SCLD LAB ASSIGNMENT 2

GROUP NO : 31

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1 Question 1 (BCD)

1. Develop circuits to convert from 4-bit binary to 2-digit BCD

Solution:

Table 1: Binary to BCD Converter

Binary Code (Input)				BCD Code (Output)				
A	B	C	D	V	W	X	Y	Z
0	0	0	0	0	0	0	0	0
0	0	0	1	0	0	0	0	1
0	0	1	0	0	0	0	1	0
0	0	1	1	0	0	0	1	1
0	1	0	0	0	0	1	0	0
0	1	0	1	0	0	1	0	1
0	1	1	0	0	0	1	1	0
0	1	1	1	0	0	1	1	1
1	0	0	0	0	1	0	0	0
1	0	0	1	0	1	0	0	1
1	0	1	0	1	0	0	0	0
1	0	1	1	1	0	0	0	1
1	1	0	0	1	0	0	1	0
1	1	0	1	1	0	0	1	1
1	1	1	0	1	0	1	0	0
1	1	1	1	1	0	1	0	1

From above table we can construct logical expressions for V, W, X, Y, Z as follow:
For V:

$$\begin{gathered}
\text{V} = A\overline{B}C\overline{D} + A\overline{B}CD + AB\overline{C}.\overline{D} + AB\overline{C}D + ABC\overline{D} + ABCD \\
\text{V} = A\overline{B}C(\overline{D} + D) + AB\overline{C}(\overline{D} + D) + ABC(\overline{D} + D) \\
\text{V} = A\overline{B}C + AB\overline{C} + ABC \\
\text{V} = A\overline{B}C + AB(\overline{C} + C) \\
\text{V} = A\overline{B}C + AB \\
\text{V} = A(\overline{B}C + B) \\
\text{V} = A((B + C)(B + \overline{B})) \\
\mathbf{V = AB + AC}
\end{gathered}$$

For W:

$$\begin{gathered}
\text{W} = A\overline{B}.\overline{C}.\overline{D} + A\overline{B}.\overline{C}D \\
\text{W} = A\overline{B}.\overline{C}(\overline{D} + D) \\
\mathbf{W = A\overline{B}.\overline{C}}
\end{gathered}$$

For X:

$$\text{X} = \overline{A}B\overline{C}.\overline{D} + \overline{A}B\overline{C}D + \overline{A}BC\overline{D} + \overline{A}BCD + ABC\overline{D} + ABCD$$
$$\text{X} = \overline{A}B\overline{C}(\overline{D} + D) + \overline{A}BC(\overline{D} + D) + ABC(\overline{D} + D)$$
$$\text{X} = \overline{A}B\overline{C} + \overline{A}BC + ABC$$
$$\text{X} = \overline{A}B(\overline{C} + C) + ABC$$
$$\text{X} = \overline{A}B + ABC$$
$$\text{X} = B(\overline{A} + AC)$$
$$\text{X} = B((\overline{A} + A)(\overline{A} + C))$$
$$\mathbf{X = \overline{A}B + BC}$$

For Y:

$$\text{Y} = \overline{A}.\overline{B}C\overline{D} + \overline{A}.\overline{B}CD + \overline{A}BC\overline{D} + \overline{A}BCD + AB\overline{B}.\overline{D} + AB\overline{C}D$$
$$\text{Y} = \overline{A}.\overline{B}C(\overline{D} + D) + \overline{A}BC(\overline{D} + D) + AB\overline{C}(\overline{D} + D)$$
$$\text{Y} = \overline{A}.\overline{B}C + \overline{A}BC + AB\overline{C}$$
$$\text{Y} = \overline{A}C(\overline{B} + B) + AB\overline{C}$$
$$\mathbf{Y = AB\overline{C} + \overline{A}C}$$

For Z:

For Z, it can be easily seen from the table that Z is 1 whenever D is one. So, we can conclude that:

$$\mathbf{Z = D}$$

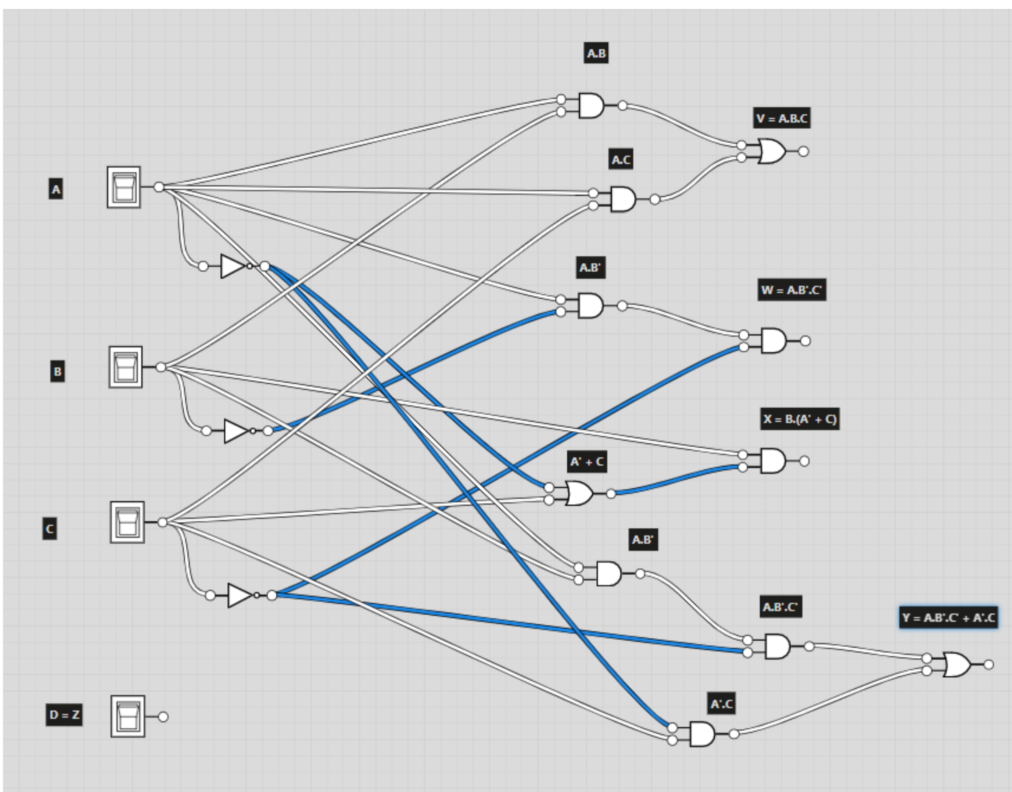

Fig 1: Circuit diagram to convert from 4-bit binary to 2-digit BCD

2 Question 2 (Gray)

1. Develop circuits to convert from 4-bit Gray to 4-bit binary and vice-versa

Solution:

Table 2: Binary to Gray Converter

Binary Code (Input)				Gray Code (Output)			
B1	B2	B3	B4	G1	G2	G3	G4
0	0	0	0	0	0	0	0
0	0	0	1	0	0	0	1
0	0	1	0	0	0	1	1
0	0	1	1	0	0	1	0
0	1	0	0	0	1	1	0
0	1	0	1	0	1	1	1
0	1	1	0	0	1	0	1
0	1	1	1	0	1	0	0
1	0	0	0	1	1	0	0
1	0	0	1	1	1	0	1
1	0	1	0	1	1	1	1
1	0	1	1	1	1	1	0
1	1	0	0	1	0	1	0
1	1	0	1	1	0	1	1
1	1	1	0	1	0	0	1
1	1	1	1	1	0	0	0

Conversion from binary code to gray code:

1. Most Significant Bit (MSB) of Gray code is same as that of Binary code.
2. For subsequent bits, the below mentioned rule is followed:

$$G_i = B_i \oplus B_{i+1}$$

3. Thus, for 4-bit binary to 4-bit gray conversion, we have the following:

G1 = B1
G2 = B1 $\oplus B2$
G3 = B2 $\oplus B3$
G4 = B3 $\oplus B4$

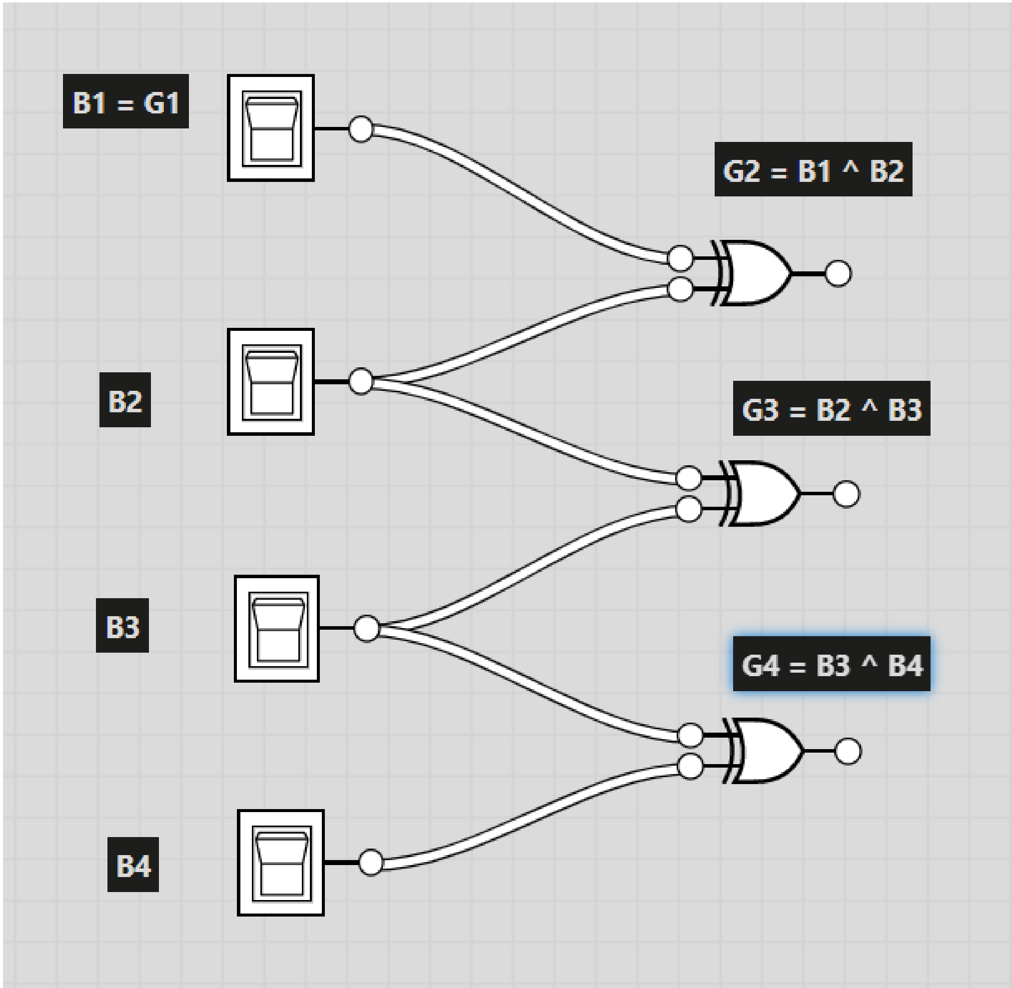

Fig 2: Circuit diagram to convert from 4-bit binary to 4-bit Gray Code.

Conversion from gray code to binary code:

1. Most Significant Bit (MSB) of Binary code is same as that of Gray code.
2. For subsequent bits, the below mentioned rule is followed:

$$B_i = G_i \oplus B_{i-1}$$

3. Thus, for 4-bit gray to 4-bit binary conversion, we have the following:

$$\begin{gathered} \text{B1} = \text{G1} \\ \text{B2} = \text{G2} \oplus B1 \\ \text{B3} = \text{G3} \oplus B2 \\ \text{B4} = \text{G4} \oplus B3 \end{gathered}$$

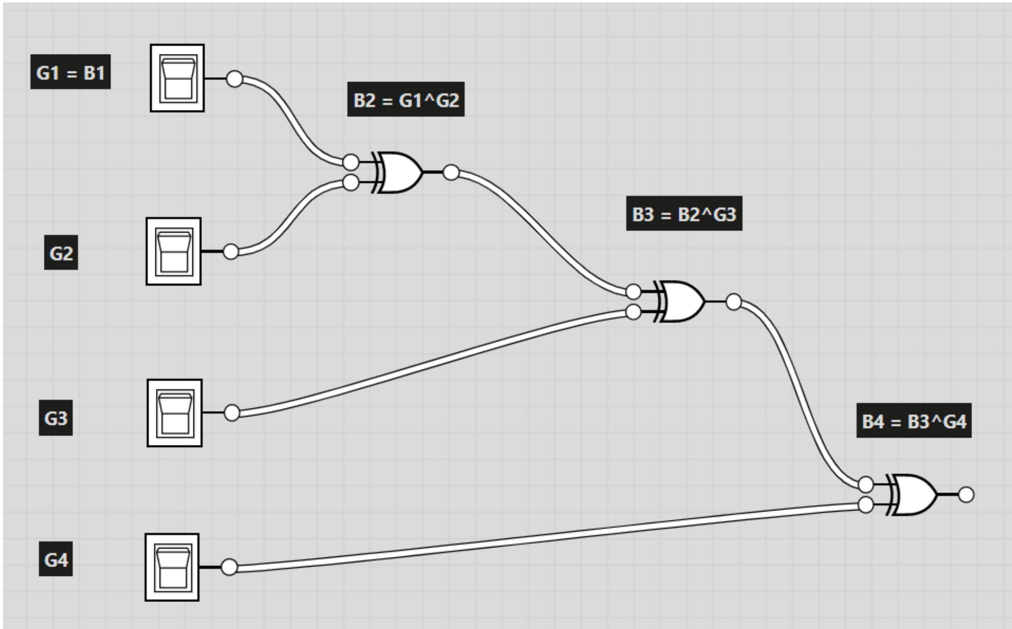

Fig 3: Circuit diagram to convert from 4-bit Gray Code to 4-bit binary.

