ORGANISASI DAN ARSITEKTUR KOMPUTER

Pertemuan 4 :
Computer Arithmetic

ARITHMATIC LOGIC UNIT

1. FIXED POINT ARITHMATIC YANG MENCAKUP :
   - Adder (Penambahan)
   - Subtracter(Pengurangan)
   - Multiplication (Perkalian)
   - Division (Pembagian)

2. FLOATING POINT ARITHMATIC

ALU Inputs and Outputs

Nilai Tanda

- Bit paling kiri adalah sebagai bit tanda
- 0 berari positive
- 1 berarti negative
- +18 = 00010010
- -18 = 10010010
- Problems :

  - memerlukan pertimbangan tanda maupuan nilai bilangan untuk penjumlahan dan pengurangan
  - Two representations of zero (+0 and -0)

Komplemen 2 (*Two's Compliment*)

Merupakan perbaikan nilai tanda yang memiliki kekurangan pada operasi penjumlahan dan pengurangan serta representasi bilangan nol

- +3 = 00000011
- +2 = 00000010
- +1 = 00000001
- +0 = 00000000
- -1 = 11111111
- -2 = 11111110
- -3 = 11111101

Contoh :

$+ 21_{10} = 0001\ 0101_2$

bilangan negatif dibentuk dengan cara

$+ 21_{10} = 0001\ 0101_2$

Dibalik sehingga menjadi :

$= 1110\ 1010_2$

Ditambah LSB 1, menjadi:

$= 1110\ 1011_2 = -21_{10}$

Range of Numbers

- 8 bit komplemen 2
  - +127 = 01111111 = 2^7 -1
  - -128 = 10000000 = -2^7
- 16 bit komplemen 2
  - +32767 = 011111111 11111111 = 2^{15} - 1
  - -32768 = 100000000 00000000 = -2^{15}

Conversion Between Lengths

Nilai positif dengan memberikan nilai tanda nol

- +18 = 00010010
- +18 = 00000000 00010010

Nilai positif dengan memberikan nilai tanda satu

- -18 = 10010010
- -18 = 11111111 10010010
- i.e. pack with MSB (sign bit)

Aritmatik Integer

Komplemen 2 :

a. Penjumlahan
b. Pengurangan
c. Perkalian
d. Pembagian

Contoh:

(- 6) + (+3)
1010
0011
1101 (-3)

(+2) + (+3)
0010
0011
0101 (+5)

6 + 3
0110
0011
1001 overflow

7 + (-7)
0111
1001
10000 (0)

(-1) + (-5)
1111
1011
1010 (-6)

