## RISC-V REFERENCE

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#### **RISC-V Instruction Set**

#### **Core Instruction Formats**

31	27	26	25	24	20	19		15	14	12	11	7	6	C	)	
funct7 rs2			rs1 funct3		rd		opo	code		R-type						
imm[11:0]					rs1		fun	ct3	rd opcode				I-type			
imm[11:5] rs2			rs1		funct3		imm[4:0]		opo	code		S-type				
im	m[12	10:5	5]	rs	2		rs1		fun	ct3	imm	[4:1 11]	opo	code		B-type
imm[31:12]										rd	opo	code		U-type		
imm[20 10:1 11 19:12]									rd	opo	code		J-type			

#### **RV32I Base Integer Instructions**

Inst	Name	FMT	Opcode	funct3	funct7	Description (C)	Note
add	ADD	R	0110011	0x0	0x00	rd = rs1 + rs2	
sub	SUB	R	0110011	0x0	0x20	rd = rs1 - rs2	
xor	XOR	R	0110011	0x4	0x00	rd = rs1 ^ rs2	
or	OR	R	0110011	0x6	0x00	rd = rs1   rs2	
and	AND	R	0110011	0x7	0x00	rd = rs1 & rs2	
sll	Shift Left Logical	R	0110011	0x1	0x00	rd = rs1 << rs2	
srl	Shift Right Logical	R	0110011	0x5	0x00	rd = rs1 >> rs2	
sra	Shift Right Arith*	R	0110011	0x5	0x20	rd = rs1 >> rs2	msb-extends
slt	Set Less Than	R	0110011	0x2	0x00	rd = (rs1 < rs2)?1:0	
sltu	Set Less Than (U)	R	0110011	0x3	0x00	rd = (rs1 < rs2)?1:0	zero-extends
addi	ADD Immediate	I	0010011	0x0		rd = rs1 + imm	
xori	XOR Immediate	I	0010011	0x4		rd = rs1 ^ imm	
ori	OR Immediate	I	0010011	0x6		rd = rs1   imm	
andi	AND Immediate	I	0010011	0x7		rd = rs1 & imm	
slli	Shift Left Logical Imm	I	0010011	0x1	imm[5:11]=0x00	rd = rs1 << imm[0:4]	
srli	Shift Right Logical Imm	I	0010011	0x5	imm[5:11]=0x00	rd = rs1 >> imm[0:4]	
srai	Shift Right Arith Imm	I	0010011	0x5	imm[5:11]=0x20	rd = rs1 >> imm[0:4]	msb-extends
slti	Set Less Than Imm	I	0010011	0x2		rd = (rs1 < imm)?1:0	
sltiu	Set Less Than Imm (U)	I	0010011	0x3		rd = (rs1 < imm)?1:0	zero-extends
lb	Load Byte	I	0000011	0x0		rd = M[rs1+imm][0:7]	
lh	Load Half	I	0000011	0x1		rd = M[rs1+imm][0:15]	
lw	Load Word	I	0000011	0x2		rd = M[rs1+imm][0:31]	
lbu	Load Byte (U)	I	0000011	0x4		rd = M[rs1+imm][0:7]	zero-extends
lhu	Load Half (U)	I	0000011	0x5		rd = M[rs1+imm][0:15]	zero-extends
sb	Store Byte	S	0100011	0x0		M[rs1+imm][0:7] = rs2[0:7]	
sh	Store Half	S	0100011	0x1		M[rs1+imm][0:15] = rs2[0:15]	
SW	Store Word	S	0100011	0x2		M[rs1+imm][0:31] = rs2[0:31]	
beq	Branch ==	В	1100011	0x0		if(rs1 == rs2) PC += imm	
bne	Branch !=	В	1100011	0x1		if(rs1 != rs2) PC += imm	
blt	Branch <	В	1100011	0x4		if(rs1 < rs2) PC += imm	
bge	Branch ≥	В	1100011	0x5		if(rs1 >= rs2) PC += imm	
bltu	Branch < (U)	В	1100011	0x6		if(rs1 < rs2) PC += imm	zero-extends
bgeu	Branch $\geq$ (U)	В	1100011	0x7		if(rs1 >= rs2) PC += imm	zero-extends
jal	Jump And Link	J	1101111			rd = PC+4; PC += imm	
jalr	Jump And Link Reg	I	1100111	0x0		rd = PC+4; PC = rs1 + imm	
lui	Load Upper Imm	U	0110111			rd = imm << 12	
auipc	Add Upper Imm to PC	U	0010111			rd = PC + (imm << 12)	
ecall	Environment Call	I	1110011	0x0	imm=0x0	Transfer control to OS	
ebreak	Environment Break	I	1110011	0x0	imm=0x1	Transfer control to debugger	
	1		1	1	1		1

