Hybrid Electronics Laboratory

Design and Simulation of Various Code Converters

Aim: To Design and Simulate Binary to Gray, Gray to Binary , BCD to Excess 3, Excess 3 to BCD code converters.

Objectives:

1. To understand different codes
2. To design various Code converters using logic gates
3. To simulate various code converters
4. To understand the importance of code converters in real life applications

Theory

Binary Codes

A symbolic representation of data/ information is called code. The base or radix of the binary number is 2. Hence, it has two independent symbols. The symbols used are 0 and 1. A binary digit is called as a bit. A binary number consists of sequence of bits, each of which is either a 0 or 1. Each bit carries a weight based on its position relative to the binary point. The weight of each bit position is one power of 2 greater than the weight of the position to its immediate right. e. g. of binary number is 100011 which is equivalent to decimal number 35.

BCD Codes

Numeric codes represent numeric information i.e. only numbers as a series of 0's and 1's. Numeric codes used to represent decimal digits are called Binary Coded Decimal (BCD) codes. A BCD code is one, in which the digits of a decimal number are encoded-one at a time into group of four binary digits. There are a large number of BCD codes in order to represent decimal digits0, 1, 2 …9, it is necessary to use a sequence of at least four binary digits. Such a sequence of binary digits which represents a decimal digit is called code word.

Gray Codes

It is a non-weighted code; therefore, it is not a suitable for arithmetic operations. It is a cyclic code because successive code words in this code differ in one bit position only i.e. it is a unit distance code.

***Applications of Gray Code*:**

In instrumentation and data acquisition systems, where linear or angular displacement is measured. In shaft encoders, input-output devices, A/D converters and the other peripheral equipment.

Excess-3 code

It is a non-weighted code. It is also a self-complementing BCD code used in decimal arithmetic units. The Excess-3 code for the decimal number is performed in the same manner as BCD except that decimal number 3 is added to the each decimal unit before encoding it to binary.

Code Converters

The availability of a large variety of codes for the same discrete elements of information results in the use of different codes by different digital systems. It is some time necessary to use the output of one system as the input to the other. The conversion circuit must be inserted between the two systems if each uses different codes for the same information. Thus a code converter is a circuit that makes the two systems compatible even though each uses the different code.

Binary to Gray code

Truth Table:

Decimal	Binary Code (input)	Gray Code (output)
0	0000	0000
1	0001	0001
2	0010	0011
3	0011	0010
4	0100	0110
5	0101	0111
6	0110	0101
7	0111	0100
8	1000	1100
9	1001	1101
10	1010	1111
11	1011	1110
12	1100	1010
13	1101	1011
14	1110	1001
15	1111	1000

Equations:

$$G0 = B \oplus A$$

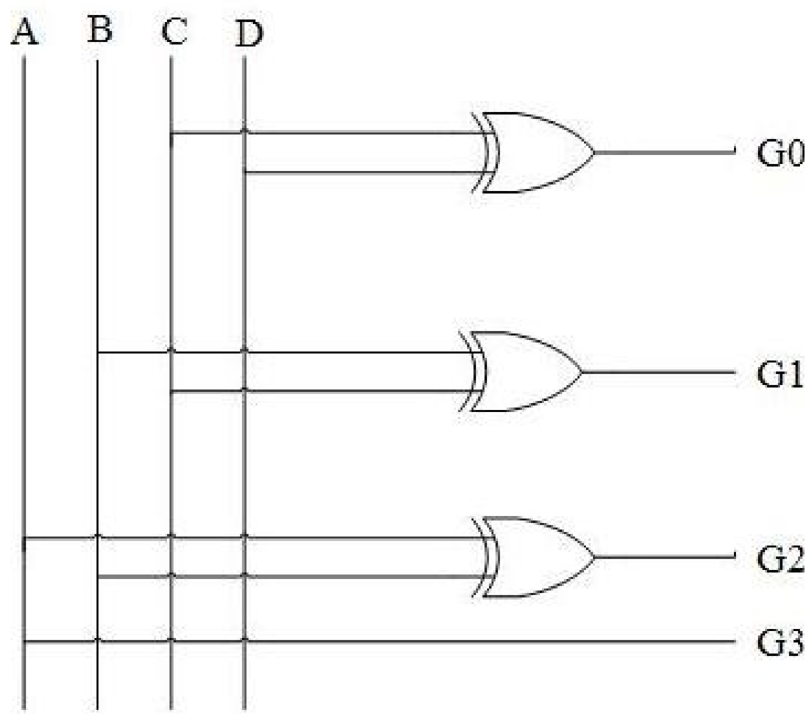
$$G1 = C \oplus B$$

$$G2 = D \oplus C$$

$$G3 = D$$

Diagram:

Logic diagram for Binary to Gray Convertor is given below:



Gray Code Input				Binary Code Output			
G3	G2	G1	G0	B3	B2	B1	B0
0	0	0	0	0	0	0	0
0	0	0	1	0	0	0	1
0	0	1	1	0	0	1	0
0	0	1	0	0	0	1	1
0	1	1	0	0	1	0	0
0	1	1	1	0	1	0	1
0	1	0	1	0	1	1	0
0	1	0	0	0	1	1	1
1	1	0	0	1	0	0	0
1	1	0	1	1	0	0	1
1	1	1	1	1	0	1	0
1	1	1	0	1	0	1	1
1	0	1	0	1	1	0	0
1	0	1	1	1	1	0	1
1	0	0	1	1	1	1	0
1	0	0	0	1	1	1	1

Equations:

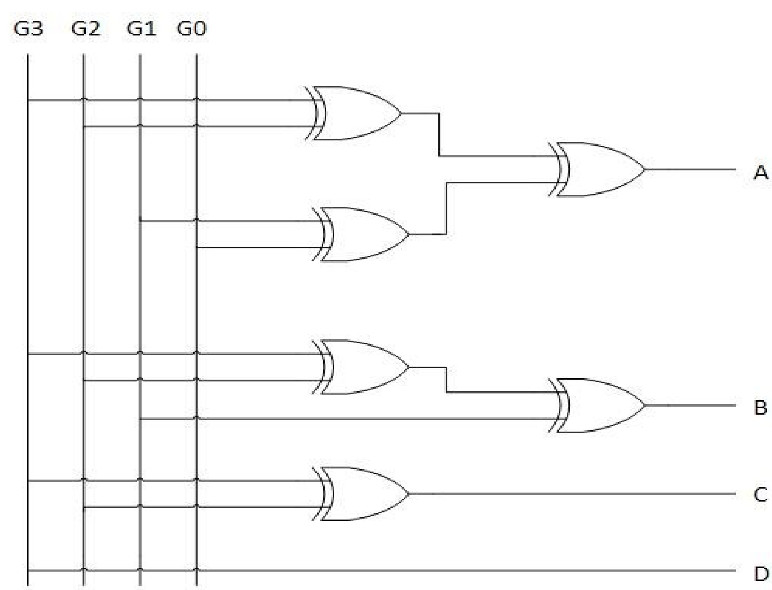
$$A = (G3 \oplus G2) \oplus (G1 \oplus G0)$$

$$B = G3 \oplus G2 \oplus G1$$

$$C = G3 \oplus G2$$

$$D = G3$$

Diagram:



BCD to Excess-3:

To convert from binary code A to binary code B, the input lines must supply the bit combination of elements as specified by code A and the output lines must generate the corresponding bit combination of code B. A combinational circuit performs this transformation by means of logic gates. As we want to design 4-bit code, we must use four input variables and four output variables. Designate the four input binary variables by the symbols A,B,C,D, and the four output variables by w, x, y, and z. The truth table relating the input and output variables is as shown. A two-level logic diagram may be obtained directly from the Boolean expressions derived by the maps. The expressions obtained may be manipulated for the purpose of using common gates for two or more outputs. This manipulation illustrates flexibility obtained with multiple-output systems when implemented with three or more levels of gates.

