

## 1.2 Accelerating multiplication

### 1.2.1 Multiplier performance

Ex. 1  $X = 1001 \ 1101 \mid 0$

Booth  $X' = \overline{1}010 \ 0\overline{1}1\overline{1}$

Booth  $\rightarrow 5$  arithmetic ops.

Roberts  $\rightarrow 5$  arithmetic ops.

### Booth encoding

$x_i$	$x_{i-1}$	$Op$
0	0	0
0	1	1 $+M$
1	0	$\overline{1}$ $-M$
1	1	0

Ex. 2

$X = 1110 \ 0111 \mid 0$

Booth  $\rightarrow 3$  ops.

$X' = 00\overline{1}0 \ 100\overline{1}$

Roberts  $\rightarrow 6$  ops.

Ex. 3

$X = 01010101 \mid 0$

Booth  $\rightarrow 8$  ops.

$X' = 1\overline{1}1\overline{1}1\overline{1}1\overline{1}$

Roberts  $\rightarrow 4$  ops.

### 1.2.2 Modified Booth's algorithm

$\downarrow$   
 $x_{i+1} \ x_i \ x_{i-1}$   
 $(010) \rightarrow -2^i \cdot y + 2^{i+1} \cdot y = 2^i \cdot y(-1+2) = 2^i \cdot y$

$(101) \xrightarrow{\text{current step}} +2^i \cdot y - 2^{i+1} \cdot y = 2^i \cdot y(1-2) = -2^i \cdot y$

$x_{i+1}$	$x_i$	$R$	$Op$	$R^*$
0	0	0	0	0
0	0	1	1	0
0	1	0	1	0
0	1	1	0	1
1	0	0	0	0
1	0	1	$\overline{1}$	1
1	1	0	$\overline{1}$	1
1	1	1	0	1

Ex. 1  $X = 11001 \ 1101 \mid 0$

Mod. Booth  $X'' = \overline{1}010 \ 0\overline{1}01$

$R = 1001 \ 11000$

Mod. Booth  $\rightarrow 4$  ops.

Ex. 2

$X = 1110 \ 0111$

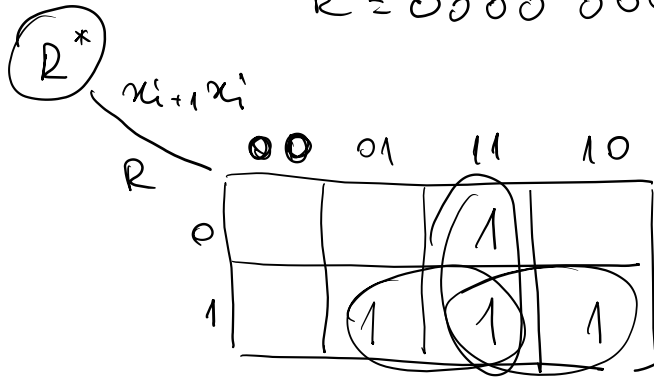
$X'' = 00\overline{1}0 \ 100\overline{1}$

$R = 1110 \ 01110$

Mod. Booth  $\rightarrow 3$  ops.

Ex 3\*  
 $X = 001010101$   
 $X'' = 01010101$   
 $R = 000000000$

MBooth  $\rightarrow$  4op.



$$R^* = x_{i+1} \cdot x_i + R x_i + R x_{i+1}$$

$$X = 11101001_{SM} = 10010111_{E_2}$$

$$Y = 11111011_{SM} = 10000101_{E_2}$$

Example

$$X = -105$$

$$Y = -123$$

$$P = + \begin{array}{r} 315 \\ 210 \\ 105 \\ \hline \end{array}$$

$$+ 12915$$

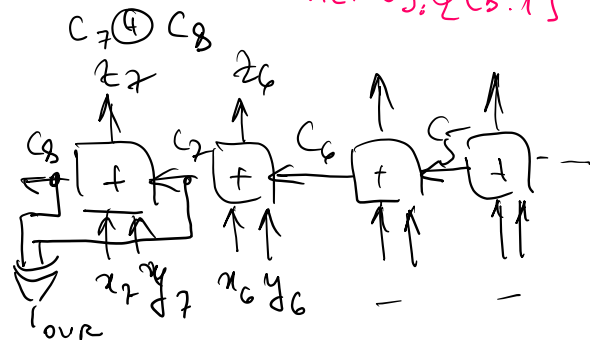
$$-M = 01111011$$

COUNT	OV R	A	Q[3]	Q	R	M
000	0	0000 0000 01111011	1	1001 0111	0	1000 0101
	+	01111011 00111101	1	1100 1011	1	
001	0	00011110	1	1110 0101	1	
010	0	00001111	0	1111 0010	1	
011	+	01111011 10001010 01000101	0	0111 1001	1	
100	0	00100010	1	0011 1100	1	
101	+	10000101 10100111 11010011	1	1001 1110	0	
110	0	11101001	1	1100 1111	0	
111	+	01111011 01100100 00110010	0	1110 0111	1	

$$A[7] \cdot \overline{OVR} + \overline{A[7]} \cdot OVR =$$

$$= A'[7] = A[7] \oplus OVR$$

$$A[7:0], Q[8:1]$$



$$\begin{array}{r} 19+ \\ 32 \\ 64 \\ 512 \\ 4096 \\ 8192 \\ \hline \end{array}$$

$$+ 12915 \checkmark$$