer number that can be represented is (2**63)-1. The largest negative value is -(2**63). Regardless of the base (for example, decimal, hexadecimal, or octal), the assembler regards integers as 32-bit constants.

The interpretation of a constant is dependent upon the assembly mode. In 32-bit mode, the AIX assembler behaves in the same manner as earlier AIX versions: the assembler regards integers as 32-bit constants. In 64-bit mode, all constants are interpreted as 64-bit values. This may lead to results that differ from expectations. For example, in 32-bit mode, the hexadecimal value 0xFFFFFFFF is equivalent to the decimal value of ″-1″. In 64-bit mode, however, the decimal equivalent is 4294967295. To obtain the value ″-1″ the hexadecimal constant 0xFFFF_FFFF_FFFF_FFFF (or the octal equivalent), or the decimal value -1, should be used.

In both 32-bit and 64-bit mode, the result of integer expressions may be truncated if the size of the target storage area is too small to contain an expression result. (In this context, truncation refers to the removal of the excess most-significant bits.)

To improve readability of large constants, especially 64-bit values, the assembler will accept constants containing the underscore (″_″) character. The underscore may appear anywhere within the number except the first numeric position. For example, consider the following table:

Constant Value	Valid/Invalid?
1_800_500	Valid
0xFFFFFFFF_00000000	Valid
0b111010_00100_00101_00000000001000_00	Valid (this is the ″ld 4,8(5)″ instruction)
0x_FFFF	Invalid

The third example shows a binary representation of an instruction where the underscore characters are used to delineate the various fields within the instruction. The last example contains a hexadecimal prefix, but the character immediately following is not a valid digit; the constant is therefore invalid.

Arithmetic Evaluation

In 32-bit mode, arithmetic evaluation takes place using 32-bit math. For the **.llong** pseudo-op, which is used to specify a 64-bit quantity, any evaluation required to initialize the value of the storage area uses 32-bit arithmetic.

For 64-bit mode, arithmetic evaluation uses 64-bit math. No sign extension occurs, even if a number might be considered negative in a 32-bit context. Negative numbers must be specified using decimal format, or (for example, in hexadecimal format) by using a full complement of hexadecimal digits (16 of them).

Decimal Constants

Base 10 is the default base for arithmetic constants. If you want to specify a decimal number, type the number in the appropriate place:

```
ai 5,4,10
# Add the decimal value 10 to the contents
# of GPR 4 and put the result in GPR 5.
```

Do not prefix decimal numbers with a 0. A leading zero indicates that the number is octal.

Octal Constants

To specify that a number is octal, prefix the number with a `0`:

```
ai 5,4,0377
# Add the octal value 0377 to the contents
# of GPR 4 and put the result in GPR 5.
```

Hexadecimal Constants

To specify a hexadecimal number, prefix the number with `0X` or `0x`. You can use either uppercase or lowercase for the hexadecimal numerals A through F.

```
ai 5,4,0xF
# Add the hexadecimal value 0xF to the
# contents of GPR 4 and put the result
# in GPR 5.
```

Binary Constants

To specify a binary number, prefix the number with `0B` or `0b`.

```
ori 3,6,0b0010_0001
# OR (the decimal value) 33 with the
# contents of GPR 6 and put the result
# in GPR 3.
```

Floating-Point Constants

A floating-point constant has the following components in the specified order:

Integer Part	Must be one or more digits.
Decimal Point	. (period). Optional if no fractional part follows.
Fraction Part	Must be one or more digits. The fraction part is optional.
Exponent Part	Optional. Consists of an `e` or `E`, possibly followed by a `+` or `-`, followed by one or more digits.

For assembler input, you can omit the fraction part. For example, the following are valid floating-point constants:

- `0.45`
- `1e+5`
- `4E-11`

- 0.99E6
- 357.22e12

Floating-point constants are allowed only where **fcon** expressions are found.

There is no bounds checking for the operand.

> **Note:**In AIX 4.3 and later, the assembler uses the **strtold** subroutine to perform the conversion to floating point. Check current documentation for restrictions and return values.

Character Constants

To specify an ASCII character constant, prefix the constant with a ' (single quotation mark). Character constants can appear anywhere an arithmetic constant is allowed, but you can only specify one character constant at a time. For example 'A represents the ASCII code for the character A.

Character constants are convenient when you want to use the code for a particular character as a constant, for example:

```
cal 3,'X(0)
# Loads GPR 3 with the ASCII code for
# the character X (that is, 0x58).
# After the cal instruction executes, GPR 3 will
# contain binary
# 0x0000 0000 0000 0000 0000 0000 0101 1000.
```

Symbolic Constants

A symbol can be used as a constant by giving the symbol a value. The value can then be referred to by the symbol name, instead of by using the value itself.

Using a symbol as a constant is convenient if a value occurs frequently in a program. Define the symbolic constant once by giving the value a name. To change its value, simply change the definition (not every reference to it) in the program. The changed file must be reassembled before the new symbol constant is valid.

A symbolic constant can be defined by using it as a label or by using it in a **.set** statement.

String Constants

String constants differ from other types of constants in that they can be used only as operands to certain pseudo-ops, such as the **.rename**, **.byte**, or **.string** pseudo-ops.

The syntax of string constants consists of any number of characters enclosed in "" (double quotation marks):

```
"any number of characters"
```

To use a " in a string constant, use double quotation marks twice. For example:

```
"a double quote character is specified like this "" "
```

Related Information

"Character Set" on page 25

"Reserved Words" on page 26

"Line Format" on page 26

"Statements" on page 27

“Symbols” on page 29

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The **atof** subroutine.

“.comm Pseudo-op” on page 467, “.csect Pseudo-op” on page 469, “.double Pseudo-op” on page 471, “.dsect Pseudo-op” on page 473, “.float Pseudo-op” on page 479, “.lcomm Pseudo-op” on page 483, “.tc Pseudo-op” on page 499, “.toc Pseudo-op” on page 500, “.tocof Pseudo-op” on page 500.

Operators

All operators evaluate from left to right except for the unary operators, which evaluate from right to left.

The assembler provides the following unary operators:

+	unary positive
-	unary negative
~	one’s complement (unary)

The assembler provides the following binary operators:

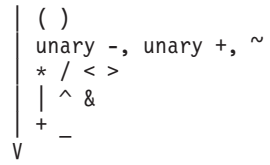
*****	multiplication
/	division
>	right shift
<	left shift
|	bitwise inclusive or
&	bitwise AND
^	bitwise exclusive or
+	addition
-	subtraction

Parentheses can be used in expressions to change the order in which the assembler evaluates the expression. Operations within parentheses are performed before operations outside parentheses. Where nested parentheses are involved, processing starts with the innermost set of parentheses and proceeds outward.

Operator Precedence

Operator precedence for 32-bit expressions is shown in the following figure.

Highest Priority



Lowest Priority

In 32-bit mode, all the operators perform 32-bit signed integer operations. In 64-bit mode, all computations are performed using 64-bit signed integer operations.

The division operator produces an integer result; the remainder has the same sign as the dividend. For example:

Operation	Result	Remainder
8/3	2	2
8/-3	-2	2
(-8)/3	-2	-2
(-8)/(-3)	2	-2

The left shift (<) and right shift (>) operators take an integer bit value for the right-hand operand. For example:

```
.set mydata,1
.set newdata,mydata<2
# Shifts 1 left 2 bits.
# Assigns the result to newdata.
```

Related Information

"Character Set" on page 25

"Reserved Words" on page 26

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The **atof** subroutine.

".comm Pseudo-op" on page 467, ".csect Pseudo-op" on page 469, ".double Pseudo-op" on page 471, ".dsect Pseudo-op" on page 473, ".float Pseudo-op" on page 479, ".lcomm Pseudo-op" on page 483, ".tc Pseudo-op" on page 499, ".toc Pseudo-op" on page 500, ".tocof Pseudo-op" on page 500.

Expressions

A *term* is the smallest element that the assembler parser can recognize when processing an expression. Each term has a value and a type. An expression is formed by one or more terms. The assembler evaluates each expression into a single value, and uses that value as an operand. Each expression also has a type. If an expression is formed by one term, the expression has the same type as the type of the term. If an expression consists of more than one term, the type is determined by the expression handler according to certain rules applied to all the types of terms contained in the expression. Expression types are important because:

- Some pseudo-ops and instructions require expressions with a particular type.
- Only certain operators are allowed in certain types of expressions.

Object Mode Considerations

One aspect of assembly language expressions is that of the object mode and relocation vs. the size of the data value being calculated. In 32-bit mode, relocation is applied to 32-bit quantities; expressions resulting in a requirement for relocation (for example, a reference to an external symbol) can not have their value

stored in any storage area other than a word. For the **.llong** pseudo-op, it is worthwhile to point out that expressions used to initialize the contents of a .llong may not require relocation. In 64-bit mode, relocation is applied to double-word quantities. Thus, expression results that require relocation can not have their value stored in a location smaller than a double-word.

Arithmetic evaluations of expressions in 32-bit mode is consistent with the behavior found in prior releases of the assembler. Integer constants are considered to be 32-bit quantities, and the calculations are 32-bit calculations. In 64-bit mode constants are 64-bit values, and expressions are evaluated using 64-bit calculations.

Types and Values of Terms

The following is a list of all the types of terms and an abbreviated name for each type:

- Absolute (E_ABS)
- Relocatable (E_REL)
- External relocatable (E_EXT)
- TOC-relative relocatable (E_TREL)
- TOCOF relocatable (E_TOCOF)

Absolute Terms

A term is absolute if its value does not change upon program relocation. In other words, a term is absolute if its value is independent of any possible code relocation operation.

An absolute term is one of the following items:

- A constant (including all the kinds of constants defined in “Constants” on page 33).
- A symbol set to an absolute expression.

The value of an absolute term is the constant value.

Relocatable Terms

A term is relocatable if its value changes upon program relocation. The value of a relocatable term depends on the location of the control section containing it. If the control section moves to a different storage location (for example, a csect is relocated by the binder at bind time), the value of the relocatable term changes accordingly.

A relocatable term is one of the following items:

- A label defined within a csect that does not have TD or TC as its Storage Mapping Class (SMC)
- A symbol set to a relocatable expression
- A label defined within a dsect
- A dsect name
- A location counter reference (which uses $**,** the dollar sign)

If it is not used as a displacement for a D-form instruction, the value of a csect label or a location counter reference is its relocatable address, which is the sum of the containing csect address and the offset relative to the containing csect. If it is used as a displacement for a D-form instruction, the assembler implicitly subtracts the containing csect address so that only the the offset is used for the displacement. A csect address is the offset relative to the beginning of the first csect of the file.

A dsect is a reference control section that allows you to describe the layout of data in a storage area without actually reserving any storage. A dsect provides a symbolic format that is empty of data. The assembler does assign location counter values to the labels that are defined in a dsect. The values are the offsets relative to the beginning of the dsect. The data in a dsect at run time can be referenced symbolically by using the labels defined in a dsect.

Relocatable terms based on a dsect location counter (either the dsect name or dsect labels) are meaningful only in the context of a **.using** statement. Since this is the only way to associate a base address with a dsect, the addressability of the dsect is established in combination with the storage area.

A relocatable term may be based on any control section, either csect or dsect, in all the contexts except if it is used as a relocatable address constant. If a csect label is used as an address constant, it represents a relocatable address, and its value is the offset relative to the csect plus the address of the csect. A dsect label cannot be used as a relocatable address constant since a dsect is only a data template and has no address.

If two dsect labels are defined in the same dsect, their difference can be used as an absolute address constant.

External Relocatable Terms

A term is external relocatable (`E_EXT`) if it is an external symbol (a symbol not defined, but declared within the current module, or defined in the current module and globally visible), a csect name, or a TOC entry name.

This term is relocatable because its value will change if it, or its containing control section, is relocated.

An external relocatable term or expression cannot be used as the operand of a **.set** pseudo-op.

An external relocatable term is one of the following items:

- A symbol defined with the **.comm** pseudo-op
- A symbol defined with the **.lcomm** pseudo-op
- A csect name
- A symbol declared with the **.globl** pseudo-op
- A TOC entry name
- An undefined symbol declared with the **.extern** pseudo-op

Except for the undefined symbol, if this term is not used as a displacement for a D-form instruction, its value is its relocatable address, which is the offset relative to the beginning of the first csect in the file. If it is used as a displacement for a D-form instruction, the assembler implicitly subtracts the containing csect address (except for a TOC entry name), usually producing a zero displacement because the csect address is subtracted from itself. If a TOC entry name is used as a displacement for a D-form instruction, the assembler implicitly subtracts the address of the TOC anchor, so the offset relative to the TOC anchor is the displacement.

An undefined symbol cannot be used as a displacement for a D-form instruction. In other cases, its value is zero.

TOC-Relative Relocatable Terms

A term is TOC-relative relocatable (`E_TREL`) if it is a label contained within the TOC.

This type of term is relocatable since its value will change if the TOC is relocated.

A TOC-relative relocatable term is one of the following items:

- A label on a **.tc** pseudo-op
- A label defined within a csect that has TD or TC as its storage mapping class.

If this term is not used as a displacement for a D-form instruction, its value is its relocatable address, which is the sum of the offset relative to the TOC and the TOC anchor address. If it is used as a displacement for a D-form instruction, the assembler implicitly subtracts the TOC anchor address, so the offset relative to the TOC anchor is the displacement.

TOCOF Relocatable Terms

A term has TOCOF relocatable (E_TOCOF) type if it is the first operand of a **.tocof** pseudo-op.

This type of term has a value of zero. It cannot be used as a displacement for a D-form instruction. It cannot participate in any arithmetic operation.

Types and Values of Expressions

Expressions can have all the types that terms can have. An expression with only one term has the same type as its term. Expressions can also have restricted external relocatable (E_REXT) type, which a term cannot have because this type requires at least two terms.

Restricted External Relocatable Expressions

An expression has restricted external relocatable (E_REXT) type if it contains two relocatable terms that are defined in different control sections (terms not meeting the requirements for *paired relocatable terms*, as defined in "Expression Type of Combined Expressions" on page 41) and have opposite signs.

The following are examples of combinations of relocatable terms that produce an expression with restricted external relocatable type:

- <E_EXT> - <E_EXT>
- <E_REL> - <E_REL>
- <E_TREL> - <E_TREL>
- <E_EXT> - <E_REL>
- <E_REL> - <E_EXT>
- <E_EXT> - <E_TREL>
- <E_TREL> - <E_REL>

  The value assigned to an expression of this type is based on the results of the assembler arithmetic evaluation of the values of its terms. When participating in an arithmetic operation, the value of a term is its relocatable address.

Combination Handling of Expressions

Terms within an expression can be combined with binary operators. Also, a term can begin with one or more unary operators. The assembler expression handler evaluates and determines the resultant expression type, value, and relocation table entries.

Expression Value Calculations

The following rules apply when calculating a value:

- If it is participating in an arithmetic operation, the value of an absolute term is its constant value, and the value of a relocatable term (E_EXT, E_REL, or E_TREL) is its relocatable address.
- If the resultant expression is used as a displacement in a D-form instruction, the assembler implicitly subtracts the containing csect address from the final result for expressions of type E_EXT or E_REL, or subtracts the TOC anchor address for expressions of type E_TREL. There is no implicit subtracting for expressions with E_ABS or E_REXT type.

Object File Relocation Table Entries of Expressions

The assembler applies the following rules when determining the requirements for object file relocation table entries for an expression.

- When an expression is used in a data definition, TOC entry definition, or a branch target address, it may require from zero to two relocation table entries (RLDs) depending on the resultant type of the expression.
  - E_ABS requires zero relocation entries.
  - E_REL requires one relocation entry, except that a dsect name or a dsect label does not require a relocation entry.

  - E_EXT requires one relocation entry
  - E_REXT requires two relocation entries
  - E_TREL requires one relocation entry
  - E_TOCOF requires one relocation entry
- When an expression is used as a displacement within a D-form instruction operand, only E_TREL and E_REXT expressions have relocation entries. They each require one relocation entry.

Expression Type of Combined Expressions

The assembler applies the following rules when determining the type of a combined expression.

Combining Expressions with Group 1 Operators: The following operators belong to group #1:

- *****, **/**, **>**, **<**, **|**, **&**, **^**

Operators in group #1 have the following rules:

- <E_ABS> <op1> <E_ABS> ==> E_ABS
- Applying an operator in group #1 to any type of expression other than an absolute expression produces an error.

Combining Expressions with Group 2 Operators: The following operators belong to group # 2:

- **+**, **-**

Operators in group # 2 have the following rules:

- <E_ABS> <op2> <E_ABS> ==> E_ABS
- <E_ABS> <op2> <E_REXT> ==> E_REXT
- <E_REXT> <op2> <E_ABS> ==> E_REXT
- <E_ABS> <op2> <E_TOCOF> ==> an error
- <E_TOCOF> <op2> <E_ABS> ==> an error
- <non E_ABS> <op2> <E_REXT> ==> an error
- <E_REXT> <op2> < non E_ABS> ==> an error
- <E_ABS> - <E_TREL> ==> an error
- Unary **+** and **-** are treated the same as the binary operators with absolute value 0 (zero) as the left term.
- Other situations where one of the terms is not an absolute expression require more complex rules.

The following definitions will be used in later discussion:

paired relocatable terms Have opposite signs and are defined in the same section. The value represented by paired relocatable terms is absolute. The result type for paired relocatable terms is E_ABS. Paired relocatable terms are not required to be contiguous in an expression. Two relocatable terms cannot be paired if they are not defined in the same section. A E_TREL term can be paired with another E_TREL term or E_EXT term, but cannot be paired with a E_REL term (because they will never be in the same section). A E_EXT or E_REL term can be paired with another E_EXT or E_REL term. A E_REXT term cannot be paired with any term.

opposite terms Have opposite signs and point to the same symbol table entry. Any term can have its opposite term. The value represented by opposite terms is zero. The result type for opposite terms is almost identical to E_ABS, except that a relocation table entry (RLD) with a type R_REF is generated when it is used for data definition. Opposite terms are not required to be contiguous in an expression.

The main difference between opposite terms and paired relocatable terms is that paired relocatable terms do not have to point to the same table entry, although they must be defined in the same section.

In the following example L1 and -L1 are opposite terms ; and L1 and -L2 are paired relocatable terms.

```
     .file "f1.s"
     .csect Dummy[PR]
L1:  ai 10, 20, 30
L2:  ai 11, 21, 30
     br
     .csect A[RW]
     .long L1 - L1
     .long L1 - L2
```

The following table shows rules for determining the type of complex combined expressions:

Type	Conditions for Expression to have Type	Relocation Table Entries
E_ABS	All the terms of the expression are paired relocatable terms, opposite terms, and absolute terms.	An RLD with type R_REF is generated for each opposite term.
E_REXT	The expression contains two unpaired relocatable terms with opposite signs in addition to all the paired relocatable terms, opposite terms, and absolute terms.	Two RLDs, one with a type of R_POS and one with a type of R_NEG, are generated for the unpaired relocatable terms. In addition, an RLD with a type of R_REF is generated for each opposite term.
E_REL, E_EXT	The expression contains only one unpaired E_REL or E_RXT term in addition to all the paired relocatable terms, opposite terms, and absolute terms.	If the expression is used in a data definition, one RLD with type R_POS or R_NEG will be generated. In addition, an RLD with type R_REF is generated for each opposite term.
E_TREL	The expression contains only one unpaired E_TREL term in addition to all the paired relocatable terms, opposite terms, and absolute terms.	If the expression is used as a displacement in a D-form instruction, one RLD with type R_TOC will be generated, otherwise one RLD with type R_POS or R_NEG will be generated. In addition, an RLD with type R_REF is generated for each opposite term.
Error	If the expression contains more than two unpaired relocatable terms, or it contains two unpaired relocatable terms with the same sign, an error is reported.	

The following example illustrates the preceding table:

```
     .file "f1.s"
     .csect A[PR]
L1:  ai 10, 20, 30
L2:  ai 10, 20, 30
EL1: l 10, 20(20)
    .extern EL1
    .extern EL2
EL2: l 10, 20(20)
     .csect B[PR]
BL1: l 10, 20(20)
BL2: l 10, 20(20)
      ba 16 + EL2 - L2 + L1              # Result is E_REL
      l 10, 16+EL2-L2+L1(20)             # No RLD
     .csect C[RW]
BL3: .long BL2 - B[PR]                  # Result is E_ABS
     .long BL2 - (L1 - L1)              # Result is E_REL
     .long 14-(-EL2+BL1) + BL1 - (L2-L1) # Result is E_REL
     .long 14 + EL2 - BL1 - L2 + L1     # Result is E_REL
     .long (B[PR] -A[PR]) + 32          # Result is E_REXT
```

Related Information

“Character Set” on page 25

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The **atof** subroutine.

“.comm Pseudo-op” on page 467, “.csect Pseudo-op” on page 469, “.double Pseudo-op” on page 471, “.dsect Pseudo-op” on page 473, “.float Pseudo-op” on page 479, “.lcomm Pseudo-op” on page 483, “.tc Pseudo-op” on page 499, “.toc Pseudo-op” on page 500, “.tocof Pseudo-op” on page 500.

Chapter 4. Addressing

The addressing articles discuss addressing modes and addressing considerations, including:

- “Absolute Addressing”
- “Absolute Immediate Addressing”
- “Relative Immediate Addressing” on page 46
- “Explicit-Based Addressing” on page 46
- “Implicit-Based Addressing” on page 48
- “Location Counter” on page 49

Absolute Addressing

An absolute address is represented by the contents of a register. This addressing mode is absolute in the sense that it is not specified relative to the current instruction address.

Both the Branch Conditional to Link Register instructions and the Branch Conditional to Count Register instructions use an absolute addressing mode. The target address is a specific register, not an input operand. The target register is the Link Register (LR) for the Branch Conditional to Link Register instructions. The target register is the Count Register (CR) for the Branch Conditional to Count Register instructions. These registers must be loaded prior to execution of the branch conditional to register instruction.

Related Information

“Absolute Immediate Addressing”.

“Relative Immediate Addressing” on page 46.

“Explicit-Based Addressing” on page 46.

“Implicit-Based Addressing” on page 48.

“Location Counter” on page 49.

“Branch Processor” on page 17.

“bcctr or bcc (Branch Conditional to Count Register) Instruction” on page 145, “bclr or bcr (Branch Conditional Link Register) Instruction” on page 147, “b (Branch) Instruction” on page 141, “bc (Branch Conditional) Instruction” on page 142.

Absolute Immediate Addressing

An absolute immediate address is designated by immediate data. This addressing mode is absolute in the sense that it is not specified relative to the current instruction address.

For Branch and Branch Conditional instructions, an absolute immediate addressing mode is used if the Absolute Address bit (AA bit) is on.

The operand for the immediate data can be an absolute, relocatable, or external expression.

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Related Information

“Absolute Addressing” on page 45.

“Relative Immediate Addressing”.

“Explicit-Based Addressing”.

“Implicit-Based Addressing” on page 48.

“Location Counter” on page 49.

“Branch Processor” on page 17.

“bcctr or bcc (Branch Conditional to Count Register) Instruction” on page 145, “bclr or bcr (Branch Conditional Link Register) Instruction” on page 147, “b (Branch) Instruction” on page 141, “bc (Branch Conditional) Instruction” on page 142.

Relative Immediate Addressing

Relative immediate addresses are specified as immediate data within the object code and are calculated relative to the current instruction location. All the instructions that use relative immediate addressing are branch instructions. These instructions have immediate data that is the displacement in full words from the current instruction location. At execution, the immediate data is sign extended, logically shifted to the left two bits, and added to the address of the branch instruction to calculate the branch target address. The immediate data must be a relocatable expression or an external expression.

Related Information

“Absolute Addressing” on page 45.

“Absolute Immediate Addressing” on page 45.

“Explicit-Based Addressing”.

“Implicit-Based Addressing” on page 48.

“Location Counter” on page 49.

“Branch Processor” on page 17.

“bcctr or bcc (Branch Conditional to Count Register) Instruction” on page 145, “bclr or bcr (Branch Conditional Link Register) Instruction” on page 147, “b (Branch) Instruction” on page 141, “bc (Branch Conditional) Instruction” on page 142.

“.using Pseudo-op” on page 501, “.drop Pseudo-op” on page 472.

Explicit-Based Addressing

Explicit-based addresses are specified as a base register number, *RA*, and a displacement, *D*. The base register holds a base address. At run time, the processor adds the displacement to the contents of the base register to obtain the effective address. If an instruction does not have an operand form of *D*(*RA*), then the instruction cannot have an explicit-based address. Error 159 is reported if the *D*(*RA*) form is used for these instructions.

A displacement can be an absolute expression, a relocatable expression, a restricted external expression, or a TOC-relative expression. A displacement can be an external expression only if it is a csect (control section) name or the name of a common block specified defined by a **.comm** pseudo-op.

Notes:

1. An externalized label is still relocatable, so an externalized label can also be used as a displacement.
2. When a relocatable expression is used for the displacement, no RLD entry is generated, because only the offset from the label (that is, the relocatable expression) for the csect is used for the displacement.

Although programmers must use an absolute expression to specify the base register itself, the contents of the base register can be specified by an absolute, a relocatable, or an external expression. If the base register holds a relocatable value, the effective address is relocatable. If the base register holds an absolute value, the effective address is absolute. If the base register holds a value specified by an external expression, the type of the effective address is absolute if the expression is eventually defined as absolute, or relocatable if the expression is eventually defined as relocatable.

When using explicit-based addressing, remember that:

- GPR 0 cannot be used as a base register. Specifying 0 tells the assembler not to use a base register at all.
- Because *D* occupies a maximum of 16 bits, a displacement must be in the range -2**15 to (2**15)-1. Therefore, the difference between the base address and the address of the item to which reference is made must be less than 2**15 bytes.

  Note: *D* and *RA* are required for the *D*(*RA*) form. The form 0(*RA*) or *D*(0) may be used, but both the *D* and *RA* operands are required. There are two exceptions:
  - When *D* is an absolute expression,
  - When *D* is a restricted external expression.

  If the *RA* operand is missing in these two cases, *D*(0) is assumed.

Related Information

"Absolute Addressing" on page 45.

"Absolute Immediate Addressing" on page 45.

"Relative Immediate Addressing" on page 46.

"Implicit-Based Addressing" on page 48.

"Location Counter" on page 49.

"Branch Processor" on page 17.

"bcctr or bcc (Branch Conditional to Count Register) Instruction" on page 145, "bclr or bcr (Branch Conditional Link Register) Instruction" on page 147, "b (Branch) Instruction" on page 141, "bc (Branch Conditional) Instruction" on page 142.

".using Pseudo-op" on page 501, ".drop Pseudo-op" on page 472.

Implicit-Based Addressing

An implicit-based address is specified as an operand for an instruction by omitting the *RA* operand and writing the **.using** pseudo-op at some point before the instruction. After assembling the appropriate **.using** and **.drop** pseudo-ops, the assembler can determine which register to use as the base register. At run time, the processor computes the effective address just as if the base were explicitly specified in the instruction.

Implicit-based addresses can be relocatable or absolute, depending on the type of expression used to specify the contents of the *RA* operand at run time. Usually, the contents of the *RA* operand are specified with a relocatable expression, thus making a relocatable implicit-based address. In this case, when the object module produced by the assembler is relocated, only the contents of the base register *RA* will change. The displacement remains the same, so *D*(*RA*) still points to the correct address after relocation.

A dsect is a reference control section that allows you to describe the layout of data in a storage area without actually reserving any storage. An implicit-based address can also be made by specifying the contents of *RA* with a dsect name or a a dsect label, thus associating a base with a dummy section. The value of the *RA* content is resolved at run time when the dsect is instantiated.

If the contents of the *RA* operand are specified with an absolute expression, an absolute implicit-based address is made. In this case, the contents of the *RA* will not change when the object module is relocated.

The assembler only supports relocatable implicit-based addressing.

Perform the following when using implicit-based addressing:

1. Write a **.using** statement to tell the assembler that one or more general-purpose registers (GPRs) will now be used as base registers.
2. In this **.using** statement, tell the assembler the value each base register will contain at execution. Until it encounters a **.drop** pseudo-op, the assembler will use this base register value to process all instructions that require a based address.
3. Load each base register with the previously specified value.

For implicit-based addressing the *RA* operand is always omitted, but the *D* operand remains. The *D* operand can be an absolute expression, a TOC-relative expression, a relocatable expression, or a restricted external expression.

Notes:

1. When the *D* operand is an absolute expression or a restricted external expression, the assembler always converts it to *D*(0) form, so the **.using** pseudo-op has no effect.
2. The **.using** and **.drop** pseudo-ops affect only based addresses.

```
.toc
T.data: .tc data[tc],data[rw]
.csect data[rw]
        foo: .long 2,3,4,5,6
        bar: .long 777

        .csect text[pr]
        .align 2
        l 10,T.data(2)   # Loads the address of
                                # csect data[rw] into GPR 10.

        .using data[rw], 10      # Specify displacement.
        l 3,foo          # The assembler generates l 3,0(10)
        l 4,foo+4        # The assembler generates l 4,4(10)
        l 5,bar          # The assembler generates l 5,20(10)
```

See the ".using Pseudo-op" on page 501 for more information.

Related Information

“Absolute Addressing” on page 45.

“Absolute Immediate Addressing” on page 45.

“Relative Immediate Addressing” on page 46.

“Explicit-Based Addressing” on page 46.

“Location Counter”.

“Branch Processor” on page 17.

“bcctr or bcc (Branch Conditional to Count Register) Instruction” on page 145, “bclr or bcr (Branch Conditional Link Register) Instruction” on page 147, “b (Branch) Instruction” on page 141, “bc (Branch Conditional) Instruction” on page 142.

“.using Pseudo-op” on page 501, “.drop Pseudo-op” on page 472.

Location Counter

Each section of an assembler language program has a location counter used to assign storage addresses to your program’s statements. As the instructions of a source module are being assembled, the location counter keeps track of the current location in storage. You can use a **$** (dollar sign) as an operand to an instruction to refer to the current value of the location counter.

Related Information

“Absolute Addressing” on page 45.

“Absolute Immediate Addressing” on page 45.

“Relative Immediate Addressing” on page 46.

“Explicit-Based Addressing” on page 46.

“Implicit-Based Addressing” on page 48.

“Branch Processor” on page 17.

“bcctr or bcc (Branch Conditional to Count Register) Instruction” on page 145, “bclr or bcr (Branch Conditional Link Register) Instruction” on page 147, “b (Branch) Instruction” on page 141, “bc (Branch Conditional) Instruction” on page 142.

“.using Pseudo-op” on page 501, “.drop Pseudo-op” on page 472.

Chapter 5. Assembling and Linking a Program

This section provides information on the following:

- "Assembling and Linking a Program"
- "Understanding Assembler Passes" on page 55
- "Interpreting an Assembler Listing" on page 57
- "Interpreting a Symbol Cross-Reference" on page 61
- "Subroutine Linkage Convention" on page 63
- "Understanding and Programming the TOC" on page 80
- "Running a Program" on page 85

Assembling and Linking a Program

Assembly language programs can be assembled with the **as** command or the **cc** command. The **ld** command or the **cc** command can be used to link assembled programs. This section discusses the following:

- "Assembling with the as Command"
- "Assembling and Linking with the cc Command" on page 54

Assembling with the as Command

The **as** command invokes the assembler. The syntax for the **as** command is as follows:

```
as [ -a Mode ] [ -oObjectFile ] [ -n Name ] [ -u ] [ -l[ListFile] ]
 [ -W | -w ] [ -x[XCrossFile] ] [ -s [ListFile] ] [ -m ModeName ]
 [ -Eoff|on ] [ -poff|on ] [-i] [-v] [ File ]
```

The **as** command reads and assembles the file specified by the *File* parameter. By convention, this file has a suffix of **.s**. If no file is specified, the **as** command reads and assembles standard input. By default, the **as** command stores its output in a file named **a.out**. The output is stored in the XCOFF file format.

All flags for the **as** command are optional.

The **ld** command is used to link object files. See the **ld** command for more information.

The assembler respects the setting of the OBJECT_MODE environment variable. If neither **-a32** or **-a64** is used, the environment is examined for this variable. If the value of the variable is anything other than the values listed in the following table, an error message is generated and the assembler exits with a non-zero return code. The implied behavior corresponding to the valid settings are as follows:

OBJECT_MODE=**32**	Produce 32-bit object code. The default machine setting is **com**.
OBJECT_MODE=**64**	Produce 64-bit object code (XCOFF64 files). The default machine setting is **ppc64**.
OBJECT_MODE=**32_64**	Invalid.
OBJECT_MODE=*anything else*	Invalid.

as Command Flags

The following flags are recognized by the **as** command:

-a *Mode*
: Specifies the mode in which the **as** command operates. By default, the **as** command operates in 32-bit mode, but the mode can be explicitly set by using the flag **-a32** for 32-bit mode operation or **-a64** for 64-bit mode operation.

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-E[*off*|*on*] Specifies whether to report errors due to the v2.00 syntax (**-E***on*), or to ignore them (**-E***off*). By default, v2.00 errors are ignored.

File Specifies the source file. If no file is specified, the source code is taken from standard input.

-i Specifies that branch prediction suffixes are to be encoded. By default, this option is *not* set. This option is ignored if the **-p** option is specified.

-l[*ListFile*] Produces an assembler listing. If you do not specify a file name, a default name is produced by replacing the suffix extension of the source file name with a **.lst** extension. (By convention, the source file suffix is a **.s**.) For example:

```
sourcefile.xyz
```

produces a default name of:

```
sourcefile.lst
```

If the source code is from standard input and the **-l** flag is used without specifying an assembler-listing file name, the listing file name is **a.lst**.

-m *ModeName* Indicates the assembly mode. This flag has lower priority than the **.machine** pseudo-op.

If this flag is not used and no **.machine** pseudo-op is present in the source program, the default assembly mode is used. The default assembly mode has the POWER family/PowerPC intersection as the target environment, but treats all POWER family/PowerPC incompatibility errors (including instructions outside the POWER family/PowerPC intersection and invalid form errors) as instructional warnings.

If an assembly mode that is not valid is specified and no **.machine** pseudo-op is present in the source program, an error is reported and the default assembly mode is used for instruction validation in pass 1 of the assembler.

If the **-m** flag is used, the *ModeName* variable can specify one of the following values:

"" Explicitly specifies the default assembly mode which has the POWER family/PowerPC intersection as the target environment, but treats instructions outside the POWER family/PowerPC intersection and invalid form errors as instructional warnings. A space is required between **-m** and the null string argument (two double quotation marks).

com Specifies the POWER family/PowerPC intersection mode. A source program can contain only instructions that are common to both POWER family and PowerPC; any other instruction causes an error. Any instruction with an invalid form causes errors, terminates the assembly process, and results in no object code being generated.

> **Note:**Certain POWER family instructions are supported by the PowerPC 601 RISC Microprocessor, but do not conform to the PowerPC architecture. These instructions cause errors when using the **com** assembly mode.

any Specifies the indiscriminate mode. The assembler generates object code for any recognized instruction, regardless of architecture. This mode is used primarily for operating system development and for testing and debugging purposes.
Note: All POWER family/PowerPC incompatibility errors are ignored when using the **any** assembly mode, and no warnings are generated.

-m *ModeName* continued

ppc Specifies the PowerPC mode. A source program can contain only PowerPC instructions. Any other instruction causes an error.

Notes:

1. The PowerPC optional instructions are not implemented in every PowerPC processor and do not belong to the **ppc** mode. These instructions generate an error if they appear in a source program which is assembled using the **ppc** assembly mode.
2. Certain instructions conform to the PowerPC architecture, but are not supported by the PowerPC 601 RISC Microprocessor.

ppc64 Specifies the PowerPC 64-bit mode. A source program can contain 64-bit PowerPC instructions.

pwr Specifies the POWER family mode. A source program can contain only instructions for the POWER family implementation of the POWER family architecture.

pwr2(pwrx)
Specifies the POWER2 mode. A source program can contain only instructions for the POWER2 implementation of the POWER family architecture. **pwr2** is the preferred value. The alternate assembly mode value **pwrx** means the same thing as **pwr2**.
Note: The POWER family implementation instruction set is a subset of the POWER2 implementation instruction set.

601 Specifies the PowerPC 601 RISC Microprocessor mode. A source program can contain only instructions for the PowerPC 601 RISC Microprocessor.
Note: The PowerPC 601 RISC Microprocessor design was completed before the PowerPC architecture. Therefore, some PowerPC instructions may not be supported by the PowerPC 601 RISC Microprocessor.

Attention: It is recommended that the **601** assembly mode not be used for applications that are intended to be portable to future PowerPC systems. The **com** or **ppc** assembly mode should be used for such applications.

The PowerPC 601 RISC Microprocessor implements the PowerPC architecture plus some POWER family instructions which are not included in the PowerPC architecture. This allows existing POWER family applications to run with acceptable performance on PowerPC systems. Future PowerPC systems will not have this feature. The **601** assembly mode may result in applications that will not run on existing POWER family systems and that may not have acceptable performance on future PowerPC systems, because the **601** assembly mode permits the use of all the instructions provided by the PowerPC 601 RISC Microprocessor.

603 Specifies the PowerPC 603 RISC Microprocessor mode. A source program can contain only instructions for the PowerPC 603 RISC Microprocessor.

604 Specifies the PowerPC 604 RISC Microprocessor mode. A source program can contain only instructions for the PowerPC 604 RISC Microprocessor.

A35 Specifies the A35 mode. A source program can contain only instructions for the A35.

-n *Name* Specifies the name that appears in the header of the assembler listing. By default, the header contains the name of the assembler source file.

-o *ObjectFile* Writes the output of the assembly process to the specified file instead of to the **a.out** file.

-p[*off*|*on*] Specifies whether to use the v2.00 branch prediction (**-p***on*) or pre-v2.00 branch prediction (**-p***off*). By default, pre-v2.00 branch prediction is used.

-s[*ListFile*] Indicates whether or not a mnemonics cross-reference for POWER family and PowerPC is included in the assembler listing. If this flag is omitted, no mnemonics cross-reference is produced. If this flag is used, the assembler listing will have POWER family mnemonics if the source contains PowerPC mnemonics, and will have PowerPC mnemonics if the source contains POWER family mnemonics.

The mnemonics cross-reference is restricted to instructions that have different mnemonics in POWER family and PowerPC, but that have the same op code, function, and input operand format.

Because the **-s** flag is used to change the assembler-listing format, it implies the **-l** flag. If both option flags are used and different assembler-listing file names (specified by the *ListFile* variable) are given, the listing file name specified by the *ListFile* variable used with the **-l** flag is used. If an assembler-listing file name is not specified with either the **-l** or **-s** flag, a default assembler listing file name is produced by replacing the suffix extension of the source file name with a **.lst** extension.

-u Accepts an undefined symbol as an extern so that an error message is not displayed. Otherwise, undefined symbols are flagged with error messages.

-v Displays the version number of this command.

-W Turns off all warning message reporting, including the instructional warning messages (the POWER family and PowerPC incompatibility warnings).

-w Turns on warning message reporting, including reporting of instructional warning messages (the POWER family and PowerPC incompatibility warnings).
Note: When neither **-W** nor **-w** is specified, the instructional warnings are reported, but other warnings are suppressed.

-x[*XCrossFile*] Produces cross-reference output. If you do not specify a file name, a default name is produced by replacing the suffix extension of the source file name with an **.xref** extension. By convention, the suffix is a **.s**. For example:

```
sourcefile.xyz
```

produces a default name of:

```
sourcefile.xref
```

Note: The assembler does not generate an object file when the **-x** flag is used.

Assembling and Linking with the cc Command

The **cc** command can be used to assemble and link an assembly source program. The following example links object files compiled or assembled with the **cc** command:

```
cc pgm.o subs1.o subs2.o
```

When the **cc** command is used to link object files, the object files should have the suffix of **.o** as in the previous example.

When the **cc** command is used to assemble and link source files, any assembler source files must have the suffix of **.s**. The **cc** command invokes the assembler for any files having this suffix. Option flags for the **as** command can be directed to the assembler through the **cc** command. The syntax is:

-Wa,*Option1*,*Option2*,...

The following example invokes the assembler to assemble the source program using the **com** assembly mode, and produces an assembler listing and an object file:

```
cc -c -Wa,-mcom,-l file.s
```

The **cc** command invokes the assembler and then continues processing normally. Therefore:

```
cc -Wa,-l,-oXfile.o file.s
```

will fail because the object file produced by the assembler is named `Xfile.o`, but the linkage editor (**ld** command) invoked by the **cc** command searches for `file.o`.

If no option flag is specified on the command line, the **cc** command uses the compiler, assembler, and link options, as well as the necessary support libraries defined in the **xlc.cfg** configuration file.

Note: Some option flags defined in the assembler and the linkage editor use the same letters. Therefore, if the **xlc.cfg** configuration file is used to define the assembler options (**asopt**) and the link-editor options (**ldopt**), duplicate letters should not occur in **asopt** and **ldopt** because the **cc** command is unable to distinguish the duplicate letters.

For more information on the option flags passed to the **cc** command, see the **cc** command.

Related Information

"Understanding Assembler Passes".

"Interpreting an Assembler Listing" on page 57.

"Interpreting a Symbol Cross-Reference" on page 61.

"Subroutine Linkage Convention" on page 63.

"Understanding and Programming the TOC" on page 80.

"Running a Program" on page 85.

The **as** command, and the **ld** command.

Understanding Assembler Passes

When you enter the **as** command, the assembler makes two passes over the source program.

First Pass

On the first pass, the assembler performs the following tasks:

- Checks to see if the instructions are legal in the current assembly mode.
- Allocates space for instructions and storage areas you request.
- Fills in the values of constants, where possible.
- Builds a symbol table, also called a cross-reference table, and makes an entry in this table for every symbol it encounters in the label field of a statement.

The assembler reads one line of the source file at a time. If this source statement has a valid symbol in the label field, the assembler ensures that the symbol has not already been used as a label. If this is the first time the symbol has been used as a label, the assembler adds the label to the symbol table and assigns the value of the current location counter to the symbol. If the symbol has already been used as a label, the assembler returns the error message `Redefinition of symbol` and reassigns the symbol value.

Next, the assembler examines the instruction's mnemonic. If the mnemonic is for a machine instruction that is legal for the current assembly mode, the assembler determines the format of the instruction (for example, XO format). The assembler then allocates the number of bytes necessary to hold the machine code for the instruction. The contents of the location counter are incremented by this number of bytes.

When the assembler encounters a comment (preceded by a # (pound sign)) or an end-of-line character, the assembler starts scanning the next instruction statement. The assembler keeps scanning statements and building its symbol table until there are no more statements to read.

At the end of the first pass, all the necessary space has been allocated and each symbol defined in the program has been associated with a location counter value in the symbol table. When there are no more source statements to read, the second pass starts at the beginning of the program.

> **Note:** If an error is found in the first pass, the assembly process terminates and does not continue to the second pass. If this occurs, the assembler listing only contains errors and warnings generated during the first pass of the assembler.

Second Pass

On the second pass, the assembler:

- Examines the operands for symbolic references to storage locations and resolves these symbolic references using information in the symbol table.
- Ensures that no instructions contain an invalid instruction form.
- Translates source statements into machine code and constants, thus filling the allocated space with object code.
- Produces a file containing error messages, if any have occurred.

At the beginning of the second pass, the assembler scans each source statement a second time. As the assembler translates each instruction, it increments the value contained in the location counter.

If a particular symbol appears in the source code, but is not found in the symbol table, then the symbol was never defined. That is, the assembler did not encounter the symbol in the label field of any of the statements scanned during the first pass, or the symbol was never the subject of a **.comm**, **.csect**, **.lcomm**, **.sect**, or **.set** pseudo-op.

This could be either a deliberate external reference or a programmer error, such as misspelling a symbol name. The assembler indicates an error. All external references must appear in a **.extern** or **.globl** statement.

The assembler logs errors such as incorrect data alignment. However, many alignment problems are indicated by statements that do not halt assembly. The **-w** flag must be used to display these warning messages.

After the programmer corrects assembly errors, the program is ready to be linked.

Note: If only warnings are generated in the first pass, the assembly process continues to the second pass. The assembler listing contains errors and warnings generated during the second pass of the assembler. Any warnings generated in the first pass do not appear in the assembler listing.

Related Information

“Assembling and Linking a Program” on page 51.

“Interpreting an Assembler Listing” on page 57.

“Interpreting a Symbol Cross-Reference” on page 61.

“Subroutine Linkage Convention” on page 63.

“Understanding and Programming the TOC” on page 80.

“Running a Program” on page 85.

The **as** command.

Interpreting an Assembler Listing

The **-l** flag of the **as** command produces a listing of an assembler language file.

Assume that a programmer wants to display the words ″hello, world.″ The C program would appear as follows:

```
main ( )
{
     printf ("hello, world\n");
}
```

Assembling the **hello.s** file with the following command:

```
as -l hello.s
```

produces an output file named **hello.lst**. The complete assembler listing for **hello.lst** is as follows:

```
hello.s                           V4.0               01/25/1994
File# Line#  Mode Name    Loc Ctr   Object Code        Source
0       1 |                                         ############################
0       2 |                                         # C source code
0       3 |                                         ############################
0       4 |                                         #   hello()
0       5 |                                         #   {
0       6 |                                         #    printf("hello,world\n");
0       7 |                                         #   }
0       8 |                                         ############################
0       9 |                                         #   Compile as follows:
0      10 |                                         #   cc -o helloworld hello.s
0      11 |                                         #
0      12 |                                         ############################
0      13 |                                          .file  "hello.s"
0      14 |                                         #Static data entry in
0      15 |                                         #T(able)O(f)C(ontents)
0      16 |                                          .toc
0      17 |  COM  data   00000000  00000040         T.data:   .tc data[tc],data[rw]
0      18 |                                          .globl main[ds]
0      19 |                                         #main[ds] contains definitions for
0      20 |                                         #runtime linkage of function main
0      21 |                                          .csect   main[ds]
0      22 |  COM  main   00000000  00000000           .long   .main[PR]
0      23 |  COM  main   00000004  00000050           .long   TOC[tc0]
0      24 |  COM  main   00000008  00000000           .long   0
0      25 |                                         #Function entry in
0      26 |                                         #T(able)O(f)C(ontents)
0      27 |                                          .toc
0      28 |  COM  .main  00000000  00000034         T.hello: .tc .main[tc],main[ds]
0      29 |                                          .globl   .main[PR]
0      30 |
0      31 |                                         #Set routine stack variables
0      32 |                                         #Values are specific to
0      33 |                                         #the current routine and can
0      34 |                                         #vary from routine to routine
0      35 |                           00000020        .set   argarea,     32
0      36 |                           00000018        .set   linkarea,    24
0      37 |                           00000000        .set   locstckarea, 0
0      38 |                           00000001        .set   ngprs,       1
0      39 |                           00000000        .set   nfprs,       0
0      40 |                           0000003c        .set   szdsa,       8*nfprs+4*ngprs+linkarea+
                                                                 argarea+locstckarea
0      41 |
0      42 |                                         #Main routine
0      43 |                                          .csect           .main[PR]
0      44 |
0      45 |
0      46 |                                         #PROLOG: Called Routines
```

```
0      47 |                                      #        Responsibilities
0      48 |                                       #Get link reg.
0      49 |  COM  .main  00000000  7c0802a6          mflr  0
0      50 |                                       #Not required to Get/Save CR
0      51 |                                       #because current routine does
0      52 |                                       #not alter it.
0      53 |
0      54 |                                       #Not required to Save FPR's
0      55 |                                       #14-31 because current routine
0      56 |                                       #does not alter them.
0      57 |
0      58 |                                       #Save GPR 31.
0      59 |  COM  .main  00000004  bfe1fffc         stm   31, -8*nfprs-4*ngprs(1)
0      60 |                                       #Save LR if non-leaf routine.
0      61 |  COM  .main  00000008  90010008         st    0, 8(1)
0      62 |                                       #Decrement stack ptr and save
0      63 |                                       #back chain.
0      64 |  COM  .main  0000000c  9421ffc4         stu   1, -szdsa(1)
0      65 |
0      66 |
0      67 |                                      #Program body
0      68 |                                      #Load static data address
0      69 |  COM  .main  00000010  81c20000        l      14,T.data(2)
0      70 |                                       #Line 3, file hello.c
0      71 |                                      #Load address of data string
0      72 |                                      #from data addr.
0      73 |                                      #This is a parameter to printf()
0      74 |  COM  .main  00000014  386e0000        cal    3,_helloworld(14)
0      75 |                                      #Call printf function
0      76 |  COM  .main  00000018  4bfffe9         bl     .printf[PR]
0      77 |  COM  .main  0000001c  4def7b82        cror   15, 15, 15
0      78 |
0      79 |
0      80 |                                      #EPILOG: Return Sequence
0      81 |                                       #Get saved LR.
0      82 |  COM  .main  00000020  80010044         l     0, szdsa+8(1)
0      83 |
0      84 |                                       #Routine did not save CR.
0      85 |                                       #Restore of CR not necessary.
0      86 |
0      87 |                                       #Restore stack ptr
0      88 |  COM  .main  00000024  3021003c         ai    1, 1, szdsa
0      89 |                                       #Restore GPR 31.
0      90 |  COM  .main  00000028  bbe1fffc         lm    31, -8*nfprs-4*ngprs(1)
0      91 |
0      92 |                                       #Routine did not save FPR's.
0      93 |                                       #Restore of FPR's not necessary.
0      94 |
0      95 |                                       #Move return address
0      96 |                                       #to Link Register.
0      97 |  COM  .main  0000002c  7c0803a6              mtlr0
0      98 |                                       #Return to address
0      99 |                                       #held in Link Register.
0     100 |  COM  .main  00000030  4e800021              brl
0     101 |
0     102 |
0     103 |                                      #External variables
0     104 |                                          .extern.printf[PR]
0     105 |
0     106 |                                      ##############################
0     107 |                                                 #Data
0     108 |                                      ##############################
0     109 |                                      #String data placed in
0     110 |                                      #static csect data[rw]
0     111 |                                             .csect data[rw]
0     112 |                                             .align2
0     113 |                                      _helloworld:
```

```
0     114 |  COM  data   00000000  68656c6c        .byte  0x68,0x65,0x6c,0x6c
0     115 |  COM  data   00000004  6f2c776f        .byte  0x6f,0x2c,0x77,0x6f
0     116 |  COM  data   00000008  726c640a        .byte  0x72,0x6c,0x64,0xa,0x0
          |  COM  data   0000000c  00
```

The first line of the assembler listing gives two pieces of information:

- Name of the source file (in this case, **hello.s**)
- Date the listing file was created

The assembler listing contains several columns. The column headings are:

File#	Lists the source file number. Files included with the M4 macro processor (**-I** option) are displayed by the number of the file in which the statement was found.
Line#	Refers to the line number of the assembler source code.
Mode	Indicates the current assembly mode for this instruction.
Name	Lists the name of the csect where this line of source code originates.
Loc Ctr	Lists the value contained in the assembler's location counter. The listing shows a location counter value only for assembler language instructions that generate object code.
Object Code	Shows the hexadecimal representation of the object code generated by each line of the assembler program. Since each instruction is 32 bits, each line in the assembler listing shows a maximum of 4 bytes. Any remaining bytes in a line of assembler source code are shown on the following line or lines. **Note:** If pass two failed, the assembler listing will not contain object code.
Source	Lists the assembler source code for the program. A limit of 100 ASCII characters will be displayed per line.

If the **-s** option flag is used on the command line, the assembler listing contains mnemonic cross-reference information.

If the assembly mode is in the PowerPC category (**com**, **ppc**, or **601**), one column heading is PowerPC. This column contains the PowerPC mnemonic for each instance where the POWER family mnemonic is used in the source program. The **any** assembly mode does not belong to any category, but is treated as though in the PowerPC category.

If the assembly mode is in the POWER family category (**pwr** or **pwr2**), one column heading is POWER family. This column contains the POWER family mnemonic for each instance where the PowerPC mnemonic is used in the source program.

The following assembler listing uses the **com** assembly mode. The source program uses POWER family mnemonics. The assembler listing has a PowerPC mnemonic cross-reference.

```
L_dfmt_1.s                              V4.0                01/26/1994
File# Line#  Mode  Name   Loc Ctr  Object Code  PowerPC      Source
0       1 |                                                 #%% -L
0       2 |                                                  machine   "com"
0       3 |                                                  csect dfmt[PR]
0       4 |                                                  using data,5
0       5 |
0       6 |  COM  dfmt   00000000  8025000c       lwz        l1,d1             # 8025000c
0       7 |  COM  dfmt   00000004  b8c50018       lmw        lm    6,d0        # b8650018
0       8 |  COM  dfmt   00000008  b0e50040                  sth   7,d8        # b0e50040
0       9 |  COM  dfmt   0000000c  80230020       lwz        l     1,0x20(3)   # 80230020
0      10 |  COM  dfmt   00000010  30220003       addic      ai    1,2,3       # 30220003
0      11 |  COM  dfmt   00000014  0cd78300       twi        ti    6,23,-32000 # 0cd78300
0      12 |  COM  dfmt    00000018  2c070af0                 cmpi  0,7,2800    # 2c070af0
0      13 |  COM  dfmt   0000001c  2c070af0                  cmpi  0,0,7,2800  # 2c070af0
0      14 |  COM  dfmt   00000020  30220003       subic      si    1,2,-3      # 30220003
0      15 |  COM  dfmt   00000024  34220003       subic.     si.   1,2,-3      # 34220003
0      16 |  COM  dfmt   00000028  703e00ff       andi.      andil.30,1,0xFF   # 703e00ff
0      17 |  COM  dfmt   0000002c  2b9401f4                  cmpli 7,20,500    # 2b9401f4
```

```
0      18 |  COM  dfmt   00000030  0c2501a4       twlgti     tlgti 5,420       # 0c2501a4
0      19 |  COM  dfmt   00000034  34220003       addic.     ai.   1,2,3       # 34220003
0      20 |  COM  dfmt   00000038  2c9ff380                  cmpi  1,31,-3200  # 2c9ff380
0      21 |  COM  dfmt   0000003c  281f0c80                  cmpli 0,31,3200   # 281f0c80
0      22 |  COM  dfmt   00000040  8ba5000c                  lbz   29,d1       # 8ba5000c
0      23 |  COM  dfmt   00000044  85e5000c       lwzu       lu    15,d1       # 85e5000c
0      24 |  COM  dfmt   00000048  1df5fec0       mulli      muli  15,21,-320  # 1df5fec0
0      25 |  COM  dfmt   0000004c  62af0140       ori        oril  15,21,320   # 62af0140
0      26 |  COM  dfmt   00000050  91e5000c       stw        st    15,d1       # 91e5000c
0      27 |  COM  dfmt   00000054  bde5000c       stmw       stm   15,d1       # bde5000c
0      28 |  COM  dfmt   00000058  95e5000c       stwu       stu   15,d1       # 95e5000c
0      29 |  COM  dfmt   0000005c  69ef0960       xori       xoril 15,15,2400  # 69ef0960
0      30 |  COM  dfmt   00000060  6d8c0960       xoris      xoriu 12,12,2400  # 6d8c0960
0      31 |  COM  dfmt   00000064  3a9eff38                  addi  20,30,-200  # 3a9eff38
0      32 |
0      33 |                                                      .csect also[RW]
0      34 |                                                 data:
0      35 |  COM  also   00000000  00000000                  .long  0,0,0
          |              00000004    ....
          |  COM  also   00000008  00000000
0      36 |  COM  also   0000000c  00000003              d1:.long  3,4,5   # d1 = 0xC = 12
          |  COM  also   00000010  00000004
          |  COM  also   00000014  00000005
0      37 |  COM  also   00000018  00000068                 d0:    .long   data # d0 = 0x18 = 24
0      38 |  COM  also   0000001c  00000000                 data2: .space  36
          |              00000020    ....
          |  COM  also   0000003c  000000000
       39 |  COM  also   00000040  000023e0                 d8:    .long   9184  # d8 = 0x40 = 64
0      40 |  COM  also   00000044  ffffffff                 d9:    .long   0xFFFFFFFF # d9 = 0x44
0      41 |                                             #
0      42 |                                             # 0000 00000000 00000000 00000000 00000003
0      43 |                                             # 0010 00000004 00000005 0000000C 00000000
0      44 |                                             # 0020 00000000 00000000 00000000 00000000
0      45 |                                             # 0030 000023E0
```

The following assembler listing uses the **pwr** assembly mode. The source program uses PowerPC mnemonics. The assembler listing has a POWER family mnemonic cross-reference.

```
 L_dfmt_2.s                              V4.0                 01/26/1994
File# Line#  Mode Name    Loc Ctr  Object Code  POWER       Source
0       1 |                                               #%% -L
0       2 |                                               .machine  "pwr"
0       3 |                                               .csect dfmt[PR]
0       4 |                                               .using data,5
0       5 |  PWR  dfmt   00000000  8025000c       l          lwz      1,d1
0       6 |  PWR  dfmt   00000004  b8650018       lm         lmw      3,d0
0       7 |  PWR  dfmt   00000008  b0e50040                  sth      7,d8
0       8 |  PWR  dfmt   0000000c  80230020       l          lwz      1,0x20(3)
0       9 |  PWR  dfmt   00000010  30220003       ai         addic    1,2,3
0      10 |  PWR  dfmt   00000014  0cd78300       ti         twi      6,23,-32000
0      11 |  PWR  dfmt   00000018  2c070af0                  cmpi     0,7,2800
0      12 |  PWR  dfmt   0000001c  2c070af0                  cmpi     0,0,7,2800
0      13 |  PWR  dfmt   00000020  30220003       si         subic    1,2,-3
0      14 |  PWR  dfmt   00000024  34220003       si.        subic.   1,2,-3
0      15 |  PWR  dfmt   00000028  703e00ff       andil.     andi.    30,1,0xFF
0      16 |  PWR  dfmt   0000002c  2b9401f4                  cmpli    7,20,500
0      17 |  PWR  dfmt   00000030  0c2501a4       tlgti      twlgti   5,420
0      18 |  PWR  dfmt   00000034  34220003       ai.        addic.   1,2,3
0      19 |  PWR  dfmt   00000038  2c9ff380                  cmpi     1,31,-3200
0      20 |  PWR  dfmt   0000003c  281f0c80                  cmpli    0,31,3200
0      21 |  PWR  dfmt   00000040  8ba5000c                  lbz      29,d1
0      22 |  PWR  dfmt   00000044  85e5000c       lu         lwzu     15,d1
0      23 |  PWR  dfmt   00000048  1df5fec0       muli       mulli    15,21,-320
0      24 |  PWR  dfmt   0000004c  62af0140       oril       ori      15,21,320
0      25 |  PWR  dfmt   00000050  91e5000c       st         stw      15,d1
0      26 |  PWR  dfmt   00000054  bde5000c       stm        stmw     15,d1
0      27 |  PWR  dfmt   00000058  95e5000c       stu        stwu     15,d1
```

```
0      28 |  PWR  dfmt   0000005c  69ef0960       xoril     xori     15,15,2400
0      29 |  PWR  dfmt   00000060  6d8c0960       xoriu     xoris    12,12,2400
0      30 |  PWR  dfmt   00000064  3a9eff38                 addi     20,30,-200
0      31 |
0      32 |
0      33 |                                                          .csect also[RW]
0      34 |                                             data:
0      35 |  PWR  also   00000000  00000000                  .long     0,0,0
           |              00000004    ....
           |  PWR  also   00000008  00000000
0      36 |  PWR  also   0000000c  00000003               d1: long     3,4,5
           |  PWR  also   00000010  00000004                           # d1 = 0xc = 12
           |  PWR  also   00000014  00000005
0      37 |  PWR  also   00000018  00000068               d0: long     data       # d0 = 0x18 = 24
0      38 |  PWR  also   0000001c  00000000             data2: space  36
           |              00000020    ....
           |  PWR  also   0000003c  00000000
0      39 |  PWR  also   00000040  000023e0               d8: long     9184       # d8 = 0x40 = 64
0      40 |  PWR  also   00000044  ffffffff               d9: long     0xFFFFFFFF # d9 = 0x44
0      41 |                                                  #
0      42 |                                              # 0000 00000000 00000000 00000000 00000003
0      43 |                                              # 0010 00000004 00000005 0000000C 00000000
0      44 |                                              # 0020 00000000 00000000 00000000 00000000
0      45 |                                              # 0030 000023E0
```

Related Information

“Assembling and Linking a Program” on page 51.

“Understanding Assembler Passes” on page 55.

“Interpreting a Symbol Cross-Reference”.

“Subroutine Linkage Convention” on page 63.

“Understanding and Programming the TOC” on page 80.

“Running a Program” on page 85.

The **as** command.

Interpreting a Symbol Cross-Reference

The following is an example of the symbol cross-reference for the **hello.s** assembly program:

```
Symbol          File            CSECT           Line #
.main           hello.s         --                22
.main           hello.s         .main             28   *
.main           hello.s         --                29
.main           hello.s         .main             43   *
.printf         hello.s         --                76
.printf         hello.s         --               104
T.data          hello.s         data              17   *
T.data          hello.s         data              69
T.hello         hello.s         .main             28   *
TOC             hello.s         TOC               23
_helloworld     hello.s         --                74
_helloworld     hello.s         data             113   *
argarea         hello.s         --                35   *
argarea         hello.s         --                40
data            hello.s         --                17
data            hello.s         data              17   *
data            hello.s         data             111   *
linkarea        hello.s         --                36   *
```

```
linkarea        hello.s          --              40
locstckarea     hello.s          --              37   *
locstckarea     hello.s          --              40
main            hello.s          --              18
main            hello.s          main            21   *
main            hello.s          main            28
nfprs           hello.s          --              39   *
nfprs           hello.s          --              40
nfprs           hello.s          --              59
nfprs           hello.s          --              90
ngprs           hello.s          --              38   *
ngprs           hello.s          --              40
ngprs           hello.s          --              59
ngprs           hello.s          --              90
szdsa           hello.s          --              40   *
szdsa           hello.s          --              64
szdsa           hello.s          --              82
szdsa           hello.s          --              88
```

The first column lists the symbol names that appear in the source program. The second column lists the source file name in which the symbols are located. The third column lists the csect names in which the symbols are defined or located.

In the column listing the csect names, a — (double dash) means one of the following:

- The symbol's csect has not been defined yet. In the example, the first and third `.main` (`.main[PR]`) is defined through line 42.
- The symbol is an external symbol. In the example, `.printf` is an external symbol and, therefore, is not associated with any csect.
- The symbol to be defined is a symbolic constant. When the **.set** pseudo-op is used to define a symbol, the symbol is a symbolic constant and does not have a csect associated with it. In the example, `argarea`, `linkarea`, `locstckarea`, `nfprs`, `ngprs`, and `szdsa` are symbolic constants.

The fourth column lists the line number in which the symbol is located. An * (asterisk) after the line number indicates that the symbol is defined in this line. If there is no asterisk after the line number, the symbol is referenced in the line.

Related Information

"Assembling and Linking a Program" on page 51.

"Understanding Assembler Passes" on page 55.

"Interpreting an Assembler Listing" on page 57.

"Subroutine Linkage Convention" on page 63.

"Understanding and Programming the TOC" on page 80.

"Running a Program" on page 85.

Chapter 7, "Migrating Source Programs" on page 111.

The **as** command.

Subroutine Linkage Convention

This article discusses the following:

- "Linkage Convention Overview"
- "Calling Routine's Responsibilities" on page 75
- "Called Routine's Responsibilities" on page 76
- "Using Milicode Routines" on page 78

Linkage Convention Overview

The subroutine linkage convention describes the machine state at subroutine entry and exit. When followed, this scheme allows routines compiled separately in the same or different languages to be linked and executed when called.

The linkage convention allows for parameter passing and return values to be in floating-point registers (FPRs), general-purpose registers (GPRs), or both.

Object Mode Considerations

The following discussion applies to both 32-bit mode and 64-bit mode with the following notes:

- General purpose registers in 64-bit mode are 64 bits wide (double- word). This implies that space usage of the stack increases by a factor of two for register storage. Wherever, below, the term *word* is used, assume (unless otherwise stated) that the size of the object in question is 1 word in 32-bit mode, and 2 words (a double-word) in 64-bit mode.
- The offsets shown in the run-time stack figure should be doubled for 64-bit mode. In 32-bit mode, the stack as shown requires 56 bytes:
  - 1 word for each of the 6 registers CR, LR, compiler-reserved, linker-reserved, and saved-TOC.
  - 8 words for the 8 volatile registers.

  This totals 14 words, or 56 bytes. In 64-bit mode, each field is twice as large (a double-word), thus requiring 28 words, or 112 bytes.
- Floating point registers are saved in the same format in both modes. The storage requirements are the same.
- Stack pointer alignment requirements remain the same for both modes.
- The GPR save routine listed below illustrates the methodology for saving registers in 32-bit mode. For 64-bit mode, the offsets from GPR1, the stack pointer register, would be twice the values shown. Additionally, the load instruction used would be `ld` and the store instuction would be `stdu`.

Register Usage and Conventions

The PowerPC 32-bit architecture has 32 GPRs and 32 FPRs. Each GPR is 32 bits wide, and each FPR is 64 bits wide. There are also special registers for branching, exception handling, and other purposes. The General-Purpose Register Convention table shows how GPRs are used.

General-Purpose Register Conventions		
Register	**Status**	**Use**
GPR0	volatile	In function prologs.
GPR1	dedicated	Stack pointer.
GPR2	dedicated	Table of Contents (TOC) pointer.
GPR3	volatile	First word of a function's argument list; first word of a scalar function return.
GPR4	volatile	Second word of a function's argument list; second word of a scalar function return.
GPR5	volatile	Third word of a function's argument list.

GPR6	volatile	Fourth word of a function's argument list.
GPR7	volatile	Fifth word of a function's argument list.
GPR8	volatile	Sixth word of a function's argument list.
GPR9	volatile	Seventh word of a function's argument list.
GPR10	volatile	Eighth word of a function's argument list.
GPR11	volatile	In calls by pointer and as an environment pointer for languages that require it (for example, PASCAL).
GPR12	volatile	For special exception handling required by certain languages and in **glink** code.
GPR13	reserved	Reserved under 64-bit environment; not restored across system calls.
GPR14:GPR31	nonvolatile	These registers must be preserved across a function call.

The preferred method of using GPRs is to use the volatile registers first. Next, use the nonvolatile registers in descending order, starting with GPR31 and proceeding down to GPR14. GPR1 and GPR2 must be dedicated as stack and Table of Contents (TOC) area pointers, respectively. GPR1 and GPR2 must appear to be saved across a call, and must have the same values at return as when the call was made.

Volatile registers are scratch registers presumed to be destroyed across a call and are, therefore, not saved by the callee. Volatile registers are also used for specific purposes as shown in the previous table. Nonvolatile and dedicated registers are required to be saved and restored if altered and, thus, are guaranteed to retain their values across a function call.

The Floating-Point Register Conventions table shows how the FPRs are used.

Table 2. Floating-Point Register Conventions

Register	Status	Use
FPR0	volatile	As a scratch register.
FPR1	volatile	First floating-point parameter; first 8 bytes of a floating-point scalar return.
FPR2	volatile	Second floating-point parameter; second 8 bytes of a floating-point scalar return.
FPR3	volatile	Third floating-point parameter; third 8 bytes of a floating-point scalar return.
FPR4	volatile	Fourth floating-point parameter; fourth 8 bytes of a floating-point scalar return.
FPR5	volatile	Fifth floating-point parameter.
FPR6	volatile	Sixth floating-point parameter.
FPR7	volatile	Seventh floating-point parameter.
FPR8	volatile	Eighth floating-point parameter.
FPR9	volatile	Ninth floating-point parameter.
FPR10	volatile	Tenth floating-point parameter.
FPR11	volatile	Eleventh floating-point parameter.
FPR12	volatile	Twelfth floating-point parameter.
FPR13	volatile	Thirteenth floating-point parameter.
FPR14:FPR31	nonvolatile	If modified, must be preserved across a call.

The preferred method of using FPRs is to use the volatile registers first. Next, the nonvolatile registers are used in descending order, starting with FPR31 and proceeding down to FPR14.

Only scalars are returned in multiple registers. The number of registers required depends on the size and type of the scalar. For floating-point values, the following results occur:

- A 128-bit floating-point value returns the high-order 64 bits in FPR1 and the low-order 64 bits in FPR2.
- An 8-byte or 16-byte complex value returns the real part in FPR1 and the imaginary part in FPR2.
- A 32-byte complex value returns the real part as a 128-bit floating-point value in FPR1 and FPR2, with the high-order 64 bits in FPR1 and the low-order 64 bits in FPR2. The imaginary part of a 32-byte complex value returns the high-order 64 bits in FPR3 and the low-order 64 bits in FPR4.

Special Registers in the PowerPC

The Special-Purpose Register Conventions table shows the PowerPC special purpose registers (SPRs). These are the only SPRs for which there is a register convention.

Table 3. Special-Purpose Register Conventions

Register or Register Field	Status	Use
LR	volatile	Used as a branch target address or holds a return address.
CTR	volatile	Used for loop count decrement and branching.
XER	volatile	Fixed-point exception register.
FPSCR	volatile	Floating-point exception register.
CR0, CR1	volatile	Condition-register bits.
CR2, CR3, CR4	nonvolatile	Condition-register bits.
CR5, CR6, CR7	volatile	Condition-register bits.

Routines that alter CR2, CR3, and CR4 must save and restore at least these fields of the CR. Use of other CR fields does not require saving or restoring.

Run-Time Process Stack

The stack format convention is designed to enhance the efficiency of the following:

- Prolog and epilog function usage
- Parameter passing
- Shared library support

The Run-Time Stack figure illustrates the run-time stack. It shows the stack after the **sender** function calls the **catcher** function, but before the **catcher** function calls another function. This figure is based on the assumption that the **catcher** function will call another function. Therefore, the **catcher** function requires another link area (as described in the stack layout). **PW***n* refers to the *n*th word of parameters that are passed.

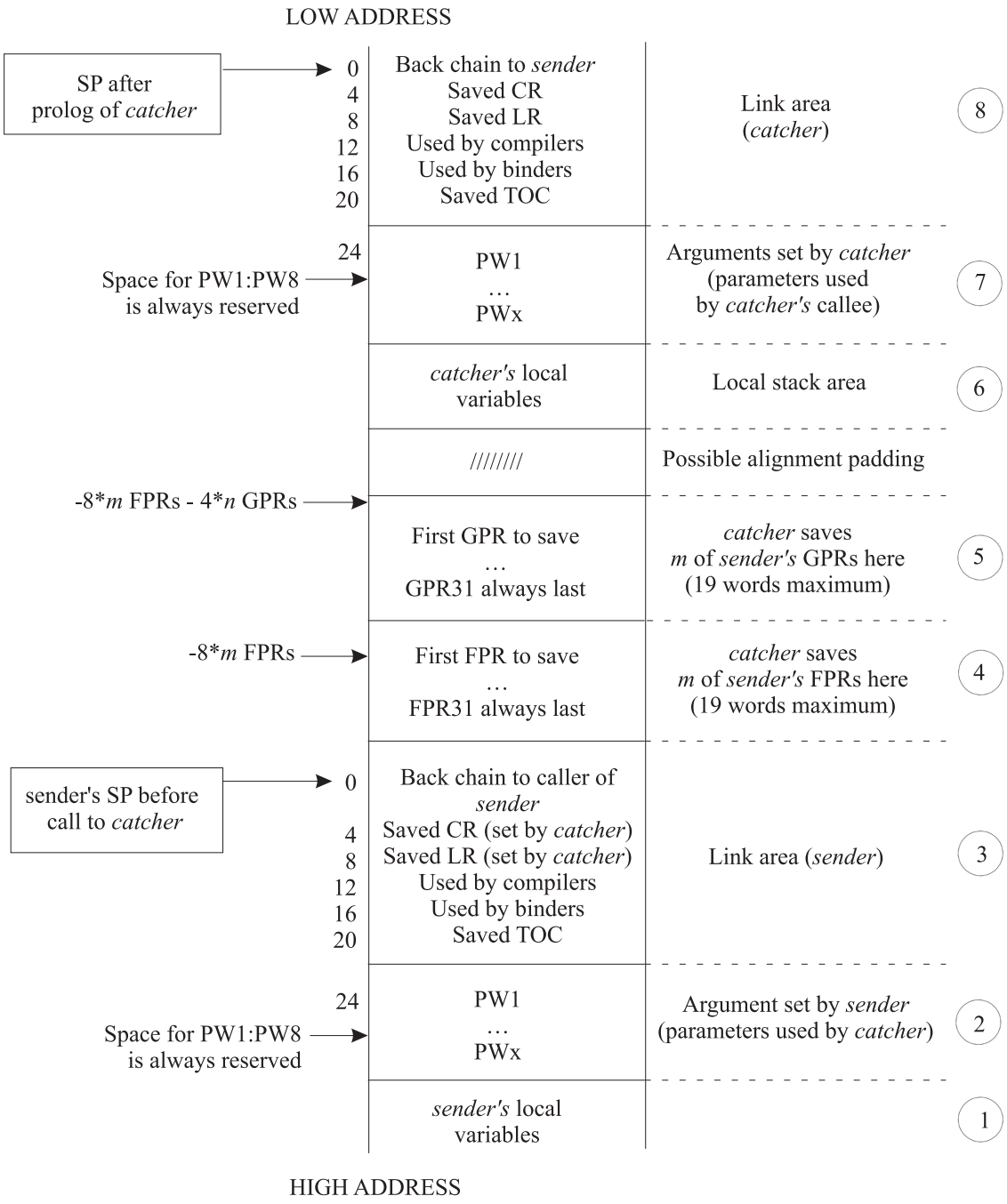

Figure 2. Run-Time Stack

Stack Layout: Only one register, referred to as the stack pointer (SP), is used for addressing the stack, and GPR1 is the dedicated stack pointer register. It grows from numerically higher storage addresses to numerically lower addresses.

The Run-Time Stack figure illustrates what happens when the **sender** function calls the **catcher** function, and how the **catcher** function requires a stack frame of its own. When a function makes no calls and requires no local storage of its own, no stack frame is required and the SP is not altered.

Notes:

1. To reduce confusion, data being passed from the **sender** function (the caller) is referred to as arguments, and the same data being received by the **catcher** function (the callee) is referred to as parameters. The output argument area of **sender** is the same as the input parameter area of **catcher**.
2. The address value in the stack pointer must be quadword-aligned. (The address value must be a multiple of 16.)

Stack Areas: For convenience, the stack layout has been divided into eight areas numbered 1 to 8, starting from the bottom of the diagram (high address) to the top of the diagram (low address). The sender's stack pointer is pointing to the top of area 3 when the call to the **catcher** function is made, which is also the same SP value that is used by the **catcher** function on entry to its prolog. The following is a description of the stack areas, starting from the bottom of the diagram (area 1) and moving up to the top (area 8):

- **Area 1: Sender's Local Variable Area**

  Area 1 is the local variable area for the **sender** function, contains all local variables and temporary space required by this function.

- **Area 2: Sender's Output Argument Area**

  Area 2 is the output argument area for the **sender** function. This area is at least eight words in size and must be doubleword-aligned. The first eight words are not used by the caller (the **sender** function) because their corresponding values are placed directly in the argument registers (GPR3:GPR10). The storage is reserved so that if the callee (the **catcher** function) takes the address of any of its parameters, the values passed in GPR3:GPR10 can be stored in their address locations (PW1:PW8, respectively). If the **sender** function is passing more than eight arguments to the **catcher** function, then it must reserve space for the excess parameters. The excess parameters must be stored as register images beyond the eight reserved words starting at offset 56 from the **sender** function's SP value.

  Note: This area may also be used by language processors and is volatile across calls to other functions.

- **Area 3: Sender's Link Area**

  Area 3 is the link area for the **sender** function. This area consists of six words and is at offset 0 from the **sender** function's SP at the time the call to the **catcher** function is made. Certain fields in this area are used by the **catcher** function as part of its prolog code, those fields are marked in the Run-Time Stack figure and are explained below.

  The first word is the *back chain*, the location where the **sender** function saved its caller's SP value prior to modifying the SP. The second word (at offset 4) is where the **catcher** function can save the CR if it modifies any of the nonvolatile CR fields. The third word (offset 8) is where the **catcher** function can save the LR if the **catcher** function makes any calls.

  The fourth word is reserved for compilers, and the fifth word is used by binder-generated instructions. The last word in the link area (offset 20) is where the TOC area register (see "Understanding and Programming the TOC" on page 80 for description) is saved by the global linkage (glink) interface routine. This occurs when an out-of-module call is performed, such as when a shared library function is called.

- **Area 4: Catcher's Floating-Point Registers Save Area**

  Area 4 is the floating-point register save area for the callee (the **catcher** function) and is doubleword-aligned. It represents the space needed to save all the nonvolatile FPRs used by the called program (the **catcher** function). The FPRs are saved immediately above the link area (at a lower address) at a negative displacement from the **sender** function's SP. The size of this area varies from zero to a maximum of 144 bytes, depending on the number of FPRs being saved (maximum number is 18 FPRs * 8 bytes each).

- **Area 5: Catcher's General-Purpose Registers Save Area**

  Area 5 is the general-purpose register save area for the **catcher** function and is at least word-aligned. It represents the space needed by the called program (the **catcher** function) to save all the nonvolatile GPRs. The GPRs are saved immediately above the FPR save area (at a lower address) at a negative

displacement from the **sender** function's SP. The size of this area varies from zero to a maximum of 76 bytes, depending on the number of GPRs being saved (maximum number is 19 GPRs * 4 bytes each).

Notes:

1. A stackless leaf procedure makes no calls and requires no local variable area, but it may use nonvolatile GPRs and FPRs.
2. The save area consists of the FPR save area (4) and the GPR save area (5), which have a combined maximum size of 220 bytes. The stack floor of the currently executing function is located at 220 bytes less than the value in the SP. The area between the value in the SP and the stack floor is the maximum save area that a stackless leaf function may use without acquiring its own stack. Functions may use this area as temporary space which is volatile across calls to other functions. Execution elements such as interrupt handlers and binder-inserted code, which cannot be seen by compiled codes as calls, must not use this area.

The system-defined stack floor includes the maximum possible save area. The formula for the size of the save area is:

```
18*8
(for FPRs)
 + 19*4
(for GPRs)
 = 220
```

- **Area 6: Catcher's Local Variable Area**

  Area 6 is the local variable area for the **catcher** function and contains local variables and temporary space required by this function. The **catcher** function addresses this area using its own SP, which points to the top of area 8, as a base register.

- **Area 7: Catcher's Output Argument Area**

  Area 7 is the output argument area for the **catcher** function and is at least eight words in size and must be doubleword-aligned. The first eight words are not used by the caller (the **catcher** function), because their corresponding values are placed directly in the argument registers (GPR3:GPR10). The storage is reserved so that if the **catcher** function's callee takes the address of any of its parameters, then the values passed in GPR3:GPR10 can be stored in their address locations. If the **catcher** function is passing more than eight arguments to its callee (PW1:PW8, respectively), it must reserve space for the excess parameters. The excess parameters must be stored as register images beyond the eight reserved words starting at offset 56 from the **catcher** function's SP value.

  Note: This area can also be used by language processors and is volatile across calls to other functions.

- **Area 8: Catcher's Link Area**

  Area 8 is the link area for the **catcher** function and contains the same fields as those in the **sender** function's link area (area 3).

Stack-Related System Standard

All language processors and assemblers must maintain the stack-related system standard that the SP must be atomically updated by a single instruction. This ensures that there is no timing window where an interrupt that would result in the stack pointer being only partially updated can occur.

Note: The examples of program prologs and epilogs show the most efficient way to update the stack pointer.

Prologs and Epilogs

Prologs and epilogs may be used for functions, including setting the registers on function entry and restoring the registers on function exit.

No predetermined code sequences representing function prologs and epilogs are dictated. However, certain operations must be performed under certain conditions. The following diagram shows the stack frame layout.

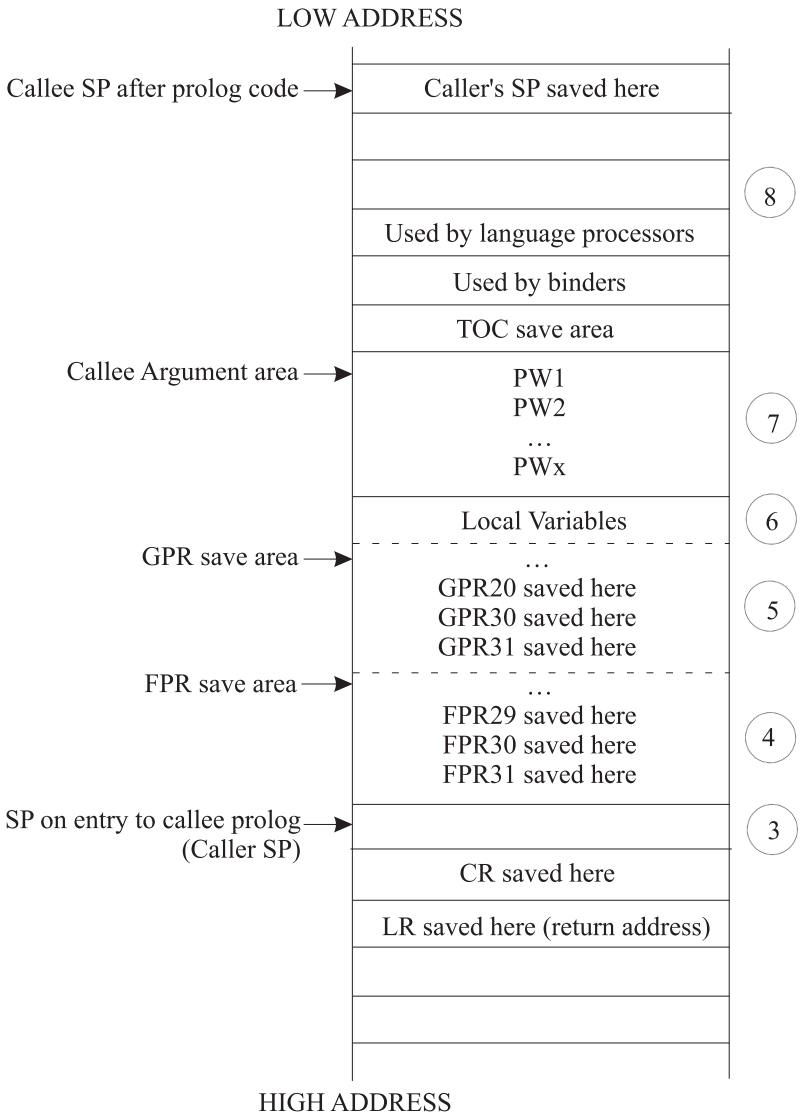

Figure 3. Stack Frame Layout

A typical function's execution stack is:

- Prolog action
- Body of function
- Epilog action

The Prolog Actions and Epilog Actions tables show the conditions and actions required for prologs and epilogs.

Table 4. Prolog Actions

If:	**Then:**
Any nonvolatile FPRs (FPR14:FPR31) are used	Save them in the FPR save area (area 4 in the previous figure).

Table 4. Prolog Actions (continued)

If:	Then:
Any nonvolatile GPRs (GPR13:GPR31) are used	Save them in the GPR save area (area 5 in the previous figure).
LR is used for a nonleaf procedure	Save the LR at offset eight from the caller function SP.
Any of the nonvolatile condition register (CR) fields are used.	Save the CR at offset four from the caller function SP.
A new stack frame is required	Get a stack frame and decrement the SP by the size of the frame padded (if necessary) to a multiple of 16 to acquire a new SP and save caller's SP at offset 0 from the new SP.

Note: A leaf function that does not require stack space for local variables and temporaries can save its caller registers at a negative offset from the caller SP without actually acquiring a stack frame.

Table 5. Epilog Actions

If:	Then:
Any nonvolatile FPRs were saved	Restore the FPRs that were used.
Any nonvolatile GPRs were saved	Restore the GPRs that were saved.
The LR was altered because a nonleaf procedure was invoked	Restore LR.
The CR was altered	Restore CR.
A new stack was acquired	Restore the old SP to the value it had on entry (the caller's SP). Return to caller.

While the PowerPC architecture provides both load and store multiple instructions for GPRs, it discourages their use because their implementation on some machines may not be optimal. In fact, use of the load and store multiple instructions on some future implementations may be significantly slower than the equivalent series of single word loads or stores. However, saving many FPRs or GPRs with single load or store instructions in a function prolog or epilog leads to increased code size. For this reason, the system environment must provide routines that can be called from a function prolog and epilog that will do the saving and restoring of the FPRs and GPRs. The interface to these routines, their source code, and some prolog and epilog code sequences are provided.

As shown in the stack frame layout, the GPR save area is not at a fixed position from either the caller SP or the callee SP. The FPR save area starts at a fixed position, directly above the SP (lower address) on entry to that callee, but the position of the GPR save area depends on the number of FPRs saved. Thus, it is difficult to write a general-purpose GPR-saving function that uses fixed displacements from SP.

If the routine needs to save both GPRs and FPRs, use GPR12 as the pointer for saving and restoring GPRs. (GPR12 is a volatile register, but does not contain input parameters.) This results in the definition of multiple-register save and restore routines, each of which saves or restores *m* FPRs and *n* GPRs. This is achieved by executing a **bla** (Branch and Link Absolute) instruction to specially provided routines containing multiple entry points (one for each register number), starting from the lowest nonvolatile register.

Notes:

1. There are no entry points for saving and restoring GPR and FPR numbers greater than 29. It is more efficient to save a small number of registers in the prolog than it is to call the save and restore functions.

2. If the LR is not saved or restored in the following code segments, the language processor must perform the saving and restoring as appropriate.

Language processors must use a proprietary method to conserve the values of nonvolatile registers across a function call.

Three sets of save and restore routines must be made available by the system environment. These routines are:

- A pair of routines to save and restore GPRs when FPRs are not being saved and restored.
- A pair of routines to save and restore GPRs when FPRs are being saved and restored.
- A pair of routines to save and restore FPRs.

Saving GPRs Only: For a function that saves and restores *n* GPRs and no FPRs, the saving can be done using individual store and load instructions or by calling system-provided routines as shown in the following example:

Note: The number of registers being saved is *n*. Sequences such as <32-n> in the following examples indicate the first register number to be saved and restored. All registers from <32-n> to 31, inclusive, are saved and restored.

```
#Following are the prolog/epilog of a function that saves n GPRS #(n>2):
mflr    r0                      #move LR into GPR0
bla     _savegpr0_<32-n>        #branch and link to save GPRs
stwu    r1,<-frame_size>(r1)    #update SP and save caller's SP
...                             #frame_size is the size of the
                                #stack frame to be required
<save CR if necessary>
...
...                             #body of function
...
<reload save CR if necessary>
...
<reload caller's SP into R!>    #see note below
ba      _restgpr0_<32-n>        #restore GPRs and return
```

Note: The restoring of the calling function SP can be done by either adding the `frame_size` value to the current SP whenever `frame_size` is known, or by reloading it from offset 0 from the current SP. The first approach is more efficient, but not possible for functions that use the **alloca** subroutine to dynamically allocate stack space.

The following example shows a GPR save routine when FPRs are not saved:

```
_savegpr0_13    stw     r13,-76(r1)             #save r13
_savegpr0_14    stw     r14,-72(r1)             #save r14
_savegpr0_15    stw     r15,-68(r1)             #save r15
_savegpr0_16    stw     r16,-64(r1)             #save r16
_savegpr0_17    stw     r17,-60(r1)             #save r17
_savegpr0_18    stw     r18,-56(r1)             #save r18
_savegpr0_19    stw     r19,-52(r1)             #save r19
_savegpr0_20    stw     r20,-48(r1)             #save r20
_savegpr0_21    stw     r21,-44(r1)             #save r21
_savegpr0_22    stw     r22,-40(r1)             #save r22
_savegpr0_23    stw     r23,-36(r1)             #save r23
_savegpr0_24    stw     r24,-32(r1)             #save r24
_savegpr0_25    stw     r25,-28(r1)             #save r25
_savegpr0_26    stw     r26,-24(r1)             #save r26
_savegpr0_27    stw     r27,-20(r1)             #save r27
_savegpr0_28    stw     r28,-16(r1)             #save r28
_savegpr0_29    stw     r29,-12(r1)             #save r29
                stw     r30,-8(r1)              #save r30
                stw     r31,-4(r1)              #save r31
```

```
                stw     r0 , 8(r1)              #save LR in
                                                #caller's frame
                blr                             #return
```

Note: This save routine must not be called when GPR30 or GPR31, or both, are the only registers beings saved. In these cases, the saving and restoring must be done inline.

The following example shows a GPR restore routine when FPRs are not saved:

```
_restgpr0_13    lwz     r13,-76(r1)             #restore r13
_restgpr0_14    lwz     r14,-72(r1)             #restore r14
_restgpr0_15    lwz     r15,-68(r1)             #restore r15
_restgpr0_16    lwz     r16,-64(r1)             #restore r16
_restgpr0_17    lwz     r17,-60(r1)             #restore r17
_restgpr0_18    lwz     r18,-56(r1)             #restore r18
_restgpr0_19    lwz     r19,-52(r1)             #restore r19
_restgpr0_20    lwz     r20,-48(r1)             #restore r20
_restgpr0_21    lwz     r21,-44(r1)             #restore r21
_restgpr0_22    lwz     r22,-40(r1)             #restore r22
_restgpr0_23    lwz     r23,-36(r1)             #restore r23
_restgpr0_24    lwz     r24,-32(r1)             #restore r24
_restgpr0_25    lwz     r25,-28(r1)             #restore r25
_restgpr0_26    lwz     r26,-24(r1)             #restore r26
_restgpr0_27    lwz     r27,-20(r1)             #restore r27
_restgpr0_28    lwz     r28,-16(r1)             #restore r28
_restgpr0_29    lwz     r0,8(r1)                #get return
                                                #address from
                                                #frame
                lwz     r29,-12(r1)             #restore r29
                mtlr    r0                      #move return
                                                #address to LR
                lwz     r30,-8(r1)              #restore r30
                lwz     r31,-4(r1)              #restore r31
                blr                             #return
```

Note: This restore routine must not be called when GPR30 or GPR31, or both, are the only registers beings saved. In these cases, the saving and restoring must be done inline.

Saving GPRs and FPRs: For a function that saves and restores *n* GPRs and *m* FPRs (*n*>2 and *m*>2), the saving can be done using individual store and load instructions or by calling system-provided routines as shown in the following example:

```
#The following example shows the prolog/epilog of a function #which save n GPRs and m FPRs:
mflr    r0                      #move LR into GPR 0
subi    r12,r1,8*m              #compute GPR save pointer
bla     _savegpr1_<32-n>        #branch and link to save GPRs
bla     _savefpr_<32-m>
stwu    r1,<-frame_size>(r1)    #update SP and save caller's SP
...
<save CR if necessary>
...
...                             #body of function
...
<reload save CR if necessary>
...
<reload caller's SP into r1>    #see note below on
subi    r12,r1,8*m              #compute CPR restore pointer
bla     _restgpr1_<32-n>        #restore GPRs
ba      _restfpr_<32-m>         #restore FPRs and return
```

Note: The calling function SP can be restored by either adding the `frame_size` value to the current SP whenever the `frame_size` is known or by reloading it from offset 0 from the current SP. The first approach is more efficient, but not possible for functions that use the **alloca** subroutine to dynamically allocate stack space.

The following example shows a GPR save routine when FPRs are saved:

```
_savegpr1_13    stw     r13,-76(r12)            #save r13
_savegpr1_14    stw     r14,-72(r12)            #save r14
_savegpr1_15    stw     r15,-68(r12)            #save r15
_savegpr1_16    stw     r16,-64(r12)            #save r16
_savegpr1_17    stw     r17,-60(r12)            #save r17
_savegpr1_18    stw     r18,-56(r12)            #save r18
_savegpr1_19    stw     r19,-52(r12)            #save r19
_savegpr1_20    stw     r20,-48(r12)            #save r20
_savegpr1_21    stw     r21,-44(r12)            #save r21
_savegpr1_22    stw     r22,-40(r12)            #save r22
_savegpr1_23    stw     r23,-36(r12)            #save r23
_savegpr1_24    stw     r24,-32(r12)            #save r24
_savegpr1_25    stw     r25,-28(r12)            #save r25
_savegpr1_26    stw     r26,-24(r12)            #save r26
_savegpr1_27    stw     r27,-20(r12)            #save r27
_savegpr1_28    stw     r28,-16(r12)            #save r28
_savegpr1_29    stw     r29,-12(r12)            #save r29
                stw     r30,-8(r12)             #save r30
                stw     r31,-4(r12)             #save r31
                blr                             #return
```

The following example shows an FPR save routine:

```
_savefpr_14     stfd    f14,-144(r1)            #save f14
_savefpr_15     stfd    f15,-136(r1)            #save f15
_savefpr_16     stfd    f16,-128(r1)            #save f16
_savefpr_17     stfd    f17,-120(r1)            #save f17
_savefpr_18     stfd    f18,-112(r1)            #save f18
_savefpr_19     stfd    f19,-104(r1)            #save f19
_savefpr_20     stfd    f20,-96(r1)             #save f20
_savefpr_21     stfd    f21,-88(r1)             #save f21
_savefpr_22     stfd    f22,-80(r1)             #save f22
_savefpr_23     stfd    f23,-72(r1)             #save f23
_savefpr_24     stfd    f24,-64(r1)             #save f24
_savefpr_25     stfd    f25,-56(r1)             #save f25
_savefpr_26     stfd    f26,-48(r1)             #save f26
_savefpr_27     stfd    f27,-40(r1)             #save f27
_savefpr_28     stfd    f28,-32(r1)             #save f28
_savefpr_29     stfd    f29,-24(r1)             #save f29
                stfd    f30,-16(r1)             #save f30
                stfd    f31,-8(r1)              #save f31
                stw     r0 , 8(r1)              #save LR in
                                                #caller's frame
                blr                             #return
```

The following example shows a GPR restore routine when FPRs are saved:

```
_restgpr1_13    lwz     r13,-76(r12)            #restore r13
_restgpr1_14    lwz     r14,-72(r12)            #restore r14
_restgpr1_15    lwz     r15,-68(r12)            #restore r15
_restgpr1_16    lwz     r16,-64(r12)            #restore r16
_restgpr1_17    lwz     r17,-60(r12)            #restore r17
_restgpr1_18    lwz     r18,-56(r12)            #restore r18
_restgpr1_19    lwz     r19,-52(r12)            #restore r19
_restgpr1_20    lwz     r20,-48(r12)            #restore r20
_restgpr1_21    lwz     r21,-44(r12)            #restore r21
_restgpr1_22    lwz     r22,-40(r12)            #restore r22
_restgpr1_23    lwz     r23,-36(r12)            #restore r23
_restgpr1_24    lwz     r24,-32(r12)            #restore r24
_restgpr1_25    lwz     r25,-28(r12)            #restore r25
_restgpr1_26    lwz     r26,-24(r12)            #restore r26
_restgpr1_27    lwz     r27,-20(r12)            #restore r27
_restgpr1_28    lwz     r28,-16(r12)            #restore r28
_restgpr1_29    lwz     r29,-12(r12)            #restore r29
```

```
                lwz     r30,-8(r12)             #restore r30
                lwz     r31,-4(r12)             #restore r31
                blr                             #return
```

The following example shows an FPR restore routine:

```
_restfpr_14     lfd     r14,-144(r1)            #restore r14
_restfpr_15     lfd     r15,-136(r1)            #restore r15
_restfpr_16     lfd     r16,-128(r1)            #restore r16
_restfpr_17     lfd     r17,-120(r1)            #restore r17
_restfpr_18     lfd     r18,-112(r1)            #restore r18
_restfpr_19     lfd     r19,-104(r1)            #restore r19
_restfpr_20     lfd     r20,-96(r1)             #restore r20
_restfpr_21     lfd     r21,-88(r1)             #restore r21
_restfpr_22     lfd     r22,-80(r1)             #restore r22
_restfpr_23     lfd     r23,-72(r1)             #restore r23
_restfpr_24     lfd     r24,-64(r1)             #restore r24
_restfpr_25     lfd     r25,-56(r1)             #restore r25
_restfpr_26     lfd     r26,-48(r1)             #restore r26
_restfpr_27     lfd     r27,-40(r1)             #restore r27
_restfpr_28     lfd     r28,-32(r1)             #restore r28
_restfpr_29     lwz     r0,8(r1)                #get return
                                                #address from
                                                #frame
                lfd     r29,-24(r1)             #restore r29
                mtlr    r0                      #move return
                                                #address to LR
                lfd     r30,-16(r1)             #restore r30
                lfd     r31,-8(r1)              #restore r31
                blr                             #return
```

Saving FPRs Only: For a function that saves and restores *m* FPRs (*m*>2), the saving can be done using individual store and load instructions or by calling system-provided routines as shown in the following example:

```
#The following example shows the prolog/epilog of a function #which saves m FPRs and no GPRs:
mflr    r0                      #move LR into GPR 0
bla     _savefpr_<32-m>
stwu    r1,<-frame_size>(r1)    #update SP and save caller's SP
...
<save CR if necessary>
...
...                             #body of function
...
<reload save CR if necessary>
...
<reload caller's SP into r1>    #see note below
ba      _restfpr_<32-m>         #restore FPRs and return
```

Notes:

1. There are no entry points for saving and restoring GPR and FPR numbers higher than 29. It is more efficient to save a small number of registers in the prolog than to call the save and restore functions.
2. The restoring of the calling function SP can be done by either adding the `frame_size` value to the current SP whenever `frame_size` is known, or by reloading it from offset 0 from the current SP. The first approach is more efficient, but not possible for functions that use the **alloca** subroutine to dynamically allocate stack space.

Updating the Stack Pointer: The PowerPC **stwu** (Store Word with Update) instruction is used for computing the new SP and saving the back chain. This instruction has a signed 16-bit displacement field that can represent a maximum signed value of 32,768. A stack frame size greater than 32K bytes requires two instructions to update the SP, and the update must be done atomically.

The two assembly code examples illustrate how to update the SP in a prolog.

To compute a new SP and save the old SP for stack frames larger than or equal to 32K bytes:

```
addis   r12, r0, (<-frame_size> > 16) & 0XFFFF
                        # set r12 to left half of frame size
ori     r12, r12 (-frame_size> & 0XFFFF
                        # Add right halfword of frame size
stwux   r1, r1, r12     # save old SP and compute new SP
```

To compute a new SP and save the old SP for stack frames smaller than 32K bytes:

```
stwu   r1, <-frame_size>(r1)   #update SP and save caller's SP
```

Calling Routine's Responsibilities

When an assembler language program calls another program, the caller should not use the names of the called program's commands, functions, or procedures as global assembler language symbols. To avoid confusion, follow the naming conventions for the language of the called program when you create symbol names. For example, if you are calling a C language program, be certain you use the naming conventions for that language.

A called routine has two symbols associated with it: a function descriptor (*Name*) and an entry point (*.Name*). When a call is made to a routine, the compiler branches to the name point directly.

Except for when loading parameters into the proper registers, calls to functions are expanded by compilers to include an NOP instruction after each branch and link instruction. This extra instruction is modified by the linkage editor to restore the contents of the TOC register (register 2) on return from an out-of-module call.

The instruction sequence produced by compilers is:

```
bl .foo            #Branch to foo
cror 31,31,31     #Special NOP 0x4ffffb82
```

Note: Some compilers produce a **cror 15,15,15** (0x4def7b82) instruction. To avoid having to restore condition register 15 after a call, the linkage editor transforms **cror 15,15,15** into **cror 31,31,31**. Condition register bit 31 is not preserved across a call and does not have to be restored.

The linkage editor will do one of two things when it sees the **bl** instruction (in the previous instruction sequence, on a call to the **foo** function):

- If the **foo** function is imported (not in the same executable module), the linkage editor:
  - Changes the **bl .foo** instruction to **bl .glink_of_foo** (a global linkage routine).
  - Inserts the **.glink** code sequence into the (**/usr/lib/glink.o** file) module.
  - Replaces the NOP **cror** instruction with an **l** (load) instruction to restore the TOC register.

  The **bl .foo** instruction sequence is changed to:

  ```
  bl .glink_of_foo  #Branch to global linkage routine for foo
  l 2,20(1)         #Restore TOC register instruction 0x80410014
  ```
- If the **foo** function is bound in the same executable module as its caller, the linkage editor:
  - Changes the **bl .glink_of_foo** sequence (a global linkage routine) to **bl .foo**.
  - Replaces the restore TOC register instruction with the special NOP **cror** instruction.

  The **bl .glink_of_foo** instruction sequence is changed to:

  ```
  bl .foo          #Branch to foo
  cror 31,31,31    #Special NOP instruction 0x4ffffb82
  ```

Note: For any export, the linkage editor inserts the procedure's descriptor into the module.

Called Routine's Responsibilities

Prologs and epilogs are used in the called routines. On entry to a routine, the following steps should be performed:

1. Use some or all of the prolog actions described in the Prolog Actions table.
2. Store the back chain and decrement the stack pointer (SP) by the size of the stack frame.

   Note: If a stack overflow occurs, it will be known immediately when the store of the back chain is completed.

On exit from a procedure, use some or all of the epilog actions described in the Epilog Actions table.

Traceback Tags

Every assembly (compiled) program needs traceback information for the debugger to examine if the program traps or crashes during execution. This information is in a traceback table at the end of the last machine instruction in the program and before the program's constant data.

The traceback table starts with a full word of zeros, X'00000000', which is not a valid system instruction. The zeros are followed by 2 words (64 bits) of mandatory information and several words of optional information, as defined in the **/usr/include/sys/debug.h** file. Using this traceback information, the debugger can unwind the CALL chain and search forward from the point where the failure occurred until it reaches the end of the program (the word of zeros).

In general, the traceback information includes the name of the source language and information about registers used by the program, such as which general-purpose and floating-point registers were saved.

Example

The following is an example of assembler code called by a C routine:

```
#      Call this assembly routine from C routine:
#       callfile.c:
#       main()
#       {
#       examlinkage();
#       }
#       Compile as follows:
#       cc -o callfile callfile.c examlinkage.s
#
#################################################################
#       On entry to a procedure(callee), all or some of the
#       following steps should be done:
#       1.  Save the link register at offset 8 from the
#           stack pointer for non-leaf procedures.
#       2.  If any of the CR bits 8-19(CR2,CR3,CR4) is used
#           then save the CR at displacement 4 of the current
#            stack pointer.
#       3.  Save all non-volatile FPRs used by this routine.
#           If more that three non-volatile FPR are saved,
#            a call to ._savefn can be used to
#           save them (n is the number of the first FPR to be
#            saved).
#       4.  Save all non-volatile GPRs used by this routine
#           in the caller's GPR SAVE area (negative displacement
#           from the current stack pointer r1).
#       5.  Store back chain and decrement stack pointer by the
#           size of the stack frame.
#
#       On exit from a procedure (callee), all or some of the
#       following steps should be done:
#       1.  Restore all GPRs saved.
#       2.  Restore stack pointer to value it had on entry.
```

```
#       3.  Restore Link Register if this is a non-leaf
#           procedure.
#       4.  Restore bits 20-31 of the CR is it was saved.
#       5.  Restore all FPRs saved.  If any FPRs were saved then
#           a call to ._savefn can be used to restore them
#           (n is the first FPR to be restored).
#       6.  Return to caller.
################################################################
#       The following routine calls printf() to print a string.
#       The routine performs entry steps 1-5 and exit steps 1-6.
#       The prolog/epilog code is for small stack frame size.
#       DSA + 8 < 32k
################################################################
        .file   "examlinkage.s"
#Static data entry in T(able)O(f)C(ontents)
        .toc
T.examlinkage.c:        .tc     examlinkage.c[tc],examlinkage.c[rw]
        .globl  examlinkage[ds]
#examlinkage[ds] contains definitions needed for
#runtime linkage of function examlinkage
        .csect  examlinkage[ds]
        .long   .examlinkage[PR]
        .long   TOC[tc0]
        .long   0
#Function entry in T(able)O(f)C(ontents)
        .toc
T.examlinkage:  .tc     .examlinkage[tc],examlinkage[ds]
#Main routine
        .globl  .examlinkage[PR]
        .csect  .examlinkage[PR]
#       Set current routine stack variables
#       These values are specific to the current routine and
#       can vary from routine to routine
        .set    argarea,     32
        .set    linkarea,    24
       .set    locstckarea,   0
        .set    nfprs,       18
        .set    ngprs,       19
        .set    szdsa,
8*nfprs+4*ngprs+linkarea+argarea+locstckarea
#PROLOG:  Called Routines Responsibilities
        #    Get link reg.
        mflr    0
        #    Get CR if current routine alters it.
        mfcr    12
        #    Save FPRs 14-31.
        bl      ._savef14
        cror 31, 31, 31
        #    Save GPRs 13-31.
        stm     13, -8*nfprs-4*ngprs(1)
        #    Save LR if non-leaf routine.
        st      0, 8(1)
        #    Save CR if current routine alters it.
        st      12, 4(1)
        #    Decrement stack ptr and save back chain.
        stu     1, -szdsa(1)
################################
#load static data address
################################
        l       14,T.examlinkage.c(2)
        #  Load string address which is an argument to printf.
        cal 3, printing(14)
        #  Call to printf routine
        bl      .printf[PR]
        cror 31, 31, 31
#EPILOG:  Return Sequence
        #    Restore stack ptr
```

```
        ai      1, 1, szdsa
        #    Restore GPRs 13-31.
        lm      13, -8*nfprs-4*ngprs(1)
        #    Restore FPRs 14-31.
        bl      ._restf14
        cror 31, 31, 31
 #    Get saved LR.
        l       0, 8(1)
        #    Get saved CR if this routine saved it.
        l       12, 4(1)
        #    Move return address to link register.
        mtlr    0
        #    Restore CR2, CR3, & CR4 of the CR.
        mtcrf   0x38,12
        #    Return to address held in Link Register.
        brl
        .tbtag 0x0,0xc,0x0,0x0,0x0,0x0,0x0,0x0
          #       External variables
        .extern ._savef14
        .extern ._restf14
        .extern .printf[PR]
###############################
#       Data
###############################
        .csect  examlinkage.c[rw]
        .align  2
printing:       .byte  'E,'x,'a,'m,'p,'l,'e,' ,'f,'o,'r,'
                .byte   'P,'R,'I,'N,'T,'I,'N,'G
        .byte   0xa,0x0
```

Using Milicode Routines

All of the fixed-point divide instructions, and some of the multiply instructions, are different for POWER family and PowerPC. To allow programs to run on systems based on either architecture, a set of special routines is provided by the operating system. These are called milicode routines and contain machine-dependent and performance-critical functions. Milicode routines are located at fixed addresses in the kernel segment. These routines can be reached by a **bla** instruction. All milicode routines use the link register.

Notes:

1. No unnecessary registers are destroyed. Refer to the definition of each milicode routine for register usage information.
2. Milicode routines do not alter any floating-point register, count register, or general-purpose registers (GPRs) 10-12. The link register can be saved in a GPR (for example, GPR 10) if the call appears in a leaf procedure that does not use nonvolatile GPRs.
3. Milicode routines do not make use of a TOC.

The following milicode routines are available:

__mulh Calculates the high-order 32 bits of the integer product *arg1* * *arg2*.

Input R3 = *arg1* (signed integer)

R4 = *arg2* (signed integer)

Output R3 = high-order 32 bits of *arg1*arg2*

POWER family Register Usage
GPR3, GPR4, MQ

PowerPC Register Usage
GPR3, GPR4

__mull Calculates 64 bits of the integer product *arg1* * *arg2*, returned in two 32-bit registers.

Input R3 = *arg1* (signed integer)

R4 = *arg2* (signed integer)

Output R3 = high-order 32 bits of *arg1***arg2*

R4 = low-order 32 bits of *arg1***arg2*

POWER family Register Usage
GPR3, GPR4, MQ

PowerPC Register Usage
GPR0, GPR3, GPR4

__divss Calculates the 32-bit quotient and 32-bit remainder of signed integers *arg1*/*arg2*. For division by zero and overflow, the quotient and remainder are undefined and may vary by implementation.

Input R3 = *arg1* (dividend) (signed integer)

R4 = *arg2* (divisor) (signed integer)

Output R3 = quotient of *arg1*/*arg2* (signed integer)

R4 = remainder of *arg1*/*arg2* (signed integer)

POWER family Register Usage
GPR3, GPR4, MQ

PowerPC Register Usage
GPR0, GPR3, GPR4

__divus Calculated the 32-bit quotient and 32-bit remainder of unsigned integers *arg1*/*arg2*. For division by zero and overflow, the quotient and remainder are undefined and may vary by implementation.

Input R3 = *arg1* (dividend) (unsigned integer)

R4 = *arg2* (divisor) (unsigned integer)

Output R3 = quotient of *arg1*/*arg2* (unsigned integer)

R4 = remainder of *arg1*/*arg2* (unsigned integer)

POWER family Register Usage
GPR0, GPR3, GPR4, MQ, CR0 and CR1 of CR

PowerPC Register Usage
GPR0, GPR3, GPR4

__quoss Calculates the 32-bit quotient of signed integers *arg1*/*arg2*. For division by zero and overflow, the quotient and remainder are undefined and may vary by implementation.

Input R3 = *arg1* (dividend) (signed integer)

R4 = *arg2* (divisor) (signed integer)

Output R3 = quotient of *arg1*/*arg2* (signed integer)

POWER family Register Usage
GPR3, GPR4, MQ

PowerPC Register Usage
GPR3, GPR4

__quous Calculates the 32-bit quotient of unsigned integers *arg1*/*arg2*. For division by zero and overflow, the quotient and remainder are undefined and may vary by implementation.

Input R3 = *arg1* (dividend) (unsigned integer)

R4 = *arg2* (divisor) (unsigned integer)

Output R3 = quotient of *arg1*/*arg2* (unsigned integer)

POWER family Register Usage
GPR0, GPR3, GPR4, MQ, CR0 and CR1 of CR

PowerPC Register Usage
GPR3, GPR4

The following example uses the **mulh** milicode routine in an assembler program:

```
li R3, -900
li R4, 50000
bla .__mulh
...
.extern .__mulh
```

Related Information

"Assembling and Linking a Program" on page 51.

"Understanding Assembler Passes" on page 55.

"Interpreting an Assembler Listing" on page 57.

"Interpreting a Symbol Cross-Reference" on page 61.

"Understanding and Programming the TOC".

"Running a Program" on page 85.

"b (Branch) Instruction" on page 141, "cror (Condition Register OR) Instruction" on page 166.

Understanding and Programming the TOC

The Table of Contents (TOC) of an XCOFF file is analogous to the table of contents of a book. The TOC is used to find objects in an XCOFF file. An XCOFF file is composed of sections that contain different types of data to be used for specific purposes. Some sections can be further subdivided into subsections or *csects*. A csect is the smallest replaceable unit of an XCOFF file. At run time, the TOC can contain the csect locations (and the locations of labels inside of csects).

The three sections that contain csects are:

.text Indicates that this csect contains code or read-only data.
.data Indicates that this csect contains read-write data.
.bss Indicates that this csect contains uninitialized mapped data.

The storage class of the csect determines the section in which the csect is grouped.

The TOC is located in the **.data** section of an XCOFF object file and is composed of TOC entries. Each TOC entry is a csect with storage mapping class of TC or TD.

A TOC entry with TD storage mapping class contains scalar data which can be directly accessed from the TOC. This permits some frequently used global symbols to be accessed directly from the TOC rather than indirectly through an address pointer csect contained within the TOC. To access scalar data in the TOC, two pieces of information are required:

- The location of the beginning of the TOC (i.e. the TOC anchor).
- The offset from the TOC anchor to the specific TOC entry that contains the data.

A TOC entry with TC storage mapping class contains the addresses of other csects or global symbols. Each entry can contain one or more addresses of csects or global symbols, but putting only one address in each TOC entry is recommended.

When a program is assembled, the csects are sorted such that the **.text** csects are written first, followed by all **.data** csects except for the TOC. The TOC is written after all the other **.data** csects. The TOC entries are relocated, so that the TOC entries with TC storage mapping class contain the csect addresses after the sort, rather than the csect addresses in the source program.

When an XCOFF module is loaded, TOC entries with TC storage mapping class are relocated again so that the TOC entries are filled with the real addresses where the csects will reside in memory. To access a csect in the module, two pieces of information are required:

- The location of the beginning of the TOC.
- The offset from the beginning of the TOC to the specific TOC entry that points to the csect. If a TOC entry has more than one address, each address can be calculated by adding (0...(*n*-1))*4 to the offset, where *n* is the position of the csect address defined with the ".tc Pseudo-op" on page 499.

Using the TOC

To use the TOC, you must follow certain conventions:

- General-Purpose Register 2 always contains a pointer to the TOC.
- All references from the **.text** section of an assembler program to **.data** or the **.bss** sections must occur via the TOC.

The TOC register (General-Purpose Register 2) is set up by the system when a program is invoked. It must be maintained by any code written. The TOC register provides module context so that any routines in the module can access data items.

The second of these conventions allows the **.text** and **.data** sections to be easily loaded into different locations in memory. By following this convention, you can assure that the only parts of the module to need relocating are the TOC entries.

Accessing Data through the TOC Entry with TC Storage Mapping Class

An external data item is accessed by first getting that item's address out of the TOC, and then using that address to get the data. In order to do this, proper relocation information must be provided to access the correct TOC entry. The **.toc** and **.tc** pseudo-ops generate the correct information to access a TOC entry. The following code shows how to access item `a` using its TOC entry:

```
       .set     RTOC,2
       .csect prog1[pr]          #prog1 is a csect
                                 #containing instrs.
       ...
       l  5,TCA(RTOC)            #Now GPR5 contains the
                                 #address of a[rw].
...
       .toc
TCA:   .tc  a[tc],a[rw]          #1st parameter is TOC entry
                                 #name, 2nd is contents of
                                 #TOC entry.
       .extern a[rw]             #a[rw] is an external symbol.
```

This same method is used to access a program's static internal data, which is data that retains its value over a call, but which can only be accessed by the procedures in the file where the data items are declared. Following is the C language data having the **static** attribute:

```
static int xyz;
```

This data is given a name determined by convention. In XCOFF, the name is preceded by an underscore:

```
       .csect prog1[pr]
       ...
       l 1,STprog1(RTOC)         #Load r1 with the address
                                 #prog1's static data.
       ...
       .csect _prog1[rw]         #prog1's static data.
       .long    0
       ...
       .toc
STprog1: .tc.prog1[tc],_prog1[rw]       #TOC entry with address of
                                        #prog1's static data.
```

Accessing Data through the TOC entry with TD Storage Mapping Class

A scalar data item can be stored into a TOC entry with TD storage mapping class and retrieved directly from the TOC entry.

Note: TOC entries with TD storage mapping class should be used only for *frequently used* scalars. If the TOC grows too big (either because of many entries or because of large entries) the assembler may report message 1252-171 indicating an out of range displacement.

The following examples show several ways to store and retrieve a scalar data item as a TOC with TD storage mapping class. Each example includes C source for a main program, assembler source for one module, instructions for linking and assembling, and output from running the program.

Example Using .csect Pseudo-op with TD Storage Mapping Class

1. The following is the source for the C main program `td1.c`:

```
/* This C module named td1.c   */
extern long   t_data;
extern  void mod_s();
main()
{
         mod_s();
         printf("t_data is %d\n", t_data);
}
```

2. The following is the assembler source for module `mod1.s`:

```
        .file  "mod1.s"
        .csect .mod_s[PR]
        .globl .mod_s[PR]
        .set    RTOC, 2
        l   5, t_data[TD](RTOC)  # Now GPR5 contains the
                                 # t_data value 0x10
        ai  5,5,14
        stu 5, t_data[TD](RTOC)
        br
        .globl  t_data[TD]
        .toc
        .csect  t_data[TD]  # t_data is a global symbol
                            # that has value of 0x10
                            # using TD csect will put this
                            # data into TOC area
        .long    0x10
```

3. The following commands assemble and compile the source programs into an executable `td1`:

```
as -o mod1.o mod1.s
cc -o td1 td1.c mod1.o
```

4. Running td1 prints the following:

```
t_data is 30
```

Example Using .comm Pseudo-op with TD Storage Mapping Class

1. The following is the source for the C main program td2.c:

```
/* This C module named td2.c   */
extern long   t_data;
extern  void mod_s();
main()
{
        t_data = 1234;
         mod_s();
         printf("t_data is %d\n", t_data);
}
```

2. The following is the assembler source for module mod2.s:

```
        .file "mod2.s"
        .csect .mod_s[PR]
        .globl .mod_s[PR]
        .set    RTOC, 2
        l   5, t_data[TD](RTOC)  # Now GPR5 contains the
                                 # t_data value
        ai  5,5,14
        stu 5, t_data[TD](RTOC)
        br
        .toc
        .comm  t_data[TD],4  # t_data is a global symbol
```

3. The following commands assemble and compile the source programs into an executable td2:

```
as -o mod2.o mod2.s
cc -o td2 td2.c mod2.o
```

4. Running td2 prints the following:

```
t_data is 1248
```

Example Using an External TD Symbol

1.
```
/* This C module named td3.c   */
long   t_data;
extern  void mod_s();
main()
{
        t_data = 234;
         mod_s();
         printf("t_data is %d\n", t_data);
}
```

2. The following is the assembler source for module mod3.s:

```
        .file "mod3.s"
        .csect .mod_s[PR]
        .globl .mod_s[PR]
        .set    RTOC, 2
        l   5, t_data[TD](RTOC)  # Now GPR5 contains the
                                 # t_data value
        ai  5,5,14
        stu 5, t_data[TD](RTOC)
        br
        .toc
        .extern  t_data[TD]  # t_data is a external symbol
```

3. The following commands assemble and compile the source programs into an executable td3:

```
./as -o mod3.o mod3.s
cc -o td3 td3.c mod3.o
```

4. Running td3 prints the following:

```
t_data is 248
```

Intermodule Calls Using the TOC

Because the only access from the text to the data section is through the TOC, the TOC provides a feature that allows intermodule calls to be used. As a result, routines can be linked together without resolving all the addresses or symbols at link time. In other words, a call can be made to a common utility routine without actually having that routine linked into the same module as the calling routine. In this way, groups of routines can be made into modules, and the routines in the different groups can call each other, with the bind time being delayed until load time. In order to use this feature, certain conventions must be followed when calling a routine that is in another module.

To call a routine in another module, an interface routine (or *global linkage* routine) is called that switches context from the current module to the new module. This context switch is easily performed by saving the TOC pointer to the current module, loading the TOC pointer of the new module, and then branching to the new routine in the other module. The other routine then returns to the original routine in the original module, and the original TOC address is loaded into the TOC register.

To make global linkage as transparent as possible, a call can be made to external routines without specifying the destination module. During bind time, the binder (linkage editor) determines whether to call global linkage code, and inserts the proper global linkage routine to perform the intermodule call. Global linkage is controlled by an import list. An import list contains external symbols that are resolved during run time, either from the system or from the dynamic load of another object file. See the **ld** command for information about import lists.

The following example calls a routine that may go through global linkage:

```
.csect  prog1[PR]
...
.extern prog2[PR]        #prog2 is an external symbol.
bl      .prog2[PR]       #call prog2[PR], binder may insert
                         #global linkage code.
cror    31,31,31         #place holder for instruction to
                         #restore TOC address.
```

The following example shows a call through a global linkage routine:

```
#AIX linkage register conventions:
#         R2      TOC
#         R1      stack pointer
#         R0, R12 work registers, not preserved
#         LR      Link Register, return address.
          .csect  .prog1[PR]
          bl      .prog2[GL]             #Branch to global
                                         #linkage code.
          l        2,stktoc(1)           #Restore TOC address
          .toc
prog2:    .tc      prog2[TC],prog2[DS]   #TOC entry:
                                         # address of descriptor
                                         # for out-of-module
                                         # routine
         .extern   prog2[DS]
##
## The following is an example of global linkage code.
         .set      stktoc,20
         .csect   .prog2[GL]
         .globl   .prog2
.prog2:   l        12,prog2(2)           #Get address of
                                         #out-of-module
                                         #descriptor.
          st       2,stktoc(1)           #save callers' toc.
          l        0,0(12)               #Get its entry address
                                         #from descriptor.
          l        2,4(12)               #Get its toc from
                                         #descriptor.
          mtctr    0                     #Put into Count Register.
```

```
bctr                            #Return to entry address
                                #in Count Register.
                                #Return is directly to
                                #original caller.
```

Related Information

“Assembling and Linking a Program” on page 51.

“Understanding Assembler Passes” on page 55.

“Interpreting an Assembler Listing” on page 57.

“Interpreting a Symbol Cross-Reference” on page 61.

“Subroutine Linkage Convention” on page 63.

“Running a Program”.

“.csect Pseudo-op” on page 469, “.tbtag Pseudo-op” on page 497, “.tc Pseudo-op” on page 499, “.toc Pseudo-op” on page 500, “.tocof Pseudo-op” on page 500.

Running a Program

A program is ready to run when it has been assembled and linked without producing any error messages. To run a program, first ensure that you have operating system permission to execute the file. Then type the program’s name at the operating system prompt:

```
$ progname
```

By default, any program output goes to standard output. To direct output somewhere other than standard output, use the operating system shell **>** (more than symbol) operator.

Run-time errors can be diagnosed by invoking the symbolic debugger with the **dbx** command. This symbolic debugger works with any code that adheres to XCOFF format conventions. The **dbx** command can be used to debug all compiler- and assembler-generated code.

Related Information

“Assembling and Linking a Program” on page 51.

“Understanding Assembler Passes” on page 55.

“Interpreting an Assembler Listing” on page 57.

“Interpreting a Symbol Cross-Reference” on page 61.

“Subroutine Linkage Convention” on page 63.

“Understanding and Programming the TOC” on page 80.

The **dbx** command.

The **as** command, **dbx** command, **ld** command.

“b (Branch) Instruction” on page 141, “cror (Condition Register OR) Instruction” on page 166.

“.csect Pseudo-op” on page 469, “.tbtag Pseudo-op” on page 497, “.tc Pseudo-op” on page 499, “.toc Pseudo-op” on page 500, “.tocof Pseudo-op” on page 500.