#### **Standard Extensions**

## **RV32M Multiply Extension**

Inst	Name	FMT	Opcode	${ m funct3}$	funct7	Description (C)
mul	MUL	R	0110011	0x0	0x01	rd = (rs1 * rs2)[31:0]
mulh	MUL High	R	0110011	0x1	0x01	rd = (rs1 * rs2)[63:32]
mulsu	MUL High (S) (U)	R	0110011	0x2	0x01	rd = (rs1 * rs2)[63:32]
mulu	MUL High (U)	R	0110011	0x3	0x01	rd = (rs1 * rs2)[63:32]
div	DIV	R	0110011	0x4	0x01	rd = rs1 / rs2
divu	DIV (U)	R	0110011	0x5	0x01	rd = rs1 / rs2
rem	Remainder	R	0110011	0x6	0x01	rd = rs1 % rs2
remu	Remainder (U)	R	0110011	0x7	0x01	rd = rs1 % rs2

#### **RV32A Atomic Extension**

31	27	26	25	24	20 1	.9	15	14	12	11 7	6 0
func	t5	aq	rl	r	s2	rs1		funct	t3	rd	opcode
5		1	1		5	5		3	•	5	7
Inst	Name			FMT	Opcode	funct3	fun	ct5	Desc	cription (C)	
lr.w	Load l	Reserve	ed	R	0101111	0x2	0x0	2	rd =	M[rs1], rese	rve M[rs1]
SC.W	sc.w Store Conditional			R	0101111	0x2	0x0	3	if (reserved) { M[rs1] = rs2; rd = 0 }		
									else	e { rd = 1 }	
amoswap.w	Atomi	c Swap	)	R	0101111	0x2	0x0	1	rd = M[rs1]; swap(rd, rs2); M[rs1] = rd		
amoadd.w	Atomi	c ADD		R	0101111	0x2	0x0	0	rd =	M[rs1] + rs2	; M[rs1] = rd
amoand.w	Atomi	c AND		R	0101111	0x2	0x0	C	rd = M[rs1] & rs2; M[rs1] = rd		
amoor.w	Atomi	c OR		R	0101111	0x2	0x0	A	rd =	M[rs1]   rs2	; M[rs1] = rd
amoxor.w	Atomi	x XOR		R	0101111	0x2	0x0	4	rd =	M[rs1] ^ rs2	; M[rs1] = rd
amomax.w	Atomi	c MAX		R	0101111	0x2	0x1	4	rd =	max(M[rs1], ı	rs2); M[rs1] = rd
amomin.w	Atomi	c MIN		R	0101111	0x2	0x1	0	rd =	min(M[rs1], ı	rs2); M[rs1] = rd