3 Question 3 (Excess-3)

1. - Develop a half adder for handling two bits
   - Develop a full adder using half adders and any additional logic
   - Develop a ripple carry adder needed for this assignment using full adders
   - Develop circuits to convert from excess-3 to 4-bit binary and vice-versa

Solution:

a) The circuit that adds two bits is called half adder

A B	Sum	Carry
0 0	0	0
0 1	1	0
1 0	1	1
1 1	0	1

Table 3: Truth Table for Half Adder

From the above truth table it can be seen that:
Sum $= \mathbf{A\overline{B} + \overline{A}B}$ **= A XOR B**
Carry = AB

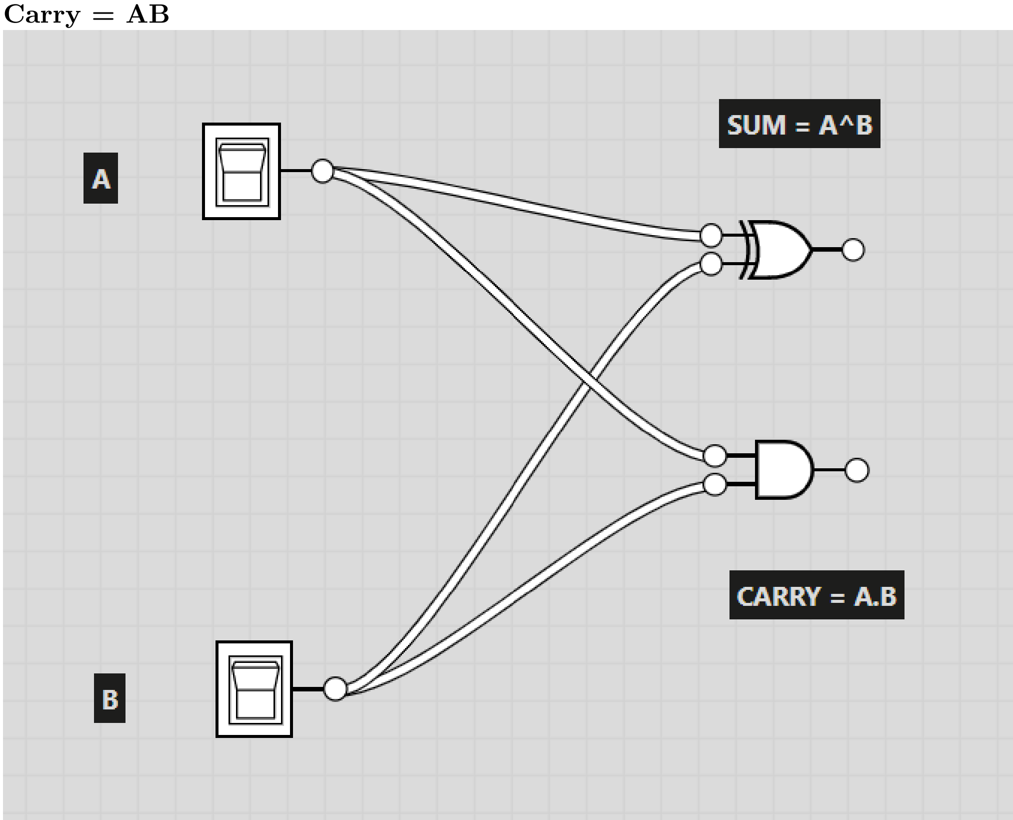

Fig 2: Circuit diagram for Half Adder

b) Full Adder is the adder which adds three inputs and produces two outputs. The first two inputs are A and B and the third input is an input carry as C-IN. The output carry is designated as C-OUT and the normal output is designated as S which is SUM.