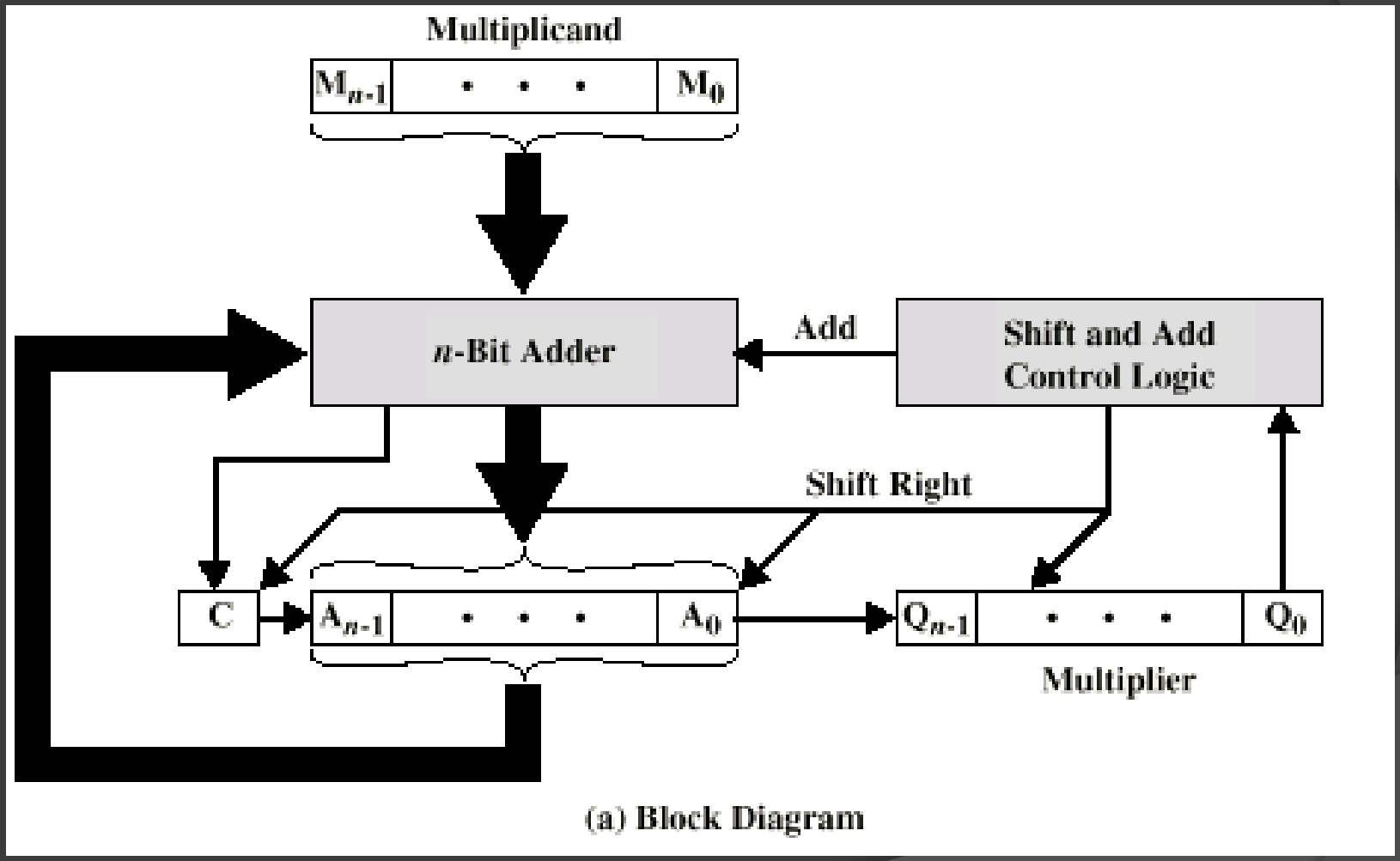
Multiplication

- 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

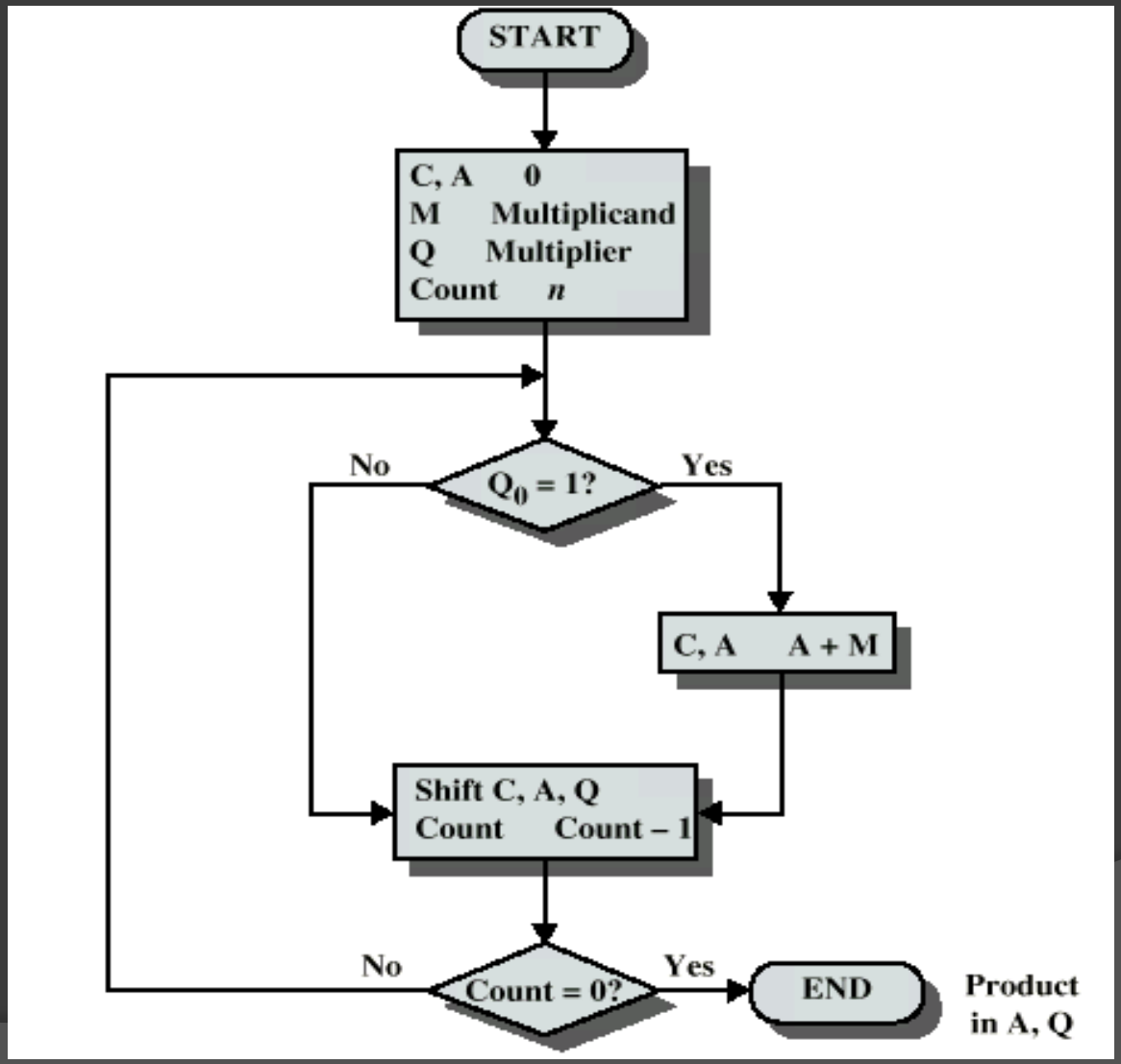