## RV32F / D Floating-Point Extensions

Inst	Name	FMT	Opcode	funct3	funct5	Description (C)
flw	Flt Load Word	*				rd = M[rs1 + imm]
fsw	Flt Store Word	*				M[rs1 + imm] = rs2
fmadd.s	Flt Fused Mul-Add	*				rd = rs1 * rs2 + rs3
fmsub.s	Flt Fused Mul-Sub	*				rd = rs1 * rs2 - rs3
fnmadd.s	Flt Neg Fused Mul-Add	*				rd = -rs1 * rs2 + rs3
fnmsub.s	Flt Neg Fused Mul-Sub	*				rd = -rs1 * rs2 - rs3
fadd.s	Flt Add	*				rd = rs1 + rs2
fsub.s	Flt Sub	*				rd = rs1 - rs2
fmul.s	Flt Mul	*				rd = rs1 * rs2
fdiv.s	Flt Div	*				rd = rs1 / rs2
fsqrt.s	Flt Square Root	*				rd = sqrt(rs1)
fsgnj.s	Flt Sign Injection	*				rd = abs(rs1) * sgn(rs2)
fsgnjn.s	Flt Sign Neg Injection	*				rd = abs(rs1) * -sgn(rs2)
fsgnjx.s	Flt Sign Xor Injection	*				rd = rs1 * sgn(rs2)
fmin.s	Flt Minimum	*				rd = min(rs1, rs2)
fmax.s	Flt Maximum	*				rd = max(rs1, rs2)
fcvt.s.w	Flt Conv from Sign Int	*				rd = (float) rs1
fcvt.s.wu	Flt Conv from Uns Int	*				rd = (float) rs1
fcvt.w.s	Flt Convert to Int	*				rd = (int32_t) rs1
fcvt.wu.s	Flt Convert to Int	*				rd = (uint32_t) rs1
fmv.x.w	Move Float to Int	*				rd = *((int*) &rs1)
fmv.w.x	Move Int to Float	*				rd = *((float*) &rs1)
feq.s	Float Equality	*				rd = (rs1 == rs2) ? 1 : 0
flt.s	Float Less Than	*				rd = (rs1 < rs2) ? 1 : 0
fle.s	Float Less / Equal	*				rd = (rs1 <= rs2) ? 1 : 0
fclass.s	Float Classify	*				rd = 09

## **RV32C Compressed Extension**

15 14 13	12	11	10	9	8	7	6	5	4	3	2	1	0	
funct	4	rd/rs1 5			rs2 5				О	p	CR-type			
funct3	imm	imm rd/rs1 5				imm 5				О	p	CI-type		
funct3	imm 6						1	rs2 5			О	p	CSS-type	
funct3		imm 8					•			rď 3		0	p	CIW-type
funct3	im	m 3		1	′s1'	3	im	m		rd' 3		0	p	CL-type
funct3	im 3 rd'/rs1			1'	im	m	1	s2' 3		О	p	CS-type		
funct3	imm 3 rs1'						imm 5			0	p	CB-type		
funct3	offset 11					-					0	p	CJ-type	

Inst	Name	FMT	OP	Funct	Description
c.lwsp	Load Word from SP	CI	10	010	lw rd, (4*imm)(sp)
c.swsp	Store Word to SP	CSS	10	110	sw rs2, (4*imm)(sp)
c.lw	Load Word	CL	00	010	lw rd', (4*imm)(rs1')
C.SW	Store Word	CS	00	110	sw rs1', (4*imm)(rs2')
	ch load and store: Double v	vord wit	h Func	ct = x11, Qu	ad with Funct = x01
c.j	Jump	CJ	01	101	jal x0, 2*offset
c.jal	Jump And Link	CJ	01	001	jal ra, 2*offset
c.jr	Jump Reg	CR	10	1000	jalr x0, rs1, 0
c.jalr	Jump And Link Reg	CR	10	1001	jalr ra, rs1, 0
c.beqz	Branch $== 0$	CB	01	110	beq rs', x0, 2*imm
c.bnez	Branch != 0	CB	01	111	bne rs', x0, 2*imm
c.li	Load Immediate	CI	01	010	addi rd, x0, imm
c.lui	Load Upper Imm	CI	01	011	lui rd, imm
c.addi	ADD Immediate	CI	01	000	addi rd, rd, imm
c.addiw	ADD Immediate Word	CI	01	001	addiw rd, rd, imm
c.addi16sp	ADD Imm * 16 to SP	CI	01	011	addi sp, sp, 16*imm
c.addi4spn	ADD Imm * 4 + SP	CIW	00	000	addi rd', sp, 4*imm
c.slli	Shift Left Logical Imm	CI	10	000	slli rd, rd, imm
c.srli	Shift Right Logical Imm	CB	01	100x00	srli rd', rd', imm
c.srai	Shift Right Arith Imm	CB	01	100x01	srai rd', rd', imm
c.andi	AND Imm	CB	01	100x10	andi rd', rd', imm
c.mv	MoVe	CR	10	1000	add rd, x0, rs2
c.add	ADD	CR	10	1001	add rd, rd, rs2
c.and	AND	CS	01	10001111	and rd', rd', rs2'
c.or	OR	CS	01	10001110	or rd', rd', rs2'
c.xor	XOR	CS	01	10001101	xor rd', rd', rs2'
c.sub	SUB	CS	01	10001100	sub rd', rd', rs2'
c.addw	ADD Word	CS	01	10011101	addw rd', rd', rs2'
c.subw	SUB Word	CS	01	10011100	subw rd', rd', rs2'
c.nop	No OPeration	CI	01	000	addi x0, x0, 0
c.ebreak	Environment BREAK	CR	10	1001	ebreak

