Processor: Datapath and Control

[Single Cycle Processor and ALU Construction]

Chapter Four

Book of David A. Patterson

Appendix: B.5

Implementing Jump

- **Format of J-type Instruction:**

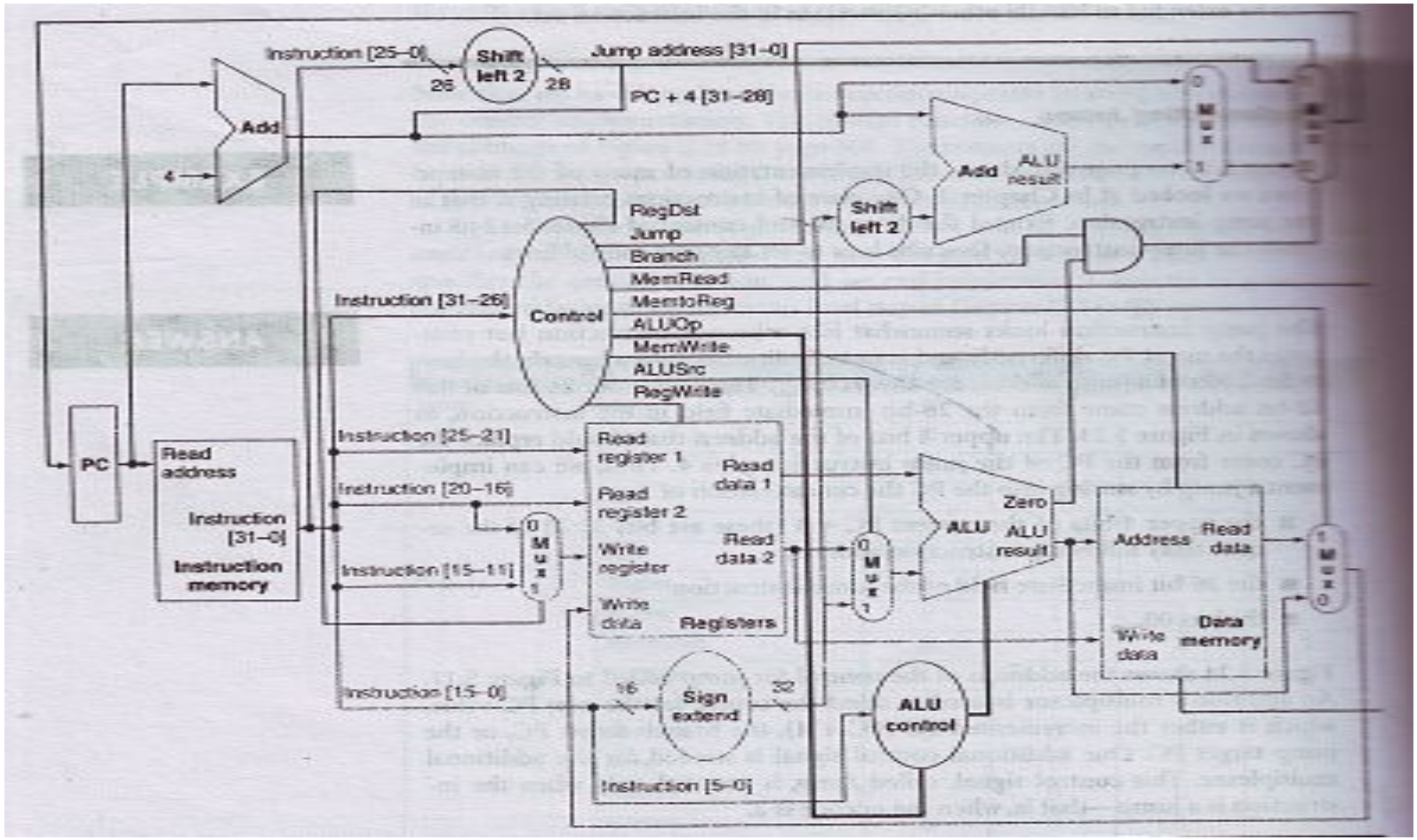
- Jump address is calculated as follows:

  The upper 4-bits of the current PC+4 [31:28] + 26 bits immediate field of the Jump instruction + 00_2

- Implementation of Jump requires:

  1. An additional multiplexor
  2. Control signal *Jump* from the main control unit.

Control and Datapath to Handle the Jump Instruction



Drawback of Single Cycle Processor

- ✔ The clock cycle must have same length for every instruction. The cycle time must be long enough for the load instruction.

