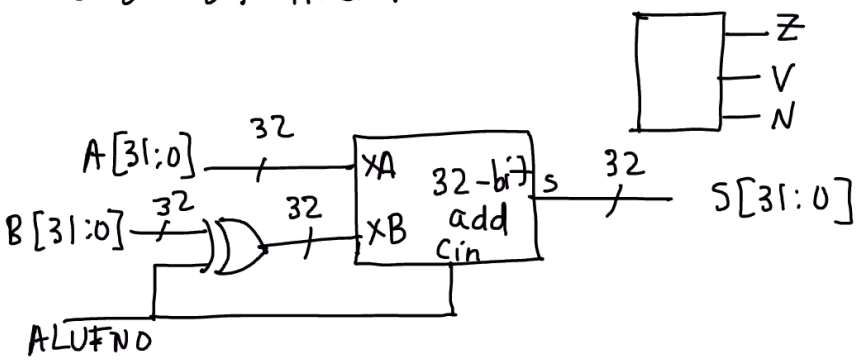
- 32-bit Adder



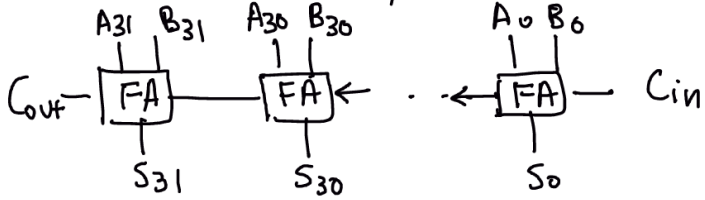
$Z = \overline{S_{31} + S_{30} + \cdots + S_0}$

$V = A_{31} \cdot B_{31} \cdot \overline{S_{31}} + \overline{A_{31}} \cdot \overline{B_{31}} \cdot S_{31}$

$N = S_{31}$

To compute 1's complement of B[31:0] do: $B_i \oplus 1$

For 32-bit add, cascade 32 ripple-carry FA



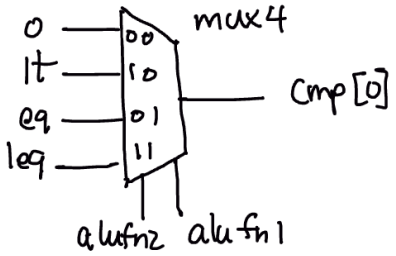
Full Adder: $S = A \oplus B \oplus C_{in}$

$C_{out} = (A \oplus B) \cdot C_{in} + A \cdot B$

- 32-bit Compare Unit

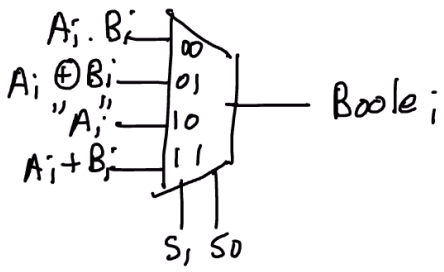
Comparison	Eq^n for LSB	ALUFN2	ALUFN1
$A = B$	$LSB = Z$	0	1
$A < B$	$LSB = N \oplus V$	1	0
$A \leq B$	$LSB = Z + (N \oplus V)$	1	1

Note: ALUFN0 to force subtract



- 32-bit Bookean Unit

Operation	ALU FN
AND	1000
OR	1110
XOR	0110
"A"	1010



Truth Table for S_1, S_0

ALUFN [3:0]	S_1	S_0
1000	0	0
1110	1	1
0110	0	1
1010	1	0

$S_0 = AF_3 \cdot AF_2 \cdot AF_1 \cdot \overline{AF_0} + \overline{AF_3} \cdot AF_2 \cdot AF_1 \cdot AF_0$

$S_1 = AF_3 \cdot AF_2 \cdot AF_1 \cdot \overline{AF_0} + AF_3 \cdot \overline{AF_2} \cdot AF_1 \cdot \overline{AF_0}$

