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:

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

(ie 3 bit input $\mathbf{-2x_{i+1}}$, $\mathbf{x_i}$, $\mathbf{x_{i-1}}$ 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 $F = X^3$ COEN6501_Oct_10

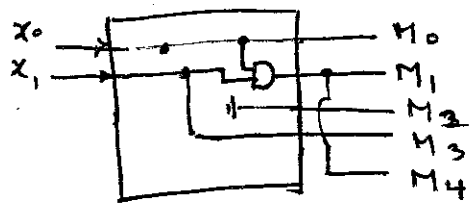
a) Using Truth Table max value of $F = (11)^3 = 27$

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

$M_0 = x_0$

$M_1 = x_1 x_0$

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



b) Using CSA method

$x_1 x_0$

$x_1 x_0$

$x_1 x_0$ $x_0 x_0$

$x_1 x_1$ $x_1 x_0$

$x_1 + x_1 x_0$ 0 x_0 $= X^2$

$*$

$x_1 x_0$ $\leftarrow X$

$x_0 (x_1 + x_1 \cdot x_0)$ x_0 x_0

$x_1 (x_1 + x_1 x_0)$ 0 $x_1 x_0$

$x_1 + x_1 x_0$ $x_0 x_1 + x_1 x_0$ $x_1 x_0$ x_0

$x_1 + x_1 x_0 + x_1 x_0$ 0 $x_1 x_0$ x_0

$x_1 x_0$ x_1 0 $x_1 x_0$ x_0

M_4 M_3 M_2 M_1 M_0

$A = (-23)_{10}$ $\quad A = 0010111$

$-A = 1101001$

$B = 0000110$

$A * B$ = $\quad 11101001$

$00000\overbrace{11}^{2}\overbrace{00}^{-2}$ Code (0 2 −2)

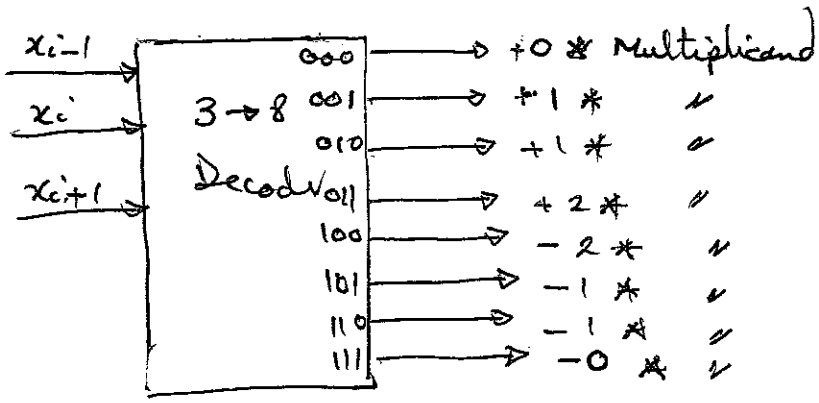
Then $A \times B$ =

$$\begin{array}{r} 11101001 \quad * \\ 0 \quad 2 \quad -2 \\ \hline 00001011110 \\ 11010010 \\ \hline 11101110110 \end{array}$$