Truth table:

BCD Input				Excess-3 Output			
B3	B2	B1	B0	G3	G2	G1	G0
0	0	0	0	0	0	1	1
0	0	0	1	0	1	0	0
0	0	1	0	0	1	0	1
0	0	1	1	0	1	1	0
0	1	0	0	0	1	1	1
0	1	0	1	1	0	0	0
0	1	1	0	1	0	0	1
0	1	1	1	1	0	1	0
1	0	0	0	1	0	1	1
1	0	0	1	1	1	0	0
1	0	1	0	x	x	x	x
1	0	1	1	x	x	x	x
1	1	0	0	x	x	x	x
1	1	0	1	x	x	x	x
1	1	1	0	x	x	x	x
1	1	1	1	x	x	x	x

Equations:

$$z = D$$

$$y = CD+C'D'=CD(C+D)'$$

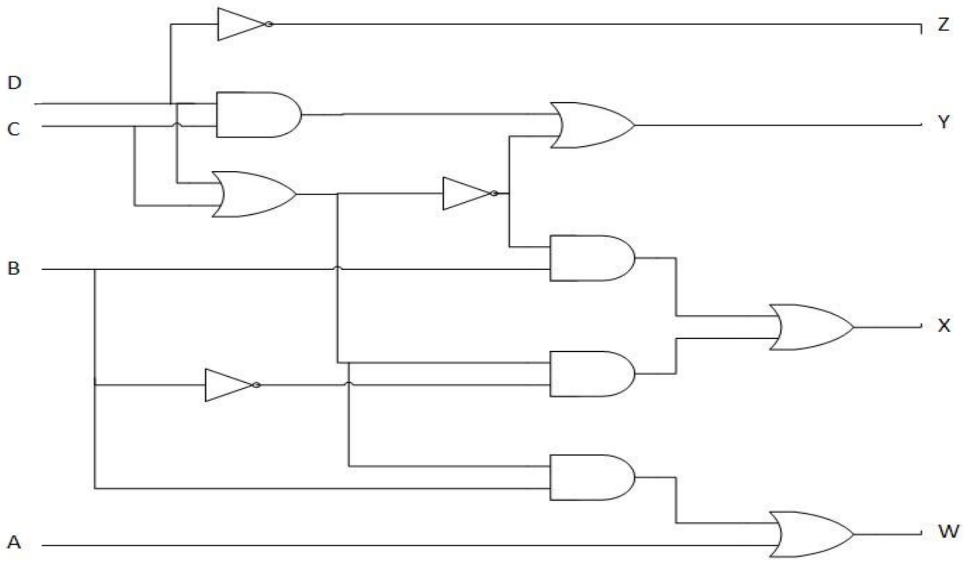
$$x = B'C+B'D+BC'D'= B'(C+D) +BC'D'$$

$$x = B'(C+D) +B(C+D)'$$

$$w= A+BC+BD=A+B(C+D)$$

Diagram:

Logic Diagram for BCD to Excess-3 Code Converter



Excess-3 to BCD :

The truth table relating the input and output variables is as shown.

Excess-3 Input				BCD Output			
G3	G3	G3	G3	B3	B2	B1	B0
0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	1
0	0	0	0	0	0	1	0
0	0	0	0	0	0	1	1
0	0	0	0	0	1	0	0
1	1	1	1	0	1	0	1
1	1	1	1	0	1	1	0
1	1	1	1	0	1	1	1
1	1	1	1	1	0	0	0
1	1	1	1	1	0	0	1

Equations:

$$B0 = E0 \oplus (E1' . (E2 . E3)')$$

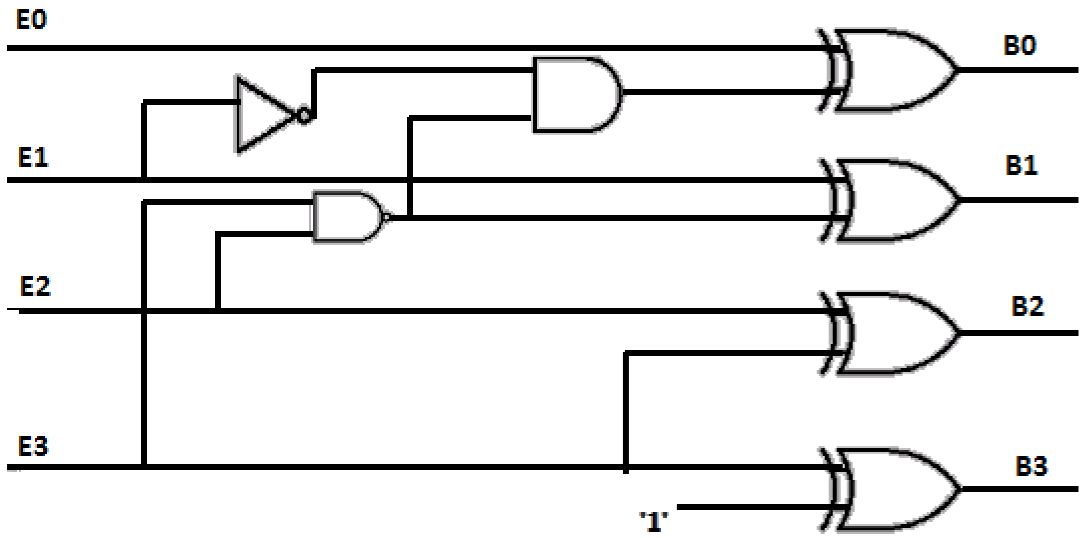
$$B1 = E1 \oplus (E2 . E3)'$$

$$B2 = E2 \oplus E3$$

$$B3 = E3 \oplus 1$$

Diagram:

Logic Diagram for Excess-3 to BCD Code Converter



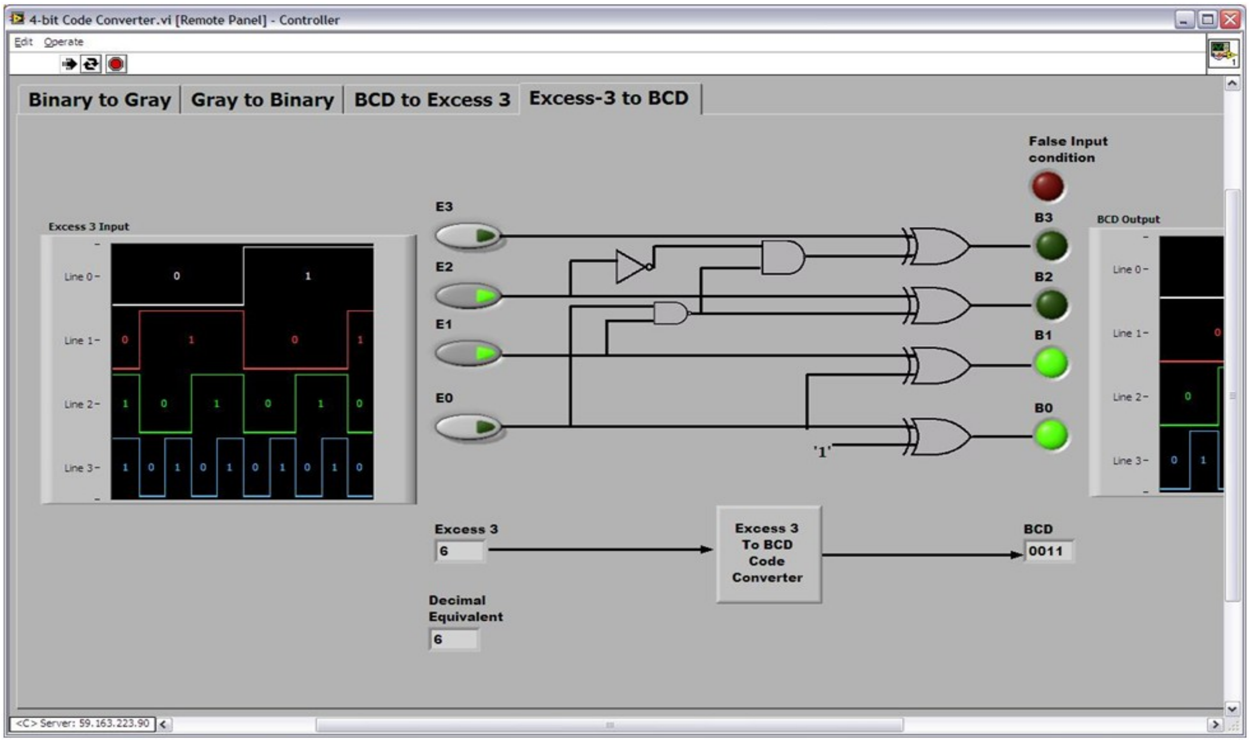
Procedure:

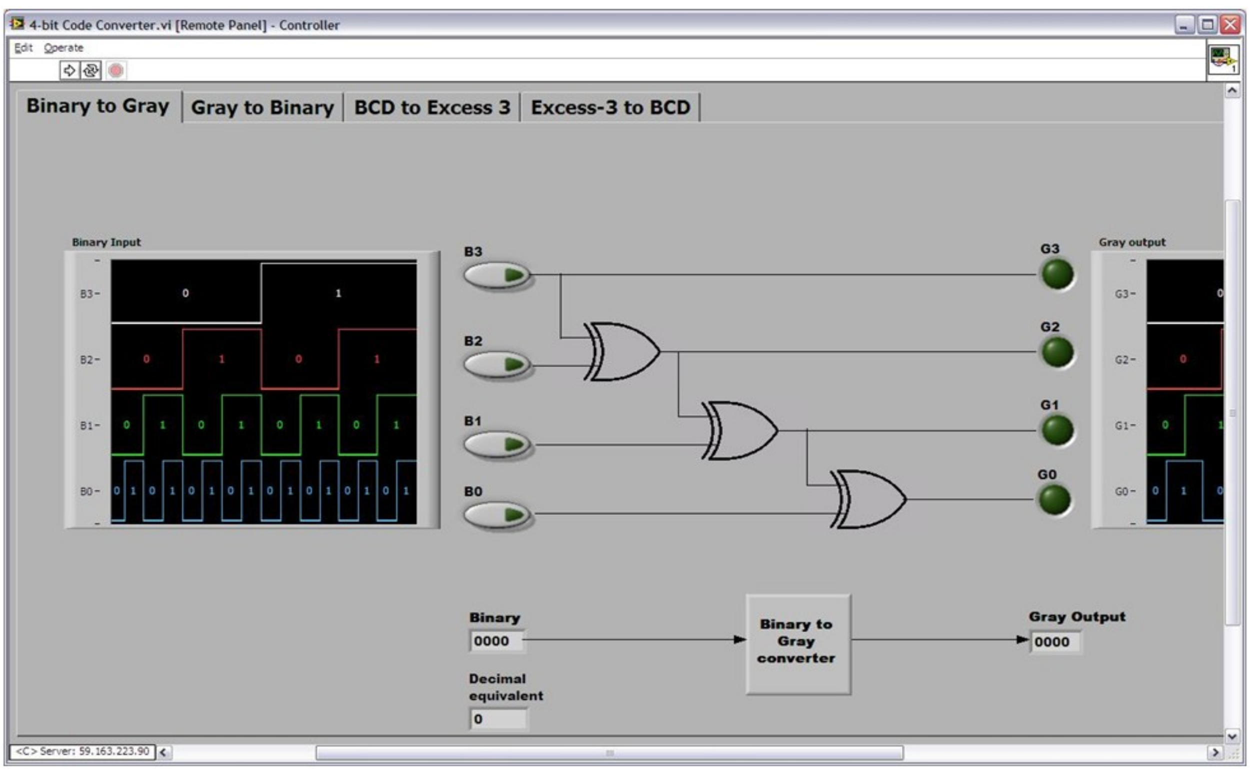
1. Select appropriate code converter from tab menu.

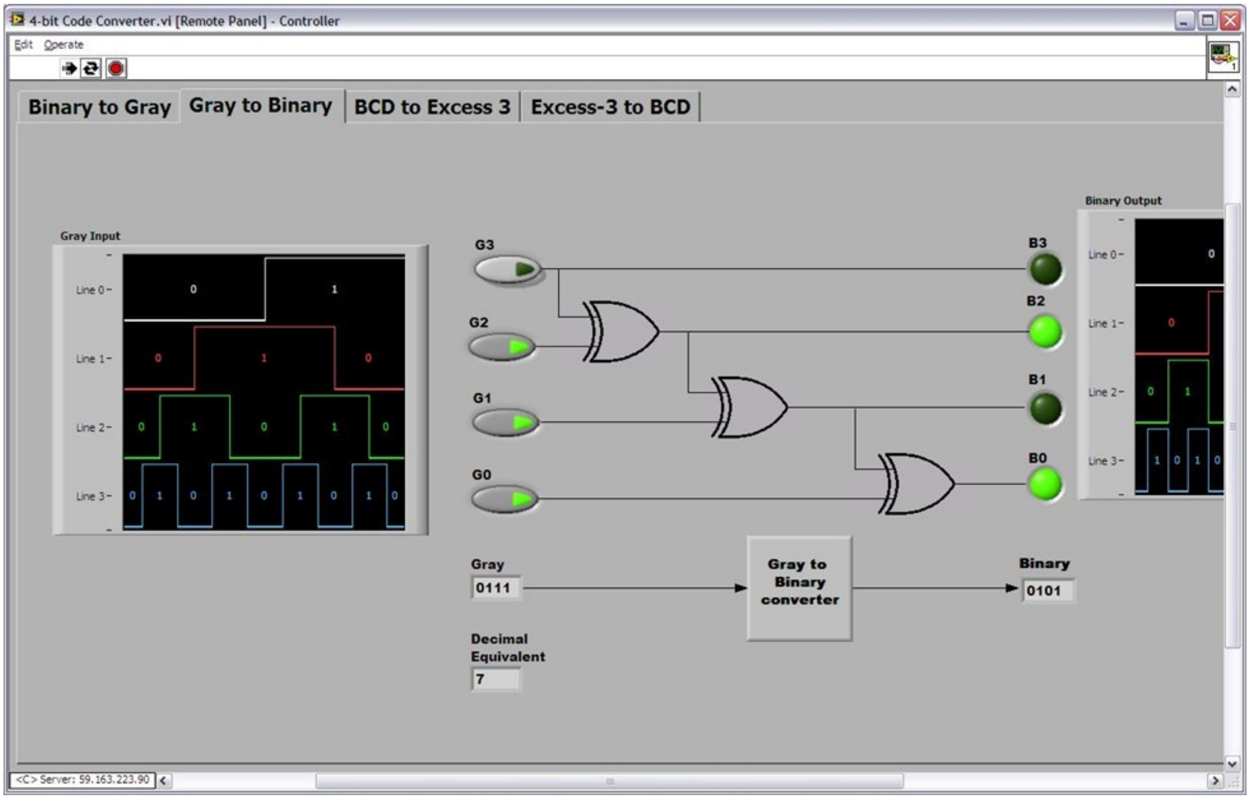
2. Run / execute the simulation by pressing the run button and observe the output of code converters on the output LED.

