见下页

mul rd, rs1, rs2

乘*(Multiply)*. R-type, RV32M and RV64M.

把寄存器x[*rs2*]乘到寄存器x[*rs1*]上，乘积写入x[*rd*]。忽略算术溢出。

31 25 24 20 19 15 14 12 11 7 6 0

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| 0000001 | rs2 | rs1 | 000 | rd | 0110011 |

mulh rd, rs1, rs2

高位乘*(Multiply High)*. R-type, RV32M and RV64M.

把寄存器x[*rs2*]乘到寄存器x[*rs1*]上，都视为2的补码，将乘积的高位写入x[*rd*]。

31 25 24 20 19 15 14 12 11 7 6 0

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| 0000001 | rs2 | rs1 | 001 | rd | 0110011 |

mulhsu rd, rs1, rs2

高位有符号-无符号乘*(Multiply High Signed-Unsigned)*. R-type, RV32M and RV64M.

把寄存器x[*rs2*]乘到寄存器x[*rs1*]上，x[*rs1*]为2的补码，x[*rs2*]为无符号数，将乘积的高位写入x[*rd*]。

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| 0000001 | rs2  31 25 24 20 19 15 14 12 11 7 6 0 | rs1 | 010 | rd | 0110011 |

mulw rd, rs1, rs2

乘字*(Multiply Word)*. R-type, RV64M only.

把寄存器x[*rs2*]乘到寄存器x[*rs1*]上，乘积截为32位，进行有符号扩展后写入x[*rd*]。忽略算术溢出。

31 25 24 20 19 15 14 12 11 7 6 0

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| 0000001 | rs2 | rs1 | 000 | rd | 0111011 |

mv rd, rs1

移动*(Move)*. 伪指令(Pseudoinstruction), RV32I and RV64I.

把寄存器x[*rs1*]复制到x[*rd*]中。实际被扩展为**addi** rd, rs1, 0

neg rd, rs2

取非*(Negate)*. 伪指令(Pseudoinstruction), RV32I and RV64I.

把寄存器x[*rs2*]的补码写入x[*rd*]。实际被扩展为**sub** rd, x0, rs2。

neg rd, rs2

取非字*(Negate Word)*. 伪指令(Pseudoinstruction), RV64I only.

计算寄存器x[*rs2*]对于2的补码，结果截为32位，进行符号扩展后写入x[*rd*]。实际被扩展为**subw** rd, x0, rs2。

nop

无操作*(No operation)*. 伪指令(Pseudoinstruction), RV32I and RV64I.

将*pc*推进到下一条指令。实际被扩展为**addi** x0, x0, 0。

not rd, rs1

取反*(NOT)*. 伪指令(Pseudoinstruction), RV32I and RV64I.

把寄存器x[*rs1*]对于1的补码写入x[*rd*]。实际被扩展为**xori** rd, rs1, -1。

or rd, rs1, rs2

取或*(OR)*. R-type, RV32I and RV64I.

把寄存器x[*rs1*]和寄存器x[*rs2*]按位取或，结果写入x[*rd*]。

压缩形式：**c.or** rd, rs2

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| 0000000 | rs2  31 25 24 20 19 15 14 12 11 7 6 0 | rs1 | 110 | rd | 0110011 |

ori rd, rs1, immediate

立即数取或*(OR Immediate)*. R-type, RV32I and RV64I.

把寄存器x[*rs1*]和有符号扩展的立即数*immediate*按位取或，结果写入x[*rd*]。

压缩形式：**c.or** rd, rs2

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Immediate[11:0] | rs2  31 25 24 20 19 15 14 12 11 7 6 0 | rs1 | 110 | rd | 0010011 |

rdcycle rd

读周期计数器*(Read Cycle Counter)*. 伪指令(Pseudoinstruction), RV32I and RV64I.

把周期数写入x[*rd*]。实际被扩展为**csrrs** rd, cycle, x0。

rdcycleh rd

读周期计数器高位*(Read Cycle Counte High)*. 伪指令(Pseudoinstruction), RV32I only.

把周期数右移32位后写入x[*rd*]。实际被扩展为**csrrs** rd, cycleh, x0。

rdinstret rd

读已完成指令计数器*(Read Instruction-Retired Counter)*. 伪指令(Pseudoinstruction), RV32I and RV64I.

把已完成指令数写入x[*rd*]。实际被扩展为**csrrs** rd, instret, x0。

rdinstreth rd

读已完成指令计数器高位*(Read Instruction-Retired Counter High)*. 伪指令(Pseudoinstruction), RV32I only.

把已完成指令数右移32位后写入x[*rd*]。实际被扩展为**csrrs** rd, instreth, x0。

rdtime rd

读取时间*(Read Time)*. 伪指令(Pseudoinstruction), RV32I and RV64I.

把当前时间写入x[*rd*]，时间频率与平台相关。实际被扩展为**csrrs** rd, time, x0。

rdtimeh rd

读取时间高位*(Read Time High)*. 伪指令(Pseudoinstruction), RV32I only.

把当前时间右移32位后写入x[*rd*]，时间频率与平台相关。实际被扩展为**csrrs** rd, timeh, x0。

rem rd, rs1, rs2

求余数*(Remainder)*. R-type, RV32M and RV64M.

x[*rs1*]除以x[*rs2*]，向0舍入，都视为2的补码，余数写入x[*rd*]。

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| 0000001 | rs2  31 25 24 20 19 15 14 12 11 7 6 0 | rs1 | 110 | rd | 0110011 |

remu rd, rs1, rs2

求无符号数的余数*(Remainder, Unsigned)*. R-type, RV32M and RV64M.

x[*rs1*]除以x[*rs2*]，向0舍入，都视为无符号数，余数写入x[*rd*]。

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| 0000001 | rs2  31 25 24 20 19 15 14 12 11 7 6 0 | rs1 | 111 | rd | 0110011 |

remuw rd, rs1, rs2

求无符号数的余数字*(Remainder Word, Unsigned)*. R-type, RV64M only.

x[*rs1*]的低32位除以x[*rs2*]的低32位，向0舍入，都视为无符号数，将余数的有符号扩展写入x[*rd*]。

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| 0000001 | rs2  31 25 24 20 19 15 14 12 11 7 6 0 | rs1 | 111 | rd | 0111011 |

remw rd, rs1, rs2

求余数字*(Remainder Word)*. R-type, RV64M only.

x[*rs1*]的低32位除以x[*rs2*]的低32位，向0舍入，都视为2的补码，将余数的有符号扩展写入x[*rd*]。

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| 0000001 | rs2  31 25 24 20 19 15 14 12 11 7 6 0 | rs1 | 110 | rd | 0111011 |

ret

返回*(Return)*. 伪指令(Pseudoinstruction), RV32I and RV64I.

从子过程返回。实际被扩展为**jalr** x0, 0(x1)。

sb rs2, offset(rs1)

存字节*(Store Byte)*. S-type, RV32I and RV64I.

将x[*rs2*]的低位字节存入内存地址x[*rs1*]+*sign-extend(offset)*。

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| offset[11:5] | rs2  31 25 24 20 19 15 14 12 11 7 6 0 | rs1 | 000 | offset[4:0] | 0100011 |

sc.d rd, rs2, (rs1)

条件存入双字*(Store-Conditional Doubleword)*. R-type, RV64A only.

如果内存地址x[*rs1*]上存在加载保留，将x[*rs2*]寄存器中的8字节数存入该地址。如果存入成功，向寄存器x[*rd*]中存入0，否则存入一个非0的错误码。

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| 00011  31 27 26 25 24 20 19 15 14 12 11 7 6 0 | aq | rl | rs2 | rs1 | 011 | rd | 0101111 |

sc.w rd, rs2, (rs1)

条件存入字*(Store-Conditional Word)*. R-type, RV32A and RV64A.

内存地址x[*rs1*]上存在加载保留，将x[*rs2*]寄存器中的4字节数存入该地址。如果存入成功，向寄存器x[*rd*]中存入0，否则存入一个非0的错误码。

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| 00011  31 27 26 25 24 20 19 15 14 12 11 7 6 0 | aq | rl | rs2 | rs1 | 010 | rd | 0101111 |

sd rs2, offset(rs1)

存双字*(Store Doubleword)*. S-type, RV64I only.

将x[*rs2*]中的8字节存入内存地址x[*rs1*]+*sign-extend(offset)*。

压缩形式：**c.sdsp** rs2, offset; **c.sd** rs2, offset(rs1)

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| offset[11:5] | rs2  31 25 24 20 19 15 14 12 11 7 6 0 | rs1 | 011 | offset[4:0] | 0100011 |

seqz rd, rs1

等于0则置位*(Set if Equal to Zero)*. 伪指令(Pseudoinstruction), RV32I and RV64I.

如果x[*rs1*]等于0，向x[*rd*]写入1，否则写入0。实际被扩展为**sltiu** rd, rs1, 1。

sext.w rd, rs1

有符号字扩展*(Sign-extend Word)*. 伪指令(Pseudoinstruction), RV64I only.

读入x[*rs1*]的低32位，有符号扩展，结果写入x[*rd*]。实际被扩展为**addiw** rd, rs1, 0。

sfence.vma rs1, rs2

虚拟内存屏障*(Fence Virtual Memory)*. R-type, RV32I and RV64I特权指令。

根据后续的虚拟地址翻译对之前的页表存入进行排序。当*rs2*=0时，所有地址空间的翻译都会受到影响；否则，仅对x[*rs2*]标识的地址空间的翻译进行排序。当*rs1*=0时，对所选地址空间中的所有虚拟地址的翻译进行排序；否则，仅对其中包含虚拟地址x[*rs1*]的页面地址翻译进行排序。

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| 0001001 | rs2  31 25 24 20 19 15 14 12 11 7 6 0 | rs1 | 000 | 00000 | 1110011 |

sgtz rd, rs2

大于0则置位*(Set if Greater Than Zero)*. 伪指令(Pseudoinstruction), RV32I and RV64I.

如果x[*rs2*]大于0，向x[*rd*]写入1，否则写入0。实际被扩展为**slt** rd, x0, rs2。

sh rs2, offset(rs1)

存半字*(Store Halfword)*. S-type, RV32I and RV64I.

将x[*rs2*]的低位2个字节存入内存地址x[*rs1*]+*sign-extend(offset)*。

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| offset[11:5] | rs2  31 25 24 20 19 15 14 12 11 7 6 0 | rs1 | 001 | offset[4:0] | 0100011 |

sw rs2, offset(rs1)

存字*(Store Word)*. S-type, RV32I and RV64I.

将x[*rs2*]的低位4个字节存入内存地址x[*rs1*]+*sign-extend(offset)*。

压缩形式：**c.swsp** rs2, offset; **c.sw** rs2, offset(rs1)

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| offset[11:5] | rs2  31 25 24 20 19 15 14 12 11 7 6 0 | rs1 | 010 | offset[4:0] | 0100011 |

sll rd, rs1, rs2

逻辑左移*(Shift Left Logical)*. R-type, RV32I and RV64I.

把寄存器x[*rs1*]左移x[*rs2*]位，空出的位置填入0，结果写入x[*rd*]。x[*rs2*]的低5位（如果是RV64I则是低6位）代表移动位数，其高位则被忽略。

31 25 24 20 19 15 14 12 11 7 6 0

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| 0000000 | rs2 | rs1 | 001 | rd | 0110011 |

slli rd, rs1, shamt

立即数逻辑左移*(Shift Left Logical Immediate)*. I-type, RV32I and RV64I.

把寄存器x[*rs1*]左移*shamt*位，空出的位置填入0，结果写入x[*rd*]。对于RV32I，仅当*shamt*[5]=0时，指令才是有效的。

压缩形式：**c.slli** rd, shamt

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| 000000 | shamt | rs1 | 001 | rd  31 26 25 20 19 15 14 12 11 7 6 0 | 0100011 |

slliw rd, rs1, shamt

立即数逻辑左移字*(Shift Left Logical Word Immediate)*. I-type, RV64I only.

把寄存器x[*rs1*]左移*shamt*位，空出的位置填入0，结果截为32位，进行有符号扩展后写入x[*rd*]。仅当*shamt*[5]=0时，指令才是有效的。

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| 000000 | shamt | rs1 | 001 | rd  31 26 25 20 19 15 14 12 11 7 6 0 | 0011011 |

sllw rd, rs1, rs2

逻辑左移字*(Shift Left Logical Word)*. R-type, RV64I only.

把寄存器x[*rs1*]的低32位左移x[*rs2*]位，空出的位置填入0，结果进行有符号扩展后写入x[*rd*]。x[*rs2*]的低5位代表移动位数，其高位则被忽略。

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| 0000000 | rs2 | rs1 | 001 | rd  31 25 24 20 19 15 14 12 11 7 6 0 | 0111011 |

slt rd, rs1, rs2

小于则置位*(Set if Less Than)*. R-type, RV32I and RV64I.

比较x[*rs1*]和x[*rs2*]中的数，如果x[*rs1*]更小，向x[*rd*]写入1，否则写入0。

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| 0000000 | rs2  31 25 24 20 19 15 14 12 11 7 6 0 | rs1 | 010 | rd | 0110011 |

slti rd, rs1, immediate

小于立即数则置位*(Set if Less Than Immediate)*. I-type, RV32I and RV64I.

比较x[*rs1*]和有符号扩展的*immediate*，如果x[*rs1*]更小，向x[*rd*]写入1，否则写入0。

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| immediate[11:0] | rs1  31 20 19 15 14 12 11 7 6 0 | 010 | rd | 0010011 |

sltiu rd, rs1, immediate

无符号小于立即数则置位*(Set if Less Than Immediate, Unsigned)*. I-type, RV32I and RV64I.

比较x[*rs1*]和有符号扩展的*immediate*，比较时视为无符号数。如果x[*rs1*]更小，向x[*rd*]写入1，否则写入0。

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| immediate[11:0] | rs1  31 20 19 15 14 12 11 7 6 0 | 011 | rd | 0010011 |

sltu rd, rs1, rs2

无符号小于则置位*(Set if Less Than, Unsigned)*. R-type, RV32I and RV64I.

比较x[*rs1*]和x[*rs2*]，比较时视为无符号数。如果x[*rs1*]更小，向x[*rd*]写入1，否则写入0。

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| 0000000 | rs2  31 25 24 20 19 15 14 12 11 7 6 0 | rs1 | 011 | rd | 0110011 |

sltz rd, rs1

小于0则置位*(Set if Less Than to Zero)*. 伪指令(Pseudoinstruction), RV32I and RV64I.

如果x[*rs1*]小于0，向x[*rd*]写入1，否则写入0。实际扩展为**slt** rd, rs1, x0。

snez rd, rs2

不等于0则置位*(Set if Not Equal to Zero)*. 伪指令(Pseudoinstruction), RV32I and RV64I.

如果x[*rs1*]不等于0，向x[*rd*]写入1，否则写入0。实际扩展为**sltu** rd, x0, rs2。

sra rd, rs1, rs2

算术右移*(Shift Right Arithmetic)*. R-type, RV32I and RV64I.

把寄存器x[*rs1*]右移x[*rs2*]位，空位用x[*rs1*]的最高位填充，结果写入x[*rd*]。x[*rs2*]的低5位（如果是RV64I则是低6位）为移动位数，高位则被忽略。

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| 0100000 | rs2  31 25 24 20 19 15 14 12 11 7 6 0 | rs1 | 101 | rd | 0110011 |

srai rd, rs1, shamt

立即数算术右移*(Shift Right Arithmetic Immediate)*. I-type, RV32I and RV64I.

把寄存器x[*rs1*]右移*shamt*位，空位用x[*rs1*]的最高位填充，结果写入x[*rd*]。对于RV32I，仅当*shamt*[5]=0时指令有效。

压缩形式：**c.srai** rd, shamt

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| 010000 | shamt  31 26 25 20 19 15 14 12 11 7 6 0 | rs1 | 101 | rd | 0010011 |

sraiw rd, rs1, shamt

立即数算术右移字*(Shift Right Arithmetic Word Immediate)*. I-type, RV64I only.

把寄存器x[*rs1*]的低32位右移*shamt*位，空位用x[*rs1*][31]填充，结果进行有符号扩展后写入x[*rd*]。仅当*shamt*[5]=0时指令有效。

压缩形式：**c.srai** rd, shamt

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| 010000 | shamt | rs1 | 101  31 26 25 20 19 15 14 12 11 7 6 0 | rd | 0011011 |

sraw rd, rs1, rs2

算术右移字*(Shift Right Arithmetic Word)*. R-type, RV64I only.

把寄存器x[*rs1*]的低32位右移x[*rs2*]位，空位用x[*rs1*][31]填充，结果进行有符号扩展后写入x[*rd*]。x[*rs2*]的低5位为移动位数，高位则被忽略。

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| 0100000 | rs2  31 25 24 20 19 15 14 12 11 7 6 0 | rs1 | 101 | rd | 0111011 |

sret

管理员模式例外返回*(Supervisor-mode Exception Return)*. R-type, RV32I and RV64I特权指令。

从管理员模式的例外处理程序中返回，设置*pc*为CSRs[spec]，权限模式为CSRs[sstatus].SPP，CSRs[sstatus].SIE为CSRs[sstatus].SPIE，CSRs[sstatus].SPIE为1，CSRs[sstatus].spp为0。

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| 0001000 | 00010  31 25 24 20 19 15 14 12 11 7 6 0 | 00000 | 000 | 00000 | 1110011 |

srl rd, rs1, rs2

逻辑右移*(Shift Right Logical)*. R-type, RV32I and RV64I.

把寄存器x[*rs1*]右移x[*rs2*]位，空出的位置填入0，结果写入x[*rd*]。x[*rs2*]的低5位（如果是RV64I则是低6位）代表移动位数，其高位则被忽略。

31 25 24 20 19 15 14 12 11 7 6 0

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| 0000000 | rs2 | rs1 | 101 | rd | 0110011 |

srli rd, rs1, shamt

立即数逻辑右移*(Shift Right Logical Immediate)*. I-type, RV32I and RV64I.

把寄存器x[*rs1*]右移*shamt*位，空出的位置填入0，结果写入x[*rd*]。对于RV32I，仅当*shamt*[5]=0时，指令才是有效的。

压缩形式：**c.srli** rd, shamt

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| 000000 | shamt | rs1 | 101 | rd  31 26 25 20 19 15 14 12 11 7 6 0 | 0100011 |

srliw rd, rs1, shamt

立即数逻辑右移字*(Shift Right Logical Word Immediate)*. I-type, RV64I only.

把寄存器x[*rs1*]右移*shamt*位，空出的位置填入0，结果截为32位，进行有符号扩展后写入x[*rd*]。仅当*shamt*[5]=0时，指令才是有效的。

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| 000000 | shamt | rs1 | 101 | rd  31 26 25 20 19 15 14 12 11 7 6 0 | 0011011 |

srlw rd, rs1, rs2

逻辑右移字*(Shift Right Logical Word)*. R-type, RV64I only.

把寄存器x[*rs1*]的低32位右移x[*rs2*]位，空出的位置填入0，结果进行有符号扩展后写入x[*rd*]。x[*rs2*]的低5位代表移动位数，其高位则被忽略。

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| 0000000 | rs2 | rs1 | 101 | rd  31 25 24 20 19 15 14 12 11 7 6 0 | 0111011 |

sub rd, rs1, rs2

减*(Substract)*. R-type, RV32I and RV64I.

x[*rs1*]减去x[*rs2*]，结果写入x[*rd*]。忽略算术溢出。

压缩形式：**c.sub** rd, rs2

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| 0100000 | rs2  31 25 24 20 19 15 14 12 11 7 6 0 | rs1 | 000 | rd | 0110011 |

subw rd, rs1, rs2

减去字*(Substract Word)*. R-type, RV64I only.

x[*rs1*]减去x[*rs2*]，结果截为32位，有符号扩展后写入x[*rd*]。忽略算术溢出。

压缩形式：**c.subw** rd, rs2

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| 0100000 | rs2  31 25 24 20 19 15 14 12 11 7 6 0 | rs1 | 000 | rd | 0111011 |

tail symbol

尾调用*(Tail call)*. 伪指令(Pseudoinstuction), RV32I and RV64I.

设置*pc*为*symbol*，同时覆写x[6]。实际扩展为**auipc** x6, offsetHi和**jalr** x0, offsetLo(x6)。

wfi

等待中断*(Wait for Interrupt)*. R-type, RV32I and RV64I特权指令。

如果没有待处理的中断，则使处理器处于空闲状态。

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| 0001000 | 00101  31 25 24 20 19 15 14 12 11 7 6 0 | 00000 | 000 | 00000 | 1110011 |

xor rd, rs1, rs2

异或*(Exclusive-OR)*. R-type, RV32I and RV64I.

x[*rs1*]和x[*rs2*]按位异或，结果写入x[*rd*]。

压缩形式：**c.xor** rd, rs2

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| 0000000 | rs2  31 25 24 20 19 15 14 12 11 7 6 0 | rs1 | 100 | rd | 0110011 |

xori rd, rs1, immediate

立即数异或*(Exclusive-OR Immediate)*. I-type, RV32I and RV64I.

x[*rs1*]和有符号扩展的*immediate*按位异或，结果写入x[*rd*]。

压缩形式：**c.xor** rd, rs2

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| immediate[11:0] | rs1  31 20 19 15 14 12 11 7 6 0 | 100 | rd | 0010011 |