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

00010001010_2 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

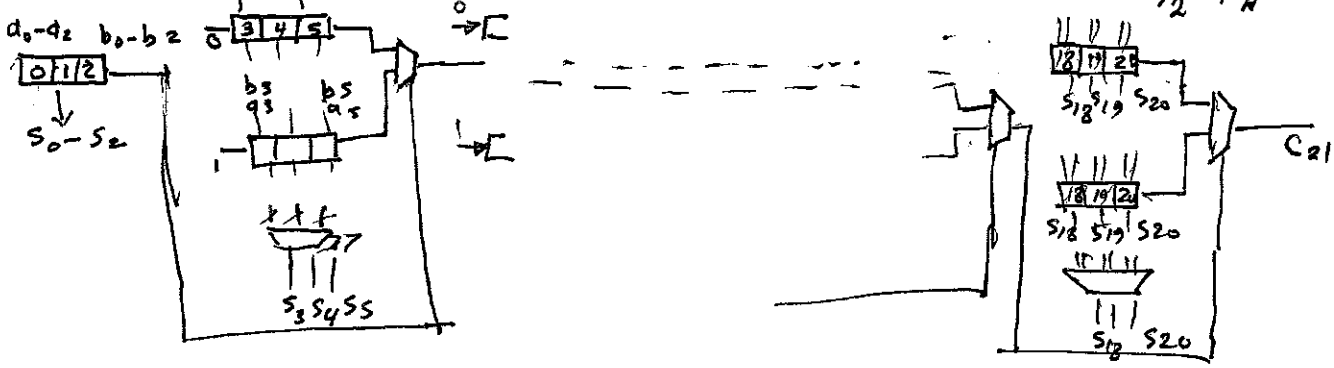
2 * 2 * 2 * 2 * 2 * 2 * 2 * 2 * 2 * 3 — $3 + 7 * 1/2 = 6\ 1/2\ \gamma_{FA}$

3 * 3 * 3 * 3 * 3 * 3 * 3 — $3\gamma_{FA} + 6 * 1/2\ \gamma_{FA} = 6\ \gamma_{FA}$ — Optimal

4 * 4 * 4 * 4 * 5 — $5\gamma_{FA} + 2 * 1/2\ \gamma_{FA} = 6\gamma_{FA}$ — Optimal

5 * 5 * 5 * 6 — $6\ \gamma_{FA} + 1/2\ \gamma_{FA} = 6\ 1/2$

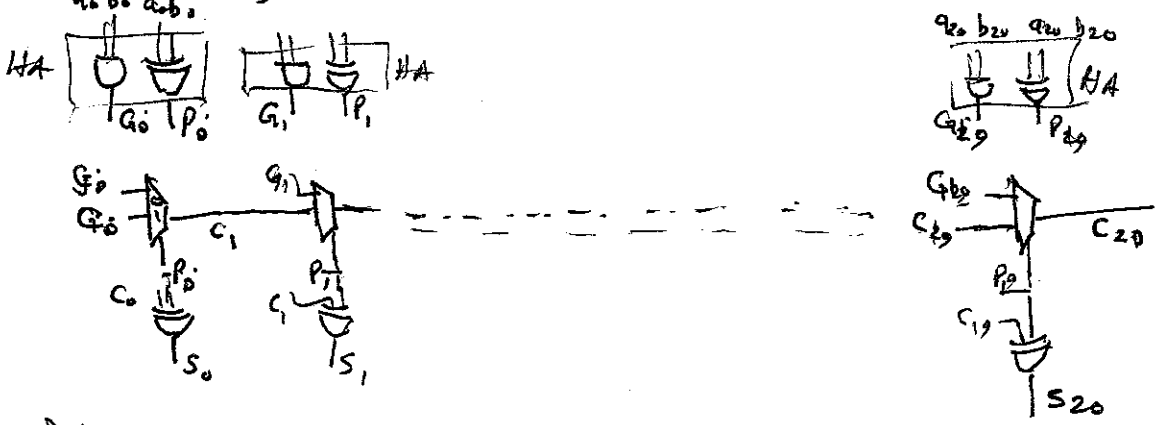
3 * 6 * 6 * 6 — $6\ \gamma_{FA} + 3\ 1/2\ \gamma_{FA} = 7\ 1/2\ \gamma_{FA}$



Delay = $3\gamma_{FA} + 6 * 1/2\ \gamma_{FA} = 6\ \gamma_{FA}$

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

→ Manchester Carry



Delay = $\gamma_{HA} + 20\ \gamma_{MUX} + \gamma_{XOR}$

Area = $21\ A_{HA} + 20\ A_{MUX} + 20\ A_{MUX}$

Area wise Manchester carry outperforms carry select Adder

Speed wise Carry select Adder outperform Manchester carry Adder