Radix 2 Booth

$X = -113$

$X_{C_2} = -128 + 15$

$= 1000\,1111$

$Y = 79$

$Y_{C_2} = 64 + 15$

$Y_{C_2} = 0100\,1111$

$-Y_{C_2} = 1011\,0001$

$$\begin{array}{r} -113 \\ +\ 79 \\ \hline 1017 \\ 791 \\ \hline -8927 \end{array}$$

CNT	A	Q	Q−1	
000	0000 0000	1000 1111	0	−m
	+1011 0001			
	1011 0001			
	1101 1000	1100 0111	1	sh
001	1110 1100	0110 0011	1	sh
010	1111 0110	0011 0001	1	sh
011	1111 1011	0001 1000	1	+m
100	+0100 1111			
	0100 1010			
	0010 0101	0000 1100	0	sh
101	0001 0010	1000 0110	0	sh
110	0000 1001	0100 0011	0	−m
111	+1011 0001			
	1100 1010			
	1101 1101	0010 0001	1	

Radix 4 Booth

$X = 11000\ 1111$

$Y = 00100\ 1111$

$-Y = 11011\ 0001$

$2Y = 01\ 0011110$

$-2Y = 10110\ 00010$

CNT	A	Q	Q_{-1}
00	0 0000 0000	1000 1111	0
	+ 1 1011 0001		−M
	1 1011 0001		
	1 1101 1100	0 1100 0111	1
			−M
01	1 1101 1100	0001 1000	1
			+M
10	+ 0010 0 1111		
	0010 0 1010		
	0001 0010	1000 1100	0
			−2M
11	+ 1011 0001 0		
	1011 1010 0		
	1 1101 1101	0010 0001	

✓

Radix 8 Booth

1 1 1 0 1 1 0 0 0 1
1 1 0 1 1 0 0 1 1 0
---
1 1 0 0 0 1 0 0 1 1

$X = 11000\ 1111$

$Y = 00010\ 0011\ 1111$

$-Y = 11101\ 1100\ 0001$

$2Y = 00100\ 0111\ 1110$

$-2Y = 11011\ 0001\ 0$

$3Y = 00110\ 1101\ 01$

$-3Y = 11001\ 0010\ 11$

CNT	A	Q	Q_{-1}
00	00 0000 0000	1 1000 1111	0
	+ 1 1 1 0 1 1 0001		-M
	1 1 1 0 1 1 0001		
	1 1 1 1 1 1 0110	0 0 1 1 1 0001	1
			+2M
01	+ 0 0 1 0 0 1 1 1 1 0		
	0 0 1 0 0 1 0100		
	0 0 0 0 0 1 0010	1 0 0 0 1 1 1 0	0
			-2M
10	+ 1 1 0 1 1 0 0 1 0		
	1 1 0 1 1 1 0 1 0 0		
	1 1 1 1 1 0 1 1 1 0	1 0 0 1 0 0 0 0 1	1

108 / 25 $X = 108 = 64 + 44 : 64 + 32 + 8 + 4$

4 ; 8 $= 0000\ 0000\ 0110\ 1100$

$Y = 25 = 0001\ 1001$

$-Y = = 1110\ 0111$

Restoring

CNT	A	Q
000	0000 0000	0110 1100
+	1110 0111	
	(1) 1100 1111	
+	0001 1001	
	0000 0000 +sh	
	0000 0000	1101 1000
001	1111 −−− sh	
+	0000 0001	1011 0000
010	0000 0011	
011	0000 0111	0110 0000
100	0000 1110	1100 0000
101	0001 1101	1000 0000
11p	+ 1110 0111	
	0000 0100	1000 0001
	0000 1001	0000 0011
111	+ 1110 0111	
	1110 1000	0000 0110
	+ 0001 1000	
	0000 1000	

