SNS COLLEGE OF ENGINEERING

Kurumbapalayam (PO), Coimbatore – 641 107
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DEPARTMENT OF INFORMATION TECHNOLOGY

COURSE NAME: 19IT301 COMPUTER ORGANIZATION AND ARCHITECTURE

II YEAR/ III SEM

Unit 2 : ARITHMETIC OPERATIONS

Topic 4: Signed Multiplication: Booth Algorithm

Decimal to Binary Number Conversion

Convert decimal number 112 into binary number

Division	Remainder (R)
112 / 2 = 56	0
56 / 2 = 28	0
28 / 2 = 14	0
14 / 2 = 7	0
7 / 2 = 3	1
3 / 2 = 1	1
1 / 2 = 0	1

Binary to Decimal Conversion

1110000_2 -> decimal

= 1110000

= $1\times2^6+1\times2^5+1\times2^4+0\times2^3+0\times2^2+0\times2^1+0\times2^0$

=64+32+16+0+0+0+0

$=112_{10}$

Write remainder from bottom to up (in reverse order), this will be 1110000_2

2’s Complement

$112_{10} = 01110000_2$

-112 = ?

1’s complement of 01110000 = 10001111

2’s complement = 1 +

-112 = 10010000

Signed Multiplication

Considering 2's-complement signed operands, what will happen to (-13)□(+11) if following the same method of unsigned multiplication?

13 = 0000001101

					1	0	0	1	1	(-13)
					0	1	0	1	1	(+11)
1	1	1	1	1	1	0	0	1	1	
1	1	1	1	1	0	0	1	1		
0	0	0	0	0	0	0	0			
1	1	1	0	0	1	1				
0	0	0	0	0	0					
1	1	0	1	1	1	0	0	0	1	(-143)

Sign extension is shown in blue

Sign extension of negative multiplicand

2's complement of -143 = +143 = 0 0 1 0 0 0 1 1 1

Normal Multiplication

Consider in a multiplication, the multiplier is positive 0011110, how many appropriately shifted versions of the multiplicand are added in a standard procedure? 4

							0	1	0	1	1	0	1
							0	0	+1	+1	+1	+1	0
							0	0	0	0	0	0	0
						0	1	0	1	1	0	1	
					0	1	0	1	1	0	1		
				0	1	0	1	1	0	1			
			0	1	0	1	1	0	1				
		0	0	0	0	0	0	0					
	0	0	0	0	0	0	0						
0	0	0	1	0	1	0	1	0	0	0	1	1	0

Normal Multiplication Scheme

Booth Algorithm

Since 0011110 = 0100000 – 0000010, if we use the expression, what will happen?

							0	1	0	1	1	0	1	
							0	+1	0	0	0	-1	0	
0	0	0	0	0	0	0	0	0	0	0	0	0	0	
1	1	1	1	1	1	1	0	1	0	0	1	1		← 2's complement of the multiplicand
0	0	0	0	0	0	0	0	0	0	0	0			
0	0	0	0	0	0	0	0	0	0	0				
0	0	0	0	0	0	0	0	0	0					
0	0	0	1	0	1	1	0	1						
0	0	0	0	0	0	0	0							
0	0	0	1	0	1	0	1	0	0	0	1	1	0	

Booth multiplier recoding table

Multiplier		Version of multiplicand selected by bit *i*
Bit *i*	Bit *i* -1	
0	0	0 X M
0	1	+ 1 X M
1	0	– 1 X M
1	1	0 X M