Chapter 6. Extended Instruction Mnemonics

The assembler supports a set of extended mnemonics and symbols to simplify assembly language programming. All extended mnemonics should be in the same assembly mode as their base mnemonics. Although different extended mnemonics are provided for POWER family and PowerPC, the assembler generates the same object code for the extended mnemonics if the base mnemonics are in the **com** assembly mode. The assembly mode for the extended mnemonics are listed in each extended mnemonics section. The POWER family and PowerPC extended mnemonics are listed separately in the following sections for migration purposes:

- "Extended Mnemonics of Branch Instructions"
- "Extended Mnemonics of Condition Register Logical Instructions" on page 94
- "Extended Mnemonics of Fixed-Point Arithmetic Instructions" on page 95
- "Extended Mnemonics of Fixed-Point Compare Instructions" on page 96
- "Extended Mnemonics of Fixed-Point Load Instructions" on page 97
- "Extended Mnemonics of Fixed-Point Logical Instructions" on page 98
- "Extended Mnemonics of Fixed-Point Trap Instructions" on page 98
- "Extended Mnemonic mtcr for Moving to the Condition Register" on page 100
- "Extended Mnemonics of Moving from or to Special-Purpose Registers" on page 100
- "Extended Mnemonics of 32-bit Fixed-Point Rotate and Shift Instructions" on page 105

Extended Mnemonics of Branch Instructions

The assembler supports extended mnemonics for Branch Conditional, Branch Conditional to Link Register, and Branch Conditional to Count Register instructions. Since the base mnemonics for all the Branch Conditional instructions are in the **com** assembly mode, all of their extended mnemonics are also in the **com** assembly mode.

Extended mnemonics are constructed by incorporating the *BO* and *BI* input operand into the mnemonics. Extended mnemonics always omit the *BH* input operand and assume its value to be 0b00.

Branch Mnemonics That Incorporate Only the BO Operand

The following tables show the instruction format for extended mnemonics that incorporate only the *BO* field. The target address is specified by the *target_addr* operand. The bit in the condition register for condition comparison is specified by the *BI* operand. The value of the *BI* operand can be specified by an expression. The CR field number should be multiplied by four to get the correct CR bit, since each CR field has four bits.

Note: Some extended mnemonics have two input operand formats.

Table 6. POWER family Extended Mnemonics (BO Field Only)

Mnemonics	Input Operands	Equivalent to	
bdz, **bdza**, **bdzl**, **bdzla**	*target_addr*	**bc, bca, bcl, bcla**	**18, 0,** *target_addr*
bdn, **bdna**, **bdnl**, **bdnla**	*target_addr*	**bc, bca, bcl, bcla**	**16, 0,** *target_addr*
bdzr, **bdzrl**	None	**bcr, bcrl**	**18, 0**
bdnr, **bdnrl**	None	**bcr**, **bcrl**	**16, 0**
bbt, **bbta**, **bbtl**, **bbtla**	1) *BI*, *target_addr*	**bc, bca, bcl, bcla**	**12,** *BI*, *target_addr*
	2) *target_addr*		**12, 0,** *target_addr*
bbf, **bbfa**, **bbfl**, **bbfla**	1) *BI*, *target_addr*	**bc, bca, bcl, bcla**	**4,** *BI*, *target_addr*
	2) *target_addr*		**4, 0,** *target_addr*

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Table 6. POWER family Extended Mnemonics (BO Field Only) (continued)

Mnemonics	Input Operands	Equivalent to	
bbtr, **bbtc**, **bbtrl**, **bbtcl**	1) *BI*	**bcr, bcc, bcrl, bccl**	**12,** *BI*
	2) None		**12, 0**
bbfr, **bbfc**, **bbfrl**, **bbfcl**	1) *BI*	**bcr, bcc, bcrl, bccl**	**4,** *BI*
	2) None		**4, 0**
br, **bctr**, **brl**, **bctrl**	None	**bcr, bcc, bcrl, bccl**	**20, 0**

Table 7. PowerPC Extended Mnemonics (BO Field Only)

Mnemonics	Input Operands	Equivalent to
bdz, **bdza**, **bdzl**, **bdzla**	*target_addr*	**bc, bca, bcl, bcla 18, 0,** *target_addr*
bdnz, **bdnza**, **bdnzl**, **bdnzla**	*target_addr*	**bc, bca, bcl, bcla 16, 0,** *target_addr*
bdzlr, **bdzlrl**	None	**bclr, bclrl 18, 0**
bdnzlr, **bdnzlrl**	None	**bclr, bclrl 16, 0**
bt, **bta**, **btl**, **btla**	1) *BI*, *target_addr*	**bc, bca, bcl, bcla 12,** *BI*, *target_addr*
	2) *target_addr*	**12, 0,** *target_addr*
bf, **bfa**, **bfl**, **bfla**	1) *BI*, *target_addr*	**bc, bca, bcl, bcla 4,** *BI, target_addr*
	2) *target_addr*	**4, 0,** *target_addr*
bdzt, **bdzta**, **bdztl**, **bdztla**	1) *BI*, *target_addr*	**bc, bca, bcl, bcla 10,** *BI, target_addr*
	2) *target_addr*	**10, 0,** *target_addr*
bdzf, **bdzfa**, **bdzfl**, **bdzfla**	1) *BI*, *target_addr*	**bc, bca, bcl, bcla 2,** *BI, target_addr*
	2) *target_addr*	**2, 0,** *target_addr*
bdnzt, **bdnzta**, **bdnztl**, **bdnztla**	1) *BI*, *target_addr*	**bc, bca, bcl, bcla 8,** *BI, target_addr*
	2) *target_addr*	**8, 0,** *target_addr*
bdnzf, **bdnzfa**, **bdnzfl**, **bdnzfla**	1) *BI*, *target_addr*	**bc, bca, bcl, bcla 0,** *BI, target_addr*
	2) *target_addr*	**0, 0,** *target_addr*
btlr, btctr, btlrl, btctrl	1) *BI*	**bclr, bcctr, bclrl, bcctrl 12,** *BI*
	2) None	**12, 0**
bflr, **bfctr**, **bflrl**, **bfctrl**	1) *BI*	**bclr, bcctr, bclrl, bcctrl 4,** *BI*
	2) None	**4, 0**
bdztlr, **bdztlrl**	1) *BI*	**bclr, bclrl 10,** *BI*
	2) None	**10, 0**
bdzflr, **bdzflrl**	1) *BI*	**bclr, bclrl 2,** *BI*
	2) None	**2, 0**
bdnztlr, **bdnztlrl**	1) *BI*	**bclr, bclrl 8,** *BI*
	2) None	**8, 0**
bdnzflr, **bdnzflrl**	1) *BI*	**bclr, bclrl 0,** *BI*
	2) None	**0, 0**
blr, **bctr**, **blrl**, **bctrl**	None	**bclr, bcctr, bclrl, bcctrl 20, 0**

Extended Branch Mnemonics That Incorporate the BO Field and a Partial BI Field

When the *BO* field and a partial *BI* field are incorporated, the instruction format is one of the following:

- mnemonic *BIF*, *target_addr*
- mnemonic *target_addr*

where the *BIF* operand specifies the CR field number (0-7) and the *target_addr* operand specifies the target address. If CR0 is used, the *BIF* operand can be omitted.

Based on the bits definition in the CR field, the following set of codes has been defined for the most common combinations of branch conditions:

Branch Code	Meaning
lt	less than *
eq	equal to *
gt	greater than *
so	summary overflow *
le	less than or equal to * (not greater than)
ge	greater than or equal to * (not less than)
ne	not equal to *
ns	not summary overflow *
nl	not less than
ng	not greater than
z	zero
nu	not unordered (after floating-point comparison)
nz	not zero
un	unordered (after floating-point comparison)

The assembler supports six encoding values for the *BO* operand:

- Branch if condition true (*BO*=12):

POWER family	PowerPC
b*xx*	b*xx*
b*xx***a**	b*xx***a**
b*xx***l**	b*xx***l**
b*xx***la**	b*xx***la**
b*xx***r**	b*xx***lr**
b*xx***rl**	b*xx***lrl**
b*xx***c**	b*xx***ctr**
b*xx***cl**	b*xx***ctrl**

  where *xx* specifies a *BI* operand branch code of `lt`, `gt`, `eq`, `so`, `z`, or `un`.

- Branch if condition false (*BO*=04):

POWER family	PowerPC
b*xx*	b*xx*
b*xx***a**	b*xx***a**
b*xx***l**	b*xx***l**
b*xx***la**	b*xx***la**
b*xx***r**	b*xx***lr**
b*xx***rl**	b*xx***lrl**
b*xx***c**	b*xx***ctr**
b*xx***cl**	b*xx***ctrl**

where *xx* specifies a *BI* operand branch code of `ge`, `le`, `ne`, `ns`, `nl`, `ng`, `nz`, or `nu`.

- Decrement CTR, then branch if CTR is nonzero and condition is true (*BO*=08):
  - **bdn***xx*

  where *xx* specifies a *BI* operand branch code of `lt`, `gt`, `eq`, or `so` (marked by an * (asterisk) in the Branch Code list).
- Decrement CTR, then branch if CTR is nonzero and condition is false (*BO*=00):
  - **bdn***xx*

  where *xx* specifies a *BI* operand branch code of `le`, `ge`, `ne`, or `ns` (marked by an * (asterisk) in the Branch Code list).
- Decrement CTR, then branch if CTR is zero and condition is true (*BO*=10):
  - **bdz***xx*

  where *xx* specifies a *BI* operand branch code of `lt`, `gt`, `eq`, or `so` (marked by an * (asterisk) in the Branch Code list).
- Decrement CTR, then branch if CTR is zero and condition is false (*BO*=02):
  - **bdz***xx*

  where *xx* specifies a *BI* operand branch code of `le`, `ge`, `ne`, or `ns` (marked by an * (asterisk) in the Branch Code list).

BI Operand of Branch Conditional Instructions for Basic and Extended Mnemonics

The *BI* operand specifies a bit (0:31) in the Condition Register for condition comparison. The bit is set by a compare instruction. The bits in the Condition Register are grouped into eight 4-bit fields. These fields are named CR field 0 through CR field 7 (CR0...CR7). The bits of each field are interpreted as follows:

Bit	Description
0	Less than; floating-point less than
1	Greater than; floating-point greater than
2	Equal; floating-point equal
3	Summary overflow; floating-point unordered

Normally the symbols shown in the BI Operand Symbols for Basic and Extended Branch Conditional Mnemonics table are defined for use in *BI* operands. The assembler supports expressions for the *BI* operands. The expression is a combination of values and the following symbols.

Table 8. BI Operand Symbols for Basic and Extended Branch Conditional Mnemonics

Symbol	Value	Meaning
lt	0	less than
gt	1	greater than
eq	2	equal
so	3	summary overflow
un	3	unordered (after floating-point comparison)
cr0	0	CR field 0
cr1	1	CR field 1
cr2	2	CR field 2
cr3	3	CR field 3

Table 8. BI Operand Symbols for Basic and Extended Branch Conditional Mnemonics (continued)

Symbol	Value	Meaning
cr4	4	CR field 4
cr5	5	CR field 5
cr6	6	CR field 6
cr7	7	CR field 7

When using an expression for the *BI* field in the basic or extended mnemonics with only the *BO* field incorporated, the CR field number should be multiplied by 4 to get the correct CR bit, since each CR field has four bits.

1. To decrement CTR, then branch only if CTR is not zero and condition in CR5 is equal:

   ```
   bdnzt   4*cr5+eq, target_addr
   ```

   This is equivalent to:

   ```
   bc   8, 22, target_addr
   ```

2. To decrement CTR, then branch only if CTR is not zero and condition in CR0 is equal:

   ```
   bdnzt   eq, target_addr
   ```

   This is equivalent to:

   ```
   bc   8, 2, target_addr
   ```

   If the *BI* operand specifies Bit 0 of CR0, the *BI* operand can be omitted.

3. To decrement CTR, then branch only if CTR is zero:

   ```
   bdz   target_addr
   ```

   This is equivalent to:

   ```
   bc   18, 0, target_addr
   ```

For extended mnemonics with the *BO* field and a partial *BI* field incorporated, the value of the *BI* operand indicates the CR field number. Valid values are 0-7. If a value of 0 is used, the *BI* operand can be omitted.

1. To branch if CR0 reflects a condition of not less than:

   ```
   bge   target_addr
   ```

   This is equivalent to:

   ```
   bc   4, 0, target_addr
   ```

2. To branch to an absolute target if CR4 indicates greater than, and set the Link register:

   ```
   bgtla   cr4, target_addr
   ```

   This is equivalent to:

   ```
   bcla   12, 17, target_addr
   ```

   The *BI* operand CR4 is internally expanded to 16 by the assembler. After the gt (greater than) is incorporated, the result of the *BI* field is 17.

Extended Mnemonics for Branch Prediction

If the likely outcome (branch or fall through) of a given Branch Conditional instruction is known, the programmer can include this information in the assembler source program by adding a branch prediction suffix to the mnemonic of the instruction. The assembler uses the branch prediction information to determine the value of a bit in the machine instruction. Using a branch prediction suffix may improve the average performance of a Branch Conditional instruction.

The following suffixes can be added to any Branch Conditional mnemonic, either basic or extended:

+ Predict branch to be taken
- Predict branch not to be taken (fall through)

The branch prediction suffix should be placed immediately after the rest of the mnemonic (with no separator character). A separator character (space or tab) should be used between the branch prediction suffix and the operands.

If no branch prediction suffix is included in the mnemonic, the assembler uses the following default assumptions in constructing the machine instruction:

- For relative or absolute branches (**bc**[**l**][**a**]) with negative displacement fields, the branch is predicted to be taken.
- For relative or absolute branches (**bc**[**l**][**a**]) with nonnegative displacement fields, the branch is predicted not to be taken (fall through predicted).
- For branches to an address in the LR or CTR (**bclr**[**l**]) or (**bcctr**[**l**]), the branch is predicted not to be taken (fall through predicted).

The portion of the machine instruction which is controlled by the branch prediction suffix is the *y* bit of the *BO* field. The *y* bit is set as follows:

- Specifying no branch prediction suffix, or using the suffix which is the same as the default assumption causes the *y* bit to be set to 0.
- Specifying a branch prediction suffix which is the opposite of the default assumption causes the *y* bit to be set to 1.

The following examples illustrate use of branch prediction suffixes:

1. Branch if CR0 reflects condition less than. Executing the instruction will usually result in branching.

   ```
   blt+  target
   ```

2. Branch if CR0 reflects condition less than. Target address is in the Link Register. Executing the instruction will usually result in falling through to the next instruction.

   ```
   bltlr-
   ```

The following is a list of the Branch Prediction instructions that are supported by the AIX assembler:

```
bc+             bc-             bca+            bca-
bcctr+          bcctr-          bcctrl+         bcctrl-
bcl+            bcl-            bcla+           bcla-
bclr+           bclr-           bclrl+          bclrl-
bdneq+          bdneq-          bdnge+          bdnge-
bdngt+          bdngt-          bdnle+          bdnle-
bdnlt+          bdnlt-          bdnne+          bdnne-
bdnns+          bdnns-          bdnso+          bdnso-
bdnz+           bdnz-           bdnza+          bdnza-
bdnzf+          bdnzf-          bdnzfa+         bdnzfa-
bdnzfl+         bdnzfl-         bdnzfla+        bdnzfla-
bdnzflr+        bdnzflr-        bdnzflrl+       bdnzflrl-
bdnzl+          bdnzl-          bdnzla+         bdnzla-
bdnzlr+         bdnzlr-         bdnzlrl+        bdnzlrl-
bdnzt+          bdnzt-          bdnzta+         bdnzta-
bdnztl+         bdnztl-         bdnztla+        bdnztla-
bdnztlr+        bdnztlr-        bdnztlrl+       bdnztlrl-
bdz+            bdz-            bdza+           bdza-
bdzeq+          bdzeq-          bdzf+           bdzf-
bdzfa+          bdzfa-          bdzfl+          bdzfl-
bdzfla+         bdzfla-         bdzflr+         bdzflr-
bdzflrl+        bdzflrl-        bdzge+          bdzge-
bdzgt+          bdzgt-          bdzl+           bdzl-
bdzla+          bdzla-          bdzle+          bdzle-
```

```
bdzlr+          bdzlr-          bdzlrl+         bdzlrl-
bdzlt+          bdzlt-          bdzne+          bdzne-
bdzns+          bdzns-          bdzso+          bdzso-
bdzt+           bdzt-           bdzta+          bdzta-
bdztl+          bdztl-          bdztla+         bdztla-
bdztlr+         bdztlr-         bdztlrl+        bdztlrl-
beq+            beq-            beqa+           beqa-
beqctr+         beqctr-         beqctrl+        beqctrl-
beql+           beql-           beqla+          beqla-
beqlr+          beqlr-          beqlrl+         beqlrl-
bf+             bf-             bfa+            bfa-
bfctr+          bfctr-          bfctrl+         bfctrl-
bfl+            bfl-            bfla+           bfla-
bflr+           bflr-           bflrl+          bflrl-
bge+            bge-            bgea+           bgea-
bgectr+         bgectr-         bgectrl+        bgectrl-
bgel+           bgel-           bgela+          bgela-
bgelr+          bgelr-          bgelrl+         bgelrl-
bgt+            bgt-            bgta+           bgta-
bgtctr+         bgtctr-         bgtctrl+        bgtctrl-
bgtl+           bgtl-           bgtla+          bgtla-
bgtlr+          bgtlr-          bgtlrl+         bgtlrl-
ble+            ble-            blea+           blea-
blectr+         blectr-         blectrl+        blectrl-
blel+           blel-           blela+          blela-
blelr+          blelr-          blelrl+         blelrl-
blt+            blt-            blta+           blta-
bltctr+         bltctr-         bltctrl+        bltctrl-
bltl+           bltl-           bltla+          bltla-
bltlr+          bltlr-          bltlrl+         bltlrl-
bne+            bne-            bnea+           bnea-
bnectr+         bnectr-         bnectrl+        bnectrl-
bnel+           bnel-           bnela+          bnela-
bnelr+          bnelr-          bnelrl+         bnelrl-
bng+            bng-            bnga+           bnga-
bngctr+         bngctr-         bngctrl+        bngctrl-
bngl+           bngl-           bngla+          bngla-
bnglr+          bnglr-          bnglrl+         bnglrl-
bnl+            bnl-            bnla+           bnla-
bnlctr+         bnlctr-         bnlctrl+        bnlctrl-
bnll+           bnll-           bnlla+          bnlla-
bnllr+          bnllr-          bnllrl+         bnllrl-
bns+            bns-            bnsa+           bnsa-
bnsctr+         bnsctr-         bnsctrl+        bnsctrl-
bnsl+           bnsl-           bnsla+          bnsla-
bnslr+          bnslr-          bnslrl+         bnslrl-
bnu+            bnu-            bnua+           bnua-
bnuctr+         bnuctr-         bnuctrl+        bnuctrl-
bnul+           bnul-           bnula+          bnula-
bnulr+          bnulr-          bnulrl+         bnulrl-
bnz+            bnz-            bnza+           bnza-
bnzctr+         bnzctr-         bnzctrl+        bnzctrl-
bnzl+           bnzl-           bnzla+          bnzla-
bnzlr+          bnzlr-          bnzlrl+         bnzlrl-
bso+            bso-            bsoa+           bsoa-
bsoctr+         bsoctr-         bsoctrl+        bsoctrl-
bsol+           bsol-           bsola+          bsola-
bsolr+          bsolr-          bsolrl+         bsolrl-
bt+             bt-             bta+            bta-
btctr+          btctr-          btctrl+         btctrl-
btl+            btl-            btla+           btla-
btlr+           btlr-           btlrl+          btlrl-
bun+            bun-            buna+           buna-
bunctr+         bunctr-         bunctrl+        bunctrl-
bunl+           bunl-           bunla+          bunla-
bunlr+          bunlr-          bunlrl+         bunlrl-
bz+             bz-             bza+            bza-
```

```
bzctr+          bzctr-          bzctrl+         bzctrl-
bzl+            bzl-            bzla+           bzla-
bzlr+           bzlr-           bzlrl+          bzlrl-
```

Related Information

Chapter 6, “Extended Instruction Mnemonics” on page 87.

“Extended Mnemonics of Condition Register Logical Instructions”.

“Extended Mnemonics of Fixed-Point Arithmetic Instructions” on page 95.

“Extended Mnemonics of Fixed-Point Compare Instructions” on page 96.

“Extended Mnemonics of Fixed-Point Load Instructions” on page 97.

“Extended Mnemonics of Fixed-Point Logical Instructions” on page 98.

“Extended Mnemonics of Fixed-Point Trap Instructions” on page 98.

“Extended Mnemonics of Moving from or to Special-Purpose Registers” on page 100.

“Extended Mnemonics of 32-bit Fixed-Point Rotate and Shift Instructions” on page 105.

“bc (Branch Conditional) Instruction” on page 142, “bclr or bcr (Branch Conditional Link Register) Instruction” on page 147, “bcctr or bcc (Branch Conditional to Count Register) Instruction” on page 145.

Extended Mnemonics of Condition Register Logical Instructions

Extended mnemonics of condition register logical instructions are available in POWER family and PowerPC. These extended mnemonics are in the **com** assembly mode. Condition register logical instructions can be used to perform the following operations on a given condition register bit.

- Set bit to 1.
- Clear bit to 0.
- Copy bit.
- Invert bit.

The extended mnemonics shown in the following table allow these operations to be easily coded.

Table 9. Condition Register Logical Instruction Extended Mnemonics

Extended Mnemonic	Equivalent to	Meaning
crset *bx*	**creqv** *bx*, *bx*, *bx*	Condition register set
crclr *bx*	**crxor** *bx*, *bx*, *bx*	Condition register clear
crmove *bx*, *by*	**cror** *bx*, *by*, *by*	Condition register move
crnot *bx*, *by*	**crnor** *bx*, *by*, *by*	Condition register NOT

Since the condition register logical instructions perform the operation on the condition register bit, the assembler supports expressions in all input operands. When using a symbol name to indicate a condition register (CR) field, the symbol name should be multiplied by four to get the correct CR bit, because each CR field has four bits.

Examples

1. To clear the SO bit (bit 3) of CR0:

   ```
   crclr   so
   ```

   This is equivalent to:

   ```
   crxor 3, 3, 3
   ```

2. To clear the EQ bit of CR3:

   ```
   crclr   4*cr3+eq
   ```

   This is equivalent to:

   ```
   crxor   14, 14, 14
   ```

3. To invert the EQ bit of CR4 and place the result in the SO bit of CR5:

   ```
   crnot   4*cr5+so, 4*cr4+eq
   ```

   This is equivalent to:

   ```
   crnor   23, 18, 18
   ```

Related Information

Chapter 6, “Extended Instruction Mnemonics” on page 87.

“Extended Mnemonics of Branch Instructions” on page 87.

“Extended Mnemonics of Fixed-Point Arithmetic Instructions”.

“Extended Mnemonics of Fixed-Point Compare Instructions” on page 96.

“Extended Mnemonics of Fixed-Point Load Instructions” on page 97.

“Extended Mnemonics of Fixed-Point Logical Instructions” on page 98.

“Extended Mnemonics of Fixed-Point Trap Instructions” on page 98.

“Extended Mnemonics of Moving from or to Special-Purpose Registers” on page 100.

“Extended Mnemonics of 32-bit Fixed-Point Rotate and Shift Instructions” on page 105.

“creqv (Condition Register Equivalent) Instruction” on page 163, “cror (Condition Register OR) Instruction” on page 166, “crnor (Condition Register NOR) Instruction” on page 165, “crxor (Condition Register XOR) Instruction” on page 168.

Extended Mnemonics of Fixed-Point Arithmetic Instructions

The following table shows the extended mnemonics for fixed-point arithmetic instructions for POWER family and PowerPC. Except as noted, these extended mnemonics are for POWER family and PowerPC and are in the **com** assembly mode.

Table 10. Fixed-Point Arithmetic Instruction Extended Mnemonics

Extended Mnemonic	Equivalent to	Meaning
subi *rx, ry, value*	**addi** *rx, ry, -value*	**Subtract Immediate**
subis *rx, ry, value*	**addis** *rx, ry, -value*	**Subtract Immediate Shifted**
subic[.] *rx, ry, value*	**addic[.]** *rx, ry, -value*	**Subtract Immediate**
subc[o][.] *rx, ry, rz*	**subfc[o][.]** *rx, ry, rz*	**Subtract From Carrying**

Table 10. Fixed-Point Arithmetic Instruction Extended Mnemonics (continued)

Extended Mnemonic	Equivalent to	Meaning
si[.] *rt, ra, value*	**ai[.]** *rt, ra, -value*	**Subtract Immediate**
sub[o][.] *rx, ry, rz*	**subf[o][.]** *rx, ry, rz*	**Subtract From**

Note: The **sub**[**o**][**.**] extended mnemonic is for PowerPC, since its base mnemonic **subf**[**o**][**.**] is for PowerPC only.

Related Information

Chapter 6, “Extended Instruction Mnemonics” on page 87.

“Extended Mnemonics of Branch Instructions” on page 87.

“Extended Mnemonics of Condition Register Logical Instructions” on page 94.

“Extended Mnemonics of Fixed-Point Compare Instructions”.

“Extended Mnemonics of Fixed-Point Load Instructions” on page 97.

“Extended Mnemonics of Fixed-Point Logical Instructions” on page 98.

“Extended Mnemonics of Fixed-Point Trap Instructions” on page 98.

“Extended Mnemonics of Moving from or to Special-Purpose Registers” on page 100.

“Extended Mnemonics of 32-bit Fixed-Point Rotate and Shift Instructions” on page 105.

“addic or ai (Add Immediate Carrying) Instruction” on page 129, “addic. or ai. (Add Immediate Carrying and Record) Instruction” on page 130.

Extended Mnemonics of Fixed-Point Compare Instructions

The extended mnemonics for fixed-point compare instructions are shown in the following table. The input format of operands are different for POWER family and PowerPC. The L field for PowerPC supports 64-bit implementations. This field must have a value of 0 for 32-bit implementations. Since the POWER family architecture supports only 32-bit implementations, this field does not exist in POWER family. The assembler ensures that this bit is set to 0 for POWER family implementations. These extended mnemonics are in the **com** assembly mode.

Table 11. Fixed-Point Compare Instruction Extended Mnemonics

Extended Mnemonic	Equivalent to	Meaning
cmpdi *ra, value*	**cmpi 0, 1**, *ra, value*	**Compare Word Immediate**
cmpwi *bf, ra, si*	**cmpi** *bf,* **0**, *ra, si*	**Compare Word Immediate**
cmpd *ra, rb*	**cmp 0, 1,** *ra, rb*	**Compare Word**
cmpw *bf, ra, rb*	**cmp** *bf,* **0**, *ra, rb*	**Compare Word**
cmpldi *rA, value*	**cmpli 0, 1**, *ra, value*	**Compare Logical Word Immediate**
cmplwi *bf, ra, ui*	**cmpli** *bf,* **0**, *ra, ui*	**Compare Logical Word Immediate**
cmpld *ra, rb*	**cmpl 0, 1**, *ra, rb*	**Compare Logical Word**
cmplw *bf, ra, rb*	**cmpl** *bf,* **0**, *ra, rb*	**Compare Logical Word**

Related Information

Chapter 6, “Extended Instruction Mnemonics” on page 87.

“Extended Mnemonics of Branch Instructions” on page 87.

“Extended Mnemonics of Condition Register Logical Instructions” on page 94.

“Extended Mnemonics of Fixed-Point Arithmetic Instructions” on page 95.

“Extended Mnemonics of Fixed-Point Load Instructions”.

“Extended Mnemonics of Fixed-Point Logical Instructions” on page 98.

“Extended Mnemonics of Fixed-Point Trap Instructions” on page 98.

“Extended Mnemonics of Moving from or to Special-Purpose Registers” on page 100.

“Extended Mnemonics of 32-bit Fixed-Point Rotate and Shift Instructions” on page 105.

“cmpi (Compare Immediate) Instruction” on page 155, “cmp (Compare) Instruction” on page 154, “cmpli (Compare Logical Immediate) Instruction” on page 158, “cmpl (Compare Logical) Instruction” on page 157.

Extended Mnemonics of Fixed-Point Load Instructions

The following table shows the extended mnemonics for fixed-point load instructions for POWER family and PowerPC. These extended mnemonics are in the **com** assembly mode.

Table 12. Fixed-Point Load Instruction Extended Mnemonics

Extended Mnemonic	Equivalent to	Meaning
li *rx, value*	**addi** *rx*, 0, *value*	**Load Immediate**
la *rx, disp*(*ry*)	**addi** *rx, ry, disp*	**Load Address**
lil *rt, value*	**cal** *rt, value*(0)	**Load Immediate Lower**
liu *rt, value*	**cau** *rt*, 0, *value*	**Load Immediate Upper**
lis *rx, value*	**addis** *rx*, 0, *value*	**Load Immediate Shifted**

Related Information

Chapter 6, “Extended Instruction Mnemonics” on page 87.

“Extended Mnemonics of Branch Instructions” on page 87.

“Extended Mnemonics of Condition Register Logical Instructions” on page 94.

“Extended Mnemonics of Fixed-Point Arithmetic Instructions” on page 95.

“Extended Mnemonics of Fixed-Point Compare Instructions” on page 96.

“Extended Mnemonics of Fixed-Point Logical Instructions” on page 98.

“Extended Mnemonics of Fixed-Point Trap Instructions” on page 98.

“Extended Mnemonics of Moving from or to Special-Purpose Registers” on page 100.

“Extended Mnemonics of 32-bit Fixed-Point Rotate and Shift Instructions” on page 105.

“addi (Add Immediate) or cal (Compute Address Lower) Instruction” on page 128, “addis or cau (Add Immediate Shifted) Instruction” on page 131.

Extended Mnemonics of Fixed-Point Logical Instructions

The extended mnemonics for fixed-point logical instructions are shown in the following table. These POWER family and PowerPC extended mnemonics are in the **com** assembly mode.

Table 13. Fixed-Point Logical Instruction Extended Mnemonics

Extended Mnemonic	Equivalent to	Meaning
nop	**ori 0, 0, 0**	**OR Immediate**
mr[.] *rx,ry*	**or[.]** *rx, ry, ry*	**OR**
not[.] *rx,ry*	**nor[.]** *rx, ry, ry*	**NOR**

Related Information

Chapter 6, “Extended Instruction Mnemonics” on page 87.

“Extended Mnemonics of Branch Instructions” on page 87.

“Extended Mnemonics of Condition Register Logical Instructions” on page 94.

“Extended Mnemonics of Fixed-Point Arithmetic Instructions” on page 95.

“Extended Mnemonics of Fixed-Point Compare Instructions” on page 96.

“Extended Mnemonics of Fixed-Point Load Instructions” on page 97.

“Extended Mnemonics of Fixed-Point Trap Instructions”.

“Extended Mnemonics of Moving from or to Special-Purpose Registers” on page 100.

“Extended Mnemonics of 32-bit Fixed-Point Rotate and Shift Instructions” on page 105.

“nor (NOR) Instruction” on page 330, “or (OR) Instruction” on page 331, “ori or oril (OR Immediate) Instruction” on page 333.

Extended Mnemonics of Fixed-Point Trap Instructions

The extended mnemonics for fixed-point trap instructions incorporate the most useful TO operand values. A standard set of codes, shown in the following table, has been adopted for the most common combinations of trap conditions. These extended mnemonics are in the **com** assembly mode.

Table 14. Fixed-Point Trap Instruction Codes

Code	TO Encoding	Meaning
lt	**10000**	less than
le	**10100**	less than or equal
ng	**10100**	not greater than
eq	**00100**	equal
ge	**01100**	greater than or equal

Table 14. Fixed-Point Trap Instruction Codes (continued)

Code	TO Encoding	Meaning
nl	**01100**	not less than
gt	**01000**	greater than
ne	**11000**	not equal
llt	**00010**	logically less than
lle	**00110**	logically less than or equal
lng	**00110**	logically not greater than
lge	**00101**	logically greater than or equal
lnl	**00101**	logically not less than
lgt	**00001**	logically greater than
lne	**00011**	logically not equal
None	**11111**	Unconditional

The POWER family extended mnemonics for fixed-point trap instructions have the following format:

- **t***xx* or **t***xx***i**

where *xx* is one of the codes specified in the preceding table.

The 64-bit PowerPC extended mnemonics for double-word, fixed-point trap instructions have the following format:

- **td***xx* or **td***xx***i**

The PowerPC extended mnemonics for fixed-point trap instructions have the following formats:

- **tw***xx* or **tw***xx***i**

where *xx* is one of the codes specified in the preceding table.

The **trap** instruction is an unconditional trap:

- **trap**

Examples

1. To trap if R10 is less than R20:

   ```
   tlt   10, 20
   ```

   This is equivalent to:

   ```
   t   16, 10, 20
   ```

2. To trap if R4 is equal to 0x10:

   ```
   teqi   4, 0x10
   ```

   This is equivalent to:

   ```
   ti   0x4, 4, 0x10
   ```

3. To trap unconditionally:

   ```
   trap
   ```

   This is equivalent to:

   ```
   tw   31, 0, 0
   ```

4. To trap if R*X* is not equal to R*Y:*

```
twnei   RX. RY
```

This is equivalent to:

```
twi   24, RX, RY
```

5. To trap if R*X* is logically greater than 0x7FF:

```
twlgti   RX, 0x7FF
```

This is equivalent to:

```
twi   1, RX, 0x7FF
```

Related Information

Chapter 6, “Extended Instruction Mnemonics” on page 87.

“Extended Mnemonics of Branch Instructions” on page 87.

“Extended Mnemonics of Condition Register Logical Instructions” on page 94.

“Extended Mnemonics of Fixed-Point Arithmetic Instructions” on page 95.

“Extended Mnemonics of Fixed-Point Compare Instructions” on page 96.

“Extended Mnemonics of Fixed-Point Load Instructions” on page 97.

“Extended Mnemonics of Fixed-Point Logical Instructions” on page 98.

“Extended Mnemonics of Moving from or to Special-Purpose Registers”.

“Extended Mnemonics of 32-bit Fixed-Point Rotate and Shift Instructions” on page 105.

“tw or t (Trap Word) Instruction” on page 453, “twi or ti (Trap Word Immediate) Instruction” on page 454.

Extended Mnemonic mtcr for Moving to the Condition Register

The **mtcr** (Move to Condition Register) extended mnemonic copies the contents of the low order 32 bits of a general purpose register (GPR) to the condition register using the same style as the **mfcr** instruction.

The extended mnemonic **mtcr** *Rx* is equivalent to the instruction **mtcrf** `0xFF`,*Rx*.

This extended mnemonic is in the **com** assembly mode.

Extended Mnemonics of Moving from or to Special-Purpose Registers

This article discusses the following extended mnemonics:

- “mfspr Extended Mnemonics for POWER family” on page 101
- “mtspr Extended Mnemonics for POWER family” on page 101
- “mfspr Extended Mnemonics for PowerPC” on page 101
- “mtspr Extended Mnemonics for PowerPC” on page 102
- “mfspr Extended Mnemonics for PowerPC 601 RISC Microprocessor” on page 104
- “mtspr Extended Mnemonics for PowerPC 601 RISC Microprocessor” on page 104

mfspr Extended Mnemonics for POWER family

Table 15. mfspr Extended Mnemonics for POWER family

Extended Mnemonic	Equivalent to	Privileged	SPR Name
mfxer *rt*	**mfspr** *rt*,**1**	no	XER
mflr *rt*	**mfspr** *rt*,**8**	no	LR
mfctr *rt*	**mfspr** *rt*,**9**	no	CTR
mfmq *rt*	**mfspr** *rt*,**0**	no	MQ
mfrtcu *rt*	**mfspr** *rt*,**4**	no	RTCU
mfrtcl *rt*	**mfspr** *rt*,**5**	no	RTCL
mfdec *rt*	**mfspr** *rt*,**6**	no	DEC
mftid *rt*	**mfspr** *rt*,**17**	yes	TID
mfdsisr *rt*	**mfspr** *rt*,**18**	yes	DSISR
mfdar *rt*	**mfspr** *rt*,**19**	yes	DAR
mfsdr0 *rt*	**mfspr** *rt*,**24**	yes	SDR0
mfsdr1 *rt*	**mfspr** *rt*,**25**	yes	SDR1
mfsrr0 *rt*	**mfspr** *rt*,**26**	yes	SRR0
mfsrr1 *rt*	**mfspr** *rt*,**27**	yes	SRR1

mtspr Extended Mnemonics for POWER family

Table 16. mtspr Extended Mnemonics for POWER family

Extended Mnemonic	Equivalent to	Privileged	SPR Name
mfxer *rs*	**mtspr 1,***rs*	no	XER
mflr *rs*	**mtspr 8,***rs*	no	LR
mtctr *rs*	**mtspr 9,***rs*	no	CTR
mtmq *rs*	**mtspr 0,***rs*	no	MQ
mtrtcu *rs*	**mtspr 20,***rs*	yes	RTCU
mtrtcl *rs*	**mtspr 21,***rs*	yes	RTCL
mtdec *rs*	**mtspr 22,***rs*	yes	DEC
mttid *rs*	**mtspr 17,***rs*	yes	TID
mtdsisr *rs*	**mtspr 18,***rs*	yes	DSISR
mtdar *rs*	**mtspr 19,***rs*	yes	DAR
mtsdr0 *rs*	**mtspr 24,***rs*	yes	SDR0
mtsdr1 *rs*	**mtspr 25,***rs*	yes	SDR1
mtsrr0 *rs*	**mtspr 26,***rs*	yes	SRR0
mtsrr1 *rs*	**mtspr 27,***rs*	yes	SRR1

mfspr Extended Mnemonics for PowerPC

Table 17. mfspr Extended Mnemonics for PowerPC

Extended Mnemonic	Equivalent to	Privileged	SPR Name
mfxer *rt*	**mfspr** *rt*,**1**	no	XER

Table 17. mfspr Extended Mnemonics for PowerPC (continued)

Extended Mnemonic	Equivalent to	Privileged	SPR Name
mflr *rt*	**mfspr** *rt*,**8**	no	LR
mfctr *rt*	**mfspr** *rt*,**9**	no	CTR
mfdsisr *rt*	**mfspr** *rt*,**18**	yes	DSISR
mfdar *rt*	**mfspr** *rt*,**19**	yes	DAR
mfdec *rt*	**mfspr** *rt*,**22**	yes	DEC
mfsdr1 *rt*	**mfspr** *rt*,**25**	yes	SDR1
mfsrr0 *rt*	**mfspr** *rt*,**26**	yes	SRR0
mfsrr1 *rt*	**mfspr** *rt*,**27**	yes	SRR1
mfsprg *rt*,**0**	**mfspr** *rt*,**272**	yes	SPRG0
mfsprg *rt*,**1**	**mfspr** *rt*,**273**	yes	SPRG1
mfsprg *rt*,**2**	**mfspr** *rt*,**274**	yes	SPRG2
mfsprg *rt*,**3**	**mfspr** *rt*,**275**	yes	SPRG3
mfear *rt*	**mfspr** *rt*,**282**	yes	EAR
mfpvr *rt*	**mfspr** *rt*,**287**	yes	PVR
mfibatu *rt*,**0**	**mfspr** *rt*,**528**	yes	IBAT0U
mfibatl *rt*,**1**	**mfspr** *rt*,**529**	yes	IBAT0L
mfibatu *rt*,**1**	**mfspr** *rt*,**530**	yes	IBAT1U
mfibatl *rt*,**1**	**mfspr** *rt*,**531**	yes	IBAT1L
mfibatu *rt*,**2**	**mfspr** *rt*,**532**	yes	IBAT2U
mfibatl *rt*,**2**	**mfspr** *rt*,**533**	yes	IBAT2L
mfibatu *rt*,**3**	**mfspr** *rt*,**534**	yes	IBAT3U
mfibatl *rt*,**3**	**mfspr** *rt*,**535**	yes	IBAT3L
mfdbatu *rt*,**0**	**mfspr** *rt*,**536**	yes	DBAT0U
mfdbatl *rt*,**0**	**mfspr** *rt*,**537**	yes	DBAT0L
mfdbatu *rt*,**1**	**mfspr** *rt*,**538**	yes	DBAT1U
mfdbatl *rt*,**1**	**mfspr** *rt*,**539**	yes	DBAT1L
mfdbatu *rt*,**2**	**mfspr** *rt*,**540**	yes	DBAT2U
mfdbatl *rt*,**2**	**mfspr** *rt*,**541**	yes	DBAT2L
mfdbatu *rt*,**3**	**mfspr** *rt*,**542**	yes	DBAT3U
mfdbatl *rt*,**3**	**mfspr** *rt*,**543**	yes	DBAT3L

Note: The **mfdec** instruction is a privileged instruction in PowerPC. The encoding for this instruction in PowerPC differs from that in POWER family. See the “mfspr (Move from Special-Purpose Register) Instruction” on page 300 for information on this instruction. “Differences between POWER family and PowerPC Instructions with the Same Op Code” on page 113 provides a summary of the differences for this instruction for POWER family and PowerPC.

mtspr Extended Mnemonics for PowerPC

Table 18. mtspr Extended Mnemonics for PowerPC

Extended Mnemonic	Equivalent to	Privileged	SPR Name
mtxer *rs*	**mtspr 1,***rs*	**no**	**XER**

Table 18. mtspr Extended Mnemonics for PowerPC (continued)

Extended Mnemonic	Equivalent to	Privileged	SPR Name
mtlr *rs*	**mtspr 8,***rs*	**no**	**LR**
mtctr *rs*	**mtspr 9,***rs*	**no**	**CTR**
mtdsisr *rs*	**mtspr 19,***rs*	**yes**	**DSISR**
mtdar *rs*	**mtspr 19,***rs*	**yes**	**DAR**
mtdec *rs*	**mtspr 22,***rs*	**yes**	**DEC**
mtsdr1 *rs*	**mtspr 25,***rs*	**yes**	**SDR1**
mtsrr0 *rs*	**mtspr 26,***rs*	**yes**	**SRR0**
mtsrr1 *rs*	**mtspr 27,***rs*	**yes**	**SRR1**
mtsprg 0,*rs*	**mtspr 272,***rs*	**yes**	**SPRG0**
mtsprg 1,*rs*	**mtspr 273,***rs*	**yes**	**SPRG1**
mtsprg 2,*rs*	**mtspr 274,***rs*	**yes**	**SPRG2**
mtsprg 3,*rs*	**mtspr 275,***rs*	**yes**	**SPRG3**
mtear *rs*	**mtspr 282,***rs*	**yes**	**EAR**
mttbl *rs* (or mttb *rs*)	**mtspr 284,***rs*	**yes**	**TBL**
mttbu *rs*	**mtspr 285,***rs*	**yes**	**TBU**
mtibatu 0,*rs*	**mtspr 528,***rs*	**yes**	**IBAT0U**
mtibatl 0,*rs*	**mtspr 529,***rs*	**yes**	**IBAT0L**
mtibatu 1,*rs*	**mtspr 530,***rs*	**yes**	**IBAT1U**
mtibatl 1,*rs*	**mtspr 531,***rs*	**yes**	**IBAT1L**
mtibatu 2,*rs*	**mtspr 532,***rs*	**yes**	**IBAT2U**
mtibatl 2,*rs*	**mtspr 533,***rs*	**yes**	**IBAT2L**
mtibatu 3,*rs*	**mtspr 534,***rs*	**yes**	**IBAT3U**
mtibatl 3,*rs*	**mtspr 535,***rs*	**yes**	**IBAT3L**
mtdbatu 0,*rs*	**mtspr 536,***rs*	**yes**	**DBAT0U**
mtdbatl 0,*rs*	**mtspr 537,***rs*	**yes**	**DBAT0L**
mtdbatu 1,*rs*	**mtspr 538,***rs*	**yes**	**DBAT1U**
mtdbatl 1,*rs*	**mtspr 539,***rs*	**yes**	**DBAT1L**
mtdbatu 2,*rs*	**mtspr 540,***rs*	**yes**	**DBAT2U**
mtdbatl 2,*rs*	**mtspr 541,***rs*	**yes**	**DBAT2L**
mtdbatu 3,*rs*	**mtspr 542,***rs*	**yes**	**DBAT3U**
mtdbatl 3,*rs*	**mtspr 543,***rs*	**yes**	**DBAT3L**

Note: The **mfdec** instruction is a privileged instruction in PowerPC. The encoding for this instruction in PowerPC differs from that in POWER family. See the “mfspr (Move from Special-Purpose Register) Instruction” on page 300 for information on this instruction. “Differences between POWER family and PowerPC Instructions with the Same Op Code” on page 113 provides a summary of the differences for this instruction for POWER family and PowerPC.

mfspr Extended Mnemonics for PowerPC 601 RISC Microprocessor

Table 19. mfspr Extended Mnemonics for PowerPC 601 RISC Microprocessor

Extended Mnemonic	Equivalent to	Privileged	SPR Name
mfmq *rt*	**mfspr** *rt*,0	**no**	**MQ**
mfxer *rt*	**mfspr** *rt*,1	**no**	**XER**
mfrtcu *rt*	**mfspr** *rt*,4	**no**	**RTCU**
mfrtcl *rt*	**mfspr** *rt*,5	**no**	**RTCL**
mfdec *rt*	**mfspr** *rt*,6	**no**	**DEC**
mflr *rt*	**mfspr** *rt*,8	**no**	**LR**
mfctr *rt*	**mfspr** *rt*,9	**no**	**CTR**
mfdsisr *rt*	**mfspr** *rt*,18	**yes**	**DSISR**
mfdar *rt*	**mfspr** *rt*,19	**yes**	**DAR**
mfsdr1 *rt*	**mfspr** *rt*,25	**yes**	**SDR1**
mfsrr0 *rt*	**mfspr** *rt*,26	**yes**	**SRR0**
mfsrr1 *rt*	**mfspr** *rt*,27	**yes**	**SRR1**
mfsprg *rt*,0	**mfspr** *rt*,272	**yes**	**SPRG0**
mfsprg *rt*,1	**mfspr** *rt*,273	**yes**	**SPRG1**
mfsprg *rt*,2	**mfspr** *rt*,274	**yes**	**SPRG2**
mfsprg *rt*,3	**mfspr** *rt*,275	**yes**	**SPRG3**
mfear *rt*	**mfspr** *rt*,282	**yes**	**EAR**
mfpvr *rt*	**mfspr** *rt*,287	**yes**	**PVR**

mtspr Extended Mnemonics for PowerPC 601 RISC Microprocessor

Table 20. mtspr Extended Mnemonics for PowerPC 601 RISC Microprocessor

Extended Mnemonic	Equivalent to	Privileged	SPR Name
mtmq *rs*	**mtspr 0,***rs*	**no**	**MQ**
mtxer *rs*	**mtspr 1,***rs*	**no**	**XER**
mtlr *rs*	**mtspr 8,***rs*	**no**	**LR**
mtctr *rs*	**mtspr 9,***rs*	**no**	**CTR**
mtdsisr *rs*	**mtspr 18,***rs*	**yes**	**DSISR**
mtdar *rs*	**mtspr 19,***rs*	**yes**	**DAR**
mtrtcu *rs*	**mtspr 20,***rs*	**yes**	**RTCU**
mtrtcl *rs*	**mtspr 21,***rs*	**yes**	**RTCL**
mtdec *rs*	**mtspr 22,***rs*	**yes**	**DEC**
mtsdr1 *rs*	**mtspr 25,***rs*	**yes**	**SDR1**
mtsrr0 *rs*	**mtspr 26,***rs*	**yes**	**SRR0**
mtsrr1 *rs*	**mtspr 27,***rs*	**yes**	**SRR1**
mtsprg 0,*rs*	**mtspr 272,***rs*	**yes**	**SPRG0**
mtsprg 1,*rs*	**mtspr 273,***rs*	**yes**	**SPRG1**
mtsprg 2,*rs*	**mtspr 274,***rs*	**yes**	**SPRG2**
mtsprg 3,*rs*	**mtspr 275,***rs*	**yes**	**SPRG3**

Table 20. mtspr Extended Mnemonics for PowerPC 601 RISC Microprocessor (continued)

Extended Mnemonic	Equivalent to	Privileged	SPR Name
mtear *rs*	**mtspr 282,***rs*	**yes**	**EAR**

Related Information

Chapter 6, “Extended Instruction Mnemonics” on page 87.

“Extended Mnemonics of Branch Instructions” on page 87.

“Extended Mnemonics of Condition Register Logical Instructions” on page 94.

“Extended Mnemonics of Fixed-Point Arithmetic Instructions” on page 95.

“Extended Mnemonics of Fixed-Point Compare Instructions” on page 96.

“Extended Mnemonics of Fixed-Point Load Instructions” on page 97.

“Extended Mnemonics of Fixed-Point Logical Instructions” on page 98.

“Extended Mnemonics of Fixed-Point Trap Instructions” on page 98.

“Extended Mnemonics of 32-bit Fixed-Point Rotate and Shift Instructions”.

“mfspr (Move from Special-Purpose Register) Instruction” on page 300, “mtspr (Move to Special-Purpose Register) Instruction” on page 312.

Extended Mnemonics of 32-bit Fixed-Point Rotate and Shift Instructions

A set of extended mnemonics are provided for extract, insert, rotate, shift, clear, and clear left and shift left operations. This article discusses the following:

- “Alternative Input Format”
- “32-bit Rotate and Shift Extended Mnemonics for POWER family and PowerPC” on page 106

Alternative Input Format

The alternative input format is applied to the following POWER family and PowerPC instructions.

POWER family	PowerPC
rlimi[**.**]	rlwimi[**.**]
rlinm[**.**]	rlwinm[**.**]
rlnm[**.**]	rlwnm[**.**]
rlmi[**.**]	Not applicable

Five operands are normally required for these instructions. These operands are:

RA, *RS*, *SH*, *MB*, *ME*

MB indicates the first bit with a value of 1 in the mask, and *ME* indicates the last bit with a value of 1 in the mask. The assembler supports the following operand format.

RA, *RS*, *SH*, *BM*

BM is the mask itself. The assembler generates the *MB* and *ME* operands from the *BM* operand for the instructions. The assembler checks the *BM* operand first. If an invalid *BM* is entered, error 78 is reported.

A valid mask is defined as a single series (one or more) of bits with a value of 1 surrounded by zero or more bits with a value of z0. A mask of all bits with a value of 0 may not be specified.

Examples of Valid 32-bit Masks

The following shows examples of valid 32-bit masks.

```
                          0             15              31
                          |              |               |
------------------------------------------------------------
MB = 0       ME = 31      11111111111111111111111111111111
MB = 0       ME = 0       10000000000000000000000000000000
MB = 0       ME = 22      11111111111111111111110000000000
MB = 12      ME = 25      00000000000111111111111110000000
------------------------------------------------------------
MB = 22      ME = 31      00000000000000000000011111111111
MB = 29      ME = 6       11111110000000000000000000000111
```

Examples of 32-bit Masks That Are Not Valid

The following shows examples of 32-bit masks that are not valid.

```
0              15             31
|               |              |
00000000000000000000000000000000
01010101010101010101010101010101
00000000000011110000011000000000
11111100000111111111111111000000
```

32-bit Rotate and Shift Extended Mnemonics for POWER family and PowerPC

The extended mnemonics for the rotate and shift instructions are in the POWER family and PowerPC intersection area (**com** assembly mode). A set of rotate and shift extended mnemonics provide for the following operations:

Extract	Selects a field of *n* bits starting at bit position *b* in the source register. This field is right- or left-justified in the target register. All other bits of the target register are cleared to 0.
Insert	Selects a left- or right-justified field of *n* bits in the source register. This field is inserted starting at bit position *b* of the target register. Other bits of the target register are unchanged. No extended mnemonic is provided for insertion of a left-justified field when operating on doublewords, since such an insertion requires more than one instruction.
Rotate	Rotates the contents of a register right or left *n* bits without masking.
Shift	Shifts the contents of a register right or left *n* bits. Vacated bits are cleared to 0 (logical shift).
Clear	Clears the leftmost or rightmost *n* bits of a register to 0.
Clear left and shift left	Clears the leftmost *b* bits of a register, then shifts the register by *n* bits. This operation can be used to scale a known nonnegative array index by the width of an element.

The rotate and shift extended mnemonics are shown in the following table. The *N* operand specifies the number of bits to be extracted, inserted, rotated, or shifted. Because expressions are introduced when the extended mnemonics are mapped to the base mnemonics, certain restrictions are imposed to prevent the result of the expression from causing an overflow in the *SH*, *MB*, or *ME* operand.

To maintain compatibility with previous versions of AIX, *n* is not restricted to a value of 0. If *n* is 0, the assembler treats 32-*n* as a value of 0.

Table 21. 32-bit Rotate and Shift Extended Mnemonics for PowerPC

Operation	Extended Mnemonic	Equivalent to	Restrictions
Extract and left justify immediate	**extlwi** *RA, RS, n, b*	**rlwinm** *RA, RS, b,* **0**, *n*-**1**	32 > *n* > 0
Extract and right justify immediate	**extrwi** *RA, RS, n, b*	**rlwinm** *RA, RS, b*+*n,* **32-***n,* **31**	32 > *n* > 0 & *b*+*n* =< 32
Insert from left immediate	**inslwi** *RA, RS, n, b*	**rlwinm** *RA, RS,* **32-***b, b, (b+n)*-**1**	*b*+*n* <=32 & 32>*n* > 0 & 32 > *b* >= 0
Insert from right immediate	**insrwi** *RA, RS, n, b*	**rlwinm** *RA, RS,* **32-***(b+n), b, (b+n)*-**1**	*b*+*n* <= 32 & 32>*n* > 0
Rotate left immediate	**rotlwi** *RA, RS, n*	**rlwinm** *RA, RS, n,* **0, 31**	32 > *n* >= 0
Rotate right immediate	**rotrwi** *RA, RS, n*	**rlwinm** *RA, RS,* **32-***n***, 0, 31**	32 > *n* >= 0
Rotate left	**rotlw** *RA, RS, b*	**rlwinm** *RA, RS, RB,* **0, 31**	None
Shift left immediate	**slwi** *RA, RS, n*	**rlwinm** *RA, RS, n,* **0, 31-***n*	32 > *n* >= 0
Shift right immediate	**srwi** *RA, RS, n*	**rlwinm** *RA, RS,* **32-***n, n***, 31**	32 > *n* >= 0
Clear left immediate	**clrlwi** *RA, RS, n*	**rlwinm** *RA, RS,* **0**, *n,* **31**	32 > *n* >= 0
Clear right immediate	**clrrwi** *RA, RS, n*	**rlwinm** *RA, RS,* **0, 0, 31-***n*	32 > *n* >= 0
Clear left and shift left immediate	**clrslwi** *RA, RS, b, n*	**rlwinm** *RA, RS, b-n,* **31-***n*	*b-n* >= 0 & 32 > *n* >= 0 & 32 > *b*>= 0

Notes:

1. In POWER family, the mnemonic **slwi**[**.**] is **sli**[**.**]. The mnemonic **srwi**[**.**] is **sri**[**.**].
2. All of these extended mnemonics can be coded with a final . (period) to cause the Rc bit to be set in the underlying instruction.

Examples

1. To extract the sign bit (bit 31) of register *RY* and place the result right-justified into register *RX*:

   ```
   extrwi   RX, RY, 1, 0
   ```

   This is equivalent to:

   ```
   rlwinm   RX, RY, 1, 31, 31
   ```

2. To insert the bit extracted in Example 1 into the sign bit (bit 31) of register *RX*:

   ```
   insrwi   RZ, RX, 1, 0
   ```

   This is equivalent to:

   ```
   rlwimi   RZ, RX, 31, 0, 0
   ```

3. To shift the contents of register *RX* left 8 bits and clear the high-order 32 bits:

   ```
   slwi   RX, RX, 8
   ```

   This is equivalent to:

   ```
   rlwinm   RX, RX, 8, 0, 23
   ```

4. To clear the high-order 16 bits of the low-order 32 bits of register *RY* and place the result in register *RX*, and clear the high-order 32 bits of register *RX*:

   ```
   clrlwi   RX, RY, 16
   ```

   This is equivalent to:

```
rlwinm   RX, RY, 0, 16, 31
```

Related Information

Chapter 6, “Extended Instruction Mnemonics” on page 87.

“Extended Mnemonics of Branch Instructions” on page 87.

“Extended Mnemonics of Condition Register Logical Instructions” on page 94.

“Extended Mnemonics of Fixed-Point Arithmetic Instructions” on page 95.

“Extended Mnemonics of Fixed-Point Compare Instructions” on page 96.

“Extended Mnemonics of Fixed-Point Load Instructions” on page 97.

“Extended Mnemonics of Fixed-Point Logical Instructions” on page 98.

“Extended Mnemonics of Fixed-Point Trap Instructions” on page 98.

“Extended Mnemonics of Moving from or to Special-Purpose Registers” on page 100.

“addic or ai (Add Immediate Carrying) Instruction” on page 129, “addic. or ai. (Add Immediate Carrying and Record) Instruction” on page 130, “bc (Branch Conditional) Instruction” on page 142, “bclr or bcr (Branch Conditional Link Register) Instruction” on page 147, “bcctr or bcc (Branch Conditional to Count Register) Instruction” on page 145, “addi (Add Immediate) or cal (Compute Address Lower) Instruction” on page 128, “addis or cau (Add Immediate Shifted) Instruction” on page 131, “cmpi (Compare Immediate) Instruction” on page 155, “cmp (Compare) Instruction” on page 154, “cmpli (Compare Logical Immediate) Instruction” on page 158, “cmpl (Compare Logical) Instruction” on page 157, “creqv (Condition Register Equivalent) Instruction” on page 163, “cror (Condition Register OR) Instruction” on page 166, “crnor (Condition Register NOR) Instruction” on page 165, “crxor (Condition Register XOR) Instruction” on page 168, “mfspr (Move from Special-Purpose Register) Instruction” on page 300, “mtspr (Move to Special-Purpose Register) Instruction” on page 312, “nor (NOR) Instruction” on page 330, “or (OR) Instruction” on page 331, “rlwinm or rlinm (Rotate Left Word Immediate Then AND with Mask) Instruction” on page 351, “tw or t (Trap Word) Instruction” on page 453, “twi or ti (Trap Word Immediate) Instruction” on page 454.

Extended Mnemonics of 64-bit Fixed-Point Rotate and Shift Instructions

A set of extended mnemonics are provided for extract, insert, rotate, shift, clear, and clear left and shift left operations. This article discusses the following:

- “Alternative Input Format” on page 105
- “32-bit Rotate and Shift Extended Mnemonics for POWER family and PowerPC” on page 106

Alternative Input Format

The alternative input format is applied to the following POWER family and PowerPC instructions.

POWER family	PowerPC
rlimi[**.**]	rlwimi[**.**]
rlinm[**.**]	rlwinm[**.**]
rlnm[**.**]	rlwnm[**.**]
rlmi[**.**]	Not applicable

Five operands are normally required for these instructions. These operands are:

RA, *RS*, *SH*, *MB*, *ME*

MB indicates the first bit with a value of 1 in the mask, and *ME* indicates the last bit with a value of 1 in the mask. The assembler supports the following operand format.

RA, *RS*, *SH*, *BM*

BM is the mask itself. The assembler generates the *MB* and *ME* operands from the *BM* operand for the instructions. The assembler checks the *BM* operand first. If an invalid *BM* is entered, error 78 is reported.

A valid mask is defined as a single series (one or more) of bits with a value of 1 surrounded by zero or more bits with a value of z0. A mask of all bits with a value of 0 may not be specified.

64-bit Rotate and Shift Extended Mnemonics for POWER family and PowerPC

The extended mnemonics for the rotate and shift instructions are in the POWER family and PowerPC intersection area (**com** assembly mode). A set of rotate and shift extended mnemonics provide for the following operations:

Extract	Selects a field of *n* bits starting at bit position *b* in the source register. This field is right- or left-justified in the target register. All other bits of the target register are cleared to 0.
Insert	Selects a left- or right-justified field of *n* bits in the source register. This field is inserted starting at bit position *b* of the target register. Other bits of the target register are unchanged. No extended mnemonic is provided for insertion of a left-justified field when operating on doublewords, since such an insertion requires more than one instruction.
Rotate	Rotates the contents of a register right or left *n* bits without masking.
Shift	Shifts the contents of a register right or left *n* bits. Vacated bits are cleared to 0 (logical shift).
Clear	Clears the leftmost or rightmost *n* bits of a register to 0.
Clear left and shift left	Clears the leftmost *b* bits of a register, then shifts the register by *n* bits. This operation can be used to scale a known nonnegative array index by the width of an element.

The rotate and shift extended mnemonics are shown in the following table. The *N* operand specifies the number of bits to be extracted, inserted, rotated, or shifted. Because expressions are introduced when the extended mnemonics are mapped to the base mnemonics, certain restrictions are imposed to prevent the result of the expression from causing an overflow in the *SH*, *MB*, or *ME* operand.

To maintain compatibility with previous versions of AIX, *n* is not restricted to a value of 0. If *n* is 0, the assembler treats 32-*n* as a value of 0.

Table 22. 63-bit Rotate and Shift Extended Mnemonics for PowerPC

Operation	Extended Mnemonic	Equivalent to	Restrictions
Extract double word and right justify immediate	**extrdi** *RA, RS, n, b*	**rldicl** *RA, RS, b + n,* **64** - *n*	*n* > 0
Rotate double word left immediate	**rotldi** *RA, RS, n*	**rldicl** *RA, RS, n,* **0**	None
Rotate double word right immediate	**rotrdi** *RA, RS, n*	**rldicl** *RA, RS,* 64 - *n,* **0**	None
Rotate double word right immediate	**srdi** *RA, RS, n*	**rldicl** *RA, RS,* 64 - *n, n*	*n* < 64

Table 22. 63-bit Rotate and Shift Extended Mnemonics for PowerPC (continued)

Operation	Extended Mnemonic	Equivalent to	Restrictions
Clear left double word immediate	**clrldi** *RA, RS, n*	**rldicl** *RA, RS,* **0**, *n*	*n* < 64
Extract double word and left justify immediate	**extldi** *RA, RS, n, b*	**rldicr** *RA, RS, b, n* - 1	None
Shift left double word immediate	**sldi** *RA, RS, n*	**rldicr** *RA, RS, n,* **63** - *n*	None
Clear right double word immediate	**clrrdi** *RA, RS, n*	**rldicr** *RA, RS,* **0, 63** - *n*	None
Clear left double word and shift left immediate	**clrlsldi** *RA, RS, b, n*	**rldic** *RA, RS, n, b - n*	None
Insert double word from right immediate	**insrdi** *RA, RS, n, b*	**rldimi** *RA, RS, 64 - (b + n), b*	None
Rotate double word left	**rotld** *RA, RS, RB*	**rldcl** *RA, RS, RB,* **0**	None

Note: All of these extended mnemonics can be coded with a final . (period) to cause the Rc bit to be set in the underlying instruction.

Related Information

Chapter 6, “Extended Instruction Mnemonics” on page 87.

“Extended Mnemonics of Branch Instructions” on page 87.

“Extended Mnemonics of Condition Register Logical Instructions” on page 94.

“Extended Mnemonics of Fixed-Point Arithmetic Instructions” on page 95.

“Extended Mnemonics of Fixed-Point Compare Instructions” on page 96.

“Extended Mnemonics of Fixed-Point Load Instructions” on page 97.

“Extended Mnemonics of Fixed-Point Logical Instructions” on page 98.

“Extended Mnemonics of Fixed-Point Trap Instructions” on page 98.

“Extended Mnemonics of Moving from or to Special-Purpose Registers” on page 100.

“addic or ai (Add Immediate Carrying) Instruction” on page 129, “addic. or ai. (Add Immediate Carrying and Record) Instruction” on page 130, “bc (Branch Conditional) Instruction” on page 142, “bclr or bcr (Branch Conditional Link Register) Instruction” on page 147, “bcctr or bcc (Branch Conditional to Count Register) Instruction” on page 145, “addi (Add Immediate) or cal (Compute Address Lower) Instruction” on page 128, “addis or cau (Add Immediate Shifted) Instruction” on page 131, “cmpi (Compare Immediate) Instruction” on page 155, “cmp (Compare) Instruction” on page 154, “cmpli (Compare Logical Immediate) Instruction” on page 158, “cmpl (Compare Logical) Instruction” on page 157, “creqv (Condition Register Equivalent) Instruction” on page 163, “cror (Condition Register OR) Instruction” on page 166, “crnor (Condition Register NOR) Instruction” on page 165, “crxor (Condition Register XOR) Instruction” on page 168, “mfspr (Move from Special-Purpose Register) Instruction” on page 300, “mtspr (Move to Special-Purpose Register) Instruction” on page 312, “nor (NOR) Instruction” on page 330, “or (OR) Instruction” on page 331, “rlwinm or rlinm (Rotate Left Word Immediate Then AND with Mask) Instruction” on page 351, “tw or t (Trap Word) Instruction” on page 453, “twi or ti (Trap Word Immediate) Instruction” on page 454.

Chapter 7. Migrating Source Programs

The assembler issues errors and warnings if a source program contains instructions that are not in the current assembly mode. Source compatibility of POWER family programs is maintained on PowerPC platforms. All POWER family user instructions are emulated in PowerPC by the operating system. Because the emulation of instructions is much slower than the execution of hardware-supported instructions, for performance reasons it may be desirable to modify the source program to use hardware-supported instructions.

The ″invalid instruction form″ problem occurs when restrictions are required in PowerPC but not required in POWER family. The assembler checks for invalid instruction form errors, but it cannot check the **lswx** instruction for these errors. The **lswx** instruction requires that the registers specified by the second and third operands (*RA* and *RB*) are not in the range of registers to be loaded. Since this is determined by the content of the Fixed-Point Exception Register (XER) at run time, the assembler cannot perform an invalid instruction form check for the **lswx** instruction. At run time, some of these errors may cause a silence failure, while others may cause an interruption. It may be desirable to eliminate these errors. See “Detection Error Conditions” on page 4 for more information on invalid instruction forms.

If the **mfspr** and **mtspr** instructions are used, check for proper coding of the special-purpose register (SPR) operand. The assembler requires that the low-order five bits and the high-order five bits of the SPR operand be reversed before they are used as the input operand. POWER family and PowerPC have different sets of SPR operands for nonprivileged instructions. Check for the proper encoding of these operands. Five POWER family SPRs (TID, SDR0, MQ, RTCU, and RTCL) are dropped from PowerPC, but the MQ, RTCU, and RTCL instructions are emulated in PowerPC. While these instructions can still be used, there is some performance degradation due to the emulation. (You can sometimes use the **read_real_time** and **time_base_to_time** routines instead of code accessing the real time clock or time base SPRs.)

More information on migrating source programs can be found in the following:

- “Functional Differences for POWER family and PowerPC Instructions” on page 112
- “Differences between POWER family and PowerPC Instructions with the Same Op Code” on page 113
- “Extended Mnemonics Changes” on page 114
- “POWER family Instructions Deleted from PowerPC” on page 117
- “Added PowerPC Instructions” on page 118
- “Instructions Available Only for the PowerPC 601 RISC Microprocessor” on page 119
- “Migration of Branch Conditional Statements with No Separator after Mnemonic” on page 119

Related Information

Chapter 6, “Extended Instruction Mnemonics” on page 87.

“Functional Differences for POWER family and PowerPC Instructions” on page 112.

“Differences between POWER family and PowerPC Instructions with the Same Op Code” on page 113.

“Extended Mnemonics Changes” on page 114.

“POWER family Instructions Deleted from PowerPC” on page 117.

“Added PowerPC Instructions” on page 118.

“Instructions Available Only for the PowerPC 601 RISC Microprocessor” on page 119.

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Functional Differences for POWER family and PowerPC Instructions

The following table lists the POWER family and PowerPC instructions that share the same op code on POWER family and PowerPC platforms, but differ in their functional definition. Use caution when using these instructions in **com** assembly mode.

Table 23. POWER family and PowerPC Instructions with Functional Differences

POWER family	PowerPC	Description
dcs	**sync**	The **sync** instruction causes more pervasive synchronization in PowerPC than the **dcs** instruction does in POWER family.
ics	**isync**	The **isync** instruction causes more pervasive synchronization in PowerPC than the **ics** instruction does in POWER family.
svca	**sc**	In POWER family, information from MSR is saved into CTR. In PowerPC, this information is saved into SRR1. PowerPC only supports one vector. POWER family allows instruction fetching to continue at any of 128 locations. POWER family saves the low-order 16 bits of the instruction in CTR. PowerPC does not save the low-order 16 bits of the instruction.
mtsri	**mtsrin**	POWER family uses the `RA` field to compute the segment register number and, in some cases, the effective address (EA) is stored. PowerPC has no `RA` field, and the EA is not stored.
lsx	**lswx**	POWER family does not alter the target register *RT* if the string length is 0. PowerPC leaves the contents of the target register *RT* undefined if the string length is 0.
mfsr	**mfsr**	This is a nonprivileged instruction in POWER family. It is a privileged instruction in PowerPC.
mfmsr	**mfmsr**	This is a nonprivileged instruction in POWER family. It is a privileged instruction in PowerPC.
mfdec	**mfdec**	The **mfdec** instruction is nonprivileged in POWER family, but becomes a privileged instruction in PowerPC. As a result, the DEC encoding number for the **mfdec** instruction is different for POWER family and PowerPC.
mffs	**mffs**	POWER family sets the high-order 32 bits of the result to `0xFFFF FFFF`. In PowerPC, the high-order 32 bits of the result are undefined.

See “Features of the AIX Assembler” on page 1 for more information on the PowerPC-specific features of the assembler.

Related Information

Chapter 7, “Migrating Source Programs” on page 111.

“Differences between POWER family and PowerPC Instructions with the Same Op Code” on page 113.

“Extended Mnemonics Changes” on page 114.

“POWER family Instructions Deleted from PowerPC” on page 117.

“Added PowerPC Instructions” on page 118.

“Instructions Available Only for the PowerPC 601 RISC Microprocessor” on page 119.

Differences between POWER family and PowerPC Instructions with the Same Op Code

This section discusses the following:

- "Instructions with the Same Op Code, Mnemonic, and Function"
- "Instructions with the Same Op Code and Function"
- "mfdec Instructions" on page 114

Instructions with the Same Op Code, Mnemonic, and Function

The following instructions are available in POWER family and PowerPC. These instructions share the same op code and mnemonic, and have the same function in POWER family and PowerPC, but use different input operand formats.

- **cmp**
- **cmpi**
- **cmpli**
- **cmpl**

The input operand format for POWER family is:

BF, *RA*, *SI* | *RB* | *UI*

The input operand format for PowerPC is:

BF, *L*, *RA*, *SI* | *RB* | *UI*

The assembler handles these as the same instructions in POWER family and PowerPC, but with different input operand formats. The *L* operand is one bit. For POWER family, the assembler presets this bit to 0. For 32-bit PowerPC platforms, this bit must be set to 0, or an invalid instruction form results.

Instructions with the Same Op Code and Function

The instructions listed in the following table are available in POWER family and PowerPC. These instructions share the same op code and function, but have different mnemonics and input operand formats. The assembler still places them in the POWER family/PowerPC intersection area, because the same binary code is generated. If the **-s** option is used, no cross-reference is given, because it is necessary to change the source code when migrating from POWER family to PowerPC, or vice versa.

Table 24. Instructions with Same Op Code and Function

POWER family	PowerPC
cal	**addi**
mtsri	**mtsrin**
svca	**sc**
cau	**addis**

Notes:

1. **lil** is an extended mnemonic of **cal**, and **li** is an extended mnemonic of **addi**. Since the op code, function, and input operand format are the same, the assembler provides a cross-reference for **lil** and **li**.
2. **liu** is an extended mnemonic of **cau**, and **lis** is an extended mnemonic of **addis**. Since the input operand format is different, the assembler does not provide a cross-reference for **liu** and **lis**.

3. The immediate value for the **cau** instruction is a 16-bit unsigned integer, while the immediate value for the **addis** instruction is a 16-bit signed integer. The assembler performs a (0, 65535) value range check for the `UI` field and a (-32768, 32767) value range check for the `SI` field.

   To maintain source compatibility of the **cau** and **addis** instructions, the assembler expands the value range check to (-65536, 65535) for the **addis** instruction. The sign bit is ignored and the assembler ensures only that the immediate value fits in 16 bits. This expansion does not affect the behavior of a 32-bit implementation.

   For a 64-bit implementation, if bit 32 is set, it is propagated through the upper 32 bits of the 64-bit general-purpose register (GPR). Therefore, if an immediate value within the range (32768, 65535) or (-65536, -32767) is used for the **addis** instruction in a 32-bit mode, this immediate value may not be directly ported to a 64-bit mode.

mfdec Instructions

Moving from the DEC (decrement) special purpose register is privileged in PowerPC, but nonprivileged in POWER family. One bit in the instruction field that specifies the register is 1 for privileged operations, but 0 for nonprivileged operations. As a result, the encoding number for the DEC SPR for the **mfdec** instruction has different values in PowerPC and POWER family. The DEC encoding number is 22 for PowerPC and 6 for POWER family. If the **mfdec** instruction is used, the assembler determines the DEC encoding based on the current assembly mode. The following list shows the assembler processing of the **mfdec** instruction for each assembly mode value:

- If the assembly mode is **pwr**, **pwr2**, or **601**, the DEC encoding is 6.
- If the assembly mode is **ppc**, **603**, or **604**, the DEC encoding is 22.
- If the default assembly mode, which treats POWER family/PowerPC incompatibility errors as instructional warnings, is used, the DEC encoding is 6. Instructional warning 158 reports that the DEC SPR encoding 6 is used to generate the object code. The warning can be suppressed with the **-W** flag.
- If the assembly mode is **any**, the DEC encoding is 6. If the **-w** flag is used, a warning message (158) reports that the DEC SPR encoding 6 is used to generate the object code.
- If the assembly mode is **com**, an error message reports that the **mfdec** instruction is not supported. No object code is generated. In this situation, the **mfspr** instruction must be used to encode the DEC number.

Related Information

Chapter 7, “Migrating Source Programs” on page 111.

“Functional Differences for POWER family and PowerPC Instructions” on page 112.

“Extended Mnemonics Changes”.

“POWER family Instructions Deleted from PowerPC” on page 117.

“Added PowerPC Instructions” on page 118.

“Instructions Available Only for the PowerPC 601 RISC Microprocessor” on page 119.

Extended Mnemonics Changes

The following lists show the added extended mnemonics for POWER family and PowerPC. The assembler places all POWER family and PowerPC extended mnemonics in the POWER family/PowerPC intersection area if their basic mnemonics are in this area. Extended mnemonics are separated for POWER family and PowerPC only for migration purposes. See Chapter 6, “Extended Instruction Mnemonics” on page 87 for more information.

Extended Mnemonics in com Mode

The following PowerPC extended mnemonics for branch conditional instructions have been added:

- **bdzt**
- **bdzta**
- **bdztl**
- **bdztla**
- **bdzf**
- **bdzfa**
- **bdzfl**
- **bdzfla**
- **bdnzt**
- **bdnzta**
- **bdnztl**
- **bdnztla**
- **bdnzf**
- **bdnzfa**
- **bdnzfl**
- **bdnzfla**
- **bdztlr**
- **bdztlrl**
- **bdzflr**
- **bdzflrl**
- **bdnztlr**
- **bdnztlrl**
- **bdnzflr**
- **bdnzflrl**
- **bun**
- **buna**
- **bunl**
- **bunla**
- **bunlr**
- **bunlrl**
- **bunctr**
- **bunctrl**
- **bnu**
- **bnua**
- **bnul**
- **bnula**
- **bnulr**
- **bnulrl**
- **bnuctr**
- **bnuctrl**

The following PowerPC extended mnemonics for condition register logical instructions have been added:

- **crset**

- **crclr**
- **crmove**
- **crnot**

The following PowerPC extended mnemonics for fixed-point load instructions have been added:
- **li**
- **lis**
- **la**

The following PowerPC extended mnemonics for fixed-point arithmetic instructions have been added:
- **subi**
- **subis**
- **subc**

The following PowerPC extended mnemonics for fixed-point compare instructions have been added:
- **cmpwi**
- **cmpw**
- **cmplwi**
- **cmplw**

The following PowerPC extended mnemonics for fixed-point trap instructions have been added:
- **trap**
- **twlng**
- **twlngi**
- **twlnl**
- **twlnli**
- **twng**
- **twngi**
- **twnl**
- **twnli**

The following PowerPC extended mnemonics for fixed-point logical instructions have been added:
- **nop**
- **mr**[**.**]
- **not**[**.**]

The following PowerPC extended mnemonics for fixed-point rotate and shift instructions have been added:
- **extlwi**[**.**]
- **extrwi**[**.**]
- **inslwi**[**.**]
- **insrwi**[**.**]
- **rotlw**[**.**]
- **rotlwi**[**.**]
- **rotrwi**[**.**]
- **clrlwi**[**.**]
- **clrrwi**[**.**]
- **clrlslwi**[**.**]

Extended Mnemonics in ppc Mode

The following PowerPC extended mnemonic for fixed-point arithmetic instructions has been added for **ppc** mode:

- **sub**

Related Information

Chapter 7, “Migrating Source Programs” on page 111.

“Functional Differences for POWER family and PowerPC Instructions” on page 112.

“Differences between POWER family and PowerPC Instructions with the Same Op Code” on page 113.

“POWER family Instructions Deleted from PowerPC”.

“Added PowerPC Instructions” on page 118.

“Instructions Available Only for the PowerPC 601 RISC Microprocessor” on page 119.

Chapter 6, “Extended Instruction Mnemonics” on page 87.

POWER family Instructions Deleted from PowerPC

The following table lists the POWER family instructions that have been deleted from PowerPC, yet are still supported by the PowerPC 601 RISC Microprocessor. AIX provides services to emulate most of these instructions if an attempt to execute one of them is made on a processor that does not include the instruction, such as PowerPC 603 RISC Microprocessor or PowerPC 604 RISC Microprocessor, but no emulation services are provided for the **mtrtcl**, **mtrtcu**, or **svcla** instructions. Using the code to emulate an instruction is much slower than executing an instruction.

Table 25. POWER family Instructions Deleted from PowerPC, Supported byPowerPC 601 RISC Microprocessor

abs[o][.]	**clcs**	**div[o][.]**	**divs[o][.]**
doz[o][.]	**dozi**	**lscbx[.]**	**maskg[.]**
maskir[.]	**mfmq**	**mfrtcl**	**mfrtcu**
mtmq	**mtrtcl**	**mtrtcu**	**mul[o][.]**
nabs[o][.]	**rlmi[.]**	**rrib[.]**	**sle[.]**
sleq[.]	**sliq[.]**	**slliq[.]**	**sllq[.]**
slq[.]	**sraiq[.]**	**sraq[.]**	**sre[.]**
srea[.]	**sreq[.]**	**sriq[.]**	**srliq[.]**
srlq[.]	**srq[.]**	**svcla**	

Note: Extended mnemonics are not included in the previous table, except for extended mnemonics for the **mfspr** and **mtspr** instructions.

The following table lists the POWER family instructions that have been deleted from PowerPC and that are not supported by the PowerPC 601 RISC Microprocessor. AIX does *not* provide services to emulate most of these instructions. However, emulation services are provided for the **clf**, **dclst**, and **dclz** instructions. Also, the **cli** instruction is emulated, but only when it is executed in privileged mode.

Table 26. POWER family Instructions Deleted from PowerPC, Not Supported by PowerPC 601 RISC Microprocessor

clf	**cli**	**dclst**	**dclz**
mfsdr0	**mfsri**	**mftid**	**mtsdr0**

Table 26. POWER family Instructions Deleted from PowerPC, Not Supported by PowerPC 601 RISC Microprocessor (continued)

mttid	**rac**[.]	**rfsvc**	**svc**
svcl	**tlbi**		

Related Information

Chapter 7, “Migrating Source Programs” on page 111.

“Functional Differences for POWER family and PowerPC Instructions” on page 112.

“Differences between POWER family and PowerPC Instructions with the Same Op Code” on page 113.

“Extended Mnemonics Changes” on page 114.

“Added PowerPC Instructions”.

“Instructions Available Only for the PowerPC 601 RISC Microprocessor” on page 119.

Added PowerPC Instructions

The following table lists instructions that have been added to PowerPC, but are not in POWER family. These instructions are supported by the PowerPC 601 RISC Microprocessor.

Table 27. Added PowerPC Instructions, Supported by PowerPC 601 RISC Microprocessor

dcbf	**dcbi**	**dcbst**	**dcbt**
dcbtst	**dcbz**	**divw[o][.]**	**divwu[o][.]**
eieio	**extsb[.]**	**fadds[.]**	**fdivs[.]**
fmadds[.]	**fmsubs[.]**	**fmuls[.]**	**fnmadds[.]**
fnmsubs[.]	**fsubs[.]**	**icbi**	**lwarx**
mfear	**mfpvr**	**mfsprg**	**mfsrin**
mtear	**mtsprg**	**mulhw[.]**	**mulhwu[.]**
stwcx.	**subf[o][.]**		

Note: Extended mnemonics are not included in the previous table, except for extended mnemonics for the **mfspr** and **mtspr** instructions.

The following table lists instructions that have been added to PowerPC, but are not in POWER family. These instructions are not supported by the PowerPC 601 RISC Microprocessor.

Table 28. PowerPC Instructions, Not Supported by PowerPC 601 RISC Microprocessor

mfdbatl	**mfdbatu**	**mtdbatl**	**mtdbatu**
mttb	**mttbu**	**mftb**	**mftbu**
mfibatl	**mfibatu**	**mtibatl**	**mtibatu**

Related Information

Chapter 7, “Migrating Source Programs” on page 111.

“Functional Differences for POWER family and PowerPC Instructions” on page 112.

“Differences between POWER family and PowerPC Instructions with the Same Op Code” on page 113.

“Extended Mnemonics Changes” on page 114.

“POWER family Instructions Deleted from PowerPC” on page 117.

“Instructions Available Only for the PowerPC 601 RISC Microprocessor”.

Instructions Available Only for the PowerPC 601 RISC Microprocessor

The following table lists PowerPC optional instructions that are implemented in the PowerPC 601 RISC Microprocessor:

Table 29. PowerPC 601 RISC Microprocessor-Unique Instructions

eciwx	**ecowx**	**mfbatl**	**mfbatu**
mtbatl	**mtbatu**	**tlbie**	

Note: Extended mnemonics, with the exception of **mfspr** and **mtspr** extended mnemonics, are not provided.

Related Information

Chapter 7, “Migrating Source Programs” on page 111.

“Functional Differences for POWER family and PowerPC Instructions” on page 112.

“Differences between POWER family and PowerPC Instructions with the Same Op Code” on page 113.

“Extended Mnemonics Changes” on page 114.

“POWER family Instructions Deleted from PowerPC” on page 117.

“Added PowerPC Instructions” on page 118.

Migration of Branch Conditional Statements with No Separator after Mnemonic

The AIX assembler may parse some statements different from the previous version of the assembler. This different parsing is only a possibility for statements that meet all the following conditions:

- The statement does not have a separator character (space or tab) between the mnemonic and the operands.
- The first character of the first operand is a plus sign (+) or a minus sign (-).
- The mnemonic represents a Branch Conditional instruction.

If an assembler program has statements that meet all the conditions above, and the minus sign, or a plus sign in the same location, is intended to be part of the operands, not part of the mnemonic, the source program must be modified. This is especially important for minus signs, because moving a minus sign can significantly change the meaning of a statement.

The possibility of different parsing occurs in AIX because the assembler was modified to support branch prediction extended mnemonics which use the plus sign and minus sign as part of the mnemonic. In previous versions of the assembler, letters and period (.) were the only possible characters in mnemonics. For information, see “Extended Mnemonics for Branch Prediction” on page 91.

Examples

1. The following statement is parsed by the AIX assembler so that the minus sign is part of the mnemonic (but previous versions of the assembler parsed the minus sign as part of the operands) and must be modified if the minus sign is intended to be part of the operands:

```
bnea-   16  #  Separator after the - , but none before
            #  Now: bnea- is a Branch Prediction Mnemonic
            #       and 16 is operand.
            #  Previously: bnea was mnemonic
            #              and -16 was operand.
```

2. The following are several sample statements which the AIX assembler parses the same as previous assemblers (the minus sign will be interpreted as part of the operands):

```
bnea  -16  # Separator in source program - Good practice
bnea-16    #  No separators before or after minus sign
bnea  - 16 # Separators before and after the minus sign
```

Related Information

"Features of the AIX Assembler" on page 1.

"Extended Mnemonics for Branch Prediction" on page 91.

Chapter 8. Instruction Set

This chapter contains reference articles for the operating system assembler instruction set. The following appendixes also provide information on the operating system assembler instruction set:

- Appendix B. Instruction Set Sorted by Mnemonic
- Appendix C. Instruction Set Sorted by Primary and Extended Op Code
- Appendix D. Instructions Common to POWER family, POWER2, and PowerPC
- Appendix E. POWER family and POWER2 Instructions
- Appendix F. PowerPC Instructions
- Appendix G. PowerPC 601 RISC Microprocessor Instructions

abs (Absolute) Instruction

Purpose

Takes the absolute value of the contents of a general-purpose register and places the result in another general-purpose register.

Note: The **abs** instruction is supported only in the POWER family architecture.

Syntax

Bits	Value
0-5	31
6-10	RT
11-15	RA
16-20	///
21	OE
22-30	360
31	Rc

POWER family

abs *RT*, *RA*
abs. *RT*, *RA*
abso *RT*, *RA*
abso. *RT*, *RA*

Description

The **abs** instruction places the absolute value of the contents of general-purpose register (GPR) *RA* into the target GPR *RT*.

If GPR *RA* contains the most negative number (’8000 0000’), the result of the instruction is the most negative number, and the instruction will set the Overflow bit in the Fixed-Point Exception Register to 1 if the OE bit is set to 1.

The **abs** instruction has four syntax forms. Each syntax form has a different effect on Condition Register Field 0 and the Fixed-Point Exception Register.

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Syntax Form	Overflow Exception (OE)	Fixed-Point Exception Register	Record Bit (Rc)	Condition Register Field 0
abs	0	None	0	None
abs.	0	None	1	LT,GT,EQ,SO
abso	1	SO,OV	0	None
abso.	1	SO,OV	1	LT,GT,EQ,SO

The four syntax forms of the **abs** instruction always affect the Carry bit (CA) in the Fixed-Point Exception Register. If the syntax form sets the Overflow Exception (OE) bit to 1, the instruction affects the Summary Overflow (SO) and Overflow (OV) bits in the Fixed-Point Exception Register. If the syntax form sets the Record (Rc) bit to 1, the instruction affects the Less Than (LT) zero, Greater Than (GT) zero, Equal To (EQ) zero, and Summary Overflow (SO) bits in Condition Register Field 0.

Parameters

RT Specifies the target general-purpose register where result of operation is stored.
RA Specifies the source general-purpose register for operation.

Examples

1. The following code takes the absolute value of the contents of GPR 4 and stores the result in GPR 6:

```
# Assume GPR 4 contains 0x7000 3000.
abs 6,4
# GPR 6 now contains 0x7000 3000.
```

2. The following code takes the absolute value of the contents of GPR 4, stores the result in GPR 6, and sets Condition Register Field 0 to reflect the result of the operation:

```
# Assume GPR 4 contains 0xFFFF FFFF.
abs. 6,4
# GPR 6 now contains 0x0000 0001.
```

3. The following code takes the absolute value of the contents of GPR 4, stores the result in GPR 6, and sets the Summary Overflow and Overflow bits in the Fixed-Point Exception Register to reflect the result of the operation:

```
# Assume GPR 4 contains 0xB004 3000.
abso 6,4
# GPR 6 now contains 0x4FFB D000.
```

4. The following code takes the absolute value of the contents of GPR 4, stores the result in GPR 6, and sets the Summary Overflow and Overflow bits in the Fixed-Point Exception Register and Condition Register Field 0 to reflect the result of the operation:

```
# Assume GPR 4 contains 0x8000 0000.
abso. 6,4
# GPR 6 now contains 0x8000 0000.
```

Related Information

Fixed-Point Processor .

Fixed-Point Arithmetic Instructions .

---

add (Add) or cax (Compute Address) Instruction

Purpose

Adds the contents of two general-purpose registers.

Syntax

Bits	Value
0-5	31
6-10	RT
11-15	RA
16-20	RB
21	OE
22-30	266
31	Rc

PowerPC

add *RT*, *RA*, *RB*
add. *RT*, *RA*, *RB*
addo *RT*, *RA*, *RB*
addo. *RT*, *RA*, *RB*

POWER family

cax *RT*, *RA*, *RB*
cax. *RT*, *RA*, *RB*
caxo *RT*, *RA*, *RB*
caxo. *RT*, *RA*, *RB*

Description

The **add** and **cax** instructions place the sum of the contents of general-purpose register (GPR) *RA* and GPR *RB* into the target GPR *RT*.

The **add** and **cax** instructions have four syntax forms. Each syntax form has a different effect on Condition Register Field 0 and the Fixed-Point Exception Register.

Syntax Form	Overflow Exception (OE)	Fixed-Point Exception Register	Record Bit (Rc)	Condition Register Field 0
add	0	None	0	None
add.	0	None	1	LT,GT,EQ,SO
addo	1	SO,OV	0	None
addo.	1	SO,OV	1	LT,GT,EQ,SO
cax	0	None	0	None
cax.	0	None	1	LT,GT,EQ,SO
caxo	1	SO,OV	0	None
caxo.	1	SO,OV	1	LT,GT,EQ,SO

The four syntax forms of the **add** instruction and the four syntax forms of the **cax** instruction never affect the Carry bit (CA) in the Fixed-Point Exception Register. If the syntax form sets the Overflow Exception (OE) bit to 1, the instruction affects the Summary Overflow (SO) and Overflow (OV) bits in the Fixed-Point Exception Register. If the syntax form sets the Record (Rc) bit to 1, the instruction affects the Less Than (LT) zero, Greater Than (GT) zero, Equal To (EQ) zero, and Summary Overflow (SO) bits in Condition Register Field 0.

Parameters

RT Specifies target general-purpose register where result of operation is stored.
RA Specifies source general-purpose register for operation.
RB Specifies source general-purpose register for operation.

Examples

1. The following code adds the address or contents in GPR 6 to the address or contents in GPR 3 and stores the result in GPR 4:

```
# Assume GPR 6 contains 0x0004 0000.
# Assume GPR 3 contains 0x0000 4000.
add 4,6,3
# GPR 4 now contains 0x0004 4000.
```

2. The following code adds the address or contents in GPR 6 to the address or contents in GPR 3, stores the result in GPR 4, and sets Condition Register Field 0 to reflect the result of the operation:

```
# Assume GPR 6 contains 0x8000 7000.
# Assume GPR 3 contains 0x7000 8000.
 add. 4,6,3
# GPR 4 now contains 0xF000 F000.
```

3. The following code adds the address or contents in GPR 6 to the address or contents in GPR 3, stores the result in GPR 4, and sets the Summary Overflow, Overflow, and Carry bits in the Fixed-Point Exception Register to reflect the result of the operation:

```
# Assume GPR 6 contains 0xEFFF FFFF.
# Assume GPR 3 contains 0x8000 0000.
addo 4,6,3
# GPR 4 now contains 0x6FFF FFFF.
```

4. The following code adds the address or contents in GPR 6 to the address or contents in GPR 3, stores the result in GPR 4, and sets the Summary Overflow, Overflow, and Carry bits in the Fixed-Point Exception Register and Condition Register Field 0 to reflect the result of the operation:

```
# Assume GPR 6 contains 0xEFFF FFFF.
# Assume GPR 3 contains 0xEFFF FFFF.
addo. 4,6,3
# GPR 4 now contains 0xDFFF FFFE.
```

Related Information

Fixed-Point Processor .

Fixed-Point Address Computation Instructions .

---

addc or a (Add Carrying) Instruction

Purpose

Adds the contents of two general-purpose registers and places the result in a general-purpose register.

Syntax

Bits	Value
0-5	31
6-10	RT
11-15	RA
16-20	RB

Bits	Value
21	OE
22-30	10
31	Rc

PowerPC

addc *RT*, *RA*, *RB*
addc. *RT*, *RA*, *RB*
addco *RT*, *RA*, *RB*
addco. *RT*, *RA*, *RB*

a *RT*, *RA*, *RB*
a. *RT*, *RA*, *RB*
ao *RT*, *RA*, *RB*
ao. *RT*, *RA*, *RB*

Description

The **addc** and **a** instructions place the sum of the contents of general-purpose register (GPR) *RA* and GPR *RB* into the target GPR *RT*.

The **addc** instruction has four syntax forms. Each syntax form has a different effect on Condition Register Field 0 and the Fixed-Point Exception Register.

The **a** instruction has four syntax forms. Each syntax form has a different effect on Condition Register Field 0 and the Fixed-Point Exception Register.

Syntax Form	Overflow Exception (OE)	Fixed-Point Exception Register	Record Bit (Rc)	Condition Register Field 0
addc	0	CA	0	None
addc.	0	CA	1	LT,GT,EQ,SO
addco	1	SO,OV,CA	0	None
addco.	1	SO,OV,CA	1	LT,GT,EQ,SO
a	0	CA	0	None
a.	0	CA	1	LT,GT,EQ,SO
ao	1	SO,OV,CA	0	None
ao.	1	SO,OV,CA	1	LT,GT,EQ,SO

The four syntax forms of the **addc** instruction and the four syntax forms of the **a** instruction always affect the Carry bit (CA) in the Fixed-Point Exception Register. If the syntax form sets the Overflow Exception (OE) bit to 1, the instruction affects the Summary Overflow (SO) and Overflow (OV) bits in the Fixed-Point Exception Register. If the syntax form sets the Record (Rc) bit to 1, the instruction affects the Less Than (LT) zero, Greater Than (GT) zero, Equal To (EQ) zero, and Summary Overflow (SO) bits in Condition Register Field 0.

Parameters

RT Specifies target general-purpose register where result of operation is stored.
RA Specifies source general-purpose register for operation.

RB Specifies source general-purpose register for operation.

Examples

1. The following code adds the contents of GPR 4 to the contents of GPR 10 and stores the result in GPR 6:

```
# Assume GPR 4 contains 0x9000 3000.
# Assume GPR 10 contains 0x8000 7000.
addc 6,4,10
# GPR 6 now contains 0x1000 A000.
```

2. The following code adds the contents of GPR 4 to the contents of GPR 10, stores the result in GPR 6, and sets Condition Register Field 0 to reflect the result of the operation:

```
# Assume GPR 4 contains 0x7000 3000.
# Assume GPR 10 contains 0xFFFF FFFF.
addc. 6,4,10
# GPR 6 now contains 0x7000 2FFF.
```

3. The following code adds the contents of GPR 4 to the contents of GPR 10, stores the result in GPR 6, and sets the Summary Overflow, Overflow, and Carry bits in the Fixed-Point Exception Register to reflect the result of the operation:

```
# Assume GPR 4 contains 0x9000 3000.
# Assume GPR 10 contains 0x7B41 92C0.
addco 6,4,10
# GPR 6 now contains 0x0B41 C2C0.
```

4. The following code adds the contents of GPR 4 to the contents of GPR 10, stores the result in GPR 6, and sets the Summary Overflow, Overflow, and Carry bits in the Fixed-Point Exception Register and Condition Register Field 0 to reflect the result of the operation:

```
# Assume GPR 4 contains 0x8000 0000.
# Assume GPR 10 contains 0x8000 7000.
addco. 6,4,10
# GPR 6 now contains 0x0000 7000.
```

Related Information

Fixed-Point Processor .

Fixed-Point Arithmetic Instructions .

---

adde or ae (Add Extended) Instruction

Purpose

Adds the contents of two general-purpose registers to the value of the Carry bit in the Fixed-Point Exception Register and places the result in a general-purpose register.

Syntax

Bits	Value
0-5	31
6-10	RT
11-15	RA
16-20	RB
21	OE
22-30	138

Bits	Value
31	Rc

PowerPC

adde *RT*, *RA*, *RB*
adde. *RT*, *RA*, *RB*
addeo *RT*, *RA*, *RB*
addeo. *RT*, *RA*, *RB*

POWER family

ae *RT*, *RA*, *RB*
ae. *RT*, *RA*, *RB*
aeo *RT*, *RA*, *RB*
aeo. *RT*, *RA*, *RB*

Description

The **adde** and **ae** instructions place the sum of the contents of general-purpose register (GPR) *RA*, GPR *RB*, and the Carry bit into the target GPR *RT*.

The **adde** instruction has four syntax forms. Each syntax form has a different effect on Condition Register Field 0 and the Fixed-Point Exception Register.

The **ae** instruction has four syntax forms. Each syntax form has a different effect on Condition Register Field 0 and the Fixed-Point Exception Register.

Syntax Form	Overflow Exception (OE)	Fixed-Point Exception Register	Record Bit (Rc)	Condition Register Field 0
adde	0	CA	0	None
adde.	0	CA	1	LT,GT,EQ,SO
addeo	1	SO,OV,CA	0	None
addeo.	1	SO,OV,CA	1	LT,GT,EQ,SO
ae	0	CA	0	None
ae.	0	CA	1	LT,GT,EQ,SO
aeo	1	SO,OV,CA	0	None
aeo.	1	SO,OV,CA	1	LT,GT,EQ,SO

The four syntax forms of the **adde** instruction and the four syntax forms of the **ae** instruction always affect the Carry bit (CA) in the Fixed-Point Exception Register. If the syntax form sets the Overflow Exception (OE) bit to 1, the instruction affects the Summary Overflow (SO) and Overflow (OV) bits in the Fixed-Point Exception Register. If the syntax form sets the Record (Rc) bit to 1, the instruction affects the Less Than (LT) zero, Greater Than (GT) zero, Equal To (EQ) zero, and Summary Overflow (SO) bits in Condition Register Field 0.

Parameters

RT Specifies target general-purpose register where result of operation is stored.
RA Specifies source general-purpose register for operation.
RB Specifies source general-purpose register for operation.

Examples

1. The following code adds the contents of GPR 4, the contents of GPR 10, and the Fixed-Point Exception Register Carry bit and stores the result in GPR 6:

```
# Assume GPR 4 contains 0x1000 0400.
# Assume GPR 10 contains 0x1000 0400.
# Assume the Carry bit is one.
adde 6,4,10
# GPR 6 now contains 0x2000 0801.
```

2. The following code adds the contents of GPR 4, the contents of GPR 10, and the Fixed-Point Exception Register Carry bit; stores the result in GPR 6; and sets Condition Register Field 0 to reflect the result of the operation:

```
# Assume GPR 4 contains 0x9000 3000.
# Assume GPR 10 contains 0x7B41 92C0.
# Assume the Carry bit is zero.
adde. 6,4,10
# GPR 6 now contains 0x0B41 C2C0.
```

3. The following code adds the contents of GPR 4, the contents of GPR 10, and the Fixed-Point Exception Register Carry bit; stores the result in GPR 6; and sets the Summary Overflow, Overflow, and Carry bits in the Fixed-Point Exception Register to reflect the result of the operation:

```
# Assume GPR 4 contains 0x1000 0400.
# Assume GPR 10 contains 0xEFFF FFFF.
# Assume the Carry bit is one.
addeo 6,4,10
# GPR 6 now contains 0x0000 0400.
```

4. The following code adds the contents of GPR 4, the contents of GPR 10, and the Fixed-Point Exception Register Carry bit; stores the result in GPR 6; and sets the Summary Overflow, Overflow, and Carry bits in the Fixed-Point Exception Register and Condition Register Field 0 to reflect the result of the operation:

```
# Assume GPR 4 contains 0x9000 3000.
# Assume GPR 10 contains 0x8000 7000.
# Assume the Carry bit is zero.
addeo. 6,4,10
# GPR 6 now contains 0x1000 A000.
```

Related Information

Fixed-Point Processor .

Fixed-Point Arithmetic Instructions .

---

addi (Add Immediate) or cal (Compute Address Lower) Instruction

Purpose

Calculates an address from an offset and a base address and places the result in a general-purpose register.

Syntax

Bits	Value
0-5	14
6-10	RT
11-15	RA
16-31	SI/D

PowerPC
addi *RT*, *RA*, *SI*

POWER family
cal *RT*, *D*(*RA*)

See Extended Mnemonics of Fixed-Point Arithmetic Instructions and Extended Mnemonics of Fixed-Point Load Instructions for more information.

Description

The **addi** and **cal** instructions place the sum of the contents of general-purpose register (GPR) *RA* and the 16-bit two's complement integer *SI* or *D*, sign-extended to 32 bits, into the target GPR *RT*. If GPR *RA* is GPR 0, then *SI* or *D* is stored into the target GPR *RT*.

The **addi** and **cal** instructions have one syntax form and do not affect Condition Register Field 0 or the Fixed-Point Exception Register.

Parameters

RT Specifies target general-purpose register where result of operation is stored.
RA Specifies source general-purpose register for operation.
D Specifies 16-bit two's complement integer sign extended to 32 bits.
SI Specifies 16-bit signed integer for operation.

Examples

The following code calculates an address or contents with an offset of 0xFFFF 8FF0 from the contents of GPR 5 and stores the result in GPR 4:

```
# Assume GPR 5 contains 0x0000 0900.
addi 4,0xFFFF8FF0(5)
# GPR 4 now contains 0xFFFF 98F0.
```

Related Information

Fixed-Point Processor .

Fixed-Point Address Computation Instructions .

---

addic or ai (Add Immediate Carrying) Instruction

Purpose

Adds the contents of a general-purpose register and a 16-bit signed integer, places the result in a general-purpose register, and effects the Carry bit of the Fixed-Point Exception Register.

Syntax

Bits	Value
0-5	12
6-10	RT
11-15	RA
16-31	SI

PowerPC
addic *RT*, *RA*, *SI*

POWER family
ai *RT*, *RA*, *SI*

See Extended Mnemonics of Fixed-Point Arithmetic Instructions for more information.

Description

The **addic** and **ai** instructions place the sum of the contents of general-purpose register (GPR) *RA* and a 16-bit signed integer, *SI,* into target GPR *RT*.

The 16-bit integer provided as immediate data is sign-extended to 32 bits prior to carrying out the addition operation.

The **addic** and **ai** instructions have one syntax form and can set the Carry bit of the Fixed-Point Exception Register; these instructions never affect Condition Register Field 0.

Parameters

RT Specifies target general-purpose register where result of operation is stored.
RA Specifies source general-purpose register for operation.
SI Specifies 16-bit signed integer for operation.

Examples

The following code adds 0xFFFF FFFF to the contents of GPR 4, stores the result in GPR 6, and sets the Carry bit to reflect the result of the operation:

```
# Assume GPR 4 contains 0x0000 2346.
addic 6,4,0xFFFFFFFF
# GPR 6 now contains 0x0000 2345.
```

Related Information

Fixed-Point Processor .

Fixed-Point Arithmetic Instructions .

---

addic. or ai. (Add Immediate Carrying and Record) Instruction

Purpose

Performs an addition with carry of the contents of a general-purpose register and an immediate value.

Syntax

Bits	Value
0-5	13
6-10	RT
11-15	RA
16-31	SI

PowerPC
addic. *RT*, *RA*, *SI*

POWER family
ai. *RT*, *RA*, *SI*

See Extended Mnemonics of Fixed-Point Arithmetic Instructions for more information.

Description

The **addic.** and **ai.** instructions place the sum of the contents of general-purpose register (GPR) *RA* and a 16-bit signed integer, *SI,* into the target GPR *RT*.

The 16-bit integer *SI* provided as immediate data is sign-extended to 32 bits prior to carrying out the addition operation.

The **addic.** and **ai.** instructions have one syntax form and can set the Carry Bit of the Fixed-Point Exception Register. These instructions also affect Condition Register Field 0.

Parameters

RT Specifies target general-purpose register where result of operation is stored.
RA Specifies source general-purpose register for operation.
SI Specifies 16-bit signed integer for operation.

Examples

The following code adds a 16-bit signed integer to the contents of GPR 4, stores the result in GPR 6, and sets the Fixed-Point Exception Register Carry bit and Condition Register Field 0 to reflect the result of the operation:

```
# Assume GPR 4 contains 0xEFFF FFFF.
addic. 6,4,0x1000
# GPR 6 now contains 0xF000 0FFF.
```

Related Information

Fixed-Point Processor .

Fixed-Point Arithmetic Instructions .

addis or cau (Add Immediate Shifted) Instruction

Purpose

Calculates an address from a concatenated offset and a base address and loads the result in a general-purpose register.

Syntax

Bits	Value
0-5	15
6-10	RT
11-15	RA

Bits	Value
16-31	SI/UI

PowerPC
addis *RT*, *RA*, *SI*

POWER family
cau *RT*, *RA*, *UI*

See Extended Mnemonics of Fixed-Point Arithmetic Instructions and Extended Mnemonics of Fixed-Point Load Instructions for more information.

Description

The **addis** and **cau** instructions place the sum of the contents of general-purpose register (GPR) *RA* and the concatenation of a 16-bit unsigned integer, *SI* or *UI,* and x'0000' into the target GPR *RT*. If GPR *RA* is GPR 0, then the sum of the concatenation of 0, *SI* or *UI*, and x'0000' is stored into the target GPR *RT*.

The **addis** and **cau** instructions have one syntax form and do not affect Condition Register Field 0 or the Fixed-Point Exception Register.

> **Note:** The immediate value for the **cau** instruction is a 16-bit unsigned integer, whereas the immediate value for the **addis** instruction is a 16-bit signed integer. This difference is a result of extending the architecture to 64 bits.

The assembler does a 0 to 65535 value-range check for the *UI* field, and a -32768 to 32767 value-range check for the *SI* field.

To keep the source compatibility of the **addis** and **cau** instructions, the assembler expands the value-range check for the **addis** instruction to -65536 to 65535. The sign bit is ignored and the assembler only ensures that the immediate value fits into 16 bits. This expansion does not affect the behavior of a 32-bit implementation or 32-bit mode in a 64-bit implementation.

The **addis** instruction has different semantics in 32-bit mode than it does in 64-bit mode. If bit 32 is set, it propagates through the upper 32 bits of the 64-bit general-purpose register. Use caution when using the **addis** instruction to construct an unsigned integer. The **addis** instruction with an unsigned integer in 32-bit may not be directly ported to 64-bit mode. The code sequence needed to construct an unsigned integer in 64-bit mode is significantly different from that needed in 32-bit mode.

Parameters

RT Specifies target general-purpose register where result of operation is stored.
RA Specifies first source general-purpose register for operation.
UI Specifies 16-bit unsigned integer for operation.
SI Specifies
16-bit signed integer for operation.

Examples

The following code adds an offset of 0x0011 0000 to the address or contents contained in GPR 6 and loads the result into GPR 7:

```
# Assume GPR 6 contains 0x0000 4000.
addis 7,6,0x0011
# GPR 7 now contains 0x0011 4000.
```

Related Information

Fixed-Point Processor .

Fixed-Point Address Computation Instructions .

---

addme or ame (Add to Minus One Extended) Instruction

Purpose

Adds the contents of a general-purpose register, the Carry bit in the Fixed-Point Exception Register, and -1 and places the result in a general-purpose register.

Syntax

Bits	Value
0-5	31
6-10	RT
11-15	RA
16-20	///
21	OE
22-30	234
31	Rc

PowerPC

addme *RT*, *RA*
addme. *RT*, *RA*
addmeo *RT*, *RA*
addmeo. *RT*, *RA*

POWER family

ame *RT*, *RA*
ame. *RT*, *RA*
ameo *RT*, *RA*
ameo. *RT*, *RA*

Description

The **addme** and **ame** instructions place the sum of the contents of general-purpose register (GPR) *RA*, the Carry bit of the Fixed-Point Exception Register, and -1 (0xFFFF FFFF) into the target GPR *RT*.

The **addme** instruction has four syntax forms. Each syntax form has a different effect on Condition Register Field 0 and the Fixed-Point Exception Register.

The **ame** instruction has four syntax forms. Each syntax form has a different effect on Condition Register Field 0 and the Fixed-Point Exception Register.

Syntax Form	Overflow Exception (OE)	Fixed-Point Exception Register	Record Bit (Rc)	Condition Register Field 0
addme	0	CA	0	None
addme.	0	CA	1	LT,GT,EQ,SO

addmeo	1	SO,OV,CA	0	None
addmeo.	1	SO,OV,CA	1	LT,GT,EQ,SO
ame	0	CA	0	None
ame.	0	CA	1	LT,GT,EQ,SO
ameo	1	SO,OV,CA	0	None
ameo.	1	SO,OV,CA	1	LT,GT,EQ,SO

The four syntax forms of the **addme** instruction and the four syntax forms of the **ame** instruction always affect the Carry bit (CA) in the Fixed-Point Exception Register. If the syntax form sets the Overflow Exception (OE) bit to 1, the instruction affects the Summary Overflow (SO) and Overflow (OV) bits in the Fixed-Point Exception Register. If the syntax form sets the Record (Rc) bit to 1, the instruction affects the Less Than (LT) zero, Greater Than (GT) zero, Equal To (EQ) zero, and Summary Overflow (SO) bits in Condition Register Field 0.

Parameters

RT Specifies target general-purpose register where result of operation is stored.
RA Specifies source general-purpose register for operation.

Examples

1. The following code adds the contents of GPR 4, the Carry bit in the Fixed-Point Exception Register, and -1 and stores the result in GPR 6:

```
# Assume GPR 4 contains 0x9000 3000.
# Assume the Carry bit is zero.
addme 6,4
# GPR 6 now contains 0x9000 2FFF.
```

2. The following code adds the contents of GPR 4, the Carry bit in the Fixed-Point Exception Register, and -1; stores the result in GPR 6; and sets Condition Register Field 0 to reflect the result of the operation:

```
# Assume GPR 4 contains 0xB000 42FF.
# Assume the Carry bit is zero.
addme. 6,4
# GPR 6 now contains 0xB000 42FE.
```

3. The following code adds the contents of GPR 4, the Carry bit in the Fixed-Point Exception Register, and -1; stores the result in GPR 6; and sets the Summary Overflow, Overflow, and Carry bits in the Fixed-Point Exception Register to reflect the result of the operation:

```
# Assume GPR 4 contains 0x8000 0000.
# Assume the Carry bit is zero.
addmeo 6,4
# GPR 6 now contains 0x7FFF FFFF.
```

4. The following code adds the contents of GPR 4, the Carry bit in the Fixed-Point Exception Register, and -1; stores the result in GPR 6; and sets the Summary Overflow, Overflow, and Carry bits in the Fixed-Point Exception Register and Condition Register Field 0 to reflect the result of the operation:

```
# Assume GPR 4 contains 0x8000 0000.
# Assume the Carry bit is one.
addmeo. 6,4
# GPR 6 now contains 0x8000 000.
```

Related Information

Fixed-Point Processor .

Fixed-Point Arithmetic Instructions .

addze or aze (Add to Zero Extended) Instruction

Purpose

Adds the contents of a general-purpose register, zero, and the value of the Carry bit in the FIxed-Point Exception Register and places the result in a general-purpose register.

Syntax

Bits	Value
0-5	31
6-10	RT
11-15	RA
16-20	///
21	OE
22-30	202
31	Rc

PowerPC

addze *RT*, *RA*
addze. *RT*, *RA*
addzeo *RT*, *RA*
addzeo. *RT*, *RA*

POWER family

aze *RT*, *RA*
aze. *RT*, *RA*
azeo *RT*, *RA*
azeo. *RT*, *RA*

Description

The **addze** and **aze** instructions add the contents of general-purpose register (GPR) *RA*, the Carry bit, and 0x0000 0000 and place the result into the target GPR *RT*.

The **addze** instruction has four syntax forms. Each syntax form has a different effect on Condition Register Field 0 and the Fixed-Point Exception Register.

The **aze** instruction has four syntax forms. Each syntax form has a different effect on Condition Register Field 0 and the Fixed-Point Exception Register.

Syntax Form	Overflow Exception (OE)	Fixed-Point Exception Register	Record Bit (Rc)	Condition Register Field 0
addze	0	CA	0	None
addze.	0	CA	1	LT,GT,EQ,SO
addzeo	1	SO,OV,CA	0	None
addzeo.	1	SO,OV,CA	1	LT,GT,EQ,SO
aze	0	CA	0	None
aze.	0	CA	1	LT,GT,EQ,SO

azeo	1	SO,OV,CA	0	None
azeo.	1	SO,OV,CA	1	LT,GT,EQ,SO

The four syntax forms of the **addze** instruction and the four syntax forms of the **aze** instruction always affect the Carry bit (CA) in the Fixed-Point Exception Register. If the syntax form sets the Overflow Exception (OE) bit to 1, the instruction affects the Summary Overflow (SO) and Overflow (OV) bits in the Fixed-Point Exception Register. If the syntax form sets the Record (Rc) bit to 1, the instruction affects the Less Than (LT) zero, Greater Than (GT) zero, Equal To (EQ) zero, and Summary Overflow (SO) bits in Condition Register Field 0.

Parameters

RT Specifies target general-purpose register where result of operation is stored.
RA Specifies source general-purpose register for operation.

Examples

1. The following code adds the contents of GPR 4, 0, and the Carry bit and stores the result in GPR 6:

```
# Assume GPR 4 contains 0x7B41 92C0.
# Assume the Carry bit is zero.
addze 6,4
# GPR 6 now contains 0x7B41 92C0.
```

2. The following code adds the contents of GPR 4, 0, and the Carry bit, stores the result in GPR 6, and sets Condition Register Field 0 to reflect the result of the operation:

```
# Assume GPR 4 contains 0xEFFF FFFF.
# Assume the Carry bit is one.
addze. 6,4
# GPR 6 now contains 0xF000 0000.
```

3. The following code adds the contents of GPR 4, 0, and the Carry bit; stores the result in GPR 6; and sets the Summary Overflow, Overflow, and Carry bits in the Fixed-Point Exception Register to reflect the result of the operation:

```
# Assume GPR 4 contains 0x9000 3000.
# Assume the Carry bit is one.
addzeo 6,4
# GPR 6 now contains 0x9000 3001.
```

4. The following code adds the contents of GPR 4, 0, and the Carry bit; stores the result in GPR 6; and sets the Summary Overflow, Overflow, and Carry bits in the Fixed-Point Exception Register and Condition Register Field 0 to reflect the result of the operation:

```
# Assume GPR 4 contains 0xEFFF FFFF.
# Assume the Carry bit is zero.
adzeo. 6,4
# GPR 6 now contains 0xEFFF FFFF.
```

Related Information

Fixed-Point Processor .

Fixed-Point Arithmetic Instructions .

---

and (AND) Instruction

Purpose

Logically ANDs the contents of two general-purpose registers and places the result in a general-purpose register.

Syntax

Bits	Value
0-5	31
6-10	RS
11-15	RA
16-20	RB
21-30	28
31	Rc

and *RA*, *RS*, *RB*
and. *RA*, *RS*, *RB*

Description

The **and** instruction logically ANDs the contents of general-purpose register (GPR) *RS* with the contents of GPR *RB* and places the result into the target GPR *RA*.

The **and** instruction has two syntax forms. Each syntax form has a different effect on Condition Register Field 0.

Syntax Form	Overflow Exception (OE)	Fixed-Point Exception Register	Record Bit (Rc)	Condition Register Field 0
and	None	None	0	None
and.	None	None	1	LT,GT,EQ,SO

The two syntax forms of the **and** instruction never affect the Fixed-Point Exception Register. If the syntax form sets the Record (Rc) bit to 1, the instruction affects the Less Than (LT) zero, Greater Than (GT) zero, Equal To (EQ) zero, and Summary Overflow (SO) bits in Condition Register Field 0.

Parameters

RA Specifies target general-purpose register where result of operation is stored.
RS Specifies source general-purpose register for operation.
RB Specifies source general-purpose register for operation.

Examples

1. The following code logically ANDs the contents of GPR 4 with the contents of GPR 7 and stores the result in GPR 6:

```
# Assume GPR 4 contains 0xFFF2 5730.
# Assume GPR 7 contains 0x7B41 92C0.
and 6,4,7
# GPR 6 now contains 0x7B40 1200.
```

2. The following code logically ANDs the contents of GPR 4 with the contents of GPR 7, stores the result in GPR 6, and sets Condition Register Field 0 to reflect the result of the operation:

```
# Assume GPR 4 contains 0xFFF2 5730.
# Assume GPR 7 contains 0xFFFF EFFF.
and. 6,4,7
# GPR 6 now contains 0xFFF2 4730.
```

Related Information

Fixed-Point Processor .

Fixed-Point Logical Instructions .

---

andc (AND with Complement) Instruction

Purpose

Logically ANDs the contents of a general-purpose register with the complement of the contents of a general-purpose register.

Syntax

Bits	Value
0-5	31
6-10	RS
11-15	RA
16-20	RB
21-30	60
31	Rc

andc *RA*, *RS*, *RB*
andc. *RA*, *RS*, *RB*

Description

The **andc** instruction logically ANDs the contents of general-purpose register (GPR) *RS* with the complement of the contents of GPR *RB* and places the result into GPR *RA*.

The **andc** instruction has two syntax forms. Each syntax form has a different effect on Condition Register Field 0.

Syntax Form	Overflow Exception (OE)	Fixed-Point Exception Register	Record Bit (Rc)	Condition Register Field 0
andc	None	None	0	None
andc.	None	None	1	LT,GT,EQ,SO

The two syntax forms of the **andc** instruction never affect the Fixed-Point Exception Register. If the syntax form sets the Record (Rc) bit to 1, the instruction affects the Less Than (LT) zero, Greater Than (GT) zero, Equal To (EQ) zero, and Summary Overflow (SO) bits in Condition Register Field 0.

Parameters

RA Specifies target general-purpose register where result of operation is stored.
RS Specifies source general-purpose register for operation.
RB Specifies source general-purpose register for operation.

Examples

1. The following code logically ANDs the contents of GPR 4 with the complement of the contents of GPR 5 and stores the result in GPR 6:

```
# Assume GPR 4 contains 0x9000 3000.
# Assume GPR 5 contains 0xFFFF FFFF.
# The complement of 0xFFFF FFFF becomes 0x0000 0000.
andc 6,4,5
# GPR 6 now contains 0x0000 0000.
```

2. The following code logically ANDs the contents of GPR 4 with the complement of the contents of GPR 5, stores the result in GPR 6, and sets Condition Register Field 0 to reflect the result of the operation:

```
# Assume GPR 4 contains 0xB004 3000.
# Assume GPR 5 contains 0x7676 7676.
# The complement of 0x7676 7676 is 0x8989 8989.
andc. 6,4,5
# GPR 6 now contains 0x8000 0000.
```

Related Information

Fixed-Point Processor .

Fixed-Point Logical Instructions .

---

andi. or andil. (AND Immediate) Instruction

Purpose

Logically ANDs the contents of a general-purpose register with an immediate value.

Syntax

Bits	Value
0-5	28
6-10	RS
11-15	RA
16-31	UI

PowerPC
andi. *RA*, *RS*, *UI*

POWER family
andil. *RA*, *RS*, *UI*

Description

The **andi.** and **andil.** instructions logically AND the contents of general-purpose register (GPR) *RS* with the concatenation of x'0000' and a 16-bit unsigned integer, *UI,* and place the result in GPR *RA*.

The **andi.** and **andil.** instructions have one syntax form and never affect the Fixed-Point Exception Register. The **andi.** and **andil.** instructions copies the Summary Overflow (SO) bit from the Fixed-Point Exception Register into Condition Register Field 0 and sets one of the Less Than (LT), Greater Than (GT), or Equal To (EQ) bits of Condition Register Field 0.

Parameters

RA Specifies target general-purpose register where result of operation is stored.
RS Specifies source general-purpose register for operation.
UI Specifies 16-bit unsigned integer for operation.

Examples

The following code logically ANDs the contents of GPR 4 with 0x0000 5730, stores the result in GPR 6, and sets Condition Register Field 0 to reflect the result of the operation:

```
# Assume GPR 4 contains 0x7B41 92C0.
andi. 6,4,0x5730
# GPR 6 now contains 0x0000 1200.
# CRF 0 now contains 0x4.
```

Related Information

Fixed-Point Processor .

Fixed-Point Logical Instructions .

andis. or andiu. (AND Immediate Shifted) Instruction

Purpose

Logically ANDs the most significant 16 bits of the contents of a general-purpose register with a 16-bit unsigned integer and stores the result in a general-purpose register.

Syntax

Bits	Value
0-5	29
6-10	RS
11-15	RA
16-31	UI

PowerPC
andis. *RA*, *RS*, *UI*

POWER family
andiu. *RA*, *RS*, *UI*

Description

The **andis.** and **andiu.** instructions logically AND the contents of general-purpose register (GPR) *RS* with the concatenation of a 16-bit unsigned integer, *UI,* and x'0000' and then place the result into the target GPR *RA*.

The **andis.** and **andiu.** instructions have one syntax form and never affect the Fixed-Point Exception Register. The **andis.** and **andiu.** instructions set the Less Than (LT) zero, Greater Than (GT) zero, Equal To (EQ) zero, or Summary Overflow (SO) bit in Condition Register Field 0.

Parameters

RA Specifies target general-purpose register where result of operation is stored.
RS Specifies source general-purpose register for operation.
UI Specifies 16-bit unsigned integer for operation.

Examples

The following code logically ANDs the contents of GPR 4 with 0x5730 0000, stores the result in GPR 6, and sets Condition Register Field 0 to reflect the result of the operation:

```
# Assume GPR 4 contains 0x7B41 92C0.
andis. 6,4,0x5730
# GPR 6 now contains 0x5300 0000.
```

Related Information

Fixed-Point Processor .

Fixed-Point Logical Instructions .

b (Branch) Instruction

Purpose

Branches to a specified target address.

Syntax

Bits	Value
0-5	18
6-29	LL
30	AA
31	LK

b *target_address*
ba *target_address*
bl *target_address*
bla *target_address*

Description

The **b** instruction branches to an instruction specified by the branch target address. The branch target address is computed one of two ways.

Consider the following when using the **b** instruction:

- If the Absolute Address bit (AA) is 0, the branch target address is computed by concatenating the 24-bit *LI* field. This field is calculated by subtracting the address of the instruction from the target address and dividing the result by 4 and b'00'. The result is then sign-extended to 32 bits and added to the address of this branch instruction.
- If the AA bit is 1, then the branch target address is the *LI* field concatenated with b'00' sign-extended to 32 bits. The *LI* field is the low-order 26 bits of the target address divided by four.

The **b** instruction has four syntax forms. Each syntax form has a different effect on the Link bit and Link Register.

