PLX 1.0 – September 2001

PLX is a small, general-purpose, subword-parallel instruction-set architecture (ISA) designed at Princeton University, Department of Electrical Engineering. PLX was designed to be a simple yet high-performance Instruction-Set Architecture (ISA) for multimedia information processing.

PLX History

The design goals for PLX were specified by Prof. R.B. Lee. The architecture was first encoded, documented and implemented as a class project for ELE 572 during Spring 2001, by R. Adler '01 and G. Reis '01. PLX was then thoroughly revised and re-encoded by R.B. Lee and A.M. Fiskiran. It is documented in this ISA manual as PLX 1.0.

PLX Architectural Highlights

PLX is a RISC architecture designed for high-performance multimedia information processing.

PLX specifies 32 general-integer registers, numbered R0 through R31. For a given PLX implementation, the register size can be 32, 64 or 128 bits. The default size is 64 bits. No ISA changes are required to scale the datapath down to 32 bits or up to 128 bits. However, for word size and datapaths of 128 bits, some features are incomplete. Of the 32 general-integer registers, R0 is hardwired to 0, therefore it always returns 0 when read. Writing a value to R0 has no effect. GR31 is the implied link register for `jmp.reg` (jump register) and `jmp.reg.link` (jump register and link) instructions.

PLX is a fully subword-parallel ISA. Subword parallelism has been shown to be critical for achieving high-performance in multimedia applications. Subword sizes in PLX can be 1,2,4 or 8-bytes. The size of the largest subword for a given PLX implementation is limited by the datapath width of that implementation.

PLX uses 32-bit instructions, which are classified under 5 major instruction formats.

All PLX instructions are predicated. There are eight 1-bit predicate registers, numbered P0 through P7, forming a predicate register set of 1 byte long. There are 16 of these 1-byte predicate register sets, however only one of them is active at a given time. The active predicate register set is changed in software. In the active predicate register set, P0 is hardwired to 1, therefore, the instructions predicated on P0 always execute. This definition of predication is novel to PLX.

Currently, PLX does not have floating-point instructions, but this is viewed as a necessary future addition.

PLX Instructions (grouped by functionality)

Program Flow Control Instructions

jmp	Jump
jmp.link	Jump and Link
jmp.reg	Jump Register
jmp.reg.link	Jump Register and Link
trap	Trap

Compare Instructions and Predication

changepr	Change Predicate Register Set
changepr.ld	Change Predicate Register Set and Load
cmp.rel	Compare
cmpi.rel	Compare Immediate
testbit	Test Bit

Memory Access Instructions

loadi.hi	Load High Immediate
loadi.lo	Load Low Immediate
load	Load
load.update	Load Update
store	Store
store.update	Store Update

ALU Instructions (Immediate)

addi	Add Immediate
andi	And Immediate
ori	Or Immediate
subi	Subtract Immediate
xori	Xor Immediate

Shift and Bit Field Instructions (Immediate)

slli	Shift Left Logical Immediate
srai	Shift Right Arithmetic Immediate
srli	Shift Right Logical Immediate
shrp	Shift Right Pair
extract	Extract
deposit	Deposit

ALU Instructions (Packed)

padd	Packed Add
paddincr	Packed Add Increment
psub	Packed Subtract

psubdecr	Packed Subtract Decrement
pavg	Packed Average
pavg.raz	Packed Average Round Away From Zero
psubavg	Packed Subtract Average
and	And
andcm	And Complement
or	Or
xor	Xor
not	Not
pcmp.eq	Packed Compare Equal To
pcmp.gt	Packed Compare Greater Than
pmax	Packed Maximum
pmin	Packed Minimum
pshiftadd.l	Packed Shift Left and Add
pshiftadd.r	Packed Shift Right and Add

Multiply Instructions (Packed)

pmul.odd	Packed Multiply Odd
pmul.even	Packed Multiply Even
pmulshr	Packed Multiply and Shift Right Logical
pmulshr.a	Packed Multiply and Shift Right Arithmetic

Shift Instructions (Packed)

pshift.l	Packed Shift Left Logical
pshift.r	Packed Shift Right Logical
pshift.ra	Packed Shift Right Arithmetic

Shift Instructions (Packed Immediate)

pshifti.l	Packed Shift Immediate Left Logical
pshifti.r	Packed Shift Immediate Right Logical
pshifti.ra	Packed Shift Immediate Right Arithmetic

Subword Permutation Instructions

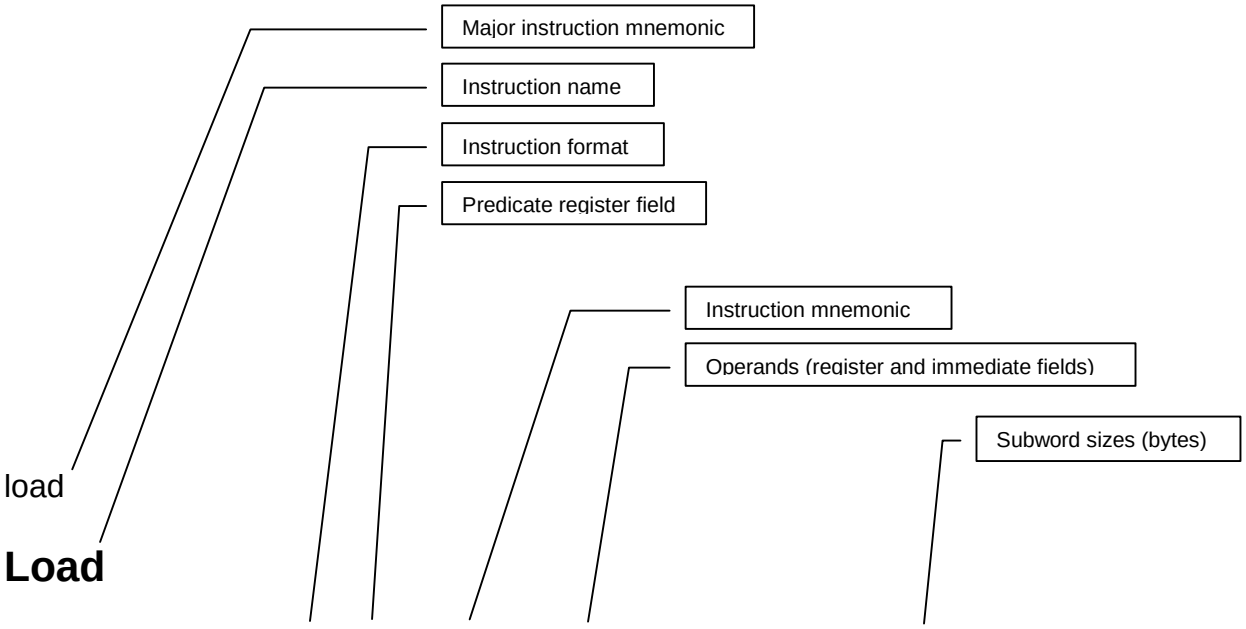
mix.l	Mix Left
mix.r	Mix Right
mux.rev	Mux Reverse
mux.mix	Mux Mix
mux.shuf	Mux Shuffle
mux.alt	Mux Alternate
mux.brcst	Mux Broadcast
perm	Permute