Unsigned Binary Multiplication



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	

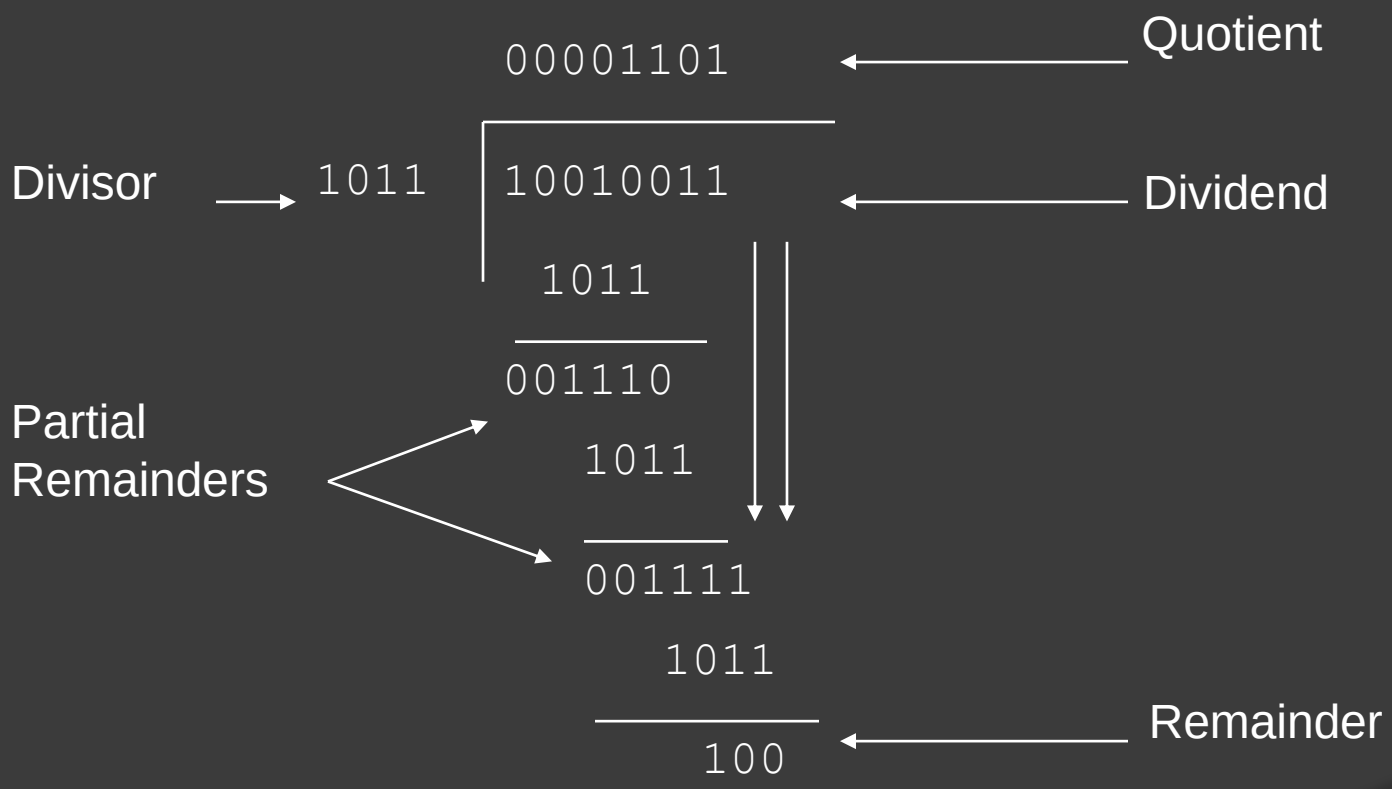
Flowchart for Unsigned Binary Multiplication