Instruction class	Functional units used by the instruction class				
R-type	Instruction fetch	Register access	ALU	Register access	
Load word	Instruction fetch	Register access	ALU	Memory access	Register access
Store word	Instruction fetch	Register access	ALU	Memory access	
Branch	Instruction fetch	Register access	ALU		
Jump	Instruction fetch				

- ✔ The performance is not good since, several of the instruction classes could fit in a shorter clock cycle.

Constructing a Basic Arithmetic Logic Unit

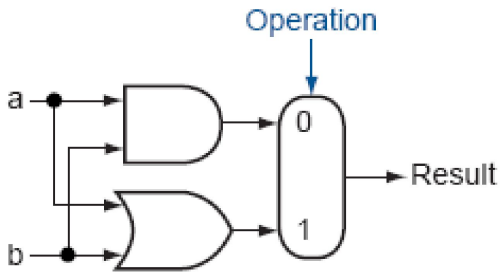


Fig: 1-bit logical unit for AND and OR

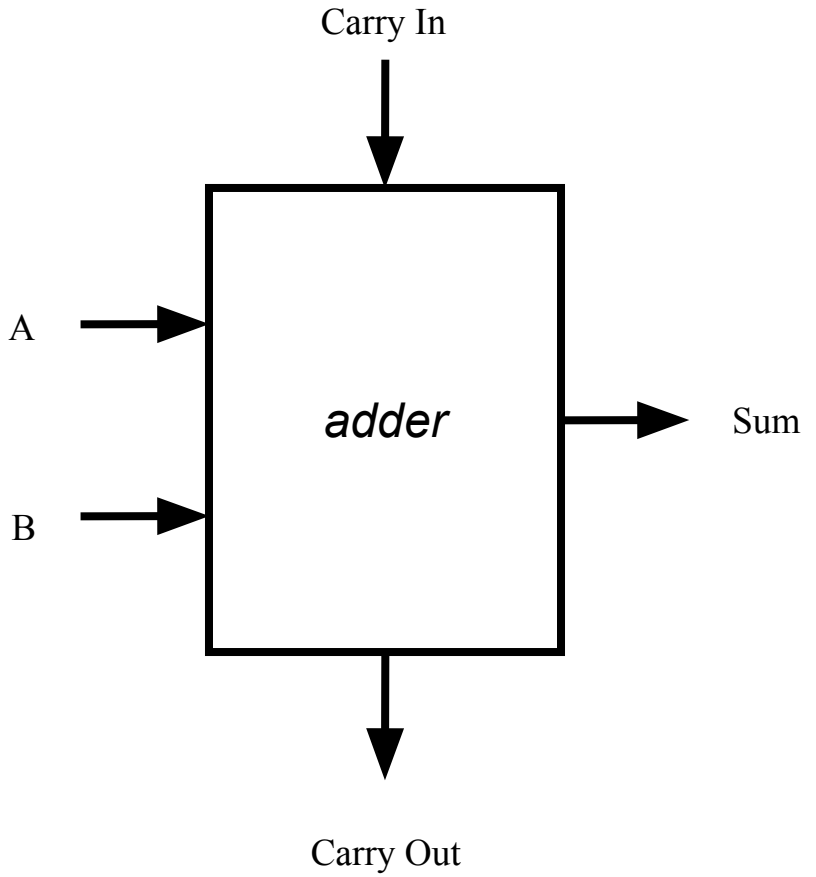
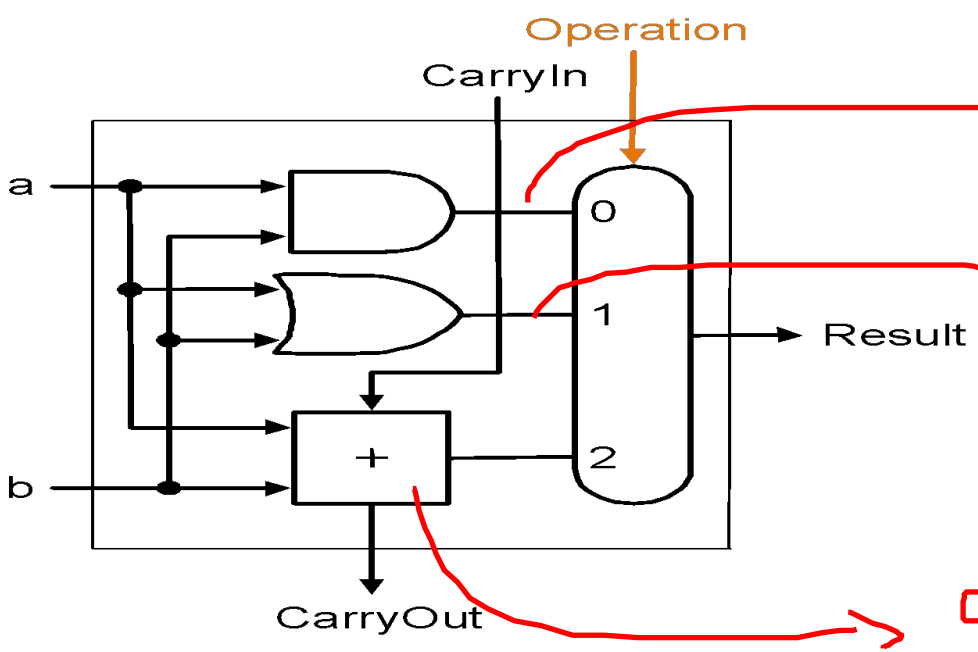
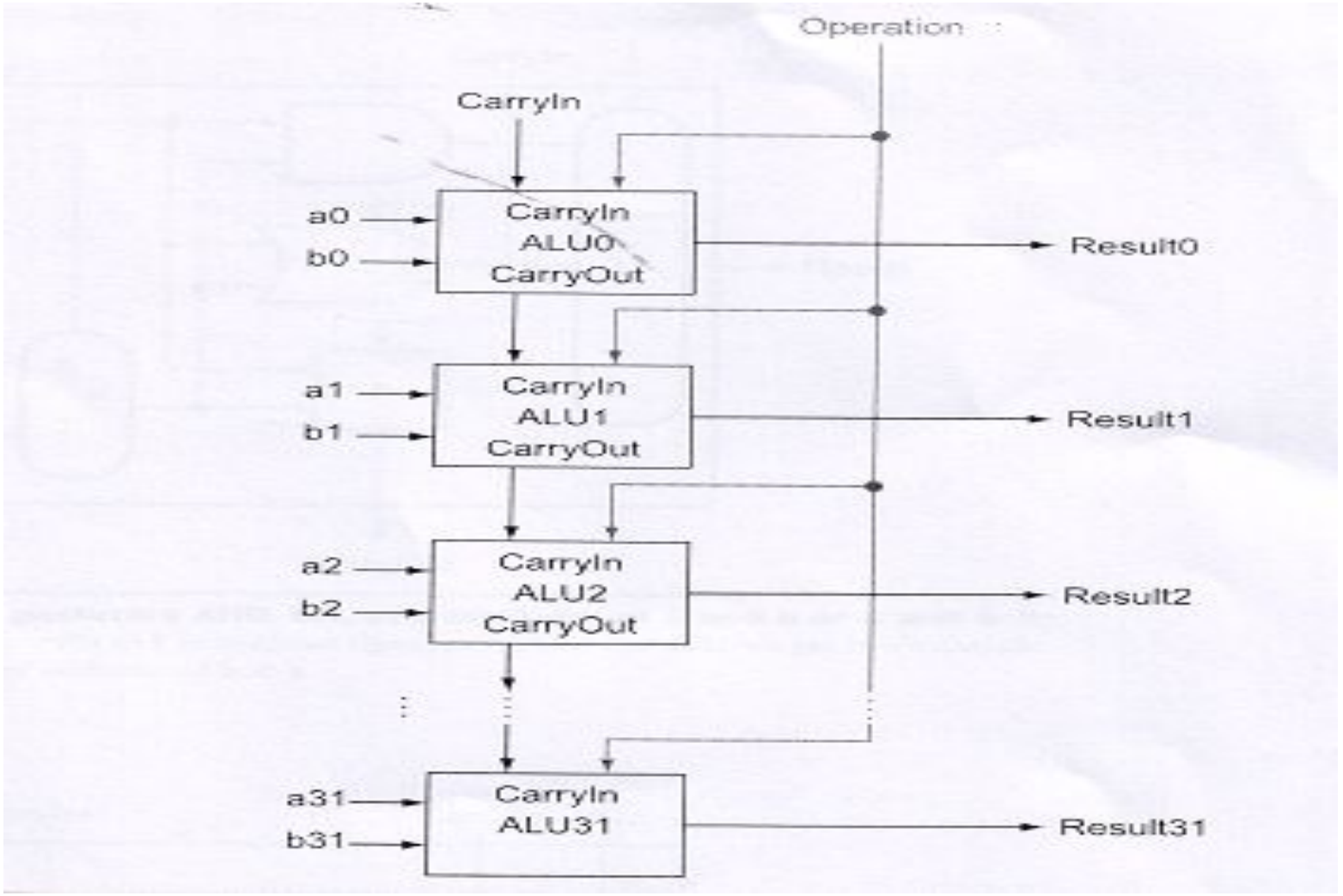