Syntax Form	Absolute Address Bit (AA)	Fixed-Point Exception Register	Link Bit (LK)	Condition Register Field 0
b	0	None	0	None
ba	1	None	0	None
bl	0	None	1	None
bla	1	None	1	None

The four syntax forms of the **b** instruction never affect the Fixed-Point Exception Register or Condition Register Field 0. The syntax forms set the AA bit and the Link bit (LK) and determine which method of calculating the branch target address is used. If the Link bit (LK) is set to 1, then the effective address of the instruction is placed in the Link Register.

Parameters

target_address Specifies the target address.

Examples

1. The following code transfers the execution of the program to `there`:

```
here: b there
      cror 31,31,31
# The execution of the program continues at there.
there:
```

2. The following code transfers the execution of the program to `here` and sets the Link Register:

```
        bl here
return: cror 31,31,31
# The Link Register now contains the address of return.
# The execution of the program continues at here.
here:
```

Related Information

Branch Processor .

Branch Instructions .

---

bc (Branch Conditional) Instruction

Purpose

Conditionally branches to a specified target address.

Syntax

Bits	Value
0-5	16
6-10	BO
11-15	BI
16-29	BD

Bits	Value
30	AA
31	LK

bc *"BO" on page 144*, *"BI" on page 144*, *"target_address" on page 144*
bca *"BO" on page 144*, *"BI" on page 144*, *"target_address" on page 144*
bcl *"BO" on page 144*, *"BI" on page 144*, *"target_address" on page 144*
bcla *"BO" on page 144*, *"BI" on page 144*, *"target_address" on page 144*

See "Extended Mnemonics of Branch Instructions" on page 87 for more information.

Description

The **bc** instruction branches to an instruction specified by the branch target address. The branch target address is computed one of two ways:

- If the Absolute Address bit (AA) is 0, then the branch target address is computed by concatenating the 14-bit Branch Displacement (BD) and b'00', sign-extending this to 32 bits, and adding the result to the address of this branch instruction.
- If the AA is 1, then the branch target address is BD concatenated with b'00' sign-extended to 32 bits.

The **bc** instruction has four syntax forms. Each syntax form has a different effect on Condition Register Field 0 and the Fixed-Point Exception Register.

Syntax Form	Absolute Address Bit (AA)	Fixed-Point Exception Register	Link Bit (LK)	Condition Register Field 0
bc	0	None	0	None
bca	1	None	0	None
bcl	0	None	1	None
bcla	1	None	1	None

The four syntax forms of the **bc** instruction never affect the Fixed-Point Exception Register or Condition Register Field 0. The syntax forms set the AA bit and the Link bit (LK) and determine which method of calculating the branch target address is used. If the Link Bit (LK) is set to 1, then the effective address of the instruction is placed in the Link Register.

The Branch Option field (BO) is used to combine different types of branches into a single instruction. Extended mnemonics are provided to set the Branch Option field automatically.

The encoding for the BO field is defined in PowerPC architecture. The following list gives brief descriptions of the possible values for this field using pre-V2.00 encoding:

Table 30. BO Field Values Using pre-V2.00 Encoding

BO	Description
0000y	Decrement the CTR; then branch if the decremented CTR is not 0 and the condition is False.
0001y	Decrement the CTR; then branch if the decremented CTR is 0 and the condition is False.
001zy	Branch if the condition is False.
0100y	Decrement the CTR; then branch if bits the decremented CTR is not 0 and the condition is True.
0101y	Decrement the CTR; then branch if the decremented CTR is 0 and the condition is True.
011zy	Branch if the condition is True.
1z00y	Decrement the CTR; then branch if the decremented CTR is not 0.
1z01y	Decrement the CTR; then branch if the decremented CTR is 0.
1z1zz	Branch always.

In the PowerPC architecture, the bits are as follows:

- The z bit denotes a bit that must be 0. If the bit is not 0, the instruction form is invalid.
- The y bit provides a hint about whether a conditional branch is likely to be taken. The value of this bit can be either 0 or 1. The default value is 0.

In the POWER family architecture, the z and y bits can be either 0 or 1.

The encoding for the BO field using V2.00 encoding is briefly described below:

Table 31. BO Field Values Using V2.00 Encoding

BO	Description
0000z	Decrement the CTR; then branch if the decremented CTR is not 0 and the condition is False.
0001z	Decrement the CTR; then branch if the decremented CTR is 0 and the condition is False.
001at	Branch if the condition is False.
0100z	Decrement the CTR; then branch if bits the decremented CTR is not 0 and the condition is True.
0101z	Decrement the CTR; then branch if the decremented CTR is 0 and the condition is True.
011at	Branch if the condition is True.
1a00t	Decrement the CTR; then branch if the decremented CTR is not 0.
1a01t	Decrement the CTR; then branch if the decremented CTR is 0.
1z1zz	Branch always.

The a and t bits of the BO field can be used by software to provide a hint about whether a branch is likely to be taken, as shown below:

at	Hint
00	No hint is given.
01	Reserved
01	The branch is very likely not to be taken.
11	The branch is very likely to be taken.

Parameters

target_address	Specifies the target address. For absolute branches such as **bca** and **bcla**, the target address can be immediate data containable in 16 bits.
BI	Specifies bit in Condition Register for condition comparison.
BO	Specifies Branch Option field used in instruction.

Examples

The following code branches to a target address dependent on the value in the Count Register:

```
addi 8,0,3
# Loads GPR 8 with 0x3.
mtctr 8
# The Count Register (CTR) equals 0x3.
addic. 9,8,0x1
# Adds one to GPR 8 and places the result in GPR 9.
# The Condition Register records a comparison against zero
# with the result.
bc 0xC,0,there
# Branch is taken if condition is true. 0 indicates that
# the 0 bit in the Condition Register is checked to
# determine if it is set (the LT bit is on). If it is set,
# the branch is taken.
bcl 0x8,2,there
```

```
# CTR is decremented by one, becomming 2.
# The branch is taken if CTR is not equal to 0 and CTR bit 2
# is set (the EQ bit is on).
# The Link Register contains address of next instruction.
```

Related Information

Chapter 1, “Assembler Overview” on page 1.

“Branch Processor” on page 17.

“Branch Instructions” on page 17.

bcctr or bcc (Branch Conditional to Count Register) Instruction

Purpose

Conditionally branches to the address contained within the Count Register.

Syntax

Bits	Value
0-5	19
6-10	BO
11-15	BI
16-18	///
19-20	BH
21-30	528
31	LK

PowerPC

bcctr *“BO” on page 147*, *“BI” on page 147*, *“BH” on page 147*
bcctrl *“BO” on page 147*, *“BI” on page 147*, *“BH” on page 147*

POWER family

bcc *“BO” on page 147*, *“BI” on page 147*, *“BH” on page 147*
bccl *“BO” on page 147*, *“BI” on page 147*, *“BH” on page 147*

See “Extended Mnemonics of Branch Instructions” on page 87 for more information.

Description

The **bcctr** and **bcc** instructions conditionally branch to an instruction specified by the branch target address contained within the Count Register. The branch target address is the concatenation of Count Register bits 0-29 and b’00’.

The **bcctr** and **bcc** instructions have two syntax forms. Each syntax form has a different effect on the Link bit and Link Register.

Syntax Form	Absolute Address Bit (AA)	Fixed-Point Exception Register	Link Bit (LK)	Condition Register Field 0
bcctr	None	None	0	None

bcctrl	None	None	1	None
bcc	None	None	0	None
bccl	None	None	1	None

The two syntax forms of the **bcctr** and **bcc** instructions never affect the Fixed-Point Exception Register or Condition Register Field 0. If the Link bit is 1, then the effective address of the instruction following the branch instruction is placed into the Link Register.

The Branch Option field (BO) is used to combine different types of branches into a single instruction. Extended mnemonics are provided to set the Branch Option field automatically.

The encoding for the BO field is defined in PowerPC architecture. The following list gives brief descriptions of the possible values for this field using pre-V2.00 encoding:

BO	Description
0000y	Decrement the CTR; then branch if the decremented CTR is not 0 and the condition is False.
0001y	Decrement the CTR; then branch if the decremented CTR is 0 and the condition is False.
001zy	Branch if the condition is False.
0100y	Decrement the CTR; then branch if bits the decremented CTR is not 0 and the condition is True.
0101y	Decrement the CTR; then branch if the decremented CTR is 0 and the condition is True.
011zy	Branch if the condition is True.
1z00y	Decrement the CTR; then branch if the decremented CTR is not 0.
1z01y	Decrement the CTR; then branch if the decremented CTR is 0.
1z1zz	Branch always.

In the PowerPC architecture, the bits are as follows:

- The z bit denotes a bit that must be 0. If the bit is not 0, the instruction form is invalid.
- The y bit provides a hint about whether a conditional branch is likely to be taken. The value of this bit can be either 0 or 1. The default value is 0.

In the POWER family Architecture, the z and y bits can be either 0 or 1.

The encoding for the BO field using V2.00 encoding is briefly described below:

Table 32. BO Field Values Using V2.00 Encoding

BO	Description
0000z	Decrement the CTR; then branch if the decremented CTR is not 0 and the condition is False.
0001z	Decrement the CTR; then branch if the decremented CTR is 0 and the condition is False.
001at	Branch if the condition is False.
0100z	Decrement the CTR; then branch if bits the decremented CTR is not 0 and the condition is True.
0101z	Decrement the CTR; then branch if the decremented CTR is 0 and the condition is True.
011at	Branch if the condition is True.
1a00t	Decrement the CTR; then branch if the decremented CTR is not 0.
1a01t	Decrement the CTR; then branch if the decremented CTR is 0.
1z1zz	Branch always.

The a and t bits of the BO field can be used by software to provide a hint about whether a branch is likely to be taken, as shown below:

at	Hint
00	No hint is given.
01	Reserved
01	The branch is very likely not to be taken.

at	Hint
11	The branch is very likely to be taken.

The Branch Hint field (BH) is used to provide a hint about the use of the instruction, as shown below:

BH	Hint
00	The instruction is not a subroutine return; the target address is likely to be the same as the target address used the preceding time the branch was taken.
01	Reserved
10	Reserved
11	The target address is not predictable.

Parameters

BO Specifies Branch Option field.
BI Specifies bit in Condition Register for condition comparison.
BIF Specifies the Condition Register field that specifies the Condition Register bit (LT, GT, EQ, or SO) to be used for condition comparison.
BH Provides a hint about the use of the instruction.

Examples

The following code branches from a specific address, dependent on a bit in the Condition Register, to the address contained in the Count Register, and no branch hints are given:

```
bcctr 0x4,0,0
cror 31,31,31
# Branch occurs if LT bit in the Condition Register is 0.
# The branch will be to the address contained in
# the Count Register.
bcctrl 0xC,1,0
return: cror 31,31,31
# Branch occurs if GT bit in the Condition Register is 1.
# The branch will be to the address contained in
# the Count Register.
# The Link register now contains the address of return.
```

Related Information

Chapter 1, “Assembler Overview” on page 1.

“Branch Processor” on page 17.

“Branch Instructions” on page 17.

bclr or bcr (Branch Conditional Link Register) Instruction

Purpose

Conditionally branches to an address contained in the Link Register.

Syntax

Bits	Value
0-5	19
6-10	BO

Bits	Value
11-15	BI
16-18	///
19-20	BH
21-30	16
31	LK

PowerPC
bclr *"BO" on page 149*, *"BI" on page 149*, *"BH" on page 149*
bclrl *"BO" on page 149*, *"BI" on page 149*, *"BH" on page 149*

POWER family
bcr *"BO" on page 149*, *"BI" on page 149*, *"BH" on page 149*
bcrl *"BO" on page 149*, *"BI" on page 149*, *"BH" on page 149*

See "Extended Mnemonics of Branch Instructions" on page 87 for more information.

Description

The **bclr** and **bcr** instructions branch to an instruction specified by the branch target address. The branch target address is the concatenation of bits 0-29 of the Link Register and b'00'.

The **bclr** and **bcr** instructions have two syntax forms. Each syntax form has a different effect on the Link bit and Link Register.

Syntax Form	Absolute Address Bit (AA)	Fixed-Point Exception Register	Link Bit (LK)	Condition Register Field 0
bclr	None	None	0	None
bclrl	None	None	1	None
bcr	None	None	0	None
bcrl	None	None	1	None

The two syntax forms of the **bclr** and **bcr** instruction never affect the Fixed-Point Exception Register or Condition Register Field 0. If the Link bit (LK) is 1, then the effective address of the instruction that follows the branch instruction is placed into the Link Register.

The Branch Option field (BO) is used to combine different types of branches into a single instruction. Extended mnemonics are provided to set the Branch Option field automatically.

The encoding for the BO field is defined in PowerPC architecture. The following list gives brief descriptions of the possible values for this field:

BO **Description**
`0000y` Decrement the CTR; then branch if the decremented CTR is not 0 and the condition is False.
`0001y` Decrement the CTR; then branch if the decremented CTR is 0 and the condition is False.
`001zy` Branch if the condition is False.
`0100y` Decrement the CTR; then branch if bits the decremented CTR is not 0 and the condition is True.
`0101y` Decrement the CTR; then branch if the decremented CTR is 0 and the condition is True.
`011zy` Branch if the condition is True.
`1z00y` Decrement the CTR; then branch if the decremented CTR is not 0.

BO	Description
1z01y	Decrement the CTR; then branch if the decremented CTR is 0.
1z1zz	Branch always.

In the PowerPC architecture, the bits are as follows:

- The z bit denotes a bit that must be 0. If the bit is not 0, the instruction form is invalid.
- The y bit provides a hint about whether a conditional branch is likely to be taken. The value of this bit can be either 0 or 1. The default value is 0.

In the POWER family Architecture, the z and y bits can be either 0 or 1.

The encoding for the BO field using V2.00 encoding is briefly described below:

Table 33. BO Field Values Using V2.00 Encoding

BO	Description
0000z	Decrement the CTR; then branch if the decremented CTR is not 0 and the condition is False.
0001z	Decrement the CTR; then branch if the decremented CTR is 0 and the condition is False.
001at	Branch if the condition is False.
0100z	Decrement the CTR; then branch if bits the decremented CTR is not 0 and the condition is True.
0101z	Decrement the CTR; then branch if the decremented CTR is 0 and the condition is True.
011at	Branch if the condition is True.
1a00t	Decrement the CTR; then branch if the decremented CTR is not 0.
1a01t	Decrement the CTR; then branch if the decremented CTR is 0.
1z1zz	Branch always.

The a and t bits of the BO field can be used by software to provide a hint about whether a branch is likely to be taken, as shown below:

at	Hint
00	No hint is given.
01	Reserved
01	The branch is very likely not to be taken.
11	The branch is very likely to be taken.

The Branch Hint field (BH) is used to provide a hint about the use of the instruction, as shown below:

BH	Hint
00	The instruction is not a subroutine return; the target address is likely to be the same as the target address used the preceding time the branch was taken.
01	Reserved
10	Reserved
11	The target address is not predictable.

Parameters

BO	Specifies Branch Option field.
BI	Specifies bit in Condition Register for condition comparison.
BH	Provides a hint about the use of the instruction.

Examples

The following code branches to the calculated branch target address dependent on bit 0 of the Condition Register, and no branch hint is given:

```
bclr 0x0,0,0
# The Count Register is decremented.
# A branch occurs if the LT bit is set to zero in the
# Condition Register and if the Count Register
# does not equal zero.
# If the conditions are met, the instruction branches to
# the concatenation of bits 0-29 of the Link Register and b'00'.
```

Related Information

Chapter 1, “Assembler Overview” on page 1.

“Branch Processor” on page 17.

“Branch Instructions” on page 17.

clcs (Cache Line Compute Size) Instruction

Purpose

Places a specified cache line size in a general-purpose register.

Note: The **clcs** instruction is supported only in the POWER family architecture.

Syntax

Bits	Value
0-5	31
6-10	RT
11-15	RA
16-20	///
21-30	531
31	Rc

POWER family

clcs *RT*, *RA*

Description

The **clcs** instruction places the cache line size specified by *RA* into the target general-purpose register (GPR) *RT*. The value of *RA* determines the cache line size returned in GPR *RT*.

Value of RA	Cache Line Size Returned in RT
00xxx	Undefined
010xx	Undefined
01100	Instruction Cache Line Size
01101	Data Cache Line Size
01110	Minimum Cache Line Size

01111	Maximum Cache Line Size
1xxxx	Undefined

Note: The value in GPR *RT* must lie between 64 and 4096, inclusive, or results will be undefined.

The **clcs** instruction has only one syntax form and does not affect the Fixed-Point Exception Register. If the Record (Rc) bit is set to 1, the Condition Register Field 0 is undefined.

Parameters

RT Specifies target general-purpose register where result of operation is stored.
RA Specifies cache line size requested.

Examples

The following code loads the maximum cache line size into GPR 4:

```
# Assume that 0xf is the cache
line size requested
.
    clcs 4,0xf
# GPR 4 now contains the maximum Cache Line size.
```

Related Information

The **clf** (Cache Line Flush) instruction, **cli** (Cache Line Invalidate) instruction, **dcbf** (Data Cache Block Flush) instruction, **dcbi** (Data Cache Block Invalidate) instruction, **dcbst** (Data Cache Block Store) instruction, **dcbt** (Data Cache Block Touch) instruction, **dcbtst** (Data Cache Block Touch for Store) instruction, **dcbz** or **dclz** (Data Cache Block Set to Zero) instruction, **dclst** (Data Cache Line Store) instruction, **icbi** (Instruction Cache Block Invalidate) instruction, **sync** (Synchronize) or **dcs** (Data Cache Synchronize) instruction.

Processing and Storage: Overview.

clf (Cache Line Flush) Instruction

Purpose

Writes a line of modified data from the data cache to main memory, or invalidates cached instructions or unmodified data.

Note: The **clf** instruction is supported only in the POWER family architecture.

Syntax

Bits	Value
0-5	31
6-10	///
11-15	RA
16-20	RB
21-30	118
31	Rc

POWER family
clf *RA*, *RB*

Description

The **clf** instruction calculates an effective address (EA) by adding the contents of general-purpose register (GPR) *RA* to the contents of GPR *RB*. If the *RA* field is 0, EA is the sum of the contents of *RB* and 0. If the *RA* field is not 0 and if the instruction does not cause a data storage interrupt, the result of the operation is placed back into GPR *RA*.

Consider the following when using the **clf** instruction:

- If the Data Relocate (DR) bit of the Machine State Register (MSR) is set to 0, the effective address is treated as a real address.
- If the MSR DR bit is set to 1, the effective address is treated as a virtual address. The MSR Instruction Relocate bit (IR) is ignored in this case.
- If a line containing the byte addressed by the EA is in the data cache and has been modified, writing the line to main memory is begun. If a line containing the byte addressed by EA is in one of the caches, the line is not valid.
- When MSR (DR) = 1, if the virtual address has no translation, a Data Storage interrupt occurs, setting the first bit of the Data Storage Interrupt Segment register to 1.
- A machine check interrupt occurs when the virtual address translates to an invalid real address and the line exists in the data cache.
- Address translation treats the instruction as a load to the byte addressed, ignoring protection and data locking. If this instruction causes a Translation Look-Aside buffer (TLB) miss, the reference bit is set.
- If the EA specifies an I/O address, the instruction is treated as a no-op, but the EA is placed in GPR *RA*.

The **clf** instruction has one syntax form and does not effect the Fixed-Point Exception register. If the Record (Rc) bit is set to 1, Condition Register Field 0 is undefined.

Parameters

RA Specifies the source general-purpose register for EA calculation and, if *RA* is not GPR 0, the target general-purpose register for operation.

RB Specifies the source general-purpose register for EA calculation.

Examples

The processor is not required to keep instruction storage consistent with data storage. The following code executes storage synchronization instructions prior to executing an modified instruction:

```
# Assume that instruction A is assigned to storage location
# ox0033 0020.
# Assume that the storage location to which A is assigned
# contains 0x0000 0000.
# Assume that GPR 3 contains 0x0000 0020.
# Assume that GPR 4 contains 0x0033 0020.
# Assume that GPR 5 contains 0x5000 0020.
st      R5,R4,R3         # Store branch instruction in memory
clf     R4,R3            # Flush A from cache to main memory
dcs                      # Ensure clf is complete
ics                      # Discard prefetched instructions
b       0x0033 0020      # Go execute the new instructions
```

After the store, but prior to the execution of the **clf**, **dcs**, and **ics** instructions, the copy of A in the cache contains the branch instruction. However, it is possible that the copy of A in main memory still contains 0.

The **clf** instruction copies the new instruction back to main memory and invalidates the cache line containing location A in both the instruction and data caches. The sequence of the **dcs** instruction followed by the **ics** instruction ensures that the new instruction is in main memory and that the copies of the location in the data and instruction caches are invalid before fetching the next instruction.

Related Information

The **clcs** (Cache Line Compute Size) instruction, **cli** (Cache Line Invalidate) instruction, **dcbf** (Data Cache Block Flush) instruction, **dcbi** (Data Cache Block Invalidate) instruction, **dcbst** (Data Cache Block Store) instruction, **dcbt** (Data Cache Block Touch) instruction, **dcbtst** (Data Cache Block Touch for Store) instruction, **dcbz** or **dclz** (Data Cache Block Set to Zero) instruction, **dclst** (Data Cache Line Store) instruction, **icbi** (Instruction Cache Block Invalidate) instruction, **sync** (Synchronize) or **dcs** (Data Cache Synchronize) instruction.

Processing and Storage: Overview.

---

cli (Cache Line Invalidate) Instruction

Purpose

Invalidates a line containing the byte addressed in either the data or instruction cache, causing subsequent references to retrieve the line again from main memory.

Note: The **cli** instruction is supported only in the POWER family architecture.

Syntax

Bits	Value
0-5	31
6-10	///
11-15	RA
16-20	RB
21-30	502
31	Rc

POWER family

cli *RA*, *RB*

Description

The **cli** instruction invalidates a line containing the byte addressed in either the data or instruction cache. If *RA* is not 0, the **cli** instruction calculates an effective address (EA) by adding the contents of general-purpose register (GPR) *RA* to the contents of GPR *RB*. If *RA* is not GPR 0 or the instruction does not cause a Data Storage interrupt, the result of the calculation is placed back into GPR *RA*.

Consider the following when using the **cli** instruction:

- If the Data Relocate (DR) bit of the Machine State Register (MSR) is 0, the effective address is treated as a real address.
- If the MSR DR bit is 1, the effective address is treated as a virtual address. The MSR Relocate (IR) bit is ignored in this case.
- If a line containing the byte addressed by the EA is in the data or instruction cache, the line is made unusable so the next reference to the line is taken from main memory.

- When MSR (DR) =1, if the virtual address has no translation, a Data Storage interrupt occurs, setting the first bit of the Data Storage Interrupt Segment Register to 1.
- Address translation treats the **cli** instruction as a store to the byte addressed, ignoring protection and data locking. If this instruction causes a Translation Look-Aside buffer (TLB) miss, the reference bit is set.
- If the EA specifies an I/O address, the instruction is treated as a no-op, but the EA is still placed in *RA*.

The **cli** instruction has only one syntax form and does not effect the Fixed-Point Exception Register. If the Record (Rc) bit is set to 1, the Condition Register Field 0 is undefined.

Parameters

RA Specifies the source general-purpose register for EA calculation and possibly the target general-purpose register (when *RA* is not GPR 0) for operation.

RB Specifies the source general-purpose register for EA calculation.

Security

The **cli** instruction is privileged.

Related Information

The **clcs** (Cache Line Compute Size) instruction, **clf** (Cache Line Flush) instruction, **dcbf** (Data Cache Block Flush) instruction, **dcbi** (Data Cache Block Invalidate) instruction, **dcbst** (Data Cache Block Store) instruction, **dcbt** (Data Cache Block Touch) instruction, **dcbtst** (Data Cache Block Touch for Store) instruction, **dcbz** or **dclz** (Data Cache Block Set to Zero) instruction, **dclst** (Data Cache Line Store) instruction, **icbi** (Instruction Cache Block Invalidate) instruction, **sync** (Synchronize) or **dcs** (Data Cache Synchronize) instruction.

Processing and Storage: Overview.

---

cmp (Compare) Instruction

Purpose

Compares the contents of two general-purpose registers algebraically.

Syntax

Bits	Value
0-5	31
6-8	BF
9	/
10	L
11-15	RA
16-20	RB
21-30	0
31	/

cmp *BF*, *L*, *RA*, *RB*

See Extended Mnemonics of Fixed-Point Compare Instructions for more information.

Description

The **cmp** instruction compares the contents of general-purpose register (GPR) *RA* with the contents of GPR *RB* as signed integers and sets one of the bits in Condition Register Field *BF*.

BF can be Condition Register Field 0-7; programmers can specify which Condition Register Field will indicate the result of the operation.

The bits of Condition Register Field *BF* are interpreted as follows:

Bit	Name	Description
0	LT	(RA) < SI
1	GT	(RA) > SI
2	EQ	(RA) = SI
3	SO	SO,OV

The **cmp** instruction has one syntax form and does not affect the Fixed-Point Exception Register. Condition Register Field 0 is unaffected unless it is specified as *BF* by the programmer.

Parameters

BF Specifies Condition Register Field 0-7 which indicates result of compare.
L Must be set to 0 for the 32-bit subset architecture.
RA Specifies source general-purpose register for operation.
RB Specifies source general-purpose register for operation.

Examples

The following code compares the contents of GPR 4 and GPR 6 as signed integers and sets Condition Register Field 0 to reflect the result of the operation:

```
# Assume GPR 4 contains 0xFFFF FFE7.
# Assume GPR 5 contains 0x0000 0011.
# Assume 0 is Condition Register Field 0.
cmp 0,4,6
# The LT bit of Condition Register Field 0 is set.
```

Related Information

The **cmpi** (Compare Immediate) instruction, **cmpl** (Compare Logical) instruction, **cmpli** (Compare Logical Immediate) instruction.

Fixed-Point Processor .

---

cmpi (Compare Immediate) Instruction

Purpose

Compares the contents of a general-purpose register and a given value algebraically.

Syntax

Bits	Value
0-5	11
6-8	BF
9	/
10	L
11-15	RA
16-31	SI

cmpi *BF*, *L*, *RA*, *SI*

See Extended Mnemonics of Fixed-Point Compare Instructions for more information.

Description

The **cmpi** instruction compares the contents of general-purpose register (GPR) *RA* and a 16- bit signed integer, *S*I, as signed integers and sets one of the bits in Condition Register Field *BF*.

BF can be Condition Register Field 0-7; programmers can specify which Condition Register Field will indicate the result of the operation.

The bits of Condition Register Field *BF* are interpreted as follows:

Bit	Name	Description
0	LT	(RA) < SI
1	GT	(RA) > SI
2	EQ	(RA) = SI
3	SO	SO,OV

The **cmpi** instruction has one syntax form and does not affect the Fixed-Point Exception Register. Condition Register Field 0 is unaffected unless it is specified as *BF* by the programmer.

Parameters

BF Specifies Condition Register Field 0-7 which indicates result of compare.
L Must be set to 0 for the 32-bit subset architecture.
RA Specifies first source general-purpose register for operation.
SI Specifies 16-bit signed integer for operation.

Examples

The following code compares the contents of GPR 4 and the signed integer 0x11 and sets Condition Register Field 0 to reflect the result of the operation:

```
# Assume GPR 4 contains 0xFFFF FFE7.
cmpi 0,4,0x11
# The LT bit of Condition Register Field 0 is set.
```

Related Information

The **cmp** (Compare) instruction, **cmpl** (Compare Logical) instruction, **cmpli** (Compare Logical Immediate) instruction.

Fixed-Point Processor .

cmpl (Compare Logical) Instruction

Purpose

Compares the contents of two general-purpose registers logically.

Syntax

Bits	Value
0-5	31
6-8	BF
9	/
10	L
11-15	RA
16-20	RB
21-30	32
31	/

cmpl *BF*, *L*, *RA*, *RB*

See Extended Mnemonics of Fixed-Point Compare Instructions for more information.

Description

The **cmpl** instruction compares the contents of general-purpose register (GPR) *RA* with the contents of GPR *RB* as unsigned integers and sets one of the bits in Condition Register Field *BF*.

BF can be Condition Register Field 0-7; programmers can specify which Condition Register Field will indicate the result of the operation.

The bits of Condition Register Field *BF* are interpreted as follows:

Bit	Name	Description
0	LT	(RA) < SI
1	GT	(RA) > SI
2	EQ	(RA) = SI
3	SO	SO,OV

The **cmpl** instruction has one syntax form and does not affect the Fixed-Point Exception Register. Condition Register Field 0 is unaffected unless it is specified as *BF* by the programmer.

Parameters

BF Specifies Condition Register Field 0-7 which indicates result of compare.
L Must be set to 0 for the 32-bit subset architecture.
RA Specifies source general-purpose register for operation.
RB Specifies source general-purpose register for operation.

Examples

The following code compares the contents of GPR 4 and GPR 5 as unsigned integers and sets Condition Register Field 0 to reflect the result of the operation:

```
# Assume GPR 4 contains 0xFFFF 0000.
# Assume GPR 5 contains 0x7FFF 0000.
# Assume 0 is Condition Register Field 0.
cmpl 0,4,5
# The GT bit of Condition Register Field 0 is set.
```

Related Information

The **cmp** (Compare) instruction, **cmpi** (Compare Immediate) instruction, **cmpli** (Compare Logical Immediate) instruction.

Fixed-Point Processor .

---

cmpli (Compare Logical Immediate) Instruction

Purpose

Compares the contents of a general-purpose register and a given value logically.

Syntax

Bits	Value
0-5	10
6-8	BF
9	/
10	L
11-15	RA
16-31	UI

cmpli *BF*, *L*, *RA*, *UI*

See Extended Mnemonics of Fixed-Point Compare Instructions for more information.

Description

The **cmpli** instruction compares the contents of general-purpose register (GPR) *RA* with the concatenation of x`0000' and a 16-bit unsigned integer, *UI,* as unsigned integers and sets one of the bits in the Condition Register Field *BF*.

BF can be Condition Register Field 0-7; programmers can specify which Condition Register Field will indicate the result of the operation.

The bits of Condition Register Field *BF* are interpreted as follows:

Bit	Name	Description
0	LT	(RA) < SI
1	GT	(RA) > SI
2	EQ	(RA) = SI
3	SO	SO,OV

The **cmpli** instruction has one syntax form and does not affect the Fixed-Point Exception Register. Condition Register Field 0 is unaffected unless it is specified as *BF* by the programmer.

Parameters

BF Specifies Condition Register Field 0-7 that indicates result of compare.
L Must be set to 0 for the 32-bit subset architecture.
RA Specifies source general-purpose register for operation.
UI Specifies 16-bit unsigned integer for operation.

Examples

The following code compares the contents of GPR 4 and the unsigned integer 0xff and sets Condition Register Field 0 to reflect the result of the operation:

```
# Assume GPR 4 contains 0x0000 00ff.
cmpli 0,4,0xff
# The EQ bit of Condition Register Field 0 is set.
```

Related Information

The **cmp** (Compare) instruction, **cmpi** (Compare Immediate) instruction, **cmpl** (Compare Logical) instruction.

Fixed-Point Processor .

cntlzd (Count Leading Zeros Double Word) Instruction

Purpose

Count the number of consecutive zero bits in the contents of a general purpose register, beginning with the high-order bit.

This instruction should only be used on 64-bit PowerPC processors running a 64-bit application.

Syntax

Bits	Value
0-5	31
6-10	S
11-15	A
16-20	00000
21-30	58
31	Rc

PowerPC64
cntlzd *rA*, *rS* (Rc=0)
cntlzd. *rA*, *rS*(Rc=1)

Description

A count of the number of consecutive zero bits, starting at bit 0 (the high-order bit) of register GPR *RS* is placed into GPR *RA*. This number ranges from 0 to 64, inclusive.

This instruction is defined only for 64-bit implementations. Using it on a 32-bit implementation will cause the system illegal instruction error handler to be invoked.

Other registers altered:

Condition Register (CR0 field):

Affected: LT, GT, EQ, SO (if Rc = 1)

Note: If Rc = 1, then LT is cleard in the CR0 field.

Parameters

RA Specifies the target general purpose register for the results of the instruction.
RS Specifies the source general purpose register containing the double-word to examine.

Implementation

This instruction is defined only for 64-bit implementations. Using it on a 32-bit implementation will cause the system illegal instruction error handler to be invoked.

---

cntlzw or cntlz (Count Leading Zeros Word) Instruction

Purpose

Places the number of leading zeros from a source general-purpose register in a general-purpose register.

Syntax

Bits	Value
0-5	31
6-10	RS
11-15	RA
16-20	///
21-30	26
31	Rc

PowerPC
cntlzw *RA*, *RS*
cntlzw. *RA*, *RS*

POWER family
cntlz *RA*, *RS*
cntlz. *RA*, *RS*

Description

The **cntlzw** and **cntlz** instructions count the number (between 0 and 32 inclusive) of consecutive zero bits starting at bit 0 of general-purpose register (GPR) *RS* and store the result in the target GPR *RA*.

Syntax Form	Overflow Exception (OE)	Fixed-Point Exception Register	Record Bit (Rc)	Condition Register Field 0
cntlzw	None	None	0	None
cntlzw.	None	None	1	LT,GT,EQ,SO
cntlz	None	None	0	None
cntlz.	None	None	1	LT,GT,EQ,SO

The two syntax forms of the **cntlzw** instruction and the two syntax forms of the **cntlz** instruction never affect the Fixed-Point Exception Register. If the syntax form sets the Record (Rc) bit to 1, the instruction affects the Less Than (LT) zero, Greater Than (GT) zero, Equal To (EQ) zero, and Summary Overflow (SO) bits in Condition Register Field 0.

Parameters

RA Specifies target general-purpose register where result of operation is stored.
RS Specifies source general-purpose register for operation.

Examples

The following code counts the number of leading zeros in the value contained in GPR 3 and places the result back in GPR 3:

```
# Assume GPR 3 contains 0x0061 9920.
cntlzw 3,3
# GPR 3 now holds 0x0000 0009.
```

Related Information

Fixed-Point Processor .

Fixed-Point Logical Instructions .

crand (Condition Register AND) Instruction

Purpose

Places the result of ANDing two Condition Register bits in a Condition Register bit.

Syntax

Bits	Value
0-5	19
6-10	BT
11-15	BA

Bits	Value
16-20	BB
21-30	257
31	/

crand *BT*, *BA*, *BB*

Description

The **crand** instruction logically ANDs the Condition Register bit specified by *BA* and the Condition Register bit specified by *BB* and places the result in the target Condition Register bit specified by *BT*.

The **crand** instruction has one syntax form and does not affect the Fixed-Point Exception Register.

Parameters

BT Specifies target Condition Register bit where result of operation is stored.
BA Specifies source Condition Register bit for operation.
BB Specifies source Condition Register bit for operation.

Examples

The following code logically ANDs Condition Register bits 0 and 5 and stores the result in Condition Register bit 31:

```
# Assume Condition Register bit 0 is 1.
# Assume Condition Register bit 5 is 0.
crand 31,0,5
# Condition Register bit 31 is now 0.
```

Related Information

Branch Processor .

Condition Register Instructions .

---

crandc (Condition Register AND with Complement) Instruction

Purpose

Places the result of ANDing one Condition Register bit and the complement of a Condition Register bit in a Condition Register bit.

Syntax

Bits	Value
0-5	19
6-10	BT
11-15	BA
16-20	BB
21-30	129
31	/

crandc *BT*, *BA*, *BB*

Description

The **crandc** instruction logically ANDs the Condition Register bit specified in *BA* and the complement of the Condition Register bit specified by *BB* and places the result in the target Condition Register bit specified by *BT*.

The **crandc** instruction has one syntax form and does not affect the Fixed-Point Exception Register.

Parameters

BT Specifies target Condition Register bit where result of operation is stored.
BA Specifies source Condition Register bit for operation.
BB Specifies source Condition Register bit for operation.

Examples

The following code logically ANDs Condition Register bit 0 and the complement of Condition Register bit 5 and puts the result in bit 31:

```
# Assume Condition Register bit 0 is 1.
# Assume Condition Register bit 5 is 0.
crandc 31,0,5
# Condition Register bit 31 is now 1.
```

Related Information

Branch Processor .

Condition Register Instructions .

---

creqv (Condition Register Equivalent) Instruction

Purpose

Places the complemented result of XORing two Condition Register bits in a Condition Register bit.

Syntax

Bits	Value
0-5	19
6-10	BT
11-15	BA
16-20	BB
21-30	289
31	/

creqv *BT*, *BA*, *BB*

See Extended Mnemonics of Condition Register Logical Instructions for more information.

Description

The **creqv** instruction logically XORs the Condition Register bit specified in *BA* and the Condition Register bit specified by *BB* and places the complemented result in the target Condition Register bit specified by *BT*.

The **creqv** instruction has one syntax form and does not affect the Fixed-Point Exception Register.

Parameters

BT Specifies target Condition Register bit where result of operation is stored.
BA Specifies source Condition Register bit for operation.
BB Specifies source Condition Register bit for operation.

Examples

The following code places the complemented result of XORing Condition Register bits 8 and 4 into Condition Register bit 4:

```
# Assume Condition Register bit 8 is 1.
# Assume Condition Register bit 4 is 0.
creqv 4,8,4
# Condition Register bit 4 is now 0.
```

Related Information

Branch Processor .

Condition Register Instructions .

---

crnand (Condition Register NAND) Instruction

Purpose

Places the complemented result of ANDing two Condition Register bits in a Condition Register bit.

Syntax

Bits	Value
0-5	19
6-10	BT
11-15	BA
16-20	BB
21-30	225
31	/

crnand *BT*, *BA*, *BB*

Description

The **crnand** instruction logically ANDs the Condition Register bit specified by *BA* and the Condition Register bit specified by *BB* and places the complemented result in the target Condition Register bit specified by *BT*.

The **crnand** instruction has one syntax form and does not affect the Fixed-Point Exception Register.

Parameters

BT Specifies target Condition Register bit where result of operation is stored.
BA Specifies source Condition Register bit for operation.
BB Specifies source Condition Register bit for operation.

Examples

The following code logically ANDs Condition Register bits 8 and 4 and places the complemented result into Condition Register bit 4:

```
# Assume Condition Register bit 8 is 1.
# Assume Condition Register bit 4 is 0.
crnand 4,8,4
# Condition Register bit 4 is now 1.
```

Related Information

Branch Processor .

Condition Register Instructions .

---

crnor (Condition Register NOR) Instruction

Purpose

Places the complemented result of ORing two Condition Register bits in a Condition Register bit.

Syntax

Bits	Value
0-5	19
6-10	BT
11-15	BA
16-20	BB
21-30	33
31	/

crnor *BT*, *BA*, *BB*

See Extended Mnemonics of Condition Register Logical Instructions for more information.

Description

The **crnor** instruction logically ORs the Condition Register bit specified in *BA* and the Condition Register bit specified by *BB* and places the complemented result in the target Condition Register bit specified by *BT*.

The **crnor** instruction has one syntax form and does not affect the Fixed Point Exception Register.

Parameters

BT Specifies target Condition Register bit where result of operation is stored.
BA Specifies source Condition Register bit for operation.

BB Specifies source Condition Register bit for operation.

Examples

The following code logically ORs Condition Register bits 8 and 4 and stores the complemented result into Condition Register bit 4:

```
# Assume Condition Register bit 8 is 1.
# Assume Condition Register bit 4 is 0.
crnor 4,8,4
# Condition Register bit 4 is now 0.
```

Related Information

Branch Processor .

Condition Register Instructions .

---

cror (Condition Register OR) Instruction

Purpose

Places the result of ORing two Condition Register bits in a Condition Register bit.

Syntax

Bits	Value
0-5	19
6-10	BT
11-15	BA
16-20	BB
21-30	449
31	/

cror *BT*, *BA*, *BB*

See Extended Mnemonics of Condition Register Logical Instructions for more information.

Description

The **cror** instruction logically ORs the Condition Register bit specified by *BA* and the Condition Register bit specified by *BB* and places the result in the target Condition Register bit specified by *BT*.

The **cror** instruction has one syntax form and does not affect the Fixed-Point Exception Register.

Parameters

BT Specifies target Condition Register bit where result of operation is stored.
BA Specifies source Condition Register bit for operation.
BB Specifies source Condition Register bit for operation.

Examples

The following code places the result of ORing Condition Register bits 8 and 4 into Condition Register bit 4:

```
# Assume Condition Register bit 8 is 1.
# Assume Condition Register bit 4 is 0.
cror 4,8,4
# Condition Register bit 4 is now 1.
```

Related Information

Branch Processor .

Condition Register Instructions .

---

crorc (Condition Register OR with Complement) Instruction

Purpose

Places the result of ORing a Condition Register bit and the complement of a Condition Register bit in a Condition Register bit.

Syntax

Bits	Value
0-5	19
6-10	BT
11-15	BA
16-20	BB
21-30	417
31	/

crorc *BT*, *BA*, *BB*

Description

The **crorc** instruction logically ORs the Condition Register bit specified by *BA* and the complement of the Condition Register bit specified by *BB* and places the result in the target Condition Register bit specified by *BT*.

The **crorc** instruction has one syntax form and does not affect the Fixed-Point Exception Register.

Parameters

BT Specifies target Condition Register bit where result of operation is stored.
BA Specifies source Condition Register bit for operation.
BB Specifies source Condition Register bit for operation.

Examples

The following code places the result of ORing Condition Register bit 8 and the complement of Condition Register bit 4 into Condition Register bit 4:

```
# Assume Condition Register bit 8 is 1.
# Assume Condition Register bit 4 is 0.
crorc 4,8,4
# Condition Register bit 4 is now 1.
```

Related Information

Branch Processor .

Condition Register Instructions .

---

crxor (Condition Register XOR) Instruction

Purpose

Places the result of XORing two Condition Register bits in a Condition Register bit.

Syntax

Bits	Value
0-5	19
6-10	BT
11-15	BA
16-20	BB
21-30	193
31	/

crxor *BT*, *BA*, *BB*

See Extended Mnemonics of Condition Register Logical Instructions for more information.

Description

The **crxor** instruction logically XORs the Condition Register bit specified by *BA* and the Condition Register bit specified by *BB* and places the result in the target Condition Register bit specified by *BT*.

The **crxor** instruction has one syntax form and does not affect the Fixed-Point Exception Register.

Parameters

BT Specifies target Condition Register bit where result of operation is stored.
BA Specifies source Condition Register bit for operation.
BB Specifies source Condition Register bit for operation.

Examples

The following code places the result of XORing Condition Register bits 8 and 4 into Condition Register bit 4:

```
# Assume Condition Register bit 8 is 1.
# Assume Condition Register bit 4 is 1.
crxor 4,8,4
# Condition Register bit 4 is now 0.
```

Related Information

Branch Processor .

Condition Register Instructions .

dcbf (Data Cache Block Flush) Instruction

Purpose

Copies modified cache blocks to main storage and invalidates the copy in the data cache.

Note: The **dcbf** instruction is supported only in the PowerPC architecture.

Syntax

Bits	Value
0-5	31
6-10	///
11-15	RA
16-20	RB
21-30	86
31	/

PowerPC
dcbf *RA*, *RB*

Description

The **dcbf** instruction calculates an effective address (EA) by adding the contents of general-purpose register (GPR) *RA* to the contents of GPR *RB*. If the *RA* field is 0, EA is the sum of the contents of *RB* and 0. If the cache block containing the target storage locations is in the data cache, it is copied back to main storage, provided it is different than the main storage copy.

Consider the following when using the **dcbf** instruction:

- If a block containing the byte addressed by the EA is in the data cache and has been modified, the block is copied to main memory. If a block containing the byte addressed by EA is in one of the caches, the block is made not valid.
- If the EA specifies a direct store segment address, the instruction is treated as a no-op.

The **dcbf** instruction has one syntax form and does not effect the Fixed-Point Exception Register.

Parameters

RA Specifies the source general-purpose register for operation.
RB Specifies the source general-purpose register for operation.

Examples

The software manages the coherency of storage shared by the processor and another system component, such as an I/O device that does not participate in the storage coherency protocol. The following code flushes the shared storage from the data cache prior to allowing another system component access to the storage:

```
# Assume that the variable A is assigned to storage location
# 0x0000 4540.
# Assume that the storage location to which A is assigned
# contains 0.
# Assume that GPR 3 contains 0x0000 0040.
```

```
# Assume that GPR 4 contains 0x0000 4500.
# Assume that GPR 5 contains -1.
st      R5,R4,R3         # Store 0xFFFF FFFF to A
dcbf    R4,R3            # Flush A from cache to main memory
sync                     # Ensure dcbf is complete. Start I/O
                         # operation
```

After the store, but prior to the execution of the **dcbf** and **sync** instructions, the copy of A in the cache contains a -1. However, it is possible that the copy of A in main memory still contains 0. After the **sync** instruction completes, the location to which A is assigned in main memory contains -1 and the processor data cache no longer contains a copy of location A.

Related Information

The **clcs** (Cache Line Compute Size) instruction, **clf** (Cache Line Flush) instruction, **cli** (Cache Line Invalidate) instruction, **dcbi** (Data Cache Block Invalidate) instruction, **dcbst** (Data Cache Block Store) instruction, **dcbt** (Data Cache Block Touch) instruction, **dcbtst** (Data Cache Block Touch for Store) instruction, **dcbz** or **dclz** (Data Cache Block Set to Zero) instruction, **dclst** (Data Cache Line Store) instruction, **icbi** (Instruction Cache Block Invalidate) instruction, **sync** (Synchronize) or **dcs** (Data Cache Synchronize) instruction.

dcbi (Data Cache Block Invalidate) Instruction

Purpose

Invalidates a block containing the byte addressed in the data cache, causing subsequent references to retrieve the block again from main memory.

Note: The **dcbi** instruction is supported only in the PowerPC architecture.

Syntax

Bits	Value
0-5	31
6-10	///
11-15	RA
16-20	RB
21-30	470
31	/

PowerPC
dcbi *RA*, *RB*

Description

If the contents of general-purpose register (GPR) *RA* is not 0, the **dcbi** instruction computes an effective address (EA) by adding the contents of GPR *RA* to the contents of GPR *RB*. Otherwise, the EA is the content of GPR *RB*.

If the cache block containing the addressed byte is in the data cache, the block is made invalid. Subsequent references to a byte in the block cause a reference to main memory.

The **dcbi** instruction is treated as a store to the addressed cache block with respect to protection.

The **dcbi** instruction has only one syntax form and does not effect the Fixed-Point Exception register.

Parameters

RA Specifies the source general-purpose register for EA computation.
RB Specifies the source general-purpose register for EA computation.

Security

The **dcbi** instruction is privileged.

Related Information

The **clcs** (Cache Line Compute Size) instruction, **clf** (Cache Line Flush) instruction, **cli** (Cache Line Invalidate) instruction, **dcbf** (Data Cache Block Flush) instruction, **dcbst** (Data Cache Block Store) instruction, **dcbt** (Data Cache Block Touch) instruction, **dcbtst** (Data Cache Block Touch for Store) instruction, **dcbz** or **dclz** (Data Cache Block Set to Zero) instruction, **dclst** (Data Cache Line Store) instruction, **icbi** (Instruction Cache Block Invalidate) instruction, **sync** (Synchronize) or **dcs** (Data Cache Synchronize) instruction.

Processing and Storage

dcbst (Data Cache Block Store) Instruction

Purpose

Allows a program to copy the contents of a modified block to main memory.

Note: The **dcbst** instruction is supported only in the PowerPC architecture.

Syntax

Bits	Value
0-5	31
6-10	///
11-15	RA
16-20	RB
21-30	54
31	/

PowerPC
dcbst *RA*, *RB*

Description

The **dcbst** instruction causes any modified copy of the block to be copied to main memory. If *RA* is not 0, the **dcbst** instruction computes an effective address (EA) by adding the contents of general-purpose register (GPR) *RA* to the contents of GPR *RB*. Otherwise, the EA is the contents of *RB*. If the cache block containing the addressed byte is in the data cache and is modified, the block is copied to main memory.

The **dcbst** instruction may be used to ensure that the copy of a location in main memory contains the most recent updates. This may be important when sharing memory with an I/O device that does not participate in the coherence protocol. In addition, the **dcbst** instruction can ensure that updates are immediately copied to a graphics frame buffer.

Treat the **dcbst** instruction as a load from the addressed byte with respect to address translation and protection.

The **dcbst** instruction has one syntax form and does not effect the Fixed-Point Exception register.

Parameters

RA Specifies the source general-purpose register for EA computation.
RB Specifies the source general-purpose register for EA computation.

Examples

1. The following code shares memory with an I/O device that does not participate in the coherence protocol:

```
# Assume that location A is memory that is shared with the
# I/O device.
# Assume that GPR 2 contains a control value indicating that
# and I/O operation should start.
# Assume that GPR 3 contains the new value to be placed in
# location A.
# Assume that GPR 4 contains the address of location A.
# Assume that GPR 5 contains the address of a control register
# in the I/O device.
st      3,0,4           # Update location A.
dcbst   0,4             # Copy new content of location A and
                        # other bytes in cache block to main
                        # memory.
sync                    # Ensure the dcbst instruction has
                        # completed.
st      2,0,5           # Signal I/O device that location A has
                        # been update.
```

2. The following code copies to a graphics frame buffer, ensuring that new values are displayed without delay:

```
# Assume that target memory is a graphics frame buffer.
# Assume that GPR 2, 3, and 4 contain new values to be displayed.
# Assume that GPR 5 contains the address minus 4 of where the
# first value is to be stored.
# Assume that the 3 target locations are known to be in a single
# cache block.
addi    6,5,4           # Compute address of first memory
                        # location.
stwu    2,4(5)          # Store value and update address ptr.
stwu    3,4(5)          # Store value and update address ptr.
stwu    4,4(5)          # Store value and update address ptr.
dcbst   0,6             # Copy new content of cache block to
                        # frame buffer. New values are displayed.
```

Related Information

The **clcs** (Cache Line Compute Size) instruction, **clf** (Cache Line Flush) instruction, **cli** (Cache Line Invalidate) instruction, **dcbf** (Data Cache Block Flush) instruction, **dcbi** (Data Cache Block Invalidate) instruction, **dcbt** (Data Cache Block Touch) instruction, **dcbtst** (Data Cache Block Touch for Store) instruction, **dcbz** or **dclz** (Data Cache Block Set to Zero) instruction, **dclst** (Data Cache Line Store) instruction, **icbi** (Instruction Cache Block Invalidate) instruction, **sync** (Synchronize) or **dcs** (Data Cache Synchronize) instruction.

Processing and Storage: Overview.

dcbt (Data Cache Block Touch) Instruction

Purpose

Allows a program to request a cache block fetch before it is actually needed by the program.

Note: The **dcbt** instruction is support only in the PowerPC architecture.

Syntax

Bits	Value
0-5	31
6-8	///
9-10	TH
11-15	RA
16-20	RB
21-30	278
31	/

PowerPC
dcbt *"RA" on page 174*, *"RB" on page 174*, *"TH" on page 174*

Description

The **dcbt** instruction may improve performance by anticipating a load from the addressed byte. The block containing the byte addressed by the effective address (EA) is fetched into the data cache before the block is needed by the program. The program can later perform loads from the block and may not experience the added delay caused by fetching the block into the cache. Executing the **dcbt** instruction does not invoke the system error handler.

If general-purpose register (GPR) *RA* is not 0, the effective address (EA) is the sum of the content of GPR *RA* and the content of GPR *RB*. Otherwise, the EA is the content of GPR *RB*.

Consider the following when using the **dcbt** instruction:

- If the EA specifies a direct store segment address, the instruction is treated as a no-op.
- The access is treated as a load from the addressed cache block with respect to protection. If protection does not permit access to the addressed byte, the **dcbt** instruction performs no operations.

  Note: f a program needs to store to the data cache block, use the **dcbtst** (Data Cache Block Touch for Store) instruction.

The Touch Hint field (TH) is used to provide a hint that the program will probably load soon from the storage locations specified by the EA and the TH field. The hint is ignored for locations that are caching-inhibited or guarded. The encodings of the TH field are as follows:

TH	Description
00	The storage location is the byte addressed by EA.
01	The storage locations are the block containing the byte addressed by EA and sequentially following blocks (that is, the blocks containing the bytes addressed by EA + n * block_size, where n = 0, 1, 2...).

TH	Description
10	Reserved.
11	The storage location are the block containing the byte addressed by EA and sequentially following blocks (that is, the blocks containing the bytes addressed by EA - n * block_size, where n = 0, 1, 2...).

The **dcbt** instruction serves as both a basic and extended mnemonic. The **dcbt** mnemonic with three operands is the basic form, and the **dcbt** with two operands is the extended form. In the extended form, the TH field is omitted and assumed to be 0b00.

The **dcbt** instruction has one syntax form and does not affect the Condition Register field 0 or the Fixed-Point Exception register.

Parameters

RA Specifies source general-purpose register for EA computation.
RB Specifies source general-purpose register for EA computation.
TH Indicates when a sequence of data cache blocks might be needed.

Examples

The following code sums the content of a one-dimensional vector:

```
# Assume that GPR 4 contains the address of the first element
# of the sum.
# Assume 49 elements are to be summed.
# Assume the data cache block size is 32 bytes.
# Assume the elements are word aligned and the address
# are multiples of 4.
        dcbt    0,4             # Issue hint to fetch first
                                # cache block.
        addi    5,4,32          # Compute address of second
                                # cache block.
        addi    8,0,6           # Set outer loop count.
        addi    7,0,8           # Set inner loop counter.
        dcbt    0,5             # Issue hint to fetch second
                                # cache block.
        lwz     3,4,0           # Set sum = element number 1.
bigloop:
        addi    8,8,-1          # Decrement outer loop count
                                # and set CR field 0.
        mtspr   CTR,7           # Set counter (CTR) for
                                # inner loop.
        addi    5,5,32          # Computer address for next
                                # touch.
lttlloop:
        lwzu    6,4,4           # Fetch element.
        add     3,3,6           # Add to sum.
        bc      16,0,lttlloop   # Decrement CTR and branch
                                # if result is not equal to 0.
        dcbt    0,5             # Issue hint to fetch next
                                # cache block.
        bc      4,3,bigloop     # Branch if outer loop CTR is
                                # not equal to 0.
        end                     # Summation complete.
```

Related Information

The **clcs** (Cache Line Compute Size) instruction, **clf** (Cache Line Flush) instruction, **cli** (Cache Line Invalidate) instruction, **dcbf** (Data Cache Block Flush) instruction, **dcbi** (Data Cache Block Invalidate) instruction, **dcbst** (Data Cache Block Store) instruction, **dcbtst** (Data Cache Block Touch for Store)

instruction, **dcbz** or **dclz** (Data Cache Block Set to Zero) instruction, **dclst** (Data Cache Line Store) instruction, **icbi** (Instruction Cache Block Invalidate) instruction, **sync** (Synchronize) or **dcs** (Data Cache Synchronize) instruction.

Processing and Storage

dcbtst (Data Cache Block Touch for Store) Instruction

Purpose

Allows a program to request a cache block fetch before it is actually needed by the program.

Note: The **dcbtst** instruction is supported only in the PowerPC architecture.

Syntax

Bits	Value
0-5	31
6-10	///
11-15	RA
16-20	RB
21-30	246
31	/

PowerPC
dcbtst *RA*, *RB*

Description

The **dcbtst** instruction improves performance by anticipating a store to the addressed byte. The block containing the byte addressed by the effective address (EA) is fetched into the data cache before the block is needed by the program. The program can later perform stores to the block and may not experience the added delay caused by fetching the block into the cache. Executing the **dcbtst** instruction does not invoke the system error handler.

The **dcbtst** instruction calculates an effective address (EA) by adding the contents of general-purpose register (GPR) *RA* to the contents of GPR *RB*. If the *RA* field is 0, EA is the sum of the contents of *RB* and 0.

Consider the following when using the **dcbtst** instruction:

- If the EA specifies a direct store segment address, the instruction is treated as a no-op.
- The access is treated as a load from the addressed cache block with respect to protection. If protection does not permit access to the addressed byte, the **dcbtst** instruction performs no operations.
- If a program does not need to store to the data cache block, use the **dcbt** (Data Cache Block Touch) instruction.

The **dcbtst** instruction has one syntax form and does not affect Condition Register field 0 or the Fixed-Point Exception register.

Parameters

RA Specifies source general-purpose register for operation.

RB Specifies source general-purpose register for operation.

Related Information

The **clcs** (Cache Line Compute Size) instruction, **clf** (Cache Line Flush) instruction, **cli** (Cache Line Invalidate) instruction, **dcbf** (Data Cache Block Flush) instruction, **dcbi** (Data Cache Block Invalidate) instruction, **dcbst** (Data Cache Block Store) instruction, **dcbt** (Data Cache Block Touch) instruction, **dcbz** or **dclz** (Data Cache Block Set to Zero) instruction, **dclst** (Data Cache Line Store) instruction, **icbi** (Instruction Cache Block Invalidate) instruction, **sync** (Synchronize) or **dcs** (Data Cache Synchronize) instruction.

Processing and Storage

---

dcbz or dclz (Data Cache Block Set to Zero) Instruction

Purpose

The PowerPC instruction, **dcbz**, sets all bytes of a cache block to 0.

The POWER family instruction, **dclz**,sets all bytes of a cache line to 0.

Syntax

Bits	Value
0-5	31
6-10	///
11-15	RA
16-20	RB
21-30	1014
31	/

PowerPC
dcbz *RA*, *RB*

POWER family
dclz *RA*, *RB*

Description

The **dcbz** and **dclz** instructions work with data cache blocks and data cache lines respectively. If *RA* is not 0, the **dcbz** and **dclz** instructions compute an effective address (EA) by adding the contents of general-purpose register (GPR) *RA* to the contents of GPR *RB*. If GPR *RA* is 0, the EA is the contents of GPR *RB*.

If the cache block or line containing the addressed byte is in the data cache, all bytes in the block or line are set to 0. Otherwise, the block or line is established in the data cache without reference to storage and all bytes of the block or line are set to 0.

For the POWER family instruction **dclz**, if GPR *RA* is not 0, the EA replaces the content of GPR *RA*.

The **dcbz** and **dclz** instructions are treated as a store to the addressed cache block or line with respect to protection.

The **dcbz** and **dclz** instructions have one syntax form and do not effect the Fixed-Point Exception Register. If bit 31 is set to 1, the instruction form is invalid.

Parameters

PowerPC

RA	Specifies the source register for EA computation.
RB	Specifies the source register for EA computation.

POWER family

RA	Specifies the source register for EA computation and the target register for EA update.
RB	Specifies the source register for EA computation.

Security

The **dclz** instruction is privileged.

Related Information

The **clcs** (Cache Line Compute Size) instruction, **clf** (Cache Line Flush) instruction, **cli** (Cache Line Invalidate) instruction, **dcbf** (Data Cache Block Flush) instruction, **dcbi** (Data Cache Block Invalidate) instruction, **dcbst** (Data Cache Block Store) instruction, **dcbt** (Data Cache Block Touch) instruction, **dcbtst** (Data Cache Block Touch for Store) instruction, **dclst** (Data Cache Line Store) instruction, **icbi** (Instruction Cache Block Invalidate) instruction, **sync** (Synchronize) or **dcs** (Data Cache Synchronize) instruction.

Fixed-Point Processor .

---

dclst (Data Cache Line Store) Instruction

Purpose

Stores a line of modified data in the data cache into main memory.

Note: The **dclst** instruction is supported only in the POWER family architecture.

Syntax

Bits	Value
0-5	31
6-10	///
11-15	RA
16-20	RB
21-30	630
31	Rc

POWER family

dclst *RA*, *RB*

Description

The **dclst** instruction adds the contents of general-purpose register (GPR) *RA* to the contents of GPR *RB*. It then stores the sum in *RA* as the effective address (EA) if *RA* is not 0 and the instruction does not cause a Data Storage interrupt.

If *RA* is 0, the effective address (EA) is the sum of the contents of GPR *RB* and 0.

Consider the following when using the **dclst** instruction:

- If the line containing the byte addressed by the EA is in the data cache and has been modified, the **dclst** instruction writes the line to main memory.
- If data address translation is enabled (that is, the Machine State Register (MSR) Data Relocate (DR) bit is 1) and the virtual address has no translation, a Data Storage interrupt occurs with bit 1 of the Data Storage Interrupt Segment Register set to 1.
- If data address translation is enabled (MSR DR bit is 1), the virtual address translates to an unusable real address, the line exists in the data cache, and a Machine Check interrupt occurs.
- If data address translation is disabled (MSR DR bit is 0) the address specifies an unusable real address, the line exists in the data cache, and a Machine Check interrupt occurs.
- If the EA specifies an I/O address, the instruction is treated as a no-op, but the effective address is placed into GPR *RA*.
- Address translation treats the **dclst** instruction as a load to the byte addressed, ignoring protection and data locking. If this instruction causes a Translation Look-Aside Buffer (TLB) miss, the reference bit is set.

The **dclst** instruction has one syntax form and does not effect the Fixed-Point Exception register. If the Record (Rc) bit is set to 1, Condition Register Field 0 is undefined.

Parameters

RA Specifies the source and target general-purpose register where result of operation is stored.
RB Specifies the source general-purpose register for EA calculation.

Examples

The following code stores the sum of the contents of GPR 4 and GPR 6 in GPR 6 as the effective address:

```
# Assume that GPR 4 contains 0x0000 3000.
# Assume that GPR 6 is the target register and that it
# contains 0x0000 0000.
dclst 6,4
# GPR 6 now contains 0x0000 3000.
```

Related Information

The **clcs** (Cache Line Compute Size) instruction, **clf** (Cache Line Flush) instruction, **cli** (Cache Line Invalidate) instruction, **dcbf** (Data Cache Block Flush) instruction, **dcbi** (Data Cache Block Invalidate) instruction, **dcbst** (Data Cache Block Store) instruction, **dcbt** (Data Cache Block Touch) instruction, **dcbtst** (Data Cache Block Touch for Store) instruction, **dcbz** or **dclz** (Data Cache Block Set to Zero) instruction, **icbi** (Instruction Cache Block Invalidate) instruction, **sync** (Synchronize) or **dcs** (Data Cache Synchronize) instruction.

Processing and Storage

div (Divide) Instruction

Purpose

Divides the contents of a general-purpose register concatenated with the MQ Register by the contents of a general-purpose register and stores the result in a general-purpose register.

Note: The **div** instruction is supported only in the POWER family architecture.

Syntax

Bits	Value
0-5	31
6-10	RT
11-15	RA
16-20	RB
21	OE
22-30	331
31	Rc

POWER family

div *RT*, *RA*, *RB*
div. *RT*, *RA*, *RB*
divo *RT*, *RA*, *RB*
divo. *RT*, *RA*, *RB*

Description

The **div** instruction concatenates the contents of general-purpose register (GPR) *RA* and the contents of Multiply Quotient (MQ) Register, divides the result by the contents of GPR *RB*, and stores the result in the target GPR *RT*. The remainder has the same sign as the dividend, except that a zero quotient or a zero remainder is always positive. The results obey the equation:

```
dividend = (divisor x quotient) + remainder
```

where a `dividend` is the original (RA) || (MQ), `divisor` is the original (*RB*), `quotient` is the final (*RT*), and `remainder` is the final (MQ).

For the case of `-2**31 P -1`, the MQ Register is set to 0 and `-2**31` is placed in GPR *RT*. For all other overflows, the contents of MQ, the target GPR *RT*, and the Condition Register Field 0 (if the Record Bit (Rc) is 1) are undefined.

The **div** instruction has four syntax forms. Each syntax form has a different effect on Condition Register Field 0 and the Fixed-Point Exception Register.

Syntax Form	Overflow Exception (OE)	Fixed-Point Exception Register	Record Bit (Rc)	Condition Register Field 0
div	0	None	0	None
div.	0	None	1	LT,GT,EQ,SO
divo	1	SO,OV	0	None
divo.	1	SO,OV	1	LT,GT,EQ,SO

The four syntax forms of the **div** instruction never affect the Carry bit (CA) in the Fixed-Point Exception Register. If the syntax form sets the Overflow Exception (OE) bit to 1, the instruction affects the Summary Overflow (SO) and Overflow (OV) bits in the Fixed-Point Exception Register. If the syntax form sets the Record (Rc) bit to 1, the instruction affects the Less Than (LT) zero, Greater Than (GT) zero, Equal To (EQ) zero, and Summary Overflow (SO) bits in Condition Register Field 0.

Parameters

RT Specifies target general-purpose register where result of operation is stored.
RA Specifies source general-purpose register for operation.
RB Specifies source general-purpose register for operation.

Examples

1. The following code divides the contents of GPR 4, concatenated with the MQ Register, by the contents of GPR 6 and stores the result in GPR 4:

```
# Assume the MQ Register contains 0x0000 0001.
# Assume GPR 4 contains 0x0000 0000.
# Assume GPR 6 contains 0x0000 0002.
div 4,4,6
# GPR 4 now contains 0x0000 0000.
# The MQ Register now contains 0x0000 0001.
```

2. The following code divides the contents of GPR 4, concatenated with the MQ Register, by the contents of GPR 6, stores the result in GPR 4, and sets Condition Register Field 0 to reflect the result of the operation:

```
# Assume the MQ Register contains 0x0000 0002.
# Assume GPR 4 contains 0x0000 0000.
# Assume GPR 6 contains 0x0000 0002.
div. 4,4,6
# GPR 4 now contains 0x0000 0001.
# MQ Register contains 0x0000 0000.
```

3. The following code divides the contents of GPR 4, concatenated with the MQ Register, by the contents of GPR 6, places the result in GPR 4, and sets the Summary Overflow and Overflow bits in the Fixed-Point Exception Register to reflect the result of the operation:

```
# Assume GPR 4 contains 0x0000 0001.
# Assume GPR 6 contains 0x0000 0000.
# Assume the MQ Register contains 0x0000 0000.
divo 4,4,6
# GPR 4 now contains an undefined quantity.
# The MQ Register is undefined.
```

4. The following code divides the contents of GPR 4, concatenated with the MQ Register, by the contents of GPR 6, places the result in GPR 4, and sets the Summary Overflow and Overflow bits in the Fixed-Point Exception Register and Condition Register Field 0 to reflect the result of the operation:

```
# Assume GPR 4 contains 0x-1.
# Assume GPR 6 contains 0x2.
# Assume the MQ Register contains 0xFFFFFFFF.
divo. 4,4,6
# GPR 4 now contains 0x0000 0000.
# The MQ Register contains 0x-1.
```

Related Information

Fixed-Point Processor .

Fixed-Point Arithmetic Instructions .

divd (Divide Double Word) Instruction

Purpose

Divide the contents of a general purpose register by the contents of a general purpose register, storing the result into a general purpose register.

This instruction should only be used on 64-bit PowerPC processors running a 64-bit application.

Syntax

Bits	Value
0-5	31
6-10	D
11-15	A
16-20	B
21	OE
22-30	489
31	Rc

PowerPC64

divd	*RT*, *RA*, *RB* (OE=0 Rc=0)
divd.	*RT*, *RA*, *RB* (OE=0 Rc=1)
divdo	*RT*, *RA*, *RB* (OE=1 Rc=0)
divdo.	*RT*, *RA*, *RB* (OE=1 Rc=1)

Description

The 64-bit dividend is the contents of *RA*. The 64-bit divisor is the contents of *RB*. The 64- bit quotient is placed into *RT*. The remainder is not supplied as a result.

Both the operands and the quotient are interpreted as signed integers. The quotient is the unique signed integer that satisfies the equation-dividend = (quotient * divisor) + r, where 0 <= r < |divisor| if the dividend is non-negative, and -|divisor| < r <=0 if the dividend is negative.

If an attempt is made to perform the divisions 0x8000_0000_0000_0000 / -1 or / 0, the contents of *RT* are undefined, as are the contents of the LT, GT, and EQ bits of the condition register 0 field (if the record bit (Rc) = 1 (the **divd.** or **divdo.** instructions)). In this case, if overflow enable (OE) = 1 then the overflow bit (OV) is set.

The 64-bit signed remainder of dividing (*RA*) by (*RB*) can be computed as follows, except in the case that (*RA*) = -2**63 and (*RB*) = -1:

```
divd      RT,RA,RB      # RT = quotient
mulld     RT,RT,RB      # RT = quotient * divisor
subf      RT,RT,RA      # RT = remainder
```

Parameters

RT	Specifies target general-purpose register for the result of the computation.
RA	Specifies source general-purpose register for the dividend.

RB Specifies source general-purpose register for the divisor.

Implementation

This instruction is defined only for 64-bit implementations. Using it on a 32-bit implementation will cause the system illegal instruction error handler to be invoked.

divdu (Divide Double Word Unsigned) Instruction

Purpose

Divide the contents of a general purpose register by the contents of a general purpose register, storing the result into a general purpose register.

Syntax

Bits	Value
0-5	31
6-10	D
11-15	A
16-20	B
21	OE
22-30	457
31	Rc

PowerPC

divdu *RT*, *RA*, *RB* (OE=0 Rc=0)
divdu. *RT*, *RA*, *RB* (OE=0 Rc=1)
divduo *RT*, *RA*, *RB* (OE=1 Rc=0)
divduo. *RT*, *RA*, *RB* (OE=1 Rc=1)

Description

The 64-bit dividend is the contents of *RA*. The 64-bit divisor is the contents of *RB*. The 64- bit quotient is placed into *RT*. The remainder is not supplied as a result.

Both the operands and the quotient are interpreted as unsigned integers, except that if the record bit (Rc) is set to 1 the first three bits of th condition register 0 (CR0) field are set by signed comparison of the result to zero. The quotient is the unique unsigned integer that satisfies the equation: dividend = (quotient * divisor) + r, where 0 <= r < divisor.

If an attempt is made to perform the division (*anything*) / 0 the contents of *RT* are undefined, as are the contents of the LT, GT, and EQ bits of the CR0 field (if Rc = 1). In this case, if the overflow enable bit (OE) = 1 then the overflow bit (OV) is set.

The 64-bit unsigned remainder of dividing (*RA*) by (*RB*) can be computed as follows:

```
divdu     RT,RA,RB      # RT = quotient
mulld     RT,RT,RB      # RT = quotient * divisor
subf      RT,RT,RA      # RT = remainder
```

Other registers altered:

- Condition Register (CR0 field):
  Affected: LT, GT, EQ, SO (if Rc = 1)
- XER: Affected: SO, OV (if OE = 1)
  Note: The setting of the affected bits in the XER is mode-independent, and reflects overflow of the 64-bit result.

Parameters

RT	Specifies target general-purpose register for the result of the computation.
RA	Specifies source general-purpose register for the dividend.
RB	Specifies source general-purpose register for the divisor.

Implementation

This instruction is defined only for 64-bit implementations. Using it on a 32-bit implementation will cause the system illegal instruction error handler to be invoked.

divs (Divide Short) Instruction

Purpose

Divides the contents of a general-purpose register by the contents of a general-purpose register and stores the result in a general-purpose register.

Note: The **divs** instruction is supported only in the POWER family architecture.

Syntax

Bits	Value
0-5	31
6-10	RT
11-15	RA
16-20	RB
21	
22-30	363
31	Rc

POWER family

divs	*RT*, *RA*, *RB*
divs.	*RT*, *RA*, *RB*
divso	*RT*, *RA*, *RB*
divso.	*RT*, *RA*, *RB*

Description

The **divs** instruction divides the contents of general-purpose register (GPR) *RA* by the contents of GPR *RB* and stores the result in the target GPR *RT*. The remainder has the same sign as the dividend, except that a zero quotient or a zero remainder is always positive. The results obey the equation:

```
dividend = (divisor x quotient) + remainder
```

where a `dividend` is the original (*RA*), `divisor` is the original (*RB*), `quotient` is the final (*RT*), and `remainder` is the final (MQ).

For the case of `-2**31 P -1`, the MQ Register is set to 0 and `-2**31` is placed in GPR *RT*. For all other overflows, the contents of MQ, the target GPR *RT* and the Condition Register Field 0 (if the Record Bit (Rc) is 1) are undefined.

The **divs** instruction has four syntax forms. Each syntax form has a different effect on Condition Register Field 0 and the Fixed-Point Exception Register.

Syntax Form	Overflow Exception (OE)	Fixed-Point Exception Register	Record Bit (Rc)	Condition Register Field 0
divs	0	None	0	None
divs.	0	None	1	LT,GT,EQ,SO
divso	1	SO,OV	0	None
divso.	1	SO,OV	1	LT,GT,EQ,SO

The four syntax forms of the **divs** instruction never affect the Carry bit (CA) in the Fixed-Point Exception Register. If the syntax form sets the Overflow Exception (OE) bit to 1, the instruction affects the Summary Overflow (SO) and Overflow (OV) bits in the Fixed-Point Exception Register. If the syntax form sets the Record (Rc) bit to 1, the instruction affects the Less Than (LT) zero, Greater Than (GT) zero, Equal To (EQ) zero, and Summary Overflow (SO) bits in Condition Register Field 0.

Parameters

RT Specifies target general-purpose register where result of operation is stored.
RA Specifies source general-purpose register for operation.
RB Specifies source general-purpose register for operation.

Examples

1. The following code divides the contents of GPR 4 by the contents of GPR 6 and stores the result in GPR 4:

```
# Assume GPR 4 contains 0x0000 0001.
# Assume GPR 6 contains 0x0000 0002.
divs 4,4,6
# GPR 4 now contains 0x0.
# The MQ Register now contains 0x1.
```

2. The following code divides the contents of GPR 4 by the contents of GPR 6, stores the result in GPR 4 and sets Condition Register Field 0 to reflect the result of the operation:

```
# Assume GPR 4 contains 0x0000 0002.
# Assume GPR 6 contains 0x0000 0002.
divs. 4,4,6
# GPR 4 now contains 0x0000 0001.
# The MQ Register now contains 0x0000 0000.
```

3. The following code divides the contents of GPR 4 by the contents of GPR 6, stores the result in GPR 4, and sets the Summary Overflow and Overflow bits in the Fixed-Point Exception Register to reflect the result of the operation:

```
# Assume GPR 4 contains 0x0000 0001.
# Assume GPR 6 contains 0x0000 0000.
divso 4,4,6
# GPR 4 now contains an undefined quantity.
```

4. The following code divides the contents of GPR 4 by the contents of GPR 6, stores the result in GPR 4, and sets the Summary Overflow and Overflow bits in the Fixed-Point Exception Register and Condition Register Field 0 to reflect the result of the operation:

```
# Assume GPR 4 contains 0x-1.
# Assume GPR 6 contains 0x0000 00002.
# Assume the MQ Register contains 0x0000 0000.
divso. 4,4,6
# GPR 4 now contains 0x0000 0000.
# The MQ register contains 0x-1.
```

Related Information

Fixed-Point Processor .

Fixed-Point Arithmetic Instructions .

---

divw (Divide Word) Instruction

Purpose

Divides the contents of a general-purpose register by the contents of another general-purpose register and stores the result in a third general-purpose register.

Note: The **divw** instruction is supported only in the PowerPC architecture.

Syntax

Bits	Value
0-5	31
6-10	RT
11-15	RA
16-20	RB
21	OE
22-30	491
31	Rc

PowerPC

divw	*RT*, *RA*, *RB*
divw.	*RT*, *RA*, *RB*
divwo	*RT*, *RA*, *RB*
divwo.	*RT*, *RA*, *RB*

Description

The **divw** instruction divides the contents of general-purpose register (GPR) *RA* by the contents of GPR *RB*, and stores the result in the target GPR *RT*. The dividend, divisor, and quotient are interpreted as signed integers.

For the case of -2**31 / -1, and all other cases that cause overflow, the content of GPR *RT* is undefined.

The **divw** instruction has four syntax forms. Each syntax form has a different effect on Condition Register Field 0 and the Fixed-Point Exception Register.

Syntax Form	Overflow Exception (OE)	Fixed-Point Exception Register	Record Bit (Rc)	Condition Register Field 0
divw	0	None	0	None
divw.	0	None	1	LT,GT,EQ,SO
divwo	1	SO, OV	0	None
divwo.	1	SO, OV	1	LT,GT,EQ,SO

The four syntax forms of the **divw** instruction never affect the Carry bit (CA) in the Fixed-Point Exception Register. If the syntax form sets the Overflow Exception (OE) bit to 1, the instruction affects the Summary Overflow (SO) and Overflow (OV) bits in the Fixed-Point Exception Register. If the syntax form sets the Record (Rc) bit to 1, the instruction affects the Less Than (LT) zero, Greater Than (GT) zero, Equal To (EQ) zero, and Summary Overflow (SO) bits in Condition Register Field 0.

Parameters

RT Specifies target general-purpose register where result of operation is stored.
RA Specifies source general-purpose register for dividend.
RB Specifies source general-purpose register for divisor.

Examples

1. The following code divides the contents of GPR 4 by the contents of GPR 6 and stores the result in GPR 4:

```
# Assume GPR 4 contains 0x0000 0000.
# Assume GPR 6 contains 0x0000 0002.
divw 4,4,6
# GPR 4 now contains 0x0000 0000.
```

2. The following code divides the contents of GPR 4 by the contents of GPR 6, stores the result in GPR 4 and sets Condition Register Field 0 to reflect the result of the operation:

```
# Assume GPR 4 contains 0x0000 0002.
# Assume GPR 6 contains 0x0000 0002.
divw. 4,4,6
# GPR 4 now contains 0x0000 0001.
```

3. The following code divides the contents of GPR 4 by the contents of GPR 6, places the result in GPR 4, and sets the Summary Overflow and Overflow bits in the Fixed-Point Exception Register to reflect the result of the operation:

```
# Assume GPR 4 contains 0x0000 0001.
# Assume GPR 6 contains 0x0000 0000.
divwo 4,4,6
# GPR 4 now contains an undefined quantity.
```

4. The following code divides the contents of GPR 4 by the contents of GPR 6, places the result in GPR 4, and sets the Summary Overflow and Overflow bits in the Fixed-Point Exception Register and Condition Register Field 0 to reflect the result of the operation:

```
# Assume GPR 4 contains 0x8000 0000.
# Assume GPR 6 contains 0xFFFF FFFF.
divwo. 4,4,6
# GPR 4 now contains undefined quantity.
```

Related Information

Fixed-Point Processor .

Fixed-Point Arithmetic Instructions .

divwu (Divide Word Unsigned) Instruction

Purpose

Divides the contents of a general-purpose register by the contents of another general-purpose register and stores the result in a third general-purpose register.

Note: The **divwu** instruction is supported only in the PowerPC architecture.

Syntax

Bits	Value
0-5	31
6-10	RT
11-15	RA
16-20	RB
21	OE
22-30	459
31	Rc

PowerPC

divwu *RT*, *RA*, *RB*
divwu. *RT*, *RA*, *RB*
divwuo *RT*, *RA*, *RB*
divwuo. *RT*, *RA*, *RB*

Description

The **divwu** instruction divides the contents of general-purpose register (GPR) *RA* by the contents of GPR *RB*, and stores the result in the target GPR *RT*. The dividend, divisor, and quotient are interpreted as unsigned integers.

For the case of division by 0, the content of GPR *RT* is undefined.

Note: Although the operation treats the result as an unsigned integer, if Rc is 1, the Less Than (LT) zero, Greater Than (GT) zero, and Equal To (EQ) zero bits of Condition Register Field 0 are set as if the result were interpreted as a signed integer.

The **divwu** instruction has four syntax forms. Each syntax form has a different effect on Condition Register Field 0 and the Fixed-Point Exception Register.

Syntax Form	Overflow Exception (OE)	Fixed-Point Exception Register	Record Bit (Rc)	Condition Register Field 0
divwu	0	None	0	None
divwu.	0	None	1	LT,GT,EQ,SO
divwuo	1	SO, OV,	0	None
divwuo.	1	SO, OV	1	LT,GT,EQ,SO

The four syntax forms of the **divwu** instruction never affect the Carry bit (CA) in the Fixed-Point Exception Register. If the syntax form sets the Overflow Exception (OE) bit to 1, the instruction affects the Summary

Overflow (SO) and Overflow (OV) bits in the Fixed-Point Exception Register. If the syntax form sets the Record (Rc) bit to 1, the instruction affects the Less Than (LT) zero, Greater Than (GT) zero, Equal To (EQ) zero, and Summary Overflow (SO) bits in Condition Register Field 0.

Parameters

RT Specifies target general-purpose register where result of operation is stored.
RA Specifies source general-purpose register for EA calculation.
RB Specifies source general-purpose register for EA calculation.

Examples

1. The following code divides the contents of GPR 4 by the contents of GPR 6 and stores the result in GPR 4:

```
# Assume GPR 4 contains 0x0000 0000.
# Assume GPR 6 contains 0x0000 0002.
divwu 4,4,6
# GPR 4 now contains 0x0000 0000.
```

2. The following code divides the contents of GPR 4 by the contents of GPR 6, stores the result in GPR 4 and sets Condition Register Field 0 to reflect the result of the operation:

```
# Assume GPR 4 contains 0x0000 0002.
# Assume GPR 6 contains 0x0000 0002.
divwu. 4,4,6
# GPR 4 now contains 0x0000 0001.
```

3. The following code divides the contents of GPR 4 by the contents of GPR 6, places the result in GPR 4, and sets the Summary Overflow and Overflow bits in the Fixed-Point Exception Register to reflect the result of the operation:

```
# Assume GPR 4 contains 0x0000 0001.
# Assume GPR 6 contains 0x0000 0000.
divwuo 4,4,6
# GPR 4 now contains an undefined quantity.
```

4. The following code divides the contents of GPR 4 by the contents of GPR 6, places the result in GPR 4, and sets the Summary Overflow and Overflow bits in the Fixed-Point Exception Register and Condition Register Field 0 to reflect the result of the operation:

```
# Assume GPR 4 contains 0x8000 0000.
# Assume GPR 6 contains 0x0000 0002.
divwuo. 4,4,6
# GPR 4 now contains 0x4000 0000.
```

Related Information

Fixed-Point Processor .

Fixed-Point Arithmetic Instructions .

---

doz (Difference or Zero) Instruction

Purpose

Computes the difference between the contents of two general-purpose registers and stores the result or the value zero in a general-purpose register.

Note: The **doz** instruction is supported only in the POWER family architecture.

Syntax

Bits	Value
0-5	31
6-10	RT
11-15	RA
16-20	RB
21	OE
22-30	264
31	Rc

POWER family

doz *RT*, *RA*, *RB*
doz. *RT*, *RA*, *RB*
dozo *RT*, *RA*, *RB*
dozo. *RT*, *RA*, *RB*

Description

The **doz** instruction adds the complement of the contents of general-purpose register (GPR) *RA*, 1, and the contents of GPR *RB,* and stores the result in the target GPR *RT*.

If the value in GPR *RA* is algebraically greater than the value in GPR *RB*, then GPR *RT* is set to 0.

The **doz** instruction has four syntax forms. Each syntax form has a different effect on Condition Register Field 0 and the Fixed-Point Exception Register.

Syntax Form	Overflow Exception (OE)	Fixed-Point Exception Register	Record Bit (Rc)	Condition Register Field 0
doz	0	None	0	None
doz.	0	None	1	LT,GT,EQ,SO
dozo	1	SO,OV	0	None
dozo.	1	SO,OV	1	LT,GT,EQ,SO

The four syntax forms of the **doz** instruction never affect the Carry bit (CA) in the Fixed-Point Exception Register. If the syntax form sets the Overflow Exception (OE) bit to 1, the instruction affects the Summary Overflow (SO) and Overflow (OV) bits in the Fixed-Point Exception Register; the Overflow (OV) bit can only be set on positive overflows. If the syntax form sets the Record (Rc) bit to 1, the instruction effects the Less Than (LT) zero, Greater Than (GT) zero, Equal To (EQ) zero, and Summary Overflow (SO) bits in Condition Register Field 0.

Parameters

RT Specifies target general-purpose register where result of operation is stored.
RA Specifies source general-purpose register for operation.
RB Specifies source general-purpose register for operation.

Examples

1. The following code determines the difference between the contents of GPR 4 and GPR 6 and stores the result in GPR 4:

```
# Assume GPR 4 holds 0x0000 0001.
# Assume GPR 6 holds 0x0000 0002.
doz 4,4,6
# GPR 4 now holds 0x0000 0001.
```

2. The following code determines the difference between the contents of GPR 4 and GPR 6, stores the result in GPR 4, and sets Condition Register Field 0 to reflect the result of the operation:

```
# Assume GPR 4 holds 0x0000 0001.
# Assume GPR 6 holds 0x0000 0000.
doz. 4,4,6
# GPR 4 now holds 0x0000 0000.
```

3. The following code determines the difference between the contents of GPR 4 and GPR 6, stores the result in GPR 4, and sets the Summary Overflow and Overflow bits in the Fixed-Point Exception Register to reflect the result of the operation:

```
# Assume GPR 4 holds 0x0000 0002.
# Assume GPR 6 holds 0x0000 0008.
dozo 4,4,6
# GPR 4 now holds 0x0000 0006.
```

4. The following code determines the difference between the contents of GPR 4 and GPR 6, stores the result in GPR 4, and sets the Summary Overflow and Overflow bits in the Fixed-Point Exception Register and Condition Register Field 0 to reflect the result of the operation:

```
# Assume GPR 4 holds 0xEFFF FFFF.
# Assume GPR 6 holds 0x0000 0000.
dozo. 4,4,6
# GPR 4 now holds 0x1000 0001.
```

Related Information

Fixed-Point Processor .

Fixed-Point Arithmetic Instructions .

---

dozi (Difference or Zero Immediate) Instruction

Purpose

Computes the difference between the contents of a general-purpose register and a signed 16-bit integer and stores the result or the value zero in a general-purpose register.

Note: The **dozi** instruction is supported only in the POWER family architecture.

Syntax

Bits	Value
0-5	09
6-10	RT
11-15	RA
16-31	SI

POWER family

dozi *RT*, *RA*, *SI*

Description

The **dozi** instruction adds the complement of the contents of general-purpose register (GPR) *RA*, the 16-bit signed integer *SI*, and 1 and stores the result in the target GPR *RT*.

If the value in GPR *RA* is algebraically greater than the 16-bit signed value in the *SI* field, then GPR *RT* is set to 0.

The **dozi** instruction has one syntax form and does not effect Condition Register Field 0 or the Fixed-Point Exception Register.

Parameters

RT Specifies target general-purpose register where result of operation is stored.
RA Specifies source general-purpose register for operation.
SI Specifies signed 16-bit integer for operation.

Examples

The following code determines the difference between GPR 4 and 0x0 and stores the result in GPR 4:

```
# Assume GPR 4 holds 0x0000 0001.
dozi 4,4,0x0
# GPR 4 now holds 0x0000 0000.
```

Related Information

Fixed-Point Processor .

Fixed-Point Arithmetic Instructions .

---

eciwx (External Control In Word Indexed) Instruction

Purpose

Translates the effective address (EA) to a real address, sends the real address to a controller, and loads the word returned by the controller into a register.

Note: The **eciwx** instruction is defined only in the PowerPC architecture and is an optional instruction. It is supported on the PowerPC 601 RISC Microprocessor, PowerPC 603 RISC Microprocessor, and PowerPC 604 RISC Microprocessor.

Syntax

Bits	Value
0-5	31
6-10	RT
11-15	RA
16-20	RB
21-30	310
31	/

eciwx *RT*, *RA*, *RB*

Description

The **eciwx** instruction translates EA to a real address, sends the real address to a controller, and places the word returned by the controller in general-purpose register *RT*. If *RA* = 0, the EA is the content of *RB*, otherwise EA is the sum of the content of *RA* plus the content of *RB*.

If EAR(E) = 1, a load request for the real address corresponding to EA is sent to the controller identified by EAR(RID), bypassing the cache. The word returned by the controller is placed in *RT*.

Notes:

1. EA must be a multiple of 4 (a word-aligned address); otherwise, the result is boundedly undefined.
2. The operation is treated as a load to the addressed byte with respect to protection.

Parameters

RT Specifies target general-purpose register where result of operation is stored.
RA Specifies source general-purpose register for operation.
RB Specifies source general-purpose register for operation.

Related Information

"ecowx (External Control Out Word Indexed) Instruction".

Chapter 2, "Processing and Storage" on page 9.

---

ecowx (External Control Out Word Indexed) Instruction

Purpose

Translates the effective address (EA) to a real address and sends the real address and the contents of a register to a controller.

> **Note:** The **ecowx** instruction is defined only in the PowerPC architecture and is an optional instruction. It is supported on the PowerPC 601 RISC Microprocessor, PowerPC 603 RISC Microprocessor, and PowerPC 604 RISC Microprocessor.

Syntax

Bits	Value
0-5	31
6-10	RS
11-15	RA
16-20	RB
21-30	438
31	/

ecowx *RS*, *RA*, *RB*

Description

The **ecowx** instruction translates EA to a real address and sends the real address and the content of general-purpose register *RS* to a controller. If *RA* = 0, the EA is the content of *RB*, otherwise EA is the sum of the content of *RA* plus the content of *RB*.

If EAR(E) = 1, a store request for the real address corresponding to EA is sent to the controller identified by EAR(RID), bypassing the cache. The content of *RS* is sent with the store request.

Notes:

1. EA must be a multiple of 4 (a word-aligned address); otherwise, the result is boundedly undefined.
2. The operation is treated as a store to the addressed byte with respect to protection.

Parameters

RS Specifies target general-purpose register where result of operation is stored.
RA Specifies source general-purpose register for operation.
RB Specifies source general-purpose register for operation.

Related Information

The **eciwx** (External Control In Word Indexed) instruction.

Processing and Storage

---

eieio (Enforce In-Order Execution of I/O) Instruction

Purpose

Ensures that cache-inhibited storage accesses are performed in main memory in the order specified by the program.

Note: The **eieio** instruction is supported only in the PowerPC architecture.

Syntax

Bits	Value
0-5	31
6-10	///
11-15	///
16-20	///
21-30	854
31	/

PowerPC

eieio

Description

The **eieio** instruction provides an ordering function that ensures that all load and store instructions initiated prior to the **eieio** instruction complete in main memory before any loads or stores subsequent to the **eieio** instruction access memory. If the **eieio** instruction is omitted from a program, and the memory locations are unique, the accesses to main storage may be performed in any order.

Note: The **eieio** instruction is appropriate for cases where the only requirement is to control the order of storage references as seen by I/O devices. However, the **sync** (Synchronize) instruction provides an ordering function for all instructions.

The **eieio** instruction has one syntax form and does not affect Condition Register Field 0 or the Fixed-Point Exception Register.

Examples

The following code ensures that, if the memory locations are in cache-inhibited storage, the load from location AA and the store to location BB are completed in main storage before the content of location CC is fetched or the content of location DD is updated:

```
lwz   r4,AA(r1)
stw   r4,BB(r1)
eieio
lwz   r5,CC(r1)
stw   r5,DD(r1)
```

Note: If the memory locations of AA, BB, CC, and DD are not in cache-inhibited memory, the **eieio** instruction has no effect on the order that instructions access memory.

Related Information

The **sync** (Synchronize) or **dcs** (Data Cache Synchronize) instruction.

Processing and Storage

extsw (Extend Sign Word) Instruction

Purpose

Copy the low-order 32 bits of a general purpose register into another general purpose register, and sign extend the fullword to a double-word in size (64 bits).

Syntax

Bits	Value
0-5	31
6-10	S
11-15	A
16-20	00000
21-30	986
31	Rc

PowerPC

extsw *RA*, *RS* (Rc=0)
extsw. *RA*, *RS*(Rc=1)

Description

The contents of the low-order 32 bits of general purpose register (GPR) *RS* are placed into the low-order 32 bits of GPR *RA*. Bit 32 of GPR *RS* is used to fill the high-order 32 bits of GPR *RA*.

Other registers altered:

- Condition Register (CR0 field):
  Affected: LT, GT, EQ, SO (if Rc = 1)
- XER:
  Affected: CA

Parameters

RA Specifies the target general purpose register for the result of the operation.
RS Specifies the source general purpose register for the operand of instruction.

Implementation

This instruction is defined only for 64-bit implementations. Using it on a 32-bit implementation will cause the system illegal instruction error handler to be invoked.

eqv (Equivalent) Instruction

Purpose

Logically XORs the contents of two general-purpose registers and places the complemented result in a general-purpose register.

Syntax

Bits	Value
0-5	31
6-10	RS
11-15	RA
16-20	RB
21-30	284
31	Rc

eqv *RA*, *RS*, *RB*
eqv. *RA*, *RS*, *RB*

Description

The **eqv** instruction logically XORs the contents of general-purpose register (GPR) *RS* with the contents of GPR *RB* and stores the complemented result in the target GPR *RA*.

The **eqv** instruction has two syntax forms. Each syntax form has a different effect on Condition Register Field 0.

Syntax Form	Overflow Exception (OE)	Fixed-Point Exception Register	Record Bit (Rc)	Condition Register Field 0
eqv	None	None	0	None
eqv.	None	None	1	LT,GT,EQ,SO

The two syntax forms of the **eqv** instruction never affect the Fixed-Point Exception Register. If the syntax form sets the Record (Rc) bit to 1, the instruction affects the Less Than (LT) zero, Greater Than (GT) zero, Equal To (EQ) zero, and Summary Overflow (SO) bits in Condition Register Field 0.

Parameters

RA Specifies target general-purpose register where result of operation is stored.
RS Specifies source general-purpose register for operation.
RB Specifies source general-purpose register for operation.

Examples

1. The following code logically XORs the contents of GPR 4 and GPR 6 and stores the complemented result in GPR 4:

```
# Assume GPR 4 holds 0xFFF2 5730.
# Assume GPR 6 holds 0x7B41 92C0.
eqv 4,4,6
# GPR 4 now holds 0x7B4C 3A0F.
```

2. The following code XORs the contents of GPR 4 and GPR 6, stores the complemented result in GPR 4, and sets Condition Register Field 0 to reflect the result of the operation:

```
# Assume GPR 4 holds 0x0000 00FD.
# Assume GPR 6  holds 0x7B41 92C0.
eqv. 4,4,6
# GPR 4 now holds 0x84BE 6DC2.
```

Related Information

Fixed-Point Processor .

Fixed-Point Logical Instructions .

---

extsb (Extend Sign Byte) Instruction

Purpose

Extends the sign of the low-order byte.

Note: The **extsb** instruction is supported only in the PowerPC architecture.

Syntax

Bits	Value
0-5	31
6-10	RS
11-15	RA
16-20	///
21-30	954
31	Rc

PowerPC
extsb *RA*, *RS*
extsb. *RA*, *RS*

Description

The **extsb** instruction places bits 24-31 of general-purpose register (GPR) *RS* into bits 24-31 of GPR *RA* and copies bit 24 of register *RS* in bits 0-23 of register *RA*.

The **extsb** instruction has two syntax forms. Each syntax form has a different effect on Condition Register Field 0 and the Fixed-Point Exception Register.

If the syntax form sets the Record (Rc) bit to 1, the instruction affects the Less Than (LT) zero, Greater Than (GT) zero, Equal To (EQ) zero, and Summary Overflow (SO) bits in Condition Register Field 0.

Parameters

RA Specifies target general-purpose register where result of operation is stored.
RS Specifies source general-purpose register of containing the byte to be extended.

Examples

1. The following code extends the sign of the least significant byte contained in GPR 4 and places the result in GPR 6:

```
# Assume GPR 6 holds 0x5A5A 5A5A.
extsb 4,6
# GPR 6 now holds 0x0000 005A.
```

2. The following code extends the sign of the least significant byte contained in GPR 4 and sets Condition Register Field 0 to reflect the result of the operation:

```
# Assume GPR 4 holds 0xA5A5 A5A5.
extsb. 4,4
# GPR 4 now holds 0xFFFF FFA5.
```

Related Information

Fixed-Point Processor .

Fixed-Point Logical Instructions .

---

extsh or exts (Extend Sign Halfword) Instruction

Purpose

Extends the lower 16-bit contents of a general-purpose register.

Syntax

Bits	Value
0-5	31
6-10	RS
11-15	RA
16-20	///
21	OE
22-30	922
31	Rc

PowerPC
extsh *RA*, *RS*
extsh. *RA*, *RS*

POWER family
exts *RA*, *RS*
exts. *RA*, *RS*

Description

The **extsh** and **exts** instructions place bits 16-31 of general-purpose register (GPR) *RS* into bits 16-31 of GPR *RA* and copy bit 16 of GPR *RS* in bits 0-15 of GPR *RA*.

The **extsh** and **exts** instructions each have two syntax forms. Each syntax form has a different effect on Condition Register Field 0.

Syntax Form	Overflow Exception (OE)	Fixed-Point Exception Register	Record Bit (Rc)	Condition Register Field 0
extsh	None	None	0	None
extsh.	None	None	1	LT,GT,EQ,SO
exts	None	None	0	None
exts.	None	None	1	LT,GT,EQ,SO

The two syntax forms of the **extsh** instruction, and the two syntax forms of the **extsh** instruction, never affect the Fixed-Point Exception Register. If the syntax form sets the Record (Rc) bit to 1, the instruction affects the Less Than (LT) zero, Greater Than (GT) zero, Equal To (EQ) zero, and Summary Overflow (SO) bits in Condition Register Field 0.

Parameters

RA Specifies general-purpose register receives extended integer.
RS Specifies source general-purpose register for operation.

Examples

1. The following code places bits 16-31 of GPR 6 into bits 16-31 of GPR 4 and copies bit 16 of GPR 6 into bits 0-15 of GPR 4:

```
# Assume GPR 6 holds 0x0000 FFFF.
extsh 4,6
# GPR 6 now holds 0xFFFF FFFF.
```

2. The following code places bits 16-31 of GPR 6 into bits 16-31 of GPR 4, copies bit 16 of GPR 6 into bits 0-15 of GPR 4, and sets Condition Register Field 0 to reflect the result of the operation:

```
# Assume GPR 4 holds 0x0000 2FFF.
extsh. 6,4
# GPR 6 now holds 0x0000 2FFF.
```

Related Information

Fixed-Point Processor .

Fixed-Point Logical Instructions .

fabs (Floating Absolute Value) Instruction

Purpose

Stores the absolute value of the contents of a floating-point register in another floating-point register.

Syntax

Bits	Value
0-5	63
6-10	FRT
11-15	///
16-20	FRB
21-30	264
31	Rc

fabs *FRT*, *FRB*
fabs. *FRT*, *FRB*

Description

The **fabs** instruction sets bit 0 of floating-point register (FPR) *FRB* to 0 and places the result into FPR *FRT*.

The **fabs** instruction has two syntax forms. Each syntax form has a different effect on Condition Register Field 1.

Syntax Form	Floating-Point Status and Control Register	Record Bit (Rc)	Condition Register Field 1
fabs	None	0	None
fabs.	None	1	FX,FEX,VX,OX

The two syntax forms of the **fabs** instruction never affect the Floating-Point Status and Control Register. If the syntax form sets the Record (Rc) bit to 1, the instruction affects the Floating-Point Exception Summary (FX), Floating-Point Enabled Exception Summary (FEX), Floating-Point Invalid Operation Exception Summary (VX), and Floating-Point Overflow Exception (OX) bits in Condition Register Field 1.

Parameters

FRT Specifies target floating-point register for operation.
FRB Specifies source floating-point register for operation.

Examples

1. The following code sets bit 0 of FPR 4 to zero and place sthe result in FPR 6:

```
# Assume FPR 4 holds 0xC053 4000 0000 0000.
fabs 6,4
# GPR 6 now holds 0x4053 4000 0000 0000.
```

2. The following code sets bit 0 of FPR 25 to zero, places the result in FPR 6, and sets Condition Register Field 1 to reflect the result of the operation:

```
# Assume FPR 25 holds 0xFFFF FFFF FFFF FFFF.
fabs. 6,25
# GPR 6 now holds 0x7FFF FFFF FFFF FFFF.
```

Related Information

Floating-Point Processor .

Floating-Point Move Instructions .

Interpreting the Contents of a Floating-Point Register .

---

fadd or fa (Floating Add) Instruction

Purpose

Adds two floating-point operands and places the result in a floating-point register.

Syntax

Bits	Value
0-5	63
6-10	FRT
11-15	FRA
16-20	FRB
21-25	///
26-30	21
31	Rc

PowerPC
fadd *FRT*, *FRA*, *FRB*
fadd. *FRT*, *FRA*, *FRB*

POWER family
fa *FRT*, *FRA*, *FRB*
fa. *FRT*, *FRA*, *FRB*

Bits	Value
0-5	59
6-10	FRT
11-15	FRA
16-20	FRB
21-25	///
26-30	21
31	Rc

PowerPC
fadds *FRT*, *FRA*, *FRB*
fadds. *FRT*, *FRA*, *FRB*

Description

The **fadd** and **fa** instructions add the 64-bit, double-precision floating-point operand in floating-point register (FPR) *FRA* to the 64-bit, double-precision floating-point operand in FPR *FRB*.

The **fadds** instruction adds the 32-bit single-precision floating-point operand in FPR *FRA* to the 32-bit single-precision floating-point operand in FPR *FRB*.

The result is rounded under control of the Floating-Point Rounding Control Field *RN* of the Floating-Point Status and Control Register and is placed in FPR *FRT*.

Addition of two floating-point numbers is based on exponent comparison and addition of the two significands. The exponents of the two operands are compared, and the significand accompanying the smaller exponent is shifted right, with its exponent increased by one for each bit shifted, until the two exponents are equal. The two significands are then added algebraically to form the intermediate sum. All 53 bits in the significand as well as all three guard bits (G, R and X) enter into the computation.

The Floating-Point Result Field of the Floating-Point Status and Control Register is set to the class and sign of the result except for Invalid Operation exceptions when the Floating-Point Invalid Operation Exception Enable (VE) bit of the Floating-Point Status and Control Register is set to 1.

The **fadd**, **fadds**, and **fa** instructions each have two syntax forms. Each syntax form has a different effect on Condition Register Field 1.

Syntax Form	Floating-Point Status and Control Register	Record Bit (Rc)	Condition Register Field 1
fadd	C,FL,FG,FE,FU,FR,FI,OX,UX, XX,VXSNAN,VXISI	0	None
fadd.	C,FL,FG,FE,FU,FR,FI,OX,UX, XX,VXSNAN,VXISI	1	FX,FEX,VX,OX
fadds	C,FL,FG,FE,FU,FR,FI,OX,UX, XX,VXSNAN,VXISI	0	None
fadds.	C,FL,FG,FE,FU,FR,FI,OX,UX, XX,VXSNAN,VXISI	1	FX,FEX,VX,OX
fa	C,FL,FG,FE,FU,FR,FI,OX,UX, XX,VXSNAN,VXISI	0	None
fa.	C,FL,FG,FE,FU,FR,FI,OX,UX, XX,VXSNAN,VXISI	1	FX,FEX,VX,OX

All syntax forms of the **fadd**, **fadds**, and **fa** instructions always affect the Floating-Point Status and Control Register. If the syntax form sets the Record (Rc) bit to 1, the instruction affects the Floating-Point Exception Summary (FX), Floating-Point Enabled Exception Summary (FEX), Floating-Point Invalid Operation Exception Summary (VX), and Floating-Point Overflow Exception (OX) bits in Condition Register Field 1.

Parameters

FRT Specifies target floating-point register for operation.
FRA Specifies source floating-point register for operation.
FRB Specifies source floating-point register for operation.

Examples

1. The following code adds the contents of FPR 4 and FPR 5, places the result in FPR 6, and sets the Floating-Point Status and Control Register to reflect the result of the operation:

```
# Assume FPR 4 contains 0xC053 4000 0000 0000.
# Assume FPR 5 contains 0x400C 0000 0000 0000.
fadd 6,4,5
# FPR 6 now contains 0xC052 6000 0000 0000.
```

2. The following code adds the contents of FPR 4 and FPR 25, places the result in FPR 6, and sets Condition Register Field 1 and the Floating-Point Status and Control Register to reflect the result of the operation:

```
# Assume FPR 4 contains 0xC053 4000 0000 0000.
# Assume FPR 25 contains 0xFFFF FFFF FFFF FFFF.
fadd. 6,4,25
# GPR 6 now contains 0xFFFF FFFF FFFF FFFF.
```

Related Information

Floating-Point Processor .

Floating-Point Arithmetic Instructions .

Interpreting the Contents of a Floating-Point Register .

fcfid (Floating Convert from Integer Double Word) Instruction

Purpose

Convert the fixed-point contents of a floating-point register to a double-precision floating-point number.

Syntax

Bits	Value
0-5	63
6-10	D
11-15	00000
16-20	B
21-30	846
31	Rc

PowerPC
fcfid *FRT*, *FRB* (Rc=0)
fcfid. *FRT*, *FRB* (Rc=1)

Description

The 64-bit signed fixed-point operand in floating-point register (FPR) *FRB* is converted to an infinitely precise floating-point integer. The result of the conversion is rounded to double-precision using the rounding mode specified by FPSCR[RN] and placed into FPR *FRT*.

FPSCR[FPRF] is set to the class and sign of the result. FPSCR[FR] is set if the result is incremented when rounded. FPSCR[FI] is set if the result is inexact.

The **fcfid** instruction has two syntax forms. Each syntax form has a different effect on Condition Register Field 1.

Syntax Form	Floating-Point Status and Control Register	Record Bit (Rc)	Condition Register Field 1

fcfid	FPRF,FR,FI,FX,XX	0	None
fcfid.	FPRF,FR,FI,FX,XX	1	FX,FEX,VX,OX

Parameters

FRT Specifies the target floating-point register for the operation.
FRB Specifies the source floating-point register for the operation.

Implementation

This instruction is defined only for 64-bit implementations. Using it on a 32-bit implementation will cause the system illegal instruction error handler to be invoked.

fcmpo (Floating Compare Ordered) Instruction

Purpose

Compares the contents of two floating-point registers.

Syntax

Bits	Value
0-5	63
6-8	BF
9-10	//
11-15	FRA
16-20	FRB
21-30	32
31	/

fcmpo *BF*, *FRA*, *FRB*

Description

The **fcmpo** instruction compares the 64-bit, double-precision floating-point operand in floating-point register (FPR) *FRA* to the 64-bit, double-precision floating-point operand in FPR *FRB*. The Floating-Point Condition Code Field (FPCC) of the Floating-Point Status and Control Register (FPSCR) is set to reflect the value of the operand FPR *FRA* with respect to operand FPR *FRB*. The value *BF* determines which field in the condition register receives the four FPCC bits.

Consider the following when using the **fcmpo** instruction:

- If one of the operands is either a Quiet NaN (QNaN) or a Signaling NaN (SNaN), the Floating-Point Condition Code is set to reflect unordered (FU).
- If one of the operands is a SNaN, then the Floating-Point Invalid Operation Exception bit VXSNAN of the Floating-Point Status and Control Register is set. Also:
  - If Invalid Operation is disabled (that is, the Floating-Point Invalid Operation Exception Enable bit of the Floating-Point Status and Control Register is 0), then the Floating-Point Invalid Operation Exception bit VXVC is set (signaling an an invalid compare).

– If one of the operands is a QNaN, then the Floating-Point Invalid Operation Exception bit VXVC is set.

The **fcmpo** instruction has one syntax form and always affects the FT, FG, FE, FU, VXSNAN, and VXVC bits in the Floating-Point Status and Control Register.

Parameters

BF Specifies field in the condition register that receives the four FPCC bits.
FRA Specifies source floating-point register.
FRB Specifies source floating-point register.

Examples

The following code compares the contents of FPR 4 and FPR 6 and sets Condition Register Field 1 and the Floating-Point Status and Control Register to reflect the result of the operation:

```
# Assume CR = 0 and FPSCR = 0.
# Assume FPR 5 contains 0xC053 4000 0000 0000.
# Assume FPR 4 contains 0x400C 0000 0000 0000.
fcmpo 6,4,5
# CR now contains 0x0000 0040.
# FPSCR now contains 0x0000 4000.
```

Related Information

Floating-Point Processor .

Floating-Point Compare Instructions .

fcmpu (Floating Compare Unordered) Instruction

Purpose

Compares the contents of two floating-point registers.

Syntax

Bits	Value
0-5	63
6-8	BF
9-10	//
11-15	FRA
16-20	FRB
21-30	0
31	/

fcmpu *BF*, *FRA*, *FRB*

Description

The **fcmpu** instruction compares the 64-bit double precision floating-point operand in floating-point register (FPR) *FRA* to the 64-bit double precision floating-point operand in FPR *FRB*. The Floating-Point Condition

Code Field (FPCC) of the Floating-Point Status and Control Register (FPSCR) is set to reflect the value of the operand *FRA* with respect to operand *FRB*. The value *BF* determines which field in the condition register receives the four FPCC bits.

Consider the following when using the **fcmpu** instruction:

- If one of the operands is either a Quiet NaN or a Signaling NaN, the Floating-Point Condition Code is set to reflect unordered (FU).
- If one of the operands is a Signaling NaN, then the Floating-Point Invalid Operation Exception bit VXSNAN of the Floating-Point Status and Control Register is set.

The **fcmpu** instruction has one syntax form and always affects the FT, FG, FE, FU, and VXSNAN bits in the FPSCR.

Parameters

BF Specifies a field in the condition register that receives the four FPCC bits.
FRA Specifies source floating-point register.
FRB Specifies source floating-point register.

Examples

The following code compares the contents of FPR 5 and FPR 4:

```
# Assume FPR 5 holds 0xC053 4000 0000 0000.
# Assume FPR 4 holds 0x400C 0000 0000 0000.
# Assume CR = 0 and FPSCR = 0.
fcmpu 6,4,5
# CR now contains 0x0000 0040.
# FPSCR now contains 0x0000 4000.
```

Related Information

Floating-Point Processor .

Floating-Point Compare Instructions .

fctid (Floating Convert to Integer Double Word) Instruction

Purpose

Convert the contents of a floating-point register to a 64-bit signed fixed-point integer, placing the results into another floating-point register.

Syntax

Bits	Value
0-5	63
6-10	D
11-15	00000
16-20	B
21-30	814
31	Rc

PowerPC
fctid *FRT*, *FRB* (Rc=0)
fctid. *FRT*, *FRB* (Rc=1)

Description

The floating-point operand in floating-point register (FPR) *FRB* is converted to a 64-bit signed fixed-point integer, using the rounding mode specified by FPSCR[RN], and placed into FPR *FRT*.

If the operand in *FRB* is greater than 2**63 - 1, then FPR *FRT* is set to 0x7FFF_FFFF_FFFF_FFFF. If the operand in *FRB* is less than 2**63 , then FPR *FRT* is set to 0x8000_0000_0000_0000.

Except for enabled invalid operation exceptions, FPSCR[FPRF] is undefined. FPSCR[FR] is set if the result is incremented when rounded. FPSCR[FI] is set if the result is inexact.

The **fctid** instruction has two syntax forms. Each syntax form has a different effect on Condition Register Field 1.

Syntax Form	Floating-Point Status and Control Register	Record Bit (Rc)	Condition Register Field 1
fctid	FPRF(undefined),FR,FI,FX,XX,VXSNAN,VXCVI	0	None
fctid.	FPRF(undefined),FR,FI,FX,XX,VXSNAN,VXCVI	1	FX,FEX,VX,OX

Parameters

FRT Specifies the target floating-point register for the operation.
FRB Specifies the source floating-point register for the operation.

Implementation

This instruction is defined only for 64-bit implementations. Using it on a 32-bit implementation will cause the system illegal instruction error handler to be invoked.

---

fctidz (Floating Convert to Integer Double Word with Round toward Zero) Instruction

Purpose

Convert the contents of a floating-point register to a 64-bit signed fixed-point integer using the round-toward-zero rounding mode. Place the results into another floating-point register.

Syntax

Bits	Value
0-5	63
6-10	D
11-15	00000
16-20	B
21-30	815
31	Rc

PowerPC
fctidz *FRT*, *FRB* (Rc=0)
fctidz. *FRT*, *FRB* (Rc=1)

Description

The floating-point operand in floating-point register (FRP) *FRB* is converted to a 64-bit signed fixed-point integer, using the rounding mode round toward zero, and placed into FPR *FRT*.

If the operand in FPR *FRB* is greater than 2**63 - 1, then FPR *FRT* is set to 0x7FFF_FFFF_FFFF_FFFF. If the operand in frB is less than 2**63 , then FPR *FRT* is set to 0x8000_0000_0000_0000.

Except for enabled invalid operation exceptions, FPSCR[FPRF] is undefined. FPSCR[FR] is set if the result is incremented when rounded. FPSCR[FI] is set if the result is inexact.

The **fctidz** instruction has two syntax forms. Each syntax form has a different effect on Condition Register Field 1.

Syntax Form	Floating-Point Status and Control Register	Record Bit (Rc)	Condition Register Field 1
fctidz	FPRF(undefined),FR,FI,FX,XX,VXSNAN,VXCVI	0	None
fctidz.	FPRF(undefined),FR,FI,FX,XX,VXSNAN,VXCVI	1	FX,FEX,VX,OX

Parameters

FRT Specifies the target floating-point register for the operation.
FRB Specifies the source floating-point register for the operation.

Implementation

This instruction is defined only for 64-bit implementations. Using it on a 32-bit implementation will cause the system illegal instruction error handler to be invoked.

fctiw or fcir (Floating Convert to Integer Word) Instruction

Purpose

Converts a floating-point operand to a 32-bit signed integer.

Syntax

Bits	Value
0-5	63
6-10	FRT
11-15	///
16-20	FRB
21-30	14
31	Rc

PowerPC

fctiw	*FRT*, *FRB*
fctiw.	*FRT*, *FRB*

POWER2

fcir	*FRT*, *FRB*
fcir.	*FRT*, *FRB*

Description

The **fctiw** and **fcir** instructions convert the floating-point operand in floating-point register (FPR) *FRB* to a 32-bit signed, fixed-point integer, using the rounding mode specified by Floating-Point Status and Control Register (FPSCR) RN. The result is placed in bits 32-63 of FPR *FRT*. Bits 0-31 of FPR *FRT* are undefined.

If the operand in FPR *FRB* is greater than 231 - 1, then the bits 32-63 of FPR *FRT* are set to 0x7FFF FFFF. If the operand in FPR *FRB* is less than -231, then the bits 32-63 of FPR *FRT* are set to 0x8000 0000.

The **fctiw** and **fcir** instruction each have two syntax forms. Each syntax form has a different effect on Condition Register Field 1.

Syntax Form	Floating-Point Status and Control Register	Record Bit (Rc)	Condition Register Field 1
fctiw	C,FL,FG,FE,FU,FR,FI,FX,XX,VXCVI, VXSNAN	0	None
fctiw.	C,FL,FG,FE,FU,FR,FI,FX,XX,VXCVI, VXSNAN	1	FX,FEX,VX,OX
fcir	C,FL,FG,FE,FU,FR,FI,FX,XX,VXCVI, VXSNAN	0	None
fcir.	C,FL,FG,FE,FU,FR,FI,FX,XX,VXCVI, VXSNAN	1	FX,FEX,VX,OX

The syntax forms of the **fctiw** and **fcir** instructions always affect the FPSCR. If the syntax form sets the Record (Rc) bit to 1, the instruction affects the Floating-Point Exception (FX), Floating-Point Enabled Exception (FEX), Floating-Point Invalid Operation Exception (VX), and Floating-Point Overflow Exception (OX) bits in Condition Register Field 1. FPSCR(C,FI,FG,FE,FU) are undefined.

Parameters

FRT Specifies the floating-point register where the integer result is placed.
FRB Specifies the source floating-point register for the floating-point operand.

Examples

The following code converts a floating-point value into an integer for use as an index in an array of floating-point values:

```
# Assume GPR 4 contains the address of the first element of
# the array.
# Assume GPR 1 contains the stack pointer.
# Assume a doubleword TEMP variable is allocated on the stack
# for use by the conversion routine.
# Assume FPR 6 contains the floating-point value for conversion
# into an index.
fctiw   5,6                     # Convert floating-point value
                                # to integer.
stfd    5,TEMP(1)               # Store to temp location.
```

```
lwz     3,TEMP+4(1)             # Get the integer part of the
                                # doubleword.
lfd     5,0(3)                  # Get the selected array element.
# FPR 5 now contains the selected array element.
```

Related Information

Floating-Point Processor .

Floating-Point Arithmetic Instructions .

Interpreting the Contents of a Floating-Point Register .

---

fctiwz or fcirz (Floating Convert to Integer Word with Round to Zero) Instruction

Purpose

Converts a floating-point operand to a 32-bit signed integer, rounding the result towards 0.

Syntax

Bits	Value
0-5	63
6-10	FRT
11-15	///
16-20	FRB
21-30	15
31	Rc

PowerPC
fctiwz *FRT*, *FRB*
fctiwz. *FRT*, *FRB*

POWER2
fcirz *FRT*, *FRB*
fcirz. *FRT*, *FRB*

Description

The **fctiwz** and **fcirz** instructions convert the floating-point operand in floating-point register (FPR) *FRB* to a 32-bit, signed, fixed-point integer, rounding the operand toward 0. The result is placed in bits 32-63 of FPR *FRT*. Bits 0-31 of FPR *FRT* are undefined.

If the operand in FPR *FRB* is greater than 231 - 1, then the bits 32-63 of FPR *FRT* are set to 0x7FFF FFFF. If the operand in FPR *FRB* is less than -231, then the bits 32-63 of FPR *FRT* are set to 0x8000 0000.

The **fctiwz** and **fcirz** instructions each have two syntax forms. Each syntax form has a different effect on Condition Register Field 1.

Syntax Form	Floating-Point Status and Control Register	Record Bit (Rc)	Condition Register Field 1

fctiwz	C,FL,FG,FE,FU,FR,FI,FX,XX,VXCVI, VXSNAN	0	None
fctiwz.	C,FL,FG,FE,FU,FR,FI,FX,XX,VXCVI, VXSNAN	1	FX,FEX,VX,OX
fcirz	C,FL,FG,FE,FU,FR,FI,FX,XX,VXCVI, VXSNAN	0	None
fcirz.	C,FL,FG,FE,FU,FR,FI,FX,XX,VXCVI, VXSNAN	1	FX,FEX,VX,OX

The syntax forms of the **fctiwz** and **fcirz** instructions always affect the Floating-Point Status and Control Register. If the syntax form sets the Record (Rc) bit to 1, the instruction affects the Floating-Point Exception (FX), Floating-Point Enabled Exception (FEX), Floating-Point Invalid Operation Exception (VX), and Floating-Point Overflow Exception (OX) bits in Condition Register Field 1. FPSCR(C,FI,FG,FE,FU) are undefined.

Parameters

FRT Specifies the floating-point register where the integer result is placed.
FRB Specifies the source floating-point register for the floating-point operand.

Examples

The following code adds a floating-point value to an array element selected based on a second floating-point value. If value2 is greater than or equal to n, but less than n+1, add value1 to the nth element of the array:

```
# Assume GPR 4 contains the address of the first element of
# the array.
# Assume GPR 1 contains the stack pointer.
# Assume a doubleword TEMP variable is allocated on the stack
# for use by the conversion routine.
# Assume FPR 6 contains value2.
# Assume FPR 4 contains value1.
fctiwz  5,6                     # Convert value2 to integer.
stfd    5,TEMP(1)               # Store to temp location.
lwz     3,TEMP+4(1)             # Get the integer part of the
                                # doubleword.
lfdx    5,3,4                   # Get the selected array element.
fadd    5,5,4                   # Add value1 to array element.
stfd    5,3,4                   # Save the new value of the
                                # array element.
```

Related Information

Floating-Point Processor .

Floating-Point Arithmetic Instructions .

Interpreting the Contents of a Floating-Point Register .

fdiv or fd (Floating Divide) Instruction

Purpose

Divides one floating-point operand by another.

Syntax

Bits	Value
0-5	63

Bits	Value
6-10	FRT
11-15	FRA
16-20	FRB
21-25	///
26-30	18
31	Rc

PowerPC
fdiv *FRT*, *FRA*, *FRB*
fdiv. *FRT*, *FRA*, *FRB*

POWER family
fd *FRT*, *FRA*, *FRB*
fd. *FRT*, *FRA*, *FRB*

Bits	Value
0-5	59
6-10	FRT
11-15	FRA
16-20	FRB
21-25	///
26-30	18
31	Rc

PowerPC
fdivs *FRT*, *FRA*, *FRB*
fdivs. *FRT*, *FRA*, *FRB*

Description

The **fdiv** and **fd** instructions divide the 64-bit, double-precision floating-point operand in floating-point register (FPR) *FRA* by the 64-bit, double-precision floating-point operand in FPR *FRB*. No remainder is preserved.

The **fdivs** instruction divides the 32-bit single-precision floating-point operand in FPR *FRA* by the 32-bit single-precision floating-point operand in FPR *FRB*. No remainder is preserved.

The result is rounded under control of the Floating-Point Rounding Control Field *RN* of the Floating-Point Status and Control Register (FPSCR), and is placed in the target FPR *FRT*.

The floating-point division operation is based on exponent subtraction and division of the two significands.

> **Note:** If an operand is a denormalized number, then it is prenormalized before the operation is begun.

The Floating-Point Result Flags Field of the Floating-Point Status and Control Register is set to the class and sign of the result, except for Invalid Operation Exceptions, when the Floating-Point Invalid Operation Exception Enable bit is 1.

The **fdiv**, **fdivs**, and **fd** instructions each have two syntax forms. Each syntax form has a different effect on Condition Register Field 1.

Syntax Form	Floating-Point Status and Control Register	Record Bit (Rc)	Condition Register Field 1
fdiv	C,FL,FG,FE,FU,FR,FI,OX,UX, ZX,XX,VXSNAN,VXIDI,VXZDZ	0	None
fdiv.	C,FL,FG,FE,FU,FR,FI,OX,UX, ZX,XX,VXSNAN,VXIDI,VXZDZ	1	FX,FEX,VX,OX
fdivs	C,FL,FG,FE,FU,FR,FI,OX,UX, ZX,XX,VXSNAN,VXIDI,VXZDZ	0	None
fdivs.	C,FL,FG,FE,FU,FR,FI,OX,UX, ZX,XX,VXSNAN,VXIDI,VXZDZ	1	FX,FEX,VX,OX
fd	C,FL,FG,FE,FU,FR,FI,OX,UX, ZX,XX,VXSNAN,VXIDI,VXZDZ	0	None
fd.	C,FL,FG,FE,FU,FR,FI,OX,UX, ZX,XX,VXSNAN,VXIDI,VXZDZ	1	FX,FEX,VX,OX

All syntax forms of the **fdiv**, **fdivs**, and **fd** instructions always affect the Floating-Point Status and Control Register. If the syntax form sets the Record (Rc) bit to 1, the instruction affects the Floating-Point Exception (FX), Floating-Point Enabled Exception (FEX), Floating-Point Invalid Operation Exception (VX), and Floating-Point Overflow Exception (OX) bits in Condition Register Field 1.