RVC Register Number Integer Register Number Integer Register ABI Name Floating-Point Register Number Floating-Point Register ABI Name

000	001	010	011	100	101	110	111
x8	x9	x10	x11	x12	x13	x14	x15
s0	s1	a0	a1	a2	a3	a4	a5
f8	f9	f10	f11	f12	f13	f14	f15
fs0	fs1	fa0	fa1	fa2	fa3	fa4	fa5

Table 1: Registers shortcuts for rs1', rs2' and rd'

## **Pseudo Instructions**

la rd, symbol	Pseudoinstruction	Base Instruction(s)	Meaning
Aujnc rd, symbol[31:12]	la rd, symbol		Load address
S(b h w d) rd, symbol, rt   S(b h w d) rd, symbol[11:0](rt)   auipc rt, symbol[31:12]   fl(w d) rd, symbol, rt   fl(w d) rd, symbol[31:12]   fs(w d) rd, symbol[11:0](rt)   auipc rt, symbol[31:12]   fs(w d) rd, symbol[11:0](rt)   floating-point store global   fs(w d) rd, symbol[11:0](rt)   footnote   fs(w d) rd, symbol[11:0](rt)   floating-point store global   fs(w d) rd, rs, which is provided   fs(w d) rd, symbol[11:0](rt)   floating-point store global   fs(w d) rd, rs, who operation   Load immediate   Load immediate   Load immediate   Copy register   Copy single-precision register   Set if ≠ zero   Single-precision register   Fmoch register   Segnj.s. rd, rs, rs   Single-precision register   Segnj.s. rd, rs, rs   Copy single-precision register   Segnj.d. rd, rs, rs   Copy double-precision register   Segnj.d. rd, rs, rs   Copy double-precision register   Segnj.d. rd, rs, rs   Copy double-precision register   Copy double-precision register   Segnj.d. rd, rs, rs   Copy double-precision register   Copy double-precision register   Copy double-precision re	l{b h w d} rd, symbol	<pre>auipc rd, symbol[31:12] l{b h w d} rd, symbol[11:0](rd)</pre>	Load global
fl{w d} rd, symbol, rt fl{w d} rd, symbol[11:0](rt) auipc rt, symbol[31:12] fs{w d} rd, symbol, rt fs{w d} rd, symbol[11:0](rt)  nop addi x0, x0, 0 ir d, immediate mv rd, rs not rd, rs not rd, rs neg rd, rs negw rd, rs subw rd, x0, rs seqz rd, rs sltiu rd, rs, 1 sext.w rd, rs sulturd, x0, rs set if = zero sext.w rd, rs sltiu rd, x0, rs set if = zero sltz rd, rs sltr rd, x0, rs sltr rd, x0, rs set if < zero sgtz rd, rs sltr rd, x0, rs fsgnj.s rd, rs, rs fsgnj.s rd, rs, rs fsgnj.s rd, rs, rs fsgnj.s rd, rs, rs fsgnj.d rd, rs, rs fsgnj.d rd, rs, rs foreg.d rd, rs fsgnj.d rd, rs, rs pouble-precision negate fore reprecision negate foreg.d rd, rs fsgnj.d rd, rs, rs fsgnj.d rd, rs, rs foreg.d rd, rs fsgnj.d rd, rs, rs fsgnj.d rd, rs, rs fsgnj.d rd, rs, rs foreg.d rd, rs fsgnj.d rd, rs, r	s{b h w d} rd, symbol, rt		Store global
nop addi x0, x0, 0 No operation li rd, immediate mv rd, rs addi rd, rs, 0 Copy register not rd, rs xori rd, rs xori rd, rs Two's complement neg rd, rs xori rd, rs xori rd, rs Two's complement neg rd, rs xori rd, rs Two's complement neg rd, rs xori rd, rs Two's complement neg rd, rs xori rd, rs Two's complement xord xord xori rd, rs Two's complement xord xord xori rd, rs Xori	<pre>fl{w d} rd, symbol, rt</pre>		Floating-point load global
li rd, immediate mv rd, rs addi rd, rs, 0 copy register not rd, rs neg rd, rs sub rd, x0, rs regy rd, rs sext.w rd, rs sext.w rd, rs sequerd, rs squerd, rs s	fs{w d} rd, symbol, rt	· · · · · · · · · · · · · · · · · · ·	Floating-point store global
mv rd, rs not rd, rs not rd, rs neg rd, rs sub rd, x0, rs negw rd, rs subw rd, x0, rs sext.w rd, rs sext.fr sext.fr sext.fr sext.fr sext.m rd, rs, rs copy single-precision register Twosuble-precision register Topy double-precision register Topy double-precision register Topy double-precision re	nop		No operation
not rd, rs neg rd, rs neg rd, rs sub rd, x0, rs subw rd, x0, rs sext.w rd, rs set if = zero sez rd, rs set if ≠ zero sez rd, rs set if ≠ zero set if ≥ zero	li rd, immediate	Myriad sequences	Load immediate
neg rd, rs negw rd, rs subw rd, x0, rs sext.w rd, rs set.w rd, rs seqz rd, rs sltu rd, rs, 1 seqz rd, rs sltu rd, x0, rs set if = zero sez rd, rs sltu rd, x0, rs set if ≠ zero sltz rd, rs slt rd, rs, x0 set if ≠ zero set if ≥	mv rd, rs	addi rd, rs, 0	Copy register
negw rd, rs sext.w rd, rs sext.if ≠ zero  Sext.if ≠ zero Sext.if ≠ zero Sext.y rd, rs single-precision absolute value fneg.s rd, rs sext.y rd, rs, rs single-precision absolute value fneg.s rd, rs sext.y rd, rs, rs single-precision negate  Copy double-precision negate  Copy double-precision negate  Double-precision negate  Double-precision negate  Branch if = zero  Double-precision negate  Branch if = zero  Branch if = zero  Branch if ≤ zero  Branch if >	not rd, rs	xori rd, rs, −1	One's complement
negw rd, rs sext.w rd, rs sext.if ≠ zero  Sext.if ≠ zero Sext.if ≠ zero Sext.y rd, rs single-precision absolute value fneg.s rd, rs sext.y rd, rs, rs single-precision absolute value fneg.s rd, rs sext.y rd, rs, rs single-precision negate  Copy double-precision negate  Copy double-precision negate  Double-precision negate  Double-precision negate  Branch if = zero  Double-precision negate  Branch if = zero  Branch if = zero  Branch if ≤ zero  Branch if >			
sext.w rd, rs seqz rd, rs seqz rd, rs snez rd, rs sltu rd, x0, rs sltu rd, x0, rs slti rd, rs, x0 set if = zero set if < zero set if > zero s			
seqz rd, rs sltiu rd, rs, 1 Set if = zero snez rd, rs sltu rd, x0, rs Set if $\neq$ zero sltz rd, rs slt rd, rs, x0 Set if $\neq$ zero sgtz rd, rs slt rd, x0, rs Set if $\neq$ zero sgtz rd, rs slt rd, x0, rs Set if $\Rightarrow$ zero fmv.s rd, rs fsgnjs. rd, rs, rs Copy single-precision register fabs.s rd, rs fsgnjs.s rd, rs, rs Single-precision absolute value fneg.s rd, rs fsgnjn.s rd, rs, rs Single-precision negate fmv.d rd, rs fsgnjn.d rd, rs, rs Copy double-precision register fabs.d rd, rs fsgnjn.d rd, rs, rs Copy double-precision negate fmv.d rd, rs fsgnjn.d rd, rs, rs Copy double-precision negate fmv.d rd, rs fsgnjn.d rd, rs, rs Double-precision absolute value fneg.d rd, rs fsgnjn.d rd, rs, rs