

COEN 6501 Digital design and Synthesis

Oct. 18, 2010

Lecturer: Asim J. Al-Khalili

Answer all Questions. All Questions carry equal marks

Exam Duration: 1hr 30 min.

No books, papers or calculators are allowed.

Question 1

Design a circuit to give F

$F = X^3$ where X is a 2-bit unsigned binary number, ie $X = x_1 x_0$

- a) Use Truth Table
- b) Use carry Save Adders

Question 2

- a) Using Booth Algorithm multiply $A = -23$ and $B = 6$.
- b) Using a 3 to 8 decoder map (recode) the 3 bits of the multiplicand according to the following equation:

$$Z_i = -2x_{i+1} + x_i + x_{i-1}$$

(ie 3 bit input $-2x_{i+1}, x_i, x_{i-1}$ giving 5 bit output $+, -, 0, 1, 2$)

Question 3

- a) Use Carry Select adder to implement optimally the addition of two 21 bit unsigned numbers.
- b) How does that compare with Manchester Carry Adder of the same size ? Calculate the delay and area in terms of Half Adders, Full adders, gates and Muxes.

Q1 $F = x^3$

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P1/3

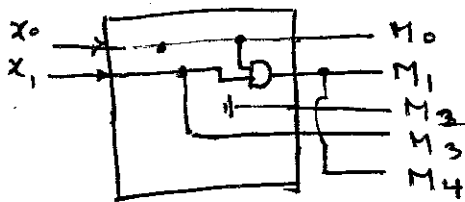
a) Using Truth Table max value of $F = (11)^3 = 27$

x_1, x_0	M_4	M_3	M_2	M_1	M_0
0 0	0	0	0	0	0
0 1	0	0	0	0	1
1 0	0	1	0	0	0
1 1	1	1		1	1

$M_0 = x_0$

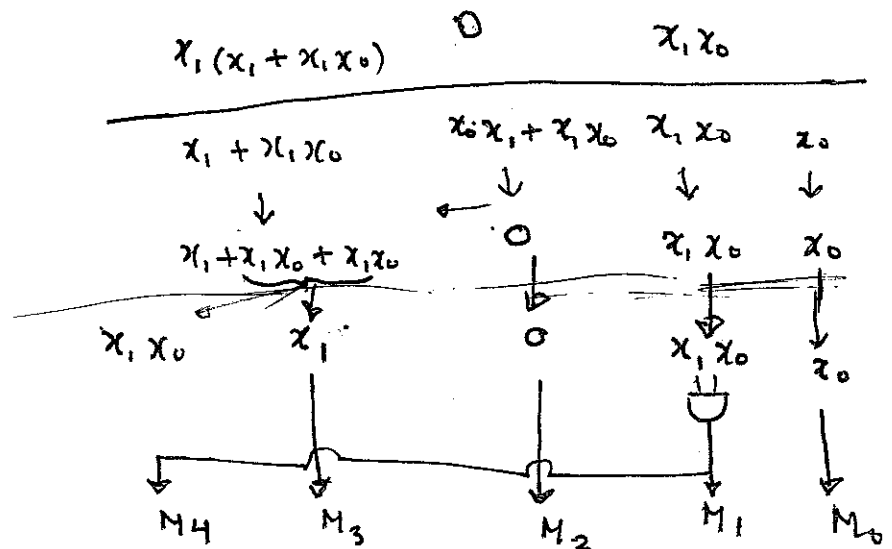
$M_1 = x_1 x_0$

$M_2 = 0 \quad M_3 = x_1 \quad M_4 = x_1 x_0$



b) Using CSA method

$$\begin{array}{r}
 x_1 x_0 \\
 x_1 x_0 \\
 \hline
 x_1 x_0 \quad x_0 x_0 \\
 \\
 x_1 x_1 \quad x_1 x_0 \\
 \hline
 x_1 + x_1 x_0 \quad 0 \quad x_0 = x^2 \\
 x_1 x_0 \quad \leftarrow x^* \\
 \hline
 x_0 (x_1 + x_1 x_0) \quad x_0 \quad x_0
 \end{array}$$



Q2

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P2/3

$$A = (-23)_{10}$$

$$A = 0010111$$

$$-A = 1101001$$

$$B = 0000110$$

$$A \times B$$

=

$$\begin{array}{r} 11101001 \\ 00000110 \\ \hline 11101001 \\ 00000110 \\ \hline 11101110 \end{array}$$