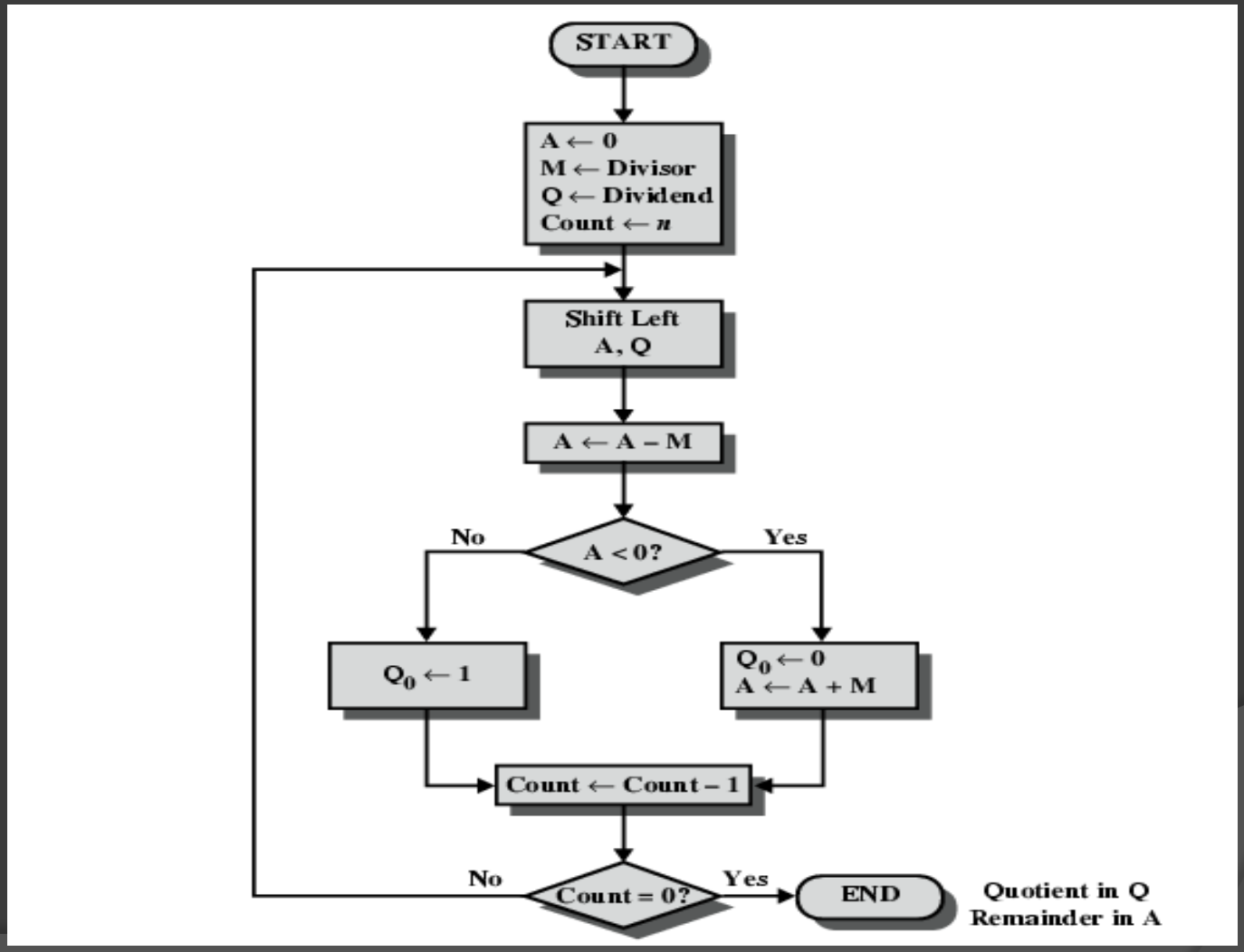
Division

- More complex than multiplication
- Negative numbers are really bad!
- Based on long division