- 32-bit Shifter

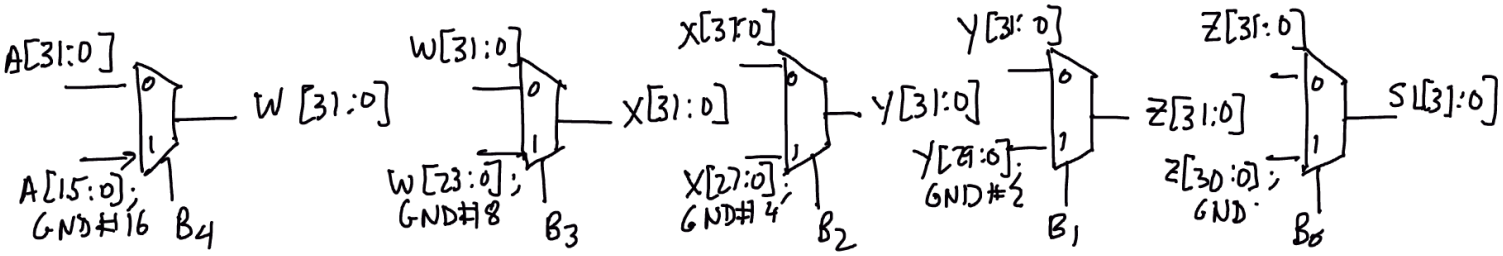
ALUFN Encoding

Operation	ALUFN[1:0]
SHL	00
SHR	01
← SRA	11

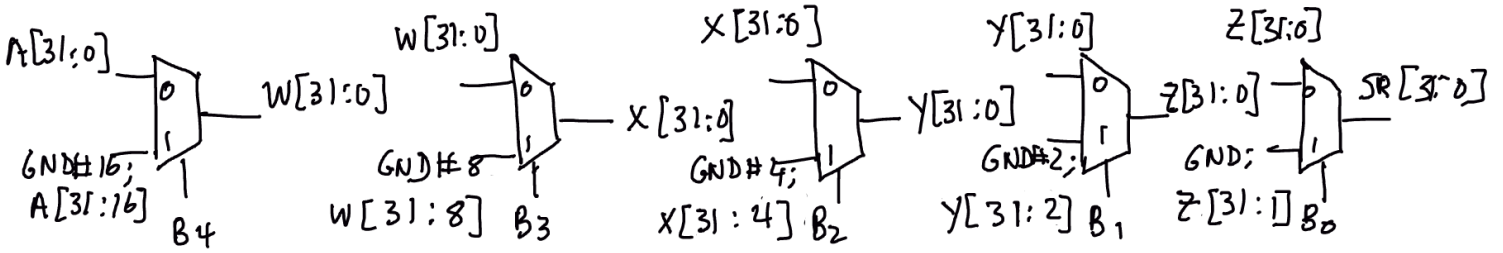
With sign extension

Shift a[31:0] based on 5 low order bits of b[31:0]

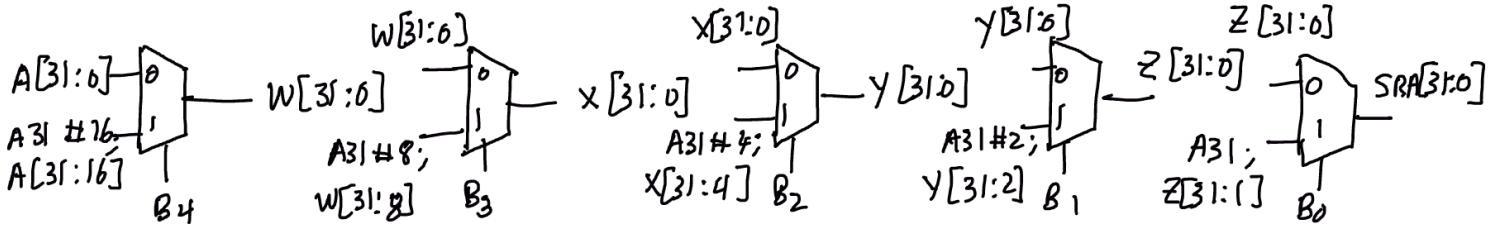
- Left Shifter



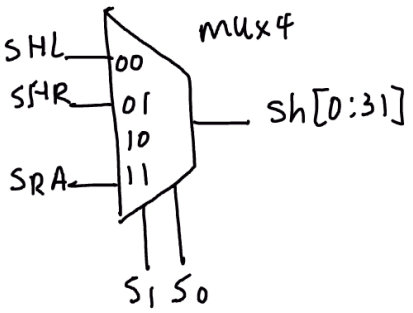
- Right Shifter



- Right Shifter w/ Sign Extension



Composite Shifter



- ALU (without Multiplier)