Parameters

FRT Specifies target floating-point register for operation.
FRA Specifies source floating-point register containing the dividend.
FRB Specifies source floating-point register containing the divisor.

Examples

1. The following code divides the contents of FPR 4 by the contents of FPR 5, places the result in FPR 6, and sets the Floating-Point Status and Control Register to reflect the result of the operation:

```
# Assume FPR 4 contains 0xC053 4000 0000 0000.
# Assume FPR 5 contains 0x400C 0000 0000 0000.
# Assume FPSCR = 0.
fdiv 6,4,5
# FPR 6 now contains 0xC036 0000 0000 0000.
# FPSCR now contains 0x0000 8000.
```

2. The following code divides the contents of FPR 4 by the contents of FPR 5, places the result in FPR 6, and sets Condition Register Field 1 and the Floating-Point Status and Control Register to reflect the result of the operation:

```
# Assume FPR 4 contains 0xC053 4000 0000 0000.
# Assume FPR 5 contains 0x400C 0000 0000 0000.
# Assume FPSCR = 0.
fdiv. 6,4,5
# FPR 6 now contains 0xC036 0000 0000 0000.
# FPSCR now contains 0x0000 8000.
# CR contains 0x0000 0000.
```

Related Information

Floating-Point Processor .

Floating-Point Arithmetic Instructions .

Interpreting the Contents of a Floating-Point Register .

fmadd or fma (Floating Multiply-Add) Instruction

Purpose

Adds one floating-point operand to the result of multiplying two floating-point operands without an intermediate rounding operation.

Syntax

Bits	Value
0-5	63
6-10	FRT
11-15	FRA
16-20	FRB
21-25	FRC
26-30	29
31	Rc

PowerPC
fmadd *FRT*, *FRA*, *FRC*, *FRB*
fmadd. *FRT*, *FRA*, *FRC*, *FRB*

POWER family
fma *FRT*, *FRA*, *FRC*, *FRB*
fma. *FRT*, *FRA*, *FRC*, *FRB*

Bits	Value
0-5	59
6-10	FRT
11-15	FRA
16-20	FRB
21-25	FRC
26-30	29
31	Rc

PowerPC
fmadds *FRT*, *FRA*, *FRC*, *FRB*
fmadds. *FRT*, *FRA*, *FRC*, *FRB*

Description

The **fmadd** and **fma** instructions multiply the 64-bit, double-precision floating-point operand in floating-point register (FPR) *FRA* by the 64-bit, double-precision floating-point operand in FPR *FRC,* and then add the result of this operation to the 64-bit, double-precision floating-point operand in FPR *FRB*.

The **fmadds** instruction multiplies the 32-bit, single-precision floating-point operand in FPR *FRA* by the 32-bit, single-precision floating-point operand in FPR *FRC* and adds the result of this operation to the 32-bit, single-precision floating-point operand in FPR *FRB*.

The result is rounded under control of the Floating-Point Rounding Control Field *RN* of the Floating-Point Status and Control Register and is placed in the target FPR *FRT*.

> **Note:** If an operand is a denormalized number, then it is prenormalized before the operation is begun.

The Floating-Point Result Flags Field of the Floating-Point Status and Control Register is set to the class and sign of the result, except for Invalid Operation Exceptions, when the Floating-Point Invalid Operation Exception Enable bit is 1.

The **fmadd**, **fmadds**, and **fm** instructions each have two syntax forms. Each syntax form has a different effect on Condition Register Field 1.

Syntax Form	Floating-Point Status and Control Register	Record Bit (Rc)	Condition Register Field 1
fmadd	C,FL,FG,FE,FU,FR,FI,OX,UX, XX,VXSNAN,VXISI,VXIMZ	0	None
fmadd.	C,FL,FG,FE,FU,FR,FI,OX,UX, XX,VXSNAN,VXISI,VXIMZ	1	FX,FEX,VX,OX
fmadds	C,FL,FG,FE,FU,FR,FI,OX,UX, XX,VXSNAN,VXISI,VXIMZ	0	None
fmadds.	C,FL,FG,FE,FU,FR,FI,OX,UX, XX,VXSNAN,VXISI,VXIMZ	1	FX,FEX,VX,OX
fma	C,FL,FG,FE,FU,FR,FI,OX,UX, XX,VXSNAN,VXISI,VXIMZ	0	None
fma.	C,FL,FG,FE,FU,FR,FI,OX,UX, XX,VXSNAN,VXISI,VXIMZ	1	FX,FEX,VX,OX

All syntax forms of the **fmadd**, **fmadds**, and **fm** instructions always affect the Floating-Point Status and Control Register. If the syntax form sets the Record (Rc) bit to 1, the instruction affects the Floating-Point Exception (FX), Floating-Point Enabled Exception (FEX), Floating-Point Invalid Operation Exception (VX), and Floating-Point Overflow Exception (OX) bits in Condition Register Field 1.

Parameters

FRT Specifies target floating-point register for operation.
FRA Specifies source floating-point register containing a multiplier.
FRB Specifies source floating-point register containing the addend.
FRC Specifies source floating-point register containing a multiplier.

Examples

1. The following code multiplies the contents of FPR 4 and FPR 5, adds the contents of FPR 7, places the result in FPR 6, and sets the Floating-Point Status and Control Register to reflect the result of the operation:

```
# Assume FPR 4 contains 0xC053 4000 0000 0000.
# Assume FPR 5 contains 0x400C 0000 0000 0000.
# Assume FPR 7 contains 0x3DE2 6AB4 B33C 110A.
# Assume FPSCR = 0.
fmadd 6,4,5,7
# FPR 6 now contains 0xC070 D7FF FFFF F6CB.
# FPSCR now contains 0x8206 8000.
```

2. The following code multiplies the contents of FPR 4 and FPR 5, adds the contents of FPR 7, places the result in FPR 6, and sets the Floating-Point Status and Control Register and Condition Register Field 1 to reflect the result of the operation:

```
# Assume FPR 4 contains 0xC053 4000 0000 0000.
# Assume FPR 5 contains 0x400C 0000 0000 0000.
# Assume FPR 7 contains 0x3DE2 6AB4 B33C 110A.
# Assume FPSCR = 0 and CR = 0.
fmadd. 6,4,5,7
# FPR 6 now contains 0xC070 D7FF FFFF F6CB.
# FPSCR now contains 0x8206 8000.
# CR now contains 0x0800 0000.
```

Related Information

Floating-Point Processor .

Interpreting the Contents of a Floating-Point Register .

---

fmr (Floating Move Register) Instruction

Purpose

Copies the contents of one floating-point register into another floating-point register.

Syntax

Bits	Value
0-5	63
6-10	FRT
11-15	///
16-20	FRB
21-30	72
31	Rc

fmr *FRT*, *FRB*
fmr. *FRT*, *FRB*

Description

The **fmr** instruction places the contents of floating-point register (FPR) *FRB* into the target FPR *FRT*.

The **fmr** instruction has two syntax forms. Each syntax form has a different effect on Condition Register Field 1.

Syntax Form	Floating-Point Status and Control Register	Record Bit (Rc)	Condition Register Field 1
fmr	None	0	None
fmr.	None	1	FX,FEX,VX,OX

The two syntax forms of the **fmr** instruction never affect the Floating-Point Status and Control Register. If the syntax form sets the Record (Rc) bit to 1, the instruction affects the Floating-Point Exception (FX), Floating-Point Enabled Exception (FEX), Floating-Point Invalid Operation Exception (VX), and Floating-Point Overflow Exception (OX) bits in Condition Register Field 1.

Parameters

FRT Specifies target floating-point register for operation.

FRB Specifies source floating-point register for operation.

Examples

1. The following code copies the contents of FPR 4 into FPR 6 and sets the Floating-Point Status and Control Register to reflect the result of the operation:

```
# Assume FPR 4 contains 0xC053 4000 0000 0000.
# Assume FPSCR = 0.
fmr 6,4
# FPR 6 now contains 0xC053 4000 0000 0000.
# FPSCR now contains 0x0000 0000.
```

2. The following code copies the contents of FPR 25 into FPR 6 and sets the Floating-Point Status and Control Register and Condition Register Field 1 to reflect the result of the operation:

```
# Assume FPR 25 contains 0xFFFF FFFF FFFF FFFF.
# Assume FPSCR = 0 and CR = 0.
fmr. 6,25
# FPR 6 now contains 0xFFFF FFFF FFFF FFFF.
# FPSCR now contains 0x0000 0000.
# CR now contains 0x0000 0000.
```

Related Information

Floating-Point Processor .

Interpreting the Contents of a Floating-Point Register .

Floating-Point Move Instructions .

---

fmsub or fms (Floating Multiply-Subtract) Instruction

Purpose

Subtracts one floating-point operand from the result of multiplying two floating-point operands without an intermediate rounding operation.

Syntax

Bits	Value
0-5	63
6-10	FRT
11-15	FRA
16-20	FRB
21-25	FRC
26-30	28
31	Rc

PowerPC

fmsub *FRT*, *FRA*, *FRC*, *FRB*
fmsub. *FRT*, *FRA*, *FRC*, *FRB*

POWER family

fms *FRT*, *FRA*, *FRC*, *FRB*
fms. *FRT*, *FRA*, *FRC*, *FRB*

Bits	Value
0-5	59
6-10	FRT
11-15	FRA
16-20	FRB
21-25	FRC
26-30	28
31	Rc

PowerPC
fmsubs *FRT*, *FRA*, *FRC*, *FRB*
fmsubs. *FRT*, *FRA*, *FRC*, *FRB*

Description

The **fmsub** and **fms** instructions multiply the 64-bit, double-precision floating-point operand in floating-point register (FPR) *FRA* by the 64-bit, double-precision floating-point operand in FPR *FRC* and subtract the 64-bit, double-precision floating-point operand in FPR *FRB* from the result of the multiplication.

The **fmsubs** instruction multiplies the 32-bit, single-precision floating-point operand in FPR *FRA* by the 32-bit, single-precision floating-point operand in FPR *FRC* and subtracts the 32-bit, single-precision floating-point operand in FPR *FRB* from the result of the multiplication.

The result is rounded under control of the Floating-Point Rounding Control Field *RN* of the Floating-Point Status and Control Register and is placed in the target FPR *FRT*.

> **Note:** If an operand is a denormalized number, then it is prenormalized before the operation is begun.

The Floating-Point Result Flags Field of the Floating-Point Status and Control Register is set to the class and sign of the result, except for Invalid Operation Exceptions, when the Floating-Point Invalid Operation Exception Enable bit is 1.

The **fmsub**, **fmsubs**, and **fms** instructions each have two syntax forms. Each syntax form has a different effect on Condition Register Field 1.

Syntax Form	Floating-Point Status and Control Register	Record Bit (Rc)	Condition Register Field 1
fmsub	C,FL,FG,FE,FU,FR,FI,OX,UX, XX,VXSNAN,VXSI,VXIMZ	0	None
fmsub.	C,FL,FG,FE,FU,FR,FI,OX,UX, XX,VXSNAN,VXSI,VXIMZ	1	FX,FEX,VX,OX
fmsubs	C,FL,FG,FE,FU,FR,FI,OX,UX, XX,VXSNAN,VXSI,VXIMZ	0	None
fmsubs.	C,FL,FG,FE,FU,FR,FI,OX,UX, XX,VXSNAN,VXSI,VXIMZ	1	FX,FEX,VX,OX
fms	C,FL,FG,FE,FU,FR,FI,OX,UX, XX,VXSNAN,VXSI,VXIMZ	0	None
fms.	C,FL,FG,FE,FU,FR,FI,OX,UX, XX,VXSNAN,VXSI,VXIMZ	1	FX,FEX,VX,OX

All syntax forms of the **fmsub**, **fmsubs**, and **fms** instructions always affect the Floating-Point Status and Control Register. If the syntax form sets the Record (Rc) bit to 1, the instruction affects the Floating-Point

Exception (FX), Floating-Point Enabled Exception (FEX), Floating-Point Invalid Operation Exception (VX), and Floating-Point Overflow Exception (OX) bits in Condition Register Field 1.

Parameters

FRT Specifies target floating-point register for operation.
FRA Specifies source floating-point register containing a multiplier.
FRB Specifies source floating-point register containing the quantity to be subtracted.
FRC Specifies source floating-point register containing a multiplier.

Examples

1. The following code multiplies the contents of FPR 4 and FPR 5, subtracts the contents of FPR 7 from the product of the multiplication, places the result in FPR 6, and sets the Floating-Point Status and Control Register to reflect the result of the operation:

```
# Assume FPR 4 contains 0xC053 4000 0000 0000.
# Assume FPR 5 contains 0x400C 0000 0000 0000.
# Assume FPR 7 contains 0x3DE2 6AB4 B33c 110A.
# Assume FPSCR = 0.
fmsub 6,4,5,7
# FPR 6 now contains 0xC070 D800 0000 0935.
# FPSCR now contains 0x8202 8000.
```

2. The following code multiplies the contents of FPR 4 and FPR 5, subtracts the contents of FPR 7 from the product of the multiplication, places the result in FPR 6, and sets the Floating-Point Status and Control Register and Condition Register Field 1 to reflect the result of the operation:

```
# Assume FPR 4 contains 0xC053 4000 0000 0000.
# Assume FPR 5 contains 0x400C 0000 0000 0000.
# Assume FPR 7 contains 0x3DE2 6AB4 B33c 110A.
# Assume FPSCR = 0 and CR = 0.
fmsub. 6,4,5,7
# FPR 6 now contains 0xC070 D800 0000 0935.
# FPSCR now contains 0x8202 8000.
# CR now contains 0x0800 0000.
```

Related Information

Floating-Point Processor .

Interpreting the Contents of a Floating-Point Register .

fmul or fm (Floating Multiply) Instruction

Purpose

Multiplies two floating-point operands.

Syntax

Bits	Value
0-5	63
6-10	FRT
11-15	FRA
16-20	///
21-25	FRC
26-30	25

Bits	Value
31	Rc

PowerPC
fmul *FRT*, *FRA*, *FRC*
fmul. *FRT*, *FRA*, *FRC*

POWER family
fm *FRT*, *FRA*, *FRC*
fm. *FRT*, *FRA*, *FRC*

Bits	Value
0-5	59
6-10	FRT
11-15	FRA
16-20	///
21-25	FRC
26-30	25
31	Rc

PowerPC
fmuls *FRT*, *FRA*, *FRC*
fmuls. *FRT*, *FRA*, *FRC*

Description

The **fmul** and **fm** instructions multiply the 64-bit, double-precision floating-point operand in floating-point register (FPR) *FRA* by the 64-bit, double-precision floating-point operand in FPR *FRC*.

The **fmuls** instruction multiplies the 32-bit, single-precision floating-point operand in FPR *FRA* by the 32-bit, single-precision floating-point operand in FPR *FRC*.

The result is rounded under control of the Floating-Point Rounding Control Field *RN* of the Floating-Point Status and Control Register and is placed in the target FPR *FRT*.

Multiplication of two floating-point numbers is based on exponent addition and multiplication of the two significands.

> **Note:** If an operand is a denormalized number, then it is prenormalized before the operation is begun.

The Floating-Point Result Flags Field of the Floating-Point Status and Control Register is set to the class and sign of the result, except for Invalid Operation Exceptions, when the Floating-Point Invalid Operation Exception Enable bit is 1.

The **fmul**, **fmuls**, and **fm** instructions each have two syntax forms. Each syntax form has a different effect on Condition Register Field 1.

Syntax Form	Floating-Point Status and Control Register	Record Bit (Rc)	Condition Register Field 1

fmul	C,FL,FG,FE,FU,FR,FI,OX,UX, XX,VXSNAN,VXIMZ	0	None
fmul.	C,FL,FG,FE,FU,FR,FI,OX,UX, XX,VXSNAN,VXIMZ	1	FX,FEX,VX,OX
fmuls	C,FL,FG,FE,FU,FR,FI,OX,UX, XX,VXSNAN,VXIMZ	0	None
fmuls.	C,FL,FG,FE,FU,FR,FI,OX,UX, XX,VXSNAN,VXIMZ	1	FX,FEX,VX,OX
fm	C,FL,FG,FE,FU,FR,FI,OX,UX, XX,VXSNAN,VXIMZ	0	None
fm.	C,FL,FG,FE,FU,FR,FI,OX,UX, XX,VXSNAN,VXIMZ	1	FX,FEX,VX,OX

All syntax forms of the **fmul**, **fmuls**, and **fm** instructions always affect the Floating-Point Status and Control Register. If the syntax form sets the Record (Rc) bit to 1, the instruction affects the Floating-Point Exception (FX), Floating-Point Enabled Exception (FEX), Floating-Point Invalid Operation Exception (VX), and Floating-Point Overflow Exception (OX) bits in Condition Register Field 1.

Parameters

FRT Specifies target floating-point register for operation.
FRA Specifies source floating-point register for operation.
FRC Specifies source floating-point register for operation.

Examples

1. The following code multiplies the contents of FPR 4 and FPR 5, places the result in FPR 6, and sets the Floating-Point Status and Control Register to reflect the result of the operation:

```
# Assume FPR 4 contains 0xC053 4000 0000 0000.
# Assume FPR 5 contains 0x400C 0000 0000 0000.
# Assume FPSCR = 0.
fmul 6,4,5
# FPR 6 now contains 0xC070 D800 0000 0000.
# FPSCR now contains 0x0000 8000.
```

2. The following code multiplies the contents of FPR 4 and FPR 25, places the result in FPR 6, and sets Condition Register Field 1 and the Floating-Point Status and Control Register to reflect the result of the operation:

```
# Assume FPR  4 contains 0xC053 4000 0000 0000.
# Assume FPR 25 contains 0xFFFF FFFF FFFF FFFF.
# Assume FPSCR = 0 and CR = 0.
fmul. 6,4,25
# FPR 6 now contains 0xFFFF FFFF FFFF FFFF.
# FPSCR now contains 0x0001 1000.
# CR now contains 0x0000 0000.
```

Related Information

Floating-Point Processor .

Floating-Point Arithmetic Instructions .

Interpreting the Contents of a Floating-Point Register .

fnabs (Floating Negative Absolute Value) Instruction

Purpose

Negates the absolute contents of a floating-point register and places the result in another floating-point register.

Syntax

Bits	Value
0-5	63
6-10	FRT
11-15	///
16-20	FRB
21-30	136
31	/

fnabs *FRT*, *FRB*
fnabs. *FRT*, *FRB*

Description

The **fnabs** instruction places the negative absolute of the contents of floating-point register (FPR) *FRB* with bit 0 set to 1 into the target FPR *FRT*.

The **fnabs** instruction has two syntax forms. Each syntax form has a different effect on Condition Register Field 1.

Syntax Form	Floating-Point Status and Control Register	Record Bit (Rc)	Condition Register Field 1
fnabs	None	0	None
fnabs.	None	1	FX,FEX,VX,OX

The two syntax forms of the **fnabs** instruction never affect the Floating-Point Status and Control Register. If the syntax form sets the Record (Rc) bit to 1, the instruction affects the Floating-Point Exception (FX), Floating-Point Enabled Exception (FEX), Floating-Point Invalid Operation Exception (VX), and Floating-Point Overflow Exception (OX) bits in Condition Register Field 1.

Parameters

FRT Specifies target floating-point register for operation.
FRB Specifies source floating-point register for operation.

Examples

1. The following code negates the absolute contents of FPR 5 and places the result into FPR 6:

```
# Assume FPR 5 contains 0x400C 0000 0000 0000.
fnabs 6,5
# FPR 6 now contains 0xC00C 0000 0000 0000.
```

2. The following code negates the absolute contents of FPR 4, places the result into FPR 6, and sets Condition Register Field 1 to reflect the result of the operation:

```
# Assume FPR 4 contains 0xC053 4000 0000 0000.
# Assume CR = 0.
fnabs. 6,4
# FPR 6 now contains 0xC053 4000 0000 0000.
# CR now contains 0x0.
```

Related Information

Floating-Point Processor .

Floating-Point Move Instructions .

Interpreting the Contents of a Floating-Point Register .

---

fneg (Floating Negate) Instruction

Purpose

Negates the contents of a floating-point register and places the result into another floating-point register.

Syntax

Bits	Value
0-5	63
6-10	FRT
11-15	///
16-20	FRB
21-30	40
31	Rc

fneg *FRT*, *FRB*
fneg. *FRT*, *FRB*

Description

The **fneg** instruction places the negated contents of floating-point register *FRB* into the target FPR *FRT*.

The **fneg** instruction has two syntax forms. Each syntax form has a different effect on Condition Register Field 1.

Syntax Form	Floating-Point Status and Control Register	Record Bit (Rc)	Condition Register Field 1
fneg	None	0	None
fneg.	None	1	FX,FEX,VX,OX

The two syntax forms of the **fneg** instruction never affect the Floating-Point Status and Control Register. If the syntax form sets the Record (Rc) bit to 1, the instruction affects the Floating-Point Exception (FX), Floating-Point Enabled Exception (FEX), Floating-Point Invalid Operation Exception (VX), and Floating-Point Overflow Exception (OX) bits in Condition Register Field 1.

Parameters

FRT Specifies target floating-point register for operation.

FRB Specifies source floating-point register for operation.

Examples

1. The following code negates the contents of FPR 5 and places the result into FPR 6:

```
# Assume FPR 5 contains 0x400C 0000 0000 0000.
fneg 6,5
# FPR 6 now contains 0xC00C 0000 0000 0000.
```

2. The following code negates the contents of FPR 4, places the result into FPR 6, and sets Condition Register Field 1 to reflect the result of the operation:

```
# Assume FPR 4 contains 0xC053 4000 0000 0000.
fneg. 6,4
# FPR 6 now contains 0x4053 4000 0000 0000.
# CR now contains 0x0000 0000.
```

Related Information

Floating-Point Processor .

Floating-Point Move Instructions .

Interpreting the Contents of a Floating-Point Register .

fnmadd or fnma (Floating Negative Multiply-Add) Instruction

Purpose

Multiplies two floating-point operands, adds the result to one floating-point operand, and places the negative of the result in a floating-point register.

Syntax

Bits	Value
0-5	63
6-10	FRT
11-15	FRA
16-20	FRB
21-25	FRC
26-30	31
31	Rc

PowerPC
fnmadd *FRT*, *FRA*, *FRC*, *FRB*
fnmadd. *FRT*, *FRA*, *FRC*, *FRB*

POWER family
fnma *FRT*, *FRA*, *FRC*, *FRB*
fnma. *FRT*, *FRA*, *FRC*, *FRB*

Bits	Value
0-5	59

Bits	Value
6-10	FRT
11-15	FRA
16-20	FRB
21-25	FRC
26-30	31
31	Rc

PowerPC
fnmadds *FRT*, *FRA*, *FRC*, *FRB*
fnmadds. *FRT*, *FRA*, *FRC*, *FRB*

Description

The **fnmadd** and **fnma** instructions multiply the 64-bit, double-precision floating-point operand in floating-point register (FPR) *FRA* by the 64,bit, double-precision floating-point operand in FPR *FRC*, and add the 64-bit, double-precision floating-point operand in FPR *FRB* to the result of the multiplication.

The **fnmadds** instruction multiplies the 32-bit, single-precision floating-point operand in FPR *FRA* by the 32-bit, single-precision floating-point operand in FPR *FRC*, and adds the 32-bit, single-precision floating-point operand in FPR *FRB* to the result of the multiplication.

The result of the addition is rounded under control of the Floating-Point Rounding Control Field *RN* of the Floating-Point Status and Control Register.

> **Note:** If an operand is a denormalized number, then it is prenormalized before the operation is begun.

The **fnmadd** and **fnma** instructions are identical to the **fmadd** and **fma** (Floating Multiply- Add Single) instructions with the final result negated, but with the following exceptions:

- Quiet NaNs (QNaNs) propagate with no effect on their ″sign″ bit.
- QNaNs that are generated as the result of a disabled Invalid Operation Exception have a ″sign″ bit of 0.
- Signaling NaNs (SNaNs) that are converted to QNaNs as the result of a disabled Invalid Operation Exception have no effect on their ″sign″ bit.

The Floating-Point Result Flags Field of the Floating-Point Status and Control Register is set to the class and sign of the result, except for Invalid Operation Exceptions, when the Floating-Point Invalid Operation Exception Enable bit is 1.

The **fnmadd**, **fnmadds**, and **fnma** instructions each have two syntax forms. Each syntax form has a different effect on Condition Register Field 1.

Syntax Form	Floating-Point Status and Control Register	Record Bit (Rc)	Condition Register Field 1
fnmadd	C,FL,FG,FE,FU,FR,FI,OX,UX, XX,VXSNAN,VXISI,VXIMZ	0	None
fnmadd.	C,FL,FG,FE,FU,FR,FI,OX,UX, XX,VXSNAN,VXISI,VXIMZ	1	FX,FEX,VX,OX
fnmadds	C,FL,FG,FE,FU,FR,FI,OX,UX, XX,VXSNAN,VXISI,VXIMZ	0	None
fnmadds.	C,FL,FG,FE,FU,FR,FI,OX,UX, XX,VXSNAN,VXISI,VXIMZ	1	FX,FEX,VX,OX
fnma	C,FL,FG,FE,FU,FR,FI,OX,UX, XX,VXSNAN,VXISI,VXIMZ	0	None
fnma.	C,FL,FG,FE,FU,FR,FI,OX,UX, XX,VXSNAN,VXISI,VXIMZ	1	FX,FEX,VX,OX

All syntax forms of the **fnmadd**, **fnmadds**, and **fnma** instructions always affect the Floating-Point Status and Control Register. If the syntax form sets the Record (Rc) bit to 1, the instruction affects the Floating-Point Exception (FX), Floating-Point Enabled Exception (FEX), Floating-Point Invalid Operation Exception (VX), and Floating-Point Overflow Exception (OX) bits in Condition Register Field 1.

> **Note:** Rounding occurs before the result of the addition is negated. Depending on *RN*, an inexact value may result.

Parameters

FRT Specifies target floating-point register for operation.
FRA Specifies source floating-point register for operation.
FRB Specifies source floating-point register for operation.
FRC Specifies source floating-point register for operation.

Examples

1. The following code multiplies the contents of FPR 4 and FPR 5, adds the result to the contents of FPR 7, stores the negated result in FPR 6, and sets the Floating-Point Status and Control Register to reflect the result of the operation:

```
# Assume FPR 4 contains 0xC053 4000 0000 0000.
# Assume FPR 5 contains 0x400C 0000 0000 0000.
# Assume FPR 7 contains 0x3DE2 6AB4 B33c 110A.
# Assume FPSCR = 0.
fnmadd 6,4,5,7
# FPR 6 now contains 0x4070 D7FF FFFF F6CB.
# FPSCR now contains 0x8206 4000.
```

2. The following code multiplies the contents of FPR 4 and FPR 5, adds the result to the contents of FPR 7, stores the negated result in FPR 6, and sets the Floating-Point Status and Control Register and Condition Register Field 1 to reflect the result of the operation:

```
# Assume FPR 4 contains 0xC053 4000 0000 0000.
# Assume FPR 5 contains 0x400C 0000 0000 0000.
# Assume FPR 7 contains 0x3DE2 6AB4 B33c 110A.
# Assume FPSCR = 0 and CR = 0.
fnmadd. 6,4,5,7
# FPR 6 now contains 0x4070 D7FF FFFF F6CB.
# FPSCR now contains 0x8206 4000.
# CR now contains 0x0800 0000.
```

Related Information

Floating-Point Processor .

Interpreting the Contents of a Floating-Point Register .

fnmsub or fnms (Floating Negative Multiply-Subtract) Instruction

Purpose

Multiplies two floating-point operands, subtracts one floating-point operand from the result, and places the negative of the result in a floating-point register.

Syntax

Bits	Value
0-5	63
6-10	FRT
11-15	FRA
16-20	FRB
21-25	FRC
26-30	30
31	Rc

PowerPC
fnmsub *FRT*, *FRA*, *FRC*, *FRB*
fnmsub. *FRT*, *FRA*, *FRC*, *FRB*

POWER family
fnms *FRT*, *FRA*, *FRC*, *FRB*
fnms. *FRT*, *FRA*, *FRC*, *FRB*

Bits	Value
0-5	59
6-10	FRT
11-15	FRA
16-20	FRB
21-25	FRC
26-30	
30	Rc

PowerPC
fnmsubs *FRT*, *FRA*, *FRC*, *FRB*
fnmsubs. *FRT*, *FRA*, *FRC*, *FRB*

Description

The **fnms** and **fnmsub** instructions multiply the 64-bit, double-precision floating-point operand in floating-point register (FPR) *FRA* by the 64,-bit double-precision floating-point operand in FPR *FRC*, subtract the 64-bit, double-precision floating-point operand in FPR *FRB* from the result of the multiplication, and place the negated result in the target FPR *FRT*.

The **fnmsubs** instruction multiplies the 32-bit, single-precision floating-point operand in FPR *FRA* by the 32-bit, single-precision floating-point operand in FPR *FRC*, subtracts the 32-bit, single-precision floating-point operand in FPR *FRB* from the result of the multiplication, and places the negated result in the target FPR *FRT*.

The subtraction result is rounded under control of the Floating-Point Rounding Control Field *RN* of the Floating-Point Status and Control Register.

Note: If an operand is a denormalized number, then it is prenormalized before the operation is begun.

The **fnms** and **fnmsub** instructions are identical to the **fmsub** and **fms** (Floating Multiply-Subtract Single) instructions with the final result negated, but with the following exceptions:

- Quiet NaNs (QNaNs) propagate with no effect on their ″sign″ bit.
- QNaNs that are generated as the result of a disabled Invalid Operation Exception have a ″sign″ bit of zero.
- Signaling NaNs (SNaNs) that are converted to QNaNs as the result of a disabled Invalid Operation Exception have no effect on their ″sign″ bit.

The Floating-Point Result Flags Field of the Floating-Point Status and Control Register is set to the class and sign of the result, except for Invalid Operation Exceptions, when the Floating-Point Invalid Operation Exception Enable bit is 1.

The **fnmsub**, **fnmsubs**, and **fnms** instructions each have two syntax forms. Each syntax form has a different effect on Condition Register Field 1.

Syntax Form	Floating-Point Status and Control Register	Record Bit (Rc)	Condition Register Field 1
fnmsub	C,FL,FG,FE,FU,FR,FI,OX,UX, XX,VXSNAN,VXISI,VXIMZ	0	None
fnmsub.	C,FL,FG,FE,FU,FR,FI,OX,UX, XX,VXSNAN,VXISI,VXIMZ	1	FX,FEX,VX,OX
fnmsubs	C,FL,FG,FE,FU,FR,FI,OX,UX, XX,VXSNAN,VXISI,VXIMZ	0	None
fnmsubs.	C,FL,FG,FE,FU,FR,FI,OX,UX, XX,VXSNAN,VXISI,VXIMZ	1	FX,FEX,VX,OX
fnms	C,FL,FG,FE,FU,FR,FI,OX,UX, XX,VXSNAN,VXISI,VXIMZ	0	None
fnms.	C,FL,FG,FE,FU,FR,FI,OX,UX, XX,VXSNAN,VXISI,VXIMZ	1	FX,FEX,VX,OX

All syntax forms of the **fnmsub**, **fnmsubs**, and **fnms** instructions always affect the Floating-Point Status and Control Register. If the syntax form sets the Record (Rc) bit to 1, the instruction affects the Floating-Point Exception (FX), Floating-Point Enabled Exception (FEX), Floating-Point Invalid Operation Exception (VX), and Floating-Point Overflow Exception (OX) bits in Condition Register Field 1.

Note: Rounding occurs before the result of the addition is negated. Depending on *RN*, an inexact value may result.

Parameters

FRT Specifies target floating-point register for operation.
FRA Specifies first source floating-point register for operation.
FRB Specifies second source floating-point register for operation.
FRC Specifies third source floating-point register for operation.

Examples

1. The following code multiplies the contents of FPR 4 and FPR 5, subtracts the contents of FPR 7 from the result, stores the negated result in FPR 6, and sets the Floating-Point Status and Control Register and Condition Register Field 1 to reflect the result of the operation:

```
# Assume FPR 4 contains 0xC053 4000 0000 0000.
# Assume FPR 5 contains 0x400C 0000 0000 0000.
# Assume FPR 7 contains 0x3DE2 6AB4 B33c 110A.
```

```
# Assume FPSCR = 0.
fnmsub 6,4,5,7
# FPR 6 now contains 0x4070 D800 0000 0935.
# FPSCR now contains 0x8202 4000.
```

2. The following code multiplies the contents of FPR 4 and FPR 5, subtracts the contents of FPR 7 from the result, stores the negated result in FPR 6, and sets the Floating-Point Status and Control Register and Condition Register Field 1 to reflect the result of the operation:

```
# Assume FPR 4 contains 0xC053 4000 0000 0000.
# Assume FPR 5 contains 0x400C 0000 0000 0000.
# Assume FPR 7 contains 0x3DE2 6AB4 B33c 110A.
# Assume FPSCR = 0 and CR = 0.
fnmsub. 6,4,5,7
# FPR 6 now contains 0x4070 D800 0000 0935.
# FPSCR now contains 0x8202 4000.
# CR now contains 0x0800 0000.
```

Related Information

Floating-Point Processor .

Interpreting the Contents of a Floating-Point Register .

---

fres (Floating Reciprocal Estimate Single) Instruction

Purpose

Calculates a single-precision estimate of the reciprocal of a floating-point operand.

> **Note:** The **fres** instruction is defined only in the PowerPC architecture and is an optional instruction. It is supported on the PowerPC 603 RISC Microprocessor, and PowerPC 604 RISC Microprocessor, but not supported on the PowerPC 601 RISC Microprocessor.

Syntax

Bits	Value
0-5	59
6-10	FRT
11-15	///
16-20	FRB
21-25	///
26-30	24
31	Rc

PowerPC

fres *FRT*, *FRB*

fres. *FRT*, *FRB*

Description

The **fres** instruction calculates a single-precision estimate of the reciprocal of the 64-bit, double-precision floating-point operand in floating-point register (FPR) *FRB* and places the result in FPR *FRT*.

The estimate placed into register *FRT* is correct to a precision of one part in 256 of the reciprocal of *FRB*. The value placed into *FRT* may vary between implementations, and between different executions on the same implementation.

The following table summarizes special conditions:

Special Conditions		
Operand	**Result**	**Exception**
Negative Infinity	Negative 0	None
Negative 0	Negative Infinity[1]	ZX
Positive 0	Positive Infinity[1]	ZX
Positive Infinity	Positive 0	None
SNaN	QNaN[2]	VXSNAN
QNaN	QNaN	None

1No result if FPSCRZE = 1.

2No result if FPSCRVE = 1.

FPSCRFPRF is set to the class and sign of the result, except for Invalid Operation Exceptions when FPSCRVE = 1 and Zero Divide Exceptions when FPSCRZE = 1.

The **fres** instruction has two syntax forms. Both syntax forms always affect the FPSCR register. Each syntax form has a different effect on Condition Register Field 1.

Syntax Form	**Floating-Point Status and Control Register**	**Record Bit (Rc)**	**Condition Register Field 1**
fres	C,FL,FG,FE,FU,FR,FI,FX,OX, UX,ZX,VXSNAN	0	None
fres.	C,FL,FG,FE,FU,FR,FI,FX,OX, UX,ZX,VXSNAN	1	FX,FEX,VX,OX

The **fres.** syntax form sets the Record (Rc) bit to 1; and the instruction affects the Floating-Point Exception (FX), Floating-Point Enabled Exception (FEX), Floating-Point Invalid Operation Exception (VX), and Floating-Point Overflow Exception (OX) bits in Condition Register Field 1 (CR1). The **fres** syntax form sets the Record (Rc) bit to 0 and does not affect Condition Register Field 1 (CR1).

Parameters

FRT Specifies target floating-point register for operation.
FRB Specifies source floating-point register for operation.

Related Information

Floating-Point Processor .

Floating-Point Arithmetic Instructions .

Interpreting the Contents of a Floating-Point Register .

frsp (Floating Round to Single Precision) Instruction

Purpose

Rounds a 64-bit, double precision floating-point operand to single precision and places the result in a floating-point register.

Syntax

Bits	Value
0-5	63
6-10	FRT
11-15	///
16-20	FRB
21-30	12
31	Rc

frsp *FRT*, *FRB*
frsp. *FRT*, *FRB*

Description

The **frsp** instruction rounds the 64-bit, double-precision floating-point operand in floating-point register (FPR) *FRB* to single precision, using the rounding mode specified by the Floating Rounding Control field of the Floating-Point Status and Control Register, and places the result in the target FPR *FRT*.

The Floating-Point Result Flags Field of the Floating-Point Status and Control Register is set to the class and sign of the result, except for Invalid Operation (SNaN), when Floating-Point Status and Control Register Floating-Point Invalid Operation Exception Enable bit is 1.

The **frsp** instruction has two syntax forms. Each syntax form has a different effect on Condition Register Field 1.

Syntax Form	Floating-Point Status and Control Register	Record Bit (Rc)	Condition Register Field 1
frsp	C,FL,FG,FE,FU,FR,FI,OX,UX, XX,VXSNAN	0	None
frsp.	C,FL,FG,FE,FU,FR,FI,OX,UX, XX,VXSNAN	1	FX,FEX,VX,OX

The two syntax forms of the **frsp** instruction always affect the Floating-Point Status and Control Register. If the syntax form sets the Record (Rc) bit to 1, the instruction affects the Floating-Point Exception (FX), Floating-Point Enabled Exception (FEX), Floating-Point Invalid Operation Exception (VX), and Floating-Point Overflow Exception (OX) bits in Condition Register Field 1.

Notes:

1. The **frsp** instruction uses the target register of a previous floating-point arithmetic operation as its source register (*FRB*). The **frsp** instruction is said to be *dependent* on the preceding floating-point arithmetic operation when it uses this register for source.
2. Less than two nondependent floating-point arithmetic operations occur between the **frsp** instruction and the operation on which it is dependent.
3. The magnitude of the double-precision result of the arithmetic operation is less than 2**128 before rounding.

4. The magnitude of the double-precision result after rounding is exactly 2**128.

Error Result
If the error occurs, the magnitude of the result placed in the target register *FRT* is 2**128:

```
X'47F0000000000000' or X'C7F0000000000000'
```

This is not a valid single-precision value. The settings of the Floating-Point Status and Control Register and the Condition Register will be the same as if the result does not overflow.

Avoiding Errors
If the above error will cause significant problems in an application, either of the following two methods can be used to avoid the error.

1. Place two nondependent floating-point operations between a floating-point arithmetic operation and the dependent **frsp** instruction. The target registers for these nondependent floating-point operations should not be the same register that the **frsp** instruction uses as source register *FRB*.
2. Insert two **frsp** operations when the **frsp** instruction may be dependent on an arithmetic operation that precedes it by less than three floating-point instructions.

Either solution will degrade performance by an amount dependent on the particular application.

Parameters

FRT Specifies target floating-point register for operation.
FRB Specifies source floating-point register for operation.

Examples

1. The following code rounds the contents of FPR 4 to single precision, places the result in a FPR 6, and sets the Floating-Point Status and Control Register to reflect the result of the operation:

```
# Assume FPR 4 contains 0xC053 4000 0000 0000.
# Assume FPSCR = 0.
frsp 6,4
# FPR 6 now contains 0xC053 4000 0000 0000.
# FPSCR now contains 0x0000 8000.
```

2. The following code rounds the contents of FPR 4 to single precision, places the result in a FPR 6, and sets the Floating-Point Status and Control Register and Condition Register Field 1 to reflect the result of the operation:

```
# Assume CR contains 0x0000 0000.
# Assume FPR 4 contains 0xFFFF FFFF FFFF FFFF.
# Assume FPSCR = 0.
frsp. 6,4
# FPR 6 now contains 0xFFFF FFFF E000 0000.
# FPSCR now contains 0x0001 1000.
# CR now contains 0x0000 0000.
```

Related Information
Floating-Point Processor .

Interpreting the Contents of a Floating-Point Register .

Floating-Point Arithmetic Instructions .

frsqrte (Floating Reciprocal Square Root Estimate) Instruction

Purpose

Calculates a double-precision estimated value of the reciprocal of the square root of a floating-point operand.

> **Note:** The **frsqrte** instruction is defined only in the PowerPC architecture and is an optional instruction. It is supported on the PowerPC 603 RISC Microprocessor and the PowerPC 604 RISC Microprocessor, but not supported on the PowerPC 601 RISC Microprocessor.

Syntax

Bits	Value
0-5	63
6-10	FRT
11-15	///
16-20	FRB
21-25	///
26-30	26
31	Rc

PowerPC
frsqrte *FRT*, *FRB*
frsqrte. *FRT*, *FRB*

Description

The **frsqrte** instruction computes a double-precision estimate of the reciprocal of the square root of the 64-bit, double-precision floating-point operand in floating-point register (FPR) *FRB* and places the result in FPR *FRT*.

The estimate placed into register *FRT* is correct to a precision of one part in 32 of the reciprocal of the square root of *FRB*. The value placed in *FRT* may vary between implementations and between different executions on the same implementation.

The following table summarizes special conditions:

Special Conditions		
Operand	**Result**	**Exception**
Negative Infinity	QNaN[1]	VXSQRT
Less Than 0	QNaN[1]	VXSQRT
Negative 0	Negative Infinity[2]	ZX
Positive 0	Positive Infinity[2]	ZX
Positive Infinity	Positive 0	None
SNaN	QNaN[1]	VXSNAN
QNaN	QNaN	None

1No result if FPSCRVE = 1.

2No result if FPSCRZE = 1.

FPSCRFPRF is set to the class and sign of the result, except for Invalid Operation Exceptions when FPSCRVE = 1 and Zero Divide Exceptions when FPSCRZE = 1.

The **frsqrte** instruction has two syntax forms. Both syntax forms always affect the FPSCR. Each syntax form has a different effect on Condition Register Field 1.

Syntax Form	Floating-Point Status and Control Register	Record Bit (Rc)	Condition Register Field 1
frsqrte	C,FL,FG,FE,FU,FR,FI,FX,ZX, VXSNAN,VXSQRT	0	None
frsqrte.	C,FL,FG,FE,FU,FR,FI,FX,ZX, VXSNAN,VXSQRT	1	FX,FEX,VX,OX

The **frstrte.** syntax form sets the Record (Rc) bit to 1; and the instruction affects the Floating-Point Exception (FX), Floating-Point Enabled Exception (FEX), Floating-Point Invalid Operation Exception (VX), and Floating-Point Overflow Exception (OX) bits in Condition Register Field 1 (CR1). The **frstrte** syntax form sets the Record (Rc) bit to 0; and the instruction does not affect Condition Register Field 1 (CR1).

Parameters

FRT Specifies target floating-point register for operation.
FRB Specifies source floating-point register for operation.

Related Information

Floating-Point Processor .

Floating-Point Arithmetic Instructions .

Interpreting the Contents of a Floating-Point Register .

fsel (Floating-Point Select) Instruction

Purpose

Puts either of two floating-point operands into the target register based on the results of comparing another floating-point operand with zero.

> **Note:** The **fsel** instruction is defined only in the PowerPC architecture and is an optional instruction. It is supported on the PowerPC 603 RISC Microprocessor and the PowerPC 604 RISC Microprocessor, but not supported on the PowerPC 601 RISC Microprocessor.

Syntax

Bits	Value
0-5	63
6-10	FRT
11-15	FRA
16-20	FRB
21-25	FRC
26-30	23
31	Rc

PowerPC

fsel *FRT*, *FRA*, *FRC*, *FRB*

fsel. *FRT*, *FRA*, *FRC*, *FRB*

Description

The double-precision floating-point operand in floating-point register (FPR) *FRA* is compared with the value zero. If the value in *FRA* is greater than or equal to zero, floating point register *FRT* is set to the contents of floating-point register *FRC*. If the value in *FRA* is less than zero or is a NaN, floating point register *FRT* is set to the contents of floating-point register *FRB*.The comparison ignores the sign of zero; both +0 and -0 are equal to zero.

The **fesl** instruction has two syntax forms. Each syntax form has a different effect on Condition Register Field 1.

Syntax Form	FPSCR bits	Record Bit (Rc)	Condition Register Field 1
fsel	None	0	None
fsel.	None	1	FX, FEX, VX, OX

The two syntax forms of the **fsel** instruction never affect the Floating-Point Status and Control Register fields. If the syntax form sets the Record (Rc) bit to 1, the instruction affects the Floating-Point Exception (FX), Floating-Point Enabled Exception (FEX), Floating Invalid Operation Exception (VX), and Floating-Point Overflow Exception (OX) bits in Condition Register Field 1.

Parameters

FRT Specifies target floating-point register for operation.
FRA Specifies floating-point register with value to be compared with zero.
FRB Specifies source floating-point register containing the value to be used if *FRA* is less than zero or is a NaN.
FRC Specifies source floating-point register containing the value to be used if *FRA* is greater than or equal to zero.

Related Information

Floating-Point Processor .

Interpreting the Contents of a Floating-Point Register .

---

fsqrt (Floating Square Root, Double-Precision) Instruction

Purpose

Calculate the square root of the contents of a floating- point register, placing the result in a floating-point register.

Syntax

Bits	Value
0-5	63
6-10	D
11-15	00000
16-20	B

Bits	Value
21-25	00000
26-30	22
31	Rc

PowerPC
fsqrt *FRT*, *FRB* (Rc=0)
fsqrt. *FRT*, *FRB* (Rc=1)

Description

The square root of the operand in floating-point register (FPR) *FRB* is placed into register FPR *FRT*.

If the most-significant bit of the resultant significand is not a one the result is normalized. The result is rounded to the target precision under control of the floating-point rounding control field RN of the FPSCR and placed into register FPR *FRT*.

Operation with various special values of the operand is summarized below.

Operand	Result	Exception
- infinity	QNaN*	VXSQRT
< 0	QNaN*	VXSQRT
- 0	- 0	None
+ infinity	+ infinity	None
SNaN	QNaN*	VXSNAN
QNaN	QNaN	None

Notes: * No result if FPSCR[VE] = 1

FPSCR[FPRF] is set to the class and sign of the result, except for invalid operation exceptions when FPSCR[VE] = 1.

The **fsqrt** instruction has two syntax forms. Each syntax form has a different effect on Condition Register Field 1.

Syntax Form	Floating-Point Status and Control Register	Record Bit (Rc)	Condition Register Field 1
fsqrt	FPRF,FR,FI,FX,XX,VXSNAN,VXSQRT	0	None
fsqrt.	FPRF,FR,FI,FX,XX,VXSNAN,VXSQRT	1	FX,FEX,VX,OX

Parameters

FRT Specifies the target floating-point register for the operation.
FRB Specifies the source floating-point register for the operation.

Implementation

This instruction is optionally defined for PowerPC implementations. Using it on an implementation that does not support this instruction will cause the system illegal instruction error handler to be invoked.

This instruction is an optional instruction of the PowerPC architecture and may not be implemented in all machines.

fsqrts (Floating Square Root Single) Instruction

Purpose

Calculate the single-precision square root of the contents of a floating- point register, placing the result in a floating-point register.

Syntax

Bits	Value
0-5	59
6-10	D
11-15	00000
16-20	B
21-25	00000
26-30	22
31	Rc

PowerPC
fsqrts *FRT*, *FRB* (Rc=0)
fsqrts. *FRT*, *FRB* (Rc=1)

Description

The square root of the floating-point operand in floating-point register (FPR) *FRB* is placed into register FPR *FRT*.

If the most-significant bit of the resultant significand is not a one the result is normalized. The result is rounded to the target precision under control of the floating-point rounding control field RN of the FPSCR and placed into register FPR *FRT*.

Operation with various special values of the operand is summarized below.

Operand	Result	Exception
- infinity	QNaN*	VXSQRT
< 0	QNaN*	VXSQRT
- 0	- 0	None
+ infinity	+ infinity	None
SNaN	QNaN*	VXSNAN
QNaN	QNaN	None

Notes: * No result if FPSCR[VE] = 1

FPSCR[FPRF] is set to the class and sign of the result, except for invalid operation exceptions when FPSCR[VE] = 1.

The **fsqrts** instruction has two syntax forms. Each syntax form has a different effect on Condition Register Field 1.

Syntax Form	Floating-Point Status and Control Register	Record Bit (Rc)	Condition Register Field 1
fsqrts	FPRF,FR,FI,FX,XX,VXSNAN,VXSQRT	0	None

fsqrts.	FPRF,FR,FI,FX,XX,VXSNAN,VXSQRT	1	FX,FEX,VX,OX

Parameters

FRT Specifies the target floating-point register for the operation.
FRB Specifies the source floating-point register for the operation.

Implementation

This instruction is optionally defined for PowerPC implementations. Using it on an implementation that does not support this instruction will cause the system illegal instruction error handler to be invoked.

This instruction is an optional instruction of the PowerPC architecture and may not be implemented in all machines.

fsub or fs (Floating Subtract) Instruction

Purpose

Subtracts one floating-point operand from another and places the result in a floating-point register.

Syntax

Bits	Value
0-5	63
6-10	FRT
11-15	FRA
16-20	FRB
21-25	///
26-30	20
31	Rc

PowerPC
fsub *FRT*, *FRA*, *FRB*
fsub. *FRT*, *FRA*, *FRB*

PowerPC
fs *FRT*, *FRA*, *FRB*
fs. *FRT*, *FRA*, *FRB*

Bits	Value
0-5	59
6-10	FRT
11-15	FRA
16-20	FRB
21-25	///
26-30	20

Bits	Value
31	Rc

PowerPC
fsubs *FRT*, *FRA*, *FRB*
fsubs. *FRT*, *FRA*, *FRB*

Description

The **fsub** and **fs** instructions subtract the 64-bit, double-precision floating-point operand in floating-point register (FPR) *FRB* from the 64-bit, double-precision floating-point operand in FPR *FRA*.

The **fsubs** instruction subtracts the 32-bit single-precision floating-point operand in FPR *FRB* from the 32-bit single-precision floating-point operand in FPR *FRA*.

The result is rounded under control of the Floating-Point Rounding Control Field *RN* of the Floating-Point Status and Control Register and is placed in the target FPR *FRT*.

The execution of the **fsub** instruction is identical to that of **fadd**, except that the contents of FPR *FRB* participate in the operation with bit 0 inverted.

The execution of the **fs** instruction is identical to that of **fa**, except that the contents of FPR *FRB* participate in the operation with bit 0 inverted.

The Floating-Point Result Flags Field of the Floating-Point Status and Control Register is set to the class and sign of the result, except for Invalid Operation Exceptions, when the Floating-Point Invalid Operation Exception Enable bit is 1.

The **fsub**, **fsubs**, and **fs** instructions each have two syntax forms. Each syntax form has a different effect on Condition Register Field 1.

Syntax Form	Floating-Point Status and Control Register	Record Bit (Rc)	Condition Register Field 1
fsub	C,FL,FG,FE,FU,FR,FI,OX,UX, XX,VXSNAN,VXISI	0	None
fsub.	C,FL,FG,FE,FU,FR,FI,OX,UX, XX,VXSNAN,VXISI	1	FX,FEX,VX,OX
fsubs	C,FL,FG,FE,FU,FR,FI,OX,UX, XX,VXSNAN,VXISI	0	None
fsubs.	C,FL,FG,FE,FU,FR,FI,OX,UX, XX,VXSNAN,VXISI	1	FX,FEX,VX,OX
fs	C,FL,FG,FE,FU,FR,FI,OX,UX, XX,VXSNAN,VXISI	0	None
fs.	C,FL,FG,FE,FU,FR,FI,OX,UX, XX,VXSNAN,VXISI	1	FX,FEX,VX,OX

All syntax forms of the **fsub**, **fsubs**, and **fs** instructions always affect the Floating-Point Status and Control Register. If the syntax form sets the Record (Rc) bit to 1, the instruction affects the Floating-Point Exception (FX), Floating-Point Enabled Exception (FEX), Floating-Point Invalid Operation Exception (VX), and Floating-Point Overflow Exception (OX) bits in Condition Register Field 1.

Parameters

FRT Specifies target floating-point register for operation.
FRA Specifies source floating-point register for operation.
FRB Specifies source floating-point register for operation.

Examples

1. The following code subtracts the contents of FPR 5 from the contents of FPR 4, places the result in FPR 6, and sets the Floating-Point Status and Control Register to reflect the result of the operation:

```
# Assume FPR 4 contains 0xC053 4000 0000 0000.
# Assume FPR 5 contains 0x400C 0000 0000 0000.
# Assume FPSCR = 0.
fsub 6,4,5
# FPR 6 now contains 0xC054 2000 0000 0000.
# FPSCR now contains 0x0000 8000.
```

2. The following code subtracts the contents of FPR 5 from the contents of FPR 4, places the result in FPR 6, and sets the Floating-Point Status and Control Register and Condition Register Field 1 to reflect the result of the operation:

```
# Assume FPR 4 contains 0xC053 4000 0000 0000.
# Assume FPR 5 contains 0x400C 0000 0000 0000.
# Assume FPSCR = 0 and CR = 0.
fsub. 6,5,4
# FPR 6 now contains 0x4054 2000 0000 0000.
# FPSCR now contains 0x0000 4000.
# CR now contains 0x0000 0000.
```

Related Information

Floating-Point Processor .

Floating-Point Arithmetic Instructions .

Interpreting the Contents of a Floating-Point Register .

---

icbi (Instruction Cache Block Invalidate) Instruction

Purpose

Invalidates a block containing the byte addressed in the instruction cache, causing subsequent references to retrieve the block from main memory.

Note: The **icbi** instruction is supported only in the PowerPC architecture.

Syntax

Bits	Value
0-5	31
6-10	///
11-15	RA
16-20	RB
21-30	982
31	/

PowerPC
icbi *RA*, *RB*

Description

The **icbi** instruction invalidates a block containing the byte addressed in the instruction cache. If *RA* is not 0, the **icbi** instruction calculates an effective address (EA) by adding the contents of general-purpose register (GPR) *RA* to the contents of GPR *RB*.

Consider the following when using the **icbi** instruction:

- If the Data Relocate (DR) bit of the Machine State Register (MSR) is 0, the effective address is treated as a real address.
- If the MSR DR bit is 1, the effective address is treated as a virtual address. The MSR Relocate (IR) bit is ignored in this case.
- If a block containing the byte addressed by the EA is in the instruction cache, the block is made unusable so the next reference to the block is taken from main memory.

The **icbi** instruction has one syntax form and does not affect Condition Register Field 0 or the Fixed-Point Exception Register.

Parameters

RA Specifies source general-purpose register for the EA calculation.
RB Specifies source general-purpose register for the EA calculation.

Examples

The following code ensures that modified instructions are available for execution:

```
# Assume GPR 3 contains a modified instruction.
# Assume GPR 4 contains the address of the memory location
# where the modified instruction will be stored.
stw     3,0(4)          # Store the modified instruction.
dcbf    0,4             # Copy the modified instruction to
                        # main memory.
sync                    # Ensure update is in main memory.
icbi    0,4             # Invalidate block with old instruction.
isync                   # Discard prefetched instructions.
b       newcode         # Go execute the new code.
```

Related Information

The **clcs** (Cache Line Compute Size) instruction, **clf** (Cache Line Flush) instruction, **cli** (Cache Line Invalidate) instruction, **dcbf** (Data Cache Block Flush) instruction, **dcbi** (Data Cache Block Invalidate) instruction, **dcbst** (Data Cache Block Store) instruction, **dcbt** (Data Cache Block Touch) instruction, **dcbtst** (Data Cache Block Touch for Store) instruction, **dcbz** or **dclz** (Data Cache Block Set to Zero) instruction, **dclst** (Data Cache Line Store) instruction, **sync** (Synchronize) or **dcs** (Data Cache Synchronize) instruction.

Processing and Storage

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isync or ics (Instruction Synchronize) Instruction

Purpose

Refetches any instructions that might have been fetched prior to this instruction.

Syntax

Bits	Value
0-5	19
6-10	///
11-15	///
16-20	///
21-30	150
31	/

PowerPC

isync

POWER family

ics

Description

The **isync** and **ics** instructions cause the processor to refetch any instructions that might have been fetched prior to the **isync** or **ics** instruction.

The PowerPC instruction **isync** causes the processor to wait for all previous instructions to complete. Then any instructions already fetched are discarded and instruction processing continues in the environment established by the previous instructions.

The POWER family instruction **ics** causes the processor to wait for any previous **dcs** instructions to complete. Then any instructions already fetched are discarded and instruction processing continues under the conditions established by the content of the Machine State Register.

The **isync** and **ics** instructions have one syntax form and do not affect Condition Register Field 0 or the Fixed-Point Exception Register.

Examples

The following code refetches instructions before continuing:

```
# Assume GPR 5 holds name.
# Assume GPR 3 holds 0x0.
name: dcbf 3,5
isync
```

Related Information

The **clcs** (Cache Line Compute Size) instruction, **clf** (Cache Line Flush) instruction, **cli** (Cache Line Invalidate) instruction, **dcbf** (Data Cache Block Flush) instruction, **dcbi** (Data Cache Block Invalidate) instruction, **dcbst** (Data Cache Block Store) instruction, **dcbt** (Data Cache Block Touch) instruction, **dcbtst** (Data Cache Block Touch for Store) instruction, **dcbz** or **dclz** (Data Cache Line Set to Zero) instruction, **dclst** (Data Cache Line Store) instruction, **icbi** (Instruction Cache Block Invalidate) instruction, **sync** (Synchronize) or **dcs** (Data Cache Synchronize) instruction.

Processing and Storage

Functional Differences for POWER family and PowerPC Instructions .

lbz (Load Byte and Zero) Instruction

Purpose

Loads a byte of data from a specified location in memory into a general-purpose register and sets the remaining 24 bits to 0.

Syntax

Bits	Value
0-5	34
6-10	RT
11-15	RA
16-31	D

lbz *RT*, *D*(*RA*)

Description

The **lbz** instruction loads a byte in storage addressed by the effective address (EA) into bits 24-31 of the target general-purpose register (GPR) *RT* and sets bits 0-23 of GPR *RT* to 0.

If *RA* is not 0, the EA is the sum of the contents of GPR *RA* and *D*, a 16-bit, signed two's complement integer sign-extended to 32 bits. If *RA* is 0, then the EA is *D*.

The **lbz** instruction has one syntax form and does not affect the Fixed-Point Exception Register or Condition Register Field 0.

Parameters

RT Specifies target general-purpose register where result of operation is stored.
D 16-bit, signed two's complement integer sign-extended to 32 bits for EA calculation.
RA Specifies source general-purpose register for EA calculation.

Examples

The following code loads a byte of data from a specified location in memory into GPR 6 and sets the remaining 24 bits to 0:

```
.csect data[rw]
storage:  .byte 'a
# Assume GPR 5 contains the address of csect data[rw].
.csect text[pr]
lbz 6,storage(5)
# GPR 6 now contains 0x0000 0061.
```

Related Information

Fixed-Point Processor .

Fixed-Point Load and Store Instructions .

lbzu (Load Byte and Zero with Update) Instruction

Purpose

Loads a byte of data from a specified location in memory into a general-purpose register, sets the remaining 24 bits to 0, and possibly places the address in a second general-purpose register.

Syntax

Bits	Value
0-5	35
6-10	RT
11-15	RA
16-31	D

lbzu *RT*, *D*(*RA*)

Description

The **lbzu** instruction loads a byte in storage addressed by the effective address (EA) into bits 24-31 of the target general-purpose register (GPR) *RT* and sets bits 0-23 of GPR *RT* to 0.

If *RA* is not 0, the EA is the sum of the contents of GPR *RA* and *D*, a 16-bit signed two's complement integer sign extended to 32 bits. If *RA* is 0, then the EA is *D*.

If *RA* does not equal *RT* and *RA* does not equal 0, and the storage access does not cause an Alignment interrupt or a Data Storage interrupt, then the EA is stored in GPR *RA*.

The **lbzu** instruction has one syntax form and does not affect the Fixed-Point Exception Register or Condition Register Field 0.

Parameters

RT Specifies target general-purpose register where result of operation is stored.
D 16-bit, signed two's complement integer sign-extended to 32 bits for EA calculation.
RA Specifies source general-purpose register for EA calculation and possible address update.

Examples

The following code loads a byte of data from a specified location in memory into GPR 6, sets the remaining 24 bits to 0, and places the address in GPR 5:

```
.csect data[rw]
storage:  .byte 0x61
# Assume GPR 5 contains the address of csect data[rw].
.csect text[pr]
lbzu 6,storage(5)
# GPR 6 now contains 0x0000 0061.
# GPR 5 now contains the storage address.
```

Related Information

Fixed-Point Processor .

Fixed-Point Load and Store with Update Instructions .

lbzux (Load Byte and Zero with Update Indexed) Instruction

Purpose

Loads a byte of data from a specified location in memory into a general-purpose register, setting the remaining 24 bits to 0, and places the address in the a second general-purpose register.

Syntax

Bits	Value
0-5	31
6-10	RT
11-15	RA
16-20	RB
21-30	119
31	/

lbzux *RT*, *RA*, *RB*

Description

The **lbzux** instruction loads a byte in storage addressed by the effective address (EA) into bits 24-31 of the target general-purpose register (GPR) *RT* and sets bits 0-23 of GPR *RT* to 0.

If *RA* is not 0, the EA is the sum of the contents of GPR *RA* and GPR *RB*. If *RA* is 0, then the EA is the contents of *RB*.

If *RA* does not equal *RT* and *RA* does not equal 0, and the storage access does not cause an Alignment interrupt or a Data Storage interrupt, then the EA is stored in GPR *RA*.

The **lbzux** instruction has one syntax form and does not affect the Fixed-Point Exception Register.

Parameters

RT Specifies target general-purpose register where result of operation is stored.
RA Specifies source general-purpose register for EA calculation and possible address update.
RB Specifies source general-purpose register for EA calculation.

Examples

The following code loads the value located at `storage` into GPR 6 and loads the address of `storage` into GPR 5:

```
storage: .byte 0x40
  .
  .
# Assume GPR 5 contains 0x0000 0000.
# Assume GPR 4 is the storage address.
lbzux 6,5,4
# GPR 6 now contains 0x0000 0040.
# GPR 5 now contains the storage address.
```

Related Information

Fixed-Point Processor .

Fixed-Point Load and Store with Update Instructions .

---

lbzx (Load Byte and Zero Indexed) Instruction

Purpose

Loads a byte of data from a specified location in memory into a general-purpose register and sets the remaining 24 bits to 0.

Syntax

Bits	Value
0-5	31
6-10	RT
11-15	RA
16-20	RB
21-30	87
31	/

lbzx *RT*, *RA*, *RB*

Description

The **lbzx** instruction loads a byte in storage addressed by the effective address (EA) into bits 24-31 of the target general-purpose register (GPR) *RT* and sets bits 0-23 of GPR *RT* to 0.

If *RA* is not 0, the EA is the sum of the contents of GPR *RA* and GPR *RB*. If *RA* is 0, then the EA is *D*.

The **lbzx** instruction has one syntax form and does not affect the Fixed-Point Exception Register.

Parameters

RT Specifies target general-purpose register where result of operation is stored.
RA Specifies source general-purpose register for EA calculation.
RB Specifies source general-purpose register for EA calculation.

Examples

The following code loads the value located at `storage` into GPR 6:

```
storage:  .byte 0x61
  .
  .
# Assume GPR 5 contains 0x0000 0000.
# Assume GPR 4 is the storage address.
lbzx 6,5,4
# GPR 6 now contains 0x0000 0061.
```

Related Information

Fixed-Point Processor .

Fixed-Point Load and Store Instructions .

---

ld (Load Double Word) Instruction

Purpose

Load a double-word of data into the specified general purpose register.

This instruction should only be used on 64-bit PowerPC processors running a 64-bit application.

Syntax

Bits	Value
0-5	58
6-10	D
11-15	A
16-29	ds
30-31	00

PowerPC64

ld *RT*, *D*(*RA*)

Description

The **ld** instruction loads a double-word in storage from a specified location in memory addressed by the effective address (EA) into the target general-purpose register (GPR) *RT*.

If GPR *RA* is not 0, the EA is the sum of the contents of GPR *RA* and *D*, a 16-bit, signed two's complement integer, fullword-aligned, sign-extended to 64 bits. If GPR *RA* is 0, then the EA is *D*.

Parameters

RT Specifies target general-purpose register where result of operation is stored.
D Specifies a 16-bit, signed two's complement integer sign-extended to 32 bits for EA calculation.
RA Specifies source general-purpose register for EA calculation.

Examples

The following code loads a double-word from memory into GPR 4:

```
.extern  mydata[RW]
.csect   foodata[rw]
.local   foodata[rw]
storage: .llong mydata  # address of mydata

.csect   text[PR]
                        # Assume GPR 5 contains address of csect foodata[RW].
ld       4,storage(5)   # GPR 5 now contains the address of mydata.
```

Implementation

This instruction is defined only for 64-bit implementations. Using it on a 32-bit implementation will cause the system illegal instruction error handler to be invoked.

Related Information

Fixed-Point Processor .

Fixed-Point Load and Store Instructions .

---

ldarx (Store Double Word Reserve Indexed) Instruction

Purpose

This instruction should only be used on 64-bit PowerPC processors running a 64-bit application.

Syntax

Bits	Value
0-5	31
6-10	D
11-15	A
16-20	B
21-30	84
31	0

PowerPC64
ldarx *rD*, *rA*, *rB*

Description

This instruction creates a reservation for use by a Store Double Word Conditional Indexed (stdcx.) instruction. An address computed from the EA is associated with the reservation, and replaces any address previously associated with the reservation. EA must be a multiple of eight. If it is not, either the system alignment exception handler is invoked or the results are boundedly undefined.

This instruction is defined only for 64-bit implementations. Using it on a 32-bit implementation will cause the system illegal instruction error handler to be invoked.

Parameters

rD Specifies source general-purpose register of stored data.
rA Specifies source general-purpose register for EA calculation.
rB Specifies source general-purpose register for EA calculation.

Examples

Related Information

---

ldu (Store Double Word with Update) Instruction

Purpose

Load a double-word of data into the specified general purpose register, updating the address base.

This instruction should only be used on 64-bit PowerPC processors running a 64-bit application.

Syntax

Bits	Value
0-5	58
6-10	D
11-15	A
16-29	ds
30-31	01

PowerPC64
ldu *RT*, *D*(*RA*)

Description

The **ldu** instruction loads a double-word in storage from a specified location in memory addressed by the effective address (EA) into the target general-purpose register (GPR) *RT*.

If GPR *RA* is not 0, the EA is the sum of the contents of GPR *RA* and *D*, a 16-bit, signed two's complement integer, fullword-aligned, sign-extended to 64 bits.

If *RA* = 0 or *RA* = *RT*, the instruction form is invalid.

Parameters

RT Specifies target general-purpose register where result of operation is stored.
D Specifies a 16-bit, signed two's complement integer sign-extended to 32 bits for EA calculation.
RA Specifies source general-purpose register for EA calculation.

Examples

The following code loads the first of 4 double-words from memory into GPR 4, incrementing GPR 5 to point to the next double-word in memory:

```
.csect   foodata[rw]
storage: .llong 5,6,7,12  # Successive double-words.

.csect   text[PR]
                          # Assume GPR 5 contains address of csect foodata[RW].
ldu       4,storage(5)    # GPR 4 now contains the first double-word of
                          # foodata; GRP 5 points to the second double-word.
```

Implementation

This instruction is defined only for 64-bit implementations. Using it on a 32-bit implementation will cause the system illegal instruction error handler to be invoked.

Related Information

Fixed-Point Processor .

Fixed-Point Load and Store with Update Instructions

---

ldux (Store Double Word with Update Indexed) Instruction

Purpose

Load a double-word of data from a specified memory location into a general purpose register. Update the address base.

Syntax

Bits	Value
0-5	31
6-10	D
11-15	A
16-20	B
21-30	53
31	0

PowerPC
ldux *RT*, *RA*, *RB*

Description

The effective address (EA) is calculated from the sum of general purpose register (GPR) *RA* and *RB*. A double-word of data is read from the memory location referenced by the EA and placed into GPR *RT*; GRP *RA* is updated with the EA.

If rA = 0 or rA = rD, the instruction form is invalid.

Parameters

RT Specifies source general-purpose register of stored data.
RA Specifies source general-purpose register for EA calculation.
RB Specifies source general-purpose register for EA calculation.

Implementation

This instruction is defined only for 64-bit implementations. Using it on a 32-bit implementation will cause the system illegal instruction error handler to be invoked.

Idx (Store Double Word Indexed) Instruction

Purpose

Load a double-word from a specified memory location into a general purpose register.

Syntax

Bits	Value
0-5	31
6-10	D
11-15	A
16-20	B
21-30	21
31	0

PowerPC
Idx *RT*, *RA*, *RB*

Description

The **Idx** instruction loads a double-word from the specified memory location referenced by the effective address (EA) into the general-purpose register (GPR) *RT*.

If GRP *RA* is not 0, the EA is the sum of the contents of GRP *RA* and *B*; otherwise, the EA is equal to the contents of *RB*.

Parameters

RT Specifies target general-purpose register where result of operation is stored.
RA Specifies source general-purpose register for EA calculation.
RB Specifies source general-purpose register for EA calculation.

Implementation

This instruction is defined only for 64-bit implementations. Using it on a 32-bit implementation will cause the system illegal instruction error handler to be invoked.

lfd (Load Floating-Point Double) Instruction

Purpose

Loads a doubleword of data from a specified location in memory into a floating-point register.

Syntax

Bits	Value
0-5	50
6-10	FRT
11-15	RA

Bits	Value
16-31	D

lfd *FRT*, *D*(*RA*)

Description

The **lfd** instruction loads a doubleword in storage from a specified location in memory addressed by the effective address (EA) into the target floating-point register (FPR) *FRT*.

If general-purpose register (GPR) *RA* is not 0, the EA is the sum of the contents of GPR *RA* and *D*, a 16-bit, signed two's complement integer sign-extended to 32 bits. If GPR *RA* is 0, then the EA is *D*.

The **lfd** instruction has one syntax form and does not affect the Floating-Point Status and Control Register or Condition Register Field 0.

Parameters

FRT Specifies target general-purpose register where result of the operation is stored.
D 16-bit, signed two's complement integer sign-extended to 32 bits for the EA calculation.
RA Specifies source general-purpose register for the EA calculation.

Examples

The following code loads a doubleword from memory into FPR 6:

```
.csect data[rw]
storage: .double 0x1
# Assume GPR 5 contains the address of csect data[rw].
.csect text[pr]
lfd 6,storage(5)
# FPR 6 now contains 0x3FF0 0000 0000 0000.
```

Related Information

Floating-Point Processor .

Floating-Point Load and Store Instructions .

---

lfdu (Load Floating-Point Double with Update) Instruction

Purpose

Loads a doubleword of data from a specified location in memory into a floating-point register and possibly places the specified address in a general-purpose register.

Syntax

Bits	Value
0-5	51
6-10	FRT
11-15	RA
16-31	D

Description

The **lfdu** instruction loads a doubleword in storage from a specified location in memory addressed by the effective address (EA) into the target floating-point register (FPR) *FRT*.

If *RA* is not 0, the EA is the sum of the contents of GPR *RA* and *D*, a 16-bit, signed two's complement integer sign-extended to 32 bits. If *RA* is 0, then the effective address (EA) is *D*.

If *RA* does not equal 0, and the storage access does not cause an Alignment interrupt or a Data Storage interrupt, then the effective address is stored in GPR *RA*.

The **lfdu** instruction has one syntax form and does not affect the Floating-Point Status and Control Register or Condition Register Field 0.

Parameters

FRT Specifies target general-purpose register where result of operation is stored.
D Specifies a 16-bit, signed two's complement integer sign-extended to 32 bits for EA calculation.
RA Specifies source general-purpose register for EA calculation and possible address update.

Examples

The following code loads a doubleword from memory into FPR 6 and stores the address in GPR 5:

```
.csect data[rw]
storage: .double 0x1
# Assume GPR 5 contains the address of csect data[rw].
.csect text[pr]
lfdu 6,storage(5)
# FPR 6 now contains 0x3FF0 0000 0000 0000.
# GPR 5 now contains the storage address.
```

Related Information

Floating-Point Processor .

Floating-Point Load and Store Instructions .

---

lfdux (Load Floating-Point Double with Update Indexed) Instruction

Purpose

Loads a doubleword of data from a specified location in memory into a floating-point register and possibly places the specified address in a general-purpose register.

Syntax

Bits	Value
0-5	31
6-10	FRT
11-15	RA
16-20	RB
21-30	631

Bits	Value
31	/

lfdux *FRT*, *RA*, *RB*

Description

The **lfdux** instruction loads a doubleword in storage from a specified location in memory addressed by the effective address (EA) into the target floating-point register (FPR) *FRT*.

If *RA* is not 0, the EA is the sum of the contents of general-purpose register (GPR) *RA* and GPR *RB*. If *RA* is 0, then the EA is the contents of *RB*.

If *RA* does not equal 0, and the storage access does not cause an Alignment interrupt or a Data Storage interrupt, then the EA is stored in GPR RA.

The **lfdux** instruction has one syntax form and does not affect the Floating-Point Status and Control Register.

Parameters

FRT Specifies target general-purpose register where result of operation is stored.
RA Specifies source general-purpose register for EA calculation.
RB Specifies source general-purpose register for EA calculation.

Examples

The following code loads a doubleword from memory into FPR 6 and stores the address in GPR 5:

```
.csect data[rw]
storage: .double 0x1
# Assume GPR 5 contains the address of csect data[rw].
# Assume GPR 4 contains the displacement of storage relative
# to .csect data[rw].
.csect text[pr]
lfdux 6,5,4
# FPR 6 now contains 0x3FF0 0000 0000 0000.
# GPR 5 now contains the storage address.
```

Related Information

Floating-Point Processor .

Floating-Point Load and Store Instructions .

lfdx (Load Floating-Point Double-Indexed) Instruction

Purpose

Loads a doubleword of data from a specified location in memory into a floating-point register.

Syntax

Bits	Value
0-5	31

Bits	Value
6-10	FRT
11-15	RA
16-20	RB
21-30	599
31	/

lfdx *FRT*, *RA*, *RB*

Description

The **lfdx** instruction loads a doubleword in storage from a specified location in memory addressed by the effective address (EA) into the target floating-point register (FPR) *FRT*.

If *RA* is not 0, the EA is the sum of the contents of general-purpose register (GPR) *RA* and GPR *RB*. If *RA* is 0, then the EA is the contents of GPR *RB*.

The **lfdx** instruction has one syntax form and does not affect the Floating-Point Status and Control Register or Condition Register Field 0.

Parameters

FRT Specifies target floating-point register where data is stored.
RA Specifies source general-purpose register for EA calculation.
RB Specifies source general-purpose register for EA calculation.

Examples

The following code loads a doubleword from memory into FPR 6:

```
storage: .double 0x1
  .
  .
# Assume GPR 4 contains the storage address.
lfdx 6,0,4
# FPR 6 now contains 0x3FF0 0000 0000 0000.
```

Related Information

Floating-Point Processor .

Floating-Point Load and Store Instructions .

lfq (Load Floating-Point Quad) Instruction

Purpose

Loads two double-precision values into floating-point registers.

> **Note:** The **lfq** instruction is supported only in the POWER2 implementation of the POWER family architecture.

Syntax

Bits	Value
0-5	56
6-10	FRT
11-15	RA
16-29	DS
30-31	00

POWER2
lfq *FRT*, *DS(RA)*

Description

The **lfq** instruction loads the two doublewords from the location in memory specified by the effective address (EA) into two floating-point registers (FPR).

DS is sign-extended to 30 bits and concatenated on the right with b'00' to form the offset value. If general-purpose register (GPR) *RA* is 0, the offset value is the EA. If GPR *RA* is not 0, the offset value is added to GPR *RA* to generate the EA. The doubleword at the EA is loaded into FPR *FRT*. If *FRT* is 31, the doubleword at EA+8 is loaded into FPR 0; otherwise, it is loaded into *FRT*+1.

The **lfq** instruction has one syntax form and does not affect the Floating-Point Status and Control Register or Condition Register Field 0.

Parameters

FRT Specifies the first of two target floating-point registers.
DS Specifies a 14-bit field used as an immediate value for the EA calculation.
RA Specifies one source general-purpose register for the EA calculation.

Examples

The following code copies two double-precision floating-point values from one place in memory to a second place in memory:

```
# Assume GPR 3 contains the address of the first source
# floating-point value.
# Assume GPR 4 contains the address of the target location.
lfq     7,0(3)          # Load first two values into FPRs 7 and
                        # 8.
stfq    7,0(4)          # Store the two doublewords at the new
                        # location.
```

Related Information

Floating-Point Processor .

Floating-Point Load and Store Instructions .

lfqu (Load Floating-Point Quad with Update) Instruction

Purpose

Loads two double-precision values into floating-point registers and updates the address base.

Note: The **lfqu** instruction is supported only in the POWER2 implementation of the POWER family architecture.

Syntax

Bits	Value
0-5	57
6-10	FRT
11-15	RA
16-29	DS
30-31	00

POWER2
lfqu *FRT*, *DS(RA)*

Description

The **lfqu** instruction loads the two doublewords from the location in memory specified by the effective address (EA) into two floating-point registers (FPR).

DS is sign-extended to 30 bits and concatenated on the right with b'00' to form the offset value. If general-purpose register GPR *RA* is 0, the offset value is the EA. If GPR *RA* is not 0, the offset value is added to GPR *RA* to generate the EA. The doubleword at the EA is loaded into FPR *FRT*. If *FRT* is 31, the doubleword at EA+8 is loaded into FPR 0; otherwise, it is loaded into *FRT*+1.

If GPR *RA* is not 0, the EA is placed into GPR *RA*.

The **lfqu** instruction has one syntax form and does not affect the Floating-Point Status and Control Register or Condition Register Field 0.

Parameters

FRT Specifies the first of two target floating-point register.
DS Specifies a 14-bit field used as an immediate value for the EA calculation.
RA Specifies one source general-purpose register for EA calculation and the target register for the EA update.

Examples

The following code calculates the sum of six double-precision floating-point values that are located in consecutive doublewords in memory:

```
# Assume GPR 3 contains the address of the first
# floating-point value.
# Assume GPR 4 contains the address of the target location.
lfq     7,0(3)          # Load first two values into FPRs 7 and
                        # 8.
lfqu    9,16(3)         # Load next two values into FPRs 9 and 10
                        # and update base address in GPR 3.
fadd    6,7,8           # Add first two values.
lfq     7,16(3)         # Load next two values into FPRs 7 and 8.
fadd    6,6,9           # Add third value.
fadd    6,6,10          # Add fourth value.
fadd    6,6,7           # Add fifth value.
fadd    6,6,8           # Add sixth value.
stfqx   7,0,4           # Store the two doublewords at the new
                        # location.
```

Related Information

Floating-Point Processor .

Floating-Point Load and Store Instructions .

---

lfqux (Load Floating-Point Quad with Update Indexed) Instruction

Purpose

Loads two double-precision values into floating-point registers and updates the address base.

> **Note:** The **lfqux** instruction is supported only in the POWER2 implementation of the POWER family architecture.

Syntax

Bits	Value
0-5	31
6-10	FRT
11-15	RA
16-20	RB
21-30	823
31	Rc

POWER2
lfqux *FRT*, *RA*, *RB*

Description

The **lfqux** instruction loads the two doublewords from the location in memory specified by the effective address (EA) into two floating-point registers (FPR).

If general-purpose register (GPR) *RA* is not 0, the EA is the sum of the contents of GPR *RA* and GPR *RB*. If GPR *RA* is 0, the EA is the contents of GPR *RB*. The doubleword at the EA is loaded into FPR *FRT*. If *FRT* is 31, the doubleword at EA+8 is loaded into FPR 0; otherwise, it is loaded into *FRT*+1.

If GPR *RA* is not 0, the EA is placed into GPR *RA*.

The **lfqux** instruction has one syntax form and does not affect the Floating-Point Status and Control Register or Condition Register Field 0.

Parameters

FRT Specifies the first of two target floating-point registers.
RA Specifies the first source general-purpose register for the EA calculation and the target register for the EA update.
RB Specifies the second source general-purpose register for the EA calculation.

Examples

The following code calculates the sum of three double-precision, floating-point, two-dimensional coordinates:

```
# Assume the two-dimensional coordinates are contained
# in a linked list with elements of the form:
# list_element:
#       .double          # Floating-point value of X.
#       .double          # Floating-point value of Y.
#       .next_elem       # Offset to next element;
#                        # from X(n) to X(n+1).
#
# Assume GPR 3 contains the address of the first list element.
# Assume GPR 4 contains the address where the resultant sums
# will be stored.
lfq     7,0(3)           # Get first pair of X_Y values.
lwz     5,16(3)          # Get the offset to second element.
lfqux   9,3,5            # Get second pair of X_Y values.
lwz     5,16(3)          # Get the offset to third element.
fadd    7,7,9            # Add first two X values.
fadd    8,8,10           # Add first two Y values.
lfqux   9,3,5            # Get third pair of X_Y values.
fadd    7,7,9            # Add third X value to sum.
fadd    8,8,10           # Add third Y value to sum.
stfq    7,0,4            # Store the two doubleword results.
```

Related Information

Floating-Point Processor .

Floating-Point Load and Store Instructions .

---

lfqx (Load Floating-Point Quad Indexed) Instruction

Purpose

Loads two double-precision values into floating-point registers.

> **Note:** The **lfqx** instruction is supported only in the POWER2 implementation of the POWER family architecture.

Syntax

Bits	Value
0-5	31
6-10	FRT
11-15	RA
16-20	RB
21-30	791
31	Rc

POWER2

lfqx *FRT*, *RA*, *RB*

Description

The **lfqx** instruction loads the two doublewords from the location in memory specified by the effective address (EA) into two floating-point registers (FPR).

If general-purpose register (GPR) *RA* is not 0, the EA is the sum of the contents of GPR *RA* and GPR *RB*. If GPR *RA* is 0, the EA is the contents of GPR *RB*. The doubleword at the EA is loaded into FPR *FRT*. If *FRT* is 31, the doubleword at EA+8 is loaded into FPR 0; otherwise, it is loaded into *FRT*+1.

The **lfqx** instruction has one syntax form and does not affect the Floating-Point Status and Control Register or Condition Register Field 0.

Parameters

FRT Specifies the first of two target floating-point registers.
RA Specifies one source general-purpose register for the EA calculation.
RB Specifies the second source general-purpose register for the EA calculation.

Examples

The following code calculates the sum of two double-precision, floating-point values that are located in consecutive doublewords in memory:

```
# Assume GPR 3 contains the address of the first floating-point
# value.
# Assume GPR 4 contains the address of the target location.
lfqx    7,0,3            # Load values into FPRs 7 and 8.
fadd    7,7,8            # Add the two values.
stfdx   7,0,4            # Store the doubleword result.
```

Related Information

Floating-Point Processor .

Floating-Point Load and Store Instructions .

---

lfs (Load Floating-Point Single) Instruction

Purpose

Loads a floating-point, single-precision number that has been converted to a floating-point, double-precision number into a floating-point register.

Syntax

Bits	Value
0-5	48
6-10	FRT
11-15	RA
16-31	D

lfs *FRT*, *D*(*RA*)

Description

The **lfs** instruction converts a floating-point, single-precision word in storage addressed by the effective address (EA) to a floating-point, double-precision word and loads the result into floating-point register (FPR) *FRT*.

If *RA* is not 0, the EA is the sum of the contents of GPR *RA* and *D*, a 16-bit, signed two's complement integer sign-extended to 32 bits. If *RA* is 0, then the EA is *D*.

The **lfs** instruction has one syntax form and does not affect the Floating-Point Status and Control Register or Condition Register Field 0.

Parameters

FRT Specifies target floating-point register where data is stored.
D 16-bit, signed two's complement integer sign-extended to 32 bits for EA calculation.
RA Specifies source general-purpose register for EA calculation.

Examples

The following code loads the single-precision contents of storage into FPR 6:

```
.csect data[rw]
storage: .float 0x1
# Assume GPR 5 contains the address csect data[rw].
.csect text[pr]
lfs 6,storage(5)
# FPR 6 now contains 0x3FF0 0000 0000 0000.
```

Related Information

Floating-Point Processor .

Floating-Point Load and Store Instructions .

lfsu (Load Floating-Point Single with Update) Instruction

Purpose

Loads a floating-point, single-precision number that has been converted to a floating-point, double-precision number into a floating-point register and possibly places the effective address in a general-purpose register.

Syntax

Bits	Value
0-5	49
6-10	FRT
11-15	RA
16-31	D

lfsu *FRT*, *D*(*RA*)

Description

The **lfsu** instruction converts a floating-point, single-precision word in storage addressed by the effective address (EA) to floating-point, double-precision word and loads the result into floating-point register (FPR) *FRT*.

If *RA* is not 0, the EA is the sum of the contents of general-purpose register (GPR) *RA* and *D*, a 16-bit signed two's complement integer sign extended to 32 bits. If *RA* is 0, then the EA is *D*.

If *RA* does not equal 0 and the storage access does not cause an Alignment interrupt or a Data Storage interrupt, then the EA is stored in GPR *RA*.

The **lfsu** instruction has one syntax form and does not affect the Floating-Point Status and Control Register or Condition Register Field 0.

Parameters

FRT Specifies target floating-point register where data is stored.
D 16-bit, signed two's complement integer sign-extended to 32 bits for EA calculation.
RA Specifies source general-purpose register for EA calculation and possible address update.

Examples

The following code loads the single-precision contents of storage, which is converted to double precision, into FPR 6 and stores the effective address in GPR 5:

```
.csect data[rw]
storage: .float 0x1
.csect text[pr]
# Assume GPR 5 contains the storage address.
lfsu 6,0(5)
# FPR 6 now contains 0x3FF0 0000 0000 0000.
# GPR 5 now contains the storage address.
```

Related Information

Floating-Point Processor .

Floating-Point Load and Store Instructions .

---

lfsux (Load Floating-Point Single with Update Indexed) Instruction

Purpose

Loads a floating-point, single-precision number that has been converted to a floating-point, double-precision number into a floating-point register and possibly places the effective address in a general-purpose register.

Syntax

Bits	Value
0-5	31
6-10	FRT
11-15	RA
16-20	RB
21-30	567
31	/

lfsux *FRT*, *RA*, *RB*

Description

The **lfsux** instruction converts a floating-point, single-precision word in storage addressed by the effective address (EA) to floating-point, double-precision word and loads the result into floating-point register (FPR) *FRT*.

If general-purpose register (GPR) *RA* is not 0, the EA is the sum of the contents of GPR *RA* and GPR *RB*. If *RA* is 0, then the EA is the contents of GPR *RB*.

If GPR *RA* does not equal 0 and the storage access does not cause an Alignment interrupt or a Data Storage interrupt, then the EA is stored in GPR *RA*.

The **lfsux** instruction has one syntax form and does not affect the Floating-Point Status Control Register.

Parameters

FRT Specifies target floating-point register where data is stored.
RA Specifies source general-purpose register for EA calculation and possible address update.
RB Specifies source general-purpose register for EA calculation.

Examples

The following code loads the single-precision contents of storage into FPR 6 and stores the effective address in GPR 5:

```
.csect data[rw]
storage: .float 0x1
# Assume GPR 4 contains the address of csect data[rw].
# Assume GPR 5 contains the displacement of storage
# relative to .csect data[rw].
.csect text[pr]
lfsux 6,5,4
# FPR 6 now contains 0x3FF0 0000 0000 0000.
# GPR 5 now contains the storage address.
```

Related Information

Floating-Point Processor .

Floating-Point Load and Store Instructions .

---

lfsx (Load Floating-Point Single Indexed) Instruction

Purpose

Loads a floating-point, single-precision number that has been converted to a floating-point, double-precision number into a floating-point register.

Syntax

Bits	Value
0-5	31
6-10	FRT
11-15	RA
16-20	RB
21-30	535

Bits	Value
31	/

lfsx *FRT*, *RA*, *RB*

Description

The **lfsx** instruction converts a floating-point, single-precision word in storage addressed by the effective address (EA) to floating-point, double-precision word and loads the result into floating-point register (FPR) *FRT*.

If general-purpose register (GPR) *RA* is not 0, the EA is the sum of the contents of GPR *RA* and GPR *RB*. If *RA* is 0, then the EA is the contents of GPR *RB*.

The **lfsx** instruction has one syntax form and does not affect the Floating-Point Status and Control Register.

Parameters

FRT Specifies target floating-point register where data is stored.
RA Specifies source general-purpose register for EA calculation.
RB Specifies source general-purpose register for EA calculation.

Examples

The following code loads the single-precision contents of storage into FPR 6:

```
storage: .float 0x1.
# Assume GPR 4 contains the address of storage.
lfsx 6,0,4
# FPR 6 now contains 0x3FF0 0000 0000 0000.
```

Related Information

Floating-Point Processor .

Floating-Point Load and Store Instructions .

lha (Load Half Algebraic) Instruction

Purpose

Loads a halfword of data from a specified location in memory into a general-purpose register and copies bit 0 of the halfword into the remaining 16 bits of the general-purpose register.

Syntax

Bits	Value
0-5	42
6-10	RT
11-15	RA
16-31	D

Description

The **lha** instruction loads a halfword of data from a specified location in memory, addressed by the effective address (EA), into bits 16-31 of the target general-purpose register (GPR) *RT* and copies bit 0 of the halfword into bits 0-15 of GPR *RT*.

If GPR *RA* is not 0, the EA is the sum of the contents of GPR *RA* and *D*, a 16-bit signed two's complement integer sign extended to 32 bits. If GPR *RA* is 0, then the EA is *D*.

The **lha** instruction has one syntax form and does not affect the Fixed-Point Exception Register or Condition Register Field 0.

Parameters

RT Specifies target general-purpose register where result of operation is stored.
D 16-bit, signed two's complement integer sign-extended to 32 bits for EA calculation.
RA Specifies source general-purpose register for EA calculation.

Examples

The following code loads a halfword of data into bits 16-31 of GPR 6 and copies bit 0 of the halfword into bits 0-15 of GPR 6:

```
.csect data[rw]
storage: .short 0xffff
# Assume GPR 5 contains the address of csect data[rw].
.csect text[pr]
lha 6,storage(5)
# GPR 6 now contains 0xffff ffff.
```

Related Information

Fixed-Point Processor .

Fixed-Point Load and Store Instructions .

---

lhau (Load Half Algebraic with Update) Instruction

Purpose

Loads a halfword of data from a specified location in memory into a general-purpose register, copies bit 0 of the halfword into the remaining 16 bits of the general-purpose register, and possibly places the address in another general-purpose register.

Syntax

Bits	Value
0-5	43
6-10	RT
11-15	RA
16-31	D

Description

The **lhau** instruction loads a halfword of data from a specified location in memory, addressed by the effective address (EA), into bits 16-31 of the target general-purpose register (GPR) *RT* and copies bit 0 of the halfword into bits 0-15 of GPR *RT*.

If GPR *RA* is not 0, the EA is the sum of the contents of GPR *RA* and *D*, a 16-bit, signed two's complement integer sign-extended to 32 bits. If GPR *RA* is 0, then the EA is *D*.

If *RA* does not equal *RT* and *RA* does not equal 0, and the storage access does not cause an Alignment interrupt or a Data Storage interrupt, then the EA is placed into GPR *RA*.

The **lhau** instruction has one syntax form and does not affect the Fixed-Point Exception Register or Condition Register Field 0.

Parameters

RT Specifies target general-purpose register where result of operation is stored.
D 16-bit, signed two's complement integer sign-extended to 32 bits for EA calculation.
RA Specifies source general-purpose register for EA calculation and possible address update.

Examples

The following code loads a halfword of data into bits 16-31 of GPR 6, copies bit 0 of the halfword into bits 0-15 of GPR 6, and stores the effective address in GPR 5:

```
.csect data[rw]
storage: .short 0xffff
# Assume GPR 5 contains the address of csect data[rw].
.csect text[pr]
lhau 6,storage(5)
# GPR 6 now contains 0xffff ffff.
# GPR 5 now contains the address of storage.
```

Related Information

Fixed-Point Processor .

Fixed-Point Load and Store with Update Instructions .

lhaux (Load Half Algebraic with Update Indexed) Instruction

Purpose

Loads a halfword of data from a specified location in memory into a general-purpose register, copies bit 0 of the halfword into the remaining 16 bits of the general-purpose register, and possibly places the address in another general-purpose register.

Syntax

Bits	Value
0-5	31
6-10	RT
11-15	RA

Bits	Value
16-20	RB
21-30	375
31	/

lhaux *RT*, *RA*, *RB*

Description

The **lhaux** instruction loads a halfword of data from a specified location in memory addressed by the effective address (EA) into bits 16-31 of the target general-purpose register (GPR) *RT* and copies bit 0 of the halfword into bits 0-15 of GPR *RT*.

If GPR *RA* is not 0, the EA is the sum of the contents of GPR *RA* and GPR *RB*. If GPR *RA* is 0, then the EA is the contents of GPR *RB*.

If *RA* does not equal *RT* and *RA* does not equal 0, and the storage access does not cause an Alignment interrupt or a Data Storage interrupt, then the EA is placed into GPR *RA*.

The **lhaux** instruction has one syntax form and does not affect the Fixed-Point Exception Register.

Parameters

RT Specifies target general-purpose register where result of operation is stored.
RA Specifies first source general-purpose register for EA calculation and possible address update.
RB Specifies second source general-purpose register for EA calculation.

Examples

The following code loads a halfword of data into bits 16-31 of GPR 6, copies bit 0 of the halfword into bits 0-15 of GPR 6, and stores the effective address in GPR 5:

```
.csect data[rw]
storage: .short 0xffff
# Assume GPR 5 contains the address of csect data[rw].
# Assume GPR 4 contains the displacement of storage relative
# to data[rw].
.csect text[pr]
lhaux 6,5,4
# GPR 6 now contains 0xffff ffff.
# GPR 5 now contains the storage address.
```

Related Information

Fixed-Point Processor .

Fixed-Point Load and Store with Update Instructions .

lhax (Load Half Algebraic Indexed) Instruction

Purpose

Loads a halfword of data from a specified location in memory into a general-purpose register and copies bit 0 of the halfword into the remaining 16 bits of the general-purpose register.

Syntax

Bits	Value
0-5	31
6-10	RT
11-15	RA
16-20	RB
21-30	343
31	/

lhax *RT*, *RA*, *RB*

Description

The **lhax** instruction loads a halfword of data from a specified location in memory, addressed by the effective address (EA), into bits 16-31 of the target general-purpose register (GPR) *RT* and copies bit 0 of the halfword into bits 0-15 of GPR *RT*.

If GPR *RA* is not 0, the EA is the sum of the contents of GPR *RA* and GPR *RB*. If GPR *RA* is 0, then the EA is the contents of GPR *RB*.

The **lhax** instruction has one syntax form and does not affect the Fixed-Point Exception Register.

Parameters

RT Specifies target general-purpose register where result of operation is stored.
RA Specifies source general-purpose register for EA calculation.
RB Specifies source general-purpose register for EA calculation.

Examples

The following code loads a halfword of data into bits 16-31 of GPR 6 and copies bit 0 of the halfword into bits 0-15 of GPR 6:

```
.csect data[rw]
.short 0x1
# Assume GPR 5 contains the address of csect data[rw].
# Assume GPR 4 contains the displacement of the halfword
# relative to data[rw].
.csect text[pr]
lhax 6,5,4
# GPR 6 now contains 0x0000 0001.
```

Related Information

Fixed-Point Processor .

Fixed-Point Load and Store Instructions .

---

lhbrx (Load Half Byte-Reverse Indexed) Instruction

Purpose

Loads a byte-reversed halfword of data from a specified location in memory into a general-purpose register and sets the remaining 16 bits of the general-purpose register to zero.

Syntax

Bits	Value
0-5	31
6-10	RT
11-15	RA
16-20	RB
21-30	790
31	/

lhbrx *RT*, *RA*, *RB*

Description

The **lhbrx** instruction loads bits 00-07 and bits 08-15 of the halfword in storage addressed by the effective address (EA) into bits 24-31 and bits 16-23 of general-purpose register (GPR) *RT,* and sets bits 00-15 of GPR *RT* to 0.

If GPR *RA* is not 0, the EA is the sum of the contents of GPR *RA* and GPR *RB*. If GPR *RA* is 0, then the EA is the contents of GPR *RB*.

The **lhbrx** instruction has one syntax form and does not affect the Fixed-Point Exception Register or Condition Register Field 0.

Parameters

RT Specifies target general-purpose register where result of operation is stored.
RA Specifies source general-purpose register for EA calculation.
RB Specifies source general-purpose register for EA calculation.

Examples

The following code loads bits 00-07 and bits 08-15 of the halfword in storage into bits 24-31 and bits 16-23 of GPR 6, and sets bits 00-15 of GPR 6 to 0:

```
.csect data[rw]
.short 0x7654
# Assume GPR 4 contains the address of csect data[rw].
# Assume GPR 5 contains the displacement relative
# to data[rw].
.csect text[pr]
lhbrx 6,5,4
# GPR 6 now contains 0x0000 5476.
```

Related Information

Fixed-Point Processor .

Fixed-Point Load and Store Instructions .

lhz (Load Half and Zero) Instruction

Purpose

Loads a halfword of data from a specified location in memory into a general-purpose register and sets the remaining 16 bits to 0.

Syntax

Bits	Value
0-5	40
6-10	RT
11-15	RA
16-31	D

lhz *RT*, *D*(*RA*)

Description

The **lhz** instruction loads a halfword of data from a specified location in memory, addressed by the effective address (EA), into bits 16-31 of the target general-purpose register (GPR) *RT* and sets bits 0-15 of GPR *RT* to 0.

If GPR *RA* is not 0, the EA is the sum of the contents of GPR *RA* and *D*, a 16-bit, signed two's complement integer sign-extended to 32 bits. If GPR *RA* is 0, then the EA is *D*.

The **lhz** instruction has one syntax form and does not affect the Fixed-Point Exception Register or Condition Register Field 0.

Parameters

RT Specifies target general-purpose register where result of operation is stored.
D 16-bit, signed two's complement integer sign-extended to 32 bits for EA calculation.
RA Specifies source general-purpose register for EA calculation.

Examples

The following code loads a halfword of data into bits 16-31 of GPR 6 and sets bits 0-15 of GPR 6 to 0:

```
.csect data[rw]
storage: .short 0xffff
# Assume GPR 4 holds the address of csect data[rw].
.csect text[pr]
lhz 6,storage(4)
# GPR 6 now holds 0x0000 ffff.
```

Related Information

Fixed-Point Processor .

Fixed-Point Load and Store Instructions .

lhzu (Load Half and Zero with Update) Instruction

Purpose

Loads a halfword of data from a specified location in memory into a general-purpose register, sets the remaining 16 bits of the general-purpose register to 0, and possibly places the address in another general-purpose register.

Syntax

Bits	Value
0-5	41
6-10	RT
11-15	RA
16-31	D

lhzu *RT*, *D*(*RA*)

Description

The **lhzu** instruction loads a halfword of data from a specified location in memory, addressed by the effective address (EA), into bits 16-31 of the target general-purpose register (GPR) *RT* and sets bits 0-15 of GPR *RT* to 0.

If GPR *RA* is not 0, the EA is the sum of the contents of GPR *RA* and *D*, a 16-bit, signed two's complement integer sign-extended to 32 bits. If GPR *RA* is 0, then the EA is *D*.

If *RA* does not equal *RT* and *RA* does not equal 0, and the storage access does not cause an Alignment interrupt or a Data Storage interrupt, then the EA is placed into GPR *RA*.

The **lhzu** instruction has one syntax form and does not affect the Fixed-Point Exception Register or Condition Register Field 0.

Parameters

RT Specifies target general-purpose register where result of operation is stored.
D 16-bit, signed two's complement integer sign-extended to 32 bits for EA calculation.
RA Specifies source general-purpose register for EA calculation and possible address update.

Examples

The following code loads a halfword of data into bits 16-31 of GPR 6, sets bits 0-15 of GPR 6 to 0, and stores the effective address in GPR 4:

```
.csect data[rw]
.short 0xffff
# Assume GPR 4 contains the address of csect data[rw].
.csect text[pr]
lhzu 6,0(4)
# GPR 6 now contains 0x0000 ffff.
```

Related Information

Fixed-Point Processor .

Fixed-Point Load and Store with Update Instructions .

---

lhzux (Load Half and Zero with Update Indexed) Instruction

Purpose

Loads a halfword of data from a specified location in memory into a general-purpose register, sets the remaining 16 bits of the general-purpose register to 0, and possibly places the address in another general-purpose register.

Syntax

Bits	Value
0-5	31
6-10	RT
11-15	RA
16-20	RB
21-30	331
31	/

lhzux *RT*, *RA*, *RB*

Description

The **lhzux** instruction loads a halfword of data from a specified location in memory, addressed by the effective address (EA), into bits 16-31 of the target general-purpose register (GPR) *RT* and sets bits 0-15 of GPR *RT* to 0.

If GPR *RA* is not 0, the EA is the sum of the contents of GPR *RA* and GPR *RB*. If GPR *RA* is 0, then the EA is the contents of GPR *RB*.

If *RA* does not equal *RT* and *RA* does not equal 0, and the storage access does not cause an Alignment interrupt or a Data Storage interrupt, then the EA is placed into GPR *RA*.

The **lhzux** instruction has one syntax form and does not affect the Fixed-Point Exception Register.

Parameters

RT Specifies target general-purpose register where result of operation is stored.
RA Specifies source general-purpose register for EA calculation and possible address update.
RB Specifies source general-purpose register for EA calculation.

Examples

The following code loads a halfword of data into bits 16-31 of GPR 6, sets bits 0-15 of GPR 6 to 0, and stores the effective address in GPR 5:

```
.csect data[rw]
storage: .short 0xffff
# Assume GPR 5 contains the address of csect data[rw].
```

```
# Assume GPR 4 contains the displacement of storage
# relative to data[rw].
.csect text[pr]
lhzux 6,5,4
# GPR 6 now contains 0x0000 ffff.
# GPR 5 now contains the storage address.
```

Related Information

Fixed-Point Processor .

Fixed-Point Load and Store with Update Instructions .

---

lhzx (Load Half and Zero Indexed) Instruction

Purpose

Loads a halfword of data from a specified location in memory into a general-purpose register and sets the remaining 16 bits of the general-purpose register to 0.

Syntax

Bits	Value
0-5	31
6-10	RT
11-15	RA
16-20	RB
21-30	279
31	/

lhzx *RT*, *RA*, *RB*

Description

The **lhzx** instruction loads a halfword of data from a specified location in memory, addressed by the effective address (EA), into bits 16-31 of the target general-purpose register (GPR) *RT* and sets bits 0-15 of GPR *RT* to 0.

If GPR *RA* is not 0, the EA is the sum of the contents of GPR *RA* and GPR *RB*. If GPR *RA* is 0, then the EA is the contents of GPR *RB*.

The **lhzx** instruction has one syntax form and does not affect the Fixed-Point Exception Register or Condition Register Field 0.

Parameters

RT Specifies target general-purpose register where result of operation is stored.
RA Specifies source general-purpose register for EA calculation.
RB Specifies source general-purpose register for EA calculation.

Examples

The following code loads a halfword of data into bits 16-31 of GPR 6 and sets bits 0-15 of GPR 6 to 0:

```
.csect data[rw]
.short 0xffff
.csect text[pr]
# Assume GPR 5 contains the address of csect data[rw].
# Assume 0xffff is the halfword located at displacement 0.
# Assume GPR 4 contains 0x0000 0000.
lhzx 6,5,4
# GPR 6 now contains 0x0000 ffff.
```

Related Information

Fixed-Point Processor .

Fixed-Point Load and Store Instructions .

---

lmw or lm (Load Multiple Word) Instruction

Purpose

Loads consecutive words at a specified location into more than one general-purpose register.

Syntax

Bits	Value
0-5	46
6-10	RT
11-15	RA
16-31	D

PowerPC
lmw *RT*, *D*(*RA*)

POWER family
lm *RT*, *D*(*RA*)

Description

The **lmw** and **lm** instructions load *N* consecutive words starting at the calculated effective address (EA) into a number of general-purpose registers (GPR), starting at GPR *RT* and filling all GPRs through GPR 31. *N* is equal to 32-*RT* field, the total number of consecutive words that are placed in consecutive registers.

If GPR *RA* is not 0, the EA is the sum of the contents of GPR *RA* and *D*. If GPR *RA* is 0, then the EA is *D*.

Consider the following when using the PowerPC instruction **lmw**:

- If GPR *RA* or GPR *RB* is in the range of registers to be loaded or *RT* = *RA* = 0, the results are boundedly undefined.
- The EA must be a multiple of 4. If it is not, the system alignment error handler may be invoked or the results may be boundedly undefined.

For the POWER family instruction **lm**, if GPR *RA* is not equal to 0 and GPR *RA* is in the range to be loaded, then GPR *RA* is not written to. The data that would have normally been written into *RA* is discarded and the operation continues normally.

The **lmw** and **lm** instructions have one syntax and do not affect the Fixed-Point Exception Register or Condition Register Field 0.

> **Note:** The **lmw** and **lm** instructions are interruptible due to a data storage interrupt. When such an interrupt occurs, the instruction should be restarted from the beginning.

Parameters

RT Specifies starting target general-purpose register for operation.
D Specifies a 16-bit signed two's complement integer sign extended to 32 bits for EA calculation
RA Specifies source general-purpose register for EA calculation.

Examples

The following code loads data into GPR 29 and GPR 31:

```
.csect data[rw]
.long 0x8971
.long -1
.long 0x7ffe c100
# Assume GPR 30 contains the address of csect data[rw].
.csect text[pr]
lmw 29,0(30)
# GPR 29 now contains 0x0000 8971.
# GPR 30 now contains the address of csect data[rw].
# GPR 31 now contains 0x7ffe c100.
```

Related Information

Fixed-Point Processor .

Fixed-Point Load and Store Instructions .

---

lq (Load Quad Word) Instruction

Purpose

Load a quad-word of data into the specified general purpose register.

Note: This instruction should only be used on 64-bit PowerPC processors running a 64-bit application.

Syntax

Bits	Value
0-5	56
6-10	RT
11-15	RA
16-27	DQ
28-31	PT

PowerPC 64

lq *"RT" on page 275*, *"DQ" on page 275*(*"RA" on page 275*), *"PT" on page 275*

Description

The **lq** instruction loads a quad word in storage from a specified location in memory addressed by the effective address (EA) into the target general-purpose registers (GPRs) *RT* and *RT+1*.

If GPR *RA* is not 0, the EA is the sum of the contents of GPR *RA* and *DQ*, a 12-bit, signed two's complement integer, which is concatenated on the right by 0b0000 and sign extended to 64 bits. If GPR *RA* is 0, then the EA is *DQ*.

Parameters

RT Specifies target general-purpose register where result of operation is stored. If RT is odd, the instruction form is invalid.

DQ Specifies a 12-bit, signed two's complement integer, concatenated on the right with 0b0000, and sign-extended to 64 bits for EA calculation.

RA Specifies source general-purpose register for EA calculation.

PT Specifies a 4-bit unsigned immediate value.

Implementation

This instruction is defined only for 64-bit implementations. Using it on a 32-bit implementation will cause the system illegal instruction error handler to be invoked.

Related Information

"Fixed-Point Processor" on page 19.

"Fixed-Point Load and Store Instructions" on page 19.

lscbx (Load String and Compare Byte Indexed) Instruction

Purpose

Loads consecutive bytes in storage into consecutive registers.

Note: The **lscbx** instruction is supported only in the POWER family architecture.

Syntax

Bits	Value
0-5	31
6-10	RT
11-15	RA
16-20	RB
21-30	277
31	Rc

POWER family

lscbx *RT*, *RA*, *RB*

lscbx. *RT*, *RA*, *RB*

Description

The **lscbx** instruction loads *N* consecutive bytes addressed by effective address (EA) into general-purpose register (GPR) *RT*, starting with the leftmost byte in register *RT*, through *RT* + *NR* - 1, and wrapping around back through GPR 0, if required, until either a byte match is found with XER16-23 or *N* bytes have been loaded. If a byte match is found, then that byte is also loaded.

If GPR *RA* is not 0, the EA is the sum of the contents of GPR *RA* and the address stored in GPR *RB*. If *RA* is 0, then EA is the contents of GPR *RB*.

Consider the following when using the **lscbx** instruction:

- XER(16-23) contains the byte to be compared.
- XER(25-31) contains the byte count before the instruction is invoked and the number of bytes loaded after the instruction has completed.
- If XER(25-31) = 0, GPR *RT* is not altered.
- *N* is XER(25-31), which is the number of bytes to load.
- *NR* is ceiling(*N*/4), which is the total number of registers required to contain the consecutive bytes.

Bytes are always loaded left to right in the register. In the case when a match was found before *N* bytes were loaded, the contents of the rightmost bytes not loaded from that register and the contents of all succeeding registers up to and including register *RT* + *NR* - 1 are undefined. Also, no reference is made to storage after the matched byte is found. In the case when a match was not found, the contents of the rightmost bytes not loaded from register *RT* + *NR* - 1 are undefined.

If GPR *RA* is not 0 and GPRs *RA* and *RB* are in the range to be loaded, then GPRs *RA* and *RB* are not written to. The data that would have been written into them is discarded, and the operation continues normally. If the byte in XER(16-23) compares with any of the 4 bytes that would have been loaded into GPR *RA* or *RB*, but are being discarded for restartability, the EQ bit in the Condition Register and the count returned in XER(25-31) are undefined. The Multiply Quotient (MQ) Register is not affected by this operation.

The **lscbx** instruction has two syntax forms. Each syntax form has a different effect on Condition Register Field 0.

Syntax Form	Overflow Exception (OE)	Fixed-Point Exception Register	Record Bit (Rc)	Condition Register Field 0
lscbx	None	XER(25-31) = # of bytes loaded	0	None
lscbx.	None	XER(25-31) = # of bytes loaded	1	LT,GT,EQ,SO

The two syntax forms of the **lscbx** instruction place the number of bytes loaded into Fixed-Point Exception Register (XER) bits 25-31. If the syntax form sets the Record (Rc) bit to 1, the instruction affects the Less Than (LT) zero, Greater Than (GT) zero, Equal To (EQ) zero, and Summary Overflow (SO) bits in Condition Register Field 0. If Rc = 1 and XER(25-31) = 0, then Condition Register Field 0 is undefined. If Rc = 1 and XER(25-31) <> 0, then Condition Register Field 0 is set as follows:

```
LT, GT, EQ, SO = b'00'||match||XER(SO)
```

> **Note:** This instruction can be interrupted by a Data Storage interrupt. When such an interrupt occurs, the instruction is restarted from the beginning.

Parameters

RT Specifies the starting target general-purpose register.
RA Specifies source general-purpose register for EA calculation.
RB Specifies source general-purpose register for EA calculation.

Examples

1. The following code loads consecutive bytes into GPRs 6, 7, and 8:

```
.csect data[rw]
string: "Hello, world"
# Assume XER16-23 = 'a.
# Assume XER25-31 = 9.
# Assume GPR 5 contains the address of csect data[rw].
# Assume GPR 4 contains the displacement of string relative
# to csect data[rw].
.csect text[pr]
lscbx 6,5,4
# GPR 6 now contains 0x4865 6c6c.
# GPR 7 now contains 0x6f2c 2077.
# GPR 8 now contains 0x6fXX XXXX.
```

2. The following code loads consecutive bytes into GPRs 6, 7, and 8:

```
# Assume XER16-23 = 'e.
# Assume XER25-31 = 9.
# Assume GPR 5 contains the address of csect data[rw].
# Assume GPR 4 contains the displacement of string relative
# to csect data[rw].
.csect text[pr]
lscbx. 6,5,4
# GPR 6 now contains 0x4865 XXXX.
# GPR 7 now contains 0xXXXX XXXX.
# GPR 8 now contains 0xXXXX XXXX.
# XER25-31 = 2.
# CRF 0 now contains 0x2.
```

Related Information

Fixed-Point Processor .

Fixed-Point String Instructions .

---

lswi or lsi (Load String Word Immediate) Instruction

Purpose

Loads consecutive bytes in storage from a specified location in memory into consecutive general-purpose registers.

Syntax

Bits	Value
0-5	31
6-10	RT
11-15	RA
16-20	NB
21-30	597

Bits	Value
31	/

PowerPC
lswi *RT*, *RA*, *NB*

POWER family
lsi *RT*, *RA*, *NB*

Description

The **lswi** and **lsi** instructions load *N* consecutive bytes in storage addressed by the effective address (EA) into general-purpose register GPR *RT,* starting with the leftmost byte, through GPR *RT*+*NR*-1, and wrapping around back through GPR 0, if required.

If GPR *RA* is not 0, the EA is the contents of GPR *RA*. If GPR *RA* is 0, then the EA is 0.

Consider the following when using the **lswi** and **lsi** instructions:

- *NB* is the byte count.
- *RT* is the starting general-purpose register.
- *N* is *NB*, which is the number of bytes to load. If *NB* is 0, then *N* is 32.
- NR is ceiling(N/4), which is the number of general-purpose registers to receive data.

For the PowerPC instruction **lswi**, if GPR *RA* is in the range of registers to be loaded or *RT* = *RA* = 0, the instruction form is invalid.

Consider the following when using the POWER family instruction **lsi**:

- If GPR *RT* + *NR* - 1 is only partially filled on the left, the rightmost bytes of that general-purpose register are set to 0.
- If GPR *RA* is in the range to be loaded, and if GPR *RA* is not equal to 0, then GPR *RA* is not written into by this instruction. The data that would have been written into it is discarded, and the operation continues normally.

The **lswi** and **lsi** instructions have one syntax form which does not affect the Fixed-Point Exception Register or Condition Register Field 0.

> **Note:** The **lswi** and **lsi** instructions can be interrupted by a Data Storage interrupt. When such an interrupt occurs, the instruction is restarted from the beginning.

Parameters

RT Specifies starting general-purpose register of stored data.
RA Specifies general-purpose register for EA calculation.
NB Specifies byte count.

Examples

The following code loads the bytes contained in a location in memory addressed by GPR 7 into GPR 6:

```
.csect data[rw]
.string "Hello, World"
# Assume GPR 7 contains the address of csect data[rw].
.csect text[pr]
lswi 6,7,0x6
# GPR 6 now contains 0x4865 6c6c.
```

Related Information

Fixed-Point Processor .

Fixed-Point String Instructions .

---

lswx or lsx (Load String Word Indexed) Instruction

Purpose

Loads consecutive bytes in storage from a specified location in memory into consecutive general-purpose registers.

Syntax

Bits	Value
0-5	31
6-10	RT
11-15	RA
16-20	RB
21-30	533
31	/

PowerPC
lswx *RT*, *RA*, *RB*

POWER family
lsx *RT*, *RA*, *RB*

Description

The **lswx** and **lsx** instructions load *N* consecutive bytes in storage addressed by the effective address (EA) into general-purpose register (GPR) *RT,* starting with the leftmost byte, through GPR *RT* + *NR* - 1, and wrapping around back through GPR 0 if required.

If GPR *RA* is not 0, the EA is the sum of the contents of GPR *RA* and the address stored in GPR *RB*. If GPR *RA* is 0, then EA is the contents of GPR *RB*.

Consider the following when using the **lswx** and **lsx** instructions:

- XER(25-31) contain the byte count.
- *RT* is the starting general-purpose register.
- *N* is XER(25-31), which is the number of bytes to load.
- *NR* is ceiling(N/4), which is the number of registers to receive data.
- If XER(25-31) = 0, general-purpose register *RT* is not altered.

For the PowerPC instruction **lswx**, if *RA* or *RB* is in the range of registers to be loaded or *RT* = *RA* = 0, the results are boundedly undefined.

Consider the following when using the POWER family instruction **lsx**:

- If GPR *RT* + *NR* - 1 is only partially filled on the left, the rightmost bytes of that general-purpose register are set to 0.
- If GPRs *RA* and *RB* are in the range to be loaded, and if GPR *RA* is not equal to 0, then GPR *RA* and *RB* are not written into by this instruction. The data that would have been written into them is discarded, and the operation continues normally.

The **lswx** and **lsx** instructions have one syntax form which does not affect the Fixed-Point Exception Register or Condition Register Field 0.

> **Note:** The **lswx** and **lsx** instructions can be interrupted by a Data Storage interrupt. When such an interrupt occurs, the instruction is restarted from the beginning.

Parameters

RT Specifies starting general-purpose register of stored data.
RA Specifies general-purpose register for EA calculation.
RB Specifies general-purpose register for EA calculation.

Examples

The following code loads the bytes contained in a location in memory addressed by GPR 5 into GPR 6:

```
# Assume XER25-31 = 4.
csect data[rw]
storage: .string "Hello, world"
# Assume GPR 4 contains the displacement of storage
# relative to data[rw].
# Assume GPR 5 contains the address of csect data[rw].
.csect text[pr]
lswx 6,5,4
# GPR 6 now contains 0x4865 6c6c.
```

Related Information

Fixed-Point Processor .

Fixed-Point String Instructions .

Functional Differences for POWER family and PowerPC Instructions .

---

lwa (Load Word Algebraic) Instruction

Purpose

Load a fullword of data from storage into the low-order 32 bits of the specified general purpose register. Sign extend the data into the high-order 32 bits of the register.

Syntax

Bits	Value
0-5	58
6-10	D

Bits	Value
11-15	A
16-29	ds
30-31	10

POWER family
lwa *RT*, *D* (*RA*)

Description

The fullword in storage located at the effective address (EA) is loaded into the low-order 32 bits of the target general purpose register (GRP) *RT*. The value is then sign-extended to fill the high-order 32 bits of the register.

If GRP *RA* is not 0, the EA is the sum of the contents of GRP *RA* and *B*; otherwise, the EA is equal to the contents of *RB*.

Parameters

RT Specifies target general-purpose register where result of the operation is stored.
D Specifies a 16-bit, signed two's complement integer sign-extended to 32 bits for EA calculation.
RA Specifies source general-purpose register for EA calculation.

Implementation

This instruction is defined only for 64-bit implementations. Using it on a 32-bit implementation will cause the system illegal instruction error handler to be invoked.

lwarx (Load Word and Reserve Indexed) Instruction

Purpose

Used in conjunction with a subsequent **stwcx.** instruction to emulate a read-modify-write operation on a specified memory location.

Note: The **lwarx** instruction is supported only in the PowerPC architecture.

Syntax

Bits	Value
0-5	31
6-10	RT
11-15	RA
16-20	RB
21-30	20
31	/

PowerPC
lwarx *RT*, *RA*, *RB*

Description

The **lwarx** and **stwcx.** instructions are primitive, or simple, instructions used to perform a read-modify-write operation to storage. If the store is performed, the use of the **lwarx** and **stwcx.** instructions ensures that no other processor or mechanism has modified the target memory location between the time the **lwarx** instruction is executed and the time the **stwcx.** instruction completes.

If general-purpose register (GPR) *RA* = 0, the effective address (EA) is the content of GPR *RB*. Otherwise, the EA is the sum of the content of GPR *RA* plus the content of GPR *RB*.

The **lwarx** instruction loads the word from the location in storage specified by the EA into the target GPR *RT*. In addition, a reservation on the memory location is created for use by a subsequent **stwcx.** instruction.

The **lwarx** instruction has one syntax form and does not affect the Fixed-Point Exception Register. If the EA is not a multiple of 4, the results are boundedly undefined.

Parameters

RT Specifies target general-purpose register where result of operation is stored.
RA Specifies source general-purpose register for EA calculation.
RB Specifies source general-purpose register for EA calculation.

Examples

1. The following code performs a ″Fetch and Store″ by atomically loading and replacing a word in storage:

```
# Assume that GPR 4 contains the new value to be stored.
# Assume that GPR 3 contains the address of the word
# to be loaded and replaced.
loop:   lwarx   r5,0,r3          # Load and reserve
        stwcx.  r4,0,r3          # Store new value if still
                                 # reserved
        bne-    loop             # Loop if lost reservation
# The new value is now in storage.
# The old value is returned to GPR 4.
```

2. The following code performs a ″Compare and Swap″ by atomically comparing a value in a register with a word in storage:

```
# Assume that GPR 5 contains the new value to be stored after
# a successful match.
# Assume that GPR 3 contains the address of the word
# to be tested.
# Assume that GPR 4 contains the value to be compared against
# the value in memory.
loop:   lwarx   r6,0,r3          # Load and reserve
        cmpw    r4,r6            # Are the first two operands
                                 # equal?
        bne-    exit             # Skip if not equal
        stwcx.  r5,0,r3          # Store new value if still
                                 # reserved
        bne-    loop             # Loop if lost reservation
exit:   mr      r4,r6            # Return value from storage
# The old value is returned to GPR 4.
# If a match was made, storage contains the new value.
```

   If the value in the register equals the word in storage, the value from a second register is stored in the word in storage. If they are unequal, the word from storage is loaded into the first register and the EQ bit of the Condition Register field 0 is set to indicate the result of the comparison.

Related Information

The **stwcx.** (Store Word Conditional Indexed) instruction.

Processing and Storage

lwaux (Load Word Algebraic with Update Indexed) Instruction

Purpose

Load a fullword of data from storage into the low-order 32b its of the specified general purpose register. Sign extend the data into the high-order 32 bits of the register. Update the address base.

Syntax

Bits	Value
0-5	31
6-10	D
11-15	A
16-20	B
21-30	373
31	0

POWER family
lwaux *RT*, *RA*, *RB*

Description

The fullword in storage located at the effective address (EA) is loaded into the low-order 32 bits of the target general puspose register (GRP). The value is then sign-extended to fill the high-order 32 bits of the register. The EA is the sum of the contents of GRP *RA* and GRP *RB*.

If *RA* = 0 or *RA* = *RT*, the instruction form is invalid.

Parameters

RT Specifies target general-purpose register where result of the operation is stored.
RA Specifies source general-purpose register for EA calculation.
RB Specifies source general-purpose register for EA calculation.

Implementation

This instruction is defined only for 64-bit implementations. Using it on a 32-bit implementation will cause the system illegal instruction error handler to be invoked.

lwax (Load Word Algebraic Indexed) Instruction

Purpose

Load a fullword of data from storage into the low-order 32 bits of the specified general purpose register. Sign extend the data into the high-order 32 bits of the register.

Syntax

Bits	Value
0-5	31
6-10	D
11-15	A
16-20	B
21-30	341
31	0

POWER family
lwax *RT*, *RA*, *RB*

Description

The fullword in storage located at the effective address (EA) is loaded into the low-order 32 bits of the target general puspose register (GRP). The value is then sign-extended to fill the high-order 32 bits of the register.

If GRP *RA* is not 0, the EA is the sum of the contents of GRP *RA* and *B*; otherwise, the EA is equal to the contents of *RB*.

Parameters

RT Specifies target general-purpose register where result of operation is stored.
RA Specifies source general-purpose register for EA calculation.
RB Specifies source general-purpose register for EA calculation.

Implementation

This instruction is defined only for 64-bit implementations. Using it on a 32-bit implementation will cause the system illegal instruction error handler to be invoked.

lwbrx or lbrx (Load Word Byte-Reverse Indexed) Instruction

Purpose

Loads a byte-reversed word of data from a specified location in memory into a general-purpose register.

Syntax

Bits	Value
0-5	31
6-10	RT
11-15	RA
16-20	RB
21-30	534
31	/

PowerPC
lwbrx *RT*, *RA*, *RB*

POWER family
lbrx *RT*, *RA*, *RB*

Description

The **lwbrx** and **lbrx** instructions load a byte-reversed word in storage from a specified location in memory addressed by the effective address (EA) into the target general-purpose register (GPR) *RT*.

Consider the following when using the **lwbrx** and **lbrx** instructions:

- Bits 00-07 of the word in storage addressed by EA are placed into bits 24-31 of GPR *RT*.
- Bits 08-15 of the word in storage addressed by EA are placed into bits 16-23 of GPR *RT*.
- Bits 16-23 of the word in storage addressed by EA are placed into bits 08-15 of GPR *RT*.
- Bits 24-31 of the word in storage addressed by EA are placed into bits 00-07 of GPR *RT*.

If GPR *RA* is not 0, the EA is the sum of the contents of GPR *RA* and GPR *RB*. If GPR *RA* is 0, then the EA is the contents of GPR *RB*.

The **lwbrx** and **lbrx** instructions have one syntax form and do not affect the Fixed-Point Exception Register or Condition Register Field 0.

Parameters

RT Specifies target general-purpose register where result of operation is stored.
RA Specifies source general-purpose register for EA calculation.
RB Specifies source general-purpose register for EA calculation.

Examples

The following code loads a byte-reversed word from memory into GPR 6:

```
storage:  .long 0x0000 ffff
 .
 .
# Assume GPR 4 contains 0x0000 0000.
# Assume GPR 5 contains address of storage.
lwbrx 6,4,5
# GPR 6 now contains 0xffff 0000.
```

Related Information

Fixed-Point Processor .

Fixed-Point Load and Store Instructions .

---

lwz or l (Load Word and Zero) Instruction

Purpose

Loads a word of data from a specified location in memory into a general-purpose register.

Syntax

Bits	Value
0-5	32
6-10	RT
11-15	RA
16-31	D

PowerPC
lwz *RT*, *D*(*RA*)

POWER family
l *RT*, *D*(*RA*)

Description

The **lwz and l** instructions load a word in storage from a specified location in memory addressed by the effective address (EA) into the target general-purpose register (GPR) *RT*.

If GPR *RA* is not 0, the EA is the sum of the contents of GPR *RA* and *D*, a 16-bit, signed two's complement integer sign-extended to 32 bits. If GPR *RA* is 0, then the EA is *D*.

The **lwz and l** instructions have one syntax form and do not affect the Fixed-Point Exception Register or Condition Register Field 0.

Parameters

RT Specifies target general-purpose register where result of operation is stored.
D Specifies a 16-bit, signed two's complement integer sign-extended to 32 bits for EA calculation.
RA Specifies source general-purpose register for EA calculation.

Examples

The following code loads a word from memory into GPR 6:

```
.csect data[rw]
# Assume GPR 5 contains address of csect data[rw].
storage: .long 0x4
.csect text[pr]
lwz 6,storage(5)
# GPR 6 now contains 0x0000 0004.
```

Related Information

Fixed-Point Processor .

Fixed-Point Load and Store Instructions .

---

lwzu or lu (Load Word with Zero Update) Instruction

Purpose

Loads a word of data from a specified location in memory into a general-purpose register and possibly places the effective address in a second general-purpose register.

Syntax

Bits	Value
0-5	33
6-10	RT
11-15	RA
16-31	D

PowerPC
lwzu *RT*, *D*(*RA*)

POWER family
lu *RT*, *D*(*RA*)

Description

The **lwzu** and **lu** instructions load a word in storage from a specified location in memory addressed by the effective address (EA) into the target general-purpose register (GPR) *RT*.

If GPR *RA* is not 0, the EA is the sum of the contents of GPR *RA* and *D*, a 16-bit, signed two's complement integer sign-extended to 32 bits. If GPR *RA* is 0, then the EA is *D*.

If *RA* does not equal *RT* and *RA* does not equal 0, and the storage access does not cause an Alignment interrupt or a Data Storage interrupt, then the EA is placed into GPR *RA*.

The **lwzu** and **lu** instructions have one syntax form and do not affect the Fixed-Point Exception Register or Condition Register Field 0.

Parameters

RT Specifies target general-purpose register where result of operation is stored.
D Specifies a 16-bit, signed two's complement integer sign-extended to 32 bits for EA calculation.
RA Specifies source general-purpose register for EA calculation and possible address update.

Examples

The following code loads a word from memory into GPR 6 and places the effective address in GPR 4:

```
.csect data[rw]
storage: .long 0xffdd 75ce
.csect text[pr]
# Assume GPR 4 contains address of csect data[rw].
lwzu 6,storage(4)
# GPR 6 now contains 0xffdd 75ce.
# GPR 4 now contains the storage address.
```

Related Information

Fixed-Point Processor .

Fixed-Point Load and Store with Update Instructions .

lwzux or lux (Load Word and Zero with Update Indexed) Instruction

Purpose

Loads a word of data from a specified location in memory into a general-purpose register and possibly places the effective address in a second general-purpose register.

Syntax

Bits	Value
0-5	31
6-10	RT
11-15	RA
16-20	RB
21-30	55
31	/

PowerPC
lwzux *RT*, *RA*, *RB*

POWER family
lux *RT*, *RA*, *RB*

Description

The **lwzux and lux** instructions load a word of data from a specified location in memory, addressed by the effective address (EA), into the target general-purpose register (GPR) *RT*.

If GPR *RA* is not 0, the EA is the sum of the contents of GPR *RA* and GPR *RB*. If GPR *RA* is 0, then the EA is the contents of GPR *RB*.

If GPR *RA* does not equal RT and *RA* does not equal 0, and the storage access does not cause an Alignment interrupt or a Data Storage interrupt, then the EA is placed into GPR *RA*.

The **lwzux** and **lux** instructions have one syntax form and do not affect the Fixed-Point Exception Register or Condition Register Field 0.

Parameters

RT Specifies target general-purpose register where result of operation is stored.
RA Specifies source general-purpose register for EA calculation and possible address update.
RB Specifies source general-purpose register for EA calculation.

Examples

The following code loads a word from memory into GPR 6 and places the effective address in GPR 5:

```
.csect data[rw]
storage: .long 0xffdd 75ce
# Assume GPR 5 contains the address of csect data[rw].
# Assume GPR 4 contains the displacement of storage
# relative to csect data[rw].
```

```
.csect text[pr]
lwzux 6,5,4
# GPR 6 now contains 0xffdd 75ce.
# GPR 5 now contains the storage address.
```

Related Information

Fixed-Point Processor .

Fixed-Point Load and Store with Update Instructions .

---

lwzx or lx (Load Word and Zero Indexed) Instruction

Purpose

Loads a word of data from a specified location in memory into a general-purpose register.

Syntax

Bits	Value
0-5	31
6-10	RT
11-15	RA
16-20	RB
21-30	23
31	/

PowerPC
lwzx *RT*, *RA*, *RB*

POWER family
lx *RT*, *RA*, *RB*

Description

The **lwzx** and **lx** instructions load a word of data from a specified location in memory, addressed by the effective address (EA), into the target general-purpose register (GPR) *RT*.

If GPR *RA* is not 0, the EA is the sum of the contents of GPR *RA* and GPR *RB*. If GPR *RA* is 0, then the EA is the contents of GPR *RB*.

The **lwzx** and **lx** instructions have one syntax form and do not affect the Fixed-Point Exception Register or Condition Register Field 0.

Parameters

RT Specifies target general-purpose register where result of operation is stored.
RA Specifies source general-purpose register for EA calculation.
RB Specifies source general-purpose register for EA calculation.

Examples

The following code loads a word from memory into GPR 6:

```
.csect data[rw]
.long 0xffdd 75ce
# Assume GPR 4 contains the displacement relative to
# csect data[rw].
# Assume GPR 5 contains the address of csect data[rw].
.csect text[pr]
lwzx 6,5,4
# GPR 6 now contains 0xffdd 75ce.
```

Related Information

Fixed-Point Processor .

Fixed-Point Load and Store Instructions .

---

maskg (Mask Generate) Instruction

Purpose

Generates a mask of ones and zeros and loads it into a general-purpose register.

Note: The **maskg** instruction is supported only in the POWER family architecture.

Syntax

Bits	Value
0-5	31
6-10	RS
11-15	RA
16-20	RB
21-30	29
31	Rc

POWER family

maskg *RA*, *RS*, *RB*
maskg. *RA*, *RS*, *RB*

Description

The **maskg** instruction generates a mask from a starting point defined by bits 27-31 of general-purpose register (GPR) *RS* to an end point defined by bits 27-31 of GPR *RB* and stores the mask in GPR *RA*.

Consider the following when using the **maskg** instruction:

- If the starting point bit is less than the end point bit + 1, then the bits between and including the starting point and the end point are set to ones. All other bits are set to 0.
- If the starting point bit is the same as the end point bit + 1, then all 32 bits are set to ones.
- If the starting point bit is greater than the end point bit + 1, then all of the bits between and including the end point bit + 1 and the starting point bit - 1 are set to zeros. All other bits are set to ones.

The **maskg** instruction has two syntax forms. Each syntax form has a different effect on Condition Register Field 0.

Syntax Form	Overflow Exception (OE)	Fixed-Point Exception Register	Record Bit (Rc)	Condition Register Field 0

maskg	None	None	0	None
maskg.	None	None	1	LT,GT,EQ,SO

The two syntax forms of the **maskg** instruction never affect the Fixed-Point Exception Register. If the syntax form sets the Record (Rc) bit to 1, the instruction affects the Less Than (LT) zero, Greater Than (GT) zero, Equal To (EQ) zero, and Summary Overflow (SO) bits in Condition Register Field 0.

Parameters

RA Specifies target general-purpose register where result of operation is stored.
RS Specifies source general-purpose register for start of mask.
RB Specifies source general-purpose register for end of mask.

Examples

1. The following code generates a mask of 5 ones and stores the result in GPR 6:

```
# Assume GPR 4 contains 0x0000 0014.
# Assume GPR 5 contains 0x0000 0010.
maskg 6,5,4
# GPR 6 now contains 0x0000 F800.
```

2. The following code generates a mask of 6 zeros with the remaining bits set to one, stores the result in GPR 6, and sets Condition Register Field 0 to reflect the result of the operation:

```
# Assume GPR 4 contains 0x0000 0010.
# Assume GPR 5 contains 0x0000 0017.
# Assume CR = 0.
maskg. 6,5,4
# GPR 6 now contains 0xFFFF 81FF.
# CR now contains 0x8000 0000.
```

Related Information

Fixed-Point Processor .

Fixed-Point Rotate and Shift Instructions .

maskir (Mask Insert from Register) Instruction

Purpose

Inserts the contents of one general-purpose register into another general-purpose register under control of a bit mask.

Note: The **maskir** instruction is supported only in the POWER family architecture.

Syntax

Bits	Value
0-5	31
6-10	RS
11-15	RA
16-20	RB
21-30	541
31	Rc

POWER family
maskir *RA*, *RS*, *RB*
maskir. *RA*, *RS*, *RB*

Description

The **maskir** stores the contents of general-purpose register (GPR) *RS* in GPR *RA* under control of the bit mask in GPR *RB*.

The value for each bit in the target GPR *RA* is determined as follows:

- If the corresponding bit in the mask GPR *RB* is 1, then the bit in the target GPR *RA* is given the value of the corresponding bit in the source GPR *RS*.
- If the corresponding bit in the mask GPR *RB* is 0, then the bit in the target GPR *RA* is unchanged.

The **maskir** instruction has two syntax forms. Each syntax form has a different effect on Condition Register Field 0.

Syntax Form	Overflow Exception (OE)	Fixed-Point Exception Register	Record Bit (Rc)	Condition Register Field 0
maskir	None	None	0	None
maskir.	None	None	1	LT, GT, EQ, SO

The two syntax forms of the **maskir** instruction never affect the Fixed-Point Exception Register. If the syntax form sets the Record (Rc) bit to 1, the instruction affects the Less Than (LT) zero, Greater Than (GT) zero, Equal To (EQ) zero, and Summary Overflow (SO) bits in Condition Register Field 0.

Parameters

RA Specifies target general-purpose register where result of operation is stored.
RS Specifies source general-purpose register for operation.
RB Specifies source general-purpose register for bit mask.

Examples

1. The following code inserts the contents of GPR 5 into GPR 6 under control of the bit mask in GPR 4:

```
# Assume GPR 6 (RA) target contains 0xAAAAAAAA.
# Assume GPR 4 (RB) mask contains   0x000F0F00.
# Assume GPR 5 (RS) source contains 0x55555555.
maskir 6,5,4
# GPR 6 (RA) target now contains    0xAAA5A5AA.
```

1. The following code inserts the contents of GPR 5 into GPR 6 under control of the bit mask in GPR 4 and sets Condition Register Field 0 to reflect the result of the operation:

```
# Assume GPR 6 (RA) target contains 0xAAAAAAAA.
# Assume GPR 4 (RB) mask contains   0x0A050F00.
# Assume GPR 5 (RS) source contains 0x55555555.
maskir. 6,5,4
# GPR 6 (RA) target now contains    0xA0AFA5AA.
```

Related Information

Fixed-Point Processor .

Fixed-Point Rotate and Shift Instructions .

mcrf (Move Condition Register Field) Instruction

Purpose

Copies the contents of one condition register field into another.

Syntax

Bits	Value
0-5	19
6-8	BF
9-10	//
11-13	BFA
14-15	//
16-20	///
21-30	0
31	/

mcrf *BF*, *BFA*

Description

The **mcrf** instruction copies the contents of the condition register field specified by *BFA* into the condition register field specified by *BF*. All other fields remain unaffected.

The **mcrf** instruction has one syntax form and does not affect Condition Register Field 0 or the Fixed-Point Exception Register.

Parameters

BF Specifies target condition register field for operation.
BFA Specifies source condition register field for operation.

Examples

The following code copies the contents of Condition Register Field 3 into Condition Register Field 2:

```
# Assume Condition Register Field 3 holds b'0110'.
mcrf 2,3
# Condition Register Field 2 now holds b'0110'.
```

Related Information

Branch Processor .

mcrfs (Move to Condition Register from FPSCR) Instruction

Purpose

Copies the bits from one field of the Floating-Point Status and Control Register into the Condition Register.

Syntax

Bits	Value
0-5	63
6-8	BF
9-10	//
11-13	BFA
14-15	//
16-20	///
21-30	64
31	/

mcrfs *BF*, *BFA*

Description

The **mcrfs** instruction copies four bits of the Floating-Point Status and Control Register (FPSCR) specified by *BFA* into Condition Register Field *BF*. All other Condition Register bits are unchanged.

If the field specified by *BFA* contains reserved or undefined bits, then bits of zero value are supplied for the copy.

The **mcrfs** instruction has one syntax form and can set the bits of the Floating-Point Status and Control Register.

BFA	FPSCR bits set
0	FX,OX
1	UX, ZX, XX, VXSNAN
2	VXISI, VXIDI, VXZDZ, VXIMZ
3	VXVC

Parameters

BF Specifies target condition register field where result of operation is stored.
BFA Specifies one of the FPSCR fields (0-7).

Examples

The following code copies bits from Floating-Point Status and Control Register Field 4 into Condition Register Field 3:

```
# Assume FPSCR 4 contains b'0111'.
mcrfs 3,4
# Condition Register Field 3 contains b'0111'.
```

Related Information

Branch Processor .

Interpreting the Contents of a Floating-Point Register .

mcrxr (Move to Condition Register from XER) Instruction

Purpose

Copies the Summary Overflow bit, Overflow bit, Carry bit, and bit 3 from the Fixed-Point Exception Register into a specified field of the Condition Register.

Syntax

Bits	Value
0-5	31
6-8	BF
9-10	//
11-15	///
16-20	///
21-30	512
31	/

mcrxr *BF*

Description

The **mcrxr** copies the contents of Fixed-Point Exception Register Field 0 bits 0-3 into Condition Register Field *BF* and resets Fixed-Point Exception Register Field 0 to 0.

The **mcrxr** instruction has one syntax form and resets Fixed-Point Exception Register bits 0-3 to 0.

Parameters

BF Specifies target condition register field where result of operation is stored.

Examples

The following code copies the Summary Overflow bit, Overflow bit, Carry bit, and bit 3 from the Fixed-Point Exception Register into field 4 of the Condition Register.

```
# Assume bits 0-3 of the Fixed-Point Exception
# Register are set to b'1110'.
mcrxr 4
# Condition Register Field 4 now holds b'1110'.
```

Related Information

Branch Processor .

Fixed-Point Move to or from Special-Purpose Registers Instructions .

mfcr (Move from Condition Register) Instruction

Purpose

Copies the contents of the Condition Register into a general-purpose register.

Syntax

Bits	Value
0-5	31
6-10	RT
11-15	///
16-20	///
21-30	19
31	Rc

mfcr *RT*

Description

The **mfcr** instruction copies the contents of the Condition Register into target general-purpose register (GPR) *RT*.

The **mfcr** instruction has one syntax form and does not affect the Fixed-Point Exception Register.

Parameters

RT Specifies target general-purpose register where result of operation is stored.

Examples

The following code copies the Condition Register into GPR 6:

```
# Assume the Condition Register contains 0x4055 F605.
mfcr 6
# GPR 6 now contains 0x4055 F605.
```

Related Information

Branch Processor .

Fixed-Point Move to or from Special-Purpose Registers Instructions .

---

mffs (Move from FPSCR) Instruction

Purpose

Loads the contents of the Floating-Point Status and Control Register into a floating-point register and fills the upper 32 bits with ones.

Syntax

Bits	Value
0-5	63
6-10	FRT
11-15	///
16-20	///
21-30	583

Bits	Value
31	Rc

mffs *FRT*
mffs. *FRT*

Description

The **mffs** instruction places the contents of the Floating-Point Status and Control Register into bits 32-63 of floating-point register (FPR) *FRT*. The bits 0-31 of floating-point register *FRT* are undefined.

The **mffs** instruction has two syntax forms. Each syntax form has a different effect on Condition Register Field 1.

Syntax Form	FPSCR bits	Record Bit (Rc)	Condition Register Field 1
mffs	None	0	None
mffs.	None	1	FX, FEX, VX, OX

The two syntax forms of the **mffs** instruction never affect the Floating-Point Status and Control Register fields. If the syntax form sets the Record (Rc) bit to 1, the instruction affects the Floating-Point Exception (FX), Floating-Point Enabled Exception (FEX), Floating Invalid Operation Exception (VX), and Floating-Point Overflow Exception (OX) bits in Condition Register Field 1.

Parameters

FRT Specifies target floating-point register where result of operation is stored.

Examples

The following code loads the contents of the Floating-Point Status and Control Register into FPR 14, and fills the upper 32 bits of that register with ones:

```
# Assume FPSCR contains 0x0000 0000.
mffs 14
# FPR 14 now contains 0xFFFF FFFF 0000 0000.
```

Related Information

Floating-Point Processor .

Interpreting the Contents of a Floating-Point Register .

Functional Differences for POWER family and PowerPC Instructions .

mfmsr (Move from Machine State Register) Instruction

Purpose

Copies the contents of the Machine State Register into a general-purpose register.

Syntax

Bits	Value
0-5	31
6-10	RT
11-15	///
16-20	///
21-30	83
31	/

mfmsr *RT*

Description

The **mfmsr** instruction copies the contents of the Machine State Register into the target general-purpose register (GPR) *RT*.

The **mfmsr** instruction has one syntax form and does not affect the Fixed-Point Exception Register or Condition Register Field 0.

Parameters

RT Specifies target general-purpose register where result of operation is stored.

Examples

The following code copies the contents of the Machine State Register into GPR 4:

```
mfmsr 4
# GPR 4 now holds a copy of the bit
# settings of the Machine State Register.
```

Security

The **mfmsr** instruction is privileged only in the PowerPC architecture.

Related Information

Branch Processor .

Floating-Point Processor .

Fixed-Point Move to or from Special-Purpose Registers Instructions .

Functional Differences for POWER family and PowerPC Instructions .

mfocrf (Move from One Condition Register Field) Instruction

Purpose

Copies the contents of one Condition Register field into a general-purpose register.

Syntax

Bits	Value
0-5	31
6-10	RT
11	1
12-19	FXM
20	///
21-30	19
31	///

mfocrf *"RT", "FXM"*

Description

The **mfocrf** instruction copies the contents of one Condition Register field specified by the field mask FXM into the target general-purpose register (GPR) *RT*.

Field mask FXM is defined as follows:

Bit	Description
12	CR 00-03 is copied into GPR *RS* 00-03.
13	CR 04-07 is copied into GPR *RS* 04-07.
14	CR 08-11 is copied into GPR *RS* 08-11.
15	CR 12-15 is copied into GPR *RS* 12-15.
16	CR 16-19 is copied into GPR *RS* 16-19.
17	CR 20-23 is copied into GPR *RS* 20-23.
18	CR 24-27 is copied into GPR *RS* 24-27.
19	CR 28-31 is copied into GPR *RS* 28-31.

The **mfocrf** instruction has one syntax form and does not affect the Fixed-Point Exception Register.

Parameters

RT Specifies target general-purpose register where result of operation is stored.
FXM Specifies field mask. Only one bit may be specified.

Examples

The following code copies the Condition Register field 3 into GPR 6:

```
# Assume the Condition Register contains 0x4055 F605.
# Field 3 (0x10 = b'0001 0000')
mfocrf 6, 0x10
# GPR 6 now contains 0x0005 0000.
```

Related Information

"Branch Processor" on page 17.

"Fixed-Point Move to or from Special-Purpose Registers Instructions" on page 21.

mfspr (Move from Special-Purpose Register) Instruction

Purpose

Copies the contents of a special-purpose register into a general-purpose register.

Syntax

Bits	Value
0-5	31
6-10	RT
11-20	spr
21-30	339
31	Rc

mfspr *RT*, *SPR*

Note: The special-purpose register is a split field.

See Extended Mnemonics of Moving from or to Special-Purpose Registers for more information.

Description

The **mfspr** instruction copies the contents of the special-purpose register *SPR* into target general-purpose register (GPR) *RT*.

The special-purpose register identifier *SPR* can have any of the values specified in the following table. The order of the two 5-bit halves of the SPR number is reversed.

SPR Values			
Decimal	**spr**$^{5:9}$ spr$^{0:4}$	**Register Name**	**Privileged**
1	00000 00001	XER	No
8	00000 01000	LR	No
9	00000 01001	CTR	No
18	00000 10010	DSISR	Yes
19	00000 10011	DAR	Yes
22	00000 10110	DEC[2]	Yes
25	00000 11001	SDR1	Yes
26	00000 11010	SRR0	Yes
27	00000 11011	SRR1	Yes
272	01000 10000	SPRG0	Yes
273	01000 10001	SPRG1	Yes
274	01000 10010	SPRG2	Yes
275	01000 10011	SPRG3	Yes
282	01000 11010	EAR	Yes
284	01000 11100	TBL	Yes

285	01000 11101	TBU	Yes
528	10000 10000	IBAT0U	Yes
529	10000 10001	IBAT0L	Yes
530	10000 10010	IBAT1U	Yes
531	10000 10011	IBAT1L	Yes
532	10000 10100	IBAT2U	Yes
533	10000 10101	IBAT2L	Yes
534	10000 10110	IBAT3U	Yes
535	10000 10111	IBAT3L	Yes
536	10000 11000	DBAT0U	Yes
537	10000 11001	DBAT0L	Yes
538	10000 11010	DBAT1U	Yes
539	10000 11011	DBAT1L	Yes
540	10000 11100	DBAT2U	Yes
541	10000 11101	DBAT2L	Yes
542	10000 11110	DBAT3U	Yes
543	10000 11111	DBAT3L	Yes
0	00000 00000	MQ[1]	No
4	00000 00100	RTCU[1]	No
5	00000 00101	RTCL[1]	No
6	00000 00110	DEC[2]	No

1Supported only in the POWER family architecture.

2In the PowerPC architecture moving from the DEC register is privileged and the SPR value is 22. In the POWER family architecture moving from the DEC register is not privileged and the SPR value is 6. For more information, see Fixed-Point Move to or from Special-Purpose Registers Instructions .

If the SPR field contains any value other than those listed in the SPR Values table, the instruction form is invalid.

The **mfspr** instruction has one syntax form and does not affect the Fixed-Point Exception Register or Condition Register Field 0.

Parameters

RT Specifies target general-purpose register where result of operation is stored.
SPR Specifies source special-purpose register for operation.

Examples

The following code copies the contents of the Fixed-Point Exception Register into GPR 6:

```
mfspr 6,1
# GPR 6 now contains the bit settings of the Fixed
# Point Exception Register.
```

Related Information

Fixed-Point Processor .

Fixed-Point Move to or from Special-Purpose Registers Instructions .

---

mfsr (Move from Segment Register) Instruction

Purpose

Copies the contents of a segment register into a general-purpose register.

Syntax

Bits	Value
0-5	31
6-8	RT
11	/
12-14	SR
16-20	///
21-30	595
31	/

mfsr *RT*, *SR*

Description

The **mfsr** instruction copies the contents of segment register (SR) into target general-purpose register (GPR) *RT*.

The **mfsr** instruction has one syntax form and does not effect the Fixed-Point Exception Register. If the Record (Rc) bit is set to 1, Condition Register Field 0 is undefined.

Parameters

RT Specifies the target general-purpose register where the result of the operation is stored.
SR Specifies the source segment register for the operation.

Examples

The following code copies the contents of Segment Register 7 into GPR 6:

```
# Assume that the source Segment Register is SR 7.
# Assume that GPR 6 is the target register.
mfsr 6,7
# GPR 6 now holds a copy of the contents of Segment Register 7.
```

Security

The **mfsr** instruction is privileged only in the PowerPC architecture.

Related Information

The **mfsri** (Move from Segment Register Indirect) instruction, **mtsr** (Move to Segment Register) instruction, **mtsrin** or **mtsri** (Move to Segment Register Indirect) instruction.

mfsri (Move from Segment Register Indirect) Instruction

Purpose

Copies the contents of a calculated segment register into a general-purpose register.

Note: The **mfsri** instruction is supported only in the POWER family architecture.

Syntax

Bits	Value
0-5	31
6-10	RS
11-15	RA
16-20	RB
21-30	627
31	Rc

POWER family
mfsri *RS*, *RA*, *RB*

Description

The **mfsri** instruction copies the contents of segment register (SR), specified by bits 0-3 of the calculated contents of the general-purpose register (GPR) *RA*, into GPR *RS*. If *RA* is not 0, the specifying bits in GPR *RA* are calculated by adding the original contents of *RA* to GPR *RB* and placing the sum in *RA*. If *RA* = *RS*, the sum is not placed in *RA*.

The **mfsri** instruction has one syntax form and does not affect the Fixed-Point Exception Register. If the Record (Rc) bit is set to 1, Condition Register Field 0 is undefined.

Parameters

RS Specifies the target general-purpose register for operation.
RA Specifies the source general-purpose register for SR calculation.
RB Specifies the source general-purpose register for SR calculation.

Examples

The following code copies the contents of the segment register specified by the first 4 bits of the sum of the contents of GPR 4 and GPR 5 into GPR 6:

```
# Assume that GPR 4 contains 0x9000 3000.
# Assume that GPR 5 contains 0x1000 0000.
# Assume that GPR 6 is the target register.
mfsri 6,5,4
# GPR 6 now contains the contents of Segment Register 10.
```

Related Information

The **mfsrin** (Move from Segment Register Indirect) instruction, **mtsr** (Move to Segment Register) instruction, **mtsrin** or **mtsri** (Move to Segment Register Indirect) instruction.

Processing and Storage

---

mfsrin (Move from Segment Register Indirect) Instruction

Purpose

Copies the contents of the specified segment register into a general-purpose register.

Note: The **mfsrin** instruction is supported only in the PowerPC architecture.

Syntax

Bits	Value
0-5	31
6-10	RT
11-15	///
16-20	RB
21-30	659
31	/

PowerPC
mfsrin *RT*, *RB*

Description

The **mfsrin** instruction copies the contents of segment register (SR), specified by bits 0-3 of the general-purpose register (GPR) *RB*, into GPR *RT*.

The **mfsrin** instruction has one syntax form and does not affect the Fixed-Point Exception Register. If the Record (Rc) bit is set to 1, the Condition Register Field 0 is undefined.

Parameters

RT Specifies the target general-purpose register for operation.
RB Specifies the source general-purpose register for SR calculation.

Security

The **mfsrin** instruction is privileged.

Related Information

The **mfsr** (Move from Segment Register) instruction, **mfsri** (Move from Segment Register Indirect) instruction, **mtsr** (Move to Segment Register) instruction, **mtsrin** or **mtsri** (Move to Segment Register Indirect) instruction.

Processing and Storage

mtcrf (Move to Condition Register Fields) Instruction

Purpose

Copies the contents of a general-purpose register into the condition register under control of a field mask.

Syntax

Bits	Value
0-5	31
6-10	RS
11	/
12-19	FXM
20	/
21-30	144
31	Rc

mtcrf *FXM*, *RS*

See Extended Mnemonics of Condition Register Logical Instructions for more information.

Description

The **mtcrf** instruction copies the contents of source general-purpose register (GPR) *RS* into the condition register under the control of field mask *FXM*.

Field mask *FXM* is defined as follows:

Bit	Description
12	CR 00-03 is updated with the contents of GPR *RS* 00-03.
13	CR 04-07 is updated with the contents of GPR *RS* 04-07.
14	CR 08-11 is updated with the contents of GPR *RS* 08-11.
15	CR 12-15 is updated with the contents of GPR *RS* 12-15.
16	CR 16-19 is updated with the contents of GPR *RS* 16-19.
17	CR 20-23 is updated with the contents of GPR *RS* 20-23.
18	CR 24-27 is updated with the contents of GPR *RS* 24-27.
19	CR 28-31 is updated with the contents of GPR *RS* 28-31.

The **mtcrf** instruction has one syntax form and does not affect the Fixed-Point Exception Register.

The preferred form of the **mtcrf** instruction has only one bit set in the *FXM* field.

Parameters

FXM Specifies field mask.
RS Specifies source general-purpose register for operation.

Examples

The following code copies bits 00-03 of GPR 5 into Condition Register Field 0:

```
# Assume GPR 5 contains 0x7542 FFEE.
# Use the mask for Condition Register
# Field 0 (0x80 = b'1000 0000').
mtcrf 0x80,5
# Condition Register Field 0 now contains b'0111'.
```

Related Information

Fixed-Point Processor .

Branch Processor .

Fixed-Point Move to or from Special-Purpose Registers Instructions .

---

mtfsb0 (Move to FPSCR Bit 0) Instruction

Purpose

Sets a specified Floating-Point Status and Control Register bit to 0.

Syntax

Bits	Value
0-5	63
6-10	BT
11-15	///
16-20	///
21-30	70
31	Rc

mtfsb0 *BT*
mtfsb0. *BT*

Description

The **mtfsb0** instruction sets the Floating-Point Status and Control Register bit specified by *BT* to 0.

The **mtfsb0** instruction has two syntax forms. Each syntax form has a different effect on Condition Register Field 0.

Syntax Form	Fixed-Point Exception Register	Record Bit (Rc)	Condition Register Field 1
mtfsb0	None	0	None
mtfsb0.	None	1	FX, FEX, VX, OX

The two syntax forms of the **mtfsb0** instruction never affect the Fixed-Point Exception Register. If the syntax form sets the Record (Rc) bit to 1, the instruction affects the Floating-Point Exception (FX), Floating-Point Enabled Exception (FEX), Floating Invalid Operation Exception (VX), and Floating-Point Overflow Exception (OX) bits in Condition Register Field 1.

Note: Bits 1-2 cannot be explicitly set or reset.

Parameters

BT Specifies Floating-Point Status and Control Register bit set by operation.

Examples

1. The following code sets the Floating-Point Status and Control Register Floating-Point Overflow Exception Bit (bit 3) to 0:

```
mtfsb0 3
# Now bit 3 of the Floating-Point Status and Control
# Register is 0.
```

2. The following code sets the Floating-Point Status and Control Register Floating-Point Overflow Exception Bit (bit 3) to 0 and sets Condition Register Field 1 to reflect the result of the operation:

```
mtfsb0. 3
# Now bit 3 of the Floating-Point Status and Control
# Register is 0.
```

Related Information

Floating-Point Processor .

Interpreting the Contents of a Floating-Point Register .

---

mtfsb1 (Move to FPSCR Bit 1) Instruction

Purpose

Sets a specified Floating-Point Status and Control Register bit to 1.

Syntax

Bits	Value
0-5	63
6-10	BT
11-15	///
16-20	///
21-30	38
31	Rc

mtfsb1 *BT*
mtfsb1. *BT*

Description

The **mtfsb1** instruction sets the Floating-Point Status and Control Register (FPSCR) bit specified by *BT* to 1.

The **mtfsb1** instruction has two syntax forms. Each syntax form has a different effect on Condition Register Field 0.

Syntax Form	FPSCR Bits	Record Bit (Rc)	Condition Register Field 1
mtfsb1	None	0	None

mtfsb1.	None	1	FX, FEX, VX, OX

The two syntax forms of the **mtfsb1** instruction never affect the Fixed-Point Exception Register. If the syntax form sets the Record (Rc) bit to 1, the instruction affects the Floating-Point Exception (FX), Floating-Point Enabled Exception (FEX), Floating Invalid Operation Exception (VX), and Floating-Point Overflow Exception (OX) bits in Condition Register Field 1.

Note: Bits 1-2 cannot be explicitly set or reset.

Parameters

BT Specifies that the FPSCR bit is set to 1 by instruction.

Examples

1. The following code sets the Floating-Point Status and Control Register bit 4 to 1:

```
mtfsb1 4
# Now bit 4 of the Floating-Point Status and Control
# Register is set to 1.
```

2. The following code sets the Floating-Point Status and Control Register Overflow Exception Bit (bit 3) to 1 and sets Condition Register Field 1 to reflect the result of the operation:

```
mtfsb1. 3
# Now bit 3 of the Floating-Point Status and Control
# Register is set to 1.
```

Related Information

Floating-Point Processor .

Interpreting the Contents of a Floating-Point Register .

---

mtfsf (Move to FPSCR Fields) Instruction

Purpose

Copies the contents of a floating-point register into the Floating-Point Status and Control Register under the control of a field mask.

Syntax

Bits	Value
0-5	63
6	/
7-14	FLM
15	/
16-20	FRB
21-30	771
31	Rc

mtfsf *FLM*, *FRB*
mtfsf. *FLM*, *FRB*

See Extended Mnemonics of Condition Register Logical Instructions for more information.

Description

The **mtfsf** instruction copies bits 32-63 of the contents of the floating-point register (FPR) *FRB* into the Floating-Point Status and Control Register under the control of the field mask specified by *FLM*.

The field mask *FLM* is defined as follows:

```
Bit   Description
7   FPSCR 00-03 is updated with the contents of FRB 32-35.
8   FPSCR 04-07 is updated with the contents of FRB 36-39.
9   FPSCR 08-11 is updated with the contents of FRB 40-43.
10   FPSCR 12-15 is updated with the contents of FRB 44-47.
11   FPSCR 16-19 is updated with the contents of FRB 48-51.
12   FPSCR 20-23 is updated with the contents of FRB 52-55.
13   FPSCR 24-27 is updated with the contents of FRB 56-59.
14   FPSCR 28-31 is updated with the contents of FRB 60-63.
```

The **mtfsf** instruction has two syntax forms. Each syntax form has a different effect on Condition Register Field 1.

Syntax Form	FPSCR Bits	Record Bit (Rc)	Condition Register Field 1
mtfsf	None	0	None
mtfsf.	None	1	FX, FEX, VX, OX

The two syntax forms of the **mtfsf** instruction never affect the Fixed-Point Exception Register. If the syntax form sets the Record (Rc) bit to 1, the instruction affects the Floating-Point Exception (FX), Floating-Point Enabled Exception (FEX), Floating Invalid Operation Exception (VX), and Floating-Point Overflow Exception (OX) bits in Condition Register Field 1.

Note: When specifying FPSCR 0-3, some bits cannot be explicitly set or reset.

Parameters

FLM Specifies field mask.
FRB Specifies source floating-point register for operation.

Examples

1. The following code copies the contents of floating-point register 5 bits 32-35 into Floating-Point Status and Control Register Field 0:

```
# Assume bits 32-63 of FPR 5
# contain 0x3000 3000.
mtfsf 0x80,5
# Floating-Point Status and Control Register
# Field 0 is set to b'0001'.
```

2. The following code copies the contents of floating-point register 5 bits 32-43 into Floating-Point Status and Control Register Fields 0-2 and sets Condition Register Field 1 to reflect the result of the operation:

```
# Assume bits 32-63 of FPR 5
# contains 0x2320 0000.
mtfsf. 0xE0,5
# Floating-Point Status and Control Register Fields 0-2
# now contain b'0010 0011 0010'.
# Condition Register Field 1 now contains 0x2.
```

Related Information

Floating-Point Processor .

Interpreting the Contents of a Floating-Point Register .

---

mtfsfi (Move to FPSCR Field Immediate) Instruction

Purpose

Copies an immediate value into a specified Floating-Point Status and Control Register field.

Syntax

Bits	Value
0-5	63
6-8	BF
9-10	//
11-15	///
16-19	U
20	/
21-30	134
31	Rc

mtfsfi *BF*, *I*
mtfsfi. *BF*, *I*

Description

The **mtfsfi** instruction copies the immediate value specified by the *I* parameter into the Floating-Point Status and Control Register field specified by *BF*. None of the other fields of the Floating-Point Status and Control Register are affected.

The **mtfsfi** instruction has two syntax forms. Each syntax form has a different effect on Condition Register Field 1.

Syntax Form	FPSCR Bits	Record Bit (Rc)	Condition Register Field 1
mtfsfi	None	0	None
mtfsfi.	None	1	FX, FEX, VX, OX

The two syntax forms of the **mtfsfi** instruction never affect the Floating-Point Status and Control Register fields. If the syntax form sets the Record (Rc) bit to 1, the instruction affects the Floating-Point Exception (FX), Floating-Point Enabled Exception (FEX), Floating Invalid Operation Exception (VX), and Floating-Point Overflow Exception (OX) bits in Condition Register Field 1.

Note: When specifying FPSCR 0-3, some bits cannot be explicitly set or reset.

Parameters

BF Specifies target Floating-Point Status and Control Register field for operation.
I Specifies source immediate value for operation.

Examples

1. The following code sets Floating-Point Status and Control Register Field 6 to b'0100':

```
mtfsfi 6,4
# Floating-Point Status and Control Register Field 6
# is now b'0100'.
```

2. The following code sets Floating-Point Status and Control Register field 0 to b'0100' and sets Condition Register Field 1 to reflect the result of the operation:

```
mtfsfi. 0,1
# Floating-Point Status and Control Register Field 0
# is now b'0001'.
# Condition Register Field 1 now contains 0x1.
```

Related Information

Floating-Point Processor .

Interpreting the Contents of a Floating-Point Register .

---

mtocrf (Move to One Condition Register Field) Instruction

Purpose

Copies the contents of a general-purpose register into one condition register field under control of a field mask.

Syntax

Bits	Value
0-5	31
6-10	RT
11	/
12-19	FXM
20	/
21-30	144
31	/

mtocrf *"FXM" on page 312*, *"RS" on page 312*

See "Extended Mnemonics of Condition Register Logical Instructions" on page 94 for more information.

Description

The **mtocrf** instruction copies the contents of source general-purpose register (GPR) *RS* into the condition register under the control of field mask *FXM*.

Field mask *FXM* is defined as follows:

Bit	Description
12	CR 00-03 is updated with the contents of GPR *RS* 00-03.
13	CR 04-07 is updated with the contents of GPR *RS* 04-07.
14	CR 08-11 is updated with the contents of GPR *RS* 08-11.
15	CR 12-15 is updated with the contents of GPR *RS* 12-15.
16	CR 16-19 is updated with the contents of GPR *RS* 16-19.
17	CR 20-23 is updated with the contents of GPR *RS* 20-23.
18	CR 24-27 is updated with the contents of GPR *RS* 24-27.
19	CR 28-31 is updated with the contents of GPR *RS* 28-31.

The **mtocrf** instruction has one syntax form and does not affect the Fixed-Point Exception Register.

Parameters

FXM Specifies field mask.
RS Specifies source general-purpose register for operation.

Examples

The following code copies bits 00-03 of GPR 5 into Condition Register Field 0:

```
# Assume GPR 5 contains 0x7542 FFEE.
# Use the mask for Condition Register
# Field 0 (0x80 = b'1000 0000').
mtocrf 0x80,5
# Condition Register Field 0 now contains b'0111'.
```

Related Information

"Fixed-Point Processor" on page 19.

"Branch Processor" on page 17.

"Fixed-Point Move to or from Special-Purpose Registers Instructions" on page 21.

mtspr (Move to Special-Purpose Register) Instruction

Purpose

Copies the contents of a general-purpose register into a special-purpose register.

Syntax

Bits	Value
0-5	31
6-10	RS
11-20	spr
21-30	467
31	Rc

Note: The special-purpose register is a split field.

See Extended Mnemonics of Moving from or to Special-Purpose Registers for more information.

Description

The **mtspr** instruction copies the contents of the source general-purpose register *RS* into the target special-purpose register *SPR*.

The special-purpose register identifier *SPR* can have any of the values specified in the following table. The order of the two 5-bit halves of the SPR number is reversed.

SPR Values			
Decimal	**spr**$^{5:9}$ spr$^{0:4}$	**Register Name**	**Privileged**
1	00000 00001	XER	No
8	00000 01000	LR	No
9	00000 01001	CTR	No
18	00000 10010	DSISR	Yes
19	00000 10011	DAR	Yes
22	00000 10110	DEC	Yes[1]
25	00000 11001	SDR1	Yes
26	00000 11010	SRR0	Yes
27	00000 11011	SRR1	Yes
272	01000 10000	SPRG0	Yes
273	01000 10001	SPRG1	Yes
274	01000 10010	SPRG2	Yes
275	01000 10011	SPRG3	Yes
282	01000 11010	EAR	Yes
284	01000 11100	TBL	Yes
285	01000 11101	TBU	Yes
528	10000 10000	IBAT0U	Yes
529	10000 10001	IBAT0L	Yes
530	10000 10010	IBAT1U	Yes
531	10000 10011	IBAT1L	Yes
532	10000 10100	IBAT2U	Yes
533	10000 10101	IBAT2L	Yes
534	10000 10110	IBAT3U	Yes
535	10000 10111	IBAT3L	Yes
536	10000 11000	DBAT0U	Yes
537	10000 11001	DBAT0L	Yes
538	10000 11010	DBAT1U	Yes
539	10000 11011	DBAT1L	Yes

540	10000 11100	DBAT2U	Yes
541	10000 11101	DBAT2L	Yes
542	10000 11110	DBAT3U	Yes
543	10000 11111	DBAT3L	Yes
0	00000 00000	MQ[2]	No
20	00000 10100	RTCU[2]	Yes
21	00000 10101	RTCL[2]	Yes

1. Moving to the DEC register is privileged in the PowerPC architecture and in the POWER family architecture. However, *moving from* the DEC register is privileged only in the PowerPC architecture.
2. 2Supported only in the POWER family architecture.

If the SPR field contains any value other than those listed in the SPR Values table, the instruction form is invalid.

The **mtspr** instruction has one syntax form and does not affect the Fixed-Point Exception Register or Condition Register Field 0.

Parameters

SPR Specifies target special-purpose register for operation.
RS Specifies source general-purpose register for operation.

Examples

The following code copies the contents of GPR 5 into the Link Register:

```
# Assume GPR 5 holds 0x1000 00FF.
mtspr 8,5
# The Link Register now holds 0x1000 00FF.
```

Related Information

Fixed-Point Processor .

Fixed-Point Move to or from Special-Purpose Registers Instructions .

mul (Multiply) Instruction

Purpose

Multiplies the contents of two general-purpose registers and stores the result in a third general-purpose register.

Note: The **mul** instruction is supported only in the POWER family architecture.

Syntax

Bits	Value
0-5	31
6-10	RT
11-15	RA
16-20	RB

Bits	Value
21	OE
22-30	107
31	Rc

POWER family

mul *RT*, *RA*, *RB*
mul. *RT*, *RA*, *RB*
mulo *RT*, *RA*, *RB*
mulo. *RT*, *RA*, *RB*

Description

The **mul** instruction multiplies the contents of general-purpose register (GPR) *RA* and GPR *RB*, and stores bits 0-31 of the result in the target GPR *RT* and bits 32-63 of the result in the MQ Register.

The **mul** instruction has four syntax forms. Each syntax form has a different effect on Condition Register Field 0 and the Fixed-Point Exception Register.

Syntax Form	Overflow Exception (OE)	Fixed-Point Exception Register	Record Bit (Rc)	Condition Register Field 0
mul	0	None	0	None
mul.	0	None	1	LT,GT,EQ,SO
mulo	1	SO,OV	0	None
mulo.	1	SO,OV	1	LT,GT,EQ,SO

The four syntax forms of the **mul** instruction never affect the Carry bit (CA) in the Fixed-Point Exception Register. If the syntax form sets the Overflow Exception (OE) bit to 1, the instruction sets the Summary Overflow (SO) and Overflow (OV) bits in the Fixed-Point Exception Register to 1 if the product is greater than 32 bits. If the syntax form sets the Record (Rc) bit to 1, then the Less Than (LT) zero, Greater Than (GT) zero and Equal To (EQ) zero bits in Condition Register Field 0 reflect the result in the low-order 32 bits of the MQ Register.

Parameters

RT Specifies target general-purpose register where the result of operation is stored.
RA Specifies source general-purpose register for operation.
RB Specifies source general-purpose register for operation.

Examples

1. The following code multiplies the contents of GPR 4 by the contents of GPR 10 and stores the result in GPR 6 and the MQ Register:

```
# Assume GPR 4 contains 0x0000 0003.
# Assume GPR 10 contains 0x0000 0002.
mul 6,4,10
# MQ Register now contains 0x0000 0006.
# GPR 6 now contains 0x0000 0000.
```

2. The following code multiplies the contents of GPR 4 by the contents of GPR 10, stores the result in GPR 6 and the MQ Register, and sets Condition Register Field 0 to reflect the result of the operation:

```
# Assume GPR 4 contains 0x0000 4500.
# Assume GPR 10 contains 0x8000 7000.
mul. 6,4,10
# MQ Register now contains 0x1E30 0000.
# GPR 6 now contains 0xFFFF DD80.
# Condition Register Field 0 now contains 0x4.
```

3. The following code multiplies the contents of GPR 4 by the contents of GPR 10, stores the result in GPR 6 and the MQ Register, and sets the Summary Overflow and Overflow bits in the Fixed-Point Exception Register to reflect the result of the operation:

```
# Assume GPR 4 contains 0x0000 4500.
# Assume GPR 10 contains 0x8000 7000.
# Assume XER = 0.
mulo 6,4,10
# MQ Register now contains 0x1E30 0000.
# GPR 6 now contains 0xFFFF DD80.
# XER now contains 0xc000 0000.
```

4. The following code multiplies the contents of GPR 4 by the contents of GPR 10, stores the result in GPR 6 and the MQ Register, and sets the Summary Overflow, Overflow, and Carry bits in the Fixed-Point Exception Register and Condition Register Field 0 to reflect the result of the operation:

```
# Assume GPR 4 contains 0x0000 4500.
# Assume GPR 10 contains 0x8000 7000.
# Assume XER = 0.
mulo. 6,4,10
# MQ Register now contains 0x1E30 0000.
# GPR 6 now contains 0xFFFF DD80.
# Condition Register Field 0 now contains 0x5.
# XER now contains 0xc000 0000.
```

Related Information

The **mulhw** (Multiply High Word) instruction, **mulhwu** (Multiply High Word Unsigned) instruction, **mulli** or **muli** (Multiply Low Immediate) instruction, **mullw** or **muls** (Multiply Low Word) instruction.

Fixed-Point Processor .

Fixed-Point Arithmetic Instructions .

Using Milicode Routines .

---

mulhd (Multiply High Double Word) Instruction

Purpose

Multiply two 64-bit values together. Place the high-order 64 bits of the result into a register.

Syntax

Bits	Value
0-5	31
6-10	D
11-15	A
16-20	B
21	0
22-30	73
31	Rc

POWER family
mulhd *RT*, *RA*, *RB* (Rc=0)
mulhd. *RT*, *RA*, *RB* (Rc=1)

Description

The 64-bit operands are the contents of general purpose registers (GPR) *RA* and *RB*. The high-order 64 bits of the 128-bit product of the operands are placed into *RT*.

Both the operands and the product are interpreted as signed integers.

This instruction may execute faster on some implementations if *RB* contains the operand having the smaller absolute value.

Parameters

RT Specifies target general-purpose register for the result of the computation.
RA Specifies source general-purpose register for an operand.
RB Specifies source general-purpose register for an operand.

Implementation

This instruction is defined only for 64-bit implementations. Using it on a 32-bit implementation will cause the system illegal instruction error handler to be invoked.

mulhdu (Multiply High Double Word Unsigned) Instruction

Purpose

Multiply 2 unsigned 64-bit values together. Place the high-order 64 bits of the result into a register.

Syntax

Bits	Value
0-5	31
6-10	D
11-15	A
16-20	B
21	0
22-30	9
31	Rc

POWER family
mulhdu *RT*, *RA*, *RB* (Rc=0)
mulhdu. *RT*, *RA*, *RB* (Rc=1)

Description

Both the operands and the product are interpreted as unsigned integers, except that if Rc = 1 (the **mulhw.** instruction) the first three bits of the condition register 0 field are set by signed comparison of the result to zero.

The 64-bit operands are the contents of *RA* and *RB*. The low-order 64 bits of the 128-bit product of the operands are placed into *RT*.

Other registers altered:

- Condition Register (CR0 field):

  Affected: LT, GT, EQ, SO (if Rc = 1)

  Note: The setting of CR0 bits LT, GT, and EQ is mode-dependent, and reflects overflow of the 64-bit result.

This instruction may execute faster on some implementations if *RB* contains the operand having the smaller absolute value.

Parameters

RT Specifies target general-purpose register for the result of the computation.
RA Specifies source general-purpose register for the multiplicand.
RB Specifies source general-purpose register for the multiplier.

Implementation

This instruction is defined only for 64-bit implementations. Using it on a 32-bit implementation will cause the system illegal instruction error handler to be invoked.

---

mulhw (Multiply High Word) Instruction

Purpose

Computes the most significant 32 bits of the 64-bit product of two 32-bit integers.

Note: The **mulhw** instruction is supported only in the PowerPC architecture.

Syntax

Bits	Value
0-5	31
6-10	RT
11-15	RA
16-20	RB
21	/
22-30	75
31	Rc

PowerPC
mulhw *RT*, *RA*, *RB*
mulhw. *RT*, *RA*, *RB*

Description

The **mulhw** instruction multiplies the contents of general-purpose register (GPR) *RA* and GPR *RB* and places the most significant 32 bits of the 64-bit product in the target GPR *RT*. Both the operands and the product are interpreted as signed integers.

The **mulhw** instruction has two syntax forms. Each syntax form has a different effect on Condition Register Field 0.

Syntax Form	Record Bit (Rc)	Condition Register Field 0
mulhw	0	None
mulhw.	1	LT,GT,EQ,SO

If the syntax form sets the Record (Rc) bit to 1, then the Less Than (LT) zero, Greater Than (GT) zero and Equal To (EQ) zero bits in Condition Register Field 0 reflect the result placed in GPR *RT*, and the Summary Overflow (SO) bit is copied from the XER to the SO bit in Condition Register Field 0.

Parameters

RT Specifies target general-purpose register where the result of operation is stored.
RA Specifies source general-purpose register for EA calculation.
RB Specifies source general-purpose register for EA calculation.

Examples

1. The following code multiplies the contents of GPR 4 by the contents of GPR 10 and stores the result in GPR 6:

```
# Assume GPR 4 contains 0x0000 0003.
# Assume GPR 10 contains 0x0000 0002.
mulhw 6,4,10
# GPR 6 now contains 0x0000 0000.
```

2. The following code multiplies the contents of GPR 4 by the contents of GPR 10, stores the result in GPR 6, and sets Condition Register Field 0 to reflect the result of the operation:

```
# Assume GPR 4 contains 0x0000 4500.
# Assume GPR 10 contains 0x8000 7000.
# Assume XER(SO) = 0.
mulhw. 6,4,10
# GPR 6 now contains 0xFFFF DD80.
# Condition Register Field 0 now contains 0x4.
```

Related Information

The **mul** (Multiply) instruction, **mulhwu** (Multiply High Word Unsigned) instruction, **mulli** or **muli** (Multiply Low Immediate) instruction, **mullw** or **muls** (Multiply Low Word) instruction.

Fixed-Point Processor .

Fixed-Point Arithmetic Instructions .

---

mulhwu (Multiply High Word Unsigned) Instruction

Purpose

Computes the most significant 32 bits of the 64-bit product of two unsigned 32-bit integers.

Note: The **mulhwu** instruction is supported only in the PowerPC architecture.

Syntax

Bits	Value
0-5	31
6-10	RT
11-15	RA
16-20	RB
21	/
22-30	11
31	Rc

PowerPC
mulhwu *RT*, *RA*, *RB*
mulhwu. *RT*, *RA*, *RB*

Description

The **mulhwu** instruction multiplies the contents of general-purpose register (GPR) *RA* and GPR *RB* and places the most significant 32 bits of the 64-bit product in the target GPR *RT*. Both the operands and the product are interpreted as unsigned integers.

> **Note:** Although the operation treats the result as an unsigned integer, the setting of the Condition Register Field 0 for the Less Than (LT) zero, Greater Than (GT) zero, and Equal To (EQ) zero bits are interpreted as signed integers.

The **mulhwu** instruction has two syntax forms. Each syntax form has a different effect on Condition Register Field 0.

Syntax Form	Record Bit (Rc)	Condition Register Field 0
mulhwu	0	None
mulhwu.	1	LT,GT,EQ,SO

If the syntax form sets the Record (Rc) bit to 1, then the Less Than (LT) zero, Greater Than (GT) zero and Equal To (EQ) zero bits in Condition Register Field 0 reflect the result placed in GPR *RT*, and the Summary Overflow (SO) bit is copied from the XER to the SO bit in Condition Register Field 0.

Parameters

RT Specifies target general-purpose register where result of operation is stored.
RA Specifies source general-purpose register for EA calculation.
RB Specifies source general-purpose register for EA calculation.

Examples

1. The following code multiplies the contents of GPR 4 by the contents of GPR 10 and stores the result in GPR 6:

```
# Assume GPR 4 contains 0x0000 0003.
# Assume GPR 10 contains 0x0000 0002.
mulhwu 6,4,10
# GPR 6 now contains 0x0000 0000.
```

2. The following code multiplies the contents of GPR 4 by the contents of GPR 10, stores the result in GPR 6, and sets Condition Register Field 0 to reflect the result of the operation:

```
# Assume GPR 4 contains 0x0000 4500.
# Assume GPR 10 contains 0x8000 7000.
# Assume XER(SO) = 0.
mulhwu. 6,4,10
# GPR 6 now contains 0x0000 2280.
# Condition Register Field 0 now contains 0x4.
```

Related Information

The **mul** (Multiply) instruction, **mulhw** (Multiply High Word) instruction, **mulli** or **muli** (Multiply Low Immediate) instruction, **mullw** or **muls** (Multiply Low Word) instruction.

Fixed-Point Processor .

Fixed-Point Arithmetic Instructions .

---

mulld (Multiply Low Double Word) Instruction

Purpose

Multiply 2 64-bit values together. Place the low-order 64 bits of the result into a register.

Syntax

Bits	Value
0-5	31
6-10	D
11-15	A
16-20	B
21	OE
22-30	233
31	Rc

POWER family

mulld *RT*, *RA*, *RB* (OE=0 Rc=0)
mulld. *RT*, *RA*, *RB* (OE=0 Rc=1)
mulldo *RT*, *RA*, *RB* (OE=1 Rc=0)
mulldo. *RT*, *RA*, *RB* (OE=1 Rc=1)

Description

The 64-bit operands are the contents of general purpose registers (GPR) *RA* and *RB*. The low-order 64 bits of the 128-bit product of the operands are placed into *RT*.

Both the operands and the product are interpreted as signed integers. The low-order 64 bits of the product are independent of whether the operands are regarded as signed or unsigned 64-bit integers. If OE = 1 (the **mulldo** and **mulldo.** instructions), then OV is set if the product cannot be represented in 64 bits.

This instruction may execute faster on some implementations if *RB* contains the operand having the smaller absolute value.

Other registers altered:

- Condition Register (CR0 field):
  Affected: LT, GT, EQ, SO (if Rc = 1)
  Note: CR0 field may not reflect the infinitely precise result if overflow occurs (see XER below).
- XER:
  Affected: SO, OV (if OE = 1)
  Note: The setting of the affected bits in the XER is mode-independent, and reflects overflow of the 64-bit result.

Parameters

RT Specifies target general-purpose register for the rsult of the computation.
RA Specifies source general-purpose register for an operand.
RB Specifies source general-purpose register for an operand.

Implementation

This instruction is defined only for 64-bit implementations. Using it on a 32-bit implementation will cause the system illegal instruction error handler to be invoked.

mulli or muli (Multiply Low Immediate) Instruction

Purpose

Multiplies the contents of a general-purpose register by a 16-bit signed integer and stores the result in another general-purpose register.

Syntax

Bits	Value
0-5	07
6-10	RT
11-15	RA
16-31	SI

PowerPC
mulli *RT*, *RA*, *SI*

POWER family
muli *RT*, *RA*, *SI*

Description

The **mulli** and **muli** instructions sign extend the *SI* field to 32 bits and then multiply the extended value by the contents of general-purpose register (GPR) *RA*. The least significant 32 bits of the 64-bit product are placed in the target GPR *RT*.

The **mulli** and **muli** instructions have one syntax form and do not affect Condition Register Field 0 or the Fixed-Point Exception Register.

Parameters

RT Specifies target general-purpose register where result of operation is stored.
RA Specifies source general-purpose register for operation.
SI Specifies 16-bit signed integer for operation.

Examples

The following code multiplies the contents of GPR 4 by 10 and places the result in GPR 6:

```
# Assume GPR 4 holds 0x0000 3000.
mulli 6,4,10
# GPR 6 now holds 0x0001 E000.
```

Related Information

The **mul** (Multiply) instruction, **mulhw** (Multiply High Word) instruction, **mulhwu** (Multiply High Word Unsigned) instruction, **mullw** or **muls** (Multiply Low Word) instruction.

Fixed-Point Processor .

Fixed-Point Arithmetic Instructions .

---

mullw or muls (Multiply Low Word) Instruction

Purpose

Computes the least significant 32 bits of the 64-bit product of two 32-bit integers.

Syntax

Bits	Value
0-5	31
6-10	RT
11-15	RA
16-20	RB
21	OE
22-30	235
31	Rc

PowerPC

mullw *RT*, *RA*, *RB*
mullw. *RT*, *RA*, *RB*
mullwo *RT*, *RA*, *RB*
mullwo. *RT*, *RA*, *RB*

POWER family

muls *RT*, *RA*, *RB*
muls. *RT*, *RA*, *RB*
mulso *RT*, *RA*, *RB*
mulso. *RT*, *RA*, *RB*

Description

The **mullw** and **muls** instructions multiply the contents of general-purpose register (GPR) *RA* by the contents of GPR *RB*, and place the least significant 32 bits of the result in the target GPR *RT*.

The **mullw** instruction has four syntax forms. Each syntax form has a different effect on Condition Register Field 0 and the Fixed-Point Exception Register.

The **muls** instruction has four syntax forms. Each syntax form has a different effect on Condition Register Field 0 and the Fixed-Point Exception Register.

Syntax Form	Overflow Exception (OE)	Fixed-Point Exception Register	Record Bit (Rc)	Condition Register Field 0
mullw	0	None	0	None
mullw.	0	None	1	LT,GT,EQ
mullwo	1	SO,OV	0	None
mullwo.	1	SO,OV	1	LT,GT,EQ
muls	0	None	0	None
muls.	0	None	1	LT,GT,EQ
mulso	1	SO,OV	0	None
mulso.	1	SO,OV	1	LT,GT,EQ

The four syntax forms of the **mullw** instruction, and the four syntax forms of the **muls** instruction, never affect the Carry bit (CA) in the Fixed-Point Exception Register. If the syntax form sets the Overflow Exception (OE) bit to 1, the instruction sets the Summary Overflow (SO) and Overflow (OV) bits in the Fixed-Point Exception Register to 1 if the result is too large to be represented in 32 bits. If the syntax form sets the Record (Rc) bit to 1, the instruction affects the Less Than (LT) zero, Greater Than (GT) zero, Equal To (EQ) zero, and Summary Overflow (SO) bits in Condition Register Field 0.

Parameters

RT Specifies target general-purpose register where result of operation is stored.
RA Specifies source general-purpose register for operation.
RB Specifies source general-purpose register for operation.

Examples

1. The following code multiplies the contents of GPR 4 by the contents of GPR 10 and stores the result in GPR 6:

```
# Assume GPR 4 holds 0x0000 3000.
# Assume GPR 10 holds 0x0000 7000.
mullw 6,4,10
# GPR 6 now holds 0x1500 0000.
```

2. The following code multiplies the contents of GPR 4 by the contents of GPR 10, stores the result in GPR 6, and sets Condition Register Field 0 to reflect the result of the operation:

```
# Assume GPR 4 holds 0x0000 4500.
# Assume GPR 10 holds 0x0000 7000.
# Assume XER(SO) = 0.
mullw. 6,4,10
# GPR 6 now holds 0x1E30 0000.
# Condition Register Field 0 now contains 0x4.
```

3. The following code multiplies the contents of GPR 4 by the contents of GPR 10, stores the result in GPR 6, and sets the Summary Overflow and Overflow bits in the Fixed-Point Exception Register to reflect the result of the operation:

```
# Assume GPR 4 holds 0x0000 4500.
# Assume GPR 10 holds 0x0007 0000.
# Assume XER = 0.
mullwo 6,4,10
# GPR 6 now holds 0xE300 0000.
# XER now contains 0xc000 0000
```

4. The following code multiplies the contents of GPR 4 by the contents of GPR 10, stores the result in GPR 6, and sets the Summary Overflow, Overflow, and Carry bits in the Fixed-Point Exception Register and Condition Register Field 0 to reflect the result of the operation:

```
# Assume GPR 4 holds 0x0000 4500.
# Assume GPR 10 holds 0x7FFF FFFF.
# Assume XER = 0.
mullwo. 6,4,10
# GPR 6 now holds 0xFFFF BB00.
# XER now contains 0xc000 0000
# Condition Register Field 0 now contains 0x9.
```

Related Information

The **mul** (Multiply) instruction, **mulhw** (Multiply High Word) instruction, **mulhwu** (Multiply High Word Unsigned) instruction, **mulli** or **muli** (Multiply Low Immediate) instruction.

Fixed-Point Processor .

Fixed-Point Arithmetic Instructions .

---

nabs (Negative Absolute) Instruction

Purpose

Negates the absolute value of the contents of a general-purpose register and stores the result in another general-purpose register.

Note: The **nabs** instruction is supported only in the POWER family architecture.

Syntax

Bits	Value
0-5	31
6-10	RT
11-15	RA
16-20	///
21	OE
22-30	488
31	Rc

POWER family

nabs *RT*, *RA*
nabs. *RT*, *RA*
nabso *RT*, *RA*
nabso. *RT*, *RA*

Description

The **nabs** instruction places the negative absolute value of the contents of general-purpose register (GPR) *RA* into the target GPR *RT*.

The **nabs** instruction has four syntax forms. Each syntax form has a different effect on Condition Register Field 0 and the Fixed-Point Exception Register.

Syntax Form	Overflow Exception (OE)	Fixed-Point Exception Register	Record Bit (Rc)	Condition Register Field 0
nabs	0	None	0	None
nabs.	0	None	1	LT,GT,EQ,SO
nabso	1	SO,OV	0	None
nabso.	1	SO,OV	1	LT,GT,EQ,SO

The four syntax forms of the **nabs** instruction never affect the Carry bit (CA) in the Fixed-Point Exception Register. If the syntax form sets the Overflow Exception (OE) bit to 1, the Summary Overflow (SO) bit is unchanged and the Overflow (OV) bit is set to zero. If the syntax form sets the Record (Rc) bit to 1, the instruction affects the Less Than (LT) zero, Greater Than (GT) zero, Equal To (EQ) zero, and Summary Overflow (SO) bits in Condition Register Field 0.

Parameters

RT Specifies target general-purpose register where result of operation is stored.
RA Specifies source general-purpose register for operation.

Examples

1. The following code takes the negative absolute value of the contents of GPR 4 and stores the result in GPR 6:

```
# Assume GPR 4 contains 0x0000 3000.
nabs 6,4
# GPR 6 now contains 0xFFFF D000.
```

2. The following code takes the negative absolute value of the contents of GPR 4, stores the result in GPR 6, and sets Condition Register Field 0 to reflect the result of the operation:

```
# Assume GPR 4 contains 0xFFFF FFFF.
nabs. 6,4
# GPR 6 now contains 0xFFFF FFFF.
```

3. The following code takes the negative absolute value of the contents of GPR 4, stores the result in GPR 6, and sets the Overflow bit in the Fixed-Point Exception Register to 0:

```
# Assume GPR 4 contains 0x0000 0001.
nabso 6,4
# GPR 6 now contains 0xFFFF FFFF.
```

4. The following code takes the negative absolute value of the contents of GPR 4, stores the result in GPR 6, sets Condition Register Field 0 to reflect the result of the operation, and sets the Overflow bit in the Fixed-Point Exception Register to 0:

```
# Assume GPR 4 contains 0x8000 0000.
nabso 6,4
# GPR 6 now contains 0x8000 0000.
```

Related Information

Fixed-Point Processor .

Fixed-Point Arithmetic Instructions .

---

nand (NAND) Instruction

Purpose

Logically complements the result of ANDing the contents of two general-purpose registers and stores the result in another general-purpose register.

Syntax

Bits	Value
0-5	31
6-10	RS
11-15	RA
16-20	RB
21-30	476
31	Rc

nand *RA*, *RS*, *RB*
nand. *RA*, *RS*, *RB*

Description

The **nand** instruction logically ANDs the contents of general-purpose register (GPR) *RS* with the contents of GPR *RB* and stores the complement of the result in the target GPR *RA*.

The **nand** instruction has two syntax forms. Each syntax form has a different effect on Condition Register Field 0.

Syntax Form	Overflow Exception (OE)	Fixed-Point Exception Register	Record Bit (Rc)	Condition Register Field 0
nand	None	None	0	None
nand.	None	None	1	LT,GT,EQ,SO

The two syntax forms of the **nand** instruction never affect the Fixed-Point Exception Register. If the syntax form sets the Record (Rc) bit to 1, the instruction affects the Less Than (LT) zero, Greater Than (GT) zero, Equal To (EQ) zero, and Summary Overflow (SO) bits in Condition Register Field 0.

Parameters

RA Specifies target general-purpose register where result of operation is stored.
RS Specifies source general-purpose register for operation.
RB Specifies source general-purpose register for operation.

Examples

1. The following code complements the result of ANDing the contents of GPR 4 and GPR 7 and stores the result in GPR 6:

```
# Assume GPR 4 contains 0x9000 3000.
# Assume GPR 7 contains 0x789A 789B.
nand 6,4,7
# GPR 6 now contains 0xEFFF CFFF.
```

2. The following code complements the result of ANDing the contents of GPR 4 and GPR 7, stores the result in GPR 6, and sets Condition Register Field 0 to reflect the result of the operation:

```
# Assume GPR 4 contains 0xB004 3000.
# Assume GPR 7 contains 0x789A 789B.
nand. 6,4,7
# GPR 6 now contains 0xCFFF CFFF.
```

Related Information

Fixed-Point Processor .

Fixed-Point Logical Instructions .

---

neg (Negate) Instruction

Purpose

Changes the arithmetic sign of the contents of a general-purpose register and places the result in another general-purpose register.

Syntax

Bits	Value
0-5	31
6-10	RT
11-15	RA
16-20	///
21	OE
22-30	104
31	Rc

neg *RT*, *RA*
neg. *RT*, *RA*
nego *RT*, *RA*
nego. *RT*, *RA*

Description

The **neg** instruction adds 1 to the one's complement of the contents of a general-purpose register (GPR) *RA* and stores the result in GPR *RT*.

If GPR *RA* contains the most negative number (that is, 0x8000 0000), the result of the instruction is the most negative number and signals the Overflow bit in the Fixed-Point Exception Register if OE is 1.

The **neg** instruction has four syntax forms. Each syntax form has a different effect on Condition Register Field 0 and the Fixed-Point Exception Register.

Syntax Form	Overflow Exception (OE)	Fixed-Point Exception Register	Record Bit (Rc)	Condition Register Field 0
neg	0	None	0	None
neg.	0	None	1	LT,GT,EQ,SO
nego	1	SO,OV	0	None
nego.	1	SO,OV	1	LT,GT,EQ,SO

The four syntax forms of the **neg** instruction never affect the Carry bit (CA) in the Fixed-Point Exception Register. If the syntax form sets the Overflow Exception (OE) bit to 1, the instruction affects the Summary Overflow (SO) and Overflow (OV) bits in the Fixed-Point Exception Register. If the syntax form sets the Record (Rc) bit to 1, the instruction affects the Less Than (LT) zero, Greater Than (GT) zero, Equal To (EQ) zero, and Summary Overflow (SO) bits in Condition Register Field 0.

Parameters

RT Specifies target general-purpose register where result of operation is stored.
RA Specifies source general-purpose register for operation.

Examples

1. The following code negates the contents of GPR 4 and stores the result in GPR 6:

```
# Assume GPR 4 contains 0x9000 3000.
neg 6,4
# GPR 6 now contains 0x6FFF D000.
```

2. The following code negates the contents of GPR 4, stores the result in GPR 6, and sets Condition Register Field 0 to reflect the result of the operation:

```
# Assume GPR 4 contains 0x789A 789B.
neg. 6,4
# GPR 6 now contains 0x8765 8765.
```

3. The following code negates the contents of GPR 4, stores the result in GPR 6, and sets the Fixed-Point Exception Register Summary Overflow and Overflow bits to reflect the result of the operation:

```
# Assume GPR 4 contains 0x9000 3000.
nego 6,4
# GPR 6 now contains 0x6FFF D000.
```

4. The following code negates the contents of GPR 4, stores the result in GPR 6, and sets Condition Register Field 0 and the Fixed-Point Exception Register Summary Overflow and Overflow bits to reflect the result of the operation:

```
# Assume GPR 4 contains 0x8000 0000.
nego. 6,4
# GPR 6 now contains 0x8000 0000.
```

Related Information

Fixed-Point Processor .

Fixed-Point Arithmetic Instructions .

nor (NOR) Instruction

Purpose

Logically complements the result of ORing the contents of two general-purpose registers and stores the result in another general-purpose register.

Syntax

Bits	Value
0-5	31
6-10	RS
11-15	RA
16-20	RB
21-30	124
31	Rc

nor *RA*, *RS*, *RB*
nor. *RA*, *RS*, *RB*

See Extended Mnemonics of Fixed-Point Logical Instructions for more information.

Description

The **nor** instruction logically ORs the contents of general-purpose register (GPR) *RS* with the contents of GPR *RB* and stores the complemented result in GPR *RA*.

The **nor** instruction has two syntax forms. Each syntax form has a different effect on Condition Register Field 0.

Syntax Form	Overflow Exception (OE)	Fixed-Point Exception Register	Record Bit (Rc)	Condition Register Field 0
nor	None	None	0	None
nor.	None	None	1	LT,GT,EQ,SO

The two syntax forms of the **nor** instruction never affect the Fixed-Point Exception Register. If the syntax form sets the Record (Rc) bit to 1, the instruction affects the Less Than (LT) zero, Greater Than (GT) zero, Equal To (EQ) zero, and Summary Overflow (SO) bits in Condition Register Field 0.

Parameters

RA Specifies target general-purpose register where result of operation is stored.
RS Specifies source general-purpose register for operation.
RB Specifies source general-purpose register for operation.

Examples

1. The following code NORs the contents of GPR 4 and GPR 7 and stores the result in GPR 6:

```
# Assume GPR 4 contains 0x9000 3000.
# Assume GPR 6 contains 0x789A 789B.
nor 6,4,7
# GPR 7 now contains 0x0765 8764.
```

2. The following code NORs the contents of GPR 4 and GPR 7, stores the result in GPR 6, and sets Condition Register Field 0 to reflect the result of the operation:

```
# Assume GPR 4 contains 0xB004 3000.
# Assume GPR 7 contains 0x789A 789B.
nor. 6,4,7
# GPR 6 now contains 0x0761 8764.
```

Related Information

Fixed-Point Processor .

Fixed-Point Logical Instructions .

---

or (OR) Instruction

Purpose

Logically ORs the contents of two general-purpose registers and stores the result in another general-purpose register.

Syntax

Bits	Value
0-5	31
6-10	RS
11-15	RA
16-20	RB
21-30	444
31	Rc

or *RA*, *RS*, *RB*
or. *RA*, *RS*, *RB*

See Extended Mnemonics of Fixed-Point Logical Instructions for more information.

Description

The **or** instruction logically ORs the contents of general-purpose register (GPR) *RS* with the contents of GPR *RB* and stores the result in GPR *RA*.

The **or** instruction has two syntax forms. Each syntax form has a different effect on Condition Register Field 0.

Syntax Form	Overflow Exception (OE)	Fixed-Point Exception Register	Record Bit (Rc)	Condition Register Field 0
or	None	None	0	None
or.	None	None	1	LT,GT,EQ,SO

The two syntax forms of the **or** instruction never affect the Fixed-Point Exception Register. If the syntax form sets the Record (Rc) bit to 1, the instruction affects the Less Than (LT) zero, Greater Than (GT) zero, Equal To (EQ) zero, and Summary Overflow (SO) bits in Condition Register Field 0.

Parameters

RA Specifies target general-purpose register where result of operation is stored.
RS Specifies source general-purpose register for operation.
RB Specifies source general-purpose register for operation.

Examples

1. The following code logically ORs the contents of GPR 4 and GPR 7 and stores the result in GPR 6:

```
# Assume GPR 4 contains 0x9000 3000.
# Assume GPR 7 contains 0x789A 789B.
or 6,4,7
# GPR 6 now contains 0xF89A 789B.
```

2. The following code logically ORs the contents of GPR 4 and GPR 7, loads the result in GPR 6, and sets Condition Register Field 0 to reflect the result of the operation:

```
# Assume GPR 4 contains 0xB004 3000.
# Assume GPR 7 contains 0x789A 789B.
or. 6,4,7
# GPR 6 now contains 0xF89E 789B.
```

Related Information

Fixed-Point Processor .

Fixed-Point Logical Instructions .

---

orc (OR with Complement) Instruction

Purpose

Logically ORs the contents of a general-purpose register with the complement of the contents of another general-purpose register and stores the result in a third general-purpose register.

Syntax

Bits	Value
0-5	31
6-10	RS
11-15	RA
16-20	RB
21-30	412
31	Rc

orc *RA*, *RS*, *RB*
orc. *RA*, *RS*, *RB*

Description

The **orc** instruction logically ORs the contents of general-purpose register (GPR) *RS* with the complement of the contents of GPR *RB* and stores the result in GPR *RA*.

The **orc** instruction has two syntax forms. Each syntax form has a different effect on Condition Register Field 0.

Syntax Form	Overflow Exception (OE)	Fixed-Point Exception Register	Record Bit (Rc)	Condition Register Field 0
orc	None	None	0	None
orc.	None	None	1	LT,GT,EQ,SO

The two syntax forms of the **orc** instruction never affect the Fixed-Point Exception Register. If the syntax form sets the Record (Rc) bit to 1, the instruction affects the Less Than (LT) zero, Greater Than (GT) zero, Equal To (EQ) zero, and Summary Overflow (SO) bits in Condition Register Field 0.

Parameters

RA Specifies target general-purpose register where result of operation is stored.
RS Specifies source general-purpose register for operation.
RB Specifies source general-purpose register for operation.

Examples

1. The following code logically ORs the contents of GPR 4 with the complement of the contents of GPR 7 and stores the result in GPR 6:

```
# Assume GPR 4 contains 0x9000 3000.
# Assume GPR 7 contains 0x789A 789B, whose
# complement is 0x8765 8764.
orc 6,4,7
# GPR 6 now contains 0x9765 B764.
```

2. The following code logically ORs the contents of GPR 4 with the complement of the contents GPR 7, stores the result in GPR 6, and sets Condition Register Field 0 to reflect the result of the operation:

```
# Assume GPR 4 contains 0xB004 3000.
# Assume GPR 7 contains 0x789A 789B, whose
# complement is 0x8765 8764.
orc. 6,4,7
# GPR 6 now contains 0xB765 B764.
```

Related Information

Fixed-Point Processor .

Fixed-Point Logical Instructions .

---

ori or oril (OR Immediate) Instruction

Purpose

Logically ORs the lower 16 bits of the contents of a general-purpose register with a 16-bit unsigned integer and stores the result in another general-purpose register.

Syntax

Bits	Value
0-5	24
6-10	RS
11-15	RA
16-31	UI

PowerPC
ori *RA*, *RS*, *UI*

POWER family
oril *RA*, *RS*, *UI*

See Extended Mnemonics of Fixed-Point Logical Instructions for more information.

Description

The **ori** and **oril** instructions logically OR the contents of general-purpose register (GPR) *RS* with the concatenation of x'0000' and a 16-bit unsigned integer, *UI*, and place the result in GPR *RA*.

The **ori** and **oril** instructions have one syntax form and do not affect Condition Register Field 0 or the Fixed-Point Exception Register.

Parameters

RA Specifies target general-purpose register where result of operation is stored.
RS Specifies source general-purpose register for operation.
UI Specifies a16-bit unsigned integer for operation.

Examples

The following code ORs the lower 16 bits of the contents of GPR 4 with 0x0079 and stores the result in GPR 6:

```
# Assume GPR 4 contains 0x9000 3000.
ori 6,4,0x0079
# GPR 6 now contains 0x9000 3079.
```

Related Information

Fixed-Point Processor .

Fixed-Point Logical Instructions .

---

oris or oriu (OR Immediate Shifted) Instruction

Purpose

Logically ORs the upper 16 bits of the contents of a general-purpose register with a 16-bit unsigned integer and stores the result in another general-purpose register.

Syntax

Bits	Value
0-5	25
6-10	RS
11-15	RA
16-31	UI

PowerPC
oris *RA*, *RS*, *UI*

POWER family
oriu *RA*, *RS*, *UI*

Description

The **oris** and **oriu** instructions logically OR the contents of general-purpose register (GPR) *RS* with the concatenation of a 16-bit unsigned integer, *UI*, and x'0000' and store the result in GPR *RA*.

The **oris** and **oriu** instructions have one syntax form and do not affect Condition Register Field 0 or the Fixed-Point Exception Register.

Parameters

RA Specifies target general-purpose register where result of operation is stored.
RS Specifies source general-purpose register for operation.
UI Specifies a16-bit unsigned integer for operation.

Examples

The following code ORs the upper 16 bits of the contents of GPR 4 with 0x0079 and stores the result in GPR 6:

```
# Assume GPR 4 contains 0x9000 3000.
oris 6,4,0x0079
# GPR 6 now contains 0x9079 3000.
```

Related Information

Fixed-Point Processor .

Fixed-Point Logical Instructions .

---

rac (Real Address Compute) Instruction

Purpose

Translates an effective address into a real address and stores the result in a general-purpose register.

Note: The **rac** instruction is supported only in the POWER family architecture.

Syntax

Bits	Value
0-5	31
6-10	RT
11-15	RA
16-20	RB
21-30	818
31	Rc

POWER family
rac *RT*, *RA*, *RB*
rac. *RT*, *RA*, *RB*

Description

The **rac** instruction computes an effective address (EA) from the sum of the contents of general-purpose register (GPR) *RA* and the contents of GPR *RB,* and expands the EA into a virtual address.

If *RA* is not 0 and if *RA* is not *RT*, then the **rac** instruction stores the EA in GPR *RA*, translates the result into a real address, and stores the real address in GPR *RT*.

Consider the following when using the **rac** instruction:

- If GPR *RA* is 0, then EA is the sum of the contents of GPR *RB* and 0.
- EA is expanded into its virtual address and translated into a real address, regardless of whether data translation is enabled.
- If the translation is successful, the EQ bit in the condition register is set and the real address is placed in GPR *RT*.
- If the translation is unsuccessful, the EQ bit is set to 0, and 0 is placed in GPR *RT*.
- If the effective address specifies an I/O address, the EQ bit is set to 0, and 0 is placed in GPR *RT*.
- The reference bit is set if the real address is not in the Translation Look-Aside buffer (TLB).

The **rac** instruction has two syntax forms. Each syntax form has a different effect on Condition Register Field 0.

Syntax Form	Overflow Exception (OE)	Fixed-Point Exception Register	Record Bit (Rc)	Condition Register Field 0
rac	None	None	0	None
rac	None	None	1	EQ,SO

The two syntax forms of the **rac** instruction do not affect the Fixed-Point Exception Register. If the syntax form sets the Record (Rc) bit to 1, the instruction effects the Equal (EQ) and Summary Overflow (SO) bit in Condition Register Field 0.

> **Note:** The hardware may first search the Translation Look-Aside buffer for the address. If this fails, the Page Frame table must be searched. In this case, it is not necessary to load a Translation Look-Aside buffer entry.

Parameters

RT Specifies the target general-purpose register where result of operation is stored.
RA Specifies the source general-purpose register for EA calculation.
RB Specifies the source general-purpose register for EA calculation.

Security

The **rac** instruction instruction is privileged.

Related Information

Processing and Storage

---

rfi (Return from Interrupt) Instruction

Purpose

Reinitializes the Machine State Register and continues processing after an interrupt.

Syntax

Bits	Value
0-5	19
6-10	///
11-15	///
16-20	///
21-30	50
31	/

rfi

Description

The **rfi** instruction places bits 16-31 of Save Restore Register1 (SRR1) into bits 16-31 of the Machine State Register (MSR), and then begins fetching and processing instructions at the address contained inSave Restore Register0 (SRR0), using the new MSR value.

If the Link bit (LK) is set to 1, the contents of the Link Register are undefined.

The **rfi** instruction has one syntax form and does not affect Condition Register Field 0 or the Fixed-Point Exception Register.

Security

The **rfi** instruction is privileged and synchronizing.

Related Information

Branch Processor .

rfid (Return from Interrupt Double Word) Instruction

Purpose

Reinitializes the Machine State Register and continues processing after an interrupt.

Syntax

Bits	Value
0-5	19
6-10	00000
11-15	00000
16-20	00000
21-30	18
31	0

rfid

Description

Bits 0, 48-55, 57-59, and 62-63 from the Save Restore Register 1 (SRR1) are placed into the corresponding bits of the Machine State Register (MSR). If the new MSR value does not enable any pending exceptions, then the next instruction is fetched under control of the new MSR value. If the SF bit in the MSR is 1, the address found in bits 0-61 of SRR0 (fullword aligned address) becomes the next instruction address. If the SF bit is zero, then bits 32-61 of SRR0, concatenated with zeros to create a word-aligned adderss, are placed in the low-order 32-bits of SRR0. The high-order 32 bits are cleared. If the new MSR value enables one or more pending exceptions, the exception associated with the highest priority pending exception is generated; in this case the value placed into SRR0 by the exception processing mechanism is the address of the instruction that would have been executed next had the exception not occurred.

Other registers altered:

- MSR

Security

The **rfid** instruction is privileged and synchronizing.

Implementation

This instruction is defined only for 64-bit implementations. Using it on a 32-bit implementation causes an illegal instruction type program exception.

rfsvc (Return from SVC) Instruction

Purpose

Reinitializes the Machine State Register and starts processing after a supervisor call (**svc**).

Note: The **rfsvc** instruction is supported only in the POWER family architecture.

Syntax

Bits	Value
0-5	19
6-10	///
11-15	///
16-20	///
21-30	82
31	LK

POWER family

rfsvc

Description

The **rfsvc** instruction reinitializes the Machine State Register (MSR) and starts processing after a supervisor call. This instruction places bits 16-31 of the Count Register into bits 16-31 of the Machine State Register (MSR), and then begins fetching and processing instructions at the address contained in the Link Register, using the new MSR value.

If the Link bit (LK) is set to 1, then the contents of the Link Register are undefined.

The **rfsvc** instruction has one syntax form and does not affect Condition Register Field 0 or the Fixed-Point Exception Register.

Security

The **rfsvc** instruction is privileged and synchronizing.

Related Information

The **svc** (Supervisor Call) instruction.

Branch Processor .

System Call Instructions .

---

rldcl (Rotate Left Double Word then Clear Left) Instruction

Purpose

Rotate the contents of a general purpose register left by the number of bits specified by the contents of another general purpose register. Generate a mask that is ANDed with the result of the shift operation. Store the result of this operation in another general purpose register.

Syntax

Bits	Value
0-5	30
6-10	S
11-15	A

Bits	Value
16-20	B
21-26	mb
27-30	8
31	Rc

POWER family
rldcl *RA*, *RS*, *RB*, *MB* (Rc=0)
rldcl. *RA*, *RS*, *RB*, *MB* (Rc=1)

Description

The contents of general purpose register (GPR) *RS* are rotated left the number of bits specified by the operand in the low-order six bits of *RB*. A mask is generated having 1 bits from bit *MB* through bit 63 and 0 bits elsewhere. The rotated data is ANDed with the generated mask and the result is placed into *RA*.

Note that the **rldcl** instruction can be used to extract and rotate bit fields using the methods shown below:

- To extract an n-bit field, that starts at variable bit position b in register *RS*, right-justified into *RA* (clearing the remaining 64 - n bits of *RA*), set the low-order six bits of *RB* to b + n and *MB* = 64 - n.
- To rotate the contents of a register left by variable n bits, set the low-order six bits of *RB* to n and *MB* = 0, and to shift the contents of a register right, set the low-order six bits of *RB* to(64 - n), and *MB* = 0.

Other registers altered:

- Condition Register (CR0 field):
  Affected: LT, GT, EQ, SO (if Rc = 1)

Parameters

RA Specifies the target general purpose register for the result of the instruction.
RS Specifies the source general purpose register containing the operand.
RB Specifies the source general purpose register containing the shift value.
MB Specifies the begin value (bit number) of the mask for the operation.

Implementation

This instruction is defined only for 64-bit implementations. Using it on a 32-bit implementation will cause the system illegal instruction error handler to be invoked.

rldicl (Rotate Left Double Word Immediate then Clear Left) Instruction

Purpose

This instruction should only be used on 64-bit PowerPC processors running a 64-bit application.

Syntax

Bits	Value
0-5	30
6-10	S
11-15	A

Bits	Value
16-20	sh
21-26	mb
27-29	0
30	sh
31	Rc

PowerPC64
rldicl *rA*, *rS*, *rB*, *MB* (Rc=0)
rldicl. *rA*, *rS*, *rB*, *MB* (Rc=1)

Description

The contents of rS are rotated left the number of bits specified by operand SH. A mask is generated having 1 bits from bit MB through bit 63 and 0 bits elsewhere. The rotated data is ANDed with the generated mask and the result is placed into rA.

This instruction is defined only for 64-bit implementations. Using it on a 32-bit implementation will cause the system illegal instruction error handler to be invoked.

Note that rldicl can be used to extract, rotate, shift, and clear bit fields using the methods shown below:

To extract an n-bit field, that starts at bit position b in rS, right-justified into rA (clearing the remaining 64 - n bits of rA), set SH = b + n and MB = 64 - n.

To rotate the contents of a register left by n bits, set SH = n and MB = 0; to rotate the contents of a register right by n bits, set SH = (64 - n), and MB = 0.

To shift the contents of a register right by n bits, set SH = 64 - n and MB = n.

To clear the high-order n bits of a register, set SH = 0 and MB = n.

Other registers altered:

- Condition Register (CR0 field):
  Affected: LT, GT, EQ, SO (if Rc = 1)

Parameters

rA ***DESCRIPTION***
rS ***DESCRIPTION***
rB ***DESCRIPTION***
MB ***DESCRIPTION***

Examples

Related Information

rldcr (Rotate Left Double Word then Clear Right) Instruction

Purpose

Rotate the contents of a general purpose register left by the number of bits specified by the contents of another general purpose register. Generate a mask that is ANDed with the result of the shift operation. Store the result of this operation in another general purpose register.

Syntax

Bits	Value
0-5	30
6-10	S
11-15	A
16-20	B
21-26	me
27-30	9
31	Rc

POWER family

rldcr *RA*, *RS*, *RB*, *ME* (Rc=0)
rldcr. *RA*, *RS*, *RB*, *ME* (Rc=1)

Description

The contents of general purpose register (GPR) *RS* are rotated left the number of bits specified by the low-order six bits of *RB*. A mask is generated having 1 bits from bit 0 through bit *ME* and 0 bits elsewhere. The rotated data is ANDed with the generated mask and the result is placed into *RA*.

Note that **rldcr** can be used to extract and rotate bit fields using the methods shown below:

- To extract an n-bit field, that starts at variable bit position b in register *RS*, left-justified into *RA* (clearing the remaining 64 - n bits of *RA*), set the low-order six bits of *RB* to b and *ME* = n - 1.
- To rotate the contents of a register left by variable n bits, set the low-order six bits of *RB* to n and *ME* = 63, and to shift the contents of a register right, set the low-order six bits of *RB* to(64 - n), and *ME* = 63.

Other registers altered:

- Condition Register (CR0 field):

  Affected: LT, GT, EQ, SO (if Rc = 1)

Parameters

RS SH Specifies shift value for operation. MB Specifies begin value of mask for operation. ME BM Specifies value of 32-bit mask

RA Specifies target general-purpose register where result of operation is stored.
RS Specifies source general-purpose register for operation.
RB Specifies the source general purpose register containing the shift value.

ME Specifies end value of mask for operation.

Implementation

This instruction is defined only for 64-bit implementations. Using it on a 32-bit implementation will cause the system illegal instruction error handler to be invoked.

rldic (Rotate Left Double Word Immediate then Clear) Instruction

Purpose

The contents of a general purpose register are rotated left a specified number of bits, then masked with a bit-field to clear some number of low-order and high-order bits. The result is placed in another general purpose register.

Syntax

Bits	Value
0-5	30
6-10	S
11-15	A
16-20	sh
21-26	mb
27-29	2
30	sh
31	Rc

POWER family

rldicl *RA*, *RS*, *SH*, *MB* (Rc=0)
rldicl. *RA*, *RS*, *SH*, *MB* (Rc=1)

Description

The contents of general purpose register (GPR) *RS* are rotated left the number of bits specified by operand *SH*. A mask is generated having 1 bits from bit *MB* through bit 63 - *SH* and 0 bits elsewhere. The rotated data is ANDed with the generated mask and the result is placed into GPR *RA*.

Note that **rldic** can be used to clear and shift bit fields using the methods shown below:

- To clear the high-order b bits of the contents of a register and then shift the result left by n bits, set *SH* = n and *MB* = b - n.
- To clear the high-order n bits of a register, set *SH* = 0 and *MB* = n.

Other registers altered:

- Condition Register (CR0 field):
  Affected: LT, GT, EQ, SO (if Rc = 1)

Parameters

RA Specifies the target general purpose register for the result of the instruction.
RS Specifies the source general purpose register containing the operand.

SH Specifies the (immediate) shift value for the operation.
MB Specifies the begin value of the bit-mask for the operation.

Implementation

This instruction is defined only for 64-bit implementations. Using it on a 32-bit implementation will cause the system illegal instruction error handler to be invoked.

rldicl (Rotate Left Double Word Immediate then Clear Left) Instruction

Purpose

Rotate the contents of a general purpose register left by a specified number of bits, clearing a specified number of high-order bits. The result is placed in another general purpose register.

Syntax

Bits	Value
0-5	30
6-10	S
11-15	A
16-20	sh
21-26	mb
27-29	0
30	sh
31	Rc

POWER family
rldicl *RA*, *RS*, *SH*, *MB* (Rc=0)
rldicl. *RA*, *RS*, *SH*, *MB* (Rc=1)

Description

The contents of general purpose register *RS* are rotated left the number of bits specified by operand *SH*. A mask is generated containing 1 bits from bit *MB* through bit 63 and 0 bits elsewhere. The rotated data is ANDed with the generated mask and the result is placed into GPR *RA*.

Note that **rldicl** can be used to extract, rotate, shift, and clear bit fields using the methods shown below:

- To extract an n-bit field, which starts at bit position b in *RS*, right-justified into GPR *RA* (clearing the remaining 64 - n bits of GPR *RA*), set *SH* = b + n and *MB* = 64 - n.
- To rotate the contents of a register left by n bits, set *SH* = n and *MB* = 0; to rotate the contents of a register right by n bits, set *SH* = (64 - n), and *MB* = 0.
- To shift the contents of a register right by n bits, set *SH* = 64 - n and *MB* = n.
- To clear the high-order n bits of a register, set *SH* = 0 and *MB* = n.

Other registers altered:

- Condition Register (CR0 field):
  Affected: LT, GT, EQ, SO (if Rc = 1)

Parameters

RA Specifies the target general purpose register for the result of the instruction.
RS Specifies the source general purpose register containing the operand.
SH Specifies the (immediate) shift value for the operation.
MB Specifies the begin value (bit number) of the mask for the operation.

Implementation

This instruction is defined only for 64-bit implementations. Using it on a 32-bit implementation will cause the system illegal instruction error handler to be invoked.

---

rldicr (Rotate Left Double Word Immediate then Clear Right) Instruction

Purpose

Rotate the contents of a general purpose register left by the number of bits specified by an immediate value. Clear a specified number of low-order bits. Place the results in another general purpose register.

Syntax

Bits	Value
0-5	30
6-10	S
11-15	A
16-20	sh
21-26	me
27-29	1
30	sh
31	Rc

POWER family

rldicr *RA*, *RS*, *SH*, *MB* (Rc=0)
rldicr. *RA*, *RS*, *SH*, *MB* (Rc=1)

Description

The contents of general purpose register (GPR) *RS* are rotated left the number of bits specified by operand *SH*. A mask is generated having 1 bits from bit 0 through bit *ME* and 0 bits elsewhere. The rotated data is ANDed with the generated mask and the result is placed into GPR *RA*.

Note that **rldicr** can be used to extract, rotate, shift, and clear bit fields using the methods shown below:

- To extract an n-bit field, that starts at bit position b in GPR *RS*, left-justified into GPR *RA* (clearing the remaining 64 - n bits of GPR *RA*), set *SH* = b and *ME* = n - 1.
- To rotate the contents of a register left (right) by n bits, set *SH* = n (64 - n) and *ME* = 63.
- To shift the contents of a register left by n bits, by setting *SH* = n and *ME* = 63 - n.
- To clear the low-order n bits of a register, by setting *SH* = 0 and *ME* = 63 - n.

Other registers altered:

- Condition Register (CR0 field):
  Affected: LT, GT, EQ, SO (if Rc = 1)

Parameters

RA Specifies the target general purpose register for the result of the instruction.
RS Specifies the source general purpose register containing the operand.
SH Specifies the (immediate) shift value for the operation.
ME Specifies the end value (bit number) of the mask for the operation.

Implementation

This instruction is defined only for 64-bit implementations. Using it on a 32-bit implementation will cause the system illegal instruction error handler to be invoked.

---

rldimi (Rotate Left Double Word Immediate then Mask Insert) Instruction

Purpose

The contents of a general purpose register are rotated left a specified number of bits. A generated mask is used to insert a specified bit-field into the corresponding bit-field of another general purpose register.

Syntax

Bits	Value
0-5	30
6-10	S
11-15	A
16-20	sh
2126	mb
27-29	3
30	sh
31	Rc

POWER family
rldimi *RA*, *RS*, *SH*, *MB* (Rc=0)
rldimi. *RA*, *RS*, *SH*, *MB* (Rc=1)

Description

The contents of general purpose register (GPR) *RS* are rotated left the number of bits specified by operand *SH*. A mask is generated having 1 bits from bit *MB* through bit 63 - *SH* and 0 bits elsewhere. The rotated data is inserted into *RA* under control of the generated mask.

Note that **rldimi** can be used to insert an n-bit field, that is right-justified in *RS*, into *RA* starting at bit position b, by setting *SH* = 64 - (b + n) and *MB* = b.

Other registers altered:
- Condition Register (CR0 field):

Affected: LT, GT, EQ, SO (if Rc = 1)

Parameters

RA Specifies the target general purpose register for the result of the instruction.
RS Specifies the source general purpose register containing the operand.
SH Specifies the (immediate) shift value for the operation.
MB Specifies the begin value of the bit-mask for the operation.

Implementation

This instruction is defined only for 64-bit implementations. Using it on a 32-bit implementation will cause the system illegal instruction error handler to be invoked.

rlmi (Rotate Left Then Mask Insert) Instruction

Purpose

Rotates the contents of a general-purpose register to the left by the number of bits specified in another general-purpose register and stores the result in a third general-purpose register under the control of a generated mask.

Note: The **rlmi** instruction is supported only in the POWER family architecture.

Syntax

Bits	Value
0-5	22
6-10	RS
11-15	RA
16-20	RB
21-25	MB
26-30	ME
31	Rc

POWER family

rlmi *RA*, *RS*, *RB*, *MB*, *ME*
rlmi. *RA*, *RS*, *RB*, *MB*, *ME*
rlmi *RA*, *RS*, *RB*, *BM*
rlmi. *RA*, *RS*, *RB*, *BM*

See Extended Mnemonics of Fixed-Point Rotate and Shift Instructions for more information.

Description

The **rlmi** instruction rotates the contents of the source general-purpose register (GPR) *RS* to the left by the number of bits specified by bits 27-31 of GPR *RB* and then stores the rotated data in GPR *RA* under control of a 32-bit generated mask defined by the values in Mask Begin (*MB*) and Mask End (*ME*).

Consider the following when using the **rlmi** instruction:

- If a mask bit is 1, the instruction places the associated bit of rotated data in GPR *RA*; if a mask bit is 0, the GPR *RA* bit remains unchanged.

- If the *MB* value is less than the *ME* value + 1, then the mask bits between and including the starting point and the end point are set to ones. All other bits are set to zeros.
- If the *MB* value is the same as the *ME* value + 1, then all 32 mask bits are set to ones.
- If the *MB* value is greater than the *ME* value + 1, then all of the mask bits between and including the *ME* value +1 and the *MB* value -1 are set to zeros. All other bits are set to ones.

The parameter *BM* can also be used to specify the mask for this instruction. The assembler will generate the *MB* and *ME* parameters from *BM*.

The **rlmi** instruction has two syntax forms. Each syntax form has a different effect on Condition Register Field 0.

Syntax Form	Overflow Exception (OE)	Fixed-Point Exception Register	Record Bit (Rc)	Condition Register Field 0
rlmi	None	None	0	None
rlmi.	None	None	1	LT,GT,EQ,SO

The two syntax forms of the **rlmi** instruction never affect the Fixed-Point Exception Register. If the syntax form sets the Record (Rc) bit to 1, the instruction affects the Less Than (LT) zero, Greater Than (GT) zero, Equal To (EQ) zero, and Summary Overflow (SO) bits in Condition Register Field 0.

Parameters

RA Specifies target general-purpose register where result of operation is stored.
RS Specifies source general-purpose register for operation.
RB Specifies general-purpose register that contains number of bits for rotation of data.
MB Specifies begin value of mask for operation.
ME Specifies end value of mask for operation.
BM Specifies value of 32-bit mask.

Examples

1. The following code rotates the contents of GPR 4 by the value contained in bits 27-31 in GPR 5 and stores the masked result in GPR 6:

```
# Assume GPR 4 contains 0x9000 3000.
# Assume GPR 5 contains 0x0000 0002.
# Assume GPR 6 contains 0xFFFF FFFF.
rlmi 6,4,5,0,0x1D
# GPR 6 now contains 0x4000 C003.
# Under the same conditions
# rlmi 6,4,5,0xFFFFFFFC
# will produce the same result.
```

2. The following code rotates the contents of GPR 4 by the value contained in bits 27-31 in GPR 5, stores the masked result in GPR 6, and sets Condition Register Field 0 to reflect the result of the operation:

```
# Assume GPR 4 contains 0xB004 3000.
# Assume GPR 5 contains 0x0000 0002.
# GPR 6 is the target register and contains 0xFFFF FFFF.
rlmi. 6,4,5,0,0x1D
# GPR 6 now contains 0xC010 C003.
# CRF 0 now contains 0x8.
# Under the same conditions
# rlmi. 6,4,5,0xFFFFFFFC
# will produce the same result.
```

Related Information

Fixed-Point Processor .

Fixed-Point Rotate and Shift Instructions .

---

rlwimi or rlimi (Rotate Left Word Immediate Then Mask Insert) Instruction

Purpose

Rotates the contents of a general-purpose register to the left by a specified number of bits and stores the result in another general-purpose register under the control of a generated mask.

Syntax

Bits	Value
0-5	20
6-10	RS
11-15	RA
16-20	SH
21-25	ME
26-30	MB
31	Rc

PowerPC

rlwimi *RA*, *RS*, *SH*, *MB*, *ME*
rlwimi. *RA*, *RS*, *SH*, *MB*, *ME*
rlwimi *RA*, *RS*, *SH*, *BM*
rlwimi. *RA*, *RS*, *SH*, *BM*

POWER family

rlimi *RA*, *RS*, *SH*, *MB*, *ME*
rlimi. *RA*, *RS*, *SH*, *MB*, *ME*
rlimi *RA*, *RS*, *SH*, *BM*
rlimi. *RA*, *RS*, *SH*, *BM*

See Extended Mnemonics of Fixed-Point Rotate and Shift Instructions for more information.

Description

The **rlwimi** and **rlimi** instructions rotate left the contents of the source general-purpose register (GPR) *RS* by the number of bits by the *SH* parameter and then store the rotated data in GPR *RA* under control of a 32-bit generated mask defined by the values in Mask Begin (*MB*) and Mask End (*ME*). If a mask bit is 1, the instructions place the associated bit of rotated data in GPR *RA*; if a mask bit is 0, the GPR *RA* bit remains unchanged.

Consider the following when using the **rlwimi** and **rlimi** instructions:

- If the *MB* value is less than the *ME* value + 1, then the mask bits between and including the starting point and the end point are set to ones. All other bits are set to zeros.
- If the *MB* value is the same as the *ME* value + 1, then all 32 mask bits are set to ones.

- If the *MB* value is greater than the *ME* value + 1, then all of the mask bits between and including the *ME* value +1 and the *MB* value -1 are set to zeros. All other bits are set to ones.

The *BM* parameter can also be used to specify the mask for these instructions. The assembler will generate the *MB* and *ME* parameters from the *BM* value.

The **rlwimi** and **rlimi** instructions each have two syntax forms. Each syntax form has a different effect on Condition Register Field 0.

Syntax Form	Overflow Exception (OE)	Fixed-Point Exception Register	Record Bit (Rc)	Condition Register Field 0
rlwimi	None	None	0	None
rlwimi.	None	None	1	LT,GT,EQ,SO
rlimi	None	None	0	None
rlimi.	None	None	1	LT,GT,EQ,SO

The syntax forms of the **rlwimi** and **rlimi** instructions never affect the Fixed-Point Exception Register. If the syntax form sets the Record (Rc) bit to 1, the instructions affect the Less Than (LT) zero, Greater Than (GT) zero, Equal To (EQ) zero, and Summary Overflow (SO) bits in Condition Register Field 0.

Parameters

RA Specifies target general-purpose register where result of operation is stored.
RS Specifies source general-purpose register for operation.
SH Specifies shift value for operation.
MB Specifies begin value of mask for operation.
ME Specifies end value of mask for operation.
BM Specifies value of 32-bit mask.

Examples

1. The following code rotates the contents of GPR 4 to the left by 2 bits and stores the masked result in GPR 6:

```
# Assume GPR 4 contains 0x9000 3000.
# Assume GPR 6 contains 0x0000 0003.
rlwimi 6,4,2,0,0x1D
# GPR 6 now contains 0x4000 C003.
# Under the same conditions
#  rlwimi 6,4,2,0xFFFFFFFC
# will produce the same result.
```

2. The following code rotates the contents of GPR 4 to the left by 2 bits, stores the masked result in GPR 6, and sets Condition Register Field 0 to reflect the result of the operation:

```
# Assume GPR 4 contains 0x789A 789B.
# Assume GPR 6 contains 0x3000 0003.
rlwimi. 6,4,2,0,0x1A
# GPR 6 now contains 0xE269 E263.
# CRF 0 now contains 0x8.
# Under the same conditions
#  rlwimi. 6,4,2,0xFFFFFFE0
# will produce the same result.
```

Related Information

Fixed-Point Processor .

Fixed-Point Rotate and Shift Instructions .

rlwinm or rlinm (Rotate Left Word Immediate Then AND with Mask) Instruction

Purpose

Logically ANDs a generated mask with the result of rotating left by a specified number of bits in the contents of a general-purpose register.

Syntax

Bits	Value
0-5	21
6-10	RS
11-15	RA
16-20	SH
21-25	MB
26-30	ME
31	Rc

PowerPC

rlwinm	*RA*, *RS*, *SH*, *MB*, *ME*
rlwinm.	*RA*, *RS*, *SH*, *MB*, *ME*
rlwinm	*RA*, *RS*, *SH*, *BM*
rlwinm.	*RA*, *RS*, *SH*, *BM*

POWER family

rlinm	*RA*, *RS*, *SH*, *MB*, *ME*
rlinm.	*RA*, *RS*, *SH*, *MB*, *ME*
rlinm	*RA*, *RS*, *SH*, *BM*
rlinm.	*RA*, *RS*, *SH*, *BM*

See Extended Mnemonics of Fixed-Point Rotate and Shift Instructions for more information.

Description

The **rlwinm** and **rlinm** instructions rotate left the contents of the source general-purpose register (GPR) *RS* by the number of bits specified by the *SH* parameter, logically AND the rotated data with a 32-bit generated mask defined by the values in Mask Begin (*MB*) and Mask End (*ME*), and store the result in GPR *RA*.

Consider the following when using the **rlwinm** and **rlinm** instructions:

- If the *MB* value is less than the *ME* value + 1, then the mask bits between and including the starting point and the end point are set to ones. All other bits are set to zeros.
- If the *MB* value is the same as the *ME* value + 1, then all 32 mask bits are set to ones.
- If the *MB* value is greater than the *ME* value + 1, then all of the mask bits between and including the *ME* value +1 and the *MB* value -1 are set to zeros. All other bits are set to ones.

The *BM* parameter can also be used to specify the mask for these instructions. The assembler will generate the *MB* and *ME* parameters from the *BM* value.

The **rlwinm** and **rlinm** instructions each have two syntax forms. Each syntax form has a different effect on Condition Register Field 0.

Syntax Form	Overflow Exception (OE)	Fixed-Point Exception Register	Record Bit (Rc)	Condition Register Field 0
rlwinm	None	None	0	None
rlwinm.	None	None	1	LT,GT,EQ,SO
rlinm	None	None	0	None
rlinm.	None	None	1	LT,GT,EQ,SO

The syntax forms of the **rlwinm** and **rlinm** instructions never affect the Fixed-Point Exception Register. If the syntax form sets the Record (Rc) bit to 1, the instructions affect the Less Than (LT) zero, Greater Than (GT) zero, Equal To (EQ) zero, and Summary Overflow (SO) bits in Condition Register Field 0.

Parameters

RA Specifies target general-purpose register where result of operation is stored.
RS Specifies source general-purpose register for operation.
SH Specifies shift value for operation.
MB Specifies begin value of mask for operation.
ME Specifies end value of mask for operation.
BM Specifies value of 32-bit mask.

Examples

1. The following code rotates the contents of GPR 4 to the left by 2 bits and logically ANDs the result with a mask of 29 ones:

```
# Assume GPR 4 contains 0x9000 3000.
# Assume GPR 6 contains 0xFFFF FFFF.
rlwinm 6,4,2,0,0x1D
# GPR 6 now contains 0x4000 C000.
# Under the same conditions
# rlwinm 6,4,2,0xFFFFFFFC
# will produce the same result.
```

2. The following code rotates the contents of GPR 4 to the left by 2 bits, logically ANDs the result with a mask of 29 ones, and sets Condition Register Field 0 to reflect the result of the operation:

```
# Assume GPR 4 contains 0xB004 3000.
# Assume GPR 6 contains 0xFFFF FFFF.
rlwinm. 6,4,2,0,0x1D
# GPR 6 now contains 0xC010 C000.
# CRF 0 now contains 0x8.
# Under the same conditions
# rlwinm. 6,4,2,0xFFFFFFFC
# will produce the same result.
```

Related Information

Fixed-Point Processor .

Fixed-Point Rotate and Shift Instructions .

rlwnm or rlnm (Rotate Left Word Then AND with Mask) Instruction

Purpose

Rotates the contents of a general-purpose register to the left by the number of bits specified in another general-purpose register, logically ANDs the rotated data with the generated mask, and stores the result in a third general-purpose register.

Syntax

Bits	Value
0-5	23
6-10	RS
11-15	RA
16-20	RB
21-25	MB
26-30	ME
31	Rc

PowerPC

rlwnm *RA*, *RS*, *RB*, *MB*, *ME*
rlwnm. *RA*, *RS*, *RB*, *MB*, *ME*
rlwnm *RA*, *RS*, *SH*, *BM*
rlwnm. *RA*, *RS*, *SH*, *BM*

POWER family

rlnm *RA*, *RS*, *RB*, *MB*, *ME*
rlnm. *RA*, *RS*, *RB*, *MB*, *ME*
rlnm *RA*, *RS*, *SH*, *BM*
rlnm. *RA*, *RS*, *SH*, *BM*

See Extended Mnemonics of Fixed-Point Rotate and Shift Instructions for more information.

Description

The **rlwnm** and **rlnm** instructions rotate the contents of the source general-purpose register (GPR) *RS* to the left by the number of bits specified by bits 27-31 of GPR *RB*, logically AND the rotated data with a 32-bit generated mask defined by the values in Mask Begin (*MB*) and Mask End (*ME*), and store the result in GPR *RA*.

Consider the following when using the **rlwnm** and **rlnm** instructions:

- If the *MB* value is less than the *ME* value + 1, then the mask bits between and including the starting point and the end point are set to ones. All other bits are set to zeros.
- If the *MB* value is the same as the *ME* value + 1, then all 32 mask bits are set to ones.
- If the *MB* value is greater than the *ME* value + 1, then all of the mask bits between and including the *ME* value +1 and the *MB* value - 1 are set to zeros. All other bits are set to ones.

The *BM* parameter can also be used to specify the mask for these instructions. The assembler will generate the *MB* and *ME* parameters from the *BM* value.

The **rlwnm** and **rlnm** instructions each have two syntax forms. Each syntax form has a different effect on Condition Register Field 0.

Syntax Form	Overflow Exception (OE)	Fixed-Point Exception Register	Record Bit (Rc)	Condition Register Field 0
rlwnm	None	None	0	None
rlwnm.	None	None	1	LT,GT,EQ,SO
rlnm	None	None	0	None
rlnm.	None	None	1	LT,GT,EQ,SO

The syntax forms of the **rlwnm** and **rlnm** instructions never affect the Fixed-Point Exception Register. If the syntax form sets the Record (Rc) bit to 1, the instructions affect the Less Than (LT) zero, Greater Than (GT) zero, Equal To (EQ) zero, and Summary Overflow (SO) bits in Condition Register Field 0.

Parameters

RA Specifies target general-purpose register where result of operation is stored.
RS Specifies source general-purpose register for operation.
RB Specifies general-purpose register that contains number of bits for rotation of data.
MB Specifies begin value of mask for operation.
ME Specifies end value of mask for operation.
SH Specifies shift value for operation.
BM Specifies value of 32-bit mask.

Examples

1. The following code rotates the contents of GPR 4 to the left by 2 bits, logically ANDs the result with a mask of 29 ones, and stores the result in GPR 6:

```
# Assume GPR 4 contains 0x9000 3000.
# Assume GPR 5 contains 0x0000 0002.
# Assume GPR 6 contains 0xFFFF FFFF.
rlwnm 6,4,5,0,0x1D
# GPR 6 now contains 0x4000 C000.
# Under the same conditions
#  rlwnm 6,4,5,0xFFFFFFFC
# will produce the same result.
```

2. The following code rotates GPR 4 to the left by 2 bits, logically ANDs the result with a mask of 29 ones, stores the result in GPR 6, and sets Condition Register Field 0 to reflect the result of the operation:

```
# Assume GPR 4 contains 0xB004 3000.
# Assume GPR 5 contains 0x0000 0002.
# Assume GPR 6 contains 0xFFFF FFFF.
rlwnm. 6,4,5,0,0x1D
# GPR 6 now contains 0xC010 C000.
# CRF 0 now contains 0x8.
# Under the same conditions
#  rlwnm. 6,4,5,0xFFFFFFFC
# will produce the same result.
```

Related Information

Fixed-Point Processor .

Fixed-Point Rotate and Shift Instructions .

rrib (Rotate Right and Insert Bit) Instruction

Purpose

Rotates bit 0 in a general-purpose register to the right by the number of bits specified by another general-purpose register and stores the rotated bit in a third general-purpose register.

Note: The **rrib** instruction is supported only in the POWER family architecture.

Syntax

Bits	Value
0-5	31
6-10	RS
11-15	RA
16-20	RB
21-30	537
31	Rc

POWER family
rrib *RA*, *RS*, *RB*
rrib. *RA*, *RS*, *RB*

Description

The **rrib** instruction rotates bit 0 of the source general-purpose register (GPR) *RS* to the right by the number of bits specified by bits 27-31 of GPR *RB* and then stores the rotated bit in GPR *RA*.

The **rrib** instruction has two syntax forms. Each syntax form has a different effect on Condition Register Field 0.

Syntax Form	Overflow Exception (OE)	Fixed-Point Exception Register	Record Bit (Rc)	Condition Register Field 0
rrib	None	None	0	None
rrib.	None	None	1	LT,GT,EQ,SO

The two syntax forms of the **rrib** instruction never affect the Fixed-Point Exception Register. If the syntax form sets the Record (Rc) bit to 1, the instruction affects the Less Than (LT) zero, Greater Than (GT) zero, Equal To (EQ) zero, and Summary Overflow (SO) bits in Condition Register Field 0.

Parameters

RA Specifies target general-purpose register where result of operation is stored.
RS Specifies source general-purpose register for operation.
RB Specifies general-purpose register that contains the number of bits for rotation of data.

Examples

1. The following code rotates bit 0 of GPR 5 to the right by 4 bits and stores its value in GPR 4:

```
# Assume GPR 5 contains 0x0000 0000.
# Assume GPR 6 contains 0x0000 0004.
# Assume GPR 4 contains 0xFFFF FFFF.
rrib 4,5,6
# GPR 4 now contains 0xF7FF FFFF.
```

2. The following code rotates bit 0 of GPR 5 to the right by 4 bits, stores its value in GPR 4, and sets Condition Register Field 0 to reflect the result of the operation:

```
# Assume GPR 5 contains 0xB004 3000.
# Assume GPR 6 contains 0x0000 0004.
# Assume GPR 4 contains 0x0000 0000.
rrib. 4,5,6
# GPR 4 now contains 0x0800 0000.
```

Related Information

Fixed-Point Processor .

Fixed-Point Rotate and Shift Instructions .

---

sc (System Call) Instruction

Purpose

Calls the system to provide a service.

Note: The **sc** instruction is supported only in the PowerPC architecture.

Syntax

Bits	Value
0-5	17
6-10	///
11-15	///
16-19	///
20-26	LEV
27-29	///
30	1
31	/

PowerPC

sc *"LEV" on page 357*

Description

The **sc** instruction causes a system call interrupt. The effective address (EA) of the instruction following the **sc** instruction is placed into the Save Restore Register 0 (SRR0). Bits 0, 5-9, and 16-31 of the Machine State Register (MSR) are placed into the corresponding bits of Save Restore Register 1 (SRR1). Bits 1-4 and 10-15 of SRR1 are set to undefined values.

The **sc** instruction serves as both a basic and an extended mnemonic. In the extended form, the *LEV* field is omitted and assumed to be 0.

The **sc** instruction has one syntax form. The syntax form does not affect the Machine State Register.

Note: The **sc** instruction has the same op code as the “svc (Supervisor Call) Instruction” on page 443.

Parameters

LEV Must be 0 or 1.

Related Information

“svc (Supervisor Call) Instruction” on page 443.

“Branch Processor” on page 17

“System Call Instruction” on page 18

“Functional Differences for POWER family and PowerPC Instructions” on page 112

scv (System Call Vectored) Instruction

Purpose

Calls the system to provide a service.

Note: The **scv** instruction is supported only in the PowerPC architecture.

Syntax

Bits	Value
0-5	17
6-10	///
11-15	///
16-19	///
20-26	LEV
27-29	///
30	0
31	1

PowerPC

scv *“LEV” on page 358*

Description

The **scv** instruction causes a system call interrupt. The effective address (EA) of the instruction following the **scv** instruction is placed into the Link Register. Bits 0-32, 37-41, and 48-63 of the Machine State Register (MSR) are placed into the corresponding bits of Count Register. Bits 33-36 and 42-47 of the Count Register are set to undefined values.

The **scv** instruction has one syntax form. The syntax form does not affect the Machine State Register.

Note: The **scv** instruction has the same op code as the “svc (Supervisor Call) Instruction” on page 443.

Parameters

LEV Must be 0 or 1.

Related Information

"svc (Supervisor Call) Instruction" on page 443.

"Branch Processor" on page 17.

"System Call Instruction" on page 18.

"Functional Differences for POWER family and PowerPC Instructions" on page 112.

si (Subtract Immediate) Instruction

Purpose

Subtracts the value of a signed integer from the contents of a general-purpose register and places the result in a general-purpose register.

Syntax

Bits	Value
0-5	12
6-10	RT
11-15	RA
16-31	SI

si *RT*, *RA*, *SINT*

Description

The **si** instruction subtracts the 16-bit signed integer specified by the *SINT* parameter from the contents of general-purpose register (GPR) *RA* and stores the result in the target GPR *RT*. This instruction has the same effect as the **ai** instruction used with a negative *SINT* value. The assembler negates *SINT* and places this value (*SI*) in the machine instruction:

```
ai RT,RA,-SINT
```

The **si** instruction has one syntax form and can set the Carry Bit of the Fixed-Point Exception Register; it never affects Condition Register Field 0.

Parameters

RT Specifies target general-purpose register for operation.
RA Specifies source general-purpose register for operation.
SINT Specifies 16-bit signed integer for operation.
SI Specifies the negative of the *SINT* value.

Examples

The following code subtracts 0xFFFF F800 from the contents of GPR 4, stores the result in GPR 6, and sets the Carry bit in the Fixed-Point Exception Register to reflect the result of the operation:

```
# Assume GPR 4 contains 0x0000 0000
si 6,4,0xFFFFF800
# GPR 6 now contains 0x0000 0800
# This instruction has the same effect as
#     ai 6,4,-0xFFFFF800.
```

Related Information

The **addic** or **ai** (Add Immediate Carrying) instruction.

Branch Processor .

Fixed-Point Arithmetic Instructions .

---

si. (Subtract Immediate and Record) Instruction

Purpose

Subtracts the value of a signed integer from the contents of a general-purpose register and places the result in a second general-purpose register.

Syntax

Bits	Value
0-5	13
6-10	RT
11-15	RA
16-31	SI

si. *RT*, *RA*, *SINT*

Description

The **si.** instruction subtracts the 16-bit signed integer specified by the *SINT* parameter from the contents of general-purpose register (GPR) *RA* and stores the result into the target GPR *RT*. This instruction has the same effect as the **ai.** instruction used with a negative *SINT*. The assembler negates *SINT* and places this value (*SI*) in the machine instruction:

```
ai. RT,RA,-SINT
```

The **si.** instruction has one syntax form and can set the Carry Bit of the Fixed-Point Exception Register. This instruction also affects the Less Than (LT) zero, Greater Than (GT) zero, Equal To (EQ) zero, or Summary Overflow (SO) bit in Condition Register Field 0.

Parameters

RT Specifies target general-purpose register for operation.
RA Specifies source general-purpose register for operation.
SINT Specifies 16-bit signed integer for operation.
SI Specifies the negative of the *SINT* value.

Examples

The following code subtracts 0xFFFF F800 from the contents of GPR 4, stores the result in GPR 6, and sets the Carry bit in the Fixed-Point Exception Register and Condition Register Field 0 to reflect the result of the operation:

```
# Assume GPR 4 contains 0xEFFF FFFF.
si. 6,4,0xFFFFF800
# GPR 6 now contains 0xF000 07FF.
# This instruction has the same effect as
#     ai. 6,4,-0xFFFFF800.
```

Related Information

The **addic.** or **ai.** (Add Immediate Carrying and Record) instruction.

Fixed-Point Processor .

Fixed-Point Arithmetic Instructions .

---

sld (Shift Left Double Word) Instruction

Purpose

Shift the contents of a general purpose register left by the number of bits specified by the contents of another general purpose register.

