Computer Arithmetic – ALU Operations

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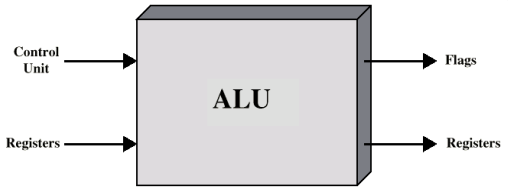
Lecture 6

Arithmetic & Logic Unit

- Does the calculations
- Everything else in the computer is there to service this unit
- Handles integers
- May handle floating point (real) numbers
- May be separate FPU (maths co-processor)
- May be on chip separate FPU (486DX +)

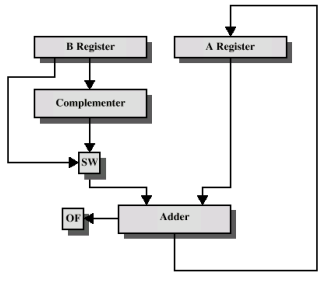
ALU Inputs and Outputs



Addition and Subtraction

- Normal binary addition
- Monitor sign bit for overflow
- Take twos compliment of subtrahend and add to minuend
  - i.e. a - b = a + (-b)
- So we only need addition and complement circuits

Hardware for Addition and Subtraction



OF = overflow bit
SW = Switch (select addition or subtraction)

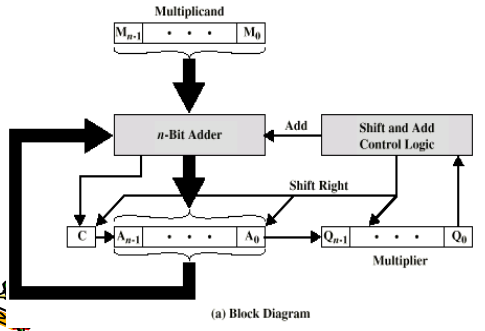
Multiplication

- Complex
- Work out partial product for each digit
- Take care with place value (column)
- Add partial products

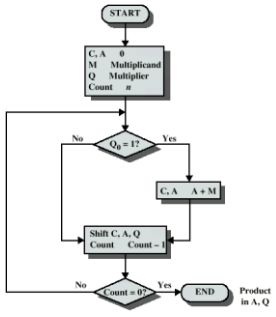
Multiplication Example

- 1011 Multiplicand (11 dec)
- x 1101 Multiplier (13 dec)
- 1011 Partial products
- 0000 Note: if multiplier bit is 1 copy
- 1011 multiplicand (place value)
- 1011 otherwise zero
- 10001111 Product (143 dec)
- Note: need double length result

Unsigned Binary Multiplication



Flowchart for Unsigned Binary Multiplication



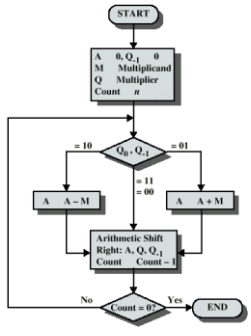
Execution of Example

C	A	Q	M		
0	0000	1101	1011	Initial Values	
0	1011	1101	1011	Add	First Cycle
0	0101	1110	1011	Shift	
0	0010	1111	1011	Shift	Second Cycle
0	1101	1111	1011	Add	Third Cycle
0	0110	1111	1011	Shift	
1	0001	1111	1011	Add	Fourth Cycle
0	1000	1111	1011	Shift	

Multiplying Negative Numbers

- This does not work!
- Solution 1
  - Convert to positive if required
  - Multiply as above
  - If signs were different, negate answer
- Solution 2
  - Booth's algorithm

Booth's Algorithm



Example of Booth's Algorithm

A	Q	Q_{-1}	M		
0000	0011	0	0111	Initial Values	
1001	0011	0	0111	A ← A - M	First Cycle
1100	1001	1	0111	Shift	First Cycle
1110	0100	1	0111	Shift	Second Cycle
0101	0100	1	0111	A ← A + M	Third Cycle
0010	1010	0	0111	Shift	Third Cycle
0001	0101	0	0111	Shift	Fourth Cycle

- Write down the steps to perform (-5) * 7 using booths algorithm
- Questions?
- -5 * -5