Twos complement.

$a_{n-1} a_{n-2} \cdots a_0$.

+ve number; $a_{n-1} = 0$

-ve " $a_{n-1} = 1$

decimal equivalent $= -2^{n-1} a_{n-1} + \sum_{i=0}^{n-2} a_i 2^i$

0101.10

1010.01 → 1s complement.

Subtracting from

$$\begin{array}{r} 1111.11 \quad (15.75) \\ -\ 0101.10 \\ \hline 1010.01 \end{array}$$

Add 0.25 to get 2s complement (since we have to subtract from 16)

Multiplication

2 twos complement numbers A, B.

$A = a_{n-1}\, a_{n-2} \cdots a_0$

$B = b_{m-1}\, b_{m-2} \cdots b_0$.

find $P = A \times B$.

$$= A \times (-2^{m-1} b_{m-1} + 2^{m-2} b_{m-2} + \cdots + 2^2 b_2 + 2 b_1 + 2^0 b_0)$$

$$= 2^0 \underbrace{A \times b_0}_{\text{AND}} + 2^1 \underbrace{A \times b_1}_{\text{AND}} + \cdots - 2^{m-1} \underbrace{A b_{m-1}}$$

+ shift left by 1

AND, shift left 'm-1' bits & take 2s complement of Ab_{m-1}

Use carry save architecture

As number of bits increases, # of partial products ↑ses ; multipliers become slower.

Try to reduce the number of partial products.

Modified Booth algorithm

$2^6 - 2^5$ $\quad$ $2^3(2-1) = 2^4 - 2^3$ $\quad$ $2^2 - 2^1$

$$A \times \left(\cdots + b_5 2^5 + b_4 2^4 + b_3 2^3 + b_2 2^2 + b_1 2^1 + b_0 2^0 \right)$$

$$= A \times \left(\cdots \underbrace{(-2b_5 + b_4 + b_3)}_{} 2^4 + (-2b_3 + b_2 + b_1) 2^2 + (-2b_1 + b_0) 2^0 \right)$$

$$\rightarrow -2b_{2i+1} + b_{2i} + b_{2i-1}$$

$i = 0, 1, 2, \ldots$

$b_{-1} = 0$

radix 4 multiplications

encoding

b_{2i+1}	b_{2i}	b_{2i-1}	PP
0	0	0	0
0	0	1	A
0	1	0	A
0	1	1	2A
1	0	0	−2A
1	0	1	−A
1	1	0	−A
1	1	1	0