4

8

Non Restoring

M = 0001 1001

−M = 1110 0111

CNT	S	A	Q
000	0	0000	0110 1100
	+1	1110	0111
	(1)	1110	0111
	1	1100	1110 1100
001	+0	0001	1001
	(1)	1110	0111
	1	1100	1111 0000
010	+0	0001	1001
	(1)	1110	1000
	1	1101	0001 0000
011	+0	0001	1001
	(1)	1110	1010
	1	1101	0100 1000
100	+0	0001	1001
	(1)	1110	1011
	1	1101	1001 0000
101	+0	0001	1001
	(1)	1110	1010
	1	1101	0100 0000
110	+0	0001	1001
	(0)	0000	0010
	0	0000	0100 0000
111	+1	1110	1011
	(1)	1101	0111
COR	+0	0001	1001
	0	0001	0011

SRT 2

$M = 01100\ 1000$

$-M = 10011\ 1000$

$M = 0001\ 1001$

$1100\ 1000$

12 $k = 3$

CNT	A	Q
000	0 0000 0000	0 110 1100
	sh 0000 0 $z_0 = 0$ 0011	0110 0000
000	0 0000 0 0110	1100 0000
	sh $z_{00} = 0$	1
001	0000 0 1101	1000 0000
	sh $z_1 = 0$	0 0
010	0000 1 1 0 1 1	0 0 0 0 0 0 0 0
	$z_2 = 0$	0 0 0
011	0001 1 0 1 1 0	0 0 0 0 0 0 0 0
	$z_3 = 0$	0 0 0
100	0011 0 1 1 0 0	0 0 0 0 0 0 0 0
	$z_4 = 1$	0 0 0 0
101	0110 1 1 0 0 0	0 0 0 0 0 0 0 1
	+ 1001 1 1 0 0 0	0 0 0 0 0 0
	0000 0 1 0 0 0	
	sh	
110	0000 1 0 0 0 0 0	0 0 0 0 0 0 1 0
		0 0 0 0 0 0 0
111	0 0 1 0 0 0 0 0 0	0 0 0 0 0 1 0 0
~~ok~~ shift	0 0 0 0 0 1 0 0 0	4
	8 ✓	✓

SRT 4 $-M = 10011000$ $M = 00011001$

$2M = 11001000$ $M = 011001000$

$-2M = 00110000$ $K = 3$ 12

CNT	A	Q
00	00000 0000 $Q=0$ 00000 0011	0110 1100 0110 0000
00	00000 1101 0	1000 0001 0
01	00011 0110 1	0000 0010
10	01101 1000 + 10011 1000 00001 0000 0	0000 0010 00 0001
11	00100 0000	0000 0100 00 0000 0
shift	00000 1000 8	0000 0100 4

(1P OF)

1. Assume a program requires the execution of

3 × 10^6 FP instructions, 15 × 10^5 INT instructions, 6 × 10^6 L/S instructions, and 12 × 10^5 branch instructions. The CPI for each type of instruction is 1, 2, 2, and 3, respectively.

Assume that the processor has a 2 GHz clock rate.

a) (1.5P) What is the execution time of the processor? What is the MIPS of the processor?
b) (1P) By how much must we improve the CPI of INT instructions if we want the program to run 1.5 times faster?
c) (1.5P) How is the execution time of the program affected if the CPI of INT and L/S instructions is reduced by 20%, but the CPI of of all other instructions is increased by 10%?

radix 4, -37 * -115.

$CR = 2\,GHz$

INSTR	CPI	IC
FP	1	$3 \cdot 10^6$
INT	2	$15 \cdot 10^5$
L/S	2	$6 \cdot 10^6$
BR	3	$12 \cdot 10^5$

$$Clk_{cycles} = 1 \cdot 3 \cdot 10^6 + 2 \cdot 15 \cdot 10^5 + 2 \cdot 6 \cdot 10^6 + 3 \cdot 12 \cdot 10^5$$

$$MIPS = \frac{IC}{CPU_{time} \cdot 10^6} = \frac{3 \cdot 10^5 + 15 \cdot \ldots}{}$$