Double-precision negate field rd, rs fsgnjn.d rd, rs, rs Double-precision negate field rd, rs fsgnjn.d rd, rs, rs Double-precision negate field rd, rs fsgnjn.d rd, rs, rs Double-precision negate field rd, rs fsgnjn.d rd, rs, rs Double-precision negate field rd, rs fsgnjn.d rd, rs, rs Double-precision negate field rd, rs fsgnjn.d rd, rs, rs Double-precision negate field rd, rs fsgnjn.d rd, rs, rs Double-precision negate field rd, rs fsgnjn.d rd, rs, rs Double-precision negate field rd, rs fsgnjn.d rd, rs, rs Double-precision negate field rd, rs fsgnjn.d rd, rs, rs Double-precision negate field rd, rs fsgnjn.d rd, rs, rs field field field field race field regression register field regression register field	sext.w rd, rs		
snez rd, rs sltu rd, x0, rs Set if $\neq$ zero sltz rd, rs slt rd, rs, x0 Set if $<$ zero sgtz rd, rs slt rd, x0, rs Set if $<$ zero fmv.s rd, rs fsgnj.s rd, rs, rs Single-precision absolute value fneg.s rd, rs fsgnjx.s rd, rs, rs Single-precision absolute value fneg.s rd, rs fsgnjx.s rd, rs, rs Single-precision negate fmv.d rd, rs fsgnjx.d rd, rs, rs Copy double-precision register fabs.d rd, rs fsgnjx.d rd, rs, rs Copy double-precision register fabs.d rd, rs fsgnjx.d rd, rs, rs Copy double-precision absolute value fneg.d rd, rs fsgnjx.d rd, rs, rs Double-precision absolute value fneg.d rd, rs fsgnjx.d rd, rs, rs Double-precision absolute value fneg.d rd, rs fsgnjx.d rd, rs, rs Double-precision absolute value fneg.d rd, rs fsgnjx.d rd, rs, rs Double-precision absolute value fneg.d rd, rs fsgnjx.d rd, rs, rs Double-precision absolute value fneg.d rd, rs fsgnjx.d rd, rs, rs Double-precision absolute value fneg.d rd, rs fsgnjx.d rd, rs, rs Double-precision absolute value fneg.d rd, rs fsgnjx.d rd, rs, rs Double-precision negate beqz rs, offset beq rs, x0, offset Branch if $\neq$ zero blez rs, offset begx x0, rs, offset Branch if $\neq$ zero blez rs, offset bge x0, rs, offset Branch if $\neq$ zero bltz rs, offset blt rs, x0, offset Branch if $\neq$ zero bgtz rs, offset blt rx, rs, offset Branch if $\neq$ zero bgt rs, rt, offset blt rt, rs, offset Branch if $\neq$ Branch if $\neq$ blt rs, rt, offset bge rt, rs, offset Branch if $\neq$ blt rt, rs, offset Branch if $\neq$ unisgned bleu rs, rt, offset bgu rt, rs, offset Branch if $\neq$ unisgned jal rfset jal x0, offset Jump and link jr rs jalr x0, rs, 0 Jump and link register ret jalr x0, rs, 0 Jump and link register ret jalr x0, x1, 0 Return from subroutine call offset auipc x6, offset[31:12] jalr x1, x1, offset[11:0] Tail call far-away subroutine			· ·