PLX Instructions (in alphabetical order of major mnemonics)

addi	Add Immediate
and	And
andcm	And Complement
andi	And Immediate
changepr	Change Predicate Register Set
cmp	Compare
cmpi	Compare Immediate
deposit	Deposit
extract	Extract
jmp	Jump
load	Load
loadi	Load Immediate
mix	Mix
mux	Mux
not	Not
or	Or
ori	Or Immediate
padd	Packed Add
paddincr	Packed Add Increment
pavg	Packed Average
pcmp	Packed Compare
perm	Permute
pmax	Packed Maximum
pmin	Packed Minimum
pmul	Packed Multiplication
pmulshr	Packed Multiply Shift Right
pshift	Packed Shift
pshiftadd	Packed Shift Add
pshifti	Packed Shift Immediate
psub	Packed Subtract
psubavg	Packed Subtract Average
psubdecr	Packed Subtract Decrement
shrp	Shift Right Pair
slli	Shift Left Logical Immediate
srai	Shift Right Arithmetic Immediate
srli	Shift Right Logical Immediate
store	Store
subi	Subtract Immediate
testbit	Test Bit
trap	Trap
xor	Xor
xori	Xor Immediate

PLX Instruction Reference

Formatting Used in Instruction Descriptions



Load

Format:

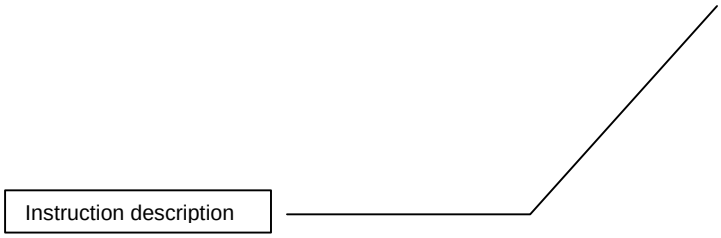
2	(P) load.sw Rd,Rs1,imm13	1,2,4,8
2	(P) load.sw.update Rd,Rs1,imm13	1,2,4,8

Description: Value in a memory location is loaded into a register.

Size of the loaded memory block is indicated in the sw field, and can be 1,2,4 or 8 bytes.

In load.sw, Rd is loaded with mem[Rs1+imm13].

If the update option is used, Rs1 is replaced with Rs1+imm13 after the load is completed.



addi

Add Immediate

Format: 2 (P) addi Rd,Rs1,imm13

Description: Imm13 is sign extended and added to Rs1. The result is written to Rd.

and

And

Format: 4a (P) and Rd,Rs1,Rs2

Description: Rs1 and Rs2 are anded. The result is written to Rd.

andcm

And Complement

Format: 4a (P) andcm Rd,Rs1,Rs2

Description: Rs1 and the complement of Rs2 are anded. The result is written to Rd.

andi

And Immediate

Format: 2 (P) andi Rd,Rs1,imm13

Description: Imm13 is zero extended and anded with Rs1. The result is written to Rd.

changepr

Change Predicate Register Set

Format:

5b (P) changepr imm4,imm8
5b (P) changepr.ld imm4,imm8

Description:

In changepr, the active predicate register set is changed to the predicate register set specified by imm4. Imm8 is ignored.

In changepr.ld, the active predicate register set is changed to the predicate register set specified by imm4, and imm8 is written to this predicate register set.

cmp

Compare

Format:

5a (P) cmp.rel Rs1,Rs2,P1,P2

Description:

Rs1 and Rs2 are compared with each other, according to the relation specified in the rel field.

If the relation is true, predicate register P1 is set; if it is false, P1 is cleared.

Complement of P1 is written to P2.

Rel	Relation	Sign of a and b
eq	a == b	N/A
ne	a != b	N/A
lt	a < b	Signed
le	a <= b	Signed
gt	a > b	Signed
ge	a >= b	Signed
ltu	a < b	Unsigned
leu	a <= b	Unsigned
gtu	a > b	Unsigned
geu	a >= b	Unsigned

cmpi

Compare Immediate

Format: 5b (P) cmpi.rel Rs1,imm8,P1,P2

Description: Rs1 is compared to sign-extended imm8 according to the relation specified in the rel field. (See the table in the description of the cmp instruction.)

If the relation is true, P1 is set; if it is false, P1 is cleared.