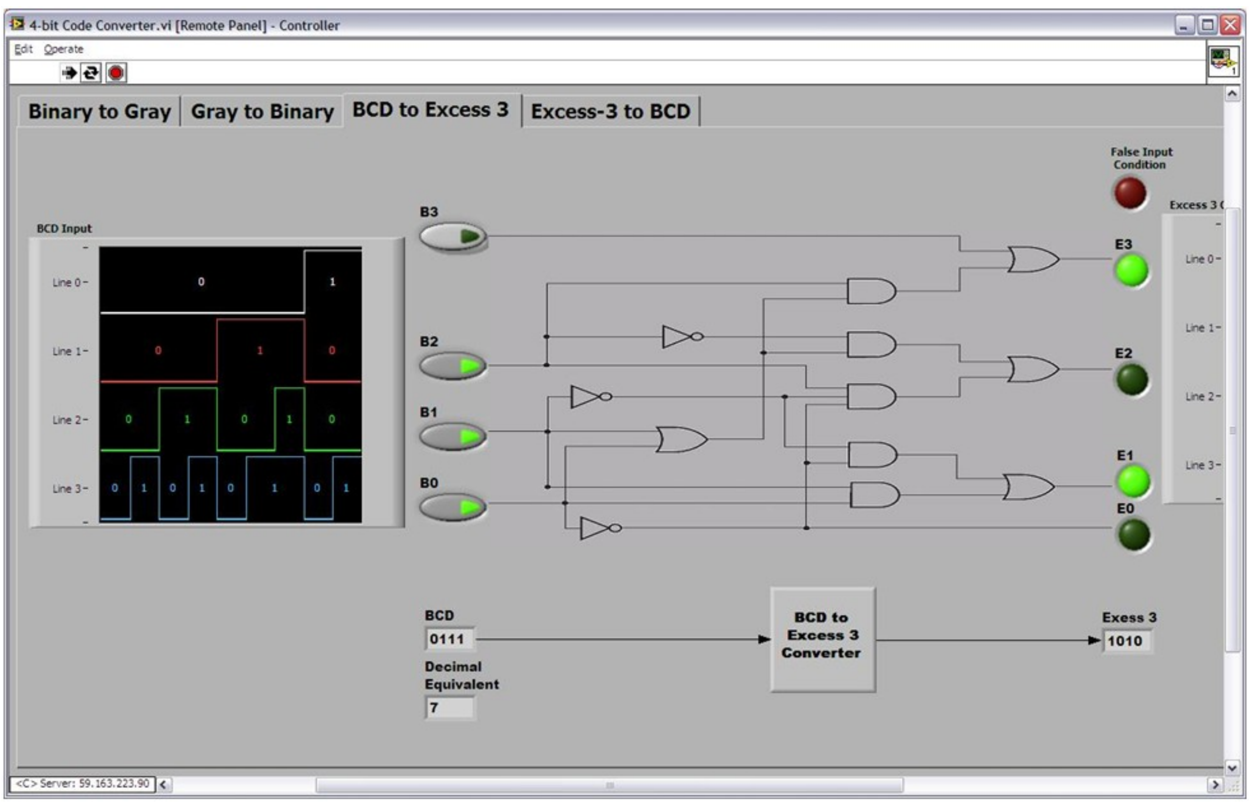
3. Repeat the procedure for different inputs and note down the corresponding outputs.

Screen Shots:






4-bit Code Converter.vi [Remote Panel] - Controller
Edit Operate
Binary to Gray
Gray to Binary
BCD to Excess 3
Excess-3 to BCD
Gray Input
Line 0
Line 1
Line 2
Line 3
G3
G2
G1
G0
B3
B2
B1
B0
Binary Output
Gray
0111
Gray to Binary converter
Binary
0101
Decimal Equivalent
7
<C> Server: 59.163.223.90


4-bit Code Converter.vi [Remote Panel] - Controller
Edit Operate
Binary to Gray
Gray to Binary
BCD to Excess 3
Excess-3 to BCD
False Input Condition
BCD Input
Line 0
Line 1
Line 2
Line 3
B3
B2
B1
B0
E3
E2
E1
E0
BCD
0111
BCD to Excess 3 Converter
Exess 3
1010
Decimal Equivalent
7
<C> Server: 59.163.223.90

Results

Binary to gray, gray to binary, Binary coded decimal (BCD) to Ex-3 code converter are simulated and the truth table are verified.

Conclusion

Using basic logic gates, universal logic gates and derived logic gates different code converters can be implemented and simulated.

Assignment

1. Design a code converter that converts a decimal digit from 8,4, -2,-1 code to BCD
2. Design a 5211 to 4211 code converter
3. Design 8 bit Binary to gray code converter and vice versa. Also explain its typical application.