Input			Output	
P	Q	C-IN	Sum	C-Out
0	0	0	0	0
0	0	1	1	0
0	1	0	1	0
0	1	1	0	1
1	0	0	1	0
1	0	1	0	1
1	1	0	0	1
1	1	1	1	1

Table 4: Truth Table of Full Adder

From the above truth table it can be seen that:
For Sum:

$$\text{Sum} = \overline{P}.\overline{Q}C + \overline{P}Q\overline{C} + P\overline{Q}.\overline{C} + PQC$$
$$\text{Sum} = C(\overline{P}.\overline{Q} + PQ) + \overline{C}(\overline{P}Q + P\overline{Q})$$
$$\mathbf{Sum = C\ XOR\ (P\ XOR\ Q)}$$

For Carry:

$$\text{Carry} = \overline{P}BC + P\overline{Q}C + PQ\overline{C} + PQC$$
$$\text{Carry} = (\overline{P}Q + P\overline{Q})C + PQ(\overline{C} + C)$$
$$\mathbf{Carry = (P\ XOR\ Q)C + PQ}$$

From the above question we can construct the circuit for Full adder as follows:

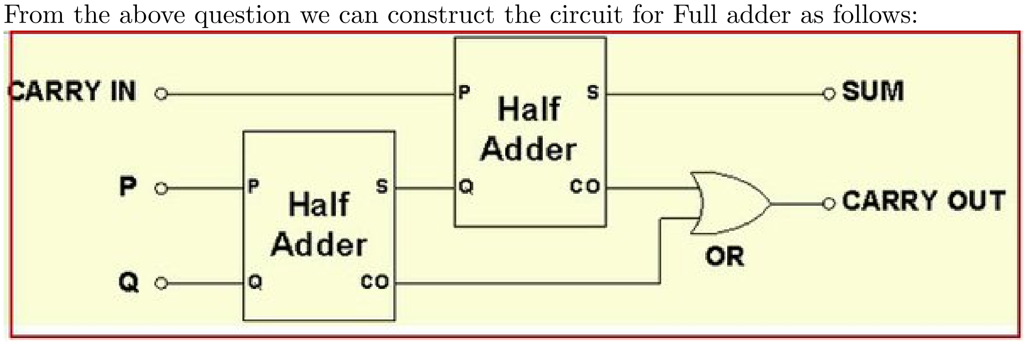

Fig 4: Circuit diagram for full adder

c) A ripple carry adder is a logic circuit in which the carry-out of each full adder is the carry in of the succeeding next most significant full adder. It is called a ripple carry adder because each carry bit gets rippled into the next stage.

A1	A2	A3	A4	B4	B3	B2	B1	S4	S3	S2	S1	Carry
0	0	0	0	0	0	0	0	0	0	0	0	0
0	1	0	0	0	1	0	0	1	0	0	0	0
1	0	0	0	1	0	0	0	0	0	0	0	1
1	0	1	0	1	0	1	0	0	1	0	0	1
1	1	0	0	1	1	0	0	1	0	0	0	1
1	1	1	0	1	1	1	0	1	1	0	0	1
1	1	1	1	1	1	1	1	1	1	1	0	1

The general equation for n-bit ripple carry adders is:

$$SUM_i = FULL - ADDER(A_i, B_i, CARRY_{i-1})$$

$$CARRY_i = FULL - ADDER(A_i, B_i, CARRY_{i-1})$$

$$CARRY_0 = 0$$

From the above question we can construct the circuit for Ripple Adder as follows:

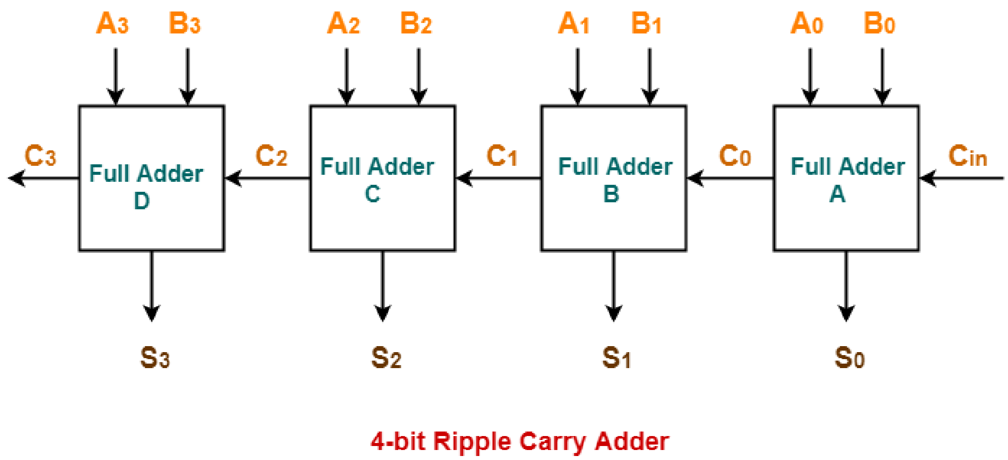

Fig 5: Circuit diagram for Ripple Adder

d) Excess-3: