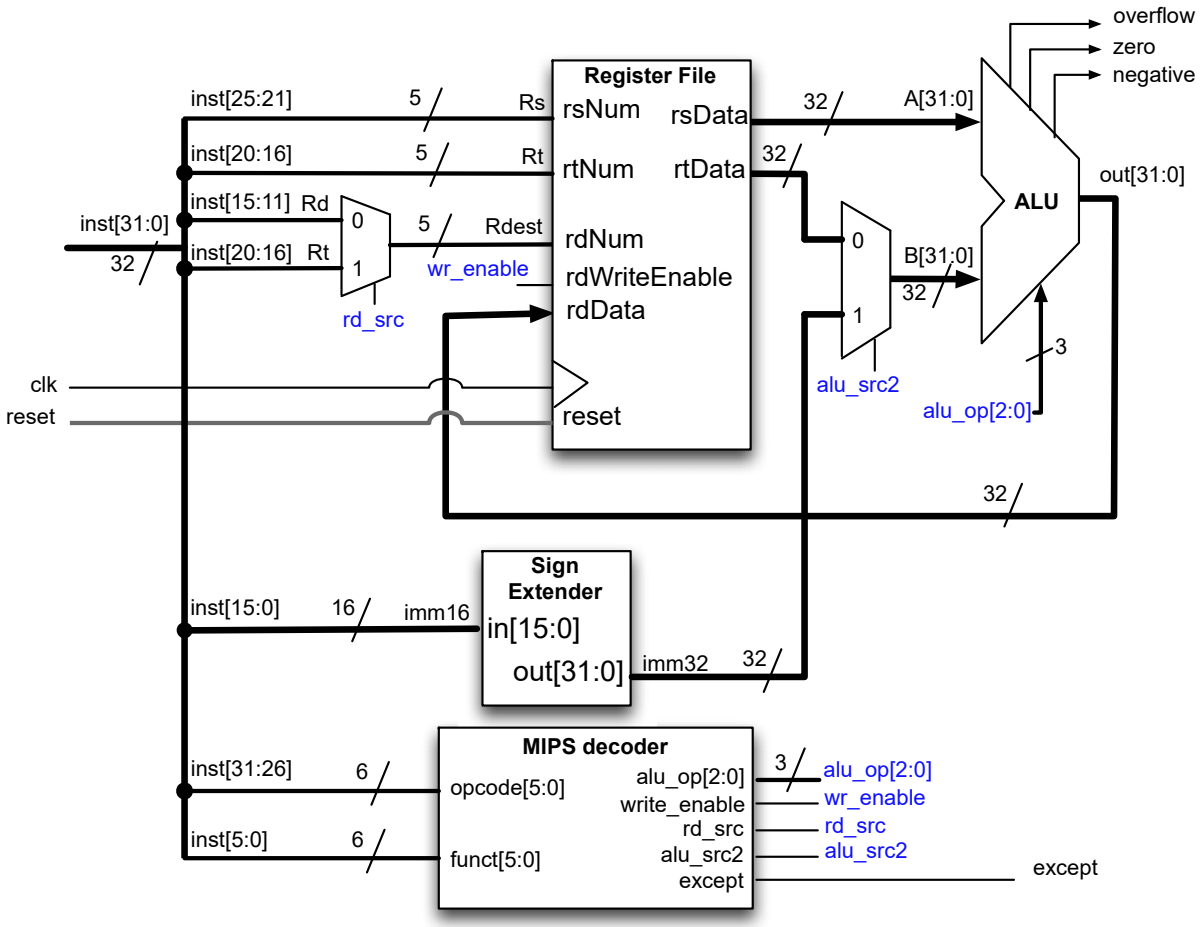
Instruction Decoding

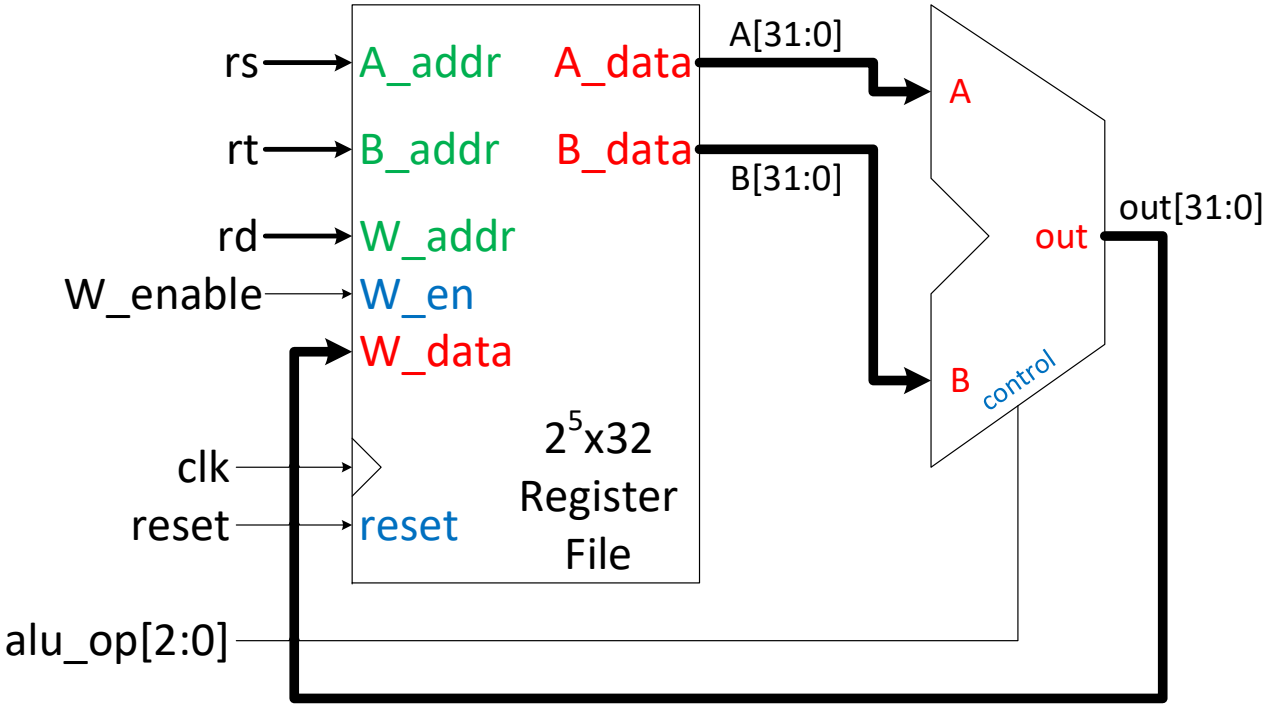
By the End of Today's Lecture



Today's lecture

- Instruction Encoding
  - R-type & I-type encodings
- Instruction Decoding
  - Operands
  - Sign-extending the immediate
  - Decoding the ALU operation

How do instructions control the datapath?

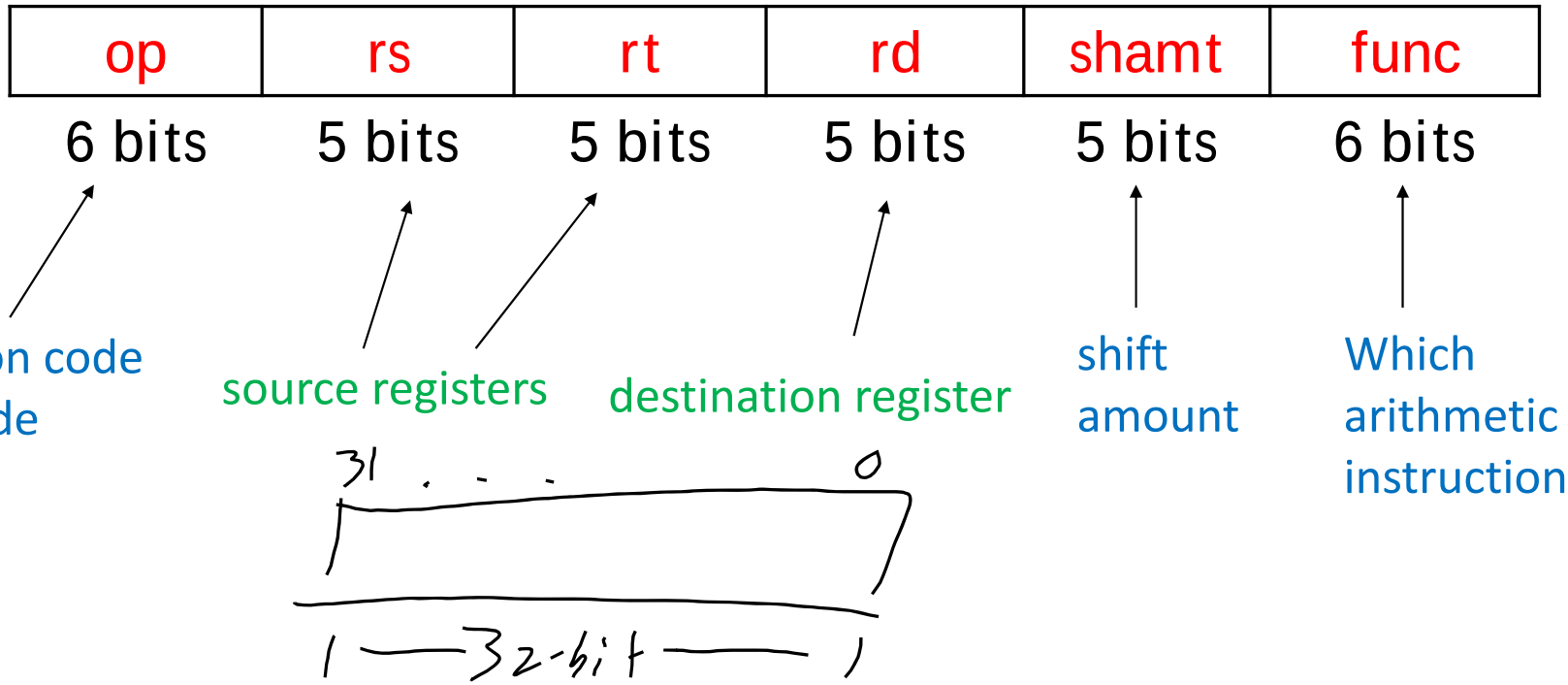


- First step is to learn how instructions are encoded

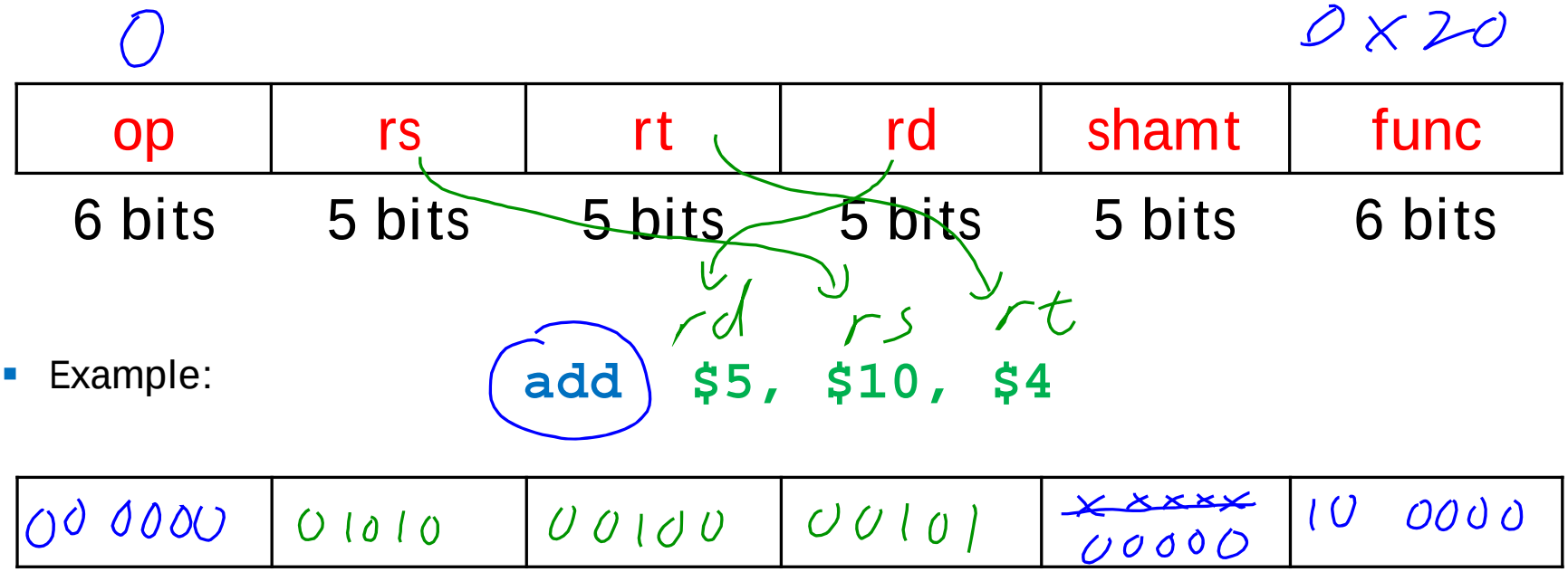
Machine language is a binary format that can be stored in memory

- MIPS machine language is easy to decode
  - Each MIPS instruction is 32 bits wide
  - There are three instruction formats

Register-to-register arithmetic instructions use the R-type format

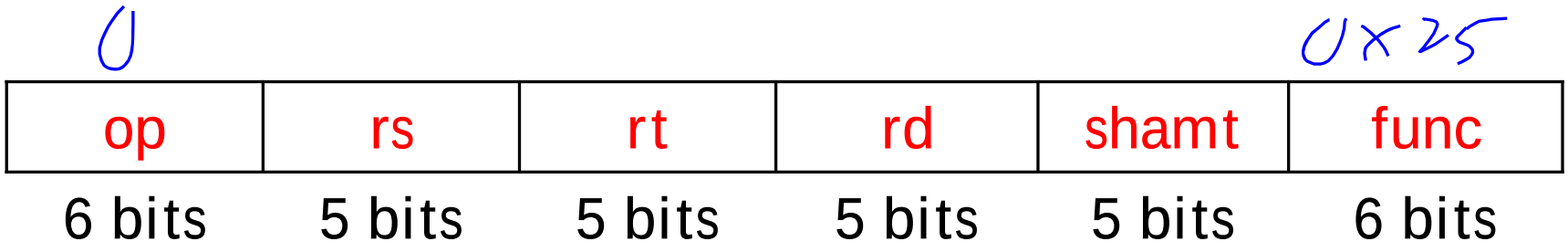


Register-to-register arithmetic instructions use the R-type format



- Example:

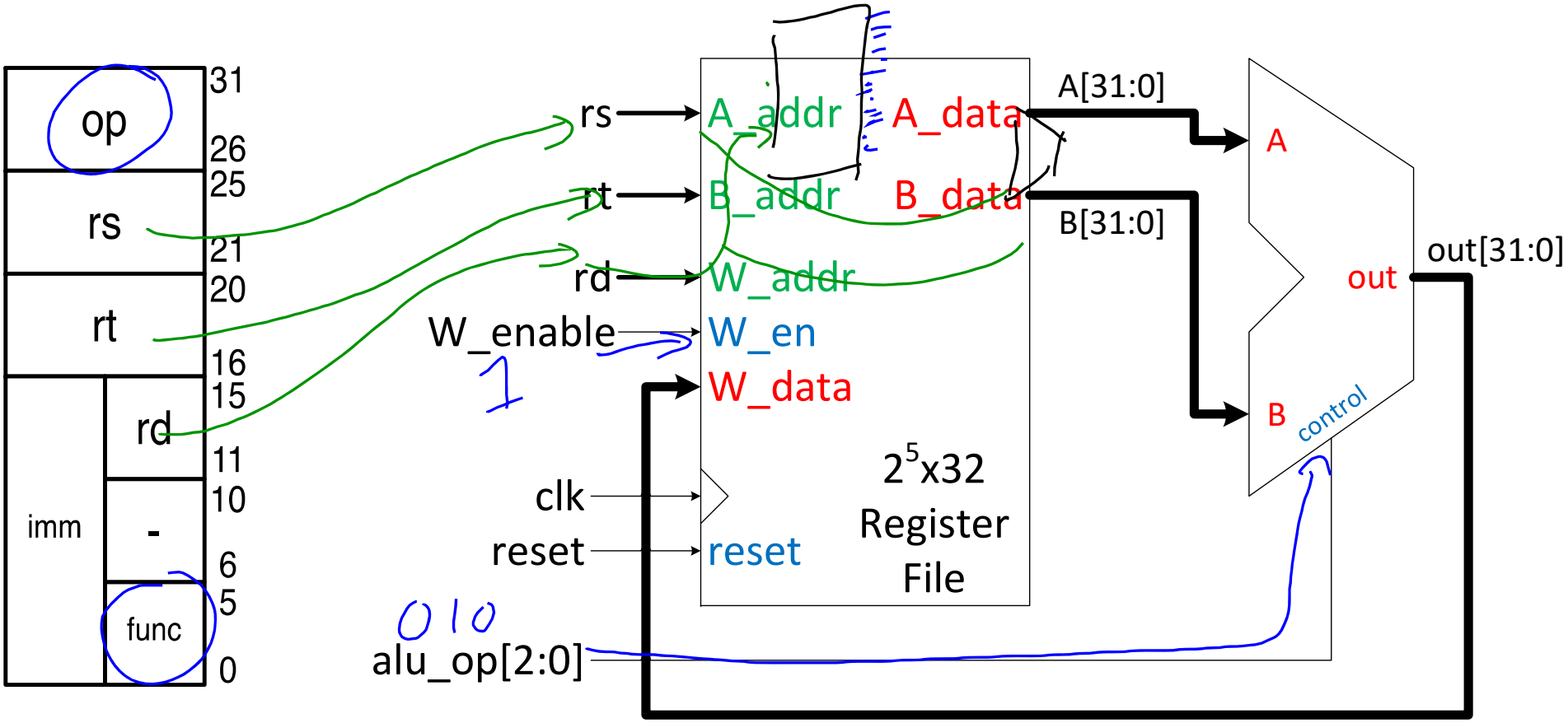
Register-to-register arithmetic instructions use the R-type format



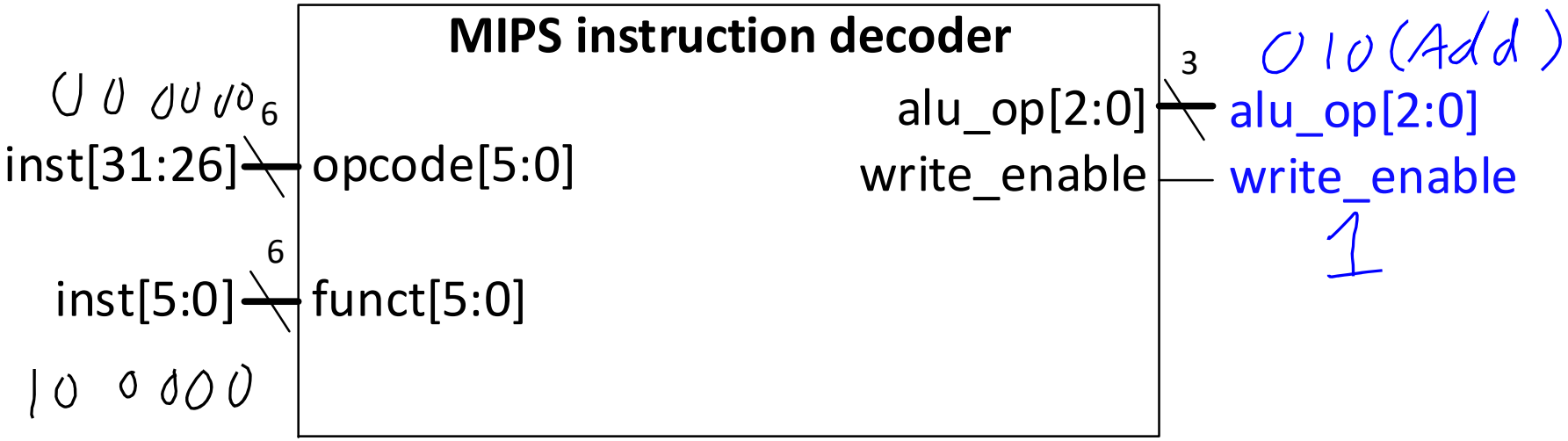
- Example: `or $22, $13, $8`

a) xxxxx
b) 01000
c) 01101
d) 10110

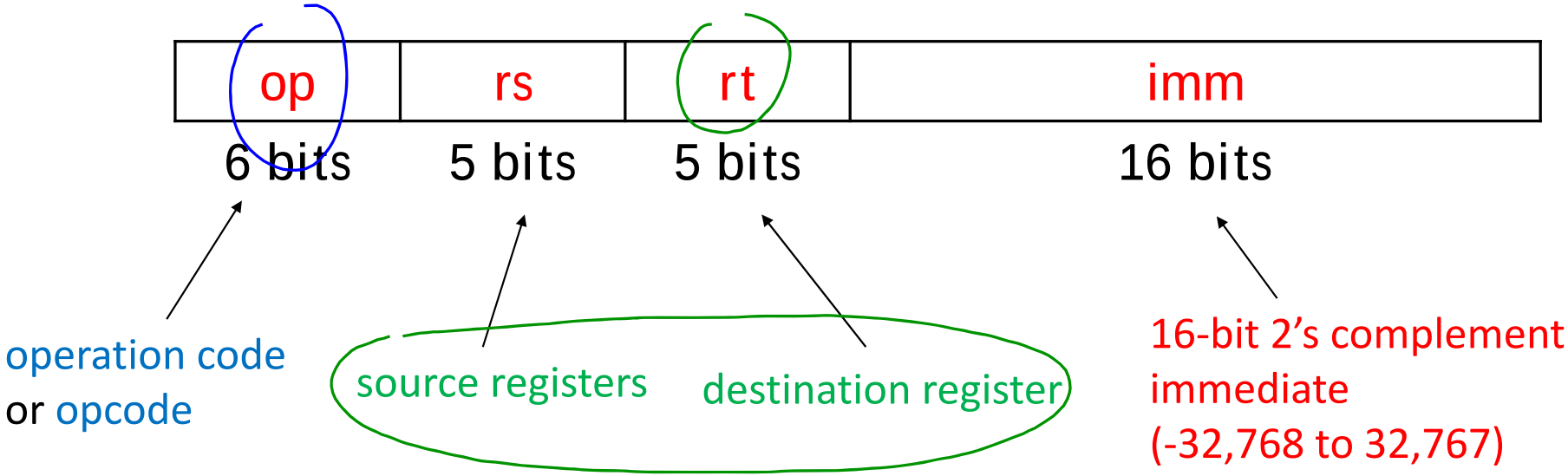
Addresses can be extracted directly from the instruction



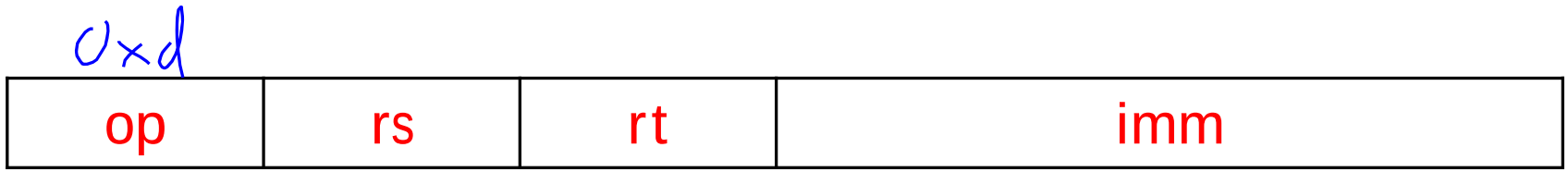
Control signals are encoded in the instruction



Instructions with immediates all use the I-type format.

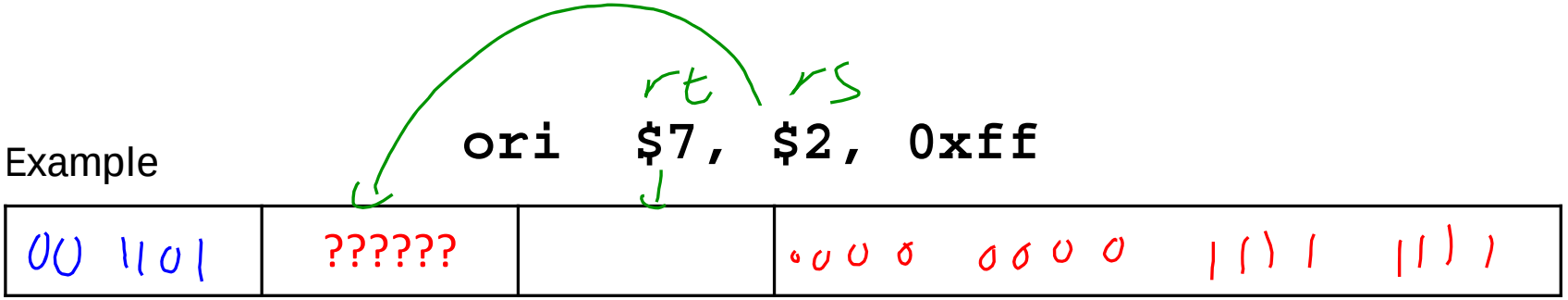


Instructions with immediates all use the I-type format.



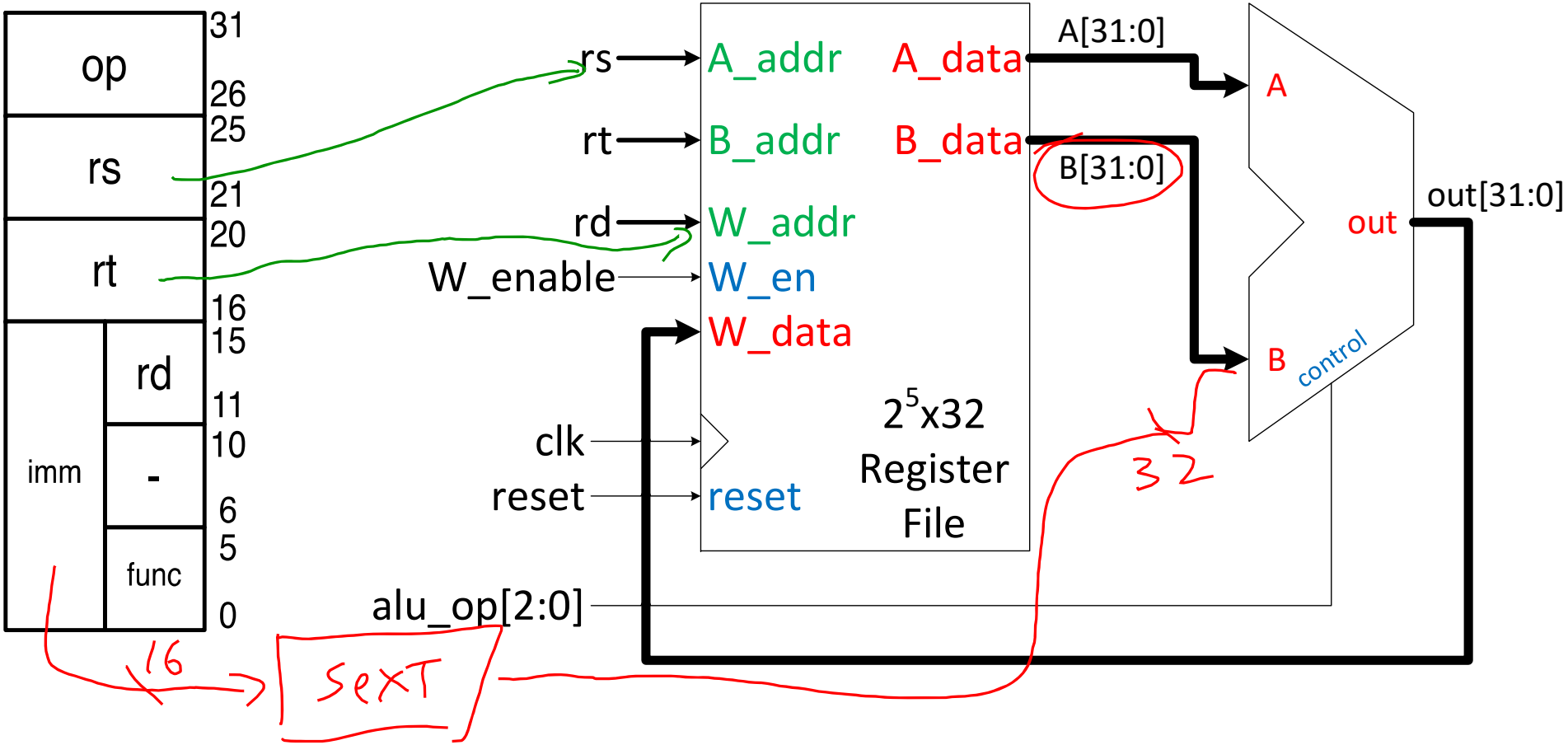
- Example

```
ori  $7, $2, 0xff
```

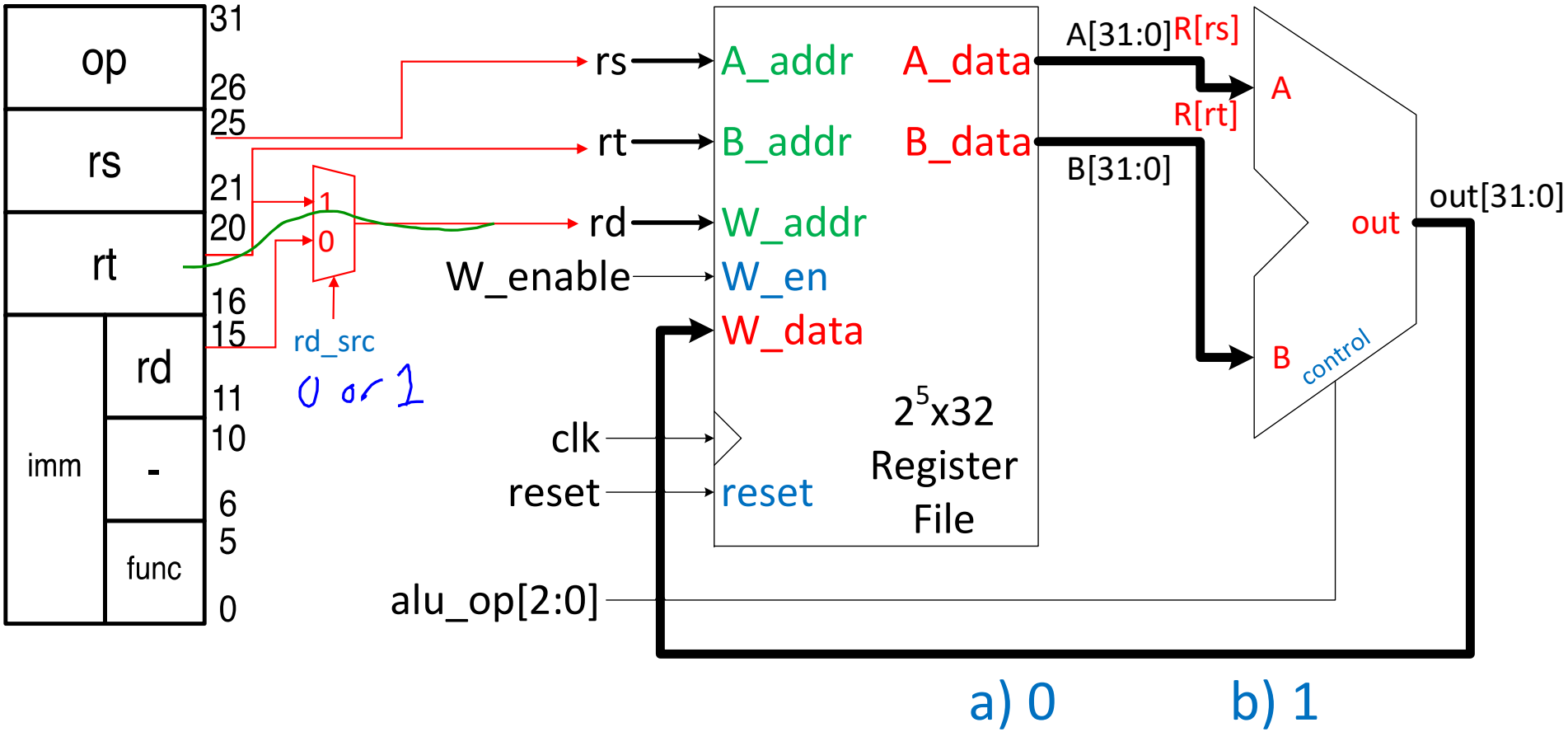


a) 01101
b) 00111
c) 00010
d) 11111

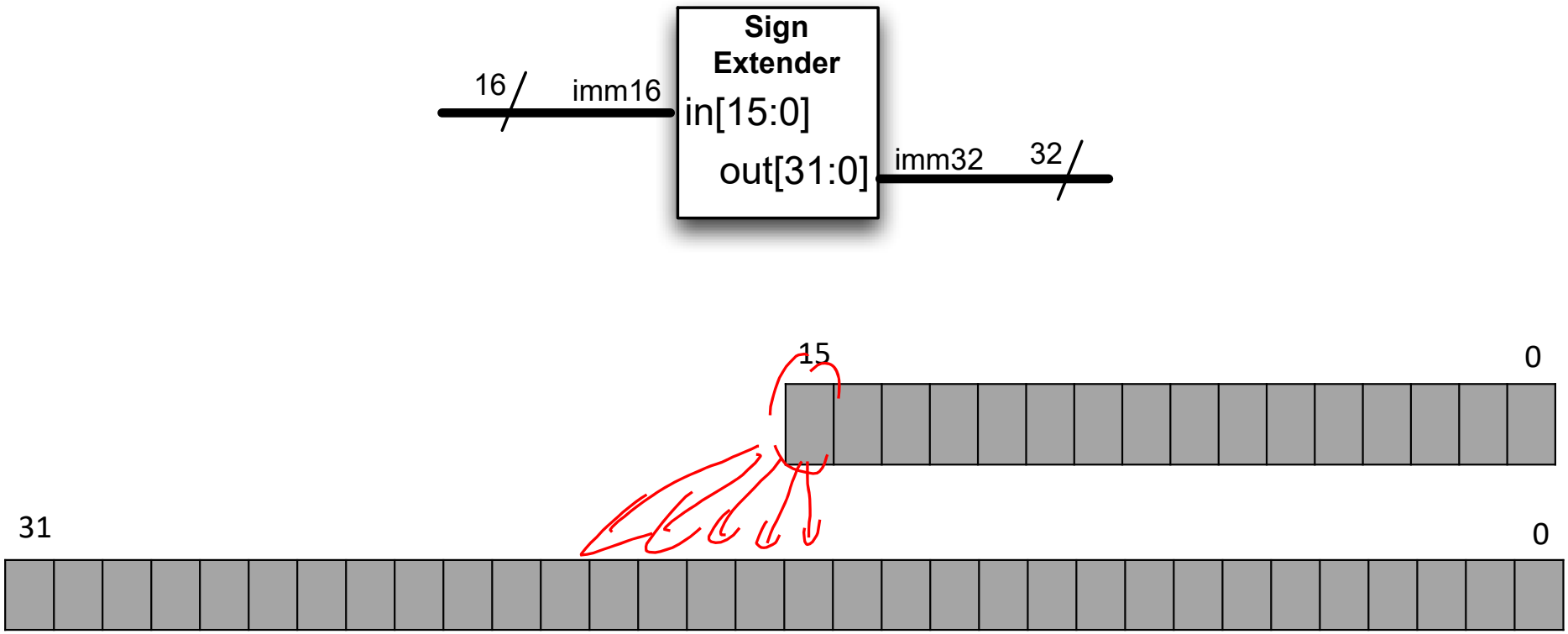
Addresses and data can be extracted directly from the instruction



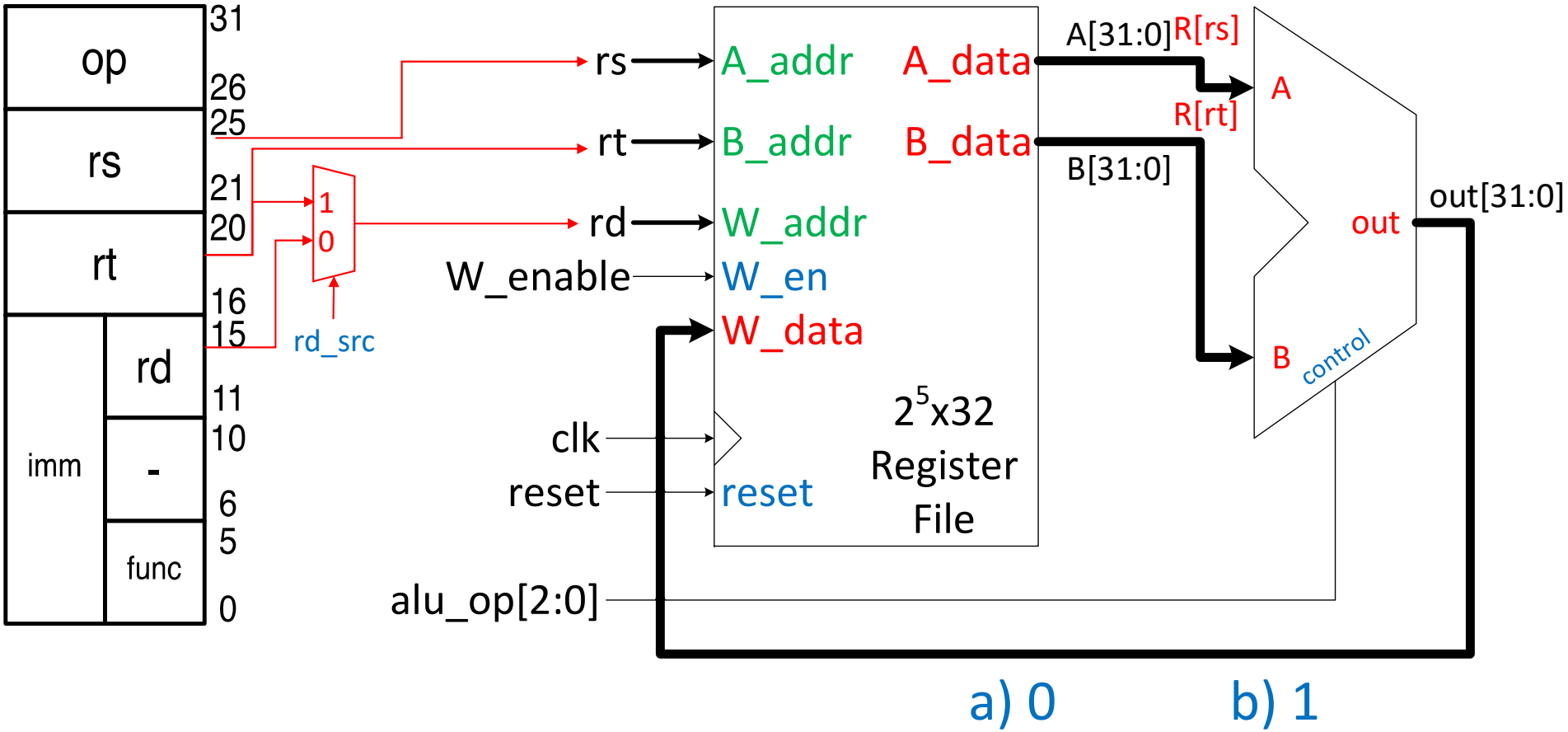
If we have an I-type instruction, what should the control signal rd_src be?



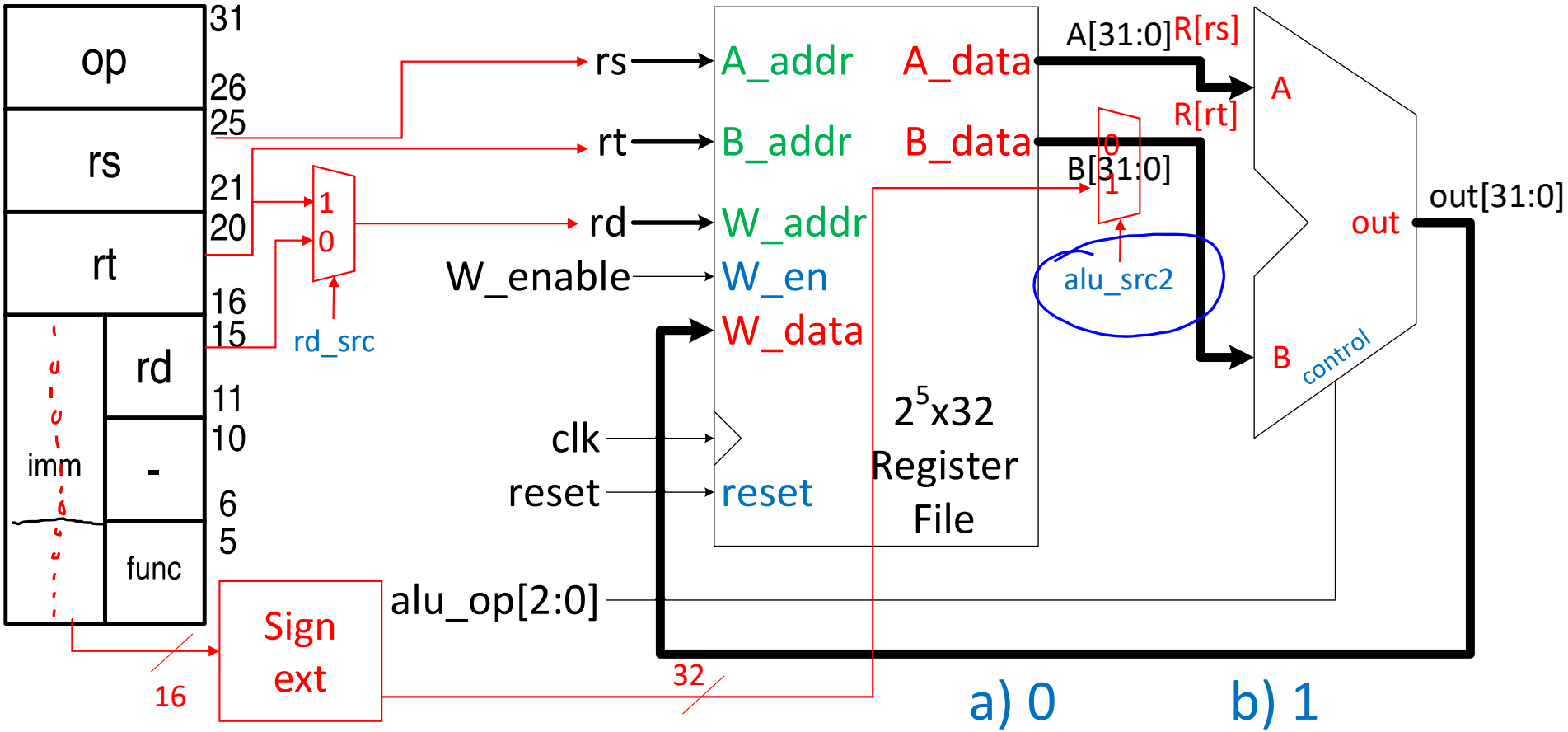
Sign Extension replicates the MSb of imm16



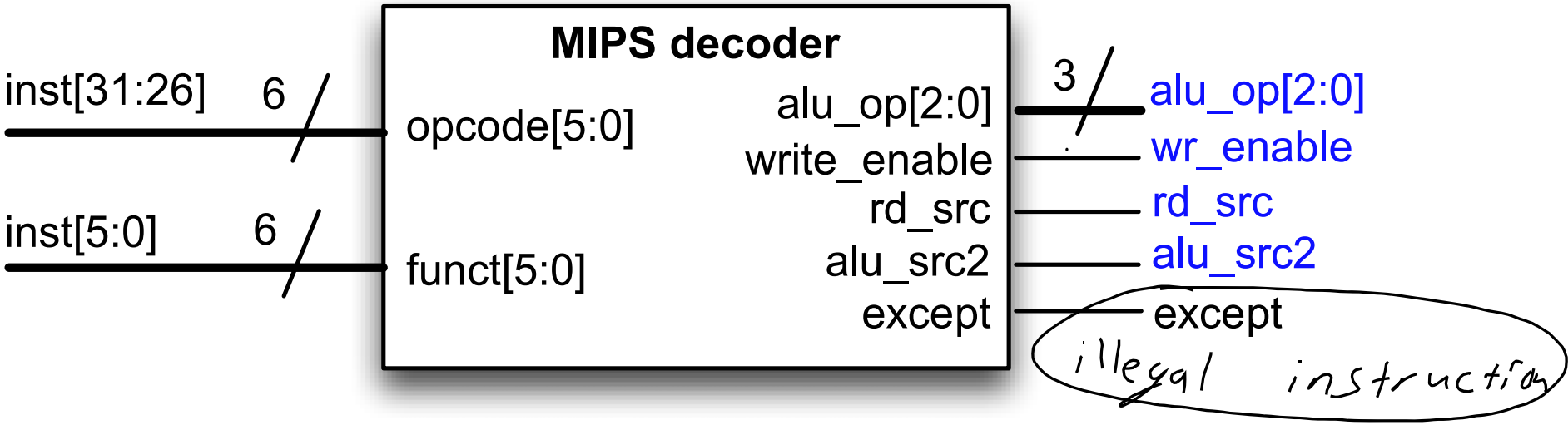
Select behavior of the ALU B input based on instruction type



If we have an R-type instruction, what should the control signal alu_src2 be?



The instruction decoder translates bits from the instruction into control signals



Use a table to decode instructions into control signals

Instruction	opcode	func	alu_op	rd_src	alu_src2	wr_enable
add	000000	10 0000	010	0	0	1
sub	000000	10 0010	011	0	0	1
and						
or						
nor						
xor						
addi						
andi						
ori	00 1101	——	101	1	1	1
xori						