Fig: 1-bit Adder

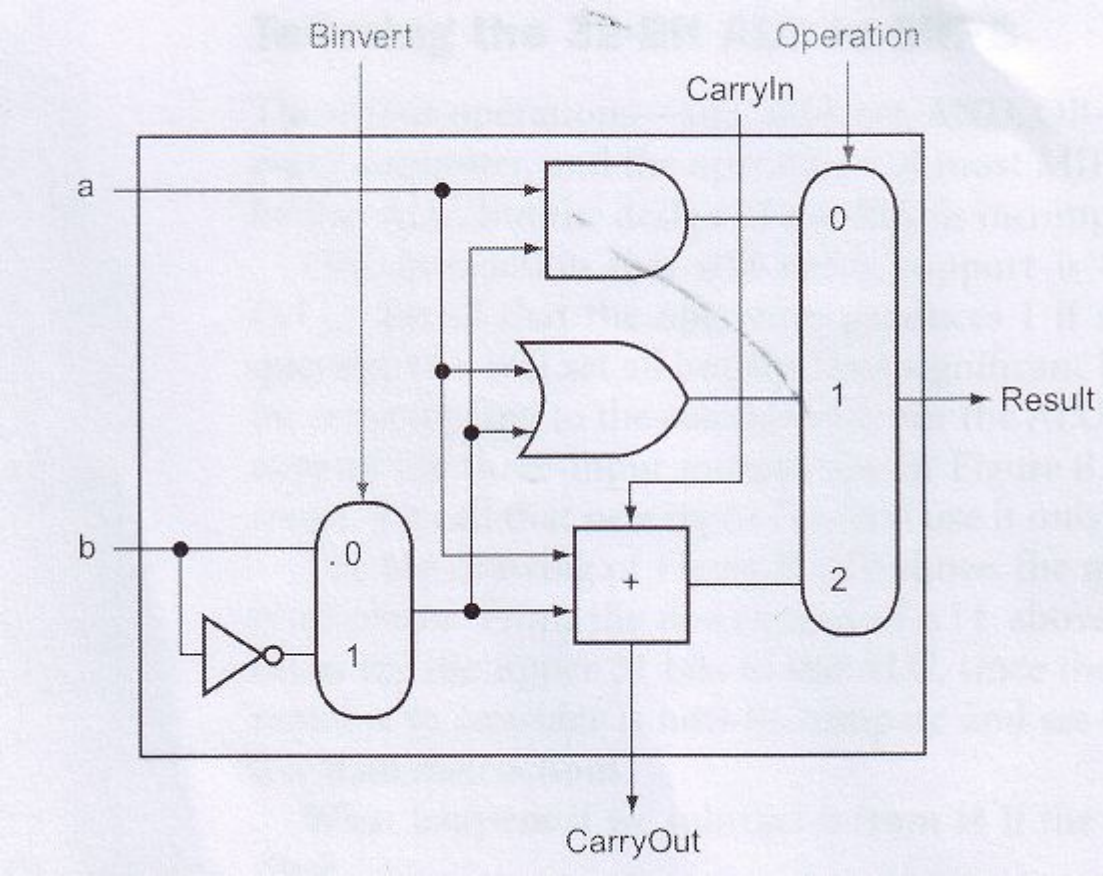
A 1-bit ALU that performs AND, OR and addition



A 32-bit ALU Constructed from 32 1-bit ALU

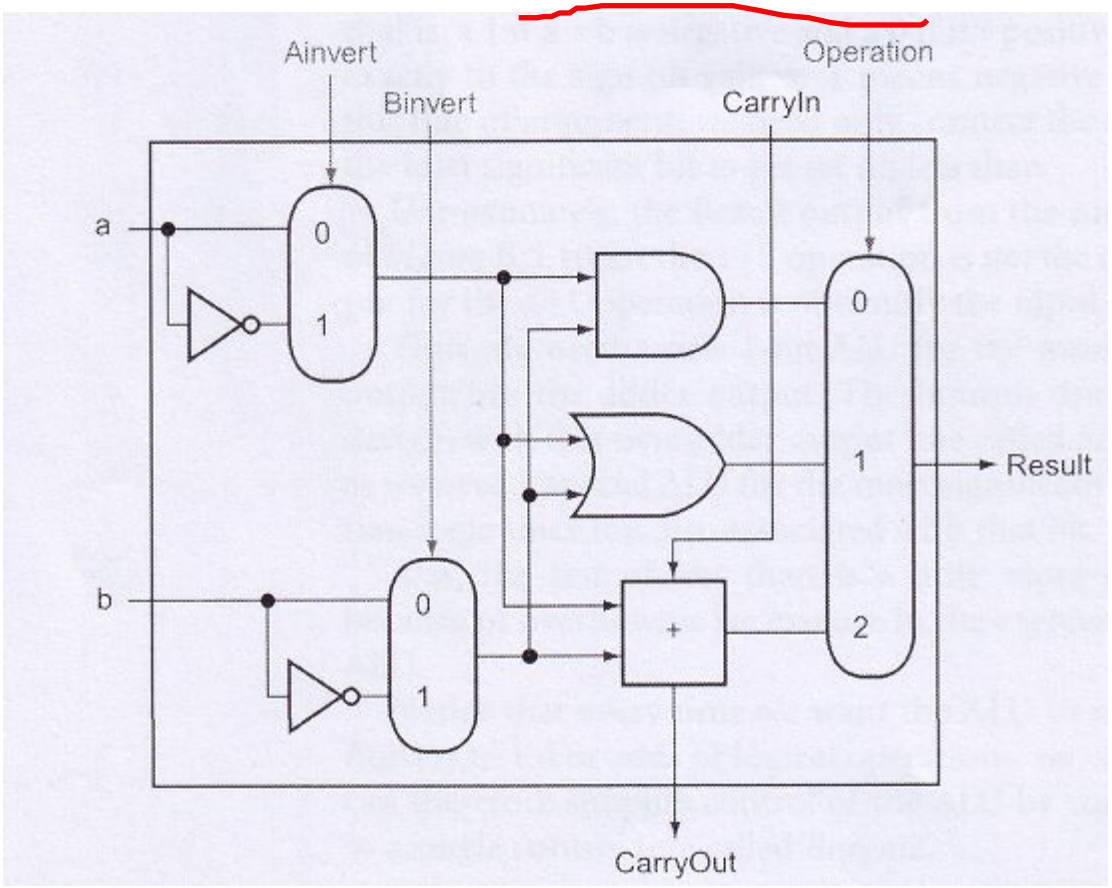


A 1-bit ALU that performs AND, OR and addition on **a** and **b** or **a** and $\overline{\mathbf{b}}$



$a + \overline{b} + 1 = a - b$[1 is set in the CarryIn signal of the LSB ALU]

A 1-bit ALU that performs AND, OR, NOR and Addition



$\overline{(a+b)} = \overline{a} \cdot \overline{b}$

32 bits ALU for MIPS to Support Slt

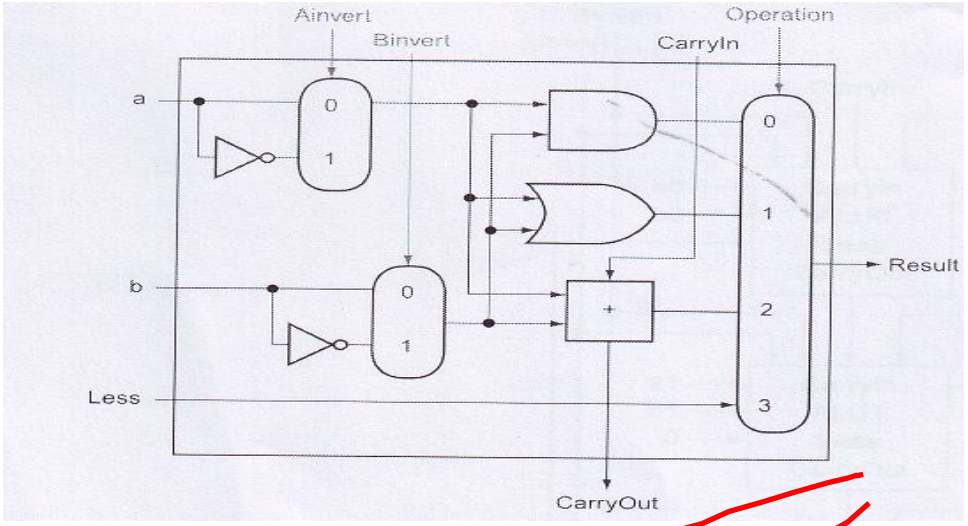


Fig: ALU for Upper 31 bits

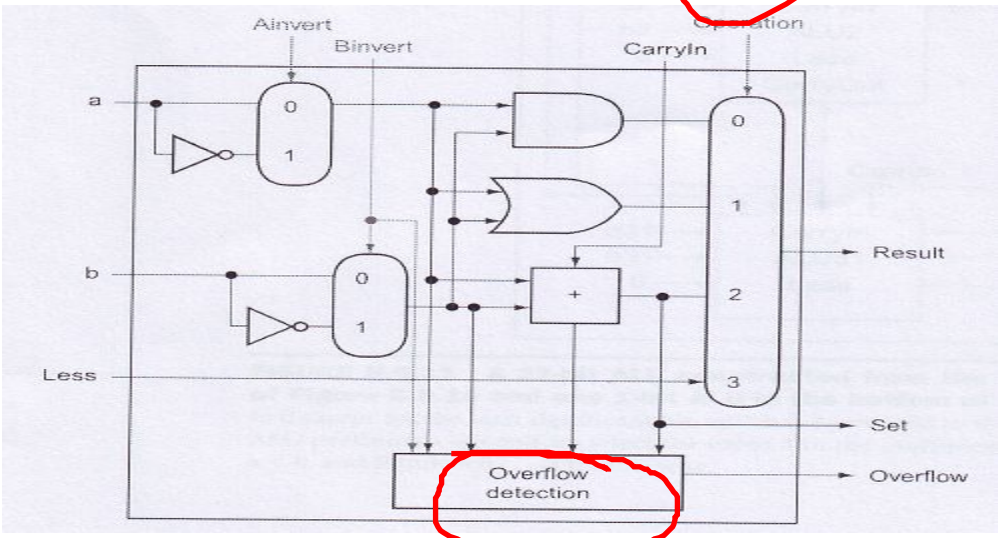
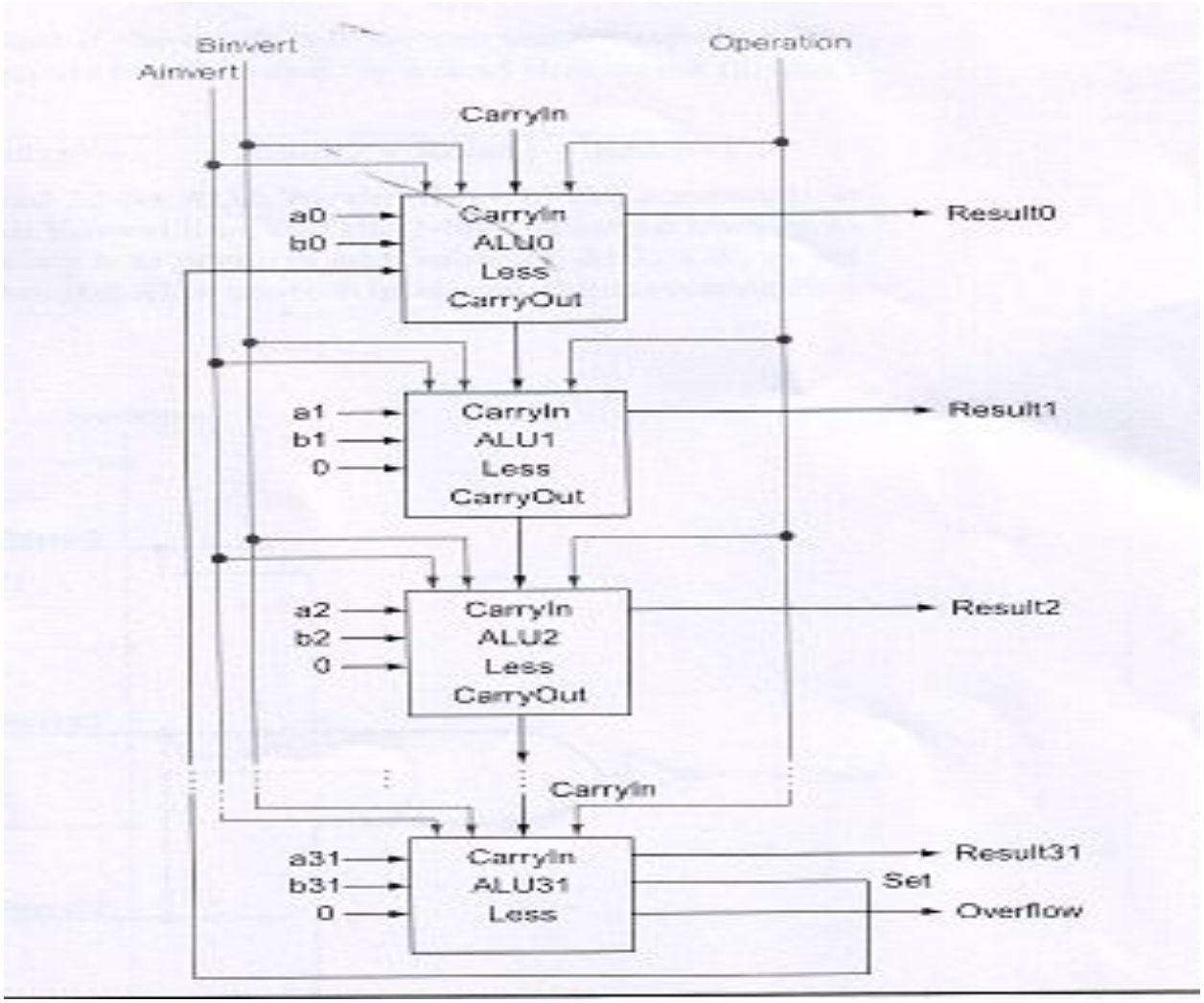
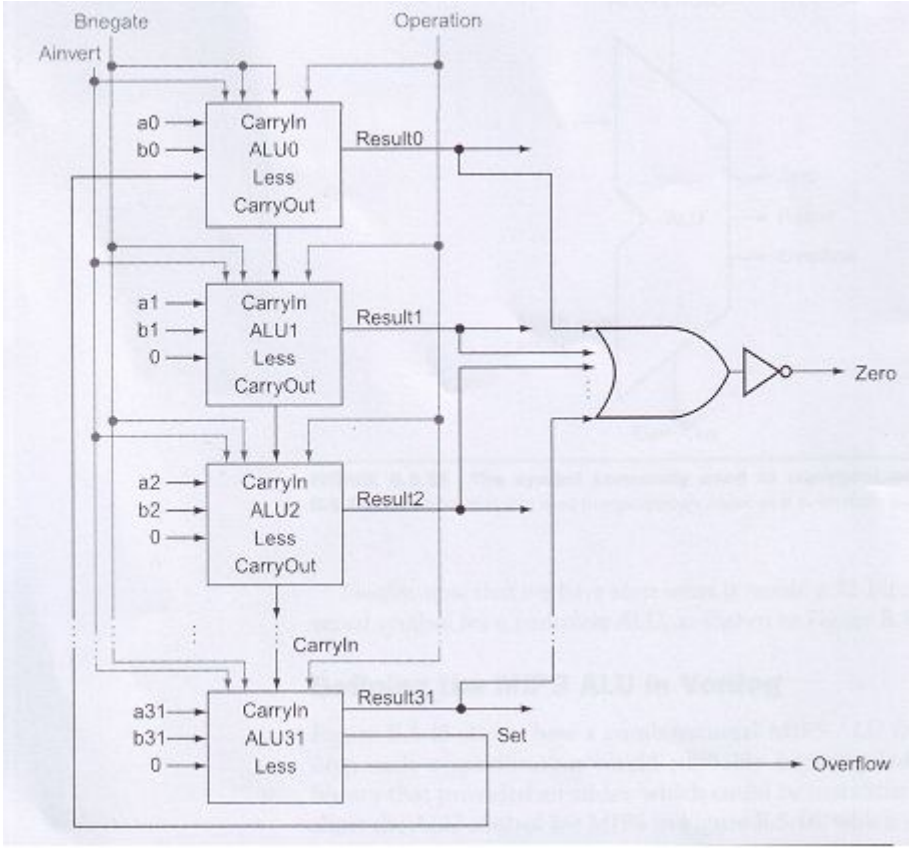


Fig: MSB ALU

32 bits ALU for MIPS to Support ALU



Final 32 bits ALU for MIPS to Zero Checking



ALU control lines	Function
0000	AND
0001	OR
0010	add
0110	subtract
0111	set on less than
1100	NOR

Fig: Control Signal for the ALU

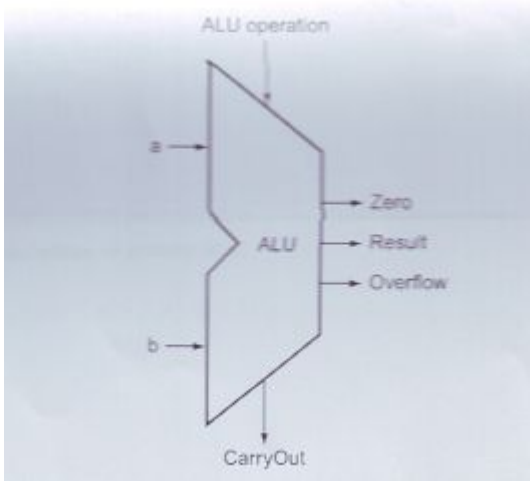


Fig: Symbol Representing the 32 bit ALU