Complement of P1 is written to P2.

deposit

Deposit

Format: 3 (P) deposit Rd,Rs1,imm7,imm6

Description: Right-aligned bit field of length imm6 from Rs1, is written to Rd, starting at location specified by imm7. Remaining bits of Rd are unchanged.

extract

Extract

Format: 3 (P) extract Rd,Rs1,imm7,imm6

Description: Bit field of length imm6 of Rs1, starting at a location specified by imm7, is written right-aligned to Rd. High order bits of Rd are cleared.

jmp

Jump

Format:

0 (P) jmp imm23
0 (P) jmp.link imm23
1 (P) jmp.reg Rd
1 (P) jmp.reg.link Rd

Description: In jmp, imm23 is added to the current PC. The result becomes the new PC.

In jmp.link, PC + 4 is written to GR[31]. The previous value of GR[31] is destroyed. Then, imm23 is added to the PC. The result becomes the new PC.

In jmp.reg, Rd is added to the current PC. The result becomes the new PC.

In jmp.reg.link, PC + 4 is written to GR[31]. The previous value of GR[31] is destroyed. Then, Rd is added to the PC. The result becomes the new PC.

load

Load

Format:

2	(P) load.sw Rd,Rs1,imm13	1,2,4,8
2	(P) load.sw.update Rd,Rs1,imm13	1,2,4,8

Description: Value in a memory location is loaded into a register.

Size of the loaded memory block is indicated in the sw field, and can be 1,2,4 or 8 bytes.

In load.sw, Rd is loaded with mem[Rs1+imm13].

If the update option is used, Rs1 is replaced with Rs1+imm13 after the load is completed.

loadi

Load Immediate

Format:

1	(P) loadi.hi imm18
1	(P) loadi.lo imm18

Description: In loadi.hi, low-order 16 bits of imm18 are loaded into low-order 16^{th} through 31^{st} bits of Rd.

In loadi.lo, low-order 16 bits of imm18 are loaded into low-order 0^{th} through 15^{th} bits of Rd.

(High-order two bits of imm18 are ignored.)

mix

Mix

Format:

3	(P) mix.sw.l Rd,Rs1,Rs2	1,2,4
3	(P) mix.sw.r Rd,Rs1,Rs2	1,2,4

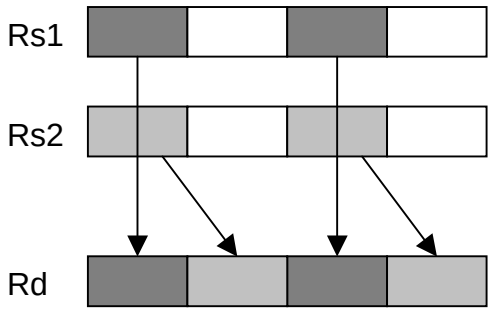
Description:

Even or odd-indexed subwords are selected alternately from Rs1 and Rs2, and written to Rd.

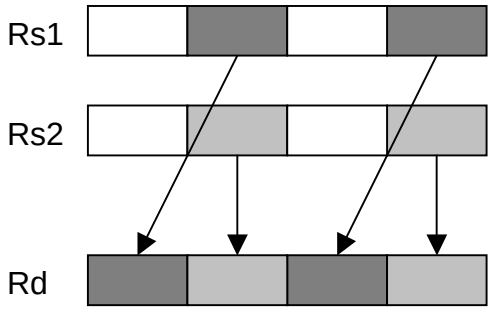
Subword size is indicated in the sw field, and can be 1,2 or 4 bytes.

In mix.sw.l, odd-indexed subwords are selected alternately from Rs1 and Rs2, and written to Rd. The first subword of Rd is the first subword of Rs1.

In mix.sw.r, even-indexed subwords are selected alternately from Rs1 and Rs2 are written to Rd. The first subword of Rd is the second subword of Rs1.



mix.2.l Rd,Rs1,Rs2



mix.2.r Rd,Rs1,Rs2

mux

Mux

Format:

4b	(P) mux.rev Rd,Rs1	1
4b	(P) mux.mix Rd,Rs1	1
4b	(P) mux.shuf Rd,Rs1	1
4b	(P) mux.alt Rd,Rs1	1
4b	(P) mux.brcst Rd,Rs1	1

Description:

A permutation is performed on the 1-byte subwords of Rs1 and the result is written to Rd.