Syntax

Bits	Value
0-5	31
6-10	S
11-15	A
16-20	B
21-30	27
31	Rc

POWER family

sld *RA*, *RS*, *RB* (OE=0 Rc=0)
sld. *RA*, *RS*, *RB* (OE=0 Rc=1)

Description

The contents of general purpose register (GPR) *RS* are shifted left the number of bits specified by the low-order seven bits of GPR *RB*. Bits shifted out of position 0 are lost. Zeros are supplied to the vacated positions on the right. The result is placed into GPR *RA*. Shift amounts from 64 to 127 give a zero result.

Other registers altered:

- Condition Register (CR0 field):
  Affected: LT, GT, EQ, SO (if Rc = 1)

Parameters

RA Specifies target general-purpose register for the result of the operation.

RS Specifies source general-purpose register containing the operand for thr shift operation.
RB The low-order seven bits specify the distance to shift the operand.

Implementation

This instruction is defined only for 64-bit implementations. Using it on a 32-bit implementation will cause the system illegal instruction error handler to be invoked.

sle (Shift Left Extended) Instruction

Purpose

Shifts the contents of a general-purpose register to the left by a specified number of bits, puts a copy of the rotated data in the MQ Register, and places the result in another general-purpose register.

Note: The **sle** instruction is supported only in the POWER family architecture.

Syntax

Bits	Value
0-5	31
6-10	RS
11-15	RA
16-20	RB
21-30	153
31	Rc

POWER family
sle *RA*, *RS*, *RB*
sle. *RA*, *RS*, *RB*

Description

The **sle** instruction rotates the contents of the source general-purpose register (GPR) *RS* to the left by *N* bits, where *N* is the shift amount specified in bits 27-31 of GPR *RB*. The instruction also stores the rotated word in the MQ Register and the logical AND of the rotated word and the generated mask in GPR *RA*. The mask consists of 32 minus *N* ones followed by *N* zeros.

The **sle** instruction has two syntax forms. Each syntax form has a different effect on Condition Register Field 0.

Syntax Form	Overflow Exception (OE)	Fixed-Point Exception Register	Record Bit (Rc)	Condition Register Field 0
sle	None	None	0	None
sle.	None	None	1	LT,GT,EQ,SO

The two syntax forms of the **sle** instruction never affect the Fixed-Point Exception Register. If the syntax form sets the Record (Rc) bit to 1, the instruction affects the Less Than (LT) zero, Greater Than (GT) zero, Equal To (EQ) zero, and Summary Overflow (SO) bits in Condition Register Field 0.

Parameters

RA Specifies target general-purpose register where result of operation is stored.
RS Specifies source general-purpose register for operation.
RB Specifies source general-purpose register for operation.

Examples

1. The following code rotates the contents of GPR 4 to the left by 4 bits, places a copy of the rotated data in the MQ Register, and places the result of ANDing the rotated data with a mask into GPR 6:

```
# Assume GPR 4 contains 0x9000 3000.
# Assume GPR 5 contains 0x0000 0004.
sle 6,4,5
# GPR 6 now contains 0x0003 0000.
# The MQ Register now contains 0x0003 0009.
```

2. The following code rotates the contents of GPR 4 to the left by 4 bits, places a copy of the rotated data in the MQ Register, places the result of ANDing the rotated data with a mask into GPR 6, and sets Condition Register Field 0 to reflect the result of the operation:

```
# Assume GPR 4 contains 0xB004 3000.
# Assume GPR 5 contains 0x0000 0004.
sle. 6,4,5
# GPR 6 now contains 0x0043 0000.
# The MQ Register now contains 0x0043 000B.
# Condition Register Field 0 now contains 0x4.
```

Related Information

Fixed-Point Processor .

Fixed-Point Rotate and Shift Instructions .

---

sleq (Shift Left Extended with MQ) Instruction

Purpose

Rotates the contents of a general-purpose register to the left by a specified number of bits, merges the result with the contents of the MQ Register under control of a mask, and places the rotated word in the MQ Register and the masked result in another general-purpose register.

Note: The **sleq** instruction is supported only in the POWER family architecture.

Syntax

Bits	Value
0-5	31
6-10	RS
11-15	RA
16-20	RB
21-30	217
31	Rc

POWER family
sleq *RA*, *RS*, *RB*
sleq. *RA*, *RS*, *RB*

Description

The **sleq** instruction rotates the contents of the source general-purpose register (GPR) *RS* left *N* bits, where *N* is the shift amount specified in bits 27-31 of GPR *RB*. The instruction merges the rotated word with the contents of the MQ Register under control of a mask, and stores the rotated word in the MQ Register and merged word in GPR *RA*. The mask consists of 32 minus *N* ones followed by *N* zeros.

The **sleq** instruction has two syntax forms. Each syntax form has a different effect on Condition Register Field 0.

Syntax Form	Overflow Exception (OE)	Fixed-Point Exception Register	Record Bit (Rc)	Condition Register Field 0
sleq	None	None	0	None
sleq.	None	None	1	LT,GT,EQ,SO

The two syntax forms of the **sleq** instruction never affect the Fixed-Point Exception Register. If the syntax form sets the Record (Rc) bit to 1, the instruction affects the Less Than (LT) zero, Greater Than (GT) zero, Equal To (EQ) zero, and Summary Overflow (SO) bits in Condition Register Field 0.

Parameters

RA Specifies target general-purpose register where result of operation is stored.
RS Specifies source general-purpose register for operation.
RB Specifies source general-purpose register for operation.

Examples

1. The following code rotates the contents of GPR 4 to the left by 4 bits, merges the rotated data with the contents of the MQ Register under a generated mask, and places the rotated word in the MQ Register and the result in GPR 6 :

```
# Assume GPR 4 contains 0x9000 3000.
# Assume GPR 5 contains 0x0000 0004.
# Assume the MQ Register contains 0xFFFF FFFF.
sleq 6,4,5
# GPR 6 now contains 0x0003 000F.
# The MQ Register now contains 0x0003 0009.
```

2. The following code rotates the contents of GPR 4 to the left by 4 bits, merges the rotated data with the contents of the MQ Register under a generated mask, places the rotated word in the MQ Register and the result in GPR 6, and sets Condition Register Field 0 to reflect the result of the operation:

```
# Assume GPR 4 contains 0xB004 3000.
# Assume GPR 5 contains 0x0000 0004.
# Assume the MQ Register contains 0xFFFF FFFF.
sleq. 6,4,5
# GPR 6 now contains 0x0043 000F.
# The MQ Register now contains 0x0043 000B.
# Condition Register Field 0 now contains 0x4.
```

Related Information

Fixed-Point Processor .

Fixed-Point Rotate and Shift Instructions .

sliq (Shift Left Immediate with MQ) Instruction

Purpose

Shifts the contents of a general-purpose register to the left by a specified number of bits in an immediate value, and places the rotated contents in the MQ Register and the result in another general-purpose register.

Note: The **sliq** instruction is supported only in the POWER family architecture.

Syntax

Bits	Value
0-5	31
6-10	RS
11-15	RA
16-20	SH
21-30	184
31	Rc

POWER family

sliq *RA*, *RS*, *SH*
sliq. *RA*, *RS*, *SH*

Description

The **sliq** instruction rotates the contents of the source general-purpose register (GPR) *RS* to the left by *N* bits, where *N* is the shift amount specified by *SH*. The instruction stores the rotated word in the MQ Register and the logical AND of the rotated word and places the generated mask in GPR *RA*. The mask consists of 32 minus *N* ones followed by *N* zeros.

The **sliq** instruction has two syntax forms. Each syntax form has a different effect on Condition Register Field 0.

Syntax Form	Overflow Exception (OE)	Fixed-Point Exception Register	Record Bit (Rc)	Condition Register Field 0
sliq	None	None	0	None
sliq.	None	None	1	LT,GT,EQ,SO

The two syntax forms of the **sliq** instruction never affect the Fixed-Point Exception Register. If the syntax form sets the Record (Rc) bit to 1, the instruction affects the Less Than (LT) zero, Greater Than (GT) zero, Equal To (EQ) zero, and Summary Overflow (SO) bits in Condition Register Field 0.

Parameters

RA Specifies target general-purpose register where result of operation is stored.
RS Specifies source general-purpose register for operation.
SH Specifies immediate value for shift amount.

Examples

1. The following code rotates the contents of GPR 4 to the left by 20 bits, ANDs the rotated data with a generated mask, and places the rotated word into the MQ Register and the result in GPR 6:

```
# Assume GPR 4 contains 0x1234 5678.
sliq 6,4,0x14
# GPR 6 now contains 0x6780 0000.
# MQ Register now contains 0x6781 2345.
```

2. The following code rotates the contents of GPR 4 to the left by 16 bits, ANDs the rotated data with a generated mask, places the rotated word into the MQ Register and the result in GPR 6, and sets Condition Register Field 0 to reflect the result of the operation:

```
# Assume GPR 4 contains 0x1234 5678.
sliq. 6,4,0x10
# GPR 6 now contains 0x5678 0000.
# The MQ Register now contains 0x5678 1234.
# Condition Register Field 0 now contains 0x4.
```

Related Information

Fixed-Point Processor .

Fixed-Point Rotate and Shift Instructions .

---

slliq (Shift Left Long Immediate with MQ) Instruction

Purpose

Rotates the contents of a general-purpose register to the left by a specified number of bits in an immediate value, merges the result with the contents of the MQ Register under control of a mask, and places the rotated word in the MQ Register and the masked result in another general-purpose register.

Note: The **slliq** instruction is supported only in the POWER family architecture.

Syntax

Bits	Value
0-5	31
6-10	RS
11-15	RA
16-20	SH
21-30	248
31	Rc

POWER family

slliq *RA*, *RS*, *SH*
slliq. *RA*, *RS*, *SH*

Description

The **slliq** instruction rotates the contents of the source general-purpose register (GPR) *RS* to the left by *N* bits, where *N* is the shift amount specified in *SH*, merges the result with the contents of the MQ Register, and stores the rotated word in the MQ Register and the final result in GPR *RA*. The mask consists of 32 minus *N* ones followed by *N* zeros.

The **slliq** instruction has two syntax forms. Each syntax form has a different effect on Condition Register Field 0.

Syntax Form	Overflow Exception (OE)	Fixed-Point Exception Register	Record Bit (Rc)	Condition Register Field 0
slliq	None	None	0	None
slliq.	None	None	1	LT,GT,EQ,SO

The two syntax forms of the **slliq** instruction never affect the Fixed-Point Exception Register. If the syntax form sets the Record (Rc) bit to 1, the instruction affects the Less Than (LT) zero, Greater Than (GT) zero, Equal To (EQ) zero, and Summary Overflow (SO) bits in Condition Register Field 0.

Parameters

RA Specifies target general-purpose register where result of operation is stored.
RS Specifies source general-purpose register for operation.
SH Specifies immediate value for shift amount.

Examples

1. The following code rotates the contents of GPR 4 to the left by 3 bits, merges the rotated data with the contents of the MQ Register under a generated mask, and places the rotated word in the MQ Register and the result in GPR 6:

```
# Assume GPR 4 contains 0x9000 3000.
# Assume the MQ Register contains 0xFFFF FFFF.
slliq 6,4,0x3
# GPR 6 now contains 0x8001 8007.
# The MQ Register now contains 0x8001 8004.
```

2. The following code rotates the contents of GPR 4 to the left by 4 bits, merges the rotated data with the contents of the MQ Register under a generated mask, places the rotated word in the MQ Register and the result in GPR 6, and sets Condition Register Field 0 to reflect the result of the operation:

```
# Assume GPR 4 contains 0xB004 3000.
# Assume the MQ Register contains 0xFFFF FFFF.
slliq. 6,4,0x4
# GPR 6 now contains 0x0043 000F.
# The MQ Register contains 0x0043 000B.
# Condition Register Field 0 now contains 0x4.
```

Related Information

Fixed-Point Processor .

Fixed-Point Rotate and Shift Instructions .

---

sllq (Shift Left Long with MQ) Instruction

Purpose

Rotates the contents of a general-purpose register to the left by the number of bits specified in a general-purpose register, merges either the rotated data or a word of zeros with the contents of the MQ Register, and places the result in a third general-purpose register.

Note: The **sliq** instruction is supported only in the POWER family architecture.

Syntax

Bits	Value
0-5	31
6-10	RS
11-15	RA
16-20	RB
21-30	216
31	Rc

POWER family
sllq *RA*, *RS*, *RB*
sllq. *RA*, *RS*, *RB*

Description

The **sllq** instruction rotates the contents of the source general-purpose register (GPR) *RS* to the left by *N* bits, where *N* is the shift amount specified in bits 27-31 of GPR *RB*. The merge depends on the value of bit 26 in GPR *RB*.

Consider the following when using the **sllq** instruction:

- If bit 26 of GPR *RB* is 0, then a mask of *N* zeros followed by 32 minus *N* ones is generated. The rotated word is then merged with the contents of the MQ Register under the control of this generated mask.
- If bit 26 of GPR *RB* is 1, then a mask of *N* ones followed by 32 minus *N* zeros is generated. A word of zeros is then merged with the contents of the MQ Register under the control of this generated mask.

The resulting merged word is stored in GPR *RA*. The MQ Register is not altered.

The **sllq** instruction has two syntax forms. Each syntax form has a different effect on Condition Register Field 0.

Syntax Form	Overflow Exception (OE)	Fixed-Point Exception Register	Record Bit (Rc)	Condition Register Field 0
sllq	None	None	0	None
sllq.	None	None	1	LT,GT,EQ,SO

The two syntax forms of the **sllq** instruction never affect the Fixed-Point Exception Register. If the syntax form sets the Record (Rc) bit to 1, the instruction affects the Less Than (LT) zero, Greater Than (GT) zero, Equal To (EQ) zero, and Summary Overflow (SO) bits in Condition Register Field 0.

Parameters

RA Specifies target general-purpose register where result of operation is stored.
RS Specifies source general-purpose register for operation.
RB Specifies source general-purpose register for operation.

Examples

1. The following code rotates the contents of GPR 4 to the left by 4 bits, merges a word of zeros with the contents of the MQ Register under a mask, and places the merged result in GPR 6:

```
# Assume GPR 4 contains 0x9000 3000.
# Assume GPR 5 contains 0x0000 0024.
# Assume MQ Register contains 0xABCD EFAB.
sllq 6,4,5
# GPR 6 now contains 0xABCD EFA0.
# The MQ Register remains unchanged.
```

2. The following code rotates the contents of GPR 4 to the left by 4 bits, merges the rotated data with the contents of the MQ Register under a mask, places the merged result in GPR 6, and sets Condition Register Field 0 to reflect the result of the operation:

```
# Assume GPR 4 contains 0xB004 3000.
# Assume GPR 5 contains 0x0000 0004.
# Assume MQ Register contains 0xFFFF FFFF.
sllq. 6,4,5
# GPR 6 now contains 0x0043 000F.
# The MQ Register remains unchanged.
# Condition Register Field 0 now contains 0x4.
```

Related Information

Fixed-Point Processor .

Fixed-Point Rotate and Shift Instructions .

---

slq (Shift Left with MQ) Instruction

Purpose

Rotates the contents of a general-purpose register to the left by the number of bits specified in a general-purpose register, places the rotated word in the MQ Register, and places the logical AND of the rotated word and a generated mask in a third general-purpose register.

Note: The **slq** instruction is supported only in the POWER family architecture.

Syntax

Bits	Value
0-5	31
6-10	RS
11-15	RA
16-20	RB
21-30	152
31	Rc

POWER family

slq *RA*, *RS*, *RB*
slq. *RA*, *RS*, *RB*

Description

The **slq** instruction rotates the contents of the source general-purpose register (GPR) *RS* to the left by *N* bits, where *N* is the shift amount specified in bits 27-31 of GPR *RB*, and stores the rotated word in the MQ Register. The mask depends on bit 26 of GPR *RB*.

Consider the following when using the **slq** instruction:

- If bit 26 of GPR *RB* is 0, then a mask of 32 minus *N* ones followed by *N* zeros is generated.
- If bit 26 of GPR *RB* is 1, then a mask of all zeros is generated.

This instruction then stores the logical AND of the rotated word and the generated mask in GPR *RA*.

The **slq** instruction has two syntax forms. Each syntax form has a different effect on Condition Register Field 0.

Syntax Form	Overflow Exception (OE)	Fixed-Point Exception Register	Record Bit (Rc)	Condition Register Field 0
slq	None	None	0	None
slq.	None	None	1	LT,GT,EQ,SO

The two syntax forms of the **slq** instruction never affect the Fixed-Point Exception Register. If the syntax form sets the Record (Rc) bit to 1, the instruction affects the Less Than (LT) zero, Greater Than (GT) zero, Equal To (EQ) zero, and Summary Overflow (SO) bits in Condition Register Field 0.

Parameters

RA Specifies target general-purpose register where result of operation is stored.
RS Specifies source general-purpose register for operation.
RB Specifies source general-purpose register for operation.

Examples

1. The following code rotates the contents of GPR 4 to the left by 4 bits, places the rotated word in the MQ Register, and places logical AND of the rotated word and the generated mask in GPR 6:

```
# Assume GPR 4 contains 0x9000 3000.
# Assume GPR 5 contains 0x0000 0024.
slq 6,4,5
# GPR 6 now contains 0x0000 0000.
# The MQ Register now contains 0x0003 0009.
```

2. The following code rotates the contents of GPR 4 to the left by 4 bits, places the rotated word in the MQ Register, places logical AND of the rotated word and the generated mask in GPR 6, and sets Condition Register Field 0 to reflect the result of the operation:

```
# Assume GPR 4 contains 0xB004 3000.
# Assume GPR 5 contains 0x0000 0004.
slq. 6,4,5
# GPR 6 now contains 0x0043 0000.
# The MQ Register now contains 0x0043 000B.
# Condition Register Field 0 now contains 0x4.
```

Related Information

Fixed-Point Processor .

Fixed-Point Rotate and Shift Instructions .

---

slw or sl (Shift Left Word) Instruction

Purpose

Rotates the contents of a general-purpose register to the left by a specified number of bits and places the masked result in another general-purpose register.

Syntax

Bits	Value
0-5	31
6-10	RS
11-15	RA
16-20	RB
21-30	24
31	Rc

PowerPC
slw *RA*, *RS*, *RB*
slw. *RA*, *RS*, *RB*

POWER family
sl *RA*, *RS*, *RB*
sl. *RA*, *RS*, *RB*

Description

The **slw** and **sl** instructions rotate the contents of the source general-purpose register (GPR) *RS* to the left *N* bits, where *N* is the shift amount specified in bits 27-31 of GPR *RB*, and store the logical AND of the rotated word and the generated mask in GPR *RA*.

Consider the following when using the **slw** and **sl** instructions:

- If bit 26 of GPR *RB* is 0, then a mask of 32-*N* ones followed by *N* zeros is generated.
- If bit 26 of GPR *RB* is 1, then a mask of all zeros is generated.

The **slw** and **sl** instructions each have two syntax forms. Each syntax form has a different effect on Condition Register Field 0.

Syntax Form	Overflow Exception (OE)	Fixed-Point Exception Register	Record Bit (Rc)	Condition Register Field 0
slw	None	None	0	None
slw.	None	None	1	LT,GT,EQ,SO
sl	None	None	0	None
sl.	None	None	1	LT,GT,EQ,SO

The two syntax forms of the **slw** instruction, and the two syntax forms of the **sl** instruction, never affect the Fixed-Point Exception Register. If the syntax form sets the Record (Rc) bit to 1, these instructions affect the Less Than (LT) zero, Greater Than (GT) zero, Equal To (EQ) zero, and Summary Overflow (SO) bits in Condition Register Field 0.

Parameters

RA Specifies target general-purpose register where result of operation is stored.
RS Specifies source general-purpose register for operation.
RB Specifies source general-purpose register for operation.

Examples

1. The following code rotates the contents of GPR 4 to the left by 15 bits and stores the result of ANDing the rotated data with a generated mask in GPR 6:

```
# Assume GPR 5 contains 0x0000 002F.
# Assume GPR 4 contains 0xFFFF FFFF.
slw 6,4,5
# GPR 6 now contains 0x0000 0000.
```

2. The following code rotates the contents of GPR 4 to the left by 5 bits, stores the result of ANDing the rotated data with a generated mask in GPR 6, and sets Condition Register Field 0 to reflect the result of the operation:

```
# Assume GPR 4 contains 0xB004 3000.
# Assume GPR 5 contains 0x0000 0005.
slw. 6,4,5
# GPR 6 now contains 0x0086 0000.
# Condition Register Field 0 now contains 0x4.
```

Related Information

Fixed-Point Processor .

Fixed-Point Rotate and Shift Instructions .

srad (Shift Right Algebraic Double Word) Instruction

Purpose

Algebraically shift the contents of a general purpose register right by the number of bits specified by the contents of another general purpose register. Place the result of the operation in another general purpose register.

Syntax

Bits	Value
0-5	31
6-10	S
11-15	A
16-20	B
21-30	794
31	Rc

POWER family

srad *RA*, *RS*, *RB* (Rc=0)
srad. *RA*, *RS*, *RB* (Rc=1)

Description

The contents of general purpose register (GPR) *RS* are shifted right the number of bits specified by the low-order seven bits of GPR *RB*. Bits shifted out of position 63 are lost. Bit 0 of GPR *RS* is replicated to fill the vacated positions on the left. The result is placed into GRP *RA*. XER[CA] is set if GPR *RS* is negative and any 1 bits are shifted out of position 63; otherwise XER[CA] is cleared. A shift amount of zero causes GRP *RA* to be set equal to GPR *RS*, and XER[CA] to be cleared. Shift amounts from 64 to 127 give a result of 64 sign bits in GRP *RA*, and cause XER[CA] to receive the sign bit of GPR *RS*.

Note that the **srad** instruction, followed by addze, can by used to divide quickly by 2**n. The setting of the CA bit, by **srad**, is independent of mode.

Other registers altered:

- Condition Register (CR0 field):
  Affected: LT, GT, EQ, SO (if Rc = 1)
- XER:
  Affected: CA

Parameters

RA Specifies target general-purpose register for the result of the operation.
RS Specifies source general-purpose register containing the operand for thr shift operation.
RB Specifies the distance to shift the operand.

Implementation

This instruction is defined only for 64-bit implementations. Using it on a 32-bit implementation will cause the system illegal instruction error handler to be invoked.

---

sradi (Shift Right Algebraic Double Word Immediate) Instruction

Purpose

Algebraically shift the contents of a general purpose register right by the number of bits specified by the immediate value. Place the result of the operation in another general purpose register.

Syntax

Bits	Value
0-5	31
6-10	S
11-15	A
16-20	sh
21-29	413
30	sh
31	Rc

POWER family
sradi *RA*, *RS*, *SH* (Rc=0)
sradi. *RA*, *RS*, *SH* (Rc=1)

Description

The contents of general purpose register (GPR) *RS* are shifted right *SH* bits. Bits shifted out of position 63 are lost. Bit 0 of GPR *RS* is replicated to fill the vacated positions on the left. The result is placed into GPR *RA*. XER[CA] is set if GPR *RS* is negative and any 1 bits are shifted out of position 63; otherwise XER[CA] is cleared. A shift amount of zero causes GPR *RA* to be set equal to GPR *RS*, and XER[CA] to be cleared.

Note that the **sradi** instruction, followed by addze, can by used to divide quickly by 2**n. The setting of the CA bit, by **sradi**, is independent of mode.

Other registers altered:

- Condition Register (CR0 field):
  Affected: LT, GT, EQ, SO (if Rc = 1)
- XER:
  Affected: CA

Parameters

RA Specifies target general-purpose register for the result of the operation.
RS Specifies source general-purpose register containing the operand for the shift operation.
SH Specifies shift value for operation.

Implementation

This instruction is defined only for 64-bit implementations. Using it on a 32-bit implementation will cause the system illegal instruction error handler to be invoked.

sraiq (Shift Right Algebraic Immediate with MQ) Instruction

Purpose

Rotates the contents of a general-purpose register to the left by a specified number of bits, merges the rotated data with a word of 32 sign bits from that general-purpose register under control of a generated mask, and places the rotated word in the MQ Register and the merged result in another general-purpose register.

Note: The **sraiq** instruction is supported only in the POWER family architecture.

Syntax

Bits	Value
0-5	31
6-10	RS
11-15	RA
16-20	SH
21-30	952
31	Rc

POWER family
sraiq *RA*, *RS*, *SH*
sraiq. *RA*, *RS*, *SH*

Description

The **sraiq** instruction rotates the contents of the source general-purpose register (GPR) *RS* to the left by 32 minus *N* bits, where *N* is the shift amount specified by *SH*, merges the rotated data with a word of 32 sign bits from GPR *RS* under control of a generated mask, and stores the rotated word in the MQ Register and the merged result in GPR *RA*. A word of 32 sign bits is generated by taking the sign bit of a GPR and

repeating it 32 times to make a full word. This word can be either 0x0000 0000 or 0xFFFF FFFF depending on the value of the GPR. The mask consists of *N* zeros followed by 32 minus *N* ones.

This instruction then ANDs the rotated data with the complement of the generated mask, ORs the 32-bit result together, and ANDs the bit result with bit 0 of GPR *RS* to produce the Carry bit (CA).

The **sraiq** instruction has two syntax forms. Each syntax form has a different effect on Condition Register Field 0.

Syntax Form	Overflow Exception (OE)	Fixed-Point Exception Register	Record Bit (Rc)	Condition Register Field 0
sraiq	None	CA	0	None
sraiq.	None	CA	1	LT,GT,EQ,SO

The two syntax forms of the **sraiq** instruction always affect the Carry bit (CA) in the Fixed-Point Exception Register. If the syntax form sets the Record (Rc) bit to 1, the instruction affects the Less Than (LT) zero, Greater Than (GT) zero, Equal To (EQ) zero, and Summary Overflow (SO) bits in Condition Register Field 0.

Parameters

RA Specifies target general-purpose register where result of operation is stored.
RS Specifies source general-purpose register for operation.
SH Specifies immediate value for shift amount.

Examples

1. The following code rotates the contents of GPR 4 to the left by 28 bits, merges the result with 32 sign bits under control of a generated mask, stores the result in GPR 6, and sets the Carry bit in the Fixed-Point Exception Register to reflect the result of the operation:

```
# Assume GPR 4 contains 0x9000 3000.
sraiq 6,4,0x4
# GPR 6 now contains 0xF900 0300.
# MQ now contains 0x0900 0300.
```

2. The following code rotates the contents of GPR 4 to the left by 28 bits, merges the result with 32 sign bits under control of a generated mask, stores the result in GPR 6, and sets the Carry bit in the Fixed-Point Exception Register and Condition Register Field 0 to reflect the result of the operation:

```
# Assume GPR 4 contains 0xB004 3000.
sraiq. 6,4,0x4
# GPR 6 now contains 0xFB00 4300.
# MQ now contains 0x0B00 4300.
# Condition Register Field 0 now contains 0x8.
```

Related Information

The **addze** or **aze** (Add to Zero Extended) instruction.

Fixed-Point Processor .

Fixed-Point Rotate and Shift Instructions .

sraq (Shift Right Algebraic with MQ) Instruction

Purpose

Rotates a general-purpose register a specified number of bits to the left, merges the result with a word of 32 sign bits from that general-purpose register under control of a generated mask, and places the rotated word in the MQ Register and the merged result in another general-purpose register.

Note: The **sraq** instruction is supported only in the POWER family architecture.

Syntax

Bits	Value
0-5	31
6-10	RS
11-15	RA
16-20	RB
21-30	920
31	Rc

POWER family

sraq *RA*, *RS*, *RB*

sraq. *RA*, *RS*, *RB*

Description

The **sraq** instruction rotates the contents of the source general-purpose register (GPR) *RS* to the left by 32 minus *N* bits, where *N* is the shift amount specified in bits 27-31 of GPR *RB*. The instruction then merges the rotated data with a word of 32 sign bits from GPR *RS* under control of a generated mask and stores the merged word in GPR *RA*. The rotated word is stored in the MQ Register. The mask depends on the value of bit 26 in GPR *RB*.

Consider the following when using the **sraq** instruction:

- If bit 26 of GPR *RB* is 0, then a mask of *N* zeros followed by 32 minus *N* ones is generated.
- If bit 26 of GPR *RB* is 1, then a mask of all zeros is generated.

A word of 32 sign bits is generated by taking the sign bit of a GPR and repeating it 32 times to make a full word. This word can be either 0x0000 0000 or 0xFFFF FFFF depending on the value of the GPR.

This instruction then ANDs the rotated data with the complement of the generated mask, ORs the 32-bit result together, and ANDs the bit result with bit 0 of GPR *RS* to produce the Carry bit (CA).

The **sraq** instruction has two syntax forms. Each syntax form has a different effect on Condition Register Field 0.

Syntax Form	Overflow Exception (OE)	Fixed-Point Exception Register	Record Bit (Rc)	Condition Register Field 0
sraq	None	CA	0	None
sraq.	None	CA	1	LT,GT,EQ,SO

The two syntax forms of the **sraq** instruction always affect the Carry bit (CA) in the Fixed-Point Exception Register. If the syntax form sets the Record (Rc) bit to 1, the instruction affects the Less Than (LT) zero, Greater Than (GT) zero, Equal To (EQ) zero, and Summary Overflow (SO) bits in Condition Register Field 0.

Parameters

RA Specifies target general-purpose register where result of operation is stored.
RS Specifies source general-purpose register for operation.
RB Specifies source general-purpose register for operation.

Examples

1. The following code rotates the contents of GPR 4 to the left by 28 bits, merges the result with 32 sign bits under control of a generated mask, places the result in GPR 6 and the rotated word in the MQ Register, and sets the Carry bit in the Fixed-Point Exception Register to reflect the result of the operation:

```
# Assume GPR 4 contains 0x9000 3000.
# Assume GPR 7 contains 0x0000 0024.
sraq 6,4,7
# GPR 6 now contains 0xFFFF FFFF.
# The MQ Register now contains 0x0900 0300.
```

2. The following code rotates the contents of GPR 4 to the left by 28 bits, merges the result with 32 sign bits under control of a generated mask, places the result in GPR 6 and the rotated word in the MQ Register, and sets the Carry bit in the Fixed-Point Exception Register and Condition Register Field 0 to reflect the result of the operation:

```
# Assume GPR 4 contains 0xB004 3000.
# Assume GPR 7 contains 0x0000 0004.
sraq. 6,4,7
# GPR 6 now contains 0xFB00 4300.
# The MQ Register now contains 0x0B00 4300.
# Condition Register Field 0 now contains 0x4.
```

Related Information

Fixed-Point Processor .

Fixed-Point Rotate and Shift Instructions .

---

sraw or sra (Shift Right Algebraic Word) Instruction

Purpose

Rotates the contents of a general-purpose register to the left by a specified number of bits, merges the rotated data with a word of 32 sign bits from that register under control of a generated mask, and places the result in another general-purpose register.

Syntax

Bits	Value
0-5	31
6-10	RS
11-15	RA
16-20	RB
21-30	792

Bits	Value
31	Rc

PowerPC
sraw *RA*, *RS*, *RB*
sraw. *RA*, *RS*, *RB*

POWER family
sra *RA*, *RS*, *RB*
sra. *RA*, *RS*, *RB*

Description

The **sraw** and **sra** instructions rotate the contents of the source general-purpose register (GPR) *RS* to the left by 32 minus *N* bits, where *N* is the shift amount specified in bits 27-31 of GPR *RB*, and merge the rotated word with a word of 32 sign bits from GPR *RS* under control of a generated mask. A word of 32 sign bits is generated by taking the sign bit of a GPR and repeating it 32 times to make a full word. This word can be either 0x0000 0000 or 0xFFFF FFFF depending on the value of the GPR.

The mask depends on the value of bit 26 in GPR *RB*.

Consider the following when using the **sraw** and **sra** instructions:

- If bit 26 of GPR *RB* is zero, then a mask of *N* zeros followed by 32 minus *N* ones is generated.
- If bit 26 of GPR *RB* is one, then a mask of all zeros is generated.

The merged word is placed in GPR *RA*. The **sraw** and **sra** instructions then AND the rotated data with the complement of the generated mask, OR the 32-bit result together, and AND the bit result with bit 0 of GPR *RS* to produce the Carry bit (CA).

The **sraw** and **sra** instructions each have two syntax forms. Each syntax form has a different effect on Condition Register Field 0.

Syntax Form	Overflow Exception (OE)	Fixed-Point Exception Register	Record Bit (Rc)	Condition Register Field 0
sraw	None	CA	0	None
sraw.	None	CA	1	LT,GT,EQ,SO
sra	None	CA	0	None
sra.	None	CA	1	LT,GT,EQ,SO

The two syntax forms of the **sraw** instruction, and the two syntax forms of the **sra** instruction, always affect the Carry bit (CA) in the Fixed-Point Exception Register. If the syntax form sets the Record (Rc) bit to 1, the instructions affect the Less Than (LT) zero, Greater Than (GT) zero, Equal To (EQ) zero, and Summary Overflow (SO) bits in Condition Register Field 0.

Parameters

RA Specifies target general-purpose register where result of operation is stored.
RS Specifies source general-purpose register for operation.
RB Specifies source general-purpose register for operation.

Examples

1. The following code rotates the contents of GPR 4 to the left by 28 bits, merges the result with 32 sign bits under control of a generated mask, stores the result in GPR 6, and sets the Carry bit in the Fixed-Point Exception Register to reflect the result of the operation:

```
# Assume GPR 4 contains 0x9000 3000.
# Assume GPR 5 contains 0x0000 0024.
sraw 6,4,5
# GPR 6 now contains 0xFFFF FFFF.
```

2. The following code rotates the contents of GPR 4 to the left by 28 bits, merges the result with 32 sign bits under control of a generated mask, stores the result in GPR 6, and sets the Carry bit in the Fixed-Point Exception Register and Condition Register Field 0 to reflect the result of the operation:

```
# Assume GPR 4 contains 0xB004 3000.
# Assume GPR 5 contains 0x0000 0004.
sraw. 6,4,5
# GPR 6 now contains 0xFB00 4300.
# Condition Register Field 0 now contains 0x8.
```

Related Information

The **addze** or **aze** (Add to Zero Extended) instruction.

Fixed-Point Processor .

Fixed-Point Rotate and Shift Instructions .

---

srawi or srai (Shift Right Algebraic Word Immediate) Instruction

Purpose

Rotates the contents of a general-purpose register a specified number of bits to the left, merges the rotated data with a word of 32 sign bits from that register under control of a generated mask, and places the result in another general-purpose register.

Syntax

Bits	Value
0-5	31
6-10	RS
11-15	RA
16-20	SH
21-30	824
31	Rc

PowerPC

srawi *RA*, *RS*, *SH*
srawi. *RA*, *RS*, *SH*

POWER family

srai *RA*, *RS*, *SH*
srai. *RA*, *RS*, *SH*

Description

The **srawi** and **srai** instructions rotate the contents of the source general-purpose register (GPR) *RS* to the left by 32 minus *N* bits, where *N* is the shift amount specified by *SH*, merge the rotated data with a word of 32 sign bits from GPR *RS* under control of a generated mask, and store the merged result in GPR *RA*. A word of 32 sign bits is generated by taking the sign bit of a GPR and repeating it 32 times to make a full word. This word can be either 0x0000 0000 or 0xFFFF FFFF depending on the value of the GPR. The mask consists of *N* zeros followed by 32 minus *N* ones.

The **srawi** and **srai** instructions then AND the rotated data with the complement of the generated mask, OR the 32-bit result together, and AND the bit result with bit 0 of GPR *RS* to produce the Carry bit (CA).

The **srawi** and **srai** instructions each have two syntax forms. Each syntax form has a different effect on Condition Register Field 0.

Syntax Form	Overflow Exception (OE)	Fixed-Point Exception Register	Record Bit (Rc)	Condition Register Field 0
srawi	None	CA	0	None
srawi.	None	CA	1	LT,GT,EQ,SO
srai	None	CA	0	None
srai.	None	CA	1	LT,GT,EQ,SO

The two syntax forms of the **srawi** instruction, and the two syntax forms of the **srai** instruction, always affect the Carry bit (CA) in the Fixed-Point Exception Register. If the syntax form sets the Record (Rc) bit to 1, the instructions affect the Less Than (LT) zero, Greater Than (GT) zero, Equal To (EQ) zero, and Summary Overflow (SO) bits in Condition Register Field 0.

Parameters

RA Specifies target general-purpose register where result of operation is stored.
RS Specifies source general-purpose register for operation.
SH Specifies immediate value for shift amount.

Examples

1. The following code rotates the contents of GPR 4 to the left by 28 bits, merges the result with 32 sign bits under control of a generated mask, stores the result in GPR 6, and sets the Carry bit in the Fixed-Point Exception Register to reflect the result of the operation:

```
# Assume GPR 4 contains 0x9000 3000.
srawi 6,4,0x4
# GPR 6 now contains 0xF900 0300.
```

2. The following code rotates the contents of GPR 4 to the left by 28 bits, merges the result with 32 sign bits under control of a generated mask, places the result in GPR 6, and sets the Carry bit in the Fixed-Point Exception Register and Condition Register Field 0 to reflect the result of the operation:

```
# Assume GPR 4 contains 0xB004 3000.
srawi. 6,4,0x4
# GPR 6 now contains 0xFB00 4300.
# Condition Register Field 0 now contains 0x8.
```

Related Information

The **addze** or **aze** (Add to Zero Extended) instruction.

Fixed-Point Processor .

srd (Shift Right Double Word) Instruction

Purpose

Shift the contents of a general purpose register right by the number of bits specified by the contents of another general purpose register.

Syntax

Bits	Value
0-5	31
6-10	S
11-15	A
16-20	B
21-30	539
31	Rc

POWER family

srd *RA*, *RS*, *RB* (Rc=0)
srd. *RA*, *RS*, *RB* (Rc=1)

Description

The contents of general purpose register (GPR) *RS* are shifted right the number of bits specified by the low-order seven bits of GPR *RB*. Bits shifted out of position 63 are lost. Zeros are supplied to the vacated positions on the left. The result is placed into GRP *RA*. Shift amounts from 64 to 127 give a zero result.

Other registers altered:

- Condition Register (CR0 field):
  Affected: LT, GT, EQ, SO (if Rc = 1)

Parameters

RA Specifies target general-purpose register for the result of the operation.
RS Specifies source general-purpose register containing the operand for thr shift operation.
RB The low-order seven bits specify the distance to shift the operand.

Implementation

This instruction is defined only for 64-bit implementations. Using it on a 32-bit implementation will cause the system illegal instruction error handler to be invoked.

sre (Shift Right Extended) Instruction

Purpose

Shifts the contents of a general-purpose register to the right by a specified number of bits and places a copy of the rotated data in the MQ Register and the result in a general-purpose register.

Note: The **sre** instruction is supported only in the POWER family architecture.

Syntax

Bits	Value
0-5	31
6-10	RS
11-15	RA
16-20	RB
21-30	665
31	Rc

POWER family

sre *RA*, *RS*, *RB*
sre. *RA*, *RS*, *RB*

Description

The **sre** instruction rotates the contents of the source general-purpose register (GPR) *RS* to the left by 32 minus *N* bits, where *N* is the shift amount specified in bits 27-31 of GPR *RB*, and stores the rotated word in the MQ Register and the logical AND of the rotated word and a generated mask in GPR *RA*. The mask consists of *N* zeros followed by 32 minus *N* ones.

The **sre** instruction has two syntax forms. Each syntax form has a different effect on Condition Register Field 0.

Syntax Form	Overflow Exception (OE)	Fixed-Point Exception Register	Record Bit (Rc)	Condition Register Field 0
sre	None	None	0	None
sre.	None	None	1	LT,GT,EQ,SO

The two syntax forms of the **sre** instruction never affect the Fixed-Point Exception Register. If the syntax form sets the Record (Rc) bit to 1, the instruction affects the Less Than (LT) zero, Greater Than (GT) zero, Equal To (EQ) zero, and Summary Overflow (SO) bits in Condition Register Field 0.

Parameters

RA Specifies target general-purpose register where result of operation is stored.
RS Specifies source general-purpose register for operation.
RB Specifies source general-purpose register for operation.

Examples

1. The following code rotates the contents of GPR 4 to the left by 20 bits, places a copy of the rotated data in the MQ Register, and places the result of ANDing the rotated data with a mask into GPR 6:

```
# Assume GPR 4 contains 0x9000 3000.
# Assume GPR 5 contains 0x0000 000C.
sre 6,4,5
# GPR 6 now contains 0x0009 0003.
# The MQ Register now contains 0x0009 0003.
```

2. The following code rotates the contents of GPR 4 to the left by 17 bits, places a copy of the rotated data in the MQ Register, places the result of ANDing the rotated data with a mask into GPR 6, and sets Condition Register Field 0 to reflect the result of the operation:

```
# Assume GPR 4 contains 0xB004 3000.
# Assume GPR 5 contains 0x0000 000F.
sre. 6,4,5
# GPR 6 now contains 0x0001 6008.
# The MQ Register now contains 0x6001 6008.
# Condition Register Field 0 now contains 0x4.
```

Related Information

Fixed-Point Processor .

Fixed-Point Rotate and Shift Instructions .

---

srea (Shift Right Extended Algebraic) Instruction

Purpose

Rotates the contents of a general-purpose register to the left by a specified number of bits, places a copy of the rotated data in the MQ Register, merges the rotated word and a word of 32 sign bits from the general-purpose register under control of a mask, and places the result in another general-purpose register.

Note: The **srea** instruction is supported only in the POWER family architecture.

Syntax

Bits	Value
0-5	31
6-10	RS
11-15	RA
16-20	RB
21-30	921
31	Rc

POWER family

srea *RA*, *RS*, *RB*
srea. *RA*, *RS*, *RB*

Description

The **srea** instruction rotates the contents of the source general-purpose register (GPR) *RS* to the left by 32 minus *N* bits, where *N* is the shift amount specified in bits 27-31 of GPR *RB*, stores the rotated word in the MQ Register, and merges the rotated word and a word of 32 sign bits from GPR *RS* under control of a generated mask. A word of 32 sign bits is generated by taking the sign bit of a general-purpose register and repeating it 32 times to make a full word. This word can be either 0x0000 0000 or 0xFFFF FFFF depending on the value of the general-purpose register. The mask consists of *N* zeros followed by 32 minus *N* ones. The merged word is stored in GPR *RA*.

This instruction then ANDs the rotated data with the complement of the generated mask, ORs together the 32-bit result, and ANDs the bit result with bit 0 of GPR *RS* to produce the Carry bit (CA).

The **srea** instruction has two syntax forms. Each syntax form has a different effect on Condition Register Field 0.

Syntax Form	Overflow Exception (OE)	Fixed-Point Exception Register	Record Bit (Rc)	Condition Register Field 0
srea	None	CA	0	None
srea	None	CA	1	LT,GT,EQ,SO

The two syntax forms of the **srea** instruction always affect the Carry bit (CA) in the Fixed-Point Exception Register. If the syntax form sets the Record (Rc) bit to 1, the instruction affects the Less Than (LT) zero, Greater Than (GT) zero, Equal To (EQ) zero, and Summary Overflow (SO) bits in Condition Register Field 0.

Parameters

RA Specifies target general-purpose register where result of operation is stored.
RS Specifies source general-purpose register for operation.
RB Specifies source general-purpose register for operation.

Examples

1. The following code rotates the contents of GPR 4 to the left by 28 bits, merges the result with 32 sign bits under control of a generated mask, places the rotated word in the MQ Register and the result in GPR 6, and sets the Carry bit in the Fixed-Point Exception Register to reflect the result of the operation:

```
# Assume GPR 4 contains 0x9000 3000.
# Assume GPR 7 contains 0x0000 0004.
srea 6,4,7
# GPR 6 now contains 0xF900 0300.
# The MQ Register now contains 0x0900 0300.
```

2. The following code rotates the contents of GPR 4 to the left by 28 bits, merges the result with 32 sign bits under control of a generated mask, places the rotated word in the MQ Register and the result in GPR 6, and sets the Carry bit in the Fixed-Point Exception Register and Condition Register Field 0 to reflect the result of the operation:

```
# Assume GPR 4 contains 0xB004 3000.
# Assume GPR 7 contains 0x0000 0004.
srea. 6,4,7
# GPR 6 now contains 0xFB00 4300.
# The MQ Register now contains 0x0B00 4300.
# Condition Register Field 0 now contains 0x8.
```

Related Information

The **addze** or **aze** (Add to Zero Extended) instruction.

Fixed-Point Processor .

Fixed-Point Rotate and Shift Instructions .

sreq (Shift Right Extended with MQ) Instruction

Purpose

Rotates the contents of a general-purpose register to the left by a specified number of bits, merges the result with the contents of the MQ Register under control of a generated mask, and places the rotated word in the MQ Register and the merged result in another general-purpose register.

Note: The **sreq** instruction is supported only in the POWER family architecture.

Syntax

Bits	Value
0-5	31
6-10	RS
11-15	RA
16-20	RB
21-30	729
31	Rc

POWER family

sreq *RA*, *RS*, *RB*
sreq. *RA*, *RS*, *RB*

Description

The **sreq** instruction rotates the contents of the source general-purpose register (GPR) *RS* to the left by 32 minus *N* bits, where *N* is the shift amount specified in bits 27-31 of GPR *RB*, merges the rotated word with the contents of the MQ Register under a generated mask, and stores the rotated word in the MQ Register and the merged word in GPR *RA*. The mask consists of *N* zeros followed by 32 minus *N* ones.

The **sreq** instruction has two syntax forms. Each syntax form has a different effect on Condition Register Field 0.

Syntax Form	Overflow Exception (OE)	Fixed-Point Exception Register	Record Bit (Rc)	Condition Register Field 0
sreq	None	None	0	None
sreq.	None	None	1	LT,GT,EQ,SO

The two syntax forms of the **sreq** instruction never affect the Fixed-Point Exception Register. If the syntax form sets the Record (Rc) bit to 1, the instruction affects the Less Than (LT) zero, Greater Than (GT) zero, Equal To (EQ) zero, and Summary Overflow (SO) bits in Condition Register Field 0.

Parameters

RA Specifies target general-purpose register where result of operation is stored.
RS Specifies source general-purpose register for operation.
RB Specifies source general-purpose register for operation.

Examples

1. The following code rotates the contents of GPR 4 to the left by 28 bits, merges the rotated data with the contents of the MQ Register under a generated mask, and places the rotated word in the MQ Register and the result in GPR 6:

```
# Assume GPR 4 contains 0x9000 300F.
# Assume GPR 7 contains 0x0000 0004.
# Assume the MQ Register contains 0xEFFF FFFF.
sreq 6,4,7
# GPR 6 now contains 0xE900 0300.
# The MQ Register now contains 0xF900 0300.
```

2. The following code rotates the contents of GPR 4 to the left by 28 bits, merges the rotated data with the contents of the MQ Register under a generated mask, places the rotated word in the MQ Register and the result in GPR 6, and sets Condition Register Field 0 to reflect the result of the operation:

```
# Assume GPR 4 contains 0xB00 300F.
# Assume GPR 18 contains 0x0000 0004.
# Assume the MQ Register contains 0xEFFF FFFF
sreq. 6,4,18
# GPR 6 now contains 0xEB00 0300.
# The MQ Register now contains 0xFB00 0300.
# Condition Register Field 0 now contains 0x8.
```

Related Information

Fixed-Point Processor .

Fixed-Point Rotate and Shift Instructions .

---

sriq (Shift Right Immediate with MQ) Instruction

Purpose

Shifts the contents of a general-purpose register to the right by a specified number of bits and places the rotated contents in the MQ Register and the result in another general-purpose register.

Note: The **sriq** instruction is supported only in the POWER family architecture.

Syntax

Bits	Value
0-5	31
6-10	RS
11-15	RA
16-20	SH
21-30	696
31	Rc

POWER family

sriq *RA*, *RS*, *SH*
sriq. *RA*, *RS*, *SH*

Description

The **sriq** instruction rotates the contents of the source general-purpose register (GPR) *RS* to the left 32 minus *N* bits, where *N* is the shift amount specified by *SH*, and stores the rotated word in the MQ Register, and the logical AND of the rotated word and the generated mask in GPR *RA*. The mask consists of *N* zeros followed by 32 minus *N* ones.

The **sriq** instruction has two syntax forms. Each syntax form has a different effect on Condition Register Field 0.

Syntax Form	Overflow Exception (OE)	Fixed-Point Exception Register	Record Bit (Rc)	Condition Register Field 0
sriq	None	None	0	None

sriq.	None	None	1	LT,GT,EQ,SO

The two syntax forms of the **sriq** instruction never affect the Fixed-Point Exception Register. If the syntax form sets the Record (Rc) bit to 1, the instruction affects the Less Than (LT) zero, Greater Than (GT) zero, Equal To (EQ) zero, and Summary Overflow (SO) bits in Condition Register Field 0.

Parameters

RA Specifies target general-purpose register where result of operation is stored.
RS Specifies source general-purpose register for operation.
SH Specifies value for shift amount.

Examples

1. The following code rotates the contents of GPR 4 to the left by 20 bits, ANDs the rotated data with a generated mask, and places the rotated word into the MQ Register and the result in GPR 6:

```
# Assume GPR 4 contains 0x9000 300F.
sriq 6,4,0xC
# GPR 6 now contains 0x0009 0003.
# The MQ Register now contains 0x00F9 0003.
```

2. The following code rotates the contents of GPR 4 to the left by 12 bits, ANDs the rotated data with a generated mask, places the rotated word into the MQ Register and the result in GPR 6, and sets Condition Register Field 0 to reflect the result of the operation:

```
# Assume GPR 4 contains 0xB000 300F.
sriq. 6,4,0x14
# GPR 6 now contains 0x0000 0B00.
# The MQ Register now contains 0x0300 FB00.
# Condition Register Field 0 now contains 0x4.
```

Related Information

Fixed-Point Processor .

Fixed-Point Rotate and Shift Instructions .

---

srliq (Shift Right Long Immediate with MQ) Instruction

Purpose

Rotates the contents of a general-purpose register to the left by a specified number of bits, merges the result with the contents of the MQ Register under control of a generated mask, and places the result in another general-purpose register.

Note: The **srliq** instruction is supported only in the POWER family architecture.

Syntax

Bits	Value
0-5	31
6-10	RS
11-15	RA
16-20	SH
21-30	760

Bits	Value
31	Rc

POWER family
srliq *RA*, *RS*, *SH*
srliq. *RA*, *RS*, *SH*

Description

The **srliq** instruction rotates the contents of the source general-purpose register (GPR) *RS* to the left by 32 minus *N* bits, where *N* is the shift amount specified by *SH*, merges the result with the contents of the MQ Register under control of a generated mask, and stores the rotated word in the MQ Register and the merged result in GPR *RA*. The mask consists of *N* zeros followed by 32 minus *N* ones.

The **srliq** instruction has two syntax forms. Each syntax form has a different effect on Condition Register Field 0.

Syntax Form	Overflow Exception (OE)	Fixed-Point Exception Register	Record Bit (Rc)	Condition Register Field 0
srliq	None	None	0	None
srliq.	None	None	1	LT,GT,EQ,SO

The two syntax forms of the **srliq** instruction never affect the Fixed-Point Exception Register. If the syntax form sets the Record (Rc) bit to 1, the instruction affects the Less Than (LT) zero, Greater Than (GT) zero, Equal To (EQ) zero, and Summary Overflow (SO) bits in Condition Register Field 0.

Parameters

RA Specifies target general-purpose register where result of operation is stored.
RS Specifies source general-purpose register for operation.
SH Specifies value for shift amount.

Examples

1. The following code rotates the contents of GPR 4 to the left by 28 bits, merges the rotated data with the contents of the MQ Register under a generated mask, and places the rotated word in the MQ Register and the result in GPR 6:

```
# Assume GPR 4 contains 0x9000 300F.
# Assume the MQ Register contains 0x1111 1111.
srliq 6,4,0x4
# GPR 6 now contains 0x1900 0300.
# The MQ Register now contains 0xF900 0300.
```

2. The following code rotates the contents of GPR 4 to the left by 28 bits, merges the rotated data with the contents of the MQ Register under a generated mask, places the rotated word in the MQ Register and the result in GPR 6, and sets Condition Register Field 0 to reflect the result of the operation:

```
# Assume GPR 4 contains 0xB004 3000
# Assume the MQ Register contains 0xFFFF FFFF.
srliq. 6,4,0x4
# GPR 6 now contains 0xFB00 4300.
# The MQ Register contains 0x0B00 4300.
# Condition Register Field 0 now contains 0x8.
```

Related Information

Fixed-Point Processor .

Fixed-Point Rotate and Shift Instructions .

---

srlq (Shift Right Long with MQ) Instruction

Purpose

Rotates the contents of a general-purpose register to the left by a specified number of bits, merges either the rotated data or a word of zeros with the contents of the MQ Register under control of a generated mask, and places the result in a general-purpose register.

Note: The **srlq** instruction is supported only in the POWER family architecture.

Syntax

Bits	Value
0-5	31
6-10	RS
11-15	RA
16-20	RB
21-30	728
31	Rc

POWER family

srlq *RA*, *RS*, *RB*
srlq. *RA*, *RS*, *RB*

Description

The **srlq** instruction rotates the contents of the source general-purpose register (GPR) *RS* to the left 32 minus *N* bits, where *N* is the shift amount specified in bits 27-31 of GPR *RB*. The merge depends on the value of bit 26 in GPR *RB*.

Consider the following when using the **srlq** instruction:

- If bit 26 of GPR *RB* is 0, then a mask of *N* zeros followed by 32 minus *N* ones is generated. The rotated word is then merged with the contents of the MQ Register under control of this generated mask.
- If bit 26 of GPR *RB* is 1, then a mask of *N* ones followed by 32 minus *N* zeros is generated. A word of zeros is then merged with the contents of the MQ Register under control of this generated mask.

The merged word is stored in GPR *RA*. The MQ Register is not altered.

The **srlq** instruction has two syntax forms. Each syntax form has a different effect on Condition Register Field 0.

Syntax Form	Overflow Exception (OE)	Fixed-Point Exception Register	Record Bit (Rc)	Condition Register Field 0
srlq	None	None	0	None
srlq.	None	None	1	LT,GT,EQ,SO

The two syntax forms of the **srlq** instruction never affect the Fixed-Point Exception Register. If the syntax form sets the Record (Rc) bit to 1, the instruction affects the Less Than (LT) zero, Greater Than (GT) zero, Equal To (EQ) zero, and Summary Overflow (SO) bits in Condition Register Field 0.

Parameters

RA Specifies target general-purpose register where result of operation is stored.
RS Specifies source general-purpose register for operation.
RB Specifies source general-purpose register for operation.

Examples

1. The following code rotates the contents of GPR 4 to the left by 28 bits, merges a word of zeros with the contents of the MQ Register under a mask, and places the merged result in GPR 6:

```
# Assume GPR 4 contains 0x9000 300F.
# Assume GPR 8 contains 0x0000 0024.
# Assume the MQ Register contains 0xFFFF FFFF.
srlq 6,4,8
# GPR 6 now contains 0x0FFF FFFF.
# The MQ Register remains unchanged.
```

2. The following code rotates the contents of GPR 4 to the left by 28 bits, merges the rotated data with the contents of the MQ Register under a mask, places the merged result in GPR 6, and sets Condition Register Field 0 to reflect the result of the operation:

```
# Assume GPR 4 contains 0xB004 3000.
# Assume GPR 8 contains 0x00000 0004.
# Assume the MQ Register contains 0xFFFF FFFF.
srlq. 6,4,8
# GPR 6 now holds 0xFB00 4300.
# The MQ Register remains unchanged.
# Condition Register Field 0 now contains 0x8.
```

Related Information

Fixed-Point Processor .

Fixed-Point Rotate and Shift Instructions .

---

srq (Shift Right with MQ) Instruction

Purpose

Rotates the contents of a general-purpose register to the left by a specified number of bits, places the rotated word in the MQ Register, and places the logical AND of the rotated word and a generated mask in a general-purpose register.

Note: The **srq** instruction is supported only in the POWER family architecture.

Syntax

Bits	Value
0-5	31
6-10	RS
11-15	RA
16-20	RB
21-30	664

Bits	Value
31	Rc

POWER family
srq *RA*, *RS*, *RB*
srq. *RA*, *RS*, *RB*

Description

The **srq** instruction rotates the contents of the source general-purpose register (GPR) *RS* to the left by 32 minus *N* bits, where *N* is the shift amount specified in bits 27-31 of GPR *RB*, and stores the rotated word in the MQ Register. The mask depends on bit 26 of GPR *RB*.

Consider the following when using the **srq** instruction:

- If bit 26 of GPR *RB* is 0, then a mask of *N* zeros followed by 32 minus *N* ones is generated.
- If bit 26 of GPR *RB* is 1, then a mask of all zeros is generated.

This instruction then stores the logical AND of the rotated word and the generated mask in GPR *RA*.

The **srq** instruction has two syntax forms. Each syntax form has a different effect on Condition Register Field 0.

Syntax Form	Overflow Exception (OE)	Fixed-Point Exception Register	Record Bit (Rc)	Condition Register Field 0
srq	None	None	0	None
srq.	None	None	1	LT,GT,EQ,SO

The two syntax forms of the **srq** instruction never affect the Fixed-Point Exception Register. If the syntax form sets the Record (Rc) bit to 1, the instruction affects the Less Than (LT) zero, Greater Than (GT) zero, Equal To (EQ) zero, and Summary Overflow (SO) bits in Condition Register Field 0.

Parameters

RA Specifies target general-purpose register where result of operation is stored.
RS Specifies source general-purpose register for operation.
RB Specifies source general-purpose register for operation.

Examples

1. The following code rotates the contents of GPR 4 to the left by 28 bits, places the rotated word in the MQ Register, and places logical AND of the rotated word and the generated mask in GPR 6:

```
# Assume GPR 4 holds 0x9000 300F.
# Assume GPR 25 holds 0x0000 00024.
srq 6,4,25
# GPR 6 now holds 0x0000 0000.
# The MQ Register now holds 0xF900 0300.
```

2. The following code rotates the contents of GPR 4 to the left by 28 bits, places the rotated word in the MQ Register, places logical AND of the rotated word and the generated mask in GPR 6, and sets Condition Register Field 0 to reflect the result of the operation:

```
# Assume GPR 4 holds 0xB000 300F.
# Assume GPR 25 holds 0x0000 0004.
srq. 6,4,8
# GPR 6 now holds 0x0B00 0300.
# The MQ Register now holds 0xFB00 0300.
# Condition Register Field 0 now contains 0x4.
```

Related Information

Fixed-Point Processor .

Fixed-Point Rotate and Shift Instructions .

---

srw or sr (Shift Right Word) Instruction

Purpose

Rotates the contents of a general-purpose register to the left by a specified number of bits and places the masked result in a general-purpose register.

Syntax

Bits	Value
0-5	31
6-10	RS
11-15	RA
16-20	RB
21-30	536
31	Rc

PowerPC

srw *RA*, *RS*, *RB*
srw. *RA*, *RS*, *RB*

POWER family

sr *RA*, *RS*, *RB*
sr. *RA*, *RS*, *RB*

Description

The **srw** and **sr** instructions rotate the contents of the source general-purpose register (GPR) *RS* to the left by 32 minus *N* bits, where *N* is the shift amount specified in bits 27-31 of GPR *RB*, and store the logical AND of the rotated word and the generated mask in GPR *RA*.

Consider the following when using the **srw** and **sr** instructions:

- If bit 26 of GPR *RB* is 0, then a mask of *N* zeros followed by 32 - *N* ones is generated.
- If bit 26 of GPR *RB* is 1, then a mask of all zeros is generated.

The **srw** and **sr** instruction each have two syntax forms. Each syntax form has a different effect on Condition Register Field 0.

Syntax Form	Overflow Exception (OE)	Fixed-Point Exception Register	Record Bit (Rc)	Condition Register Field 0

srw	None	None	0	None
srw.	None	None	1	LT,GT,EQ,SO
sr	None	None	0	None
sr.	None	None	1	LT,GT,EQ,SO

The two syntax forms of the **sr** instruction, and the two syntax forms of the **srw** instruction, never affect the Fixed-Point Exception Register. If the syntax form sets the Record (Rc) bit to 1, these instructions affect the Less Than (LT) zero, Greater Than (GT) zero, Equal To (EQ) zero, and Summary Overflow (SO) bits in Condition Register Field 0.

Parameters

RA Specifies target general-purpose register where result of operation is stored.
RS Specifies source general-purpose register for operation.
RB Specifies source general-purpose register for operation.

Examples

1. The following code rotates the contents of GPR 4 to the left by 28 bits and stores the result of ANDing the rotated data with a generated mask in GPR 6:

```
# Assume GPR 4 contains 0x9000 3000.
# Assume GPR 5 contains 0x0000 0024.
srw 6,4,5
# GPR 6 now contains 0x0000 0000.
```

2. The following code rotates the contents of GPR 4 to the left by 28 bits, stores the result of ANDing the rotated data with a generated mask in GPR 6, and sets Condition Register Field 0 to reflect the result of the operation:

```
# Assume GPR 4 contains 0xB004 3001.
# Assume GPR 5 contains 0x0000 0004.
srw. 6,4,5
# GPR 6 now contains 0x0B00 4300.
# Condition Register Field 0 now contains 0x4.
```

Related Information

The **addze** or **aze** (Add to Zero Extended) instruction.

Fixed-Point Processor .

Fixed-Point Rotate and Shift Instructions .

---

stb (Store Byte) Instruction

Purpose

Stores a byte of data from a general-purpose register into a specified location in memory.

Syntax

Bits	Value
0-5	38
6-10	RS
11-15	RA

Bits	Value
16-31	D

stb *RS*, *D*(*RA*)

Description

The **stb** instruction stores bits 24-31 of general-purpose register (GPR) *RS* into a byte of storage addressed by the effective address (EA).

If GPR *RA* is not 0, the EA is the sum of the contents of GPR *RA* and *D*, a 16-bit signed two's complement integer sign-extended to 32 bits. If GPR *RA* is 0, then the EA is *D*.

The **stb** instruction has one syntax form and does not affect the Fixed-Point Exception Register or Condition Register Field 0.

Parameters

RS Specifies source general-purpose register of stored data.
D Specifies a 16-bit, signed two's complement integer sign-extended to 32 bits for EA calculation.
RA Specifies source general-purpose register for EA calculation.

Examples

The following code stores bits 24-31 of GPR 6 into a location in memory:

```
.csect data[rw]
buffer: .long 0
# Assume GPR 4 contains address of csect data[rw].
# Assume GPR 6 contains 0x0000 0060.
.csect text[pr]
stb 6,buffer(4)
# 0x60 is now stored at the address of buffer.
```

Related Information

Fixed-Point Processor .

Fixed-Point Load and Store Instructions .

stbu (Store Byte with Update) Instruction

Purpose

Stores a byte of data from a general-purpose register into a specified location in memory and possibly places the address in another general-purpose register.

Syntax

Bits	Value
0-5	39
6-10	RS
11-15	RA
16-31	D

stbu *RS*, *D*(*RA*)

Description

The **stbu** instruction stores bits 24-31 of the source general-purpose register (GPR) *RS* into the byte in storage addressed by the effective address (EA).

If GPR *RA* is not 0, the EA is the sum of the contents of GPR *RA* and *D*, a 16-bit signed two's complement integer sign-extended to 32 bits. If GPR *RA* is 0, then the EA is *D*.

If *RA* does not equal 0 and the storage access does not cause an Alignment Interrupt, then the EA is stored in GPR *RA*.

The **stbu** instruction has one syntax form and does not affect the Fixed-Point Exception Register or Condition Register Field 0.

Parameters

RS Specifies source general-purpose register of stored data.
D Specifies a 16-bit, signed two's complement integer sign-extended to 32 bits for EA calculation.
RA Specifies source general-purpose register for EA calculation and possible address update.

Examples

The following code stores bits 24-31 of GPR 6 into a location in memory and places the address in GPR 16:

```
.csect data[rw]
buffer: .long 0
# Assume GPR 6 contains 0x0000 0060.
# Assume GPR 16 contains the address of csect data[rw].
.csect text[pr]
stbu 6,buffer(16)
# GPR 16 now contains the address of buffer.
# 0x60 is stored at the address of buffer.
```

Related Information

Fixed-Point Processor .

Fixed-Point Load and Store with Update Instructions .

---

stbux (Store Byte with Update Indexed) Instruction

Purpose

Stores a byte of data from a general-purpose register into a specified location in memory and possibly places the address in another general-purpose register.

Syntax

Bits	Value
0-5	31
6-10	RS
11-15	RA

Bits	Value
16-20	RB
21-30	247
31	/

stbux *RS*, *RA*, *RB*

Description

The **stbux** instruction stores bits 24-31 of the source general-purpose register (GPR) *RS* into the byte in storage addressed by the effective address (EA).

If GPR *RA* is not 0, the EA is the sum of the contents of GPR *RA* and the contents of GPR *RB*. If *RA* is 0, then the EA is the contents of GPR *RB*.

If GPR *RA* does not equal 0 and the storage access does not cause an Alignment Interrupt, then the EA is stored in GPR *RA*.

The **stbux** instruction exists only in one syntax form and does not affect the Fixed-Point Exception Register or Condition Register Field 0.

Parameters

RS Specifies source general-purpose register of stored data.
RA Specifies source general-purpose register for EA calculation and possible address update.
RB Specifies source general-purpose register for EA calculation.

Examples

The following code stores the contents of GPR 6 into a location in memory and places the address in GPR 4:

```
.csect data[rw]
buffer: .long 0
# Assume GPR 6 contains 0x0000 0060.
# Assume GPR 4 conteains 0x0000 0000.
# Assume GPR 19 contains the address of buffer.
.csect text[pr]
stbux 6,4,19
# Buffer now contains 0x60.
# GPR 4 contains the address of buffer.
```

Related Information

Fixed-Point Processor .

Fixed-Point Load and Store with Update Instructions .

stbx (Store Byte Indexed) Instruction

Purpose

Stores a byte from a general-purpose register into a specified location in memory.

Syntax

Bits	Value
0-5	31
6-10	RS
11-15	RA
16-20	RB
21-30	215
31	/

stbx *RS*, *RA*, *RB*

Description

The **stbx** instruction stores bits 24-31 from general-purpose register (GPR) *RS* into a byte of storage addressed by the effective address (EA). The contents of GPR *RS* are unchanged.

If GPR *RA* is not 0, the EA is the sum of the contents of GPR *RA* and the contents of GPR *RB*. If GPR *RA* is 0, then the EA is the contents of GPR *RB*.

The **stbx** instruction has one syntax form and does not affect the Fixed-Point Exception Register or Condition Register Field 0.

Parameters

RS Specifies source general-purpose register of stored data.
RA Specifies source general-purpose register for EA calculation.
RB Specifies source general-purpose register for EA calculation.

Examples

The following code stores bits 24-31 of GPR 6 into a location in memory:

```
.csect data[rw]
buffer: .long 0
# Assume GPR 4 contains the address of buffer.
# Assume GPR 6 contains 0x4865 6C6F.
.csect text[pr]
stbx 6,0,4
# buffer now contains 0x6F.
```

Related Information

Fixed-Point Processor .

Fixed-Point Load and Store Instructions .

---

std (Store Double Word) Instruction

Purpose

Store a double-word of data from a general purpose register into a specified memory location.

Syntax

Bits	Value
0-5	62
6-10	S
11-15	A
16-29	ds
30-31	00

POWER family
std *RS*, *D*(*RA*)

Description

The **std** instruction stores a double-word in storage from the source general-purpose register (GPR) *RS* into the specified location in memory referenced by the effective address (EA).

If GPR *RA* is not 0, the EA is the sum of the contents of GPR *RA* and *D*, a 16-bit, signed two's complement integer, fullword-aligned, sign-extended to 64 bits. If GPR *RA* is 0, then the EA is *D*.

Parameters

RS Specifies the source general-purpose register containing data.
D Specifies a 16-bit, signed two's complement integer sign-extended to 32 bits for EA calculation.
RA Specifies source general-purpose register for EA calculation.

Implementation

This instruction is defined only for 64-bit implementations. Using it on a 32-bit implementation will cause the system illegal instruction error handler to be invoked.

---

stdcx. (Store Double Word Conditional Indexed) Instruction

Purpose

Conditionally store the contents of a general purpose register into a storage location, based upon an existing reservation.

Syntax

Bits	Value
0-5	31
6-10	S
11-15	A
16-20	B
21-30	214
31	1

POWER family
stdcx. *RS*, *RA*, *RB*

Description

If a reservation exists, and the memory address specified by the **stdcx.** instruction is the same as that specified by the load and reserve instruction that established the reservation, the contents of *RS* are stored into the double-word in memory addressed by the effective address (EA); the reservation is cleared.

If GPR *RA* is not 0, the EA is the sum of the contents of GPR *RA* and *D*, a 16-bit, signed two's complement integer, fullword-aligned, sign-extended to 64 bits. If GPR *RA* is 0, then the EA is *D*.

If a reservation exists, but the memory address specified by the **stdcx.** instruction is not the same as that specified by the load and reserve instruction that established the reservation, the reservation is cleared, and it is undefined whether the contents of *RS* are stored into the double word in memory addressed by the EA.

If no reservation exists, the instruction completes without altering memory.

If the store is performed successfully, bits 0-2 of Condition Register Field 0 are set to 0b001, otherwise, they are set to 0b000. The SO bit of the XER is copied to to bit 4 of Condition Register Field 0.

The EA must be a multiple of eight. If it is not, either the system alignment exception handler is invoked or the results are boundedly undefined.

Note that, when used correctly, the load and reserve and store conditional instructions can provide an atomic update function for a single aligned word (load word and reserve and store word conditional) or double word (load double word and reserve and store double word conditional) of memory.

In general, correct use requires that load word and reserve be paired with store word conditional, and load double word and reserve with store double word conditional, with the same memory address specified by both instructions of the pair. The only exception is that an unpaired store word conditional or store double word conditional instruction to any (scratch) EA can be used to clear any reservation held by the processor.

A reservation is cleared if any of the following events occurs:

- The processor holding the reservation executes another load and reserve instruction; this clears the first reservation and establishes a new one.
- The processor holding the reservation executes a store conditional instruction to any address.
- Another processor executes any store instruction to the address associated with the reservation
- Any mechanism, other than the processor holding the reservation, stores to the address associated with the reservation.

Parameters

RS Specifies source general-purpose register of stored data.
RA Specifies source general-purpose register for EA calculation.
RB Specifies source general-purpose register for EA calculation.

Implementation

This instruction is defined only for 64-bit implementations. Using it on a 32-bit implementation will cause the system illegal instruction error handler to be invoked.

stdu (Store Double Word with Update) Instruction

Purpose

Store a double-word of data from a general purpose register into a specified memory location. Update the address base.

This instruction should only be used on 64-bit PowerPC processors running a 64-bit application.

Syntax

Bits	Value
0-5	62
6-10	S
11-15	A
16-29	ds
30-31	01

PowerPC64
stdu *RS*, *D* (*RA*)

Description

The **stdu** instruction stores a double-word in storage from the source general-purpose register (GPR) *RS* into the specified location in memory referenced by the effective address (EA).

If GPR *RA* is not 0, the EA is the sum of the contents of GPR *RA* and *D*, a 16-bit, signed two's complement integer, fullword-aligned, sign-extended to 64 bits. GRP *RA* is updated with the EA.

If GPR *RA* = 0, the instruction form is invalid.

Parameters

RS Specifies the source general-purpose register containing data.
D Specifies a 16-bit, signed two's complement integer sign-extended to 32 bits for EA calculation.
RA Specifies source general-purpose register for EA calculation.

Implementation

This instruction is defined only for 64-bit implementations. Using it on a 32-bit implementation will cause the system illegal instruction error handler to be invoked.

Related Information

Fixed-Point Processor .

Fixed-Point Load and Store with Update Instructions .

stdux (Store Double Word with Update Indexed) Instruction

Purpose

Store a double-word of data from a general purpose register into a specified memory location. Update the address base.

Syntax

Bits	Value
0-5	31
6-10	S
11-15	A
16-20	B
21-30	181
31	0

POWER family
stdux *RS*, *RA*, *RB*

Description

The **stdux** instruction stores a double-word in storage from the source general-purpose register (GPR) *RS* into the location in storage specified by the effective address (EA).

The EA is the sum of the contents of GPR *RA* and *RB*. GRP *RA* is updated with the EA.

If rA = 0, the instruction form is invalid.

Parameters

RS Specifies the source general-purpose register containing data.
RA Specifies source general-purpose register for EA calculation.
RB Specifies source general-purpose register for EA calculation.

Implementation

This instruction is defined only for 64-bit implementations. Using it on a 32-bit implementation will cause the system illegal instruction error handler to be invoked.

stdx (Store Double Word Indexed) Instruction

Purpose

Store a double-word of data from a general purpose register into a specified memory location.

Syntax

Bits	Value
0-5	31
6-10	S

Bits	Value
11-15	A
16-20	B
21-30	149
31	0

POWER family
stdx *RS*, *RA*, *RB*

Description

The **stdx** instruction stores a double-word in storage from the source general-purpose register (GPR) *RS* into the location in storage specified by the effective address (EA).

If GPR *RA* is not 0, the EA is the sum of the contents of GPR *RA* and *RB*. If GPR *RA* is 0, then the EA is *RB*.

Parameters

RS Specifies the source general-purpose register containing data.
RA Specifies source general-purpose register for EA calculation.
RB Specifies source general-purpose register for EA calculation.

Implementation

This instruction is defined only for 64-bit implementations. Using it on a 32-bit implementation will cause the system illegal instruction error handler to be invoked.

---

stfd (Store Floating-Point Double) Instruction

Purpose

Stores a doubleword of data in a specified location in memory.

Syntax

Bits	Value
0-5	54
6-10	FRS
11-15	RA
16-31	D

stfd *FRS*, *D*(*RA*)

Description

The **stfd** instruction stores the contents of floating-point register (FPR) *FRS* into the doubleword storage addressed by the effective address (EA).

If general-purpose register (GPR) *RA* is not 0, the EA is the sum of the contents of GPR *RA* and *D*. The sum is a 16-bit signed two's complement integer sign-extended to 32 bits. If GPR *RA* is 0, then the EA is *D*.

The **stfd** instruction has one syntax form and does not affect the Floating-Point Status and Control Register or Condition Register Field 0.

Parameters

FRS Specifies source floating-point register of stored data.
D Specifies a16-bit signed two's complement integer sign-extended to 32 bits for EA calculation.
RA Specifies source general-purpose register for EA calculation.

Examples

The following code stores the contents of FPR 6 into a location in memory:

```
.csect data[rw]
buffer: .long 0,0
# Assume FPR 6 contains 0x4865 6C6C 6F20 776F.
# Assume GPR 4 contains the address of csect data[rw].
.csect text[pr]
stfd 6,buffer(4)
# buffer now contains 0x4865 6C6C 6F20 776F.
```

Related Reading

Floating-Point Processor .

Floating-Point Load and Store Instructions .

---

stfdu (Store Floating-Point Double with Update) Instruction

Purpose

Stores a doubleword of data in a specified location in memory and in some cases places the address in a general-purpose register.

Syntax

Bits	Value
0-5	55
6-10	FRS
11-15	RA
16-31	D

stfdu *FRS*, *D*(*RA*)

Description

The **stfdu** instruction stores the contents of floating-point register (FPR) *FRS* into the doubleword storage addressed by the effective address (EA).

If general-purpose register (GPR) *RA* is not 0, the EA is the sum of the contents of GPR *RA* and *D*. The sum is a 16-bit signed two's complement integer sign-extended to 32 bits. If GPR *RA* is 0, then the EA is *D*.

If GPR *RA* does not equal 0 and the storage access does not cause Alignment Interrupt or a Data Storage Interrupt, then the EA is stored in GPR *RA*.

The **stfdu** instruction has one syntax form and does not affect the Floating-Point Status and Control Register or Condition Register Field 0.

Parameters

FRS Specifies source floating-point register of stored data.
D Specifies a 16-bit signed two's complement integer sign-extended to 32 bits for EA calculation.
RA Specifies source general-purpose register for EA calculation and possible address update.

Examples

The following code stores the doubleword contents of FPR 6 into a location in memory and stores the address in GPR 4:

```
.csect data[rw]
buffer: .long 0,0
# Assume FPR 6 contains 0x4865 6C6C 6F20 776F.
# GPR 4 contains the address of csect data[rw].
.csect text[pr]
stfdu 6,buffer(4)
# buffer now contains 0x4865 6C6C 6F20 776F.
# GPR 4 now contains the address of buffer.
```

Related Information

Floating-Point Processor .

Floating-Point Load and Store Instructions .

stfdux (Store Floating-Point Double with Update Indexed) Instruction

Purpose

Stores a doubleword of data in a specified location in memory and in some cases places the address in a general-purpose register.

Syntax

Bits	Value
0-5	31
6-10	FRS
11-15	RA
16-20	RB
21-30	759
31	/

stfdux *FRS*, *RA*, *RB*

Description

The **stfdux** instruction stores the contents of floating-point register (FPR) *FRS* into the doubleword storage addressed by the effective address (EA).

If general-purpose register (GPR) *RA* is not 0, the EA is the sum of the contents of GPRs *RA* and *RB*. If GPR *RA* is 0, then the EA is the contents of GPR *RB*.

If GPR *RA* does not equal 0 and the storage access does not cause Alignment Interrupt or a Data Storage Interrupt, then the EA is stored in GPR *RA*.

The **stfdux** instruction has one syntax form and does not affect the Floating-Point Status and Control Register or Condition Register Field 0.

Parameters

FRS Specifies source floating-point register of stored data.
RA Specifies source general-purpose register for EA calculation and possible address update.
RB Specifies source general-purpose register for EA calculation.

Examples

The following code stores the contents of FPR 6 into a location in memory and stores the address in GPR 4:

```
.csect data[rw]
buffer: .long 0,0,0,0
# Assume FPR 6 contains 0x9000 3000 9000 3000.
# Assume GPR 4 contains 0x0000 0008.
# Assume GPR 5 contains the address of buffer.
.csect text[pr]
stfdux 6,4,5
# buffer+8 now contains 0x9000 3000 9000 3000.
# GPR 4 now contains the address of buffer+8.
```

Related Information

Floating-Point Processor .

Floating-Point Load and Store Instructions .

---

stfdx (Store Floating-Point Double Indexed) Instruction

Purpose

Stores a doubleword of data in a specified location in memory.

Syntax

Bits	Value
0-5	31
6-10	FRS
11-15	RA
16-20	RB
21-30	727
31	/

stfdx *FRS*, *RA*, *RB*

Description

The **stfdx** instruction stores the contents of floating-point register (FPR) *FRS* into the doubleword storage addressed by the effective address (EA).

If general-purpose register (GPR) *RA* is not 0, the EA is the sum of the contents of GPRs *RA* and *RB*. If GPR *RA* is 0, then the EA is the contents of GPR *RB*.

The **stfdx** instruction has one syntax form and does not affect the Floating-Point Status and Control Register or Condition Register Field 0.

Parameters

FRS Specifies source floating-point register of stored data.
RA Specifies source general-purpose register for EA calculation.
RB Specifies source general-purpose register for EA calculation.

Examples

The following code stores the contents of FPR 6 into a location in memory addressed by GPR 5 and GPR 4:

```
.csect data[rw]
buffer: .long 0,0,0,0
# Assume FPR 6 contains 0x4865 6C6C 6F20 776F.
# Assume GPR 4 contains 0x0000 0008.
# Assume GPR 5 contains the address of buffer.
.csect text[pr]
stfdx 6,4,5
# 0x4865 6C6C 6F20 776F is now stored at the
# address buffer+8.
```

Related Information

Floating-Point Processor .

Floating-Point Load and Store Instructions .

---

stfiwx (Store Floating-Point as Integer Word Indexed)

Purpose

Stores the low-order 32 bits from a specified floating point register in a specified word location in memory.

> **Note:** The **stfiwx** instruction is defined only in the PowerPC architecture and is an optional instruction. It is supported on the PowerPC 603 RISC Microprocessor and the PowerPC 604 RISC Microprocessor, but not on the PowerPC 601 RISC Microprocessor.

Syntax

Bits	Value
0-5	31
6-10	FRS
11-15	RA

Bits	Value
16-20	RB
21-30	983
31	/

stfiwx *FRS*, *RA*, *RB*

Description

The **stfifx** instruction stores the contents of the low-order 32 bits of floating-point register (FPR) *FRS*,without conversion, into the word storage addressed by the effective address (EA).

If general-purpose register (GPR) *RA* is not 0, the EA is the sum of the contents of GPRs *RA* and *RB*. If GPR *RA* is 0, then the EA is the contents of GPR *RB*.

The **stfiwx** instruction has one syntax form and does not affect the Floating-Point Status and Control Register or Condition Register Field 0.

If the contents of register *FRS* was produced, either directly or indirectly by a Load Floating Point Single Instruction, a single-precision arithmetic instruction, or the **frsp** (Floating Round to Single Precision) instruction, then the value stored is undefined. (The contents of *FRS* is produced directly by such an instruction if FRS is the target register of such an instruction. The contents of register *FRS* is produced indirectly by such an instruction if *FRS* is the final target register of a sequence of one or more Floating Point Move Instructions, and the input of the sequence was produced directly by such an instruction.)

Parameters

FRS Specifies source floating-point register of stored data.
RA Specifies source general-purpose register for EA calculation.
RB Specifies source general-purpose register for EA calculation.

Examples

The following code stores the contents of FPR 6 into a location in memory addressed by GPR 5 and GPR 4:

```
.csect data[rw]
buffer: .long 0,0,0,0
# Assume FPR 6 contains 0x4865 6C6C 6F20 776F.
# Assume GPR 4 contains 0x0000 0008.
# Assume GPR 5 contains the address of buffer.
.csect text[pr]
stfiwx 6,4,5
# 6F20 776F is now stored at the
# address buffer+8.
```

Related Information

Floating-Point Processor .

Floating-Point Load and Store Instructions .

stfq (Store Floating-Point Quad) Instruction

Purpose

Stores in memory two double-precision values at two consecutive doubleword locations.

> **Note:** The **stfq** instruction is supported only in the POWER2 implementation of the POWER family architecture.

Syntax

Bits	Value
0-5	60
6-10	FRS
11-15	RA
16-29	DS
30-31	00

POWER2
stfq *FRS*, *DS(RA)*

Description

The **stfq** instruction stores in memory the contents of two consecutive floating-point registers (FPR) at the location specified by the effective address (EA).

DS is sign-extended to 30 bits and concatenated on the right with b'00' to form the offset value. If general-purpose register (GPR) *RA* is 0, the offset value is the EA. If GPR *RA* is not 0, the offset value is added to GPR *RA* to generate the EA. The contents of FPR *FRS* is stored into the doubleword of storage at the EA. If FPR *FRS* is 31, then the contents of FPR 0 is stored into the doubleword at EA+8; otherwise, the contents of *FRS*+1 are stored into the doubleword at EA+8.

The **stfq** instruction has one syntax form and does not affect the Floating-Point Status and Control Register or Condition Register Field 0.

Parameters

FRS Specifies the first of two floating-point registers that contain the values to be stored.
DS Specifies a 14-bit field used as an immediate value for the EA calculation.
RA Specifies one source general-purpose register for the EA calculation.

Related Information

The **lfqux** (Load Floating-Point Quad with Update Indexed) instruction.

Floating-Point Processor .

Floating-Point Load and Store Instructions .

stfqu (Store Floating-Point Quad with Update) Instruction

Purpose

Stores in memory two double-precision values at two consecutive doubleword locations and updates the address base.

> **Note:** The **stfqu** instruction is supported only in the POWER2 implementation of the POWER family architecture.

Syntax

Bits	Value
0-5	61
6-10	FRS
11-15	RA
16-29	DS
30-31	01

POWER2
stfqu *FRS*, *DS(RA)*

Description

The **stfqu** instruction stores in memory the contents of two consecutive floating-point registers (FPR) at the location specified by the effective address (EA).

DS is sign-extended to 30 bits and concatenated on the right with b'00' to form the offset value. If general-purpose register (GPR) *RA* is 0, the offset value is the EA. If GPR *RA* is not 0, the offset value is added to GPR *RA* to generate the EA. The contents of FPR *FRS* is stored into the doubleword of storage at the EA. If FPR *FRS* is 31, then the contents of FPR 0 is stored into the doubleword at EA+8; otherwise, the contents of *FRS*+1 is stored into the doubleword at EA+8.

If GPR *RA* is not 0, the EA is placed into GPR *RA*.

The **stfqu** instruction has one syntax form and does not affect the Floating-Point Status and Control Register or Condition Register Field 0.

Parameters

FRS Specifies the first of two floating-point registers that contain the values to be stored.
DS Specifies a 14-bit field used as an immediate value for the EA calculation.
RA Specifies one source general-purpose register for the EA calculation and the target register for the EA update.

Related Information

The **lfqux** (Load Floating-Point Quad with Update Indexed) instruction.

Floating-Point Processor .

Floating-Point Load and Store Instructions .

stfqux (Store Floating-Point Quad with Update Indexed) Instruction

Purpose

Stores in memory two double-precision values at two consecutive doubleword locations and updates the address base.

Note: The **stfqux** instruction is supported only in the POWER2 implementation of the POWER family architecture.

Syntax

Bits	Value
0-5	31
6-10	FRS
11-15	RA
16-20	RB
21-30	951
31	Rc

POWER2
stfqux *FRS*, *RA*, *RB*

Description

The **stfqux** instruction stores in memory the contents of two consecutive floating-point registers (FPR) at the location specified by the effective address (EA).

If general-purpose register (GPR) *RA* is not 0, the EA is the sum of the contents of GPR *RA* and GPR *RB*. If GPR *RA* is 0, the EA is the contents of GPR *RB*. The contents of FPR *FRS* is stored into the doubleword of storage at the EA. If FPR *FRS* is 31, then the contents of FPR 0 is stored into the doubleword at EA+8; otherwise, the contents of *FRS*+1 is stored into the doubleword at EA+8.

If GPR *RA* is not 0, the EA is placed into GPR *RA*.

The **stfqux** instruction has one syntax form and does not affect the Floating-Point Status and Control Register or Condition Register Field 0.

Parameters

FRS Specifies the first of two floating-point registers that contain the values to be stored.
RA Specifies the first source general-purpose register for the EA calculation and the target register for the EA update.
RB Specifies the second source general-purpose register for the EA calculation.

Related Information

The **lfqux** (Load Floating-Point Quad with Update Indexed) instruction.

Floating-Point Processor .

Floating-Point Load and Store Instructions .

stfqx (Store Floating-Point Quad Indexed) Instruction

Purpose

Stores in memory two double-precision values at two consecutive doubleword locations.

> **Note:** The **stfqx** instruction is supported only in the POWER2 implementation of the POWER family architecture.

Syntax

Bits	Value
0-5	31
6-10	FRS
11-15	RA
16-20	RB
21-30	919
31	Rc

POWER2
stfqx *FRS*, *RA*, *RB*

Description

The **stfqx** instruction stores in memory the contents of floating-point register (FPR) *FRS* at the location specified by the effective address (EA).

If general-purpose register (GPR) *RA* is not 0, the EA is the sum of the contents of GPR *RA* and GPR *RB*. If GPR *RA* is 0, the EA is the contents of GPR *RB*. The contents of FPR *FRS* is stored into the doubleword of storage at the EA. If FPR *FRS* is 31, then the contents of FPR 0 is stored into the doubleword at EA+8; otherwise, the contents of *FRS*+1 is stored into the doubleword at EA+8.

The **stfqx** instruction has one syntax form and does not affect the Floating-Point Status and Control Register or Condition Register Field 0.

Parameters

FRS Specifies the first of two floating-point registers that contain the values to be stored.
RA Specifies one source general-purpose register for the EA calculation.
RB Specifies the second source general-purpose register for the EA calculation.

Related Information

The **lfqux** (Load Floating-Point Quad with Update Indexed) instruction.

Floating-Point Processor .

Floating-Point Load and Store Instructions .

stfs (Store Floating-Point Single) Instruction

Purpose

Stores a word of data from a floating-point register into a specified location in memory.

Syntax

Bits	Value
0-5	52
6-10	FRS
11-15	RA
16-31	D

stfs *FRS*, *D*(*RA*)

Description

The **stfs** instruction converts the contents of floating-point register (FPR) *FRS* to single-precision and stores the result into the word of storage addressed by the effective address (EA).

If general-purpose register (GPR) *RA* is not 0, the EA is the sum of the contents of GPR *RA* and *D*, a 16-bit signed two's complement integer sign-extended to 32 bits. If GPR *RA* is 0, then the EA is *D*.

The **stfs** instruction has one syntax form and does not affect the Floating-Point Status and Control Register or Condition Register Field 0.

Parameters

FRS Specifies floating-point register of stored data.
D Specifies a 16-bit, signed two's complement integer sign-extended to 32 bits for EA calculation.
RA Specifies source general-purpose register for EA calculation.

Examples

The following code stores the single-precision contents of FPR 6 into a location in memory:

```
.csect data[rw]
buffer: .long 0
# Assume FPR 6 contains 0x4865 6C6C 6F20 776F.
# Assume GPR 4 contains the address of csect data[rw].
.csect text[pr]
stfs 6,buffer(4)
# buffer now contains 0x432B 6363.
```

Related Information

Floating-Point Processor .

Floating-Point Load and Store Instructions .

stfsu (Store Floating-Point Single with Update) Instruction

Purpose

Stores a word of data from a floating-point register into a specified location in memory and possibly places the address in a general-purpose register.

Syntax

Bits	Value
0-5	53
6-10	FRS
11-15	RA
16-31	D

stfsu *FRS*, *D*(*RA*)

Description

The **stfsu** instruction converts the contents of floating-point register (FPR) *FRS* to single-precision and stores the result into the word of storage addressed by the effective address (EA).

If general-purpose register (GPR) *RA* is not 0, the EA is the sum of the contents of GPR *RA* and *D*, a 16-bit signed two's complement integer sign-extended to 32 bits. If GPR *RA* is 0, then the EA is *D*.

If GPR *RA* does not equal 0 and the storage access does not cause Alignment Interrupt or Data Storage Interrupt, then the EA is stored in GPR *RA*.

The **stfsu** instruction has one syntax form and does not affect the Floating-Point Status and Control Register or Condition Register Field 0.

Parameters

FRS Specifies floating-point register of stored data.
D Specifies a 16-bit, signed two's complement integer sign-extended to 32 bits for EA calculation.
RA Specifies source general-purpose register for EA calculation and possible address update.

Examples

The following code stores the single-precision contents of FPR 6 into a location in memory and stores the address in GPR 4:

```
.csect data[rw]
buffer: .long 0
# Assume FPR 6 contains 0x4865 6C6C 6F20 776F.
# Assume GPR 4 contains the address of csect data[rw].
.csect text[pr]
stfsu 6,buffer(4)
# GPR 4 now contains the address of buffer.
# buffer now contains 0x432B 6363.
```

Related Information

Floating-Point Processor .

Floating-Point Load and Store Instructions .

stfsux (Store Floating-Point Single with Update Indexed) Instruction

Purpose

Stores a word of data from a floating-point register into a specified location in memory and possibly places the address in a general-purpose register.

Syntax

Bits	Value
0-5	31
6-10	FRS
11-15	RA
16-20	RB
21-30	695
31	/

stfsux *FRS*, *RA*, *RB*

Description

The **stfsux** instruction converts the contents of floating-point register (FPR) *FRS* to single-precision and stores the result into the word of storage addressed by the effective address (EA).

If general-purpose register (GPR) *RA* is not 0, the EA is the sum of the contents of GPR *RA* and GPR *RB*. If GPR *RA* is 0, then the EA is the contents of GPR *RB*.

If GPR *RA* does not equal 0 and the storage access does not cause Alignment Interrupt or Data Storage Interrupt, then the EA is stored in GPR *RA*.

The **stfsux** instruction has one syntax form and does not affect the Floating-Point Status and Control Register or Condition Register Field 0.

Parameters

FRS Specifies floating-point register of stored data.
RA Specifies source general-purpose register for EA calculation and possible address update.
RB Specifies source general-purpose register for EA calculation.

Examples

The following code stores the single-precision contents of FPR 6 into a location in memory and stores the address in GPR 5:

```
.csect data[rw]
buffer: .long 0,0,0,0
# Assume GPR 4 contains 0x0000 0008.
# Assume GPR 5 contains the address of buffer.
```

```
# Assume FPR 6 contains 0x4865 6C6C 6F20 776F.
.csect text[pr]
stfsux 6,5,4
# GPR 5 now contains the address of buffer+8.
# buffer+8 contains 0x432B 6363.
```

Related Information

Floating-Point Processor .

Floating-Point Load and Store Instructions .

---

stfsx (Store Floating-Point Single Indexed) Instruction

Purpose

Stores a word of data from a floating-point register into a specified location in memory.

Syntax

Bits	Value
0-5	31
6-10	FRS
11-15	RA
16-20	RB
21-30	663
31	/

stfsx *FRS*, *RA*, *RB*

Description

The **stfsx** instruction converts the contents of floating-point register (FPR) *FRS* to single-precision and stores the result into the word of storage addressed by the effective address (EA).

If general-purpose register (GPR) *RA* is not 0, the EA is the sum of the contents of GPR *RA* and GPR *RB*. If GPR *RA* is 0, then the EA is the contents of GPR *RB*.

The **stfsx** instruction has one syntax form and does not affect the Floating-Point Status and Control Register or Condition Register Field 0.

Parameters

FRS Specifies source floating-point register of stored data.
RA Specifies source general-purpose register for EA calculation.
RB Specifies source general-purpose register for EA calculation.

Examples

The following code stores the single-precision contents of FPR 6 into a location in memory:

```
.csect data[rw]
buffer: .long 0
# Assume FPR 6 contains 0x4865 6C6C 6F20 776F.
```

```
# Assume GPR 4 contains the address of buffer.
.csect text[pr]
stfsx 6,0,4
# buffer now contains 0x432B 6363.
```

Related Information

Floating-Point Processor .

Floating-Point Load and Store Instructions .

---

sth (Store Half) Instruction

Purpose

Stores a halfword of data from a general-purpose register into a specified location in memory.

Syntax

Bits	Value
0-5	44
6-10	RS
11-15	RA
16-31	D

sth *RS*, *D*(*RA*)

Description

The **sth** instruction stores bits 16-31 of general-purpose register (GPR) *RS* into the halfword of storage addressed by the effective address (EA).

If GPR *RA* is not 0, the EA is the sum of the contents of GPR *RA* and *D*, a 16-bit signed two's complement integer sign-extended to 32 bits. If GPR *RA* is 0, then the EA is *D*.

The **sth** instruction has one syntax form and does not affect the Fixed-Point Exception Register or Condition Register Field 0.

Parameters

RS Specifies source general-purpose register of stored data.
D Specifies a16-bit signed two's complement integer sign-extended to 32 bits for EA calculation.
RA Specifies source general-purpose register for EA calculation.

Examples

The following code stores bits 16-31 of GPR 6 into a location in memory:

```
.csect data[rw]
buffer: .long 0
# Assume GPR 4 contains the address of csect data[rw].
# Assume GPR 6 contains 0x9000 3000.
.csect text[pr]
sth 6,buffer(4)
# buffer now contains 0x3000.
```

Related Information

Floating-Point Processor .

Floating-Point Load and Store Instructions .

---

sthbrx (Store Half Byte-Reverse Indexed) Instruction

Purpose

Stores a halfword of data from a general-purpose register into a specified location in memory with the two bytes reversed.

Syntax

Bits	Value
0-5	31
6-10	RS
11-15	RA
16-20	RB
21-30	918
31	/

sthbrx *RS*, *RA*, *RB*

Description

The **sthbrx** instruction stores bits 16-31 of general-purpose register (GPR) *RS* into the halfword of storage addressed by the effective address (EA).

Consider the following when using the **sthbrx** instruction:

- Bits 24-31 of GPR *RS* are stored into bits 00-07 of the halfword in storage addressed by EA.
- Bits 16-23 of GPR *RS* are stored into bits 08-15 of the word in storage addressed by EA.

If GPR *RA* is not 0, the EA is the sum of the contents of GPR *RA* and GPR *RB*. If GPR *RA* is 0, then the EA is the contents of GPR *RB*.

The **sthbrx** instruction has one syntax form and does not affect the Fixed-Point Exception Register or Condition Register Field 0.

Parameters

RS Specifies source general-purpose register of stored data.
RA Specifies source general-purpose register for EA calculation.
RB Specifies source general-purpose register for EA calculation.

Examples

The following code stores the halfword contents of GPR 6 with the bytes reversed into a location in memory:

```
.csect data[rw]
buffer: .long 0
# Assume GPR 6 contains 0x9000 3456.
# Assume GPR 4 contains the address of buffer.
.csect text[pr]
sthbrx 6,0,4
# buffer now contains 0x5634.
```

Related Information

Floating-Point Processor .

Floating-Point Load and Store Instructions .

---

sthu (Store Half with Update) Instruction

Purpose

Stores a halfword of data from a general-purpose register into a specified location in memory and possibly places the address in another general-purpose register.

Syntax

Bits	Value
0-5	45
6-10	RS
11-15	RA
16-31	D

sthu *RS*, *D*(*RA*)

Description

The **sthu** instruction stores bits 16-31 of general-purpose register (GPR) *RS* into the halfword of storage addressed by the effective address (EA).

If GPR *RA* is not 0, the EA is the sum of the contents of GPR *RA* and *D*, a 16-bit signed two's complement integer sign-extended to 32 bits. If GPR *RA* is 0, then the EA is *D*.

If GPR *RA* does not equal 0 and the storage access does not cause an Alignment Interrupt or a Data Storage Interrupt, then the EA is placed into GPR *RA*.

The **sthu** instruction has one syntax form and does not affect the Fixed-Point Exception Register or Condition Register Field 0.

Parameters

RS Specifies source general-purpose register of stored data.
D Specifies a16-bit signed two's complement integer sign-extended to 32 bits for EA calculation.
RA Specifies source general-purpose register for EA calculation and possible address update.

Examples

The following code stores the halfword contents of GPR 6 into a memory location and stores the address in GPR 4:

```
.csect data[rw]
buffer: .long 0
# Assume GPR 6 contains 0x9000 3456.
# Assume GPR 4 contains the address of csect data[rw].
.csect text[pr]
sthu 6,buffer(4)
# buffer now contains 0x3456
# GPR 4 contains the address of buffer.
```

Related Information

Fixed-Point Processor .

Fixed-Point Load and Store with Update Instructions .

---

sthux (Store Half with Update Indexed) Instruction

Purpose

Stores a halfword of data from a general-purpose register into a specified location in memory and possibly places the address in another general-purpose register.

Syntax

Bits	Value
0-5	31
6-10	RS
11-15	RA
16-20	RB
21-30	439
31	/

sthux *RS*, *RA*, *RB*

Description

The **sthux** instruction stores bits 16-31 of general-purpose register (GPR) *RS* into the halfword of storage addressed by the effective address (EA).

If GPR *RA* is not 0, the EA is the sum of the contents of GPR *RA* and GPR *RB*. If GPR *RA* is 0, then the EA is the contents of GPR *RB*.

If GPR *RA* does not equal 0 and the storage access does not cause an Alignment Interrupt or a Data Storage Interrupt, then the EA is placed into register GPR *RA*.

The **sthux** instruction has one syntax form and does not affect the Fixed-Point Exception Register or Condition Register Field 0.

Parameters

RS Specifies source general-purpose register of stored data.
RA Specifies source general-purpose register for EA calculation and possible address update.
RB Specifies source general-purpose register for EA calculation.

Examples

The following code stores the halfword contents of GPR 6 into a memory location and stores the address in GPR 4:

```
.csect data[rw]
buffer: .long 0,0,0,0
# Assume GPR 6 contains 0x9000 3456.
# Assume GPR 4 contains 0x0000 0007.
# Assume GPR 5 contains the address of buffer.
.csect text[pr]
sthux 6,4,5
# buffer+0x07 contains 0x3456.
# GPR 4 contains the address of buffer+0x07.
```

Related Information

Fixed-Point Processor .

Fixed-Point Load and Store with Update Instructions .

---

sthx (Store Half Indexed) Instruction

Purpose

Stores a halfword of data from a general-purpose register into a specified location in memory.

Syntax

Bits	Value
0-5	31
6-10	RS
11-15	RA
16-20	RB
21-30	407
31	/

sthx *RS*, *RA*, *RB*

Description

The **sthx** instruction stores bits 16-31 of general-purpose register (GPR) *RS* into the halfword of storage addressed by the effective address (EA).

If GPR *RA* is not 0, the EA is the sum of the contents of GPR *RA* and GPR *RB*. If GPR *RA* is 0, then the EA is the contents of GPR *RB*.

The **sthx** instruction has one syntax form and does not affect the Fixed-Point Exception Register or Condition Register Field 0.

Parameters

RS Specifies source general-purpose register of stored data.
RA Specifies source general-purpose register for EA calculation.
RB Specifies source general-purpose register for EA calculation.

Examples

The following code stores halfword contents of GPR 6 into a location in memory:

```
.csect data[rw]
buffer: .long 0
# Assume GPR 6 contains 0x9000 3456.
# Assume GPR 5 contains the address of buffer.
.csect text[pr]
sthx 6,0,5
# buffer now contains 0x3456.
```

Related Information

Fixed-Point Processor .

Fixed-Point Load and Store Instructions .

---

stmw or stm (Store Multiple Word) Instruction

Purpose

Stores the contents of consecutive registers into a specified memory location.

Syntax

Bits	Value
0-5	47
6-10	RT
11-15	RA
16-31	D

PowerPC
stmw *RS*, *D*(*RA*)

POWER family
stm *RS*, *D*(*RA*)

Description

The **stmw** and **stm** instructions store *N* consecutive words from general-purpose register (GPR) *RS* through GPR 31. Storage starts at the effective address (EA). *N* is a register number equal to 32 minus *RS*.

If GPR *RA* is not 0, the EA is the sum of the contents of GPR *RA* and *D*. The sum is a 16-bit signed two's complement integer sign-extended to 32 bits. If GPR *RA* is 0, then the EA is *D*.

The **stmw** instruction has one syntax form. If the EA is not a multiple of 4, the results are boundedly undefined.

The **stm** instruction has one syntax form and does not affect the Fixed-Point Exception Register or Condition Register Field 0.

Parameters

RS Specifies source general-purpose register of stored data.
D Specifies a 16-bit signed two's complement integer sign-extended to 32 bits for EA calculation.
RA Specifies source general-purpose register for EA calculation.

Examples

The following code stores the contents of GPR 29 through GPR 31 into a location in memory:

```
.csect data[rw]
buffer: .long 0,0,0
# Assume GPR 29 contains 0x1000 2200.
# Assume GPR 30 contains 0x1000 3300.
# Assume GPR 31 contains 0x1000 4400.
.csect text[pr]
stmw 29,buffer(4)
# Three consecutive words in storage beginning at the address
# of buffer are now 0x1000 2200 1000 3300 1000 4400.
```

Related Information

Fixed-Point Processor .

Fixed-Point Load and Store Instructions .

stq (Store Quad Word) Instruction

Purpose

Store a quad-word of data from a general purpose register into a specified memory location.

Syntax

Bits	Value
0-5	62
6-10	RS
11-15	RA
16-29	DS
30-31	2

PowerPC 64

stq *"RS" on page 422*, *"DS" on page 422*(*"RA" on page 422*)

Description

The **stq** instruction stores a quad-word in storage from the source general-purpose registers (GPR) *RS* and *RS+1* into the specified location in memory referenced by the effective address (EA).

If GPR *RA* is not 0, the EA is the sum of the contents of GPR *RA* and *DS*, a 14-bit, signed two's complement integer, which is concatenated on the right by 0b00 and sign extended to 64-bits. If GPR *RA* is 0, then the EA is *DS*.

Parameters

RS Specifies the source general-purpose register containing data. If *RS* is odd, the instruction form is invalid.
DS Specifies a 14-bit, signed two's complement integer which is concatenated on the right with 0b00 and sign-extended to 64 bits for EA calculation.
RA Specifies source general-purpose register for EA calculation.

Implementation

This instruction is defined only for 64-bit implementations. Using it on a 32-bit implementation will cause the system illegal instruction error handler to be invoked.

Related Information

"Fixed-Point Processor" on page 19.

"Fixed-Point Load and Store Instructions" on page 19.

stswi or stsi (Store String Word Immediate) Instruction

Purpose

Stores consecutive bytes from consecutive registers into a specified location in memory.

Syntax

Bits	Value
0-5	31
6-10	RS
11-15	RA
16-20	NB
21-30	725
31	/

PowerPC
stswi *RS*, *RA*, *NB*

POWER family
stsi *RS*, *RA*, *NB*

Description

The **stswi** and **stsi** instructions store *N* consecutive bytes starting with the leftmost byte in general-purpose register (GPR) *RS* at the effective address (EA) from GPR *RS* through GPR *RS* + *NR* - 1.

If GPR *RA* is not 0, the EA is the contents of GPR *RA*. If *RA* is 0, then the EA is 0.

Consider the following when using the **stswi** and **stsi** instructions:

- *NB* is the byte count.
- *RS* is the starting register.
- *N* is *NB*, which is the number of bytes to store. If *NB* is 0, then *N* is 32.

- *NR* is ceiling(N/4), which is the number of registers to store data from.

For the POWER family instruction **stsi**, the contents of the MQ Register are undefined.

The **stswi** and **stsi** instructions have one syntax form and do not affect the Fixed-Point Exception Register or Condition Register Field 0.

Parameters

RS Specifies source general-purpose register of stored data.
RA Specifies source general-purpose register for EA calculation.
NB Specifies byte count for EA calculation.

Examples

The following code stores the bytes contained in GPR 6 to GPR 8 into a location in memory:

```
.csect data[rw]
buffer: .long 0,0,0
# Assume GPR 4 contains the address of buffer.
# Assume GPR 6 contains 0x4865 6C6C.
# Assume GPR 7 contains 0x6F20 776F.
# Assume GPR 8 contains 0x726C 6421.
.csect text[pr]
stswi 6,4,12
# buffer now contains 0x4865 6C6C 6F20 776F 726C 6421.
```

Related Information

Fixed-Point Processor .

Fixed-Point String Instructions .

---

stswx or stsx (Store String Word Indexed) Instruction

Purpose

Stores consecutive bytes from consecutive registers into a specified location in memory.

Syntax

Bits	Value
0-5	31
6-10	RS
11-15	RA
16-20	RB
21-30	661
31	/

PowerPC
stswx *RS*, *RA*, *RB*

POWER family
stsx *RS*, *RA*, *RB*

Description

The **stswx** and **stsx** instructions store *N* consecutive bytes starting with the leftmost byte in register *RS* at the effective address (EA) from general-purpose register (GPR) *RS* through GPR *RS* + *NR* - 1.

If GPR *RA* is not 0, the EA is the sum of the contents of GPR *RA* and the contents of GPR *RB*. If GPR *RA* is 0, then EA is the contents of GPR *RB*.

Consider the following when using the **stswx** and **stsx** instructions:

- *XER25-31* contain the byte count.
- *RS* is the starting register.
- *N* is *XER25-31*, which is the number of bytes to store.
- *NR* is ceiling(N/4), which is the number of registers to store data from.

For the POWER family instruction **stsx**, the contents of the MQ Register are undefined.

The **stswx** and **stsx** instructions have one syntax form and do not affect the Fixed-Point Exception Register or Condition Register Field 0.

Parameters

RS Specifies source general-purpose register of stored data.
RA Specifies source general-purpose register for EA calculation.
RB Specifies source general-purpose register for EA calculation.

Examples

The following code stores the bytes contained in GPR 6 to GPR 7 into the specified bytes of a location in memory:

```
.csect data[rw]
buffer: .long 0,0,0
# Assume GPR 5 contains 0x0000 0007.
# Assume GPR 4 contains the address of buffer.
# Assume GPR 6 contains 0x4865 6C6C.
# Assume GPR 7 contains 0x6F20 776F.
# The Fixed-Point Exception Register bits 25-31 contain 6.
.csect text[pr]
stswx 6,4,5
# buffer+0x7 now contains 0x4865 6C6C 6F20.
```

Related Information

Fixed-Point Processor .

Fixed-Point String Instructions .

---

stw or st (Store) Instruction

Purpose

Stores a word of data from a general-purpose register into a specified location in memory.

Syntax

Bits	Value
0-5	36

Bits	Value
6-10	RS
11-15	RA
16-31	D

PowerPC
stw *RS*, *D*(*RA*)

POWER family
st *RS*, *D*(*RA*)

Description

The **stw** and **st** instructions store a word from general-purpose register (GPR) *RS* into a word of storage addressed by the effective address (EA).

If GPR *RA* is not 0, the EA is the sum of the contents of GPR *RA* and *D*, a 16-bit signed two's complement integer sign-extended to 32 bits. If GPR *RA* is 0, then the EA is *D*.

The **stw** and **st** instructions have one syntax form and do not affect the Fixed-Point Exception Register or Condition Register Field 0.

Parameters

RS Specifies source general-purpose register of stored data.
D Specifies a16-bit signed two's complement integer sign-extended to 32 bits for EA calculation.
RA Specifies source general-purpose register for EA calculation.

Examples

The following code stores the contents of GPR 6 into a location in memory:

```
.csect data[rw]
buffer: .long 0,0
# Assume GPR 6 contains 0x9000 3000.
# Assume GPR 5 contains the address of buffer.
.csect text[pr]
stw 6,4(5)
# 0x9000 3000 is now stored at the address buffer+4.
```

Related Information

Fixed-Point Processor .

Fixed-Point Load and Store Instructions .

stwbrx or stbrx (Store Word Byte-Reverse Indexed) Instruction

Purpose

Stores a byte-reversed word of data from a general-purpose register into a specified location in memory.

Syntax

Bits	Value
0-5	31
6-10	RS
11-15	RA
16-20	RB
21-30	662
31	/

PowerPC
stwbrx *RS*, *RA*, *RB*

POWER family
stbrx *RS*, *RA*, *RB*

Description

The **stwbrx** and **stbrx** instructions store a byte-reversed word from general-purpose register (GPR) *RS* into a word of storage addressed by the effective address (EA).

Consider the following when using the **stwbrx** and **stbrx** instructions:

- Bits 24-31 of GPR *RS* are stored into bits 00-07 of the word in storage addressed by EA.
- Bits 16-23 of GPR *RS* are stored into bits 08-15 of the word in storage addressed by EA.
- Bits 08-15 of GPR *RS* are stored into bits 16-23 of the word in storage addressed by EA.
- Bits 00-07 of GPR *RS* are stored into bits 24-31 of the word in storage addressed by EA.

If GPR *RA* is not 0, the EA is the sum of the contents of GPR *RA* and GPR *RB*. If GPR *RA* is 0, then the EA is the contents of GPR *RB*.

The **stwbrx** and **stbrx** instructions have one syntax form and do not affect the Fixed-Point Exception Register or Condition Register Field 0.

Parameters

RS Specifies source general-purpose register of stored data.
RA Specifies source general-purpose register for EA calculation.
RB Specifies source general-purpose register for EA calculation.

Examples

The following code stores a byte-reverse word from GPR 6 into a location in memory:

```
.csect data[rw]
buffer: .long 0
# Assume GPR 4 contains the address of buffer.
# Assume GPR 9 contains 0x0000 0000.
# Assume GPR 6 contains 0x1234 5678.
.csect text[pr]
stwbrx 6,4,9
# 0x7856 3412 is now stored at the address of buffer.
```

Related Information

Fixed-Point Processor .

Fixed-Point Load and Store Instructions .

---

stwcx. (Store Word Conditional Indexed) Instruction

Purpose

Used in conjunction with a preceding **lwarx** instruction to emulate a read-modify-write operation on a specified memory location.

Note: The **stwcx.** instruction is supported only in the PowerPC architecture.

Syntax

Bits	Value
0-5	31
6-10	RS
11-15	RA
16-20	RB
21-30	150
31	1

PowerPC
stwcx. *RS*, *RA*, *RB*

Description

The **stwcx.** and **lwarx** instructions are primitive, or simple, instructions used to perform a read-modify-write operation to storage. If the store is performed, the use of the **stwcx.** and **lwarx** instructions ensures that no other processor or mechanism has modified the target memory location between the time the **lwarx** instruction is executed and the time the **stwcx.** instruction completes.

Consider the following when using the **stwcx.** instruction:

- If general-purpose register (GPR) *RA* is 0, the effective address (EA) is the content of GPR *RB*, otherwise EA is the sum of the content of GPR *RA* plus the content of GPR *RB*.
- If the reservation created by a **lwarx** instruction exists, the content of GPR *RS* is stored into the word in storage and addressed by EA and the reservation is cleared. Otherwise, the storage is not altered.
- If the store is performed, bits 0-2 of Condition Register Field 0 are set to 0b001, otherwise, they are set to 0b000. The SO bit of the XER is copied to to bit 4 of Condition Register Field 0.

The **stwcx** instruction has one syntax form and does not affect the Fixed-Point Exception Register. If the EA is not a multiple of 4, the results are boundedly undefined.

Parameters

RS Specifies source general-purpose register of stored data.
RA Specifies source general-purpose register for EA calculation.
RB Specifies source general-purpose register for EA calculation.

Examples

1. The following code performs a ″Fetch and Store″ by atomically loading and replacing a word in storage:

```
# Assume that GPR 4 contains the new value to be stored.
# Assume that GPR 3 contains the address of the word
# to be loaded and replaced.
loop:   lwarx   r5,0,r3          # Load and reserve
        stwcx.  r4,0,r3          # Store new value if still
                                 # reserved
        bne-    loop             # Loop if lost reservation
# The new value is now in storage.
# The old value is returned to GPR 4.
```

2. The following code performs a ″Compare and Swap″ by atomically comparing a value in a register with a word in storage:

```
# Assume that GPR 5 contains the new value to be stored after
# a successful match.
# Assume that GPR 3 contains the address of the word
# to be tested.
# Assume that GPR 4 contains the value to be compared against
# the value in memory.
loop:   lwarxr  6,0,r3           # Load and reserve
        cmpw    r4,r6            # Are the first two operands
                                 # equal?
        bne-    exit             # Skip if not equal
        stwcx.  r5,0,r3          # Store new value if still
                                 # reserved
        bne-    loop             # Loop if lost reservation
exit:   mrr     4,r6             # Return value from storage
# The old value is returned to GPR 4.
# If a match was made, storage contains the new value.
```

   If the value in the register equals the word in storage, the value from a second register is stored in the word in storage. If they are unequal, the word from storage is loaded into the first register and the EQ bit of the Condition Register Field 0 is set to indicate the result of the comparison.

Related Information

The **lwarx** (Load Word and Reserve Indexed) instruction.

Processing and Storage

---

stwu or stu (Store Word with Update) Instruction

Purpose

Stores a word of data from a general-purpose register into a specified location in memory and possibly places the address in another general-purpose register.

Syntax

Bits	Value
0-5	37
6-10	RS
11-15	RA
16-31	D

PowerPC
stwu *RS*, *D*(*RA*)

POWER family
stu *RS*, *D*(*RA*)

Description

The **stwu** and **stu** instructions store the contents of general-purpose register (GPR) *RS* into the word of storage addressed by the effective address (EA).

If GPR *RA* is not 0, the EA is the sum of the contents of GPR *RA* and *D*, a 16-bit signed two's complement integer sign-extended to 32 bits. If GPR *RA* is 0, then the EA is *D*.

If GPR *RA* is not 0 and the storage access does not cause an Alignment Interrupt or a Data Storage Interrupt, then EA is placed into GPR *RA*.

The **stwu** and **stu** instructions have one syntax form and do not affect the Fixed-Point Exception Register or Condition Register Field 0.

Parameters

RS Specifies general-purpose register of stored data.
D Specifies16-bit signed two's complement integer sign-extended to 32 bits for EA calculation.
RA Specifies source general-purpose register for EA calculation and possible address update.

Examples

The following code stores the contents of GPR 6 into a location in memory:

```
.csect data[rw]
buffer: .long 0
# Assume GPR 4 contains the address of csect data[rw].
# Assume GPR 6 contains 0x9000 3000.
.csect text[pr]
stwu 6,buffer(4)
# buffer now contains 0x9000 3000.
# GPR 4 contains the address of buffer.
```

Related Information

Fixed-Point Processor .

Fixed-Point Load and Store with Update Instructions .

stwux or stux (Store Word with Update Indexed) Instruction

Purpose

Stores a word of data from a general-purpose register into a specified location in memory and possibly places the address in another general-purpose register.

Syntax

Bits	Value
0-5	31

Bits	Value
6-10	RS
11-15	RA
16-20	RB
212-30	183
31	/

PowerPC
stwux *RS*, *RA*, *RB*

POWER family
stux *RS*, *RA*, *RB*

Description

The **stwux** and **stux** instructions store the contents of general-purpose register (GPR) *RS* into the word of storage addressed by the effective address (EA).

If GPR *RA* is not 0, the EA is the sum of the contents of GPR *RA* and GPR *RB*. If GPR *RA* is 0, then the EA is the contents of GPR *RB*.

If GPR *RA* is not 0 and the storage access does not cause an Alignment Interrupt or a Data Storage Interrupt, then the EA is placed into GPR *RA*.

The **stwux** and **stux** instructions have one syntax form and do not affect the Fixed-Point Exception Register or Condition Register Field 0.

Parameters

RS Specifies source general-purpose register of stored data.
RA Specifies source general-purpose register for EA calculation and possible address update.
RB Specifies source general-purpose register for EA calculation.

Examples

The following code stores the contents of GPR 6 into a location in memory:

```
.csect data[rw]
buffer: .long 0,0
# Assume GPR 4 contains 0x0000 0004.
# Assume GPR 23 contains the address of buffer.
# Assume GPR 6 contains 0x9000 3000.
.csect text[pr]
stwux 6,4,23
# buffer+4 now contains 0x9000 3000.
# GPR 4 now contains the address of buffer+4.
```

Related Information

Fixed-Point Processor .

Fixed-Point Load and Store with Update Instructions .

stwx or stx (Store Word Indexed) Instruction

Purpose

Stores a word of data from a general-purpose register into a specified location in memory.

Syntax

Bits	Value
0-5	31
6-10	RS
11-15	RA
16-20	RB
21-30	151
31	/

PowerPC
stwx *RS*, *RA*, *RB*

POWER family
stx *RS*, *RA*, *RB*

Description

The **stwx** and **stx** instructions store the contents of general-purpose register (GPR) *RS* into the word of storage addressed by the effective address (EA).

If GPR *RA* is not 0, the EA is the sum of the contents of GPR *RA* and GPR *RB*. If GPR *RA* is 0, then the EA is the contents of GPR *RB*.

The **stwx** and **stx** instructions have one syntax form and do not affect the Fixed-Point Exception Register or Condition Register Field 0.

Parameters

RS Specifies source general-purpose register of stored data.
RA Specifies source general-purpose register for EA calculation.
RB Specifies source general-purpose register for EA calculation.

Examples

The following code stores the contents of GPR 6 into a location in memory:

```
.csect data[pr]
buffer: .long 0
# Assume GPR 4 contains the address of buffer.
# Assume GPR 6 contains 0x4865 6C6C.
.csect text[pr]
stwx 6,0,4
# Buffer now contains 0x4865 6C6C.
```

Related Information

Fixed-Point Processor .

Fixed-Point Load and Store Instructions .

---

subf (Subtract From) Instruction

Purpose

Subtracts the contents of two general-purpose registers and places the result in a third general-purpose register.

Note: The **subf** instruction is supported only in the PowerPC architecture.

Syntax

Bits	Value
0-5	31
6-10	RT
11-15	RA
16-20	RB
21	OE
22-30	40
31	Rc

PowerPC

subf *RT*, *RA*, *RB*
subf. *RT*, *RA*, *RB*
subfo *RT*, *RA*, *RB*
subfo. *RT*, *RA*, *RB*

See Extended Mnemonics of Fixed-Point Arithmetic Instructions for more information.

Description

The **subf** instruction adds the ones complement of the contents of general-purpose register (GPR) *RA* and 1 to the contents of GPR *RB* and stores the result in the target GPR *RT*.

The **subf** instruction has four syntax forms. Each syntax form has a different effect on Condition Register Field 0 and the Fixed-Point Exception Register.

Syntax Form	Overflow Exception (OE)	Fixed-Point Exception Register	Record Bit (Rc)	Condition Register Field 0
subf	0	None	0	None
subf.	0	None	1	LT,GT,EQ,SO
subfo	1	SO,OV,CA	0	None
subfo.	1	SO,OV,CA	1	LT,GT,EQ,SO

The four syntax forms of the **subf** instruction never affect the Carry bit (CA) in the Fixed-Point Exception Register. If the syntax form sets the Overflow Exception (OE) bit to 1, the instruction affects the Summary

Overflow (SO) and Overflow (OV) bits in the Fixed-Point Exception Register. If the syntax form sets the Record (Rc) bit to 1, the instruction affects the Less Than (LT) zero, Greater Than (GT) zero, Equal To (EQ) zero, and Summary Overflow (SO) bits in Condition Register Field 0.

Parameters

RT Specifies target general-purpose register where result of operation is stored.
RA Specifies source general-purpose register for EA calculation.
RB Specifies source general-purpose register for EA calculation.

Examples

1. The following code subtracts the contents of GPR 4 from the contents of GPR 10, and stores the result in GPR 6:

```
# Assume GPR 4 contains 0x8000 7000.
# Assume GPR 10 contains 0x9000 3000.
subf 6,4,10
# GPR 6 now contains 0x0FFF C000.
```

2. The following code subtracts the contents of GPR 4 from the contents of GPR 10, stores the result in GPR 6, and sets Condition Register Field 0:

```
# Assume GPR 4 contains 0x0000 4500.
# Assume GPR 10 contains 0x8000 7000.
subf. 6,4,10
# GPR 6 now contains 0x8000 2B00.
```

3. The following code subtracts the contents of GPR 4 from the contents of GPR 10, stores the result in GPR 6, and sets the Summary Overflow and Overflow bits in the Fixed-Point Exception Register to reflect the result of the operation:

```
# Assume GPR 4 contains 0x8000 0000.
# Assume GPR 10 contains 0x0000 4500.
subfo 6,4,10
# GPR 6 now contains 0x8000 4500.
```

4. The following code subtracts the contents of GPR 4 from the contents of GPR 10, stores the result in GPR 6, and sets the Summary Overflow and Overflow bits in the Fixed-Point Exception Register and Condition Register Field 0 to reflect the result of the operation:

```
# Assume GPR 4 contains 0x8000 0000.
# Assume GPR 10 contains 0x0000 7000.
subfo. 6,4,10
# GPR 6 now contains 0x8000 7000.
```

Related Information

Fixed-Point Processor .