Code (0 2 -2)

$$\text{Then } A \times B =$$

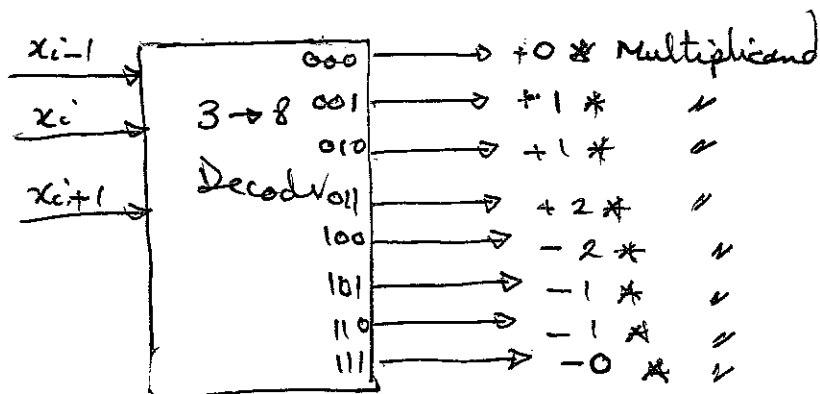
$$\begin{array}{r} 11101001 \\ 02-2 \\ \hline 0000101110 \\ 11010010 \\ \hline 11101110110 \end{array}$$

$A \times B$ is a -ve number taking its complement gives

$$00010001010_2 \text{ or } -138_{10}$$

b)

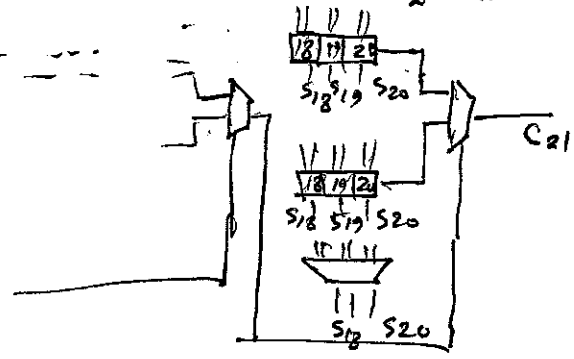
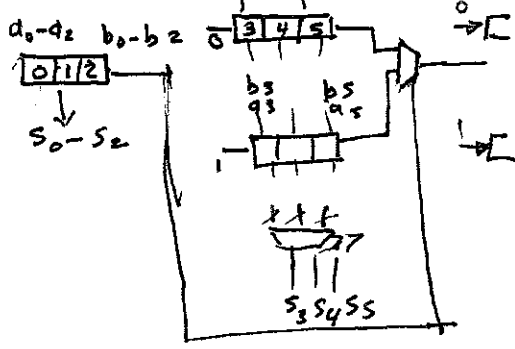
$$Z_i = -2x_{i+1} + x_i + x_{i-1}$$



Q3 → Carry Select

Various options of implementation is possible, here are some possibilities

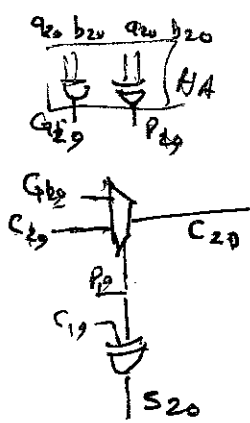
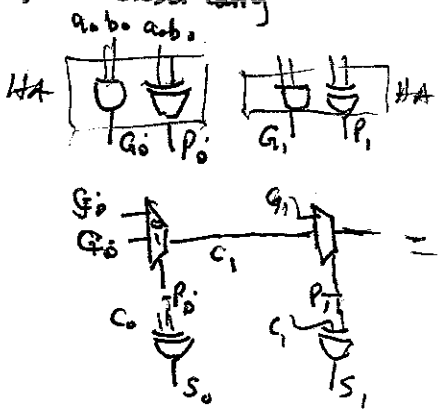
- $2 * 2 * 2 * 2 * 2 * 2 * 2 * 2 * 2 * 3$ — $3 + 7 * \frac{1}{2} = 6 \frac{1}{2} \tau_{FA}$
- $3 * 3 * 3 * 3 * 3 * 3 * 3$ — $3 \tau_{FA} + 6 * \frac{1}{2} \tau_{FA} = 6 \tau_{FA}$ — Optimal
- $4 * 4 * 4 * 4 * 5$ — $5 \tau_{FA} + 2 * \frac{1}{2} \tau_{FA} = 6 \tau_{FA}$ — Optimal
- $5 * 5 * 5 * 6$ — $6 \tau_{FA} + \frac{1}{2} \tau_{FA} = 6 \frac{1}{2} \tau_{FA}$
- $3 * 6 * 6 * 6$ — $6 \tau_{FA} + 3 * \frac{1}{2} \tau_{FA} = 7 \frac{1}{2} \tau_{FA}$



Delay = $3 \tau_{FA} + 6 * \frac{1}{2} \tau_{FA} = 6 \tau_{FA}$

Area = $3 * 13 A_{FA} + (6 * 3 + 6) A_{MUX}$

→ Manchester Carry



Delay = $\tau_{HA} + 2 \tau_{MUX} + \tau_{XOR}$

Area = $21 A_{HA} + 2 \tau_{MUX} + 2 \tau_{MUX}$

Area wise Manchester carry outperforms carry select Adder
Speed wise Carry select Adder outperform Manchester carry Adder