sltz rd, rs slt rd, rs, $x\theta$ Set if $<$ zero sgtz rd, rs slt rd, $x\theta$ , rs Set if $>$ zero fmv.s rd, rs fsgnj.s rd, rs, rs fsgnjx.s rd, rs, rs Single-precision register fabs.s rd, rs fsgnjx.s rd, rs, rs Single-precision absolute value fneg.s rd, rs fsgnjx.d rd, rs, rs Single-precision negate fmv.d rd, rs fsgnjx.d rd, rs, rs Copy double-precision register fabs.d rd, rs fsgnjx.d rd, rs, rs Copy double-precision register fabs.d rd, rs fsgnjx.d rd, rs, rs Double-precision absolute value fneg.d rd, rs fsgnjx.d rd, rs, rs Double-precision negate beqz rs, offset beq rs, $x\theta$ , offset Branch if $\neq$ zero blez rs, offset bne rs, $x\theta$ , offset Branch if $\neq$ zero blez rs, offset bgx $x\theta$ , rs, offset Branch if $\neq$ zero bgz rs, offset blt rs, $x\theta$ , offset Branch if $\neq$ zero bgtz rs, offset blt rs, $x\theta$ , offset Branch if $\neq$ zero bgtz rs, offset blt rx, rs, offset Branch if $\neq$ zero bgt rs, rt, offset blt rt, rs, offset Branch if $\neq$ zero bgt rs, rt, offset blt rt, rs, offset Branch if $\neq$ zero bgt rs, rt, offset blt rt, rs, offset Branch if $\neq$ zero bgt rs, rt, offset blt rt, rs, offset Branch if $\neq$ zero bgt rs, rt, offset blt rt, rs, offset Branch if $\neq$ zero bgt rs, rt, offset blt rt, rs, offset Branch if $\neq$ bgranch if $\neq$ bgran			Set if $\neq$ zero
sgtz rd, rs  fmv.s rd, rs  fsgnj.s rd, rs, rs  fsgnjx.s rd, rs, rs  fsgnje-precision absolute value  fneg.s rd, rs  fsgnjd.d rd, rs, rs  fsgnjould-precision register  fabs.d rd, rs  fsgnjx.d rd, rs, rs  fsgnjx.d rd, rs, rs  Double-precision absolute value  fneg.d rd, rs  fsgnjn.d rd, rs, rs  beqz rs, offset  beq rs, x0, offset  beq rs, x0, offset  blez rs, offset  bge x0, rs, offset  bge x0, rs, offset  bgt rs, offset  blt rs, x0, offset  blt rs, x0, offset  blt rs, x0, offset  blt rs, rt, offset  blt rt, rs, offset  bgt rs, rt, offset			•
$\begin{array}{cccccccccccccccccccccccccccccccccccc$			Set if > zero
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tail offset jalr x1, x1, offset[11:0] tail offset jalr x0, x6, offset[11:0]  Tail call far-away subroutine		<del>-</del>	
jalr x0, x6, offset[11:0]	call offset	<pre>jalr x1, x1, offset[11:0]</pre>	Call far-away subroutine
fence fence iorw, iorw Fence on all memory and I/O	tail offset	<pre>jalr x0, x6, offset[11:0]</pre>	•
	fence	fence iorw, iorw	Fence on all memory and I/O

# Registers

Register	ABI Name	Encoding	Description	Saver
x0	zero	00000	Zero constant	_
x1	ra	00001	Return address	Caller
x2	sp	00010	Stack pointer	Callee
x3	gp	00011	Global pointer	_
x4	tp	00100	Thread pointer	_
x5-x7	t0-t2	00101 - 00111	Temporaries	Caller
x8	s0 / fp	01000	Saved / frame pointer	Callee
x9	s1	01001	Saved register	Callee
x10-x11	a0-a1	01010 - 01011	Fn args/return values	Caller
x12-x17	a2-a7	01100 - 10001	Fn args	Caller
x18-x27	s2-s11	10010 - 11011	Saved registers	Callee
x28-x31	t3-t6	11100 - 11111	Temporaries	Caller
f0-7	ft0-7	00000 - 00111	FP temporaries	Caller
f8-9	fs0-1	01000 - 01001	FP saved registers	Callee
f10-11	fa0-1	01010 - 01011	FP args/return values	Caller
f12-17	fa2-7	01100 - 10001	FP args	Caller
f18-27	fs2-11	10010 - 11011	FP saved registers	Callee
f28-31	ft8-11	11100 - 11111	FP temporaries	Caller