Fixed-Point Arithmetic Instructions .

subfc or sf (Subtract from Carrying) Instruction

Purpose

Subtracts the contents of a general-purpose register from the contents of another general-purpose register and places the result in a third general-purpose register.

Syntax

Bits	Value
0-5	31

Bits	Value
6-10	RT
11-15	RA
16-20	RB
21	OE
22-30	8
31	Rc

PowerPC

subfc	*RT*, *RA*, *RB*
subfc.	*RT*, *RA*, *RB*
subfco	*RT*, *RA*, *RB*
subfco.	*RT*, *RA*, *RB*

POWER family

sf	*RT*, *RA*, *RB*
sf.	*RT*, *RA*, *RB*
sfo	*RT*, *RA*, *RB*
sfo.	*RT*, *RA*, *RB*

See Extended Mnemonics of Fixed-Point Arithmetic Instructions for more information.

Description

The **subfc** and **sf** instructions add the ones complement of the contents of general-purpose register (GPR) *RA* and 1 to the contents of GPR *RB* and stores the result in the target GPR *RT*.

The **subfc** instruction has four syntax forms. Each syntax form has a different effect on Condition Register Field 0 and the Fixed-Point Exception Register.

The **sf** instruction has four syntax forms. Each syntax form has a different effect on Condition Register Field 0 and the Fixed-Point Exception Register.

Syntax Form	Overflow Exception (OE)	Fixed-Point Exception Register	Record Bit (Rc)	Condition Register Field 0
subfc	0	CA	0	None
subfc.	0	CA	1	LT,GT,EQ,SO
subfco	1	SO,OV,CA	0	None
subfco.	1	SO,OV,CA	1	LT,GT,EQ,SO
sf	0	CA	0	None
sf.	0	CA	1	LT,GT,EQ,SO
sfo	1	SO,OV,CA	0	None
sfo.	1	SO,OV,CA	1	LT,GT,EQ,SO

The four syntax forms of the **subfc** instruction, and the four syntax forms of the **sf** instruction, always affect the Carry bit (CA) in the Fixed-Point Exception Register. If the syntax form sets the Overflow Exception (OE) bit to 1, the instruction affects the Summary Overflow (SO) and Overflow (OV) bits in the

Fixed-Point Exception Register. If the syntax form sets the Record (Rc) bit to 1, the instruction affects the Less Than (LT) zero, Greater Than (GT) zero, Equal To (EQ) zero, and Summary Overflow (SO) bits in Condition Register Field 0.

Parameters

RT Specifies target general-purpose register where result of operation is stored.
RA Specifies source general-purpose register for operation.
RB Specifies source general-purpose register for operation.

Examples

1. The following code subtracts the contents of GPR 4 from the contents of GPR 10, stores the result in GPR 6, and sets the Carry bit to reflect the result of the operation:

```
# Assume GPR 4 contains 0x8000 7000.
# Assume GPR 10 contains 0x9000 3000.
subfc 6,4,10
# GPR 6 now contains 0x0FFF C000.
```

2. The following code subtracts the contents of GPR 4 from the contents of GPR 10, stores the result in GPR 6, and sets Condition Register Field 0 and the Carry bit to reflect the result of the operation:

```
# Assume GPR 4 contains 0x0000 4500.
# Assume GPR 10 contains 0x8000 7000.
subfc. 6,4,10
# GPR 6 now contains 0x8000 2B00.
```

3. The following code subtracts the contents of GPR 4 from the contents of GPR 10, stores the result in GPR 6, and sets the Summary Overflow, Overflow, and Carry bits in the Fixed-Point Exception Register to reflect the result of the operation:

```
# Assume GPR 4 contains 0x8000 0000.
# Assume GPR 10 contains 0x0000 4500.
subfco 6,4,10
# GPR 6 now contains 0x8000 4500.
```

4. The following code subtracts the contents of GPR 4 from the contents of GPR 10, stores the result in GPR 6, and sets the Summary Overflow, Overflow, and Carry bits in the Fixed-Point Exception Register and Condition Register Field 0 to reflect the result of the operation:

```
# Assume GPR 4 contains 0x8000 0000.
# Assume GPR 10 contains 0x0000 7000.
subfco. 6,4,10
# GPR 6 now contains 0x8000 7000.
```

Related Information

Fixed-Point Processor .

Fixed-Point Arithmetic Instructions .

---

subfe or sfe (Subtract from Extended) Instruction

Purpose

Adds the one's complement of the contents of a general-purpose register to the sum of another general-purpose register and then adds the value of the Fixed-Point Exception Register Carry bit and stores the result in a third general-purpose register.

Syntax

Bits	Value
0-5	31
6-10	RT
11-15	RA
16-20	RB
21	OE
22-30	136
31	Rc

PowerPC

subfe *RT*, *RA*, *RB*
subfe. *RT*, *RA*, *RB*
subfeo *RT*, *RA*, *RB*
subfeo. *RT*, *RA*, *RB*

POWER family

sfe *RT*, *RA*, *RB*
sfe. *RT*, *RA*, *RB*
sfeo *RT*, *RA*, *RB*
sfeo. *RT*, *RA*, *RB*

Description

The **subfe** and **sfe** instructions add the value of the Fixed-Point Exception Register Carry bit, the contents of general-purpose register (GPR) *RB*, and the one's complement of the contents of GPR *RA* and store the result in the target GPR *RT*.

The **subfe** instruction has four syntax forms. Each syntax form has a different effect on Condition Register Field 0 and the Fixed-Point Exception Register.

The **sfe** instruction has four syntax forms. Each syntax form has a different effect on Condition Register Field 0 and the Fixed-Point Exception Register.

Syntax Form	Overflow Exception (OE)	Fixed-Point Exception Register	Record Bit (Rc)	Condition Register Field 0
subfe	0	CA	0	None
subfe.	0	CA	1	LT,GT,EQ,SO
subfeo	1	SO,OV,CA	0	None
subfeo.	1	SO,OV,CA	1	LT,GT,EQ,SO
sfe	0	CA	0	None
sfe.	0	CA	1	LT,GT,EQ,SO
sfeo	1	SO,OV,CA	0	None
sfeo.	1	SO,OV,CA	1	LT,GT,EQ,SO

The four syntax forms of the **subfe** instruction, and the four syntax forms of the **sfe** instruction, always affect the Carry bit (CA) in the Fixed-Point Exception Register. If the syntax form sets the Overflow Exception (OE) bit to 1, the instruction affects the Summary Overflow (SO) and Overflow (OV) bits in the

Fixed-Point Exception Register. If the syntax form sets the Record (Rc) bit to 1, the instruction affects the Less Than (LT) zero, Greater Than (GT) zero, Equal To (EQ) zero, and Summary Overflow (SO) bits in Condition Register Field 0.

Parameters

RT Specifies target general-purpose register where result of operation is stored.
RA Specifies source general-purpose register for operation.
RB Specifies source general-purpose register for operation.

Examples

1. The following code adds the one's complement of the contents of GPR 4, the contents of GPR 10, and the value of the Fixed-Point Exception Register Carry bit and stores the result in GPR 6:

```
# Assume GPR 4 contains 0x9000 3000.
# Assume GPR 10 contains 0x8000 7000.
# Assume the Carry bit is one.
subfe 6,4,10
# GPR 6 now contains 0xF000 4000.
```

2. The following code adds the one's complement of the contents of GPR 4, the contents of GPR 10, and the value of the Fixed-Point Exception Register Carry bit, stores the result in GPR 6, and sets Condition Register field 0 to reflect the result of the operation:

```
# Assume GPR 4 contains 0x0000 4500.
# Assume GPR 10 contains 0x8000 7000.
# Assume the Carry bit is zero.
subfe. 6,4,10
# GPR 6 now contains 0x8000 2AFF.
```

3. The following code adds the one's complement of the contents of GPR 4, the contents of GPR 10, and the value of the Fixed-Point Exception Register Carry bit, stores the result in GPR 6, and sets the Summary Overflow, Overflow, and Carry bits in the Fixed-Point Exception Register to reflect the result of the operation:

```
# Assume GPR 4 contains 0x8000 0000.
# Assume GPR 10 contains 0xEFFF FFFF.
# Assume the Carry bit is one.
subfeo 6,4,10
# GPR 6 now contains 0x6FFF FFFF.
```

4. The following code adds the one's complement of the contents of GPR 4, the contents of GPR 10, and the value of the Fixed-Point Exception Register Carry bit, stores the result in GPR 6, and sets the Summary Overflow, Overflow, and Carry bits in the Fixed-Point Exception Register and Condition Register Field 0 to reflect the result of the operation:

```
# Assume GPR 4 contains 0x8000 0000.
# Assume GPR 10 contains 0xEFFF FFFF.
# Assume the Carry bit is zero.
subfeo. 6,4,10
# GPR 6 now contains 0x6FFF FFFE.
```

Related Information

Fixed-Point Processor .

Fixed-Point Arithmetic Instructions .

subfic or sfi (Subtract from Immediate Carrying) Instruction

Purpose

Subtracts the contents of a general-purpose register from a 16-bit signed integer and places the result in another general-purpose register.

Syntax

Bits	Value
0-5	08
6-10	RT
11-15	RA
16-31	SI

PowerPC
subfic *RT*, *RA*, *SI*

POWER family
sfi *RT*, *RA*, *SI*

Description

The **subfic** and **sfi** instructions add the one's complement of the contents of general-purpose register (GPR) *RA*, 1, and a 16-bit signed integer *SI*. The result is placed in the target GPR *RT*.

> **Note:** When *SI* is -1, the **subfic** and **sfi** instructions place the one's complement of the contents of GPR *RA* in GPR *RT*.

The **subfic** and **sfi** instructions have one syntax form and do not affect Condition Register Field 0. These instructions always affect the Carry bit in the Fixed-Point Exception Register.

Parameters

RT Specifies target general-purpose register where result of operation is stored.
RA Specifies source general-purpose register for operation.
SI Specifies 16-bit signed integer for operation.

Examples

The following code subtracts the contents of GPR 4 from the signed integer 0x0000 7000 and stores the result in GPR 6:

```
# Assume GPR 4 holds 0x9000 3000.
subfic 6,4,0x00007000
# GPR 6 now holds 0x7000 4000.
```

Related Information

Fixed-Point Processor .

Fixed-Point Arithmetic Instructions .

subfme or sfme (Subtract from Minus One Extended) Instruction

Purpose

Adds the one's complement of a general-purpose register to -1 with carry.

Syntax

Bits	Value
0-5	31
6-10	RT
11-15	RA
16-20	///
21	OE
22-30	232
31	Rc

PowerPC

subfme *RT*, *RA*
subfme. *RT*, *RA*
subfmeo *RT*, *RA*
subfmeo. *RT*, *RA*

POWER family

sfme *RT*, *RA*
sfme. *RT*, *RA*
sfmeo *RT*, *RA*
sfmeo. *RT*, *RA*

Description

The **subfme** and **sfme** instructions add the one's complement of the contents of general-purpose register(GPR) *RA*, the Carry Bit of the Fixed-Point Exception Register, and x'FFFFFFFF' and place the result in the target GPR *RT*.

The **subfme** instruction has four syntax forms. Each syntax form has a different effect on Condition Register Field 0 and the Fixed-Point Exception Register.

The **sfme** instruction has four syntax forms. Each syntax form has a different effect on Condition Register Field 0 and the Fixed-Point Exception Register.

Syntax Form	Overflow Exception (OE)	Fixed-Point Exception Register	Record Bit (Rc)	Condition Register Field 0
subfme	0	CA	0	None
subfme.	0	CA	1	LT,GT,EQ,SO
subfmeo	1	SO,OV,CA	0	None
subfmeo.	1	SO,OV,CA	1	LT,GT,EQ,SO
sfme	0	CA	0	None
sfme.	0	CA	1	LT,GT,EQ,SO

sfmeo	1	SO,OV,CA	0	None
sfmeo.	1	SO,OV,CA	1	LT,GT,EQ,SO

The four syntax forms of the **subfme** instruction, and the four syntax forms of the **sfme** instruction, always affect the Carry bit (CA) in the Fixed-Point Exception Register. If the syntax form sets the Overflow Exception (OE) bit to 1, the instruction effects the Summary Overflow (SO) and Overflow (OV) bits in the Fixed-Point Exception Register. If the syntax form sets the Record (Rc) bit to 1, the instruction affects the Less Than (LT) zero, Greater Than (GT) zero, Equal To (EQ) zero, and Summary Overflow (SO) bits in Condition Register Field 0.

Parameters

RT Specifies target general-purpose register where result of operation is stored.
RA Specifies source general-purpose register for operation.

Examples

1. The following code adds the one's complement of the contents of GPR 4, the Carry bit of the Fixed-Point Exception Register, and x'FFFFFFFF' and stores the result in GPR 6:

```
# Assume GPR 4 contains 0x9000 3000.
# Assume the Carry bit is set to one.
subfme 6,4
# GPR 6 now contains 0x6FFF CFFF.
```

2. The following code adds the one's complement of the contents of GPR 4, the Carry bit of the Fixed-Point Exception Register, and x'FFFFFFFF', stores the result in GPR 6, and sets Condition Register Field 0 to reflect the result of the operation:

```
# Assume GPR 4 contains 0xB004 3000.
# Assume the Carry bit is set to zero.
subfme. 6,4
# GPR 6 now contains 0x4FFB CFFE.
```

3. The following code adds the one's complement of the contents of GPR 4, the Carry bit of the Fixed-Point Exception Register, and x'FFFFFFFF', stores the result in GPR 6, and sets the Fixed-Point Exception Register to reflect the result of the operation:

```
# Assume GPR 4 contains 0xEFFF FFFF.
# Assume the Carry bit is set to one.
subfmeo 6,4
# GPR 6 now contains 0x1000 0000.
```

4. The following code adds the one's complement of the contents of GPR 4, the Carry bit of the Fixed-Point Exception Register, and x'FFFFFFFF', stores the result in GPR 6, and sets Condition Register Field 0 and the Fixed-Point Exception Register to reflect the result of the operation:

```
# Assume GPR 4 contains 0xEFFF FFFF.
# Assume the Carry bit is set to zero.
subfmeo. 6,4
# GPR 6 now contains 0x0FFF FFFF.
```

Related Information

Fixed-Point Processor .

Fixed-Point Arithmetic Instructions .

subfze or sfze (Subtract from Zero Extended) Instruction

Purpose

Adds the one's complement of the contents of a general-purpose register, the Carry bit in the Fixed-Point Exception Register, and 0 and places the result in a second general-purpose register.

Syntax

Bits	Value
0-5	31
6-10	RT
11-15	RA
16-20	///
21	OE
22-30	200
31	Rc

PowerPC

subfze *RT*, *RA*
subfze. *RT*, *RA*
subfzeo *RT*, *RA*
subfzeo. *RT*, *RA*

POWER family

sfze *RT*, *RA*
sfze. *RT*, *RA*
sfzeo *RT*, *RA*
sfzeo. *RT*, *RA*

Description

The **subfze** and **sfze** instructions add the one's complement of the contents of general-purpose register (GPR) *RA*, the Carry bit of the Fixed-Point Exception Register, and x'00000000' and store the result in the target GPR *RT*.

The **subfze** instruction has four syntax forms. Each syntax form has a different effect on Condition Register Field 0 and the Fixed-Point Exception Register.

The **sfze** instruction has four syntax forms. Each syntax form has a different effect on Condition Register Field 0 and the Fixed-Point Exception Register.

Syntax Form	Overflow Exception (OE)	Fixed-Point Exception Register	Record Bit (Rc)	Condition Register Field 0
subfze	0	CA	0	None
subfze.	0	CA	1	LT,GT,EQ,SO
subfzeo	1	SO,OV,CA	0	None
subfzeo.	1	SO,OV,CA	1	LT,GT,EQ,SO
sfze	0	CA	0	None
sfze.	0	CA	1	LT,GT,EQ,SO

sfzeo	1	SO,OV,CA	0	None
sfzeo.	1	SO,OV,CA	1	LT,GT,EQ,SO

The four syntax forms of the **subfze** instruction, and the four syntax forms of the **sfze** instruction, always affect the Carry bit (CA) in the Fixed-Point Exception Register. If the syntax form sets the Overflow Exception (OE) bit to 1, the instruction effects the Summary Overflow (SO) and Overflow (OV) bits in the Fixed-Point Exception Register. If the syntax form sets the Record (Rc) bit to 1, the instruction affects the Less Than (LT) zero, Greater Than (GT) zero, Equal To (EQ) zero, and Summary Overflow (SO) bits in Condition Register Field 0.

Parameters

RT Specifies target general-purpose register where result of operation is stored.
RA Specifies source general-purpose register for operation.

Examples

1. The following code adds the one's complement of the contents of GPR 4, the Carry bit, and zero and stores the result in GPR 6:

```
# Assume GPR 4 contains 0x9000 3000.
# Assume the Carry bit is set to one.
subfze 6,4
# GPR 6 now contains 0x6FFF D000.
```

2. The following code adds the one's complement of the contents of GPR 4, the Carry bit, and zero, stores the result in GPR 6, and sets Condition Register Field 0 to reflect the result of the operation:

```
# Assume GPR 4 contains 0xB004 3000.
# Assume the Carry bit is set to one.
subfze. 6,4
# GPR 6 now contains 0x4FFB D000.
```

3. The following code adds the one's complement of the contents of GPR 4, the Carry bit, and zero, stores the result in GPR 6, and sets the Fixed-Point Exception Register to reflect the result of the operation:

```
# Assume GPR 4 contains 0xEFFF FFFF.
# Assume the Carry bit is set to zero.
subfzeo 6,4
# GPR 6 now contains 0x1000 0000.
```

4. The following code adds the one's complement of the contents of GPR 4, the Carry bit, and zero, stores the result in GPR 6, and sets Condition Register Field 0 and the Fixed-Point Exception Register to reflect the result of the operation:

```
# Assume GPR 4 contains 0x70FB 6500.
# Assume the Carry bit is set to zero.
subfzeo 6,4
# GPR 6 now contains 0x8F04 9AFF.
```

Related Information

Fixed-Point Processor .

Fixed-Point Arithmetic Instructions .

svc (Supervisor Call) Instruction

Purpose

Generates a supervisor call interrupt.

Note: The **svc** instruction is supported only in the POWER family architecture.

Syntax

Bits	Value
0-5	17
6-10	///
11-15	///
16-19	FLI
20-26	LEV
27-29	FL2
30	SA
31	LK

POWER family

svc *LEV*, *FL1*, *FL2*
svcl *LEV*, *FL1*, *FL2*

Bits	Value
0-5	17
6-10	///
11-15	///
16-29	SV
30	SA
31	LK

svca *SV*
svcla *SV*

Description

The **svc** instruction generates a supervisor call interrupt and places bits 16-31 of the **svc** instruction into bits 0-15 of the Count Register (CR) and bits 16-31 of the Machine State Register (MSR) into bits 16-31 of the CR.

Consider the following when using the **svc** instruction:

- If the SVC Absolute bit (SA) is set to 0, the instruction fetch and execution continues at one of the 128 offsets, b'1'|| LEV ||b'00000', to the base effective address (EA) indicated by the setting of the IP bit of the MSR. *FL1* and *FL2* fields could be used for passing data to the SVC routine but are ignored by hardware.
- If the SVC Absolute bit (SA) is set to 1, then instruction fetch and execution continues at the offset, x'1FE0', to the base EA indicated by the setting of the IP bit of the MSR.

- If the Link bit (LK) is set to 1, the EA of the instruction following the **svc** instruction is placed in the Link Register.

Notes:

1. To ensure correct operation, an **svc** instruction must be preceded by an unconditional branch or a CR instruction. If a useful instruction cannot be scheduled as specified, use a no-op version of the **cror** instruction with the following syntax:

   ```
   cror BT,BA,BB       No-op when BT = BA = BB
   ```

2. The **svc** instruction has the same op code as the **sc** (System Call) instruction.

The **svc** instruction has four syntax forms. Each syntax form affects the MSR.

Syntax Form	Link Bit (LK)	SVC Absolute Bit (SA)	Machine State Register Bits
svc	0	0	EE,PR,FE set to zero
svcl	1	0	EE,PR,FE set to zero
svca	0	1	EE,PR,FE set to zero
svcla	1	1	EE,PR,FE set to zero

The four syntax forms of the **svc** instruction never affect the FP, ME, AL, IP, IR, or DR bits of the MSR. The EE, PR, and FE bits of the MSR are always set to 0. The Fixed-Point Exception Register and Condition Register Field 0 are unaffected by the **svc** instruction.

Parameters

LEV Specifies execution address.
FL1 Specifies field for optional data passing to SVC routine.
FL2 Specifies field for optional data passing to SVC routine.
SV Specifies field for optional data passing to SVC routine.

Related Information

The **cror** (Condition Register OR) instruction, **sc** (System Call) instruction.

Branch Processor .

System Call Instructions .

Functional Differences for POWER family and PowerPC Instructions .

sync (Synchronize) or dcs (Data Cache Synchronize) Instruction

Purpose

The PowerPC instruction, **sync**, ensures that all previous instructions have completed before the next instruction is initiated.

The POWER family instruction, **dcs**, causes the processor to wait until all data cache lines have been written.

Syntax

Bits	Value
0-5	31
6-9	///
10	L
11-15	///
16-20	///
21-30	598
31	/

PowerPC
sync *“L”*

POWER family
dcs

Description

The PowerPC instruction, **sync**, provides an ordering function that ensures that all instructions initiated prior to the **sync** instruction complete, and that no subsequent instructions initiate until after the **sync** instruction completes. When the **sync** instruction completes, all storage accesses initiated prior to the **sync** instruction are complete.

The L field is used to specify a *heavyweight* sync (L = 0) or a *lightweight* sync (L = 1).

Note: The **sync** instruction takes a significant amount of time to complete. The **eieio** (Enforce In-order Execution of I/O) instruction is more appropriate for cases where the only requirement is to control the order of storage references to I/O devices.

The POWER family instruction, **dcs**, causes the processor to wait until all data cache lines being written or scheduled for writing to main memory have finished writing.

The **dcs** and **sync** instructions have one syntax form and do not affect the Fixed-Point Exception Register. If the Record (Rc) bit is set to 1, the instruction form is invalid.

Parameters

L Specifies heavyweight or a lightweight sync.

Examples

The following code makes the processor wait until the result of the **dcbf** instruction is written into main memory:

```
# Assume that GPR 4 holds 0x0000 3000.
dcbf 1,4
sync
# Wait for memory to be updated.
```

Related Information

“eieio (Enforce In-Order Execution of I/O) Instruction” on page 193.

Chapter 2, “Processing and Storage” on page 9.

td (Trap Double Word) Instruction

Purpose

Generate a program interrupt when a specific condition is true.

This instruction should only be used on 64-bit PowerPC processors running a 64-bit application.

Syntax

Bits	Value
0-5	31
6-10	TO
11-15	A
16-20	B
21-30	68
31	0

PowerPC64

td *TO*, *RA*, *RB*

Description

The contents of general-purpose register (GPR) *RA* are compared with the contents of GPR *RB*. If any bit in the TO field is set and its corresponding condition is met by the result of the comparison, then a trap-type program interrupt is generated.

The *TO* bit conditions are defined as follows:

TO bit	ANDed with Condition
0	Compares Less Than.
1	Compares Greater Than.
2	Compares Equal.
3	Compares Logically Less Than.
4	Compares Logically Greater Than.

Parameters

TO Specifies *TO* bits that are ANDed with compare results.
RA Specifies source general-purpose register for compare.
RB Specifies source general-purpose register for compare.

Implementation

This instruction is defined only for 64-bit implementations. Using it on a 32-bit implementation will cause the system illegal instruction error handler to be invoked.

Examples

The following code generates a program interrupt:

```
# Assume GPR 3 holds 0x0000_0000_0000_0001.
# Assume GPR 4 holds 0x0000_0000_0000_0000.
td 0x2,3,4 # A trap type Program Interrupt occurs.
```

Related Information

Branch Processor .

Fixed-Point Trap Instructions

---

tdi (Trap Double Word Immediate) Instruction

Purpose

Generate a program interrupt when a specific condition is true.

This instruction should only be used on 64-bit PowerPC processors running a 64-bit application.

Syntax

Bits	Value
0-5	02
6-10	TO
11-15	A
16-31	SIMM

PowerPC64

tdi *TO*, *RA*, *SIMM*

Description

The contents of general-purpose register *RA* are compared with the sign-extended value of the SIMM field. If any bit in the *TO* field is set and its corresponding condition is met by the result of the comparison, then the system trap handler is invoked.

The *TO* bit conditions are defined as follows:

TO bit	ANDed with Condition
0	Compares Less Than.
1	Compares Greater Than.
2	Compares Equal.
3	Compares Logically Less Than.
4	Compares Logically Greater Than.

Parameters

TO Specifies *TO* bits that are ANDed with compare results.
RA Specifies source general-purpose register for compare.
SIMM 16-bit two's-complement value which will be sign-extended for comparison.

Implementation

This instruction is defined only for 64-bit implementations. Using it on a 32-bit implementation will cause the system illegal instruction error handler to be invoked.

Related Information

Branch Processor .

Fixed-Point Trap Instructions

---

tlbie or tlbi (Translation Look-Aside Buffer Invalidate Entry) Instruction

Purpose

Makes a translation look-aside buffer entry invalid for subsequent address translations.

Notes:

1. The **tlbie** instruction is optional for the PowerPC architecture. It is supported on PowerPC 601 RISC Microprocessor, PowerPC 603 RISC Microprocessor and PowerPC 604 RISC Microprocessor.
2. **tlbi** is a POWER family instruction.

Syntax

Bits	Value
0-5	31
6-9	///
10	L
11-15	///
16-20	RB
21-30	306
31	/

PowerPC
tlbie *"RB" on page 449*, *"L" on page 449*

POWER family
tlbi *"RA" on page 449*, *"RB" on page 449*

Description

The PowerPC instruction **tlbie** searches the Translation Look-Aside Buffer (TLB) for an entry corresponding to the effective address (EA). The search is done regardless of the setting of Machine State Register (MSR) Instruction Relocate bit or the MSR Data Relocate bit. The search uses a portion of the EA including the least significant bits, and ignores the content of the Segment Registers. Entries that satisfy the search criteria are made invalid so will not be used to translate subsequent storage accesses.

The POWER family instruction **tlbi** expands the EA to its virtual address and invalidates any information in the TLB for the virtual address, regardless of the setting of MSR Instruction Relocate bit or the MSR Data Relocate bit. The EA is placed into the general-purpose register (GPR) *RA*.

Consider the following when using the POWER family instruction **tlbi**:

- If GPR *RA* is not 0, the EA is the sum of the contents of GPR *RA* and GPR *RB*. If GPR *RA* is 0, EA is the sum of the contents of GPR *RB* and 0.
- If GPR *RA* is not 0, EA is placed into GPR *RA*.
- If EA specifies an I/O address, the instruction is treated as a no-op, but if GPR *RA* is not 0, EA is placed into GPR *RA*.

The *L* field is used to specify a 4 KB page size (L = 0) or a large page size (L = 1).

The **tlbie** and **tlbi** instructions have one syntax form and do not affect the Fixed-Point Exception Register. If the Record bit (Rc) is set to 1, the instruction form is invalid.

Parameters

The following parameter pertains to the PowerPC instruction, **tlbie**, only:

RB Specifies the source general-purpose register containing the EA for the search.
L Specifies the page size.

The following parameters pertain to the POWER family instruction, **tlbi**, only:

RA Specifies the source general-purpose register for EA calculation and, if *RA* is not GPR 0, the target general-purpose register for operation.
RB Specifies source general-purpose register for EA calculation.

Security

The **tlbie** and **tlbi** instructions are privileged.

Related Information

Chapter 2, “Processing and Storage” on page 9.

tlbld (Load Data TLB Entry) Instruction

Purpose

Loads the data Translation Look-Aside Buffer (TLB) entry to assist a TLB reload function performed in software on the PowerPC 603 RISC Microprocessor.

Notes:

1. The **tlbld** instruction is supported only on the PowerPC 603 RISC Microprocessor. It is not part of the PowerPC architecture and not part of the POWER family architecture.
2. TLB reload is usually done by the hardware, but on the PowerPC 603 RISC Microprocessor this is done by software.
3. When AIX is installed on a system using the PowerPC 603 RISC Microprocessor, software to perform the TLB reload function is provided as part of the operating system. You are likely to need to use this instruction only if you are writing software for the PowerPC 603 RISC Microprocessor intended to operate without AIX.

Syntax

Bits	Value
0-5	31
6-10	///

Bits	Value
11-15	///
16-20	RB
21-30	978
31	/

PowerPC 603 RISC Microprocessor
tlbld *RB*

Description

For better understanding, the following information is presented:

- Information about a typical TLB reload function that would call the **tlbld** instruction.
- An explanation of what the **tlbld** instruction does.

Typical TLB Reload Function

In the processing of the address translation, the Effective Address (EA) is first translated into a Virtual Address (VA). The part of the Virtual Address is used to select the TLB entry. If an entry is not found in the TLB, a miss is detected. When a miss is detected, the EA is loaded into the data TLB Miss Address (DMISS) register. The first word of the target Page Table Entry is loaded into the data TLB Miss Compare (DCMP) register. A routine is invoked to compare the content of DCMP with all the entries in the primary Page Table Entry Group (PTEG) pointed to by the HASH1 register and all the entries in the secondary PTEG pointed to by the HASH2 register. When there is a match, the **tlbld** instruction is invoked.

tlbld Instruction Function

The **tlbld** instruction loads the data Translation Look-Aside Buffer (TLB) entry selected by the content of register *RB* in the following way:

- The content of the data TLB Miss Compare (DCMP) register is loaded into the higher word of the data TLB entry.
- The contents of the RPA register and the data TLB Miss Address (DMISS) register are merged and loaded into the lower word of the data TLB entry.

The **tlbld** instruction has one syntax form and does not affect the Fixed-Point Exception Register. If the Record bit (Rc) is set to 1, the instruction form is invalid.

Parameters

RB Specifies the source general-purpose register for EA.

Security

The **tlbld** instruction is privileged.

Related Information

“tlbli (Load Instruction TLB Entry) Instruction” on page 451.

PowerPC 603 RISC Microprocessor User’s Manual.

tlbli (Load Instruction TLB Entry) Instruction

Purpose

Loads the instruction Translation Look-Aside Buffer (TLB) entry to assist a TLB reload function performed in software on the PowerPC 603 RISC Microprocessor.

Notes:

1. The **tlbli** instruction is supported only on the PowerPC 603 RISC Microprocessor. It is not part of the PowerPC architecture and not part of the POWER family architecture.
2. TLB reload is usually done by the hardware, but on the PowerPC 603 RISC Microprocessor this is done by software.
3. When AIX is installed on a system using the PowerPC 603 RISC Microprocessor, software to perform the TLB reload function is provided as part of the operating system. You are likely to need to use this instruction only if you are writing software for the PowerPC 603 RISC Microprocessor intended to operate without AIX.

Syntax

Bits	Value
0-5	31
6-10	///
11-15	///
16-20	RB
21-30	1010
31	/

PowerPC 603 RISC Microprocessor
tlbli *RB*

Description

For better understanding, the following information is presented:

- Information about a typical TLB reload function that would call the **tlbli** instruction.
- An explanation of what the **tlbli** instruction does.

Typical TLB Reload Function

In the processing of the address translation, the Effective Address (EA) is first translated into a Virtual Address (VA). The part of the Virtual Address is used to select the TLB entry. If an entry is not found in the TLB, a miss is detected. When a miss is detected, the EA is loaded into the instruction TLB Miss Address (IMISS) register. The first word of the target Page Table Entry is loaded into the instruction TLB Miss Compare (ICMP) register. A routine is invoked to compare the content of ICMP with all the entries in the primary Page Table Entry Group (PTEG) pointed to by the HASH1 register and with all the entries in the secondary PTEG pointed to by the HASH2 register. When there is a match, the **tlbli** instruction is invoked.

tlbli Instruction Function

The **tlbli** instruction loads the instruction Translation Look-Aside Buffer (TLB) entry selected by the content of register *RB* in the following way:

- The content of the instruction TLB Miss Compare (DCMP) register is loaded into the higher word of the instruction TLB entry.
- The contents of the RPA register and the instruction TLB Miss Address (IMISS) register are merged and loaded into the lower word of the instruction TLB entry.

The **tlbli** instruction has one syntax form and does not affect the Fixed-Point Exception Register. If the Record bit (Rc) is set to 1, the instruction form is invalid.

Parameters

RB Specifies the source general-purpose register for EA.

Security

The **tlbli** instruction is privileged.

Related Information

"tlbld (Load Data TLB Entry) Instruction" on page 449.

PowerPC 603 RISC Microprocessor User's Manual.

tlbsync (Translation Look-Aside Buffer Synchronize) Instruction

Purpose

Ensures that a **tlbie** and **tlbia** instruction executed by one processor has completed on all other processors.

> **Note:** The **tlbsync** instruction is defined only in the PowerPC architecture and is an optional instruction. It is supported on the PowerPC 603 RISC Microprocessor and on the PowerPC 604 RISC Microprocessor, but not on the PowerPC 601 RISC Microprocessor.

Syntax

Bits	Value
0-5	31
6-10	///
11-15	///
16-20	///
21-30	566
31	/

PowerPC

tlbsync

Description

The **tlbsync** instruction does not complete until all previous **tlbie** and **tlbia** instructions executed by the processor executing the **tlbsync** instruction have been received and completed by all other processors.

The **tlbsync** instruction has one syntax form and does not affect the Fixed-Point Exception Register. If the Record bit (Rc) is set to 1, the instruction form is invalid.

Security

The **tlbsync** instruction is privileged.

Related Information

Processing and Storage

---

tw or t (Trap Word) Instruction

Purpose

Generates a program interrupt when a specified condition is true.

Syntax

Bits	Value
0-5	31
6-10	TO
11-15	RA
16-20	RB
21-30	4
31	/

PowerPC
tw *TO*, *RA*, *RB*

POWER family
t *TO*, *RA*, *RB*

See Extended Mnemonics of Fixed-Point Trap Instructions for more information.

Description

The **tw** and **t** instructions compare the contents of general-purpose register (GPR) *RA* with the contents of GPR *RB*, AND the compared results with *TO*, and generate a trap-type Program Interrupt if the result is not 0.

The *TO* bit conditions are defined as follows.

TO bit	ANDed with Condition
0	Compares Less Than.
1	Compares Greater Than.
2	Compares Equal.
3	Compares Logically Less Than.
4	Compares Logically Greater Than.

The **tw** and **t** instructions have one syntax form and do not affect the Fixed-Point Exception Register or Condition Register Field 0.

Parameters

TO Specifies *TO* bits that are ANDed with compare results.
RA Specifies source general-purpose register for compare.
RB Specifies source general-purpose register for compare.

Examples

The following code generates a Program Interrupt:

```
# Assume GPR 4 contains 0x9000 3000.
# Assume GPR 7 contains 0x789A 789B.
tw 0x10,4,7
# A trap type Program Interrupt occurs.
```

Related Information

Branch Processor .

Fixed-Point Trap Instructions .

---

twi or ti (Trap Word Immediate) Instruction

Purpose

Generates a program interrupt when a specified condition is true.

Syntax

Bits	Value
0-5	03
6-10	TO
11-15	RA
16-31	SI

PowerPC
twi *TO*, *RA*, *SI*

POWER family
ti *TO*, *RA*, *SI*

See Extended Mnemonics of Fixed-Point Trap Instructions for more information.

Description

The **twi** and **ti** instructions compare the contents of general-purpose register (GPR) *RA* with the sign extended *SI* field, AND the compared results with *TO*, and generate a trap-type program interrupt if the result is not 0.

The *TO* bit conditions are defined as follows.

TO bit	ANDed with Condition
0	Compares Less Than.
1	Compares Greater Than.
2	Compares Equal.
3	Compares Logically Less Than.
4	Compares Logically Greater Than.

The **twi** and **ti** instructions have one syntax form and do not affect the Fixed-Point Exception Register or Condition Register Field 0.

Parameters

TO Specifies *TO* bits that are ANDed with compare results.
RA Specifies source general-purpose register for compare.
SI Specifies sign-extended value for compare.

Examples

The following code generates a Program Interrupt:

```
# Assume GPR 4 holds 0x0000 0010.
twi 0x4,4,0x10
# A trap type Program Interrupt occurs.
```

Related Information

Branch Processor .

Fixed-Point Trap Instructions .

---

xor (XOR) Instruction

Purpose

XORs the contents of two general-purpose registers and places the result in another general-purpose register.

Syntax

Bits	Value
0-5	31
6-10	RS
11-15	RA
16-20	RB
21-30	316
31	Rc

xor *RA*, *RS*, *RB*
xor. *RA*, *RS*, *RB*

Description

The **xor** instruction XORs the contents of general-purpose register (GPR) *RS* with the contents of GPR *RB* and stores the result in GPR *RA*.

The **xor** instruction has two syntax forms. Each syntax form has a different effect on Condition Register Field 0.

Syntax Form	Overflow Exception (OE)	Fixed-Point Exception Register	Record Bit (Rc)	Condition Register Field 0
xor	None	None	0	None
xor.	None	None	1	LT,GT,EQ,SO

The two syntax forms of the **xor** instruction never affect the Fixed-Point Exception Register. If the syntax form sets the Record (Rc) bit to 1, the instruction affects the Less Than (LT) zero, Greater Than (GT) zero, Equal To (EQ) zero, and Summary Overflow (SO) bits in Condition Register Field 0.

Parameters

RA Specifies target general-purpose register where result of operation is stored.
RS Specifies source general-purpose register for operation.
RB Specifies source general-purpose register for operation.

Examples

1. The following code XORs the contents of GPR 4 and GPR 7 and stores the result in GPR 6:

```
# Assume GPR 4 contains 0x9000 3000.
# Assume GPR 7 contains 0x789A 789B.
xor 6,4,7
# GPR 6 now contains 0xE89A 489B.
```

2. The following code XORs the contents of GPR 4 and GPR 7, stores the result in GPR 6, and sets Condition Register Field 0 to reflect the result of the operation:

```
# Assume GPR 4 contains 0xB004 3000.
# Assume GPR 7 contains 0x789A 789B.
xor. 6,4,7
# GPR 6 now contains 0xC89E 489B.
```

Related Information

Fixed-Point Processor .

Fixed-Point Logical Instructions .

---

xori or xoril (XOR Immediate) Instruction

Purpose

XORs the lower 16 bits of a general-purpose register with a 16-bit unsigned integer and places the result in another general-purpose register.

Syntax

Bits	Value
0-5	26
6-10	RS
11-15	RA
16-31	UI

PowerPC
xori *RA*, *RS*, *UI*

POWER family
xoril *RA*, *RS*, *UI*

Description

The **xori** and **xoril** instructions XOR the contents of general-purpose register (GPR) *RS* with the concatenation of x'0000' and a 16-bit unsigned integer *UI* and store the result in GPR *RA*.

The **xori** and **xoril** instructions have only one syntax form and do not affect the Fixed-Point Exception Register or Condition Register Field 0.

Parameters

RA Specifies target general-purpose register where result of operation is stored.
RS Specifies source general-purpose register for operation.
UI Specifies 16-bit unsigned integer for operation.

Examples

The following code XORs GPR 4 with 0x0000 5730 and places the result in GPR 6:

```
# Assume GPR 4 contains 0x7B41 92C0.
xori 6,4,0x5730
# GPR 6 now contains 0x7B41 C5F0.
```

Related Information

Fixed-Point Processor .

Fixed-Point Logical Instructions .

---

xoris or xoriu (XOR Immediate Shift) Instruction

Purpose

XORs the upper 16 bits of a general-purpose register with a 16-bit unsigned integer and places the result in another general-purpose register.

Syntax

Bits	Value
0-5	27
6-10	RS
11-15	RA
16-31	UI

PowerPC
xoris *RA*, *RS*, *UI*

POWER family
xoriu *RA*, *RS*, *UI*

Description

The **xoris** and **xoriu** instructions XOR the contents of general-purpose register (GPR) *RS* with the concatenation of a 16-bit unsigned integer *UI* and 0x'0000' and store the result in GPR *RA*.

The **xoris** and **xoriu** instructions have only one syntax form and do not affect the Fixed-Point Exception Register or Condition Register Field 0.

Parameters

RA Specifies target general-purpose register where result of operation is stored.
RS Specifies source general-purpose register for operation.
UI Specifies 16-bit unsigned integer for operation.

Example

The following code XORs GPR 4 with 0x0079 0000 and stores the result in GPR 6:

```
# Assume GPR 4 holds 0x9000 3000.
xoris 6,4,0x0079
# GPR 6 now holds 0x9079 3000.
```

Related Information

Fixed-Point Processor .

Fixed-Point Logical Instructions .

Chapter 9. Pseudo-ops

This chapter provides an overview of assembler pseudo-ops and reference information for all pseudo-ops.

Pseudo-ops Overview

A pseudo-operation, commonly called a *pseudo-op*, is an instruction to the assembler that does not generate any machine code. The assembler resolves pseudo-ops during assembly, unlike machine instructions, which are resolved only at runtime. Pseudo-ops are sometimes called assembler instructions, assembler operators, or assembler directives.

In general, pseudo-ops give the assembler information about data alignment, block and segment definition, and base register assignment. The assembler also supports pseudo-ops that give the assembler information about floating point constants and symbolic debugger information (**dbx**).

While they do not generate machine code, the following pseudo-ops can change the contents of the assembler's location counter:

- **.align**
- **.byte**
- **.comm**
- **.csect**
- **.double**
- **.dsect**
- **.float**
- **.lcomm**
- **.long**
- **.org**
- **.short**
- **.space**
- **.string**
- **.vbyte**

Pseudo-ops Grouped by Function

Pseudo-ops can be related according to functionality into the following groups:

- "Data Alignment" on page 460
- "Data Definition" on page 460
- "Storage Definition" on page 460
- "Addressing" on page 460
- "Assembler Section Definition" on page 460
- "External Symbol Definition" on page 460
- "Static Symbol Definition" on page 461
- "Support for Calling Conventions" on page 461
- "Miscellaneous" on page 461
- "Symbol Table Entries for Debuggers" on page 461
- "Target Environment Indication" on page 461

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Data Alignment

The following pseudo-op is used in the data or text section of a program:

- **.align**

Data Definition

The following pseudo-ops are used for data definition:

- **.byte**
- **.double**
- **.float**
- **.long**
- **.short**
- **.string**
- **.vbyte**

In most instances, use these pseudo-ops to create data areas to be used by a program, as shown by this example.

```
        .csect data[rw]
greeting:       .long 'H,'O,'W,'D,'Y
        .
        .
        .csect text[pr]
                # Assume GPR 5 contains the address of
                # csect data[rw].
        lm 11, greeting(5)
```

Storage Definition

The following pseudo-ops define or map storage:

- **.dsect**
- **.space**

Addressing

The following pseudo-ops assign or dismiss a register as a base register:

- **.drop**
- **.using**

Assembler Section Definition

The following pseudo-ops define the sections of an assembly language program:

- **.comm**
- **.csect**
- **.lcomm**
- **.tc**
- **.toc**

External Symbol Definition

The following pseudo-ops define a variable as a global variable or an external variable (variables defined in external modules):

- **.extern**

- **.globl**
- **.weak**

Static Symbol Definition
The following pseudo-op defines a static symbol:

- **.lglobl**

Support for Calling Conventions

The following pseudo-op defines a debug traceback tag for performing tracebacks when debugging programs:

- **.tbtag**

Miscellaneous

The following pseudo-ops perform miscellaneous functions:

.hash	Provides type-checking information.
.org	Sets the value of the current location counter.
.ref	Creates a special type entry in the relocation table.
.rename	Creates a synonym or alias for an illegal or undesirable name.
.set	Assigns a value and type to a symbol.
.source	Identifies the source language type.
.tocof	Defines a symbol as the table of contents (TOC) of another module.
.xline	Provides file and line number information.

Symbol Table Entries for Debuggers

The following pseudo-ops provide additional information which is required by the symbolic debugger (**dbx**):

- **.bb**
- **.bc**
- **.bf**
- **.bi**
- **.bs**
- **.eb**
- **.ec**
- **.ef**
- **.ei**
- **.es**
- **.file**
- **.function**
- **.line**
- **.stabx**
- **.xline**

Target Environment Indication
The following pseudo-op defines the intended target environment:

- **.machine**

Notational Conventions

White space is required unless otherwise specified. A space may optionally occur after a comma. White space may consist of one or more white spaces.

Some pseudo-ops may not use labels. However, with the exception of the **.csect** pseudo-op, you can put a label in front of a pseudo-op statement just as you would for a machine instruction statement.

The following notational conventions are used to describe pseudo-ops:

Name	Any valid label.
Register	A general-purpose register. *Register* is an expression that evaluates to an integer between 0 and 31, inclusive.
Number	An expression that evaluates to an integer.
Expression	Unless otherwise noted, the *Expression* variable signifies a relocatable constant or absolute expression.
FloatingConstant	A floating-point constant.
StringConstant	A string constant.
[ ]	Brackets enclose optional operands except in the ".csect Pseudo-op" on page 469 and ".tc Pseudo-op" on page 499, which require brackets in syntax.

.align Pseudo-op

Purpose

Advances the current location counter until a boundary specified by the *Number* parameter is reached.

Syntax

.align *"Number"*

Description

The **.align** pseudo-op is normally used in a control section (csect) that contains data.

If the *Number* parameter evaluates to 0, alignment occurs on a byte boundary. If the *Number* parameter evaluates to 1, alignment occurs on a halfword boundary. If the *Number* parameter evaluates to 2, alignment occurs on a word boundary. If the *Number* parameter evaluates to 3, alignment occurs on a doubleword boundary.

If the location counter is not aligned as specified by the *Number* parameter, the assembler advances the current location counter until the number of low-order bits specified by the *Number* parameter are filled with the value 0 (zero).

If the **.align** pseudo-op is used within a **.csect** pseudo-op of type PR or GL which indicates a section containing instructions, alignment occurs by padding with **nop** (no-operation) instructions. In this case, the no-operation instruction is equivalent to a branch to the following instruction. If the align amount is less than a fullword, the padding consists of zeros.

Parameters

Number Specifies an absolute expression that evaluates to an integer value from 0 to 12, inclusive. The value indicates the log base 2 of the desired alignment. For example, an alignment of 8 (a doubleword) would be represented by an integer value of 3; an alignment of 4096 (one page) would be represented by an integer value of 12.

Examples

The following example demonstrates the use of the **.align** pseudo-op:

```
                .csect   progdata[RW]
                .byte    1
                         # Location counter now at odd number
                .align   1
                         # Location counter is now at the next
                         # halfword boundary.
                .byte    3,4
                .
                .
                .
                .align   2       # Insure that the label cont
                                 # and the .long pseudo-op are
                                 # aligned on a full word
                                 # boundary.
        cont:   .long    5004381
```

Related Information

"Pseudo-ops Overview" on page 459.

".byte Pseudo-op" on page 466, ".comm Pseudo-op" on page 467, ".csect Pseudo-op" on page 469, ".double Pseudo-op" on page 471, ".float Pseudo-op" on page 479, ".long Pseudo-op" on page 485, ".short Pseudo-op" on page 493.

.bb Pseudo-op

Purpose

Identifies the beginning of an inner block and provides information specific to the beginning of an inner block.

Syntax

.bb *"Number"*

Description

The **.bb** pseudo-op provides symbol table information necessary when using the symbolic debugger.

The **.bb** pseudo-op has no other effect on assembly and is customarily inserted by a compiler.

Parameters

Number Specifies the line number in the original source file on which the inner block begins.

Examples

The following example demonstrates the use of the **.bb** pseudo-op:

```
.bb   5
```

Related Information

"Pseudo-ops Overview" on page 459.

".eb Pseudo-op" on page 475.

.bc Pseudo-op

Purpose

Identifies the beginning of a common block and provides information specific to the beginning of a common block.

Syntax

.bc *StringConstant*

Description

The **.bc** pseudo-op provides symbol table information necessary when using the symbolic debugger.

The **.bc** pseudo-op has no other effect on assembly and is customarily inserted by a compiler.

Parameters

StringConstant Represents the symbol name of the common block as defined in the original source file.

Examples

The following example demonstrates the use of the **.bc** pseudo-op:

```
.bc   "commonblock"
```

Related Information

Pseudo-ops Overview.

The **.ec** pseudo-op.

.bf Pseudo-op

Purpose

Identifies the beginning of a function and provides information specific to the beginning of a function.

Syntax

.bf *Number*

Description

The **.bf** pseudo-op provides symbol table information necessary when using the symbolic debugger.

The **.bf** pseudo-op has no other effect on assembly and is customarily inserted by a compiler.

Note: The **.function** pseudo-op must be used if the **.bf** pseudo-op is used.

Parameters

Number Represents the absolute line number in the original source file on which the function begins.

Examples

The following example demonstrates the use of the **.bf** pseudo-op:

```
.bf   5
```

Related Information

Pseudo-ops Overview.

The **.ef** pseudo-op, **.function** pseudo-op.

.bi Pseudo-op

Purpose

Identifies the beginning of an included file and provides information specific to the beginning of an included file.

Syntax

.bi *StringConstant*

Description

The **.bi** pseudo-op provides symbol table information necessary when using the symbolic debugger.

The **.bi** pseudo-op has no other effect on assembly and is customarily inserted by a compiler.

The **.bi** pseudo-op should be used with the **.line** pseudo-op.

Parameters

StringConstant Represents the name of the original source file.

Examples

The following example demonstrates the use of the **.bi** pseudo-op:

```
.bi   "file.s"
```

Related Information

Pseudo-ops Overview.

The **.ei** pseudo-op, **.line** pseudo-op.

.bs Pseudo-op

Purpose

Identifies the beginning of a static block and provides information specific to the beginning of a static block.

Syntax

.bs *Name*

Description

The **.bs** pseudo-op provides symbol table information necessary when using the symbolic debugger.

The **.bs** pseudo-op has no other effect on assembly and is customarily inserted by a compiler.

Parameters

Name Represents the symbol name of the static block as defined in the original source file.

Examples

The following example demonstrates the use of the **.bs** pseudo-op:

```
.lcomm cgdat, 0x2b4
.csect .text[PR]
.bs cgdat
.stabx   "ONE:1=Ci2,0,4;",0x254,133,0
.stabx   "TWO:S2=G5TWO1:3=Cc5,0,5;,0,40;;",0x258,133,8
.es
```

Related Information

Pseudo-ops Overview.

The **.comm** pseudo-op, **.es** pseudo-op, **.lcomm** pseudo-op.

.byte Pseudo-op

Purpose

Assembles specified values represented by the *Expression* parameter into consecutive bytes.

Syntax

.byte *Expression*[**,***Expression*...]

Description

The **.byte** pseudo-op changes an expression or a string of expressions into consecutive bytes of data. ASCII character constants (for example, **'X**) and string constants (for example, `Hello, world`) can also be assembled using the **.byte** pseudo-op. Each letter will be assembled into consecutive bytes. However, an expression cannot contain externally defined symbols. Also, an expression value longer than one byte will be truncated on the left.

Parameters

Expression Specifies a value that is assembled into consecutive bytes.

Examples

The following example demonstrates the use of the **.byte** pseudo-op:

```
        .set olddata,0xCC
        .csect data[rw]
mine:   .byte 0x3F,0x7+0xA,olddata,0xFF
# Load GPR 3 with the address of csect data[rw].
        .csect text[pr]
        l 3,mine(4)
# GPR 3 now holds 0x3F11 CCFF.
# Character constants can be represented in
# several ways:
        .csect data[rw]
        .byte "Hello, world"
        .byte 'H,'e,'l,'l,'o,',,' ,'w,'o,'r,'l,'d
# Both of the .byte statements will produce
# 0x4865 6C6C 6F2C 2077 6F72 6C64.
```

Related Information

Pseudo-ops Overview.

The **.string** pseudo-op, **.vbyte** pseudo-op.

.comm Pseudo-op

Purpose

Defines an uninitialized block of storage called a common block, which can be common to more than one module.

Syntax

.comm *Qualname*, *Expression*[, *Number*]

where *QualName* = *Name*[[*StorageMappingClass*]]

> **Note:** *Name* is required. *StorageMappingClass* is optional and enclosed within brackets if specified. RW is the assumed default if*StorageMappingClass* is omitted.

Description

The **.comm** pseudo-op defines a block of storage specified by the *Qualname* parameter. The the block size is specified in bytes by the *Expression* parameter.

> **Note:** By convention, use of the TD storage mapping class is restricted to common blocks no more than four (4) bytes long.

The valid values for *StorageMappingClass* are RW, TD, UC, and BS. These values are explained in the article on the .csect pseudo-op. If any other value is used for *StorageMappingClass,* the default value RW is used and a warning message is reported if the **-w** flag is in effect.

If TD is used for the storage mapping class, a block of zeroes, the length specified by the *Expression* parameter, will be written into the TOC area as an initialized csect in the **.data** section. If RW, UC, or BS is used as the storage mapping class, the block is not initialized in the current module and has symbol type CM (Common). At load time, the space for CM control sections with RW, UC, or BC storage mapping classes is created in the **.bss** section at the end of the **.data** section.

Several modules can share the same common block. If any of those modules have an external Control Section (csect) with the same name and the csect with the same name has a storage mapping class other

than BS or UC, then the common block is initialized and becomes that other Control Section. If the common block has TD as its storage mapping class, the csect will be in the TOC area. This is accomplished at bind time.

If more than one uninitialized common block with the same *Qualname* is found at bind time, space is reserved for the largest one.

A common block can be aligned by using the *Number* parameter, which is specified as the log base 2 of the alignment desired.

Parameters

Qualname	Specifies the name and storage mapping class of the common block. If the *StorageMappingClass* part of the parameter is omitted, the default value RW is used. Valid *StorageMappingClass* values for a common block are RW, TD, UC and BS.
Expression	Specifies the absolute expression that gives the length of the specified common block in bytes.
Number	Specifies the optional alignment of the specified common block. This is specified as the log base 2 of the alignment desired. For example, an alignment of 8 (or doubleword) would be 3 and an alignment of 2048 would be 11. This is similar to the argument for the **.align** pseudo-op.

Examples

1. The following example demonstrates the use of the **.comm** pseudo-op:

```
        .comm proc,5120
# proc is an uninitialized common block of
# storage 5120 bytes long which is
# globally visible.

# Assembler SourceFile A contains:
        .comm st,1024
# Assembler SourceFile B contains:

        .globl st[RW]
        .csect st[RW]
        .long 1
        .long 2

# Using st in the above two programs refers to
# Control Section st in Assembler SourceFile B.
```

2. This example shows how two different modules access the same data:
   a. Source code for C module `td2.c`:

```
/* This C module named td2.c   */
extern long   t_data;
extern  void mod_s();
main()
{
        t_data = 1234;
         mod_s();
         printf("t_data is %d\n", t_data);
}
```

   b. Source for assembler module `mod2.s`:

```
        .file "mod2.s"
        .csect .mod_s[PR]
        .globl .mod_s[PR]
        .set    RTOC, 2
        l   5, t_data[TD](RTOC)  # Now GPR5 contains the
                                 # t_data value
        ai  5,5,14
        stu 5, t_data[TD](RTOC)
```

```
br
.toc
.comm  t_data[TD],4  # t_data is a global symbol
```

c. Instructions for making executable `td2` from the C and assembler source:

```
as -o mod2.o mod2.s
cc -o td2 td2.c mod2.o
```

d. Running `td2` will cause the following to be printed:

```
t_data is 1248
```

Related Information

Pseudo-ops Overview.

The **.align** pseudo-op, **.csect** pseudo-op, **.globl** pseudo-op, **.lcomm** pseudo-op, **.long** pseudo-op.

.csect Pseudo-op

Purpose

Groups code or data into a control section (csect) and gives that csect a name, a storage mapping class, and an alignment.

Syntax

.csect *QualName*[, *Number*]

where *QualName* = [*Name*][**[***StorageMappingClass***]**]

> **Note:** The boldfaced brackets containing *StorageMappingClass* are part of the syntax and do *not* specify an optional parameter.

Description

The following information discusses using the **.csect** pseudo-op:

- A csect *QualName* parameter takes the form:

  symbol[*XX*]

  OR

  symbol{*XX*}

  where either the [ ] (square brackets) or { } (curly brackets) surround a two- or three-character storage mapping class identifier. Both types of brackets produce the same results.

  The *QualName* parameter can be omitted. If it is omitted, the csect is unnamed and the [PR] *StorageMappingClass* is used. If a *QualName* is used, the *Name* parameter is optional and the *StorageMappingClass* is required. If no *Name* is specified, the csect is unnamed.

  Each control section has a storage mapping class associated with it that is specified in the qualification part of *QualName*. The storage mapping class determines the object data section, specifically the **.text**, **.data**, or **.bss** section, in which the control section is grouped. The **.text** section contains read-only data. The **.data** and **.bss** sections contain read/write data.

  The storage mapping class also indicates what kind of data should be contained within the control section. Many of the storage mapping classes listed have specific implementation and convention

details. In general, instructions can be contained within csects of storage mapping class PR. Modifiable data can be contained within csects of storage mapping class RW.

A csect is associated with one of the following storage mapping classes. Storage mapping class identifiers are not case-sensitive. The storage mapping class identifiers are listed in groups for the **.text**, .**data**, and **.bss** object data sections.

.text Section Storage Mapping Classes

PR Program Code. Identifies the sections that provide executable instructions for the module.

RO Read-Only Data. Identifies the sections that contain constants that are not modified during execution.

DB Debug Table. Identifies a class of sections that have the same characteristics as read-only data.

GL Glue Code. Identifies a section that has the same characteristics as Program Code. This type of section has code to interface with a routine in another module. Part of the interface code requirement is to maintain TOC addressability across the call.

XO Extended Operation. Identifies a section of code that has no dependency on the TOC (no references through the TOC). It is intended to reside at a fixed address in memory so that it can be the target of a branch to an absolute address.

Note: This storage mapping class should not be used in assembler source programs.

SV Supervisor Call. Identifies a section of code that is to be treated as a supervisor call.

TB Traceback Table. Identifies a section that contains data associated with a traceback table.

TI Traceback Index. Identifies a section that contains data associated with a traceback index.

.data Section Storage Mapping Classes

TC0 TOC Anchor used only by the predefined TOC symbol. Identifies the special symbol TOC. Used only for the TOC anchor.

TC TOC Entry. Generally indicates a csect that contains addresses of other csects or global symbols. If it contains only one address, the csect is usually four bytes long.

TD TOC Entry. Identifies a csect that contains scalar data that can be directly accessed from the TOC. For frequently used global symbols, this is an alternative to indirect access through an address pointer csect within the TOC. By convention, TD sections should not be longer than four bytes. Contains initialized data that can be modified during program execution.

UA Unknown Type. Identifies a section that contains data of an unknown storage mapping class.

RW Read/Write Data. Identifies a section that contains data that is known to require change during execution.

DS Descriptor. Identifies a function descriptor. This information is used to describe function pointers in languages such as C and FORTRAN.

.bss Section Storage Mapping Classes

BS BSS class. Identifies a section that contains uninitialized read/write data.

UC Unnamed FORTRAN Common. Identifies a section that contains read/write data.

A csect is one of the following symbol types:

ER External Reference

SD CSECT Section Definition

LD Entry Point - Label Definition

CM Common (BSS)

- All of the control sections with the same *QualName* value are grouped together, and a section can be continued with a **.csect** statement having the same *QualName*. Different csects can have the same name and different storage mapping classes. Therefore, the storage mapping class identifier must be used when referring to a csect name as an operand of other pseudo-ops or instructions.

  However, for a given name, only one csect can be externalized. If two or more csects with the same name are externalized, a run error may occur, since the linkage editor treats the csects as duplicate symbol definitions and selects only one of them to use.

- A control section is relocated as a body.
- Control sections with no specified name (*Name*) are identified with their storage mapping class, and there can be an unnamed control section of each storage mapping class. They are specified with a *QualName* that only has a storage mapping class (for instance, **.csect** [RW] has a *QualName* of [RW]).
- If no **.csect** pseudo-op is specified before any instructions appear, then an unnamed Program Code ([PR]) control section is assumed.
- A csect with the **BS** or **UC** storage mapping class will have a csect type of CM (Common), which reserves spaces but has no initialized data. All other control sections defined with the **.csect** pseudo-op are of type SD (Section Definition). The **.comm** or **.lcomm** pseudo-ops can also be used to define control sections of type CM. No external label can be defined in a control section of type CM.
- Do not label **.csect** statements. The **.csect** may be referred to by its *QualName*, and labels may be placed on individual elements of the **.csect**.

Parameters

Number Specifies an absolute expression that evaluates to an integer value from 0 to 31, inclusive. This value indicates the log base 2 of the desired alignment. For example, an alignment of 8 (a doubleword) would be represented by an integer value of 3; an alignment of 2048 would be represented by an integer value of 11. This is similar to the usage of the *Number* parameter for the **.align** pseudo-op. Alignment occurs at the beginning of the csect. Elements of the csect are not individually aligned. The *Number* parameter is optional. If it is not specified, the default value is 2.

QualName Specifies a *Name* and *StorageMappingClass* for the control section. If *Name* is not given, the csect is identified with its *StorageMappingClass*. If neither the *Name* nor the *StorageMappingClass* are given, the csect is unnamed and has a storage mapping class of [PR]. If the *Name* is specified, the *StorageMappingClass* must also be specified.

Examples

The following example defines three csects:

```
# A csect of name proga with Program Code Storage Mapping Class.
.csect proga[PR]
lh      30,0x64(5)
# A csect of name pdata_ with Read-Only Storage Mapping Class.
.csect pdata_[RO]
l1:    .long  0x7782
l2:    .byte  'a,'b,'c,'d,'e
.csect  [RW],3          # An unnamed csect with Read/Write
                        # Storage Mapping Class and doubleword
                        # alignment.
.float -5
```

Related Information

Pseudo-ops Overview.

The **.comm** pseudo-op, **.globl** pseudo-op, **.lcomm** pseudo-op, **.align** pseudo-op.

.double Pseudo-op

Purpose

Stores a double floating-point constant at the next fullword location.

Syntax

.double *FloatingConstant*

Parameters

FloatingConstant Specifies a floating-point constant to be assembled.

Examples

The following example demonstrates the use of the **.double** pseudo-op:

```
.double 3.4
.double -77
.double 134E12
.double 5e300
.double 0.45
```

Related Information

Pseudo-ops Overview.

The **.float** pseudo-op.

.drop Pseudo-op

Purpose

Stops using a specified register as a base register.

Syntax

.drop *Number*

Description

The **.drop** pseudo-op stops a program from using the register specified by the *Number* parameter as a base register in operations. The **.drop** pseudo-op does not have to precede the **.using** pseudo-op when changing the base address, and the **.drop** pseudo-op does not have to appear at the end of a program.

Parameters

Number Specifies an expression that evaluates to an integer from 0 to 31 inclusive.

Examples

The following example demonstrates the use of the **.drop** pseudo-op:

```
.using _subrA,5
        # Register 5 can now be used for addressing
        # with displacements calculated
        # relative to _subrA.

        # .using does not load GPR 5 with the address
        # of _subrA. The program must contain the
        # appropriate code to ensure this at runtime.

   .
   .
   .
.drop 5
```

```
        # Stop using Register 5.
.using _subrB,5
        # Now the assembler calculates
        # displacements relative to _subrB
```

Related Information

Pseudo-ops Overview.

The **.using** pseudo-op.

.dsect Pseudo-op

Purpose

Identifies the beginning or the continuation of a dummy control section.

Syntax

.dsect *Name*

Description

The **.dsect** pseudo-op identifies the beginning or the continuation of a dummy control section. Actual data declared in a dummy control section is ignored; only the location counter is incremented. All labels in a dummy section are considered to be offsets relative to the beginning of the dummy section. A dsect that has the same name as a previous dsect is a continuation of that dummy control section.

The **.dsect** pseudo-op can declare a data template that can then be used to map out a block of storage. The **.using** pseudo-op is involved in doing this.

Parameters

Name Specifies a dummy control section.

Examples

1. The following example demonstrates the use of the **.dsect** pseudo-op:

```
          .dsect datal
   d1:    .long 0

                           # 1 Fullwordd2:     .short 0,0,0,0,0,0,0,0,0       # 10 Halfwords
   d3:    .byte 0,0,0,0,0,0,0,0,0,0,0,0,0,0,0      # 15 bytes

          .align 3                  #Align to a double word.
   d4:    .space 64                 #Space 64 bytes

   .csect main[PR]
   .using datal,7
   l 5,d2

   # This will actually load
   # the contents of the
   # effective address calculated
   # by adding the offset d2 to
   # that in GPR 7 into GPR 5.
```

2. The following example contains several source programs which together show the use of **.dsect** and **.using** pseudo-ops in implicit-based addressing.
   a. Source program foo_pm.s:

```
        .csect   foo_data[RW]
        .long   0xaa
        .short  10
        .short   20
        .globl   .foo_pm[PR]
        .csect   .foo_pm[PR]
        .extern  l1
        .using  TOC[TC0], 2
        l    7, T.foo_data
        b   l1
        br
        .toc
T.foo_data:   .tc  foo_data[TC], foo_data[RW]
```

   b. Source program bar_pm.s:

```
        .csect   bar_data[RW]
        .long   0xbb
        .short  30
        .short   40
        .globl   .bar_pm[PR]
        .csect   .bar_pm[PR]
        .extern  l1
        .using TOC[TC0], 2
        l    7, T.bar_data
        b  l1
        br
        .toc
T.bar_data:   .tc  bar_data[TC], bar_data[RW]
```

   c. Source program c1_s:

```
        .dsect   data1
d1:     .long   0
d2:     .short   0
d3:     .short   0
        .globl   .c1[PR]
        .csect   .c1[PR]
        .globl   l1
l1:     .using   data1, 7
        l   5, d1
        stu 5, t_data[TD](2)
        br                  # this br is necessary.
                            # without it, prog hangs
        .toc
        .comm  t_data[TD],4
```

   d. Source for main program mm.c:

```
extern  long  t_data;
main()
{
     int  sw;
     sw = 2;
     if ( sw == 2 ) {
       foo_pm();
       printf ( "when sw is 2, t_data is 0x%x\n", t_data );
     }
     sw = 1;
     if ( sw == 1 ) {
       bar_pm();
       printf ( "when sw is 1, t_data is 0x%x\n", t_data );
     }
}
```

   e. Instructions for creating the executable file from the source:

```
as -o foo_pm.o foo_pm.s
as -o bar_pm.o bar_pm.s
as -o c1.o c1.s
cc -o mm mm.c foo_pm.o bar_pm.o c1.o
```

f. The following is printed if `mm` is executed:

```
when sw is 2, t_data is 0xaa
when sw is 1, t_data is 0xbb
```

Related Information

Pseudo-ops Overview.

The **.csect** pseudo-op, **.using** pseudo-op.

.eb Pseudo-op

Purpose

Identifies the end of an inner block and provides additional information specific to the end of an inner block.

Syntax

.eb *Number*

Description

The **.eb** pseudo-op identifies the end of an inner block and provides symbol table information necessary when using the symbolic debugger.

The **.eb** pseudo-op has no other effect on assembly and is customarily inserted by a compiler.

Parameters

Number Specifies a line number in the original source file on which the inner block ends.

Examples

The following example demonstrates the use of the **.eb** pseudo-op:

```
.eb   10
```

Related Information

Pseudo-ops Overview.

The **.bb** pseudo-op.

.ec Pseudo-op

Purpose

Identifies the end of a common block and provides additional information specific to the end of a common block.

Syntax

.ec

Description

The **.ec** pseudo-op identifies the end of a common block and provides symbol table information necessary when using the symbolic debugger.

The **.ec** pseudo-op has no other effect on assembly and is customarily inserted by a compiler.

Examples

The following example demonstrates the use of the **.ec** pseudo-op:

```
.bc   "commonblock"
.ec
```

Related Information

Pseudo-ops Overview.

The **.bc** pseudo-op.

.ef Pseudo-op

Purpose

Identifies the end of a function and provides additional information specific to the end of a function.

Syntax

.ef *Number*

Description

The **.ef** pseudo-op identifies the end of a function and provides symbol table information necessary when using the symbolic debugger.

The **.ef** pseudo-op has no other effect on assembly and is customarily inserted by a compiler.

Parameters

Number Specifies a line number in the original source file on which the function ends.

Examples

The following example demonstrates the use of the **.ef** pseudo-op:

```
.ef   10
```

Related Information

Pseudo-ops Overview.

The **.bf** pseudo-op.

.ei Pseudo-op

Purpose
Identifies the end of an included file and provides additional information specific to the end of an included file.

Syntax
.ei

Description
The **.ei** pseudo-op identifies the end of an included file and provides symbol table information necessary when using the symbolic debugger.

The **.ei** pseudo-op has no other effect on assembly and is customarily inserted by a compiler.

Examples
The following example demonstrates the use of the **.ei** pseudo-op:

```
.ei   "file.s"
```

Related Information
Pseudo-ops Overview.

The **.bi** pseudo-op.

.es Pseudo-op

Purpose
Identifies the end of a static block and provides additional information specific to the end of a static block.

Syntax
.es

Description
The **.es** pseudo-op identifies the end of a static block and provides symbol table information necessary when using the symbolic debugger.

The **.es** pseudo-op has no other effect on assembly and is customarily inserted by a compiler.

Examples
The following example demonstrates the use of the **.es** pseudo-op:

```
.lcomm cgdat, 0x2b4
.csect .text[PR]
.bs cgdat
.stabx "ONE:1=Ci2,0,4;",0x254,133,0
.stabx "TWO:S2=G5TWO1:3=Cc5,0,5;,0,40;;",0x258,133,8
.es
```

Related Information

Pseudo-ops Overview.

The **.bs** pseudo-op.

.extern Pseudo-op

Purpose

Identifies a symbol defined in another source module.

Syntax

.extern *Name*

Description

The **.extern** instruction identifies the *Name* value as a symbol defined in another source module, and *Name* becomes an external symbol. Any external symbols used in the current assembly that are not defined in the current assembly must be declared with an **.extern** statement. A locally defined symbol that appears in an **.extern** statement is equivalent to using that symbol in a **.globl** statement. A symbol not locally defined that appears in a **.globl** statement is equivalent to using that symbol in an **.extern** statement. An undefined symbol is flagged as an error unless the **-u** flag of the **as** command is used.

Parameters

Name Specifies an operand that is an external symbol and that can be a Qualname. (A *Qualname* parameter specifies the *Name* and *StorageMappingClass* values for the control section.)

Examples

The following example demonstrates the use of the **.extern** pseudo-op:

```
   .extern proga[PR]
   .toc
T.proga:   .tc proga[TC],proga[PR]
```

Related Information

Pseudo-ops Overview.

The **.csect** pseudo-op, **.globl** pseudo-op.

.file Pseudo-op

Purpose

Identifies a source file name.

Syntax

.file *StringConstant*

Description

The **.file** pseudo-op provides symbol table information necessary for the use of the symbolic debugger and linkage editor. The **.file** pseudo-op also provides the intended target environment and source language type for the use of the link editor.

For cascade compilers, the **.file** pseudo-op has no other effect on assembly and is customarily inserted by the compiler.

It is recommended that the **.file** pseudo-op be placed at the beginning of the source code for assembly language programs. If the **.file** pseudo-op is omitted from the source code, the assembler processes the program as if the **.file** pseudo-op were the first statement. The assembler does this by creating an entry in the symbol table with the source program name as the file name. If the source is standard input, the file name will be **noname**. The assembler listing will not have this inserted entry.

Parameters

StringConstant Specifies the file name of the original source file.

Examples

1. To use a source file named **main.c**, enter:
   ```
   .file "main.c"
   ```
2. To use a source file named **asml.s**, enter:
   ```
   .file "asml.s"
   ```

Related Information

Pseudo-ops Overview.

The **.function** pseudo-op.

.float Pseudo-op

Purpose

Stores a floating-point constant at the next fullword location.

Syntax

.float *FloatingConstant*

Description

The **.float** stores a floating-point constant at the next fullword location. Fullword alignment occurs if necessary.

Parameters

FloatingConstant Specifies a floating-point constant to be assembled.

Examples

The following example demonstrates the use of the **.float** pseudo-op:

```
.float 3.4
.float -77
.float 134E-12
```

Related Information

Pseudo-ops Overview.

The **.double** pseudo-op.

.function Pseudo-op

Purpose

Identifies a function and provides additional information specific to the function.

Syntax

.function *Name*, *Expression1*, *Expression2*, *Expression3*,[*Expression4*]

Description

The **.function** pseudo-op identifies a function and provides symbol table information necessary for the use of the symbolic debugger.

The **.function** pseudo-op has no other effect on assembly and is customarily inserted by a compiler.

Parameters

Name	Represents the function *Name* and should be defined as a symbol or control section (csect) *Qualname* in the current assembly. (A *Qualname* specifies a *Name* and *StorageMappingClass* for the control section.)
Expression1	Represents the top of the function.
Expression2	Represents the storage mapping class of the function.
Expression3	Represents the type of the function.

The third and fourth parameters to the **.function** pseudo-op serve only as place holders. These parameters are retained for downward compatibility with previous systems (RT, System V).

Expression4	Represents the size of the function (in bytes). This parameter must be an absolute expression. This parameter is optional.

> **Note:** If the *Expression4* parameter is omitted, the function size is set to the size of the csect to which the function belongs. A csect size is equal to the function size only if the csect contains one function and the beginning and end of the csect are the same as the beginning and end of the function.

Examples

The following example illustrates the use of the **.function** pseudo-op:

```
.globl   .hello[pr]
.csect   .hello[pr]
.function   .hello[pr],L.1B,16,044,0x86
L.1B:
```

Related Information

Pseudo-ops Overview.

The **.bf** pseudo-op, **.ef** pseudo-op, **.file** pseudo-op.

.globl Pseudo-op

Purpose

Makes a symbol globally visible to the linker.

Syntax

.globl *Name*

Description

The **.globl** pseudo-op makes the symbol *Name* globally visible to the linker and available to any file that is linked to the file in which the **.globl** pseudo-op occurs.

- If the **.globl** pseudo-op is not used for a symbol, then that symbol is, unless otherwise effected, only visible within the current assembly and not to other modules that may later be linked to the current assembly. Alternately, the **.extern** or **.weak** pseudo-op can be used to effect visibility.
- If *Name* is defined in the current assembly, its type and value arise from that definition, not the **.globl** definition.
- The binder maps all common segments with the same name into the same memory. If the name is declared **.globl** and defined in one of the segments, this has the same effect as declaring the common symbols to be **.globl** in all segments. In this way, common memory can be initialized.

Parameters

Name Represents any label or symbol that is defined locally and requires external visibility. This parameter can be a *Qualname*. (A *Qualname* specifies a *Name* and *StorageMappingClass* for the control section.)

Examples

The following example illustrates the use of the **.globl** pseudo-op:

```
   .globl main
main:
   .csect data[rw]
   .globl data[rw]
```

Related Information

Pseudo-ops Overview.

The **.comm** pseudo-op, **.extern** pseudo-op, and the **.weak** pseudo-op.

.hash Pseudo-op

Purpose

Associates a hash value with an external symbol.

Syntax

.hash *Name, StringConstant*

Description

The hash string value contains type-checking information. It is used by the link-editor and program loader to detect variable mismatches and argument interface errors prior to the execution of a program.

Hash string values are usually generated by compilers of strongly typed languages. The hash value for a symbol can only be set once in an assembly. See Type-Check Section in the XCOFF Object (a.out) File Format for more information on type encoding and checking.

Parameters

Name Represents a symbol. Because this should be an external symbol, *Name* should appear in an **.extern** or **.global** statement.

StringConstant Represents a type-checking hash string value. This parameter consists of characters that represent a hexadecimal hash code and must be in the set [0-9A-F] or [0-9a-f].

A hash string comprises the following three fields:

- Language Identifier is a 2-byte field representing each language. The first byte is 0x00. The second byte contains predefined language codes that are the same as those listed in the **.source** pseudo-op.
- General Hash is a 4-byte field representing the most general form by which a data symbol or function can be described. It is the greatest common denominator among languages supported by AIX. A universal hash can be used for this field.
- Language Hash is a 4-byte field containing a more detailed, language-specified representation of data symbol or function.

Note: A hash string must have a length of 10 bytes. Otherwise, a warning message is reported when the **-w** flag is used. Since each character is represented by two ASCII codes, the 10-byte hash character string is represented by a string of 20 hexadecimal digits.

Examples

The following example illustrates the use of the **.hash** pseudo-op:

```
.extern b[pr]
.extern a[pr]
.extern e[pr]
.hash b[pr],"0000A9375C1F51C2DCF0"
.hash a[pr],"ff0a2cc12365de30"  # warning may report
.hash e[pr],"00002020202051C2DCF0"
```

Related Information

Pseudo-ops Overview.

Type-Check Section in XCOFF Object (a.out) File Format.

The **.extern** pseudo-op, **.globl** pseudo-op.

.lcomm Pseudo-op

Purpose

Defines a local uninitialized block of storage.

Syntax

.lcomm *Name1, Expression*[, *Name2*]

Description

The **.lcomm** pseudo-op defines a local uninitialized block of storage called a local common (LC) section. At run time, this storage block will be reserved when the LC section is allocated at the end of the **.data** section. This storage block is for uninitialized data.

Use the **.lcomm** pseudo-op with local uninitialized data, which is data that will probably not be accessed outside the local assembly.

The symbol *Name1* is a label at the top of the local uninitialized block of storage. The location counter for this LC section is incremented by the *Expression* parameter. A specific LC section can be specified by the *Name2* parameter. Otherwise an unnamed section is used.

Parameters

Name1	Represents a relocatable symbol. The symbol *Name1* is a label at the top of the local uninitialized block of storage. *Name1* does not appear in the symbol table unless it is the operand of a **.globl** statement.
Expression	Represents an absolute expression that is defined in the first pass of the assembler. The *Expression* parameter also increments the location counter for the LC section.
Name2	Represents a control section (csect) name that has storage mapping class BS and storage type CM. The *Name2* parameter allows the programmer to specify the BS csect for the allocated storage. If a specific LC section is not specified by the *Name2* parameter, an unnamed section is used.

Examples

1. To set up 5KB of storage and refer to it as `buffer`:

```
.lcomm buffer,5120
        # Can refer to this 5K
        # of storage as "buffer".
```

2. To set up a label with the name `proga`:

```
.lcomm b3,4,proga
        # b3 will be a label in a csect of class BS
        # and type CM with name "proga".
```

Related Information

Pseudo-ops Overview.

The **.comm** pseudo-op.

.lglobl Pseudo-op

Purpose

Provides a means to keep the information of a static name in the symbol table.

Syntax

.lglobl *Name*

Description

A static label or static function name defined within a control section (csect) must be kept in the symbol table so that the static label or static function name can be referenced. This symbol has a class of ″hidden external″ and differs from a global symbol. The **.lglobl** pseudo-op gives the symbol specified by the *Name* parameter have a symbol type of LD and a class of C_HIDEXT.

> **Note:** The **.lglobl** pseudo-op does not have to apply to any csect name. The assembler automatically generates the symbol table entry for any csect name with a class of C_HIDEXT unless there is an explicit **.globl** pseudo-op applied to the csect name. If an explicit **.globl** pseudo-op applies to the csect name, the symbol table entry class for the csect is C_EXT.

Parameters

Name Specifies a static label or static function name that needs to be kept in the symbol table.

Examples

The following example demonstrates the use of the **.lglobl** pseudo-op:

```
        .toc
        .file    "test.s"
        .lglobl  .foo
        .csect   foo[DS]
foo:
        .long    .foo,TOC[tc0],0
        .csect   [PR]
.foo:
        .stabx   "foo:F-1",.foo,142,0
        .function        .foo,.foo,16,044,L..end_foo-.foo
        .
        .
        .

>
```

Related Information

Pseudo-ops Overview.

The **.function** pseudo-op, **.globl** pseudo-op.

.line Pseudo-op

Purpose

Identifies a line number and provides additional information specific to the line number.

Syntax

.line *Number*

Description

The **.line** pseudo-op identifies a line number and is used with the **.bi** pseudo-op to provide a symbol table and other information necessary for use of the symbolic debugger.

This pseudo-op is customarily inserted by a compiler and has no other effect on assembly.

Parameters

Number Represents a line number of the original source file.

Examples

The following example illustrates the use of the **.line** pseudo-op:

```
.globl .hello[pr]
.csect .hello[pr]
.align 1
.function   .hello[pr],L.1B,16,044
.stabx "hello:f-1",0,142,0
.bf 2
.line 1
.line 2
```

Related Information

Pseudo-ops Overview.

The **.bi** pseudo-op, **.bf** pseudo-op, **.function** pseudo-op.

.long Pseudo-op

Purpose

Assembles expressions into consecutive fullwords.

Syntax

.long *Expression*[,*Expression,...*]

Description

The **.long** pseudo-op assembles expressions into consecutive fullwords. Fullword alignment occurs as necessary.

Parameters

Expression Represents any expression to be assembled into fullwords.

Examples

The following example illustrates the use of the **.long** pseudo-op:

```
.long 24,3,fooble-333,0
```

Related Information

Pseudo-ops Overview.

The **.byte** pseudo-op, **.short** pseudo-op, **.vbyte** pseudo-op.

.llong Pseudo-op

Purpose

Assembles expressions into consecutive double-words.

Syntax

.llong *Expression*[,*Expression,...*]

Description

The **.llong** pseudo-op assembles expressions into consecutive double-words. In 32-bit mode, alignment occurs on fullword boundaries as necessary. In 64-bit mode, alignment occurs on double-word boundaries as necessary.

Parameters

Expression Represents any expression to be assembled into fullwords/double-words.

Examples

The following example illustrates the use of the **.llong** pseudo-op:

```
.extern  fooble
.llong   24,3,fooble-333,0
```

which fills 4 double-words, or 32 bytes, of storage.

Related Information

Pseudo-ops Overview.

The **.byte** pseudo-op, **.short** pseudo-op, **.vbyte** pseudo-op, **.long** pseudo-op.

.machine Pseudo-op

Purpose

Defines the intended target environment.

Syntax

.machine *StringConstant*

Description

The **.machine** pseudo-op selects the correct instruction mnemonics set for the target machine. It provides symbol table information necessary for the use of the linkage editor. The **.machine** pseudo-op overrides the setting of the **as** command's **-m** flag, which can also be used to specify the instruction mnemonics set for the target machine.

The **.machine** pseudo-op can occur in the source program more than once. The value specified by a **.machine** pseudo-op overrides any value specified by an earlier **.machine** pseudo-op. It is not necessary to place the first **.machine** pseudo-op at the beginning of a source program. If no **.machine** pseudo-op occurs at the beginning of a source program and the **-m** flag is not used with the **as** command, the default assembly mode is used. The default assembly mode is overridden by the first **.machine** pseudo-op.

If a **.machine** pseudo-op specifies a value that is not valid, an error is reported. As a result, the last valid value specified by the default mode value, the **-m** flag, or a previous **.machine** pseudo-op is used for the remainder of the instruction validation in the assembler pass one.

Parameters

StringConstant Specifies the assembly mode. This parameter is not case-sensitive, and can be any of the values which can be specified with the **-m** flag on the command line. Possible values, enclosed in quotation marks, are:

Null string (""") or nothing
Specifies the default assembly mode. A source program can contain only instructions that are common to both POWER family and PowerPC. Any other instruction causes an error.

push Saves the current assembly mode in the assembly mode pushdown stack.

pop Removes a previously saved value from the assembly mode pushdown stack and restore the assembly mode to this saved value.
Note: The intended use of **push** and **pop** is inside of include files which alter the current assembly mode. `.machine "push"` should be used in the included file, before it changes the current assembly mode with another **.machine**. Similarly, `.machine "pop"` should be used at the end of the included file, to restore the input assembly mode.

Attempting to hold more than 100 values in the assembly mode pushdown stack will result in an assembly error. The pseudo-ops `.machine "push"` and `.machine "pop"` are used in pairs.

ppc Specifies the PowerPC common architecture, 32-bit mode. A source program can contain only PowerPC common architecture, 32-bit instructions. Any other instruction causes an error.

ppc64 Specifies the PowerPC 64-bit mode. A source program can contain only PowerPC 64-bit instructions. Any other instruction causes an error.

com Specifies the POWER family and PowerPC architecture intersection mode. A source program can contain only instructions that are common to both POWER family and PowerPC. Any other instruction causes an error.

pwr Specifies the POWER family architecture, POWER family implementation mode. A source program can contain only instructions for the POWER family implementation of the POWER family architecture. Any other instruction causes an error.

pwr2 POWER family architecture, POWER2 implementation. A source program can contain only instructions for the POWER2 implementation of the POWER family architecture. Any other instruction causes an error. (**pwr2** is the preferred value, but the alternate value **pwrx** can also be used.)

any Any nonspecific POWER family/PowerPC architecture or implementation mode. This includes mixtures of instructions from any of the valid architectures or implementations.

601 Specifies the PowerPC architecture, PowerPC 601 RISC Microprocessor mode. A source program can contain only instructions for the PowerPC architecture, PowerPC 601 RISC Microprocessor. Any other instruction causes an error.

Attention: It is recommended that the **601** assembly mode not be used for applications that are intended to be portable to future PowerPC systems. The **com** or **ppc** assembly mode should be used for such applications.

The PowerPC 601 RISC Microprocessor implements the PowerPC architecture, plus some POWER family instructions which are not included in the PowerPC architecture. This allows existing POWER family applications to run with acceptable performance on PowerPC systems. Future PowerPC systems will not have this feature. The **601** assembly mode may result in applications that will not run on existing POWER family systems and that may not have acceptable performance on future PowerPC systems, because the **601** assembly mode permits the use of all the instructions provided by the PowerPC 601 RISC Microprocessor.

603 Specifies the PowerPC architecture, PowerPC 603 RISC Microprocessor mode. A source program can contain only instructions for the PowerPC architecture, PowerPC 603 RISC Microprocessor. Any other instruction causes an error.

604 Specifies the PowerPC architecture, PowerPC 604 RISC Microprocessor mode. A source program can contain only instructions for the PowerPC architecture, PowerPC 604 RISC Microprocessor. Any other instruction causes an error.

A35 Specifies the A35 mode. A source program can contain only instructions for the A35. Any other instruction causes an error.

Note: See “as Command Flags” on page 51 for more information on assembly mode values.

Examples

1. To set the target environment to POWER family architecture, POWER family implementation:
   ```
   .machine "pwr"
   ```
2. To set the target environment to any non-specific POWER family/PowerPC architecture or implementation mode:
   ```
   .machine "any"
   ```
3. To explicitly select the default assembly mode:
   ```
   .machine ""
   ```
4. The following example of assembler output for a fragment of code shows the usage of `.machine "push"` and `.machine "pop"`:

```
 push1.s                              V4.1               04/15/94
File# Line#  Mode Name   Loc Ctr   Object Code           Source
0       1 |                                           .machine   "pwr2"
0       2 |                                           .csect    longname1[PR]
0       3 |  PWR2 longna 00000000  0000000a           .long   10
0       4 |  PWR2 longna 00000004  329e000a           ai    20,30,10
0       5 |  PWR2 longna 00000008  81540014           l    10, 20(20)
0       6 |                                           .machine "push"
0       7 |                                           .machine  "ppc"
0       8 |                                           .csect  a2[PR]
0       9 |  PPC  a2     00000000  7d4c42e6            mftb  10
0      10 |                                           .machine "pop"
0      11 |  PWR2 a2     00000004  329e000a           ai    20,30,10
0      12 |
```

Related Information

"Host Machine Independence and Target Environment Indicator Flag" on page 2.

"Pseudo-ops Overview" on page 459.

"Assembling with the as Command" on page 51.

.org Pseudo-op

Purpose

Sets the value of the current location counter.

Syntax

.org *Expression*

Description

The **.org** pseudo-op sets the value of the current location counter to *Expression*. This pseudo-op can also decrement a location counter. The assembler is control section (csect) oriented; therefore, absolute expressions or expressions that cause the location counter to go outside of the current csect are not allowed.

Parameters

Expression Represents the value of the current location counter.

Examples

The following example illustrates the use of the **.org** pseudo-op:

```
# Assume assembler location counter is 0x114.
.org $+100
#Skip 100 decimal byte (0x64 bytes).
.
.
# Assembler location counter is now 0x178.
```

Related Information

Pseudo-ops Overview.

The **.space** pseudo-op.

.quad Pseudo-op

Purpose

Stores a quad floating-point constant at the next fullword location. Alignment requirements for floating-point data are consistent between 32-bit and 64-bit modes.

Syntax

.quad *FloatingConstant*

Examples

The following example demonstrates the use of the **.quad** pseudo-op:

```
.quad 3.4
.quad -77
.quad 134E12
.quad 5e300
.quad 0.45
```

The above declarations would reserve 16 bytes of storage each.

Related Information

Pseudo-ops Overview.

The **.float** pseudo-op , **.double** pseudo-op .

.ref Pseudo-op

Purpose

Creates a R_REF type entry in the relocation table for one or more symbols.

Syntax

.ref *Name*[**,***Name*...]

Description

The **.ref** pseudo-op supports the creation of multiple RLD entries in the same location. This psuedo-op is used in the output of some compilers to ensure the linkage editor does not discard routines that are used but not referenced explicitly in the text or data sections.

For example, in C++, constructors and destructors are used to construct and destroy class objects. Constructors and destructors are sometimes called only from the run-time environment without any explicit reference in the text section.

The following rules apply to the placement of a **.ref** pseudo-op in the source program:

- The **.ref** pseudo-op cannot be included in a dsect or csect with a storage mapping class of BS or UC.
- The **.ref** pseudo-op cannot be included in common sections or local common sections.

The following rules apply to the operands of the **.ref** pseudo-op (the *Name* parameter):

- The symbol must be defined in the current source module.
- External symbols can be used if they are defined by **.extern** or **.globl**.
- Within the current source module, the symbol can be a csect name (meaning a Qualname) or a label defined in the csect.
- The following symbols cannot be used for the **.ref** operand:
  - pseudo-op **.dsect** names
  - labels defined within a dsect
  - a csect name with a storage mapping class of BS or UC
  - labels defined within a csect with a storage mapping class of BS or UC
  - a pseudo-op **.set** *Name* operand which represents a non-relocatable expression type

Parameters

Name Specifies a symbol for which a R_REF type entry in the relocation table should be created.

Examples

The following example demonstrates the use of the **.ref** pseudo-op:

```
       .csect a1[pr]
C1:    l 10, 20(20)
       .long  0xff
       .csect  a2[pr]
       .set   r10,10
       .extern C4
C2:    .long   10
C3:    .long   20
       .ref C1,C2,C3
       .ref C4
```

Related Information

Pseudo-ops Overview.

The discussion of opposite terms concepts in Combination Handling of Expressions . (This discusses another way to generate a R_REF type entry in the relocation table.)

.rename Pseudo-op

Purpose

Creates a synonym or alias for an illegal or undesirable name.

Syntax

.rename *Name, StringConstant*

Description

The restrictions on the characters that can be used for symbols within an assembler source file are defined in “Constructing Symbols” on page 29. The symbol cannot contain any blanks or special characters, and cannot begin with a digit.

For any external symbol that must contain special characters, the **.rename** pseudo-op provides a way to do so.

The **.rename** pseudo-op changes the *Name* parameter to the *StringConstant* value for all external references at the end of assembly. Internal references to the local assembly are made to *Name*. The externally visible *Name* is *StringConstant*. The **.rename** pseudo-op is useful in referencing symbol names that are otherwise illegal in the assembler syntax.

Parameters

Name	Represents a symbol. To be externally visible, the *Name* parameter must appear in an **.extern** or **.globl** statement.
StringConstant	Represents the value to which the *Name* parameter is changed at end of assembly.

Examples

The following example illustrates the use of the **.rename** pseudo-op:

```
        .csect mst_sect[RW]
        .globl mst_sect[RW]
OK_chars:
        .globl OK_chars
        .long OK_chars
        .rename OK_chars,"$_SPECIAL_$_char"
        .rename mst_sect[RW],"MST_sect_renamed"
```

Related Information

"Pseudo-ops Overview" on page 459.

"Constructing Symbols" on page 29.

".extern Pseudo-op" on page 478, ".globl Pseudo-op" on page 481.

.set Pseudo-op

Purpose

Sets a symbol equal to an expression in both type and value.

Syntax

.set *Name, Expression*

Description

The **.set** pseudo-op sets the *Name* symbol equal to the *Expression* value in type and in value. Using the **.set** pseudo-op may help to avoid errors with a frequently used expression. Equate the expression to a symbol, then refer to the symbol rather than the expression. To change the value of the expression, only change it within the **.set** statement. However, reassembling the program is necessary since **.set** assignments occur only at assembly time.

The *Expression* parameter is evaluated when the assembler encounters the **.set** pseudo-op. This evaluation is done using the rules in Combination Handling of Expressions ; and the type and value of the evaluation result are stored internally. If evaluating the *Expression*, results in an invalid type, all instructions which use the symbol *Name* will have an error.

The stored type and value for symbol *Name*, not the original expression definition, are used when *Name* is used in other instructions.

Parameters

Name	Represents a symbol that may be used before its definition in a **.set** statement; forward references are allowed within a module.
Expression	Defines the type and the value of the symbol *Name*. The symbols referenced in the expression must be defined; forward references are not allowed. The symbols cannot be undefined external expressions.The symbols do not have to be within the control section where the **.set** pseudo-op appears.The *Expression* parameter can also refer to a register number, but not to the contents of the register at run time.

Examples

1. The following example illustrates the use of the **.set** pseudo-op:

```
.set ap,14 # Assembler assigns value 14
           # to the symbol ap -- ap
           # is absolute.
  .
  .
lil ap,2

        # Assembler substitutes value 14
        # for the symbol.
        # Note that ap is a register
        # number in context
        # as lil's operand.
```

2. The following example will result in an assembly error because of an invalid type:

```
     .csect  a1[PR]
 L1:  l       20,30(10)
      .csect  a2[rw]
      .long   0x20
 L2:  .long   0x30
      .set    r1, L2 - L1  # r1 has type of E_REXT
                           # r1 has value of 8
      .long   r1 + 10
      .long   L2 - r1      #  Error will be reported.
                           #    L2 is E_REL
                           #    r1 is E_REXT
                           #  E_REL - E_REXT ==> Invalid type
```

Related Information

Pseudo-ops Overview.

Expressions .

.short Pseudo-op

Purpose

Assembles expressions into consecutive halfwords.

Syntax

.short *Expression*[,*Expression,...*]

Description

The **.short** pseudo-op assembles *Expressions* into consecutive halfwords. Halfword alignment occurs as necessary.

Parameters

Expression Represents expressions that the instruction assembles into halfwords. The *Expression* parameter cannot refer to the contents of any register. If the *Expression* value is longer than a halfword, it is truncated on the left.

Examples

The following example illustrates the use of the **.short** pseudo-op:

```
.short 1,0x4444,fooble-333,0
```

Related Information

Pseudo-ops Overview.

The **.byte** pseudo-op, **.long** pseudo-op, **.vbyte** pseudo-op.

.source Pseudo-op

Purpose

Identifies the source language type.

Syntax

.source *StringConstant*

Description

The **.source** pseudo-op identifies the source language type and provides symbol table information necessary for the linkage editor. For cascade compilers, the symbol table information is passed from the compiler to the assembler to indicate the high-level source language type. The default source language type is ″Assembler.″

Parameters

StringConstant
: Specifies a valid program language name. This parameter is not case-sensitive. If the specified value is not valid, the language ID will be reset to ″Assembler.″ The following values are defined:

  0x00 C

  0x01 FORTRAN

  0x02 Pascal

  0x03 Ada

  0x04 PL/1

  0x05 BASIC

  0x06 LISP

  0x07 COBOL

  0x08 Modula2

  0x09 C++

  0x0a RPG

  0x0b PL8, PLIX

  0x0c Assembler

Examples

To set the source language type to C++:

```
.source "C++"
```

Related Information

Pseudo-ops Overview.

Source Language Type .

.space Pseudo-op

Purpose

Skips a specified number of bytes in the output file and fills them with binary zeros.

Syntax

.space *Number*

Description

The **.space** skips a number of bytes, specified by *Number*, in the output file and fills them with binary zeros. The **.space** pseudo-op may be used to reserve a chunk of storage in a control section (csect).

Parameters

Number Represents an absolute expression that specifies the number of bytes to skip.

Examples

The following example illustrates the use of the **.space** pseudo-op:

```
.csect data[rw]
.space 444
  .
  .
foo:    # foo currently located at offset 0x1BC within
        # csect data[rw].
```

Related Information

Pseudo-ops Overview.

.stabx Pseudo-op

Purpose

Provides additional information required by the debugger.

Syntax

.stabx *StringConstant, Expression1, Expression2, Expression3*

Description

The **.stabx** pseudo-op provides additional information required by the debugger. The assembler places the *StringConstant* argument, which provides required stabstring information for the debugger, in the .debug section.

The **.stabx** pseudo-op is customarily inserted by a compiler.

Parameters

StringConstant	Provides required Stabstring information to the debugger.
Expression1	Represents the symbol value of the character string. This value is storage mapping class dependent. For example, if the storage mapping class is C_LSYM, the value is the offset related to the stack frame. If the storage mapping class is C_FUN, the value is the offset within the containing control section (csect).
Expression2	Represents the storage class of the character string.
Expression3	Represents the symbol type of the character string.

Examples

The following example illustrates the use of the **.stabx** pseudo-op:

```
.stabx "INTEGER:t2=-1",0,140,4
```

Related Information

Pseudo-ops Overview.

Debug Section in the XCOFF Object (a.out) File Format.

The **.function** pseudo-op.

.string Pseudo-op

Purpose

Assembles character values into consecutive bytes and terminates the string with a null character.

Syntax

.string *StringConstant*

Description

The **.string** pseudo-op assembles the character values represented by *StringConstant* into consecutive bytes and terminates the string with a null character.

Parameters

StringConstant	Represents a string of character values assembled into consecutive bytes.

Examples

The following example illustrates the use of the **.string** pseudo-op:

```
mine:   .string "Hello, world!"
# This produces
# 0x48656C6C6F2C20776F726C642100.
```

Related Information

Pseudo-ops Overview.

The **.byte** pseudo-op, **.vbyte** pseudo-op.

.tbtag Pseudo-op

Purpose

Defines a debug traceback tag, preceded by a word of zeros, that can perform tracebacks for debugging programs.

Syntax

.tbtag *Expression1, Expression2, Expression3, Expression4, Expression5, Expression6, Expression7, Expression8*,[*Expression9, Expression10, Expression11, Expression12, Expression13, Expression14, Expression15, Expression16*]

Description

The **.tbtag** pseudo-op defines a traceback tag by assembling *Expression*s into consecutive bytes, words, and halfwords, depending on field requirements. An instruction can contain either 8 expressions (*Expression1* through *Expression8*) or 16 expressions (*Expression1* through *Expression16*). Anything else is a syntax error. A compiler customarily inserts the traceback information into a program at the end of the machine instructions, adding a string of zeros to signal the start of the information.

Parameters

Expression1 Byte	version	/*Traceback format version */
Expression2 Byte	lang	/*Language values */
	TB_C	0
	TB_FORTRAN	1
	TB_PASCAL	2
	TB_ADA	3
	TB_PL1	4
	TB_BASIC	5
	TB_LISP	6
	TB_COBOL	7
	TB_MODULA2	8
	TB_CPLUSPLUS	9
	TB_RPG	10
	TB_PL8	11
	TB_ASM	12
Expression3 Byte		/*Traceback control bits */
	globallink	Bit 7. Set if routine is global linkage.
	is_eprol	Bit 6. Set if out-of-town epilog/prologue.
	has_tboff	Bit 5. Set if offset from start of proc stored.
	int_proc	Bit 4. Set if routine is internal.
	has_ctl	Bit 3. Set if routine involves controlled storage.
	tocless	Bit 2. Set if routine contains no TOC.
	fp_present	Bit 1. Set if routine performs FP operations.
	log_abort	Bit 0. Set if routine involves controlled storage.
Expression4		/*Traceback control bits (continued) */

Byte		
	int_hndl	Bit 7. Set if routine is interrupt handler.
	name_present	Bit 6. Set if name is present in proc table.
	uses_alloca	Bit 5. Set if alloca used to allocate storage.
	cl_dis_inv	Bits 4, 3, 2. On-condition directives
		WALK_ONCOND 0 Walk stack; don't restore state
		DISCARD_ONCOND 1 Walk the stack and discard.
		INVOKE_ONCOND 1 Invoke specific system routine
	saves_cr	Bit 1. Set if procedure saves condition register.
	saves_lr	Bit 0. Set if procedure saves link register.
Expression5		/*Traceback control bits (continued) */
Byte		
	stores_bc	Bit 7. Set if procedure stores the backchain.
	spare2	Bit 6. Spare bit.
	fpr_saved	Bits 5, 4, 3, 2, 1, 0. Number of FPRs saved, max 32.
Expression6		/*Traceback control bits (continued) */
Byte		
	spare3	Bits 7, 6. Spare bits.
	gpr_saved	Bits 5, 4, 3, 2, 1, 0. Number of GPRs saved, max 32.
Expression7	fixedparms	/*Traceback control bits (continued) */
Byte		
Expression8		
Byte		
	floatparms	Bits 7, 6, 5, 4, 3, 2,1. Number of floating point parameters.
	parmsonstk	Bit 0. Set if all parameters placed on stack.
Expression9	parminfo	/*Order and type coding of parameters */
Word		
	'0'	Fixed parameter.
	'10'	Single-precision float parameter.
	'11'	Double-precision float parameter.
Expression10	tb_offset	/*Offset from start of code to tb table */
Word		
Expression11	hand_mask	/*What interrupts are handled */
Word		
Expression12	ctl_info	/*Number of CTL anchors */
Word		
Expression13	ctl_info_disp	/*Displacements of each anchor into stack*/
Word		
Expression14	name_len	/*Length of procedure name */
Halfword		
Expression15	name	/*Name */
Byte		
Expression16	alloca_reg	/*Register for alloca automatic storage*/
Byte		

Examples

The following example illustrates the use of the **.tbtag** pseudo-op:

```
.tbtag 1,0,0xff,0,0,16,0,0
```

Related Information

"Pseudo-ops Overview" on page 459.

"Traceback Tags" on page 76.

".byte Pseudo-op" on page 466.

.tc Pseudo-op

Purpose

Assembles expressions into a Table of Contents (TOC) entry.

Syntax

.tc [*Name*]**[**TC**]**, *Expression*[*,Expression,...*]

Note: The boldface brackets containing TC are part of the syntax and do *not* specify optional parameters.

Description

The **.tc** pseudo-op assembles *Expressions* into a TOC entry, which contains the address of a routine, the address of a function descriptor, or the address of an external variable. A **.tc** statement can only appear inside the scope of a **.toc** pseudo-op. A TOC entry can be relocated as a body. TOC entry statements can have local labels, which will be relative to the beginning of the entire TOC as declared by the first **.toc** statement. Addresses contained in the TOC entry can be accessed using these local labels and the TOC Register GPR 2.

TOC entries that contain only one address are subject to being combined by the binder. This can occur if the TOC entries have the same name and reference the same control section (csect) (symbol). Be careful when coding TOC entries that reference nonzero offsets within a csect. To prevent unintended combining of TOC entries, unique names should be assigned to TOC entries that reference different offsets within a csect.

Parameters

Name	Specifies name of the TOC entry created. The *StorageMappingClass* is TC for TOC entires. *Name***[**TC**]** can be used to refer to the TOC entry where appropriate.
Expression	Specifies symbol or expression which goes into TOC entry.

Examples

The following example illustrates the use of the **.tc** pseudo-op:

```
.toc
# Create three TOC entries, the first
# with the name proga, the second
# with the name progb, and the last
# unnamed.
T.proga:        .tc proga[TC],progr[RW],dataA
T.progb:        .tc progb[TC],proga[PR],progb[PR]
T.progax:       .tc  proga[TC],dataB
                .tc       [TC],dataB
                .csect proga[PR]
# A .csect should precede any statements following a
# .toc/.tc section which do not belong in the TOC.
                l 5,T.proga(2)   # The address of progr[RW]
                                 # is loaded into GPR 5.
                l 5,T.progax(2)  # The address of progr[RW]
                                 # is loaded into GPR 5.
                l 5,T.progb+4(2) # The address of progb[PR]
                                 # is loaded into GPR 5.
```

Related Information

“Pseudo-ops Overview” on page 459.

“.csect Pseudo-op” on page 469, “.toc Pseudo-op”, “.tocof Pseudo-op”.

.toc Pseudo-op

Purpose

Defines the table of contents of a module.

Syntax

.toc

Description

The **.toc** pseudo-op defines the table of contents (TOC) anchor of a module. Entries in the TOC section can be declared with **.tc** pseudo-op within the scope of the **.toc** pseudo-op. The **.toc** pseudo-op has scope similar to that of a **.csect** pseudo-op. The TOC can be continued throughout the assembly wherever a **.toc** appears.

Examples

The following example illustrates the use of the **.toc** pseudo-op:

```
.toc
# Create two TOC entries. The first entry, named proga,
# is of type TC and contains the address of proga[RW] and dataA.

# The second entry, named progb, is of type TC and contains
# the address of progb[PR] and progc[PR].

T.proga:          .tc proga[TC],proga[RW],dataA
T.progb:          .tc progb[TC],progb[PR],progc[PR]

.csect proga[RW]

# A .csect should precede any statements following a .toc/.tc
# section which do not belong in the TOC.

.long TOC[tc0]

# The address of the TOC for this module is placed in a fullword.
```

Related Information

The **.tc** pseudo-op, **.tocof** pseudo-op.

.tocof Pseudo-op

Purpose

Allows for the definition of a local symbol as the table of contents of an external symbol so that the local symbol can be used in expressions.

Syntax

.tocof *Name1, Name2*

Description

The **.tocof** pseudo-op makes the *Name2* value globally visible to the linker and marks the *Name1* symbol as the table of contents (TOC) of another module that contains the symbol *Name2*. As a result, a local symbol can be defined as the TOC of an external symbol so that the local symbol can be used in expressions or to refer to the TOC of another module, usually in a **.tc** statement. This pseudo-op generates a Relocation Dictionary entry (RLD) that causes this data to be initialized to the address of the TOC external symbols. The **.tocof** pseudo-op can be used for intermodule calls that require the caller to first load up the address of the called module's TOC before transferring control.

Parameters

Name1 Specifies a local symbol that acts as the TOC of a module that contains the *Name2* value. The *Name1* symbol should appear in **.tc** statements.

Name2 Specifies an external symbol that exists within a module that contains a TOC.

Examples

The following example illustrates the use of the **.tocof** pseudo-op:

```
tocbeg:   .toc
apb:   .tc [tc],pb,tpb
# This is an unnamed TOC entry
# that contains two addresses:
# the address of pb and
# the address of the TOC
# containing pb.
.tocof tpb,pb
.set always,0x14
.csect [PR]
.using tocbeg,rtoc
l 14,apb
# Load R14 with the address
# of pb.
l rtoc,apb+4
# Load the TOC register with the
# address pb's TOC.
mtspr lr,14
# Move to Link Register.
bcr always,0
# Branch Conditional Register branch
# address is contained in the Link
# register.
```

Related Information

"Pseudo-ops Overview" on page 459.

"Understanding and Programming the TOC" on page 80.

".tc Pseudo-op" on page 499, ".toc Pseudo-op" on page 500.

.using Pseudo-op

Purpose

Allows the user to specify a base address and assign a base register number.

Syntax

.using *Expression*, *Register*

Description

The **.using** pseudo-op specifies an expression as a base address, and assigns a base register, assuming that the *Register* parameter contains the program address of *Expression* at run time. Symbol names do not have to be previously defined.

> **Note:** The **.using** pseudo-op does not load the base register; the programmer should ensure that the base address is loaded into the base register before using the implicit address reference.

The **.using** pseudo-op only affects instructions with an implicit-based address. It can be issued on the control section (csect) name and all labels in the csects. It can also be used on the dsect name and all the labels in the dsects. Other types of external symbols are not allowed (**.extern**).

Using Range

The range of a **.using** pseudo-op (using range) is -32768 or 32767 bytes, beginning at the base address specified in the **.using** pseudo-op. The assembler converts each implicit address reference (or expression), which lies within the using range, to an explicit-based address form. Errors are reported for references outside the using range.

Two using ranges overlap when the base address of one **.using** pseudo-op lies within the ranges of another **.using** pseudo-op. When using range overlap happens, the assembler converts the implicit address reference by choosing the smallest signed offset from the base address as the displacement. The corresponding base register is used in the explicit address form. This applies only to implicit addresses that appear after the second **.using** pseudo-op.

In the next example, the using range of `base2` and `data[PR]` overlap. The second **l** instruction is after the second **.using** pseudo-op. Because the offset from `data[PR]` to `d12` is greater than the offset from `base2` to `d12`, `base2` is still chosen.

```
        .csect  data[PR]
        .long   0x1
dl:     .long   0x2
base2:  .long   0x3
        .long   0x4
        .long   0x4
        .long   0x5
d12:    .long   0x6
        l 12, data_block.T(2)   # Load addr. of data[PR] into r12
        ca1 14, base2(12)       # Load addr. of base2 into r14
        .using base2, 14
        l 4, d12                # Convert to 1 4, 0xc(14)
        .using data[PR], 12
        l 4, d12                # Converts to 1 4, 0xc(14)
                                # because base2 is still chosen
        .toc
data_block.T:   tc data_block[tc], data[PR]
```

There is an internal using table that is used by the assembler to track the **.using** pseudo-op. Each entry of the using table points to the csect that contains the expression or label specified by the *Expression* parameter of the **.using** pseudo-op. The using table is only updated by the **.using** pseudo-ops. The location of the **.using** pseudo-ops in the source program influences the result of the conversion of an implicit-based address. The next two examples illustrate this conversion.

Example 1:

```
            .using   label1,4
            .using   label2,5
            .csect   data[RW]
label1:     .long    label1
            .long    label2
```

```
            .long    8
label1_a:   .long    16
            .long    20
label2:     .long    label2
            .long    28
            .long    32
label2_a:   .long    36
            .long    40
            .csect   sub1[pr]
            1        6,label1_a      # base address label2 is
                                     # chosen, so convert to:
                                     # 1 6, -8(5)
            1        6,label2_a      # base address label2 is
                                     # chosen, so convert to:
                                     # 1 6, 0xc(5)
```

Example 2:

```
            .csect  data[RW]
label1:     .long   label1
            .long   label2
            .long   12
label1_a:   .long   16
            .long   20
label2:     .long   label2
            .long   28
            .csect  sub2[pr]
            .using  label1,4
            1       6,label1_a       # base address label1 is
                                     # chosen, so convert to:
                                     # 1 6, 0xc(4)
           .using   label2,5
            1       6,label1_a       # base address label2 is
                                     # chosen, so convert to:
                                     # 1 6, -8(5)
```

Two using ranges coincide when the same base address is specified in two different **.using** pseudo-ops, while the base register used is different. The assembler uses the lower numbered register as the base register when converting to explicit-based address form, because the using table is searched from the lowest numbered register to the highest numbered register. The next example shows this case:

```
        .csect  data[PR]
        .long   0x1
dl:     .long   0x2
base2;  .long   0x3
        .long   0x4
        .long   0x5
dl2:    .long   0x6
        1 12, data_block.T(2)   # Load addr. of data[PR] into r12
        1 14, data_block.T(2)   # Load addr. of data[PR] into r14
        .using data[PR], 12
        1 4, dl2                # Convert to: 1 4, 0x14(12)
        .using data[PR], 14
        1 4, dl2                # Convert to: 1 4, 0x14(12)
        .toc
data_block.T:   .tc data_block[tc], data[PR]
```

Using Domain

The domain of a **.using** pseudo-op (the using domain) begins where the **.using** pseudo-op appears in a csect and continue to the end of the source module except when:

- A subsequent **.drop** pseudo-op specifies the same base register assigned by the preceding **.using** pseudo-op.
- A subsequent **.using** pseudo-op specifies the same base register assigned by the preceding **.using** pseudo-op.

These two exceptions provide a way to use a new base address. The next two examples illustrate these exceptions:

Example 1:

```
        .csect  data[PR]
        .long   0x1
dl:     .long   0x2
base2;  .long   0x3
        .long   0x4
        .long   0x5
dl2:    .long   0x6
        l 12, data_block.T(2)   # Load addr. of data[PR] into r12
        ca1 14, base2(12)       # Load addr. of base2 into r14
        .using base2, 14
        l 4, dl2                # Convert to: l 4, 0xc(14)
                                # base address base2 is used
        l 14, data_block.T(2)   # Load addr. of data[PR] into r14
        .using data[PR], 14
        l 4, dl2                # Convert to: l 4, 0x14(14)
        .toc
data_block.T:   .tc data_block[tc], data[PR]
```

Example 2:

```
        .csect  data[PR]
        .long   0x1
dl:     .long   0x2
base2;  .long   0x3
        .long   0x4
        .long   0x5
dl2:    .long   0x6
        l 12, data_block.T(2)   # Load addr. of data[PR] into r12
        ca1 14, base2(12)       # Load addr. of base2 into r14
        .using base2, 14
        l 4, dl2                # Convert to: l 4, 0xc(14)
        .drop 14
        .using data[PR], 12
        l 4, dl2                # Convert to: l 4, 0x14(12)
        .toc
data_block.T:    .tc data_block[tc], data[PR]
```

Note: The assembler does not convert the implicit address references that are outside the Using Domain. So, if these implicit address references appear before any **.using** pseudo-op that defines a base address of the current csect, or after the **.drop** pseudo-ops drop all the base addresses of the current csect, an error is reported.

The next example shows the error conditions:

```
        .csect  data[PR]
        .long   0x1
dl:     .long   0x2
base2;  .long   0x3
        .long   0x4
        .long   0x5
dl2:    .long   0x6
        l 4, dl2                # Error is reported here
        l 12, data_block.T(2)   # Load addr. of data[PR] into r12
        l 14, data_block.T(2)   # Load addr. of data[PR] into r14
        .using data[PR], 12
        l 4, dl2
        l 4, 0x14(12)
        .drop 12
        l 4, dl2                # Error is reported here
        .using data[PR], 14
        l 4, dl2
```

```
        l 4, 0x14(14)
        .toc
data_block.T:   .tc data_block[tc], data[PR]
        .csect  data1[PR]
dl3:    .long   0x7
        .using  data[PR], 5
        l 5, dl3                # Error is reported
                                # here, dl3 is in csect
                                # data1[PR] and
                                # Using table has no entry of
                                # csect data1[PR]
        l 5, dl2                # No error, because dl2 is in
                                # data [PR]
```

Parameters

Register	Represents the register number for expressions. It must be absolute and must evaluate to an integer from 0 to 31 inclusive.
Expression	Specifies a label or an expression involving a label that represents the displacement or relative offset into the program. The *Expression* parameter can be an external symbol if the symbol is a csect or Table of Contents (TOC) entry defined within the assembly.

Examples

The following example demonstrates the use of the **.using** pseudo-op:

```
.csect data[rw]
.long 0x0, 0x0
d1:     .long 0x25
# A read/write csect contains the label d1.
.csect text[pr]
.using data[rw], 12
l 4,d1
# This will actually load the contents of
# the effective address, calculated by
# adding the address d1 to the address in
# GPR 12, into GPR 4
```

Related Information

"Pseudo-ops Overview" on page 459.

"Implicit-Based Addressing" on page 48.

".csect Pseudo-op" on page 469, ".drop Pseudo-op" on page 472.

.vbyte Pseudo-op

Purpose

Assembles the value represented by an expression into consecutive bytes.

Syntax

.vbyte *Number, Expression*

Description

The **.vbyte** pseudo-op assembles the value represented by the *Expression* parameter into a specified number of consecutive bytes.

Parameters

Number	Specifies a number of consecutive bytes. The *Number* value must range between 1 and 4.
Expression	Specifies a value that is assembled into consecutive bytes. The *Expression* parameter cannot contain externally defined symbols. If the *Expression* value is longer than the specified number of bytes, it will be truncated on the left.

Examples

The following example illustrates the use of the **.vbyte** pseudo-op:

```
.csect data[RW]
mine:   .vbyte 3,0x37CCFF
# This pseudo-op also accepts character constants.
.vbyte 1,'c
# Load GPR 4 with address of .csect data[RW].
.csect text[PR]
l 3,mine(4)
# GPR 3 now holds 0x37CCFF.
```

Related Information

Pseudo-ops Overview.

The **.byte** pseudo-op.

.weak Pseudo-op

Purpose

Makes a symbol with weak binding globally visible to the linker.

Syntax

.weak *Name*

Description

The **.weak** pseudo-op makes the symbol *Name* globally visible to the linker and available to any file that is linked to the file in which either the **.globl** or **.weak** pseudo-op occurs. However, the symbol has weak binding semantics.

- If the **.weak** pseudo-op is not used for a symbol, then that symbol is, unless otherwise effected, only visible within the current assembly and not to other modules that may later be linked to the current assembly.
- If *Name* is defined in the current assembly, its type and value arise from that definition, not the **.weak** definition.
- Once **.weak** has been seen for a symbol, latter occurances of **.globl** and **.extern** will not affect it for that file.
- The binder ignores duplicate definitions for symbols with the same name that are weak. If the name is declared **.globl** in one object file of module, and **.weak** in another, the global definition is used and the weak ones are ignored. If no global definition (such as the **C_EXT** storage class) exists, the first weak definition is used, according to link order as described by the **ld** reference page.

Parameters

Name	Represents any label or symbol that is defined locally and requires external visibility with weak storage class. This parameter can be a *Qualname*. (A *Qualname* specifies a *Name* and *StorageMappingClass* for the control section.)

Examples

The following example illustrates the use of the **.weak** pseudo-op:

```
.weak foo[RW]
.csect data[RW]
```

Related Information

- Pseudo-ops Overview
- The **.globl** and **.extern** pseudo-ops.
- The ld command.

.xline Pseudo-op

Purpose

Represents a line number.

Syntax

.xline *Number1, StringConstant*[*, Number2*]

Description

The **.xline** pseudo-op provides additional file and line number information to the assembler. The *Number2* parameter can be used to generate **.bi** and **.ei** type entries for use by symbolic debuggers. This pseudo-op is customarily inserted by the M4 macro processor.

Parameters

Number1	Represents the line number of the original source file.
StringConstant	Represents the file name of the original source file.
Number2	Represents the C_BINCL and C_EINCL classes, which indicate the beginning and ending of an included file, respectively.

Examples

The following example illustrates the use of the **.xline** pseudo-op:

```
.xline 1,"hello.c",108
.xline 2,"hello.c"
```

Related Information

Pseudo-ops Overview.

Appendix A. Messages

The messages in this appendix are error messages or warning messages. Each message contains three sections:

- Message number and message text
- Cause of the message
- Action to be taken

For some messages that are used for file headings, the Action section is omitted.

1252-001 *<name>* is defined already.

Cause The user has previously used *name* in a definition-type statement and is trying to define it again, which is not allowed. There are three instances where this message is displayed:

- A label name has been defined previously in the source code.
- A **.set** pseudo-op name has been defined previously in the source code.
- A **.lcomm** or **.comm** pseudo-op name has been previously defined in the source code.

Action Correct the name-redefined error.

1252-002 There is nesting overflow. Do not specify more than 100 **.function**, **.bb**, or **.bi** pseudo-ops without specifying the matching **.ef**, **.eb**, or **.ei** pseudo-ops.

Cause This syntax error message will only be displayed if debugger pseudo-ops are used. The **.function**, **.bb**, and **.bi** pseudo-ops generate pointers that are saved on a stack with a limiting size of 100 pointers. If more than 100 **.function** and **.bb** pseudo-ops have been encountered without encountering the matching **.ef** and **.eb** pseudo-ops, this syntax error message is displayed.

Action Rewrite the code to avoid this nesting.

Note: Debugger pseudo-ops are normally generated by compilers, rather than being inserted in the source code by the programmer.

1252-003 The **.set** operand is not defined or is a forward reference.

Cause The **.set** pseudo-op has the following syntax:

```
.set name,expr
```

The *expr* parameter can be an integer, a predefined name (specified by a label, or by a **.lcomm** or **.comm** pseudo-op) or an algebraic combination of an integer and a name. This syntax error message appears when the *expr* parameter is not defined.

Action Verify that all elements of the *expr* parameter are defined before the **.set** statement.

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1252-004 The **.globl** symbol is not valid. Check that the **.globl** name is a relocatable expression.

Cause The **.globl** name must be a relocatable expression. This syntax error message is displayed when the *Name* parameter of the **.globl** pseudo-op is not a relocatable expression.

Relocation refers to an entity that represents a memory location whose address or location can and will be changed to reflect run-time locations. Entities and symbol names that are defined as relocatable or nonrelocatable are described in "Expressions" on page 37.

Relocatable expressions include label names, **.lcomm**, **.comm** names, and **.csect** names.

The following are the nonrelocatable items and nonrelocatable expressions:

- **.dsect** names
- labels contained within a **.dsect**
- labels contained within a csect with a storage class of BS or UC
- **.set** names
- absolute expression (constant or integer)
- tocrelative (**.tc** label or name)
- tocofrelative (**.tocof** label or name)
- unknown (undefined in Pass 2 of the assembler)

Action Ensure that the *Name* parameter of the **.globl** pseudo-op is a relocatable expression. If not defined, the name is assumed to be external.

1252-005 The storage class is not valid. Specify a supported storage class for the csect name.

Cause This syntax error message is displayed when the storage mapping class value used to specify the *Qualname* in the **.csect** pseudo-op is not one of the predefined values.

Action See the **.csect** pseudo-op for the list of predefined storage mapping classes. Correct the program error and assemble and link the program again.

1252-006 The **ERRTOK** in the **ICSECT ERRTOK** is not known. Depending upon where you acquired this product, contact either your service representative or your approved supplier.

Cause This is an internal error message.

Action Contact your service representative or your approved supplier to report the problem.

1252-007 The alignment must be an absolute expression.

Cause This syntax error message is caused by an incorrect operand (the optional alignment parameter) to the **.csect** pseudo-op. This alignment parameter must be either an absolute expression (an integer) or resolve algebraically into an absolute expression.

Action Correct the alignment parameter, then assemble and link the program again.

1252-008 The **.tocof** *name1* is not valid. Check that the *name1* has not been defined previously.

Cause The *Name1* parameter of the **.tocof** pseudo-op has been defined elsewhere in the current module.

Action:
Ensure that the *name1* symbol is defined only in the **.tocof** pseudo-op.

1252-009 A Begin or End block or **.function** pseudo-op is missing. Make sure that there is a matching **.eb** statement for each **.bb** statement and that there is a matching **.ef** statement for each **.bf** statement.

Cause If there is not a matching **.eb** pseudo-op for each **.bb** pseudo-op or if there is not a matching **.ef** pseudo-op for each **.bf** pseudo-op, this error message is displayed.

Action Verify that there is a matching **.eb** pseudo-op for every **.bb** pseudo-op, and verify that there is a matching **.ef** pseudo-op for every **.bf** pseudo-op.

1252-010 The **.tocof** *Name2* is not valid. Make sure that *name2* is an external symbol.

Cause The *Name2* parameter for the **.tocof** pseudo-op has not been properly defined.

Action Ensure that the *Name2* parameter is externally defined (it must appear in an **.extern** or **.globl** pseudo-op) and ensure that it is not defined locally in this source module.

Note: If the *Name2* parameter is defined locally and is externalized using a **.extern** pseudo-op, this message is also displayed.

1252-011 A **.space** parameter is undefined.

Cause The *Number* parameter to the **.space** pseudo-op must be a positive absolute expression. This message indicates that the *Number* parameter contains an undefined element (such as a label or name for a **.lcomm**, **.comm**, or **.csect** pseudo-op that will be defined later).

Action Verify that the *Number* parameter is an absolute expression, integer expression, or an algebraic expression that resolves into an absolute expression.

1252-012 The **.space** size must be an absolute expression.

Cause The *Number* parameter to the **.space** pseudo-op must be a positive absolute expression. This message indicates that the *Number* parameter contains a nonabsolute element (such as a label or name for a **.lcomm**, **.comm**, or **.csect** pseudo-op).

Action Verify that the *Number* parameter specifies an absolute expression, or an integer or algebraic expression that resolves into an absolute expression.

1252-013 The **.space** size must be a positive absolute expression.

Cause The *Number* parameter to the **.space** pseudo-op must be a positive absolute expression. This message indicates that the *Number* parameter resolves to a negative absolute expression.

Action Verify that the *Number* parameter is a positive absolute expression.

1252-014 The **.rename** *Name* symbol must be defined in the source code.

Cause The *Name* parameter to the **.rename** pseudo-op must be defined somewhere in the source code. This message indicates that the *Name* parameter has not been defined.

Action Verify that the *Name* parameter is defined somewhere in the source code.

1252-015 A pseudo-op parameter is not defined.

Cause This is a syntax error message displayed for the **.line**, **.xline**, **.bf**, **.ef**, **.bb**, and **.eb** pseudo-ops. These expressions have an expression operand that must resolve.

Action Change the source code so that the expression resolves or is defined.

1252-016 The specified opcode or pseudo-op is not valid. Use supported instructions or pseudo-ops only.

Cause The first element (after any label) on the source line is not recognized as an instruction or pseudo-op.

Action Use only supported instructions or pseudo-ops.

1252-017 The **ERRTOK** in the *args* parameter is not valid. Depending upon where you acquired this product, contact either your service representative or your approved supplier.

Cause This is an internal error message.

Action Contact your service representative or your approved supplier to report the problem.

1252-018 Use a **.tc** inside a **.toc** scope only. Precede the **.tc** statements with a **.toc** statement.

Cause A **.tc** pseudo-op is only valid after a **.toc** pseudo-op and prior to a **.csect** pseudo-op. Otherwise, this message is displayed.

Action Ensure that a **.toc** pseudo-op precedes the **.tc** pseudo-ops. Any other pseudo-ops should be preceded by a **.csect** pseudo-op. The **.tc** pseudo-ops do not have to be followed by a **.csect** pseudo-op, if they are the last pseudo-ops in a source file.

1252-019 Do not specify externally defined symbols as **.byte** or **.vbyte** expression parameters.

Cause If the *Expression* parameter of the **.byte** or **.vbyte** pseudo-op contains externally defined symbols (the symbols appear in a **.extern** or **.globl** pseudo-op), this message is displayed.

Action Verify that the *Expression* parameter of the **.byte** or **.vbyte** pseudo-op does not contain externally defined symbols.

1252-020 Do not specify externally defined symbols as **.short** *Expression* parameters.

Cause If the *Expression* parameter of the **.short** pseudo-op contains externally defined symbols (the symbols appear in an **.extern** or **.globl** pseudo-op), this message is displayed.

Action Verify that the *Expression* parameter of the **.short** pseudo-op does not contain externally defined symbols.

1252-021 The expression must be absolute.

Cause The *Expression* parameter of the **.vbyte** pseudo-op is not an absolute expression.

Action Ensure that the expression is an absolute expression.

1252-022 The first parameter must resolve into an absolute expression from 1 through 4.

Cause The first parameter of the **.vbyte** pseudo-op must be an absolute expression ranging from 1 to 4.

Action Verify that the first parameter of the **.vbyte** pseudo-op resolves to an absolute expression from 1 to 4.

1252-023 The symbol *<name>* is not defined.

Cause An undefined symbol is used in the source program.

Action A symbol can be defined as a label, or as the *Name* parameter of a **.csect**, **.comm**, **.lcomm**, **.dsect**, **.set**, **.extern**, or **.globl** pseudo-op. The **-u** flag of the **as** command suppresses this message.

1252-024 The **.stab** string must contain a **:** character.

Cause The first parameter of the **.stabx** pseudo-op is a string constant. It must contain a **:** (colon). Otherwise, this message is displayed.

Action Verify that the first parameter of the **.stabx** pseudo-op contains a **:** (colon).

1252-025 The register, base register, or mask parameter is not valid. The register number is limited to the number of registers on your machine.

Cause The register number used as the operand of an instruction or pseudo-op is not an absolute value, or the value is out of range of the architecture.

Action An absolute expression should be used to specify this value. For PowerPC and POWER family, valid values are in the range of 0-31.

1252-026 Cannot create a temporary file. Check the **/tmp** directory permissions.

Cause This message indicates a permission problem in the **/tmp** filesystem.

Action Check the permissions on the **/tmp** directory.

1252-027 Warning: Aligning with zeroes: The **.short** pseudo-op is not on the halfword boundary.

Cause This warning indicates that a **.short** pseudo-op is not on the halfword boundary. The assembler places zeros into the current location until the statement is aligned to a halfword boundary.

Action If the user wants to control the alignment, using a **.align** pseudo-op with the *Number* parameter set to 1 prior to the **.short** pseudo-op will perform the same function. A **.byte** pseudo-op with an *Expression* parameter set to 0 prior to the **.short** pseudo-op will perform the same function that the assembler does internally.

1252-028 Cannot reopen the intermediate result file in the **/tmp** directory. Make sure that the size of the **/tmp** file system is sufficient to store the file, and check that the file system is not damaged.

Cause This message indicates that a system problem occurred while closing the intermediate file and then opening the file again.

Action The intermediate file normally resides in the **/tmp** filesystem. Check the **/tmp** filesystem space to see if it is large enough to contain the intermediate file.

1252-029 There is not enough memory available now. Cannot allocate the text and data sections. Try again later or use local problem reporting procedures.

Cause This is a memory-management problem. It is reported when the **malloc** function is called while allocating the text and data section. There is either not enough main memory, or memory pointers are being corrupted.

Action Try again later. If the problem continues to occur, check the applications load for the memory or talk to the system administrator.

1252-030 Cannot create the file *<filename>*. Check path name and permissions.

Cause This message indicates that the assembler is unable to create the output file (object file). An object file is created in the specified location if the **-o** flag of the **as** command is used. If the **-o** flag is not used, an object file with the default name of **a.out** is created in the current directory. If there are permission problems for the directory or the path name is invalid, this message is displayed.

Action Check the path name and permissions.

1252-031 There is not enough memory available now. Cannot allocate the ESD section. Try again later or use local problem reporting procedures.

Cause This is a memory-management problem. It is reported when the **malloc** function is called while allocating the ESD section. There is either not enough main memory, or memory pointers are being corrupted.

Action Try again later. If the problem continues to occur, check the applications load for the memory or talk to the system administrator.

1252-032 There is not enough memory available now. Cannot allocate the RLD section. Try again later or use local problem reporting procedures.

Cause This is a memory-management problem. It is reported when the **malloc** function is called while allocating the RLD section. There is either not enough main memory, or memory pointers are being corrupted.

Action Try again later. If the problem continues to occur, check the applications load for the memory or talk to the system administrator.

1252-033 There is not enough memory available now. Cannot allocate the string section. Try again later or use local problem reporting procedures.

Cause This is a memory-management problem. It is reported when the **malloc** function is called while allocating the string section. There is either not enough main memory, or memory pointers are being corrupted.

Action Try again later. If the problem continues occur, check applications load for the memory or talk to the system administrator.

1252-034 There is not enough memory available now. Cannot allocate the line number section. Try again later or use local problem reporting procedures.

Cause This is a memory-management problem. It is reported when the **malloc** function is called while allocating the line number section. There is either not enough main memory, or memory pointers are being corrupted.

Action Try again later. If the problem continues to occur, check the applications load for the memory or talk to the system administrator.

1252-035 through 1252-037 Obsolete messages.

1252-038 Cannot open file *<filename>*. Check path name and permissions.

Cause The specified source file is not found or has no read permission; the *listfile* or the *xcrossfile* has no write permission; or the specified path does not exist.

Action Check the path name and read/write permissions.

1252-039 Not used currently.

1252-040 The specified expression is not valid. Make sure that all symbols are defined. Check the rules on symbols used in an arithmetic expression concerning relocation.

Cause The indicated expression does not resolve into an absolute expression, relocatable expression, external expression, toc relative expression, tocof symbol, or restricted external expression.

Action Verify that all symbols are defined. Also, there are some rules concerning relocation on which symbols can be used in an arithmetic expression. See “Expressions” on page 37 for more information.

1252-041 Cannot divide the value by 0 during any arithmetic divisions.

Cause During an arithmetic division, the divisor is zero.

Action Ensure that the value is not divided by zero.

1252-042 The internal arithmetic operator is not known. Depending upon where you acquired this product, contact either your service representative or your approved supplier.

Cause This is an internal error message.

Action Contact your service representative or your approved supplier to report the problem.

1252-043 The relocatable assembler expression is not valid. Check that the expressions can be combined.

Cause This message is displayed when some invalid arithmetic combinations of the expressions are used.

Action Ensure that the correct arithmetic combination is used. See “Expressions” on page 37 for the specific rules of the valid arithmetic combinations for expressions.

1252-044 The specified source character *<char>* does not have meaning in the command context used.

Cause A source character has no meaning in the context in which it is used. For example,`.long 3@1` , the `@` is not an arithmetic operator or an integer digit, and has no meaning in this context.

Action Ensure that all characters are valid and have meaning in the context in which they are used.

1252-045 Cannot open the list file *<filename>*. Check the quality of the file system.

Cause This occurs during pass two of the assembler, and indicates a possible filesystem problem or a closing problem with the original listing file.

Action Check the file system according to the file path name.

1252-046 Not used currently.

1252-047 There is a nesting underflow. Check for missing **.function**, **.bi**, or **.bb** pseudo-ops.

Cause This syntax error message is displayed only if debugger pseudo-ops are used. The **.function**, **.bb**, and **.bi** pseudo-ops generate pointers that are saved on a stack with a limiting size of 100 pointers. The **.ef**, **.eb**, and **.ei** pseudo-ops then remove these pointers from the stack. If the number of **.ef**, **.eb**, and **.ei** pseudo-ops encountered is greater than the number of pointers on the stack, this message is displayed.

Action Rewrite the code to avoid this problem.

1252-048 Found a symbol type that is not valid when building external symbols. Depending upon where you acquired this product, contact either your service representative or your approved supplier.

Cause This is an internal error message.

Action Contact your service representative or your approved supplier to report the problem.

1252-049 There is not enough memory to contain all the hash strings. Depending upon where you acquired this product, contact either your service representative or your approved supplier.

Cause This is an internal error message.

Action Contact your service representative or your approved supplier to report the problem.

1252-050 There is not enough memory available now. Cannot allocate the debug section. Try again later or use local problem reporting procedures.

Cause This is a memory-management problem. It is reported when the **malloc** function is called while allocating the debug section. There is either not enough main memory, or memory pointers are being corrupted.

Action Try again later. If the problem continues to occur, check the applications load for the memory or talk to the system administrator.

1252-051 There is an *sclass* type of *Number*=<*number*> that is not valid. Depending upon where you acquired this product, contact either your service representative or your approved supplier.

Cause This is an internal error message.

Action Contact your service representative or your approved supplier to report the problem.

1252-052 The specified **.align** parameter must be an absolute value from 0 to 12.

Cause The *Number* parameter of the **.align** pseudo-op is not an absolute value, or the value is not in the range 0-12.

Action Verify that the *Number* parameter resolves into an absolute expression ranging from 0 to 12.

1252-053 Change the value of the **.org** parameter until it is contained in the current csect.

Cause The value of the parameter for the **.org** pseudo-op causes the location counter to go outside of the current csect.

Action Ensure that the value of the first parameter meets the following criteria:

Must be a positive value (includes 0).

Must result in an address that is contained in the current csect.

Must be an external (E_EXT) or relocatable (E_REL) expression.

2363-054 The register parameter in **.using** must be absolute and must represent a register on the current machine.

Cause The second parameter of the **.using** pseudo-op does not represent an absolute value, or the value is out of the valid register number range.

Action Ensure that the value is absolute and is within the range of 0-31 for PowerPC and POWER family.

1252-055 There is a base address in **.using** that is not valid. The base address must be a relocatable expression.

Cause The first parameter of the **.using** pseudo-op is not a relocatable expression.

Action Ensure that the first parameter is relocatable. The first parameter can be a TOC-relative label, a label/name that is relocatable (relocatable=REL), or an external symbol that is defined within the current assembly source as a csect name/TOC entry.

1252-056 Specify a **.using** argument that references only the beginning of the TOC section. The argument cannot reference locations contained within the TOC section.

Cause The first parameter of the **.using** pseudo-op is a TOC-relative expression, but it does not point to the beginning of the TOC.

Action Verify that the first parameter describes the beginning of the TOC if it is TOC-relative.

1252-057 The external expression is not valid. The symbol cannot be external. If the symbol is external, the symbol must be defined within the assembly using a **.toc** or a **.csect** entry.

Cause An external expression other than a csect name or a TOC entry is used for the first parameter of the **.using** pseudo-op.

Action Ensure that the symbol is either not external (not specified by an **.extern** pseudo-op) or is defined within the assembly source using a TOC entry or csect entry.

1252-058 Warning: The label *<name>* is aligned with csect *<csectname>*.

Cause If the label is in the same line of the **.csect** pseudo-op. this warning is reported when the **-w** flag of the **as** command is used. This message indicates that a label may not be aligned as intended. If the label should point to the top of the csect, it should be contained within the csect, in the first line next to the **.csect** pseudo-op.

Action Evaluate the intent of the label.

1252-059 The register in **.drop** must be an absolute value that is a valid register number.

Cause The parameter of the **.drop** pseudo-op is not an absolute value, or the value is not in the range of valid register numbers.

Action Use an absolute value to indicate a valid register. For PowerPC and POWER family, valid register numbers are in the range of 0-31.

1252-060 The register in **.drop** is not in use. Delete this line or insert a **.using** line previous to this **.drop** line.

Cause This message indicates that the register represented by the parameter of the **.drop** pseudo-op was never used in a previous **.using** statement.

Action Either delete the **.drop** pseudo-op or insert the **.using** pseudo-op that should have been used prior to this **.drop** pseudo-op.

1252-061 A statement within **.toc** scope is not valid. Use the **.tc** pseudo-op to define entries within **.toc** scope.

Cause If a statement other than a **.tc** pseudo-op is used within the **.toc** scope, this message is displayed.

Action Place a **.tc** pseudo-op only inside the **.toc** scope.

1252-062 The alignment must be a value from 0 to 31.

Cause The optional second parameter (*Number*) of the **.csect** parameter defines alignment for the top of the current csect. Alignment must be in the range 0-31. Otherwise, this message is displayed.

Action Ensure that the second parameter is in the valid range.

1252-063 Obsolete message.

1252-064 The **.comm** size must be an absolute expression.

Cause The second parameter of the **.comm** pseudo-op must be an absolute expression. Otherwise, this message is displayed.

Action Ensure that the second parameter is an absolute expression.

1252-065 Not used currently.

1252-066 There is not enough memory available now. Cannot allocate the typchk section. Try again later or use local problem reporting procedures.

Cause This is a memory-management problem. It is reported when the **malloc** function is called while allocating the debug section. There is either not enough main memory, or memory pointers are being corrupted.

Action Try again later. If the problem continues to occur, check the applications load for the memory or talk to the system administrator.

1252-067 The specified common storage class is not valid. Depending upon where you acquired this product, contact either your service representative or your approved supplier.

Cause This is an internal error message.

Action Contact your service representative or your approved supplier to report the problem.

1252-068 The **.hash** string is set for symbol *name* already. Check that this is the only **.hash** statement associated with the symbol name.

Cause The *Name* parameter of the **.hash** pseudo-op has already been assigned a string value in a previous **.hash** statement.

Action Ensure that the *Name* parameter is unique for each **.hash** pseudo-op.

1252-069 The character *<char>* in the hash string is not valid. The characters in the string must be in the set [0-9A-Fa-f].

Cause The characters in the hash string value (the second parameter of the **.hash** pseudo-op) are required to be in the set [0-9A-Fa-f]. The characters represent a hexadecimal hash code. Otherwise, this message is displayed.

Action Ensure that the characters specified by the *StringConstant* parameter are contained within this set.

1252-070 The specified symbol or symbol type for the hash value is not valid.

Cause If the *Name* parameter for the **.hash** pseudo-op is not a defined external symbol, this message is displayed.

Notes:

1. This message can be suppressed by using the **-u** flag of the **as** command.
2. A defined internal symbol (for example, a local label) can also cause this message to be displayed.

Action Use the **-u** flag of the **as** command, or use the **.extern** or **.globl** pseudo-op to define the *Name* parameter as an external symbol.

1252-071 and 1252-072 Not used currently.

1252-073 There is not enough memory available now. Cannot allocate a segment in memory. Try again later or use local problem reporting procedures.

Cause This indicates a **malloc**, **realloc**, or **calloc** problem. The following problems can generate this type of error:

- Not enough main memory to allocate
- Corruption in memory pointers
- Corruption in the filesystem

Action Check the file systems and memory status.

1252-074 The pseudo-op is not within the text section. The **.function**, **.bf**, and **.ef** pseudo-ops must be contained within a csect with one of the following storage classes: RO, PR, XO, SV, DB, GL, TI, or TB.

Cause If the **.function**, **.bf** and **.ef** pseudo-ops are not within a csect with a storage mapping class of RO, PR, XO, SV, DB, GL, TI, or TB, this syntax error message is displayed.

Action Ensure that the **.function**, **.bf**, and **.ef** pseudo-ops are within the scope of a text csect.

1252-075 The specified number of parameters is not valid.

Cause This is a syntax error message. The number of parameters specified with the instruction is incorrect.

Action Verify that the correct number of parameters are specified for this instruction.

1252-076 The **.line** pseudo-op must be contained within a text or data **.csect**.

Cause This is a syntax error message. The **.line** pseudo-op must be within a text or data section. If the **.line** pseudo-op is contained in a **.dsect** pseudo-op, or in a **.csect** pseudo-op with a storage mapping class of BS or UC, this error is displayed.

Action Verify that the **.line** pseudo-op is not contained within the scope of a .dsect; or in a **.csect** pseudo-op with a storage mapping class of BS or UC.

1252-077 The file table is full. Do not include more than 99 files in any single assembly source file.

Cause The **.xline** pseudo-op indicates a filename along with the number. These pseudo-ops are generated with the **-l** option of the **m4** command. A maximum of 99 files may be included with this option. If more than 99 files are included, this message is displayed.

Action Ensure that the **m4** command has not included more than 99 files in any single assembly source file.

1252-078 The bit mask parameter starting at *<positionnumber>* is not valid.

Cause This is a syntax error message. In rotate left instructions, there are two input operand formats: **rl***xx RA*,*RS*,*SH*,*MB*,*ME*, or **rl***xx RA*,*RS*,*SH*,*BM*. This message is displayed only if the second format is used. The *BM* parameter specifies the mask for this instruction. It must be constructed by certain rules. Otherwise, this message is displayed. See "Extended Mnemonics of 32-bit Fixed-Point Rotate and Shift Instructions" on page 105 for information on constructing the *BM* parameter.

Action Correct the bit mask value.

1252-079 Found a type that is not valid when counting the RLDs. Depending upon where you acquired this product, contact either your service representative or your approved supplier.

Cause This is an internal error message.

Action Contact your service representative or your approved supplier to report the problem.

1252-080 The specified branch target must be on a full word boundary.

Cause This is a syntax error message. Branch instructions have a target or location to which the program logic should jump. These target addresses must be on a fullword boundary.

Action Ensure that the branch target is on a fullword address (an address that ends in 0, 4, 8, or c). The assembler listing indicates location counter addresses. This is useful when trying to track down this type of problem.

1252-081 The instruction is not aligned properly. The instruction requires machine-specific alignment.

Cause On PowerPC and POWER family, the alignment must be fullword. If this message is displayed, it is probable that an instruction or pseudo-op prior to the current instruction has modified the location counter to result in an address that does not fall on a fullword.

Action Ensure that the instruction is on a fullword address.

1252-082 Use more parameters for the instruction.

Cause Each instruction expects a set number of arguments to be passed to it. If too few arguments are used, this error is displayed.

Action Check the instruction definition to find out how many arguments are needed for this instruction.

1252-083 Use fewer parameters for the instruction.

Cause Each instruction expects a set number of arguments to be passed to it. If too many arguments are used, this error is displayed.

Action Check the instruction definition to find out how many arguments are needed for this instruction.

1252-084 and 1252-085 Obsolete messages.

1252-086 The target of the branch instruction must be a relocatable or external expression.

Cause An absolute expression target is used where a relocatable or external expression is acceptable for a branch instruction.

Action Replace the current branch instruction with an absolute branch instruction, or replace the absolute expression target with a relocatable target.

1252-087 The target of the branch instruction must be a relocatable or external expression.

Cause This is a syntax error message. The target of the branch instruction must be either relocatable or external.

Action Ensure that the target of this branch instruction is either relocatable or external.

Relocatable expressions include label names, **.lcomm** names, **.comm** names, and **.csect** names.

Relocation refers to an entity that represents a memory location whose address or location can and will be changed to reflect run-time locations. Entities and symbol names that are defined as relocatable or non-relocatable are described in "Expressions" on page 37.

1252-088 The branch address is out of range. The target address cannot exceed the ability of the instruction to represent the bit size of the branch address value.

Cause This is a syntax error message. Branch instructions limit the target address sizes to 26 bits, 16 bits, and other instruction-specific sizes. When the target address value cannot be represented in the instruction-specific limiting space, this message is displayed.

Action Ensure that the target address value does not exceed the instruction's ability to represent the target address (bit size).

1252-089 through 1252-098 Obsolete messages.

1252-099 The specified displacement is not valid. The instruction displacement must be relocatable, absolute, or external.

Cause This is a syntax error message. The instruction displacement must be either relocatable; absolute; external which has the XTY_SD or STY_CM symbol type (a csect or common block name); or possibly TOC-relative (but not a negative TOC-relative), depending on the machine platform.

Action Verify that the displacement is valid for this instruction.

1252-100 Either the displacement value or the contents of the specified general purpose register, or both, do not yield a valid address.

Cause Indicates an invalid *d*(*r*) operand. Either *d* or *r* is missing.

Action Verify that the base/displacement operand is formed correctly. Correct the programming error, then assemble and link the program again.

Note: If *d* or *r* does not need to be specified, 0 should be put in the place.

1252-101 and 1252-102 Obsolete messages.

1252-103 The specified instruction is not supported by this machine.

Cause This is an internal error message.

Action Contact your service representative or your approved supplier to report the problem.

1252-104 The *<parm #>* parameter must be absolute.

Cause The indicated parameter must be absolute (nonrelocatable, nonexternal).

Action Refer to the specific instruction article for the instruction syntax.

1252-105 Obsolete message.

1252-106 Not currently used.

1252-107 The parameter *<parm #>* must be within range for the specific instruction.

Cause This error occurs in the following situations:

- The parameter value does not lie within the lower and upper bounds.
- The parameter value for the SPR encoding is undefined.
- The parameter value for the rotate and shift instructions is beyond the limitation.

Action See the specific instruction article for the instruction definition. See “Extended Mnemonics of Moving from or to Special-Purpose Registers” on page 100 for the list of SPR encodings. In general, if the assembly mode is **com**, **pwr**, or **pwr2**, the SPR range is 0 to 31. Otherwise, the SPR range is 0 to 1023. See “Extended Mnemonics of 32-bit Fixed-Point Rotate and Shift Instructions” on page 105 for information on restrictions. Change the source code, then assemble and link the program again.

1252-108 Warning: The alignment for label *<name>* is not valid. The label requires machine-specific alignment.

Cause Indicates that a label is not aligned properly to be the subject of a branch. In other words, the label is not aligned to a fullword address (an address ending in 0, 4, 8, or c).

Action To control the alignment, a **.align** pseudo-op prior to the label will perform the alignment function. Also, a **.byte** pseudo-op with a parameter of 0 or a **.short** pseudo-op with a parameter of 0 prior to the label will shift the alignment of the label.

1252-109 Warning: Aligning with zeros: The **.long** pseudo-op is not on fullword boundary.

Cause Indicates that a **.long** pseudo-op exists that is not aligned properly on a fullword internal address (an address that ends in 0, 4, 8, or c). The assembler generates zeros to properly align the statement.

Action To control the alignment, a **.align** pseudo-op with a parameter of 2 prior to the **.long** pseudo-op will perform the alignment. Also, a **.byte** pseudo-op with a parameter of 0 or a **.short** pseudo-op with a parameter of 0 prior to the **.long** pseudo-op will perform the alignment.

1252-110 Warning: Aligning with zeros in program csect.

Cause If the **.align** pseudo-op is used within a .csect of type [PR] or [GL], and the **.align** pseudo-op is not on a fullword address (for PowerPC and POWER family, all instructions are four bytes long and are fullword aligned), the assembler performs alignment by padding zeros, and this warning message is displayed. It is also displayed when a fullword alignment occurs in other pseudo-op statements.

Action Look for a reason why the alignment is not on a fullword. This could indicate a possible pseudo-op or instruction in the wrong place.

1252-111 Warning: Csect alignment has changed. To change alignment, check previous **.csect** statements.

Cause The beginning of the csect is aligned according to a default value (2, fullword) or the *Number* parameter. This warning indicates that the alignment that was in effect when the csect was created has been changed later in the source code.

The csect alignment change can be caused by any of the following:

- The *Number* parameter of the **.csect** pseudo-op specifies a value greater than previous **.csect** pseudo-ops that have the same *Qualname*.
- The *Number* parameter of a **.align** pseudo-op specifies a value greater than the current csect alignment.
- A **.double** pseudo-op is used, which causes the alignment to increase to 3. If the current csect alignment is less than 3, this warning is reported.

Action This message may or may not indicate a problem, depending on the user’s intent. Evaluate whether a problem has occurred or not.

1252-112 Warning: The *<inst. format>* instruction is not supported by this machine.

Cause This is an internal error message.

Action Contact your service representative or your approved supplier to report the problem

1252-113 and 1252-114 Obsolete messages.

1252-115 The sort failed with status *<number>*. Check the condition of the system sort command or use local problem reporting procedures.

Cause When the **-x** flag of the **as** command is used from the command line, the system sort routine is called. If this call is not successful, this message is displayed. Either the sort utility is not available, or a system problem has occurred.

Action Check the condition of the system sort command, check the system itself (using the **fsck** command), or use local problem reporting procedures.

1252-116 There is a system error from *<name>*. Check the condition of the system sort command or use local problem reporting procedures.

Cause *name* has the sort command. When the **-x** flag of the **as** command is used from the command line, the system sort routine is called. The assembler forks a process to call the sort utility. If this fork fails to exec the sort routine, this message is displayed. Either the sort utility is not available, or a system problem has occurred.

Action Check the condition of the system sort command, check the system itself (using the **fsck** command), or use local problem reporting procedures.

1252-117 ″Assembler:″

Cause This line defines a header to the standard error output to indicate that it is an assembly program.

1252-118 ″line *<number>*″

Cause *number* contains the line number on which an error or warning resides. When assembling a source program, this message is displayed prior to the error/warning message on the screen. This message is also printed prior to the error/warning message in the assembler listing file.

1252-119 ″.xref″

Cause This message defines the default suffix extension for the file name of the symbol cross-reference file.

1252-120 ″.lst″

Cause This message defines the default suffix extension for the file name of the assembler listing file.

1252-121 ″SYMBOL FILE CSECT LINENO″

Cause This line defines the heading of the symbol cross-reference file.

1252-122 to 1252-123 Define several formats used in the assembler listing file.

1252-124 Obsolete, replaced by 1252-179.

1252-125 to 1252-132 Define the spaces or formats for the assembler listing file.

1252-133 to 1252-134 Define formats for output numbers and names.

1252-135 Defines 8 spaces that are used in the listing file.

1252-136 Defines a format used in the listing file.

1252-137 to 1252-140 Formats for output of a number.

1252-141 There is an error in the collect pointer. Use local problem reporting procedures.

Cause This is an internal error message.

Action Contact your service representative or your approved supplier to report the problem.

1252-142 Syntax error

Cause If an error occurred in the assembly processing and the error is not defined in the message catalog, this generic error message is used. This message covers both pseudo-ops and instructions. Therefore, a usage statement would be useless.

Action Determine intent and source line construction, then consult the specific instruction article to correct the source line.

1252-143 The **.function** *Size* must be an absolute expression.

Cause The *Size* parameter of the **.function** pseudo-op represents the size of the function. It must be an absolute expression.

Action Change the *Size* parameter, then assemble and link the program again.

1252-144 Warning: Any initialized data in *<name>* csect of BS or UC storage class is ignored but required to establish length.

Cause Indicates that the statements in the csect with a storage mapping class of BS or UC are used to calculate length of the csect and are not used to initialize data.

Action None.

1252-145 and 1252-146 Obsolete, replaced by 1252-180 and 1252-181.

1252-147 Invalid **.machine** assembly mode operand: *<name>*

Cause The **.machine** pseudo-op is used in a source program to indicate the assembly mode value. This message indicates that an undefined value was used.

Action See the ".machine Pseudo-op" on page 486 for a list of the defined assembly mode values.

1252-148 Invalid **.source** language identifier operand: *<name>*

Cause The **.source** pseudo-op indicates the source language type (C, FORTRAN, etc.). This message indicates that an invalid source language type was used.

Action See the **.source** pseudo-op for a list of the defined language types.

1252-149 Instruction *<name1>* is not implemented in the current assembly mode *<name2>*.

Cause Instructions that are not in the POWER family/PowerPC intersection area are implemented only in certain assembly modes. This message indicates that the instruction in the source program is not supported in the indicated assembly mode.

Action Use a different assembly mode or a different instruction.

1252-150 The first operand value of *value* is not valid for PowerPC. A *BO* field of 6, 7 14, 15, or greater than 20 is not valid.

Cause In branch conditional instructions, the first operand is the `BO` field. If the input value is outside of the required values, this message is displayed.

Action See the "Features of the AIX Assembler" on page 1 for the BO field encoding information to find the correct value of the input operand.

1252-151 This instruction form is not valid for PowerPC. The register used in operand two must not be zero and must not be the same as the register used in operand one.

Cause In the update form of fixed-point load instructions, PowerPC requires that the *RA* operand not be equal to zero and that it not be equal to RT. If these requirements are violated, this message is displayed.

Action See the "Features of the AIX Assembler" on page 1 for a list of these instructions, and refer to the instruction articles for the syntax and restrictions of these instructions. Change the source code, then assemble and link the program again.

1252-152 Internal error related to the source program domain. Depending upon where you acquired this product, contact your service representative or your approved supplier.

Cause This is an internal error message.

Action Contact your service representative or your approved supplier to report the problem.

1252-153 Warning: Instruction *<name>* functions differently between PowerPC and POWER.

Cause This warning message is not displayed unless the **-w** flag of the **as** command is used in the command line. Some instructions have the same op code in PowerPC and POWER, but are functionally different. This message provides a warning if the assembly mode is **com** and these instructions are used.

Action See "Functional Differences for POWER family and PowerPC Instructions" on page 112 for information on instructions that have the same op code but are functionally different in POWER and PowerPC.

1252-154 The second operand is not valid. For 32-bit implementation, the second operand must have a value of zero.

Cause In the fixed-point compare instructions, the value in the `L` field must be zero for 32-bit implementation. Also, if the **mtsri** instruction is used in one of the PowerPC assembly modes, the *RA* operand must contain zero. Otherwise, this message is displayed.

Action Put the correct value in the second operand, then assemble and link the program again.

1252-155 Displacement must be divisible by 4.

Cause If an instruction has the DS form, its 16-bit signed displacement value must be divisible by 4. Otherwise, this message is displayed.

Action Change the displacement value, then assemble and link the program again.

1252-156 The sum of argument 3 and 4 must be less than 33.

Cause When some extended mnemonics for word rotate and shift instructions are converted to the base instruction, the values of the third and fourth operands are added to calculate the `SH` field, `MB` field, or `ME` field. Since these fields are 5 bits in length, the sum of the third and fourth operands must not be greater than 32.

Action See "Extended Mnemonics of 32-bit Fixed-Point Rotate and Shift Instructions" on page 105 for information on converting the extended mnemonic to the base instruction. Change the value of the input operands accordingly, then assemble and link the program again.

1252-157 The value of operand 3 must be greater than or equal to the value of operand 4.

Cause When some extended mnemonics for word rotate and shift instructions are converted to the base instruction, the value of the fourth operand is subtracted from the value of the third operand to get the `ME` or `MB` field. The result must be positive. Otherwise, this message is displayed.

Action See "Extended Mnemonics of 32-bit Fixed-Point Rotate and Shift Instructions" on page 105 for information on converting the extended mnemonic to the base instruction. Change the value of the input operands accordingly, then assemble and link the program again.

1252-158 Warning: Special-purpose register number 6 is used to designate the DEC register when the assembly mode is *name*.

Cause This warning is displayed when the **mfdec** instruction is used and the assembly mode is **any**. The DEC encoding for the **mfdec** instruction is 22 for PowerPC and 6 for POWER. When the assembly mode is **any**, the POWER encoding number is used to generate the object code, and this message is displayed to indicate this.

Action None.

1252-159 The d(r) format is not valid for operand *<value>*.

Cause Indicates an assembly programming error. The d(r) format is used in the place that a register number or an immediate value is required.

Action Correct the programming error, then assemble and link the program again.

1252-160 Warning: A hash code value should be 10 bytes long.

Cause When the **.hash** pseudo-op is used, the second parameter, *StringConstant*, gives the actual hash code value. This value should contain a 2-byte language ID, a 4-byte general hash, and a 4-byte language hash. The hash code value should be 10 bytes long. If the value length is not 10 bytes and the **-w** flag of the **as** command is used, this warning is displayed.

Action Use the correct hash code value.

1252-161 A system problem occurred while processing file *<filename>*.

Cause A problem with system I/O developed dynamically. This message is produced by the assembler to indicate an **fwrite**, **putc**, or **fclose** error. The I/O problem could be caused by corruption of the filesystem or not enough space in the file systems.

Action Check the proper file system according to the path name reported.

1252-162 Invalid **-m** flag assembly mode operand: *<name>*.

Cause When an invalid assembly mode is entered on the command line using **-m** flag of the **as** command, this message is displayed.

Action See the Chapter 5, “Assembling and Linking a Program” on page 51 for the defined assembly modes.

1252-163 The first operand’s value *<value>* is not valid for PowerPC. The third bit of the `BO` field must be one for the Branch Conditional to Count Register instruction.

Cause If the third bit of the *BO* operand is zero for the “bcctr or bcc (Branch Conditional to Count Register) Instruction” on page 145, the instruction form is invalid and this message is displayed.

Action Change the third bit to one, then assemble and link the program again.

1252-164 This instruction form is not valid for PowerPC. *RA*, and *RB* if present in the instruction, cannot be in the range of registers to be loaded. Also, *RA*=*RT*=0 is not allowed.

Cause In multiple register load instructions, PowerPC requires that the *RA* operand, and the *RB* operand if present in the instruction format, not be in the range of registers to be loaded. Also *RA*=*RT*=0 is not allowed. Otherwise, this message is displayed.

Action Check the register number of the *RA*, *RB*, or *RT* operand to ensure that this requirement is met.

1252-165 The value of the first operand must be zero for PowerPC.

Cause If the POWER **svca** instruction is used in one of the PowerPC assembly modes, the first operand is the *SV* operand. This operand must be zero. Otherwise, this message is displayed.

Action Put zero into the first operand, or use the PowerPC **sc** instruction, which does not require an operand.

1252-166 This instruction form is not valid for PowerPC. The register used in operand two must not be zero.

Cause For the update form of fixed-point store instructions and floating-point load and store instructions, PowerPC requires that the *RA* operand not be equal to zero. Otherwise, this message is displayed.

Action Check the register number specified by the *RA* operand, then assemble and link the source code again.

1252-167 Specify a name with the -*<flagname>* flag.

Cause The **-n** and **-o** flags of the **as** command require a filename as a parameter. The **-m** flag of the **as** command requires a mode name as a parameter. If the required name is missing, this error message is displayed. This message replaces message 1252-035.

Action Provide a filename with the **-n** and **-o** flags of the **as** command, and provide a mode name with the **-m** flag of the **as** command.

1252-168 **-***<name>* is not a recognized flag.

Cause An undefined flag was used on the command line. This message replaces message 1252-036.

Action Make a correction and run the command again.

1252-169 Only one input file is allowed.

Cause More than one input source file was specified on the command line. This message replaces message 1252-037

Action Specify only one input source file at a time.

1252-170 The Assembler command has the following syntax: **as -l**[*ListFile*] **-s**[*ListFile*] **-n** *Name* **-o** *ObjectFile* [**-w**|**-W**] **-x**[*XCrossFile*] **-u -m** *ModeName* [*InputFile*]

Cause This message displays the usage of the **as** command.

Action None.

1252-171 The displacement must be greater than or equal to *<value1>* and less than or equal to *<value2>*.

Cause For 16-bit displacements, the limits are 32767 and -32768. If the displacement is out of range, this message is displayed. This message replaces message 1252-106.

Action See the specific instruction articles for displacement requirements.

1252-172 The **.extern** symbol is not valid. Check that the **.extern** *Name* is a relocatable expression.

Cause The *Name* parameter of the **.extern** pseudo-op must specify a relocatable expression. This message is displayed if the *Name* parameter of the **.extern** pseudo-op does not specify a relocatable expression. For information on relocatable and nonrelocatable expressions, see message 1252-004 .

Action Ensure that the *Name* parameter of the **.extern** pseudo-op is a relocatable expression.

1252-173 Warning: The immediate value for instruction *<name>* is *<value>*. It may not be portable to a 64-bit machine if this value is to be treated as an unsigned value.

Cause This warning is reported only for the **addis** instruction (or the **lis** extended mnemonic of the **addis** instruction). The immediate value field of these instructions is defined as a signed integer, which should have a valid value range of -32768 to 32767. To maintain compatibility with the **cau** instruction, however, this range is expanded to -65536 to 65535. This should cause no problems in a 32-bit mode, because there is nowhere for sign extension to go. However, this will cause a problem on a 64-bit machine, because sign extension propagates across the upper 32 bits of the register.

Action Use caution when using the **addis** instruction to construct an unsigned integer. The **addis** instruction has different semantics on a 32-bit implementation (or in 32-bit mode on a 64-bit implementation) than it does in 64-bit mode. The **addis** instruction with an unsigned integer in 32-bit mode cannot be directly ported to a 64-bit mode. The code sequence to construct an unsigned integer in 64-bit mode is significantly different from that needed in 32-bit mode.

1252-174 Too many .machine ″push″ instructions without corresponding .machine ″pop″ instructions.

Cause The maximum size of the assembly stack has been exceeded. More than 100 entries have been added to the stack with **.machine** ″**push**″ but not removed with **.machine** ″**pop**″.

Action Change the source program to eliminate the assembly stack overflow condition.

1252-175 A .machine ″pop″ is seen without a matching .machine ″push″.

Cause Pseudo-op **.machine** ″**pop**″ attempted to remove an entry from the assembly stack, but the stack is empty. The source program may be missing a **.machine** ″**push**″.

Action Correct the source program.

1252-176 The .ref pseudo-op cannot appear in section <*name*>.

Cause A **.ref** pseudo-op appears in a dsect or a csect with a storage mapping class of BS or UC, which is not permitted.

Action Change the source program.

1252-177 The operand of the .ref <*name*> is not a relocatable symbol.

Cause **.ref** pseudo-op operand *name* is one of the following items: a dsect name or label, a csect name or label with a storage mapping class of BS or UC, a **.set** operand which represents an item that is not relocatable, or a constant value.

Action Correct the source program.

1252-178 The maximum number of sections or symbols that an expression can refer to has been exceeded.

Cause An expression refers to more than 50 control sections (csects or dsects).

Action Correct the source program.

1252-179 File# Line# Mode Name Loc Ctr Object Code Source

Cause This line defines the heading of the assembler listing file without the mnemonics cross reference of POWER and PowerPC.

1252-180 File# Line# Mode Name Loc Ctr Object Code PowerPC Source

Cause This is one of the headings of the assembler listing file with the mnemonics cross-reference of POWER and PowerPC. The assembler listing column labeled PowerPC contains PowerPC mnemonics for statements where the source program uses POWER mnemonics. This message is used for assembly modes of the PowerPC category (including **com**, **ppc**, **601**, and **any**).

1252-181 File# Line# Mode Name Loc Ctr Object Code POWER Source

Cause This is one of the headings of the assembler listing file with the mnemonics cross-reference of POWER and PowerPC. The assembler listing column labeled POWER contains POWER mnemonics for statements where the source program uses PowerPC mnemonics. This message is used for assembly modes of the POWER category (including **pwr** and **pwr2**).

1252-182 Storage mapping class <*name*> is not valid for .comm pseudo-op. RW is used as the storage mapping class for the object code.

Cause The storage mapping class of the **.comm** pseudo-op is some value other than the valid values (TD, RW, BS, and UC). The assembler reports this as a warning and uses RW as the storage mapping class.

Action Change the source program.

1252-183 TD csect only allowed inside ″.toc″ scope.

Cause A csect with storage mapping class TD has been used without first using the **.toc** pseudo-op.

Action Use the **.toc** pseudo-op before this instruction.

1252-184 TOC anchor must be defined to use a TOC-relative reference to <*name*>. Include a .toc pseudo-op in the source.

Cause A TOC-relative reference is being used, but the TOC anchor is not defined. This can happen if an external TD symbol is defined and used as a displacement in a D-form instruction, but there is no **.toc** pseudo-op in the source program.

Action Use the **.toc** pseudo-op in the program.

1252-185 Warning: Operand is missing from pseudo-op.

Cause An operand required for pseudo-ops **.byte**, **.vbyte**, **.short**, **.long**, or **.llong** is missing.

Action Provide an initial value for the data storage area created by these pseudo-ops.

1252-186 Warning: The maximum length of a stabstring is <*number*> characters. Extra characters have been discarded.

Cause A stabstring is limited in length; the specified stabstring is greater than the maximum lenght of a single string.

Action Split the string into 2 or more strings, continuing the information from one stabstring to the next.

1252-187 Warning: The alignment of the current csect is less than the alignment specified with the .align pseudo-op.

Cause The alignment of the csect is not as strict as the alignment required by the use of a **.align** pseudo-op within that csect.

Action The **.align** pseudo-op specifies alignment of an item within the csect; the alignment speicified for the csect should be equal to or greater than this value. For example, if the csect requires word alignment, and a .llong within the csect requires double-word alignment, there is a potential for the .llong value to ultimately (after linking) be only word-aligned. This may not be what is intended by the user.

1252-188 Zero is used in the L operand for the <*instruction*> instruction.

Cause Some compare instructions allowed the L operand to be optional in 32-bit mode. In 64-bit mode, the operand is not optional.

Action All 4 operands should be specified for the instruction, or, alternatively, use an extended mnemonic.

1252-189 Invalid value for environment variable OBJECT_MODE. Set the OBJECT_MODE environment variable to 32 or 64 or use the -a32 or -a64 option.

Cause The value of the *OBJECT_MODE* environment variable is not recognized by the assembler.

Action Set the *OBJECT_MODE* environment variable to either **32** or **64**, or use the -a32 or -a64 command line option. Any other value for the environment variable has no meaning to the assembler.

1252-190 Invalid reference to label <*name*>: .function pseudo-op must refer to a csect.

Cause The **.function** pseudo-op referred to a local label.

Action The reference <*name*> should be the name (label) of a csect.

1252-191 Only <*name*> should be used for relocatable expressions.

Cause The expression used to initialize <*name*> contains references to externally defined symbols (i.e. the symbols appear in **.extern** pseudo-op).

Action Verify that no externally defined symbols are contained within the expression operands for <*name*>. Relocation in 32-bit mode can only be applied to 32-bit quantities; in 64-bit mode relocation can only be applied to 64-bit quantities.

1252-192 Assembly mode is not specified. Set the *OBJECT_MODE* environment variable to 32 or 64 or use the -a32 or -a64 option.

Cause The environment variable contains the value 32_64.

Action Set the *OBJECT_MODE* environment variable to either **32** or **64**, or use the -a32 or -a64 command line option.

1252-193 Values specified with the **.set** psuedo-op are treated as 32-bit signed numbers. Unexpected results may occur when these values are used in a **.llong** expression.

Cause In 32-bit mode, an expression that results from the use of **.set** has been used to set the initial value of a **.llong**.

Action For initializing .llong's when in 32-bit mode, values are treated as 64-bit. If a .set symbol whose most significant bit is set is used as part of the initialization, the value may not be interpreted in a manner intended by the user. For example, the value 0xFFFF_0000 may have been intended to be a positive 64-bit quantity, but is a negative 32-bit number which would be sign extended to become 0xFFFF_FFFF_FFFF_0000.

1252-194 **Warning:** The immediate value for instruction <*instruction*> is <*number*>. It may not be portable to a 64-bit machine if this value is to be treated as an unsigned value.

Cause This is a alternate version of message 173; see above for more information.

Appendix B. Instruction Set Sorted by Mnemonic

In the Instruction Set Sorted by Mnemonic table the Implementation column contains the following information:

Implementation	Description
com	Supported by POWER family, POWER2, and PowerPC implementations.
POWER family	Supported only by POWER family and POWER2 implementations.
POWER2	Supported only by POWER2 implementations.
PowerPC	Supported only by PowerPC architecture.
PPC opt.	Defined only in PowerPC architecture and is an optional instruction.
603 only	Supported only on the PowerPC 603 RISC Microprocessor

Instruction Set Sorted by Mnemonic					
Mnemonic	**Instruction**	**Implementation**	**Format**	**Primary Op Code**	**Extended Op Code**
a[o][.]	Add Carrying	POWER family	XO	31	10
abs[o][.]	Absolute	POWER family	XO	31	360
add[o][.]	Add	PowerPC	XO	31	266
addc[o][.]	Add Carrying	PowerPC	XO	31	10
adde[o][.]	Add Extended	PowerPC	XO	31	138
addi	Add Immediate	PowerPC	D	14	
addic	Add Immediate Carrying	PowerPC	D	12	
addic.	Add Immediate Carrying and Record	PowerPC	D	13	
addis	Add Immediate Shifted	PowerPC	D	15	
addme[o][.]	Add to Minus One Extended	PowerPC	XO	31	234
addze[o][.]	Add to Zero Extended	PowerPC	XO	31	202
ae[o][.]	Add Extended	POWER family	XO	31	138
ai	Add Immediate	POWER family	D	12	
ai.	Add Immediate and Record	POWER family	D	13	
ame[o][.]	Add to Minus One Extended	POWER family	XO	31	234
and[.]	AND	com	X	31	28
andc[.]	AND with Complement	com	X	31	60
andi.	AND Immediate	PowerPC	D	28	
andil.	AND Immediate Lower	POWER family	D	28	
andis.	AND Immediate Shifted	PowerPC	D	29	

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andiu.	AND Immediate Upper	POWER family	D	29	
aze[o][.]	Add to Zero Extended	POWER family	XO	31	202
b[l][a]	Branch	com	I	18	
bc[l][a]	Branch Conditional	com	B	16	
bcc[l]	Branch Conditional to Count Register	POWER family	XL	19	528
bcctr[l]	Branch Conditional to Count Register	PowerPC	XL	19	528
bclr[l]	Branch Conditional Link Register	PowerPC	XL	19	16
bcr[l]	Branch Conditional Register	POWER family	XL	19	16
cal	Compute Address Lower	POWER family	D	14	
cau	Compute Address Upper	POWER family	D	15	
cax[o][.]	Compute Address	POWER family	XO	31	266
clcs	Cache Line Compute Size	POWER family	X	31	531
clf	Cache Line Flush	POWER family	X	31	118
cli	Cache Line Invalidate	POWER family	X	31	502
cmp	Compare	com	X	31	0
cmpi	Compare Immediate	com	D	11	
cmpl	Compare Logical	com	X	31	32
cmpli	Compare Logical Immediate	com	D	10	
cntlz[.]	Count Leading Zeros	POWER family	X	31	26
cntlzw[.]	Count Leading Zeros Word	PowerPC	X	31	26
crand	Condition Register AND	com	XL	19	257
crandc	Condition Register AND with Complement	com	XL	19	129
creqv	Condition Register Equivalent	com	XL	19	289
crnand	Condition Register NAND	com	XL	19	225

crnor	Condition Register NOR	com	XL	19	33
cror	Condition Register OR	com	XL	19	449
crorc	Condition Register OR with Complement	com	XL	19	417
crxor	Condition Register XOR	com	XL	19	193
dcbf	Data Cache Block Flush	PowerPC	X	31	86
dcbi	Data Cache Block Invalidate	PowerPC	X	31	470
dcbst	Data Cache Block Store	PowerPC	X	31	54
dcbt	Data Cache Block Touch	PowerPC	X	31	278
dcbtst	Data Cache Block Touch for Store	PowerPC	X	31	246
dcbz	Data Cache Block Set to Zero	PowerPC	X	31	1014
dclst	Data Cache Line Store	POWER family	X	31	630
dclz	Data Cache Line Set to Zero	POWER family	X	31	1014
dcs	Data Cache Synchronize	POWER family	X	31	598
div[o][.]	Divide	POWER family	XO	31	331
divs[o][.]	Divide Short	POWER family	XO	31	363
divw[o][.]	Divide Word	PowerPC	XO	31	491
divwu[o][.]	Divide Word Unsigned	PowerPC	XO	31	459
doz[o][.]	Difference or Zero	POWER family	XO	31	264
dozi	Difference or Zero Immediate	POWER family	D	09	
eciwx	External Control in Word Indexed	PPC opt.	X	31	310
ecowx	External Control out Word Indexed	PPC opt.	X	31	438
eieio	Enforce In-order Execution of I/O	PowerPC	X	31	854
eqv[.]	Equivalent	com	X	31	284
exts[.]	Extend Sign	POWER family	X	31	922
extsb[.]	Extend Sign Byte	PowerPC	X	31	954
extsh[.]	Extend Sign Halfword	PowerPC	XO	31	922
fa[.]	Floating Add	POWER family	A	63	21

fabs[.]	Floating Absolute Value	com	X	63	264
fadd[.]	Floating Add	PowerPC	A	63	21
fadds[.]	Floating Add Single	PowerPC	A	59	21
fcir[.]	Floating Convert to Integer Word	POWER family	X	63	14
fcirz[.]	Floating Convert to Integer Word with Round to Zero	POWER family	X	63	15
fcmpo	Floating Compare Ordered	com	X	63	32
fcmpu	Floating Compare Unordered	com	XL	63	0
fctiw[.]	Floating Convert to Integer Word	PowerPC	X	63	14
fctiwz[.]	Floating Convert to Integer Word with Round to Zero	PowerPC	XL	63	15
fd[.]	Floating Divide	POWER family	A	63	18
fdiv[.]	Floating Divide	PowerPC	A	63	18
fdivs[.]	Floating Divide Single	PowerPC	A	59	18
fm[.]	Floating Multiply	POWER family	A	63	25
fma[.]	Floating Multiply-Add	POWER family	A	63	29
fmadd[.]	Floating Multiply-Add	PowerPC	A	63	29
fmadds[.]	Floating Multiply-Add Single	PowerPC	A	59	29
fmr[.]	Floating Move Register	com	X	63	72
fms[.]	Floating Multiply-Subtract	POWER family	A	63	28
fmsub[.]	Floating Multiply-Subtract	PowerPC	A	63	28
fmsubs[.]	Floating Multiply-Subtract Single	PowerPC	A	59	28
fmul[.]	Floating Multiply	PowerPC	A	63	25
fmuls[.]	Floating Multiply Single	PowerPC	A	59	25
fnabs[.]	Floating Negative Absolute Value	com	X	63	136
fneg[.]	Floating Negate	com	X	63	40

fnma[.]	Floating Negative Multiply-Add	POWER family	A	63	31
fnmadd[.]	Floating Negative Multiply-Add	PowerPC	A	63	31
fnmadds[.]	Floating Negative Multiply-Add Single	PowerPC	A	59	31
fnms[.]	Floating Negative Multiply-Subtract	POWER family	A	63	30
fnmsub[.]	Floating Negative Multiply-Subtract	PowerPC	A	63	30
fnmsubs[.]	Floating Negative Multiply-Subtract Single	PowerPC	A	59	30
fres[.]	Floating Reciprocal Estimate Single	PPC opt.	A	59	24
frsp[.]	Floating Round to Single Precision	com	X	63	12
frsqrte[.]	Floating Reciprocal Square Root Estimate	PPC opt.	A	63	26
fs[.]	Floating Subtract	POWER family	A	63	20
fsel[.]	Floating-Point Select	PPC opt.	A	63	23
fsqrt[.]	Floating Square Root	POWER2	A	63	22
fsub[.]	Floating Subtract	PowerPC	A	63	20
fsubs[.]	Floating Subtract Single	PowerPC	A	59	20
icbi	Instruction Cache Block Invalidate	PowerPC	X	31	982
ics	Instruction Cache Synchronize	POWER family	X	19	150
isync	Instruction Synchronize	PowerPC	X	19	150
l	Load	POWER family	D	32	
lbrx	Load Byte-Reversed Indexed	POWER family	X	31	534
lbz	Load Byte and Zero	com	D	34	
lbzu	Load Byte and Zero with Update	com	D	35	
lbzux	Load Byte and Zero with Update Indexed	com	X	31	119
lbzx	Load Byte and Zero Indexed	com	X	31	87

lfd	Load Floating-Point Double	com	D	50	
lfdu	Load Floating-Point Double with Update	com	D	51	
lfdux	Load Floating-Point Double with Update Indexed	com	X	31	631
lfdx	Load Floating-Point Double Indexed	com	X	31	599
lfq	Load Floating-Point Quad	POWER2	D	56	
lfqu	Load Floating-Point Quad with Update	POWER2	D	57	
lfqux	Load Floating-Point Quad with Update Indexed	POWER2	X	31	823
lfqx	Load Floating-Point Quad Indexed	POWER2	X	31	791
lfs	Load Floating-Point Single	com	D	48	
lfsu	Load Floating-Point Single with Update	com	D	49	
lfsux	Load Floating-Point Single with Update Indexed	com	X	31	567
lfsx	Load Floating-Point Single Indexed	com	X	31	535
lha	Load Half Algebraic	com	D	42	
lhau	Load Half Algebraic with Update	com	D	43	
lhaux	Load Half Algebraic with Update Indexed	com	X	31	375
lhax	Load Half Algebraic Indexed	com	X	31	343

lhbrx	Load Half Byte-Reversed Indexed	com	X	31	790
lhz	Load Half and Zero	com	D	40	
lhzu	Load Half and Zero with Update	com	D	41	
lhzux	Load Half and Zero with Update Indexed	com	X	31	331
lhzx	Load Half and Zero Indexed	com	X	31	279
lm	Load Multiple	POWER family	D	46	
lmw	Load Multiple Word	PowerPC	D	46	
lscbx	Load String and Compare Byte Indexed	POWER family	X	31	277
lsi	Load String Immediate	POWER family	X	31	597
lswi	Load String Word Immediate	PowerPC	X	31	597
lswx	Load String Word Indexed	PowerPC	X	31	533
lsx	Load String Indexed	POWER family	X	31	533
lu	Load with Update	POWER family	D	33	
lux	Load with Update Indexed	POWER family	X	31	55
lwarx	Load Word and Reserve Indexed	PowerPC	X	31	20
lwbrx	Load Word Byte-Reversed Indexed	PowerPC	X	31	534
lwz	Load Word and Zero	PowerPC	D	32	
lwzu	Load Word with Zero Update	PowerPC	D	33	
lwzux	Load Word and Zero with Update Indexed	PowerPC	X	31	55
lwzx	Load Word and Zero Indexed	PowerPC	X	31	23
lx	Load Indexed	POWER family	X	31	23
maskg[.]	Mask Generate	POWER family	X	31	29
maskir[.]	Mask Insert from Register	POWER family	X	31	541
mcrf	Move Condition Register Field	com	XL	19	0

mcrfs	Move to Condition Register from FPSCR	com	X	63	64
mcrxr	Move to Condition Register from XER	com	X	31	512
mfcr	Move from Condition Register	com	X	31	19
mffs[.]	Move from FPSCR	com	X	63	583
mfmsr	Move from Machine State Register	com	X	31	83
mfspr	Move from Special-Purpose Register	com	X	31	339
mfsr	Move from Segment Register	com	X	31	595
mfsri	Move from Segment Register Indirect	POWER family	X	31	627
mfsrin	Move from Segment Register Indirect	PowerPC	X	31	659
mtcrf	Move to Condition Register Fields	com	XFX	31	144
mtfsb0[.]	Move to FPSCR Bit 0	com	X	63	70
mtfsb1[.]	Move to FPSCR Bit 1	com	X	63	38
mtfsf[.]	Move to FPSCR Fields	com	XFL	63	711
mtfsfi[.]	Move to FPSCR Field Immediate	com	X	63	134
mtmsr	Move to Machine State Register	com	X	31	146
mtspr	Move to Special-Purpose Register	com	X	31	467
mtsr	Move to Segment Register	com	X	31	210
mtsri	Move to Segment Register Indirect	POWER family	X	31	242
mtsrin	Move to Segment Register Indirect	PowerPC	X	31	242
mul[o][.]	Multiply	POWER family	XO	31	107
mulhw[.]	Multiply High Word	PowerPC	XO	31	75
mulhwu[.]	Multiply High Word Unsigned	PowerPC	XO	31	11

muli	Multiply Immediate	POWER family	D	07	
mulli	Multiply Low Immediate	PowerPC	D	07	
mullw[o][.]	Multiply Low Word	PowerPC	XO	31	235
muls[o][.]	Multiply Short	POWER family	XO	31	235
nabs[o][.]	Negative Absolute	POWER family	XO	31	488
nand[.]	NAND	com	X	31	476
neg[o][.]	Negate	com	XO	31	104
nor[.]	NOR	com	X	31	124
or[.]	OR	com	X	31	444
orc[.]	OR with Complement	com	X	31	412
ori	OR Immediate	PowerPC	D	24	
oril	OR Immediate Lower	POWER family	D	24	
oris	OR Immediate Shifted	PowerPC	D	25	
oriu	OR Immediate Upper	POWER family	D	25	
rac[.]	Real Address Compute	POWER family	X	31	818
rfi	Return from Interrupt	com	X	19	50
rfsvc	Return from SVC	POWER family	X	19	82
rlimi[.]	Rotate Left Immediate then Mask Insert	POWER family	M	20	
rlinm[.]	Rotate Left Immediate then AND with Mask	POWER family	M	21	
rlmi[.]	Rotate Left then Mask Insert	POWER family	M	22	
rlnm[.]	Rotate Left then AND with Mask	POWER family	M	23	
rlwimi[.]	Rotate Left Word Immediate then Mask Insert	PowerPC	M	20	
rlwinm[.]	Rotate Left Word Immediate then AND with Mask	PowerPC	M	21	
rlwnm[.]	Rotate Left Word then AND with Mask	PowerPC	M	23	
rrib[.]	Rotate Right and Insert Bit	POWER family	X	31	537
sc	System Call	PowerPC	SC	17	

sf[o][.]	Subtract from	POWER family	XO	31	08
sfe[o][.]	Subtract from Extended	POWER family	XO	31	136
sfi	Subtract from Immediate	POWER family	D	08	
sfme[o][.]	Subtract from Minus One Extended	POWER family	XO	31	232
sfze[o][.]	Subtract from Zero Extended	POWER family	XO	31	200
si	Subtract Immediate	com	D	12	
si.	Subtract Immediate and Record	com	D	13	
sl[.]	Shift Left	POWER family	X	31	24
sle[.]	Shift Left Extended	POWER family	X	31	153
sleq[.]	Shift Left Extended with MQ	POWER family	X	31	217
sliq[.]	Shift Left Immediate with MQ	POWER family	X	31	184
slliq[.]	Shift Left Long Immediate with MQ	POWER family	X	31	248
sllq[.]	Shift Left Long with MQ	POWER family	X	31	216
slq[.]	Shift Left with MQ	POWER family	X	31	152
slw[.]	Shift Left Word	PowerPC	X	31	24
sr[.]	Shift Right	POWER family	X	31	536
sra[.]	Shift Right Algebraic	POWER family	X	31	792
srai[.]	Shift Right Algebraic Immediate	POWER family	X	31	824
sraiq[.]	Shift Right Algebraic., Immediate with MQ	POWER family	X	31	952
sraq[.]	Shift Right Algebraic with MQ	POWER family	X	31	920
sraw[.]	Shift Right Algebraic Word	PowerPC	X	31	792
srawi[.]	Shift Right Algebraic Word Immediate	PowerPC	X	31	824
sre[.]	Shift Right Extended	POWER family	X	31	665

srea[.]	Shift Right Extended Algebraic	POWER family	X	31	921
sreq[.]	Shift Right Extended with MQ	POWER family	X	31	729
sriq[.]	Shift Right Immediate with MQ	POWER family	X	31	696
srliq[.]	Shift Right Long Immediate with MQ	POWER family	X	31	760
srlq[.]	Shift Right Long with MQ	POWER family	X	31	728
srq[.]	Shift RIght with MQ	POWER family	X	31	664
srw[.]	Shift Right Word	PowerPC	X	31	536
st	Store	POWER family	D	36	
stb	Store Byte	com	D	38	
stbrx	Store Byte-Reversed Indexed	POWER family	X	31	662
stbu	Store Byte with Update	com	D	39	
stbux	Store Byte with Update Indexed	com	X	31	247
stbx	Store Byte Indexed	com	X	31	215
stfd	Store Floating-Point Double	com	D	54	
stfdu	Store Floating-Point Double with Update	com	D	55	
stfdux	Store Floating-Point Double with Update Indexed	com	X	31	759
stfdx	Store Floating-Point Double Indexed	com	X	31	727
stfiwx	Store Floating-Point as Integer Word Indexed	PPC opt.	X	31	983
stfq	Store Floating-Point Quad	POWER2	DS	60	
stfqu	Store Floating-Point Quad with Update	POWER2	DS	61	

stfqux	Store Floating-Point Quad with Update Indexed	POWER2	X	31	951
stfqx	Store Floating-Point Quad Indexed	POWER2	X	31	919
stfs	Store Floating-Point Single	com	D	52	
stfsu	Store Floating-Point Single with Update	com	D	53	
stfsux	Store Floating-Point Single with Update Indexed	com	X	31	695
stfsx	Store Floating-Point Single Indexed	com	X	31	663
sth	Store Half	com	D	44	
sthbrx	Store Half Byte-Reverse Indexed	com	X	31	918
sthu	Store Half with Update	com	D	45	
sthux	Store Half with Update Indexed	com	X	31	439
sthx	Store Half Indexed	com	X	31	407
stm	Store Multiple	POWER family	D	47	
stmw	Store Multiple Word	PowerPC	D	47	
stsi	Store String Immediate	POWER family	X	31	725
stswi	Store String Word Immediate	PowerPC	X	31	725
stswx	Store String Word Indexed	PowerPC	X	31	661
stsx	Store String Indexed	POWER family	X	31	661
stu	Store with Update	POWER family	D	37	
stux	Store with Update Indexed	POWER family	X	31	183
stw	Store	PowerPC	D	36	
stwbrx	Store Word Byte-Reversed Indexed	PowerPC	X	31	662

stwcx.	Store Word Conditional Indexed	PowerPC	X	31	150
stwu	Store Word with Update	PowerPC	D	37	
stwux	Store Word with Update Indexed	PowerPC	X	31	183
stwx	Store Word Indexed	PowerPC	X	31	151
stx	Store Indexed	POWER family	X	31	151
subf[o][.]	Subtract from	PowerPC	XO	31	40
subfc[o][.]	Subtract from Carrying	PowerPC	XO	31	08
subfe[o][.]	Subtract from Extended	PowerPC	XO	31	136
subfic	Subtract from Immediate Carrying	PowerPC	D	08	
subfme[o][.]	Subtract from Minus One Extended	PowerPC	XO	31	232
subfze[o][.]	Subtract from Zero Extended	PowerPC	XO	31	200
svc[l][a]	Supervisor Call	POWER family	SC	17	
sync	Synchronize	PowerPC	X	31	598
t	Trap	POWER family	X	31	04
ti	Trap Immediate	POWER family	D	03	
tlbi	Translation Look-aside Buffer Invalidate Entry	POWER family	X	31	306
tlbie	Translation Look-aside Buffer Invalidate Entry	PPC opt.	X	31	306
tlbld	Load Data TLB Entry	603 only	X	31	978
tlbli	Load Instruction TLB Entry	603 only	X	31	1010
tlbsync	Translation Look-aside Buffer Synchronize	PPC opt.	X	31	566
tw	Trap Word	PowerPC	X	31	04
twi	Trap Word Immediate	PowerPC	D	03	
xor[.]	XOR	com	X	31	316
xori	XOR Immediate	PowerPC	D	26	
xoril	XOR Immediate Lower	POWER family	D	26	
xoris	XOR Immediate Shift	PowerPC	D	27	

xoriu	XOR Immediate Upper	POWER family	D	27	

Appendix C. Instruction Set Sorted by Primary and Extended Op Code

The Instruction Set Sorted by Primary and Extended Op Code table lists the instruction set, sorted first by primary op code and then by extended op code. The table column Implementation contains the following information:

Implementation	Description
com	Supported by POWER family, POWER2, and PowerPC implementations.
POWER family	Supported only by POWER family and POWER2 implementations.
POWER2	Supported only by POWER2 implementations.
PowerPC	Supported only by PowerPC architecture.
PPC opt.	Defined only in PowerPC architecture and is an optional instruction.
603 only	Supported only on the PowerPC 603 RISC Microprocessor

Instruction Set Sorted by Primary and Extended Op Code					
Mnemonic	**Instruction**	**Implementation**	**Format**	**Primary Op Code**	**Extended Op Code**
ti	Trap Immediate	POWER family	D	03	
twi	Trap Word Immediate	PowerPC	D	03	
muli	Multiply Immediate	POWER family	D	07	
mulli	Multiply Low Immediate	PowerPC	D	07	
sfi	Subtract from Immediate	POWER family	D	08	
subfic	Subtract from Immediate Carrying	PowerPC	D	08	
dozi	Difference or Zero Immediate	POWER family	D	09	
cmpli	Compare Logical Immediate	com	D	10	
cmpi	Compare Immediate	com	D	11	
addic	Add Immediate Carrying	PowerPC	D	12	
ai	Add Immediate	POWER family	D	12	
si	Subtract Immediate	com	D	12	
addic.	Add Immediate Carrying and Record	PowerPC	D	13	
si.	Subtract Immediate and Record	com	D	13	
ai.	Add Immediate and Record	POWER family	D	13	
addi	Add Immediate	PowerPC	D	14	

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cal	Compute Address Lower	POWER family	D	14	
addis	Add Immediate Shifted	PowerPC	D	15	
cau	Compute Address Upper	POWER family	D	15	
bc[l][a]	Branch Conditional	com	B	16	
sc	System Call	PowerPC	SC	17	
svc[l][a]	Supervisor Call	POWER family	SC	17	
b[l][a]	Branch	com	I	18	
mcrf	Move Condition Register Field	com	XL	19	0
bclr[l]	Branch Conditional Link Register	PowerPC	XL	19	16
bcr[l]	Branch Conditional Register	POWER family	XL	19	16
crnor	Condition Register NOR	com	XL	19	33
rfi	Return from Interrupt	com	X	19	50
rfsvc	Return from SVC	POWER family	X	19	82
crandc	Condition Register AND with Complement	com	XL	19	129
ics	Instruction Cache Synchronize	POWER family	X	19	150
isync	Instruction Synchronize	PowerPC	X	19	150
crxor	Condition Register XOR	com	XL	19	193
crnand	Condition Register NAND	com	XL	19	225
crand	Condition Register AND	com	XL	19	257
creqv	Condition Register Equivalent	com	XL	19	289
crorc	Condition Register OR with Complement	com	XL	19	417
cror	Condition Register OR	com	XL	19	449
bcc[l]	Branch Conditional to Count Register	POWER family	XL	19	528

bcctr[l]	Branch Conditional to Count Register	PowerPC	XL	19	528
rlimi[.]	Rotate Left Immediate then Mask Insert	POWER family	M	20	
rlwimi[.]	Rotate Left Word Immediate then Mask Insert	PowerPC	M	20	
rlinm[.]	Rotate Left Immediate then AND with Mask	POWER family	M	21	
rlwinm[.]	Rotate Left Word Immediate then AND with Mask	PowerPC	M	21	
rlmi[.]	Rotate Left then Mask Insert	POWER family	M	22	
rlnm[.]	Rotate Left then AND with Mask	POWER family	M	23	
rlwnm[.]	Rotate Left Word then AND with Mask	PowerPC	M	23	
ori	OR Immediate	PowerPC	D	24	
oril	OR Immediate Lower	POWER family	D	24	
oris	OR Immediate Shifted	PowerPC	D	25	
oriu	OR Immediate Upper	POWER family	D	25	
xori	XOR Immediate	PowerPC	D	26	
xoril	XOR Immediate Lower	POWER family	D	26	
xoris	XOR Immediate Shift	PowerPC	D	27	
xoriu	XOR Immediate Upper	POWER family	D	27	
andi.	AND Immediate	PowerPC	D	28	
andil.	AND Immediate Lower	POWER family	D	28	
andis.	AND Immediate Shifted	PowerPC	D	29	
andiu.	AND Immediate Upper	POWER family	D	29	
cmp	Compare	com	X	31	0
t	Trap	POWER family	X	31	04
tw	Trap Word	PowerPC	X	31	04
sf[o][.]	Subtract from	POWER family	XO	31	08
subfc[o][.]	Subtract from Carrying	PowerPC	XO	31	08

a[o][.]	Add Carrying	POWER family	XO	31	10
addc[o][.]	Add Carrying	PowerPC	XO	31	10
mulhwu[.]	Multiply High Word Unsigned	PowerPC	XO	31	11
mfcr	Move from Condition Register	com	X	31	19
lwarx	Load Word and Reserve Indexed	PowerPC	X	31	20
lwzx	Load Word and Zero Indexed	PowerPC	X	31	23
lx	Load Indexed	POWER family	X	31	23
sl[.]	Shift Left	POWER family	X	31	24
slw[.]	Shift Left Word	PowerPC	X	31	24
cntlz[.]	Count Leading Zeros	POWER family	X	31	26
cntlzw[.]	Count Leading Zeros Word	PowerPC	X	31	26
and[.]	AND	com	X	31	28
maskg[.]	Mask Generate	POWER family	X	31	29
cmpl	Compare Logical	com	X	31	32
subf[o][.]	Subtract from	PowerPC	XO	31	40
dcbst	Data Cache Block Store	PowerPC	X	31	54
lux	Load with Update Indexed	POWER family	X	31	55
lwzux	Load Word and Zero with Update Indexed	PowerPC	X	31	55
andc[.]	AND with Complement	com	X	31	60
mulhw[.]	Multiply High Word	PowerPC	XO	31	75
mfmsr	Move from Machine State Register	com	X	31	83
dcbf	Data Cache Block Flush	PowerPC	X	31	86
lbzx	Load Byte and Zero Indexed	com	X	31	87
neg[o][.]	Negate	com	XO	31	104
mul[o][.]	Multiply	POWER family	XO	31	107
clf	Cache Line Flush	POWER family	X	31	118
lbzux	Load Byte and Zero with Update Indexed	com	X	31	119
nor[.]	NOR	com	X	31	124

sfe[o][.]	Subtract from Extended	POWER family	XO	31	136
subfe[o][.]	Subtract from Extended	PowerPC	XO	31	136
adde[o][.]	Add Extended	PowerPC	XO	31	138
ae[o][.]	Add Extended	POWER family	XO	31	138
mtcrf	Move to Condition Register Fields	com	XFX	31	144
mtmsr	Move to Machine State Register	com	X	31	146
stwcx.	Store Word Conditional Indexed	PowerPC	X	31	150
stwx	Store Word Indexed	PowerPC	X	31	151
stx	Store Indexed	POWER family	X	31	151
slq[.]	Shift Left with MQ	POWER family	X	31	152
sle[.]	Shift Left Extended	POWER family	X	31	153
stux	Store with Update Indexed	POWER family	X	31	183
stwux	Store Word with Update Indexed	PowerPC	X	31	183
sliq[.]	Shift Left Immediate with MQ	POWER family	X	31	184
sfze[o][.]	Subtract from Zero Extended	POWER family	XO	31	200
subfze[o][.]	Subtract from Zero Extended	PowerPC	XO	31	200
addze[o][.]	Add to Zero Extended	PowerPC	XO	31	202
aze[o][.]	Add to Zero Extended	POWER family	XO	31	202
mtsr	Move to Segment Register	com	X	31	210
stbu	Store Byte with Update	com	D	39	
stbx	Store Byte Indexed	com	X	31	215
sllq[.]	Shift Left Long with MQ	POWER family	X	31	216
sleq[.]	Shift Left Extended with MQ	POWER family	X	31	217
sfme[o][.]	Subtract from Minus One Extended	POWER family	XO	31	232

subfme[o][.]	Subtract from Minus One Extended	PowerPC	XO	31	232
addme[o][.]	Add to Minus One Extended	PowerPC	XO	31	234
ame[o][.]	Add to Minus One Extended	POWER family	XO	31	234
mullw[o][.]	Multiply Low Word	PowerPC	XO	31	235
muls[o][.]	Multiply Short	POWER family	XO	31	235
mtsri	Move to Segment Register Indirect	POWER family	X	31	242
mtsrin	Move to Segment Register Indirect	PowerPC	X	31	242
dcbtst	Data Cache Block Touch for Store	PowerPC	X	31	246
stbux	Store Byte with Update Indexed	com	X	31	247
slliq[.]	Shift Left Long Immediate with MQ	POWER family	X	31	248
doz[o][.]	Difference or Zero	POWER family	XO	31	264
add[o][.]	Add	PowerPC	XO	31	266
cax[o][.]	Compute Address	POWER family	XO	31	266
lscbx	Load String and Compare Byte Indexed	POWER family	X	31	277
dcbt	Data Cache Block Touch	PowerPC	X	31	278
lhzx	Load Half and Zero Indexed	com	X	31	279
eqv[.]	Equivalent	com	X	31	284
tlbi	Translation Look-aside Buffer Invalidate Entry	POWER family	X	31	306
tlbie	Translation Look-aside Buffer Invalidate Entry	PPC opt.	X	31	306
eciwx	External Control in Word Indexed	PPC opt.	X	31	310
xor[.]	XOR	com	X	31	316
div[o][.]	Divide	POWER family	XO	31	331
lhzux	Load Half and Zero with Update Indexed	com	X	31	331
mfspr	Move from Special-Purpose Register	com	X	31	339

lhax	Load Half Algebraic Indexed	com	X	31	343
abs[o][.]	Absolute	POWER family	XO	31	360
divs[o][.]	Divide Short	POWER family	XO	31	363
lhaux	Load Half Algebraic with Update Indexed	com	X	31	375
sthx	Store Half Indexed	com	X	31	407
orc[.]	OR with Complement	com	X	31	412
ecowx	External Control out Word Indexed	PPC opt.	X	31	438
sthux	Store Half with Update Indexed	com	X	31	439
or[.]	OR	com	X	31	444
divwu[o][.]	Divide Word Unsigned	PowerPC	XO	31	459
mtspr	Move to Special-Purpose Register	com	X	31	467
dcbi	Data Cache Block Invalidate	PowerPC	X	31	470
nand[.]	NAND	com	X	31	476
nabs[o][.]	Negative Absolute	POWER family	XO	31	488
divw[o][.]	Divide Word	PowerPC	XO	31	491
cli	Cache Line Invalidate	POWER family	X	31	502
mcrxr	Move to Condition Register from XER	com	X	31	512
clcs	Cache Line Compute Size	POWER family	X	31	531
lswx	Load String Word Indexed	PowerPC	X	31	533
lsx	Load String Indexed	POWER family	X	31	533
lbrx	Load Byte-Reversed Indexed	POWER family	X	31	534
lwbrx	Load Word Byte-Reversed Indexed	PowerPC	X	31	534
lfsx	Load Floating-Point Single Indexed	com	X	31	535
sr[.]	Shift Right	POWER family	X	31	536
srw[.]	Shift Right Word	PowerPC	X	31	536

rrib[.]	Rotate Right and Insert Bit	POWER family	X	31	537
maskir[.]	Mask Insert from Register	POWER family	X	31	541
tlbsync	Translation Look-aside Buffer Synchronize	PPC opt.	X	31	566
lfsux	Load Floating-Point Single with Update Indexed	com	X	31	567
mfsr	Move from Segment Register	com	X	31	595
lsi	Load String Immediate	POWER family	X	31	597
lswi	Load String Word Immediate	PowerPC	X	31	597
dcs	Data Cache Synchronize	POWER family	X	31	598
sync	Synchronize	PowerPC	X	31	598
lfdx	Load Floating-Point Double Indexed	com	X	31	599
mfsri	Move from Segment Register Indirect	POWER family	X	31	627
dclst	Data Cache Line Store	POWER family	X	31	630
lfdux	Load Floating-Point Double with Update Indexed	com	X	31	631
mfsrin	Move from Segment Register Indirect	PowerPC	X	31	659
stswx	Store String Word Indexed	PowerPC	X	31	661
stsx	Store String Indexed	POWER family	X	31	661
stbrx	Store Byte-Reversed Indexed	POWER family	X	31	662
stwbrx	Store Word Byte-Reversed Indexed	PowerPC	X	31	662
stfsx	Store Floating-Point Single Indexed	com	X	31	663
srq[.]	Shift RIght with MQ	POWER family	X	31	664

sre[.]	Shift Right Extended	POWER family	X	31	665
stfsux	Store Floating-Point Single with Update Indexed	com	X	31	695
sriq[.]	Shift Right Immediate with MQ	POWER family	X	31	696
stsi	Store String Immediate	POWER family	X	31	725
stswi	Store String Word Immediate	PowerPC	X	31	725
stfdx	Store Floating-Point Double Indexed	com	X	31	727
srlq[.]	Shift Right Long with MQ	POWER family	X	31	728
sreq[.]	Shift Right Extended with MQ	POWER family	X	31	729
stfdux	Store Floating-Point Double with Update Indexed	com	X	31	759
srliq[.]	Shift Right Long Immediate with MQ	POWER family	X	31	760
lhbrx	Load Half Byte-Reversed Indexed	com	X	31	790
lfqx	Load Floating-Point Quad Indexed	POWER2	X	31	791
sra[.]	Shift Right Algebraic	POWER family	X	31	792
sraw[.]	Shift Right Algebraic Word	PowerPC	X	31	792
rac[.]	Real Address Compute	POWER family	X	31	818
lfqux	Load Floating-Point Quad with Update Indexed	POWER2	X	31	823
srai[.]	Shift Right Algebraic Immediate	POWER family	X	31	824
srawi[.]	Shift Right Algebraic Word Immediate	PowerPC	X	31	824
eieio	Enforce In-order Execution of I/O	PowerPC	X	31	854

sthbrx	Store Half Byte-Reverse Indexed	com	X	31	918
stfqx	Store Floating-Point Quad Indexed	POWER2	X	31	919
sraq[.]	Shift Right Algebraic with MQ	POWER family	X	31	920
srea[.]	Shift Right Extended Algebraic	POWER family	X	31	921
exts[.]	Extend Sign	POWER family	X	31	922
extsh[.]	Extend Sign Halfword	PowerPC	XO	31	922
stfqux	Store Floating-Point Quad with Update Indexed	POWER2	X	31	951
sraiq[.]	Shift Right Algebraic Immediate with MQ	POWER family	X	31	952
extsb[.]	Extend Sign Byte	PowerPC	X	31	954
tlbld	Load Data TLB Entry	603 only	X	31	978
icbi	Instruction Cache Block Invalidate	PowerPC	X	31	982
stfiwx	Store Floating-Point as Integer Word Indexed	PPC opt.	X	31	983
tlbli	Load Instruction TLB Entry	603 only	X	31	1010
dcbz	Data Cache Block Set to Zero	PowerPC	X	31	1014
dclz	Data Cache Line Set to Zero	POWER family	X	31	1014
l	Load	POWER family	D	32	
lwz	Load Word and Zero	PowerPC	D	32	
lu	Load with Update	POWER family	D	33	
lwzu	Load Word with Zero Update	PowerPC	D	33	
lbz	Load Byte and Zero	com	D	34	
lbzu	Load Byte and Zero with Update	com	D	35	
st	Store	POWER family	D	36	
stw	Store	PowerPC	D	36	
stu	Store with Update	POWER family	D	37	

stwu	Store Word with Update	PowerPC	D	37	
stb	Store Byte	com	D	38	
lhz	Load Half and Zero	com	D	40	
lhzu	Load Half and Zero with Update	com	D	41	
lha	Load Half Algebraic	com	D	42	
lhau	Load Half Algebraic with Update	com	D	43	
sth	Store Half	com	D	44	
sthu	Store Half with Update	com	D	45	
lm	Load Multiple	POWER family	D	46	
lmw	Load Multiple Word	PowerPC	D	46	
stm	Store Multiple	POWER family	D	47	
stmw	Store Multiple Word	PowerPC	D	47	
lfs	Load Floating-Point Single	com	D	48	
lfsu	Load Floating-Point Single with Update	com	D	49	
lfd	Load Floating-Point Double	com	D	50	
lfdu	Load Floating-Point Double with Update	com	D	51	
stfs	Store Floating-Point Single	com	D	52	
stfsu	Store Floating-Point Single with Update	com	D	53	
stfd	Store Floating-Point Double	com	D	54	
stfdu	Store Floating-Point Double with Update	com	D	55	

lfq	Load Floating-Point Quad	POWER2	D	56	
lfqu	Load Floating-Point Quad with Update	POWER2	D	57	
fdivs[.]	Floating Divide Single	PowerPC	A	59	18
fsubs[.]	Floating Subtract Single	PowerPC	A	59	20
fadds[.]	Floating Add Single	PowerPC	A	59	21
fres[.]	Floating Reciprocal Estimate Single	PPC opt.	A	59	24
fmuls[.]	Floating Multiply Single	PowerPC	A	59	25
fmsubs[.]	Floating Multiply-Subtract Single	PowerPC	A	59	28
fmadds[.]	Floating Multiply-Add Single	PowerPC	A	59	29
fnmsubs[.]	Floating Negative Multiply-Subtract Single	PowerPC	A	59	30
fnmadds[.]	Floating Negative Multiply-Add Single	PowerPC	A	59	31
stfq	Store Floating-Point Quad	POWER2	DS	60	
stfqu	Store Floating-Point Quad with Update	POWER2	DS	61	
fcmpu	Floating Compare Unordered	com	XL	63	0
frsp[.]	Floating Round to Single Precision	com	X	63	12
fcir[.]	Floating Convert to Integer Word	POWER family	X	63	14
fctiw[.]	Floating Convert to Integer Word	PowerPC	X	63	14
fcirz[.]	Floating Convert to Integer Word with Round to Zero	POWER family	X	63	15
fctiwz[.]	Floating Convert to Integer Word with Round to Zero	PowerPC	XL	63	15
fd[.]	Floating Divide	POWER family	A	63	18

fdiv[.]	Floating Divide	PowerPC	A	63	18
fs[.]	Floating Subtract	POWER family	A	63	20
fsub[.]	Floating Subtract	PowerPC	A	63	20
fa[.]	Floating Add	POWER family	A	63	21
fadd[.]	Floating Add	PowerPC	A	63	21
fsqrt[.]	Floating Square Root	POWER2	A	63	22
fsel[.]	Floating-Point Select	PPC opt.	A	63	23
fm[.]	Floating Multiply	POWER family	A	63	25
fmul[.]	Floating Multiply	PowerPC	A	63	25
frsqrte[.]	Floating Reciprocal Square Root Estimate	PPC opt.	A	63	26
fms[.]	Floating Multiply-Subtract	POWER family	A	63	28
fmsub[.]	Floating Multiply-Subtract	PowerPC	A	63	28
fma[.]	Floating Multiply-Add	POWER family	A	63	29
fmadd[.]	Floating Multiply-Add	PowerPC	A	63	29
fnms[.]	Floating Negative Multiply-Subtract	POWER family	A	63	30
fnmsub[.]	Floating Negative Multiply-Subtract	PowerPC	A	63	30
fnma[.]	Floating Negative Multiply-Add	POWER family	A	63	31
fnmadd[.]	Floating Negative Multiply-Add	PowerPC	A	63	31
fcmpo	Floating Compare Ordered	com	X	63	32
mtfsb1[.]	Move to FPSCR Bit 1	com	X	63	38
fneg[.]	Floating Negate	com	X	63	40
mcrfs	Move to Condition Register from FPSCR	com	X	63	64
mtfsb0[.]	Move to FPSCR Bit 0	com	X	63	70
fmr[.]	Floating Move Register	com	X	63	72
mtfsfi[.]	Move to FPSCR Field Immediate	com	X	63	134
fnabs[.]	Floating Negative Absolute Value	com	X	63	136

fabs[.]	Floating Absolute Value	com	X	63	264
mffs[.]	Move from FPSCR	com	X	63	583
mtfsf[.]	Move to FPSCR Fields	com	XFL	63	711

Appendix D. Instructions Common to POWER family, POWER2, and PowerPC

Instructions Common to POWER family**,** POWER2**, and** PowerPC				
Mnemonic	**Instruction**	**Format**	**Primary Op Code**	**Extended Op Code**
and[.]	AND	X	31	28
andc[.]	AND with Complement	X	31	60
b[l][a]	Branch	I	18	
bc[l][a]	Branch Conditional	B	16	
cmp	Compare	X	31	0
cmpi	Compare Immediate	D	11	
cmpl	Compare Logical	X	31	32
cmpli	Compare Logical Immediate	D	10	
crand	Condition Register AND	XL	19	257
crandc	Condition Register AND with Complement	XL	19	129
creqv	Condition Register Equivalent	XL	19	289
crnand	Condition Register NAND	XL	19	225
crnor	Condition Register NOR	XL	19	33
cror	Condition Register OR	XL	19	449
crorc	Condition Register OR with Complement	XL	19	417
crxor	Condition Register XOR	XL	19	193
eciwx	External Control in Word Indexed	X	31	310
ecowx	External Control out Word Indexed	X	31	438
eqv[.]	Equivalent	X	31	284
fabs[.]	Floating Absolute Value	X	63	264
fcmpo	Floating Compare Ordered	X	63	32
fcmpu	Floating Compare Unordered	XL	63	0
fmr[.]	Floating Move Register	X	63	72
fnabs[.]	Floating Negative Absolute Value	X	63	136

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fneg[.]	Floating Negate	X	63	40
frsp[.]	Floating Round to Single Precision	X	63	12
lbz	Load Byte and Zero	D	34	
lbzu	Load Byte and Zero with Update	D	35	
lbzux	Load Byte and Zero with Update Indexed	X	31	119
lbzx	Load Byte and Zero Indexed	X	31	87
lfd	Load Floating-Point Double	D	50	
lfdu	Load Floating-Point Double with Update	D	51	
lfdux	Load Floating-Point Double with Update Indexed	X	31	631
lfdx	Load Floating-Point Double Indexed	X	31	599
lfs	Load Floating-Point Single	D	48	
lfsu	Load Floating-Point Single with Update	D	49	
lfsux	Load Floating-Point Single with Update Indexed	X	31	567
lfsx	Load Floating-Point Single Indexed	X	31	535
lha	Load Half Algebraic	D	42	
lhau	Load Half Algebraic with Update	D	43	
lhaux	Load Half Algebraic with Update Indexed	X	31	375
lhax	Load Half Algebraic Indexed	X	31	343
lhbrx	Load Half Byte-Reversed Indexed	X	31	790
lhz	Load Half and Zero	D	40	
lhzu	Load Half and Zero with Update	D	41	
lhzux	Load Half and Zero with Update Indexed	X	31	331
lhzx	Load Half and Zero Indexed	X	31	279
mcrf	Move Condition Register Field	XL	19	0
mcrfs	Move to Condition Register from FPSCR	X	63	64

mcrxr	Move to Condition Register from XER	X	31	512
mfcr	Move from Condition Register	X	31	19
mffs[.]	Move from FPSCR	X	63	583
mfmsr	Move from Machine State Register	X	31	83
mfspr	Move from Special-Purpose Register	X	31	339
mfsr	Move from Segment Register	X	31	595
mtcrf	Move to Condition Register Fields	XFX	31	144
mtfsb0[.]	Move to FPSCR Bit 0	X	63	70
mtfsb1[.]	Move to FPSCR Bit 1	X	63	38
mtfsf[.]	Move to FPSCR Fields	XFL	63	711
mtfsfi[.]	Move to FPSCR Field Immediate	X	63	134
mtmsr	Move to Machine State Register	X	31	146
mtspr	Move to Special-Purpose Register	X	31	467
mtsr	Move to Segment Register	X	31	210
nand[.]	NAND	X	31	476
neg[o][.]	Negate	XO	31	104
nor[.]	NOR	X	31	124
or[.]	OR	X	31	444
orc[.]	OR with Complement	X	31	412
rfi	Return from Interrupt	X	19	50
si	Subtract Immediate	D	12	
si.	Subtract Immediate and Record	D	13	
stb	Store Byte	D	38	
stbu	Store Byte with Update	D	39	
stbux	Store Byte with Update Indexed	X	31	247
stbx	Store Byte Indexed	X	31	215
stfd	Store Floating-Point Double	D	54	
stfdu	Store Floating-Point Double with Update	D	55	

stfdux	Store Floating-Point Double with Update Indexed	X	31	759
stfdx	Store Floating-Point Double Indexed	X	31	727
stfs	Store Floating-Point Single	D	52	
stfsu	Store Floating-Point Single with Update	D	53	
stfsux	Store Floating-Point Single with Update Indexed	X	31	695
stfsx	Store Floating-Point Single Indexed	X	31	663
sth	Store Half	D	44	
sthbrx	Store Half Byte-Reverse Indexed	X	31	918
sthu	Store Half with Update	D	45	
sthux	Store Half with Update Indexed	X	31	439
sthx	Store Half Indexed	X	31	407
xor[.]	XOR	X	31	316

Appendix E. POWER family and POWER2 Instructions

In the following POWER family and POWER2 Instructions table, Instructions that are supported only in POWER2 implementations are indicated by ″POWER2″ in the POWER2 **Only** column:

POWER family **and** POWER2 **Instructions**					
Mnemonic	**Instruction**	POWER2 **Only**	**Format**	**Primary Op Code**	**Extended Op Code**
a[o][.]	Add Carrying		XO	31	10
abs[o][.]	Absolute		XO	31	360
ae[o][.]	Add Extended		XO	31	138
ai	Add Immediate		D	12	
ai.	Add Immediate and Record		D	13	
ame[o][.]	Add to Minus One Extended		XO	31	234
and[.]	AND		X	31	28
andc[.]	AND with Complement		X	31	60
andil.	AND Immediate Lower		D	28	
andiu.	AND Immediate Upper		D	29	
aze[o][.]	Add to Zero Extended		XO	31	202
b[l][a]	Branch		I	18	
bc[l][a]	Branch Conditional		B	16	
bcc[l]	Branch Conditional to Count Register		XL	19	528
bcr[l]	Branch Conditional Register		XL	19	16
cal	Compute Address Lower		D	14	
cau	Compute Address Upper		D	15	
cax[o][.]	Compute Address		XO	31	266
clcs	Cache Line Compute Size		X	31	531
clf	Cache Line Flush		X	31	118
cli	Cache Line Invalidate		X	31	502
cmp	Compare		X	31	0
cmpi	Compare Immediate		D	11	
cmpl	Compare Logical		X	31	32

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cmpli	Compare Logical Immediate		D	10	
cntlz[.]	Count Leading Zeros		X	31	26
crand	Condition Register AND		XL	19	257
crandc	Condition Register AND with Complement		XL	19	129
creqv	Condition Register Equivalent		XL	19	289
crnand	Condition Register NAND		XL	19	225
crnor	Condition Register NOR		XL	19	33
cror	Condition Register OR		XL	19	449
crorc	Condition Register OR with Complement		XL	19	417
crxor	Condition Register XOR		XL	19	193
dclst	Data Cache Line Store		X	31	630
dclz	Data Cache Line Set to Zero		X	31	1014
dcs	Data Cache Synchronize		X	31	598
div[o][.]	Divide		XO	31	331
divs[o][.]	Divide Short		XO	31	363
doz[o][.]	Difference or Zero		XO	31	264
dozi	Difference or Zero Immediate		D	09	
eciwx	External Control in Word Indexed		X	31	310
ecowx	External Control out Word Indexed		X	31	438
eqv[.]	Equivalent		X	31	284
exts[.]	Extend Sign		X	31	922
fa[.]	Floating Add		A	63	21
fabs[.]	Floating Absolute Value		X	63	264
fcir[.]	Floating Convert to Integer Word		X	63	14
fcirz[.]	Floating Convert to Integer Word with Round to Zero		X	63	15

fcmpo	Floating Compare Ordered		X	63	32
fcmpu	Floating Compare Unordered		XL	63	0
fd[.]	Floating Divide		A	63	18
fm[.]	Floating Multiply		A	63	25
fma[.]	Floating Multiply-Add		A	63	29
fmr[.]	Floating Move Register		X	63	72
fms[.]	Floating Multiply-Subtract		A	63	28
fnabs[.]	Floating Negative Absolute Value		X	63	136
fneg[.]	Floating Negate		X	63	40
fnma[.]	Floating Negative Multiply-Add		A	63	31
fnms[.]	Floating Negative Multiply-Subtract		A	63	30
frsp[.]	Floating Round to Single Precision		X	63	12
fs[.]	Floating Subtract		A	63	20
fsqrt[.]	Floating Square Root	POWER2	A	63	22
ics	Instruction Cache Synchronize		X	19	150
l	Load		D	32	
lbrx	Load Byte-Reversed Indexed		X	31	534
lbz	Load Byte and Zero		D	34	
lbzu	Load Byte and Zero with Update		D	35	
lbzux	Load Byte and Zero with Update Indexed		X	31	119
lbzx	Load Byte and Zero Indexed		X	31	87
lfd	Load Floating-Point Double		D	50	
lfdu	Load Floating-Point Double with Update		D	51	
lfdux	Load Floating-Point Double with Update Indexed		X	31	631

lfdx	Load Floating-Point Double Indexed		X	31	599
lfq	Load Floating-Point Quad	POWER2	D	56	
lfqu	Load Floating-Point Quad with Update	POWER2	D	57	
lfqux	Load Floating-Point Quad with Update Indexed	POWER2	X	31	823
lfqx	Load Floating-Point Quad Indexed	POWER2	X	31	791
lfs	Load Floating-Point Single		D	48	
lfsu	Load Floating-Point Single with Update		D	49	
lfsux	Load Floating-Point Single with Update Indexed		X	31	567
lfsx	Load Floating-Point Single Indexed		X	31	535
lha	Load Half Algebraic		D	42	
lhau	Load Half Algebraic with Update		D	43	
lhaux	Load Half Algebraic with Update Indexed		X	31	375
lhax	Load Half Algebraic Indexed		X	31	343
lhbrx	Load Half Byte-Reversed Indexed		X	31	790
lhz	Load Half and Zero		D	40	
lhzu	Load Half and Zero with Update		D	41	
lhzux	Load Half and Zero with Update Indexed		X	31	331
lhzx	Load Half and Zero Indexed		X	31	279

lm	Load Multiple		D	46	
lscbx	Load String and Compare Byte Indexed		X	31	277
lsi	Load String Immediate		X	31	597
lsx	Load String Indexed		X	31	533
lu	Load with Update		D	33	
lux	Load with Update Indexed		X	31	55
lx	Load Indexed		X	31	23
maskg[.]	Mask Generate		X	31	29
maskir[.]	Mask Insert from Register		X	31	541
mcrf	Move Condition Register Field		XL	19	0
mcrfs	Move to Condition Register from FPSCR		X	63	64
mcrxr	Move to Condition Register from XER		X	31	512
mfcr	Move from Condition Register		X	31	19
mffs[.]	Move from FPSCR		X	63	583
mfmsr	Move from Machine State Register		X	31	83
mfspr	Move from Special-Purpose Register		X	31	339
mfsr	Move from Segment Register		X	31	595
mfsri	Move from Segment Register Indirect		X	31	627
mtcrf	Move to Condition Register Fields		XFX	31	144
mtfsb0[.]	Move to FPSCR Bit 0		X	63	70
mtfsb1[.]	Move to FPSCR Bit 1		X	63	38
mtfsf[.]	Move to FPSCR Fields		XFL	63	711
mtfsfi[.]	Move to FPSCR Field Immediate		X	63	134

mtmsr	Move to Machine State Register		X	31	146
mtspr	Move to Special-Purpose Register		X	31	467
mtsr	Move to Segment Register		X	31	210
mtsri	Move to Segment Register Indirect		X	31	242
mul[o][.]	Multiply		XO	31	107
muli	Multiply Immediate		D	07	
muls[o][.]	Multiply Short		XO	31	235
nabs[o][.]	Negative Absolute		XO	31	488
nand[.]	NAND		X	31	476
neg[o][.]	Negate		XO	31	104
nor[.]	NOR		X	31	124
or[.]	OR		X	31	444
orc[.]	OR with Complement		X	31	412
oril	OR Immediate Lower		D	24	
oriu	OR Immediate Upper		D	25	
rac[.]	Real Address Compute		X	31	818
rfi	Return from Interrupt		X	19	50
rfsvc	Return from SVC		X	19	82
rlimi[.]	Rotate Left Immediate then Mask Insert		M	20	
rlinm[.]	Rotate Left Immediate then AND with Mask		M	21	
rlmi[.]	Rotate Left then Mask Insert		M	22	
rlnm[.]	Rotate Left then AND with Mask		M	23	
rrib[.]	Rotate Right and Insert Bit		X	31	537
sf[o][.]	Subtract from		XO	31	08
sfe[o][.]	Subtract from Extended		XO	31	136
sfi	Subtract from Immediate		D	08	

sfme[o][.]	Subtract from Minus One Extended		XO	31	232
sfze[o][.]	Subtract from Zero Extended		XO	31	200
si	Subtract Immediate		D	12	
si.	Subtract Immediate and Record		D	13	
sl[.]	Shift Left		X	31	24
sle[.]	Shift Left Extended		X	31	153
sleq[.]	Shift Left Extended with MQ		X	31	217
sliq[.]	Shift Left Immediate with MQ		X	31	184
slliq[.]	Shift Left Long Immediate with MQ		X	31	248
sllq[.]	Shift Left Long with MQ		X	31	216
slq[.]	Shift Left with MQ		X	31	152
sr[.]	Shift Right		X	31	536
sra[.]	Shift Right Algebraic		X	31	792
srai[.]	Shift Right Algebraic Immediate		X	31	824
sraiq[.]	Shift Right Algebraic Immediate with MQ		X	31	952
sraq[.]	Shift Right Algebraic with MQ		X	31	920
sre[.]	Shift Right Extended		X	31	665
srea[.]	Shift Right Extended Algebraic		X	31	921
sreq[.]	Shift Right Extended with MQ		X	31	729
sriq[.]	Shift Right Immediate with MQ		X	31	696
srliq[.]	Shift Right Long Immediate with MQ		X	31	760

srlq[.]	Shift Right Long with MQ		X	31	728
srq[.]	Shift RIght with MQ		X	31	664
st	Store		D	36	
stb	Store Byte		D	38	
stbrx	Store Byte-Reversed Indexed		X	31	662
stbu	Store Byte with Update		D	39	
stbux	Store Byte with Update Indexed		X	31	247
stbx	Store Byte Indexed		X	31	215
stfd	Store Floating-Point Double		D	54	
stfdu	Store Floating-Point Double with Update		D	55	
stfdux	Store Floating-Point Double with Update Indexed		X	31	759
stfdx	Store Floating-Point Double Indexed		X	31	727
stfq	Store Floating-Point Quad	POWER2	DS	60	
stfqu	Store Floating-Point Quad with Update	POWER2	DS	61	
stfqux	Store Floating-Point Quad with Update Indexed	POWER2	X	31	951
stfqx	Store Floating-Point Quad Indexed	POWER2	X	31	919
stfs	Store Floating-Point Single		D	52	
stfsu	Store Floating-Point Single with Update		D	53	

stfsux	Store Floating-Point Single with Update Indexed		X	31	695
stfsx	Store Floating-Point Single Indexed		X	31	663
sth	Store Half		D	44	
sthbrx	Store Half Byte-Reverse Indexed		X	31	918
sthu	Store Half with Update		D	45	
sthux	Store Half with Update Indexed		X	31	439
sthx	Store Half Indexed		X	31	407
stm	Store Multiple		D	47	
stsi	Store String Immediate		X	31	725
stsx	Store String Indexed		X	31	661
stu	Store with Update		D	37	
stux	Store with Update Indexed		X	31	183
stx	Store Indexed		X	31	151
svc[l][a]	Supervisor Call		SC	17	
t	Trap		X	31	04
ti	Trap Immediate		D	03	
tlbi	Translation Look-aside Buffer Invalidate Entry		X	31	306
xor[.]	XOR		X	31	316
xoril	XOR Immediate Lower		D	26	
xoriu	XOR Immediate Upper		D	27	

Appendix F. PowerPC Instructions

Table 34. PowerPC Instructions

Mnemonic	Instruction	Format	Primary Op Code	Extended Op Code
add[o][.]	Add	XO	31	266
addc[o][.]	Add Carrying	XO	31	10
adde[o][.]	Add Extended	XO	31	138
addi	Add Immediate	D	14	
addic	Add Immediate Carrying	D	12	
addic.	Add Immediate Carrying and Record	D	13	
addis	Add Immediate Shifted	D	15	
addme[o][.]	Add to Minus One Extended	XO	31	234
addze[o][.]	Add to Zero Extended	XO	31	202
and[.]	AND	X	31	28
andc[.]	AND with Complement	X	31	60
andi.	AND Immediate	D	28	
andis.	AND Immediate Shifted	D	29	
b[l][a]	Branch	I	18	
bc[l][a]	Branch Conditional	B	16	
bcctr[l]	Branch Conditional to Count Register	XL	19	528
bclr[l]	Branch Conditional Link Register	XL	19	16
cmp	Compare	X	31	0
cmpi	Compare Immediate	D	11	
cmpl	Compare Logical	X	31	32
cmpli	Compare Logical Immediate	D	10	
cntlzd	Count Leading Zeros Doubleword	X	31	58
cntlzw[.]	Count Leading Zeros Word	X	31	26
crand	Condition Register AND	XL	19	257
crandc	Condition Register AND with Complement	XL	19	129
creqv	Condition Register Equivalent	XL	19	289
crnand	Condition Register NAND	XL	19	225

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Table 34. PowerPC Instructions (continued)

Mnemonic	Instruction	Format	Primary Op Code	Extended Op Code
crnor	Condition Register NOR	XL	19	33
cror	Condition Register OR	XL	19	449
crorc	Condition Register OR with Complement	XL	19	417
crxor	Condition Register XOR	XL	19	193
dcbf	Data Cache Block Flush	X	31	86
dcbi	Data Cache Block Invalidate	X	31	470
dcbst	Data Cache Block Store	X	31	54
dcbt	Data Cache Block Touch	X	31	278
dcbtst	Data Cache Block Touch for Store	X	31	246
dcbz	Data Cache Block Set to Zero	X	31	1014
divd	Divide Doubleword	XO	31	489
divdu	Divide Doubleword Unsigned	XO	31	457
divw[o][.]	Divide Word	XO	31	491
divwu[o][.]	Divide Word Unsigned	XO	31	459
eciwx	External Control in Word Indexed (opt.)	X	31	310
ecowx	External Control out Word Indexed (opt.)	X	31	438
eieio	Enforce In-order Execution of I/O	X	31	854
eqv[.]	Equivalent	X	31	284
extsb[.]	Extend Sign Byte	X	31	954
extsh[.]	Extend Sign Halfword	XO	31	922
extsw	Extend Sign Word	X	31	986
fabs[.]	Floating Absolute Value	X	63	264
fadd[.]	Floating Add	A	63	21
fadds[.]	Floating Add Single	A	59	21
fcfid	Floating Convert from Integer Doubleword	X	63	846
fcmpo	Floating Compare Ordered	X	63	32
fcmpu	Floating Compare Unordered	XL	63	0

Table 34. PowerPC Instructions (continued)

Mnemonic	Instruction	Format	Primary Op Code	Extended Op Code
fctid	Floating Convert to Integer Doubleword	X	63	814
fctidz	Floating Convert to Integer Doubleword with Round Toward Zero	X	63	815
fctiw[.]	Floating Convert to Integer Word	X	63	14
fctiwz[.]	Floating Convert to Integer Word with Round to Zero	XL	63	15
fdiv[.]	Floating Divide	A	63	18
fdivs[.]	Floating Divide Single	A	59	18
fmadd[.]	Floating Multiply-Add	A	63	29
fmadds[.]	Floating Multiply-Add Single	A	59	29
fmr[.]	Floating Move Register	X	63	72
fmsub[.]	Floating Multiply-Subtract	A	63	28
fmsubs[.]	Floating Multiply-Subtract Single	A	59	28
fmul[.]	Floating Multiply	A	63	25
fmuls[.]	Floating Multiply Single	A	59	25
fnabs[.]	Floating Negative Absolute Value	X	63	136
fneg[.]	Floating Negate	X	63	40
fnmadd[.]	Floating Negative Multiply-Add	A	63	31
fnmadds[.]	Floating Negative Multiply-Add Single	A	59	31
fnmsub[.]	Floating Negative Multiply-Subtract	A	63	30
fnmsubs[.]	Floating Negative Multiply-Subtract Single	A	59	30
fres[.]	Floating Reciprocal Estimate Single (optional)	A	59	24
frsp[.]	Floating Round to Single Precision	X	63	12
frsqrte[.]	Floating Reciprocal Square Root Estimate (optional)	A	63	26
fsel[.]	Floating-Point Select (optional)	A	63	23

Table 34. PowerPC Instructions (continued)

Mnemonic	Instruction	Format	Primary Op Code	Extended Op Code
fsub[.]	Floating Subtract	A	63	20
fsubs[.]	Floating Subtract Single	A	59	20
icbi	Instruction Cache Block Invalidate	X	31	982
isync	Instruction Synchronize	X	19	150
lbz	Load Byte and Zero	D	34	
lbzu	Load Byte and Zero with Update	D	35	
lbzux	Load Byte and Zero with Update Indexed	X	31	119
lbzx	Load Byte and Zero Indexed	X	31	87
ld	Load Doubleword	DS	58	0
ldarx	Load Doubleword and Reserve Indexed	X	31	84
ldu	Load Doubleword with Update	DS	58	1
ldux	Load Doubleword with Update Indexed	X	31	53
ldx	Load Doubleword Indexed	X	31	21
lfd	Load Floating-Point Double	D	50	
lfdu	Load Floating-Point Double with Update	D	51	
lfdux	Load Floating-Point Double with Update Indexed	X	31	631
lfdx	Load Floating-Point Double Indexed	X	31	599
lfs	Load Floating-Point Single	D	48	
lfsu	Load Floating-Point Single with Update	D	49	
lfsux	Load Floating-Point Single with Update Indexed	X	31	567
lfsx	Load Floating-Point Single Indexed	X	31	535
lha	Load Half Algebraic	D	42	
lhau	Load Half Algebraic with Update	D	43	
lhaux	Load Half Algebraic with Update Indexed	X	31	375

Table 34. PowerPC Instructions (continued)

Mnemonic	Instruction	Format	Primary Op Code	Extended Op Code
lhax	Load Half Algebraic Indexed	X	31	343
lhbrx	Load Half Byte-Reversed Indexed	X	31	790
lhz	Load Half and Zero	D	40	
lhzu	Load Half and Zero with Update	D	41	
lhzux	Load Half and Zero with Update Indexed	X	31	331
lhzx	Load Half and Zero Indexed	X	31	279
lmw	Load Multiple Word	D	46	
lswi	Load String Word Immediate	X	31	597
lswx	Load String Word Indexed	X	31	533
lwa	Load Word Algebraic	DS	58	2
lwarx	Load Word and Reserve Indexed	X	31	20
lwaux	Load Word Algebraic with Update Indexed	X	31	373
lwax	Load Word Algebraic Indexed	X	31	341
lwbrx	Load Word Byte-Reversed Indexed	X	31	534
lwz	Load Word and Zero	D	32	
lwzu	Load Word with Zero Update	D	33	
lwzux	Load Word and Zero with Update Indexed	X	31	55
lwzx	Load Word and Zero Indexed	X	31	23
mcrf	Move Condition Register Field	XL	19	0
mcrfs	Move to Condition Register from FPSCR	X	63	64
mcrxr	Move to Condition Register from XER	X	31	512
mfcr	Move from Condition Register	X	31	19
mffs[.]	Move from FPSCR	X	63	583
mfmsr	Move from Machine State Register	X	31	83

Table 34. PowerPC Instructions (continued)

Mnemonic	Instruction	Format	Primary Op Code	Extended Op Code
mfspr	Move from Special-Purpose Register	X	31	339
mfsr	Move from Segment Register	X	31	595
mfsrin	Move from Segment Register Indirect	X	31	659
mtcrf	Move to Condition Register Fields	XFX	31	144
mtfsb0[.]	Move to FPSCR Bit 0	X	63	70
mtfsb1[.]	Move to FPSCR Bit 1	X	63	38
mtfsf[.]	Move to FPSCR Fields	XFL	63	711
mtfsfi[.]	Move to FPSCR Field Immediate	X	63	134
mtmsr	Move to Machine State Register	X	31	146
mtspr	Move to Special-Purpose Register	X	31	467
mtsr	Move to Segment Register	X	31	210
mtsrin	Move to Segment Register Indirect	X	31	242
mulhd	Multiply High Doubleword	XO	31	73
mulhdu	Multiply High Doubleword Unsigned	XO	31	9
mulhw[.]	Multiply High Word	XO	31	75
mulhwu[.]	Multiply High Word Unsigned	XO	31	11
mulld	Multiply Low Doubleword	XO	31	233
mulli	Multiply Low Immediate	D	07	
mullw[o][.]	Multiply Low Word	XO	31	235
nand[.]	NAND	X	31	476
neg[o][.]	Negate	XO	31	104
nor[.]	NOR	X	31	124
or[.]	OR	X	31	444
orc[.]	OR with Complement	X	31	412
ori	OR Immediate	D	24	
oris	OR Immediate Shifted	D	25	
rfi	Return from Interrupt	X	19	50

Table 34. PowerPC Instructions (continued)

Mnemonic	Instruction	Format	Primary Op Code	Extended Op Code
rldcl	Rotate Left Doubleword then Clear Left	MDS	30	8
rldcr	Rotate Left Doubleword then Clear Right	MDS	30	9
rldic	Rotate Left Doubleword Immediate then Clear	MD	30	2
rldicl	Rotate Left Doubleword Immediate then Clear Left	MD	30	0
rldicr	Rotate Left Doubleword Immediate then Clear Right	MD	30	1
rldimi	Rotate Left Doubleword Immediate then Mask Insert	MD	30	3
rlwimi[.]	Rotate Left Word Immediate then Mask Insert	M	20	
rlwinm[.]	Rotate Left Word Immediate then AND with Mask	M	21	
rlwnm[.]	Rotate Left Word then AND with Mask	M	23	
sc	System Call	SC	17	
si	Subtract Immediate	D	12	
si.	Subtract Immediate and Record	D	13	
slbia	SLB Invalidate All	X	31	498
slbie	SLB Invalidate Entry	X	31	434
sld	Shift Left Doubleword	X	31	27
slw[.]	Shift Left Word	X	31	24
srad	Shift Right Algebraic Doubleword	X	31	794
sradi	Shift Right Algebraic Doubleword Immediate	XS	31	413
srd	Shift Right Doubleword	X	31	539
sraw[.]	Shift Right Algebraic Word	X	31	792
srawi[.]	Shift Right Algebraic Word Immediate	X	31	824

Table 34. PowerPC Instructions (continued)

Mnemonic	Instruction	Format	Primary Op Code	Extended Op Code
srw[.]	Shift Right Word	X	31	536
stb	Store Byte	D	38	
stbu	Store Byte with Update	D	39	
stbux	Store Byte with Update Indexed	X	31	247
stbx	Store Byte Indexed	X	31	215
std	Store Doubleword	DS	62	0
stdcx	Store Doubleword Conditional Indexed	X	31	214
stdu	Store Doubleword with Update	DS	62	1
stdux	Store Doubleword with Update Indexed	X	31	181
stdx	Store Doubleword Indexed	X	31	149
stfd	Store Floating-Point Double	D	54	
stfdu	Store Floating-Point Double with Update	D	55	
stfdux	Store Floating-Point Double with Update Indexed	X	31	759
stfdx	Store Floating-Point Double Indexed	X	31	727
stfiwx	Store Floating-Point as Integer Word Indexed (optional)	X	31	983
stfs	Store Floating-Point Single	D	52	
stfsu	Store Floating-Point Single with Update	D	53	
stfsux	Store Floating-Point Single with Update Indexed	X	31	695
stfsx	Store Floating-Point Single Indexed	X	31	663
sth	Store Half	D	44	
sthbrx	Store Half Byte-Reverse Indexed	X	31	918
sthu	Store Half with Update	D	45	
sthux	Store Half with Update Indexed	X	31	439
sthx	Store Half Indexed	X	31	407
stmw	Store Multiple Word	D	47	

Table 34. PowerPC Instructions (continued)

Mnemonic	Instruction	Format	Primary Op Code	Extended Op Code
stswi	Store String Word Immediate	X	31	725
stswx	Store String Word Indexed	X	31	661
stw	Store	D	36	
stwbrx	Store Word Byte-Reversed Indexed	X	31	662
stwcx.	Store Word Conditional Indexed	X	31	150
stwu	Store Word with Update	D	37	
stwux	Store Word with Update Indexed	X	31	183
stwx	Store Word Indexed	X	31	151
subf[o][.]	Subtract from	XO	31	40
subfc[o][.]	Subtract from Carrying	XO	31	08
subfe[o][.]	Subtract from Extended	XO	31	136
subfic	Subtract from Immediate Carrying	D	08	
subfme[o][.]	Subtract from Minus One Extended	XO	31	232
subfze[o][.]	Subtract from Zero Extended	XO	31	200
sync	Synchronize	X	31	598
td	Trap Doubleword	X	31	68
tdi	Trap Doubleword Immediate	D	2	
tlbie	Translation Look-aside Buffer Invalidate Entry (optional)	X	31	306
tlbsync	Translation Look-aside Buffer Synchronize (optional)	X	31	566
tw	Trap Word	X	31	04
twi	Trap Word Immediate	D	03	
xor[.]	XOR	X	31	316
xori	XOR Immediate	D	26	
xoris	XOR Immediate Shift	D	27	

Appendix G. PowerPC 601 RISC Microprocessor Instructions

PowerPC 601 RISC Microprocessor **Instructions**				
Mnemonic	**Instruction**	**Format**	**Primary Op Code**	**Extended Op Code**
a[o][.]	Add Carrying	XO	31	10
abs[o][.]	Absolute	XO	31	360
add[o][.]	Add	XO	31	266
addc[o][.]	Add Carrying	XO	31	10
adde[o][.]	Add Extended	XO	31	138
addi	Add Immediate	D	14	
addic	Add Immediate Carrying	D	12	
addic.	Add Immediate Carrying and Record	D	13	
addis	Add Immediate Shifted	D	15	
addme[o][.]	Add to Minus One Extended	XO	31	234
addze[o][.]	Add to Zero Extended	XO	31	202
ae[o][.]	Add Extended	XO	31	138
ai	Add Immediate	D	12	
ai.	Add Immediate and Record	D	13	
ame[o][.]	Add to Minus One Extended	XO	31	234
and[.]	AND	X	31	28
andc[.]	AND with Complement	X	31	60
andi.	AND Immediate	D	28	
andil.	AND Immediate Lower	D	28	
andis.	AND Immediate Shifted	D	29	
andiu.	AND Immediate Upper	D	29	
aze[o][.]	Add to Zero Extended	XO	31	202
b[l][a]	Branch	I	18	
bc[l][a]	Branch Conditional	B	16	
bcc[l]	Branch Conditional to Count Register	XL	19	528
bcctr[l]	Branch Conditional to Count Register	XL	19	528
bclr[l]	Branch Conditional Link Register	XL	19	16
bcr[l]	Branch Conditional Register	XL	19	16

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cal	Compute Address Lower	D	14	
cau	Compute Address Upper	D	15	
cax[o][.]	Compute Address	XO	31	266
clcs	Cache Line Compute Size	X	31	531
cmp	Compare	X	31	0
cmpi	Compare Immediate	D	11	
cmpl	Compare Logical	X	31	32
cmpli	Compare Logical Immediate	D	10	
cntlz[.]	Count Leading Zeros	X	31	26
cntlzw[.]	Count Leading Zeros Word	X	31	26
crand	Condition Register AND	XL	19	257
crandc	Condition Register AND with Complement	XL	19	129
creqv	Condition Register Equivalent	XL	19	289
crnand	Condition Register NAND	XL	19	225
crnor	Condition Register NOR	XL	19	33
cror	Condition Register OR	XL	19	449
crorc	Condition Register OR with Complement	XL	19	417
crxor	Condition Register XOR	XL	19	193
dcbf	Data Cache Block Flush	X	31	86
dcbi	Data Cache Block Invalidate	X	31	470
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subf[o][.]	Subtract from	XO	31	40
subfc[o][.]	Subtract from Carrying	XO	31	08
subfe[o][.]	Subtract from Extended	XO	31	136
subfic	Subtract from Immediate Carrying	D	08	
subfme[o][.]	Subtract from Minus One Extended	XO	31	232
subfze[o][.]	Subtract from Zero Extended	XO	31	200
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Appendix H. Value Definitions

Bits 0-5

These bits represent the opcode portion of the machine instruction.

Bits 6-30

These bits contain fields defined according to the values below. Note that many instructions also contain extended opcodes, which occupy some portion of the bits in this range. Refer to specific instructions to understand the format utilized.

Value	Definition
/, //, ///	Reserved/unused; nominally zero (0).
A	Pseudonym for RA in some diagrams.
AA	Absolute address bit. • 0 - The immediate field represents an address relative to the current instruction address.. • 1 - The immediate field represents an absolute address.
B	Pseudonym for RB in some diagrams.
BA	Specifies source condition register bit for operation.
BB	Specifies source condition register bit for operation.
BD	Specifies a 14-bit value used as the branch displacement.
BF	Specifies condition register field 0-7 which indicates the result of a compare.
BFA	Specifies source condition register field for operation.
BI	Specifies bit in condition register for condition comparison.
BO	Specifies branch option field used in instruction.
BT	Specifies target condition register bit where result of operation is stored.
D	Specifies 16-bit two's-complement integer sign extended to 32 bits.
DS	Specifies a 14-bit field used as an immediate value for the calculation of an effective address (EA).
FL1	Specifies field for optional data passing the SVC routine.
FL2	Specifies field for optional data passing the SVC routine.
FLM	Specifies field mask.
FRA	Specifies source floating-point register for operation.
FRB	Specifies source floating-point register for operation.
FRC	Specifies source floating-point register for operation.
FRS	Specifies source floating-point register of stored data.
FRT	Specifies target floating-point register for operation.
FXM	Specifies field mask.
I	Specifies source immediate value for operation.
L	Must be set to 0 for the 32-bit subset architecture.
LEV	Specifies the execution address.
LI	Immediate field specifying a 24-bit signed two's complement integer that is concatenated on the right with 0b00 and sign-extended to 64 bits (32 bits in 32-bit implementations).
LK	If LK=1, the effective address of the instruction following the branch instruction is place into the link register.

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Value	Definition
MB	Specifies the begin value (bit number) of the mask for the operation.
ME	Specifies the end value (bit number) of the mask for the operation.
NB	Specifies the byte count for the operation.
OE	Specifies that the overflow bits in the Fixed-Point Exception register are affected if the operation results in overflow
RA	Specifies the source general-purpose register for the operation.
RB	Specifies the source general-purpose register for the operation.
RS	Specifies the source general-purpose register for the operation.
RT	Specifies the target general-purpose register where the operation is stored.
S	Pseudonym for RS in some diagrams.
SA	Documented in the svc instruction.
SH	Specifies the (immediate) shift value for the operation.
SI	Specifies the 16-bit signed integer for the operation.
SIMM	16-bit two's-complement value which will be sign-extended for comparison.
SPR	Specifies the source special purpose register for the operation.
SR	Specifies the source segment register for the operation.
ST	Specifies the target segment register for the operation.
TO	Specifies TO bits that are ANDed with compare results.
U	Specifies source immediate value for operation.
UI	Specifies 16-bit unsigned integer for operation.

Bit 31

Bit 31 is the record bit.

Value	Definition
0	Does not update the condition register.
1	Updates the condition register to reflect the result of the operation.

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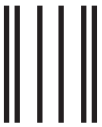

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