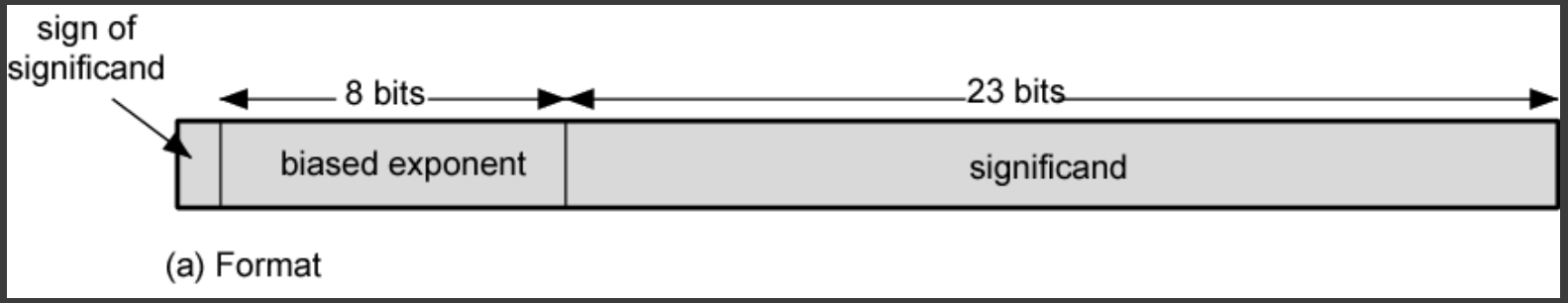
Division of Unsigned Binary Integers



Flowchart for Unsigned Binary Division

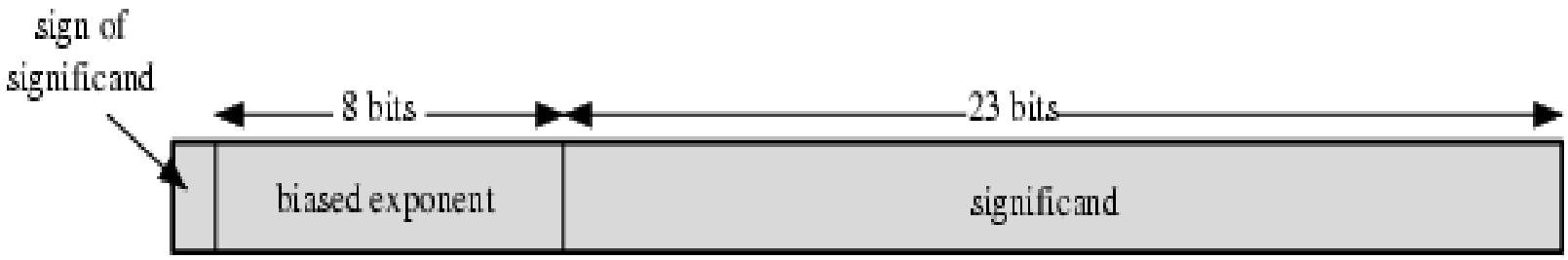


Floating Point



ALU untuk floating point dapat diimplementasikan dengan menggunakan dua rangkaian aritmatika fixed point yang terpisah yaitu unit exponent dan mantissa

Contoh Floating Point



(a) Format

$1.1010001 \times 2^{10100} = 0\ 10010011\ 10100010000000000000000 = 1.638125 \times 2^{20}$

$-1.1010001 \times 2^{10100} = 1\ 10010011\ 10100010000000000000000 = -1.638125 \times 2^{20}$

$1.1010001 \times 2^{-10100} = 0\ 01101011\ 10100010000000000000000 = 1.638125 \times 2^{-20}$

$-1.1010001 \times 2^{-10100} = 1\ 01101011\ 10100010000000000000000 = -1.638125 \times 2^{-20}$

(b) Examples