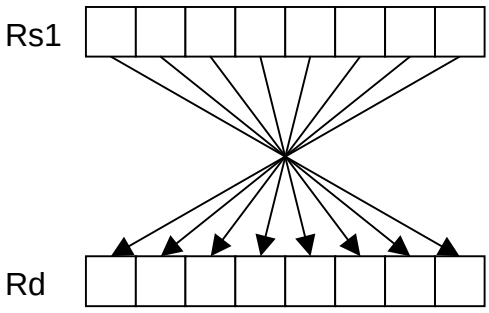
Mux.rev reverses the order of the bytes of Rs1.

Mux.mix divides Rs1 into left and right halves, then a mix operation is performed on these two halves of Rs1.

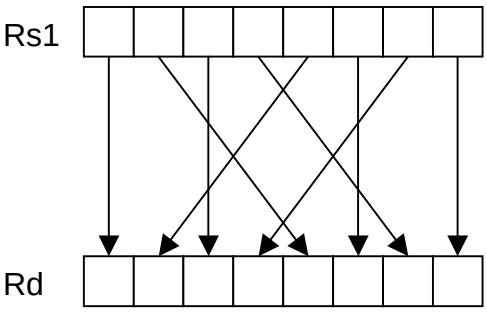
Mux.shuf divides Rs1 into left and right halves, then a shuffle operation is performed on these two halves of Rs1.

Mux.alt divides Rs1 into left and right halves, then a shuffle operation is performed on these two halves of Rs1.

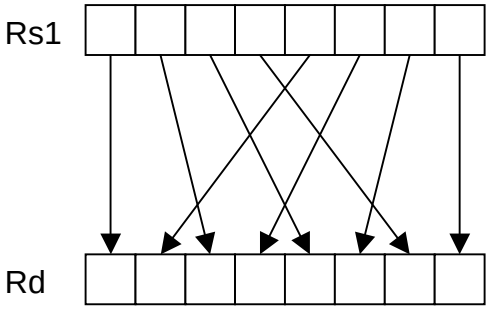
Mux.brcst writes the least-significant subword of Rs1 to all subwords of Rd.



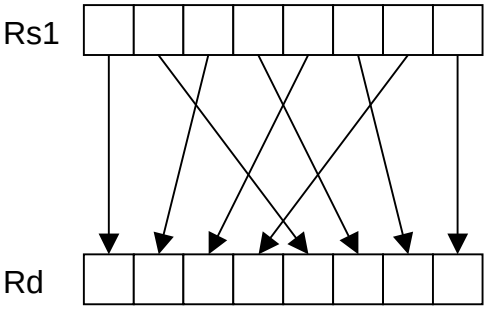
mux.rev Rd,Rs1



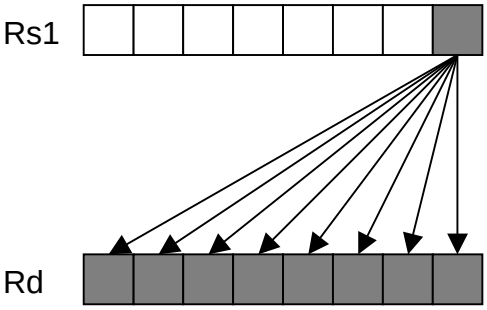
mux.mix Rd,Rs1



mux.shuf Rd,Rs1



mux.alt Rd,Rs1



mux.brcst Rd,Rs1

not

Not

Format: 4a (P) not Rd,Rs1

Description: Rs1 is complemented. The result is written to Rd. Rs2 is ignored.

(Rs2 field of 4a-type instructions is ignored for this instruction.)

or

Or

Format: 4a (P) or Rd,Rs1,Rs2

Description: Rs1 and Rs2 are ored. The result is written to Rd.

ori

Or Immediate

Format: 2 (P) ori Rd,Rs1,imm13

Description: Imm13 is zero extended and ored with Rs1. The result is written to Rd.

padd

Packed Add

Format:

4a	(P) padd.sw Rd,Rs1,Rs2	1,2,4,8
4a	(P) padd.sw.u Rd,Rs1,Rs2	1,2,4,8
4a	(P) padd.sw.s Rd,Rs1,Rs2	1,2,4,8

Description: Rs1 and Rs2 are added, and the result is written to Rd.

Subword size is specified in the sw field, and can be 1,2,4 or 8 bytes.

Padd.sw uses modular arithmetic, padd.sw.u uses unsigned saturation, and padd.sw.s uses signed saturation during the add.

paddincr

Packed Add Increment

Format: 4a (P) paddincr.sw Rd,Rs1,Rs2 1,2,4,8

Description: Rs1 and Rs2 are added, and their sum is incremented by one. The result is written to Rs2. Modular arithmetic is used.

Subword size is specified in the sw field, and can be 1,2,4 or 8 bytes.

pavg

Packed Average

Format:

4a	(P) pavg.sw Rd,Rs1,Rs2	1,2
4a	(P) pavg.sw.raz Rd,Rs1,Rs2	1,2

Description:

Averages of the subwords from Rs1 and Rs2 are written to Rd.

Subword size is specified in the sw field, and can be 1 or 2 bytes.

In pavg.sw, unsigned subwords from Rs1 and Rs2 are added, and the sums are shifted right by one bit. The highest order bit becomes the carryout of the add operation. The shifted results are written to Rs2. The least-significant bit of each result subword is the or of the two least-significant bits of the shifted sums.

In pavg.sw.raz (raz stands for round away from zero), unsigned subwords from Rs1 and Rs2 are added, and the sums are incremented by one. The incremented sums are then shifted right by one bit. The highest order bit becomes the carryout of the add operation. The shifted results are written to Rs2. The least-significant bit of each result subword is the least-significant bit of the shifted sums.

pcmp

Packed Compare

Format:

4a	(P) pcmp.sw.eq Rd,Rs1,Rs2	1,2,4,8
4a	(P) pcmp.sw.gt Rd,Rs1,Rs2	1,2,4,8

Description:

In pcmp.eq, subwords from Rs1 and Rs2 are tested for equality.

In pcmp.ge, signed subwords from Rs1 are tested for being greater-than the signed subwords of Rs2.

Subword size is specified in the sw field, and can be 1,2,4 or 8 bytes.

If the comparison condition is true, then corresponding subword of Rd is set to all ones, otherwise it is set to all zeros.

perm

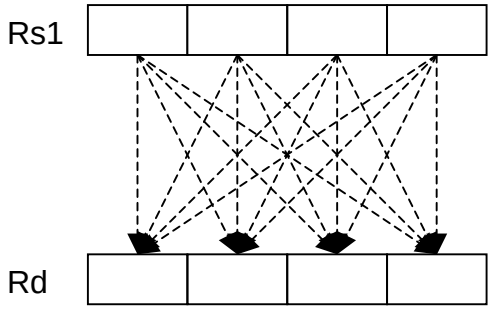
Permute

Format: 4a (P) perm Rd,Rs1,Rs2 2

Description: A permutation is performed on the 2-byte subwords of Rs1 and the result is written to Rd.

All possible permutations can be performed, with or without repetitions of subwords. The permutation is specified by the bits read from Rs2.

(If Rs1 has n subwords, this requires nlogn bits to specify a permutation. These bits are read from the low-order nlogn bits of Rs2.)



perm Rd,Rs1,Rs2

pmax

Packed Maximum

Format: 4a (P) pmax Rd,Rs1,Rs2 1,2

Description: The greater of the subwords from Rs1 and Rs2 is written to Rd.

Subwords are treated as signed values.

Subword size is specified in the sw field, and can be 1 or 2 bytes.

pmin

Packed Minimum

Format: 4a (P) pmin Rd,Rs1,Rs2 1,2

Description: The lesser of the subwords from Rs1 and Rs2 is written to Rd.

Subwords are treated as signed values.

Subword size is specified in the sw field, and can be 1 or 2 bytes.

pmul

Packed Multiply

Format:

4a	(P) pmul.odd Rd,Rs1,Rs2	2
4a	(P) pmul.even Rd,Rs1,Rs2	2

Description:

In pmul.odd, odd indexed signed 16-bit subwords from Rs1 and Rs2 are multiplied, and the 32-bit products are written to Rd.

In pmul.even, even indexed signed 16-bit subwords from Rs1 and Rs2 are multiplied, and the 32-bit products are written to Rd.

pmulshr

Packed Multiply Shift Right

Format:

4a	(P) pmulshr.sa Rd,Rs1,Rs2	2
4a	(P) pmulshr.sa.a Rd,Rs1,Rs2	2

Description:

In pmulshr.sa, unsigned 16-bit subwords from Rs1 and Rs2 are multiplied. Each product is then logically shifted to the right by sa bits, where sa can be 0,8,15, or 16. The lower halves of the shifted products are written to Rd.

In pmulshr.sa.a, signed 16-bit subwords from Rs1 and Rs2 are multiplied. Each product is then arithmetically shifted to the right by sa bits, where sa can be 0,8,15, or 16. The lower halves of the shifted products are written to Rd.

pshift

Packed Shift

Format:

4a	(P) pshift.sw.l Rd,Rs1,Rs2	2,4,8
4a	(P) pshift.sw.r Rd,Rs1,Rs2	2,4,8
4a	(P) pshift.sw.ra Rd,Rs1,Rs2	2,4,8

Description:

Subwords of Rs1 are shifted and the result is written to Rd.

Subword size is specified in the sw field, and can be 2,4 or 8 bytes.

In pshift.sw.l, subwords of Rs1 are logically shifted to the left by Rs2 bits.

In p.shift.sw.r, subwords of Rs1 are logically shifted to the right by Rs2 bits.

In, pshift.sw.ra, subwords of Rs1 are arithmetically shifted to the right by Rs2 bits.

pshiftadd

Packed Shift and Add

Format:

4a	(P) pshiftadd.sa.l Rd,Rs1,Rs2	2
4a	(P) pshiftadd.sa.r Rd,Rs1,Rs2	2

Description:

In pshiftadd.sa.l, signed 2-byte subwords of Rs1 are shifted left by sa bits, where sa can be 1, 2, or 3. The result is added to Rs2 using signed saturation arithmetic. The result is written to Rd.

In pshiftadd.sa.r, signed 2-byte subwords of Rs1 are shifted right by sa bits, where sa can be 1, 2, or 3. The result is added to Rs2 using signed saturation arithmetic. The result is written to Rd.

pshifti

Packed Shift Immediate

Format:

4b	(P) pshifti.sw.l Rd,Rs1,imm5	2,4,8
4b	(P) pshifti.sw.r Rd,Rs1,imm5	2,4,8
4b	(P) pshifti.sw.ra Rd,Rs1,imm5	2,4,8

Description:

In pshifti.sw.l, subwords of Rs1 are logically shifted to the left by imm5 bits.

Subword size is specified in the sw field, and can be 2,4 or 8 bytes.

In pshifti.sw.r, subwords of Rs1 are logically shifted to the right by imm5 bits.

In pshifti.sw.ra, subwords of Rs1 are arithmetically shifted to the right by imm5 bits.

psub

Packed Subtract

Format:

4a	(P) psub.sw Rd,Rs1,Rs2	1,2,4,8
4a	(P) psub.sw.u Rd,Rs1,Rs2	1,2,4,8
4a	(P) psub.sw.s Rd,Rs1,Rs2	1,2,4,8

Description:

Rs2 is subtracted from Rs1. The result is written to Rd.

Subword size is specified in the sw field, and can be 1,2,4 or 8 bytes.

Psub uses modular arithmetic, psub.u uses unsigned saturation, and psub.s uses signed saturation during the subtract.

psubavg

Packed Subtract Average

Format:

4a	(P) psubavg.sw Rd,Rs1,Rs2	1,2

Description:

Unsigned Rs2 is subtracted from unsigned Rs1. The differences are shifted right by one bit. The highest order bit becomes the carryout of the subtract operation. The shifted results are written to Rsd. The least-significant bit of each result subword is the or of the two least-significant bits of the shifted differences.

Subword size is specified in the sw field, and can be 1 or 2 bytes.

psubdecr

Packed Subtract Decrement

Format: 4a (P) psubdecr.sw Rd,Rs1,Rs2 1,2,4,8

Description: Rs2 is subtracted from Rs1, and the difference is decremented by one. The result is written to Rd. Modular arithmetic is used.

Subword size is specified in the sw field, and can be 1,2,4 or 8 bytes.

shrp

Shift Right Pair

Format: 4c (P) shrp Rd,Rs1,Rs2,imm8

Description: Rs1 and Rs2 are concatenated and logically shifted to the right by imm8 bits. The lower-order half of the shifted result is written to Rd. (Most-significant bit of imm8 is ignored for 64-bit processors; most-significant two bits of imm8 are ignored for 32-bit processors.)

slli

Shift Left Logical Immediate

Format: 2 (P) slli Rd,Rs1,imm13

Description: Rs1 is shifted to the left by imm13 bits. If imm13 is greater than the word size, then only the low-order bits of imm13 are used as the shift amount. The vacated bits are filled with zeroes. The result is written to Rd.

srai

Shift Right Arithmetic Immediate

Format: 2 (P) srai Rd,Rs1,imm13

Description: Rs1 is shifted to the right by imm13 bits. If imm13 is greater than the word size, then only the low-order bits of imm13 are used as the shift amount. The vacated bits are filled with the sign bit. The result is written to Rd.

srli

Shift Right Logical Immediate

Format: 2 (P) srli Rd,Rs1,imm13

Description: Rs1 is shifted to the right by imm13 bits. If imm13 is greater than the word size, then only the low-order bits of imm13 are used as the shift amount. The vacated bits are filled with zeroes. The result is written to Rd.

store

Store

Format:

2	(P) store.sw Rd,Rs1,imm13	1,2,4,8
2	(P) store.sw.update Rd,Rs1,imm13	1,2,4,8

Description: Value in a register is stored in a memory location.

Size of the stored data is specified in the sw field, and can be 1,2,4 or 8 bytes.

In store.sw, Rd is stored to mem[Rs1+imm13].

If the update option is used, Rs1 is replaced with Rs1+imm13 after the store is completed.

subi

Subtract Immediate

Format: 2 (P) subi Rd,Rs1,imm13

Description: Imm13 is sign extended and subtracted from Rs1. The result is written to Rd.

testbit

Test Bit

Format: 5b (P) testbit Rd,imm8,P1,P2,imm4

Description: The bit specified by imm8 is selected from Rd. If this bit is set, P1 is set, otherwise P1 is cleared. If imm8 is larger than the word size, no bit is selected and P1 is cleared.

Complement of P1 is written to P2.

(Imm4 is ignored.)

trap

Trap

Format: 0 (P) trap imm23

Description: The processor halts execution unconditionally.

imm23 is ignored.

xor

Xor

Format: 4a (P) xor Rd,Rs1,Rs2

Description: Rs1 and Rs2 are xored. The result is written to Rd.

xori

Xor Immediate

Format: 2 (P) xori Rd,Rs1,imm13

Description: Imm13 is zero extended and xored with Rs1. The result is written to Rd.