0 0 1 0 1 1 0 0 1 1 1 0 1 0 1 1 0 0

⇓

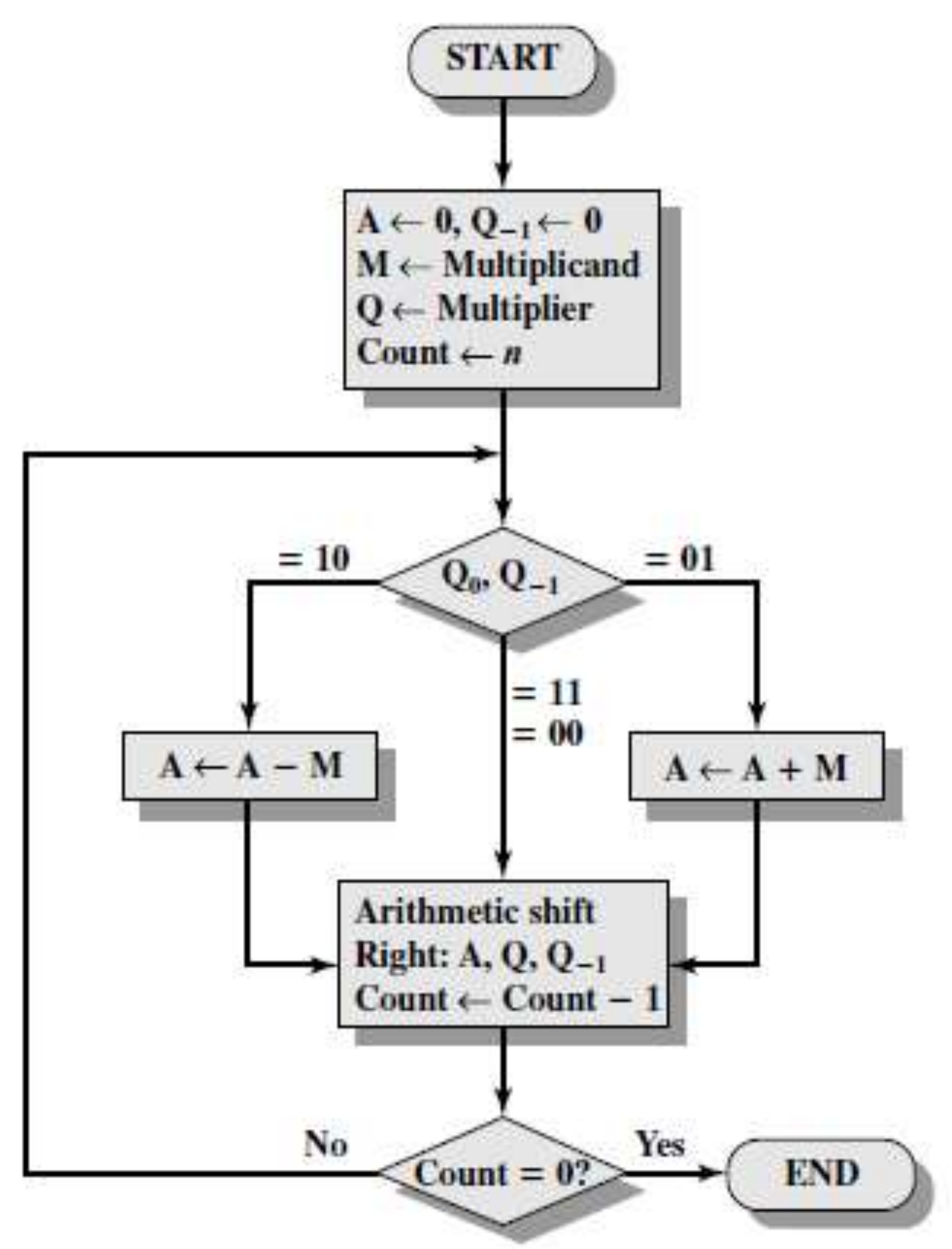
0 +1 -1 +1 0 -1 0 +1 0 0 -1 +1 -1 +1 0 -1 0 0

Booth recoding of a multiplier

Booth Algorithm

- Best case – a long string of 1's (skipping over 1s)
- Worst case – 0's and 1's are alternating

Worst-case multiplier	0	1	0	1	0	1	0	1	0	1	0	1	0	1	0	1
	+1	-1	+1	-1	+1	-1	+1	-1	+1	-1	+1	-1	+1	-1	+1	-1
Ordinary multiplier	1	1	0	0	0	1	0	1	1	0	1	1	1	1	0	0
	0	-1	0	0	+1	-1	+1	0	-1	+1	0	0	0	-1	0	0
Good multiplier	0	0	0	0	1	1	1	1	1	0	0	0	0	1	1	1
	0	0	0	+1	0	0	0	0	-1	0	0	0	+1	0	0	-1



Booth's Algorithm Flowchart

Example: Booth's Algorithm

M = -5 = 1011, M'+1 = 0101

Q = -7 = 1001

OPERATION	AC	Q	Q_{-1}	Count
	0000	1001	0	4
AC + M' + 1	0101	1001	0	
ASHR	0010	1100	1	3
AC + M	1101	1100	1	
ASHR	1110	1110	0	2
ASHR	1111	0111	0	1
AC + M' + 1	0100	0111	0	
	0010	0011	1	0

Product is calculated as follows:

Product = AC Q

Product = 0010 0011 = 35

Assessment

The two numbers given below are multiplied using the Booth's algorithm.
Multiplicand : 0101 1010 1110 1110
Multiplier : 0111 0111 1011 1101
How many additions/Subtractions are required for the multiplication of the above two numbers?
(A) 6
(B) 8
(C) 10
(D) 12

Thank You