Experiment No.3
Binary to Gray Code Conversion and Vice Versa

1. Introduction

1.1 Objective:

To study of binary to gray and gray to binary code conversion.

1.2 Components:

- ST2611 Digital Circuit Development Platform trainer with power supply cord
- DB06 – Code Conversion
- Set of wires

1.3 Theory:

From the previous experiments, we studied that the binary code of data is represented by two values such as 0's and 1's, and it is mainly used in the world of the computer. Gray Code is a form of binary that uses a different method of incrementing from one number to the next. With Gray Code, only one-bit changes state from one position to another. This feature allows a system designer to perform some error checking. Gray Code is the most popular Absolute encoder output type because its use prevents certain data errors which can occur with Natural Binary during state changes.

Code converter is a circuit that makes two systems compatible even though each uses different binary code. Code converters are used for protecting private information from spies. Moreover, they are used to enhance data portability and tractability.

We will discuss in this experiment how to convert from binary to gray code and vice versa, in order to understand how the encoder and decoder are working.

Binary to Gray Code Conversion

The following example will be very useful for knowing the conversion of binary to gray code. In this conversion method, take down the MSB bit of the present binary number, as the primary bit or MSB bit of the gray code number is similar to the binary number.

To get the straight gray coded bits for generating the corresponding gray coded digit for the given binary digits, look at the primary digit or the MSB digit of binary number and the second digit then note down 0 if they are similar to each other and 1 if they are different next to the primary bit of gray code. Do the same thing with the next binary bit and third bit then note down the product next to the 2nd bit of gray code. Similarly, follow this procedure until the final binary bit as well as note down the outcomes to generate the corresponding gray coded binary digit. The truth table of binary to gray code conversion can be seen at Table (1).
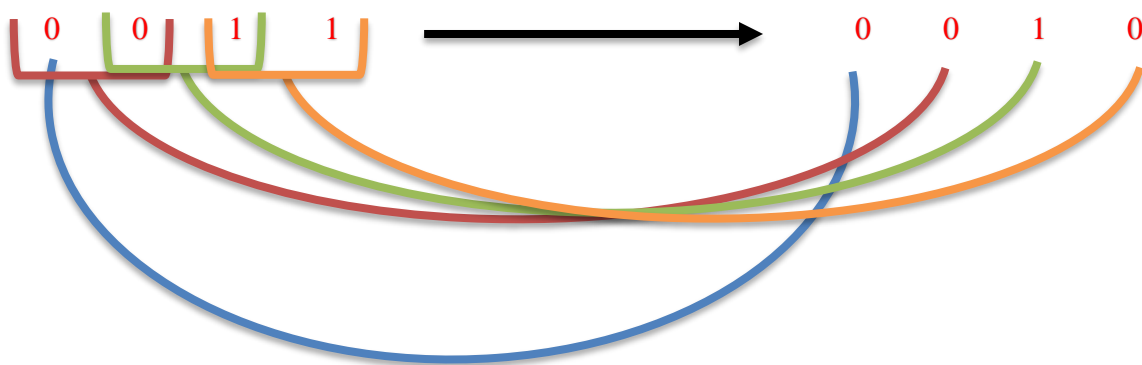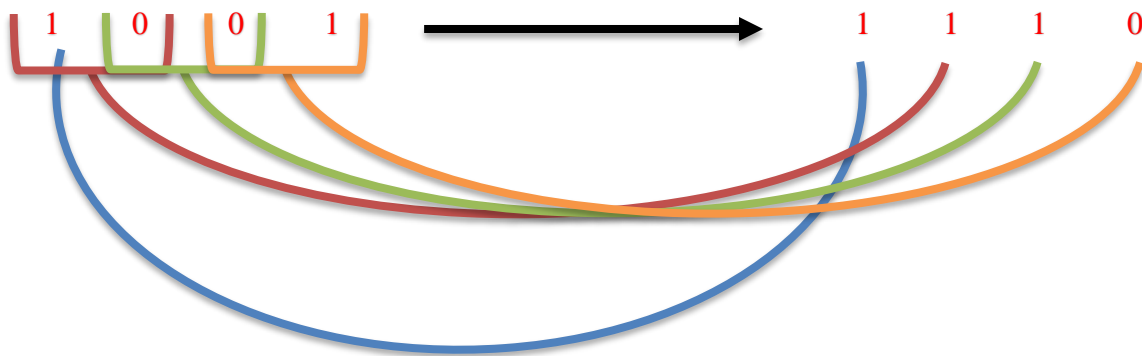
Binary Code				Gray Code			
B3	B2	B1	B0	G3	G2	G1	G0
0	0	0	0	0	0	0	0
0	0	0	1	0	0	0	1
0	0	1	0	0	0	1	1
0	0	1	1	0	0	1	0
0	1	0	0	0	1	1	0
0	1	0	1	0	1	1	1
0	1	1	0	0	1	0	1
0	1	1	1	0	1	0	0
1	0	0	0	1	1	0	0
1	0	0	1	1	1	0	1
1	0	1	0	1	1	1	1
1	0	1	1	1	1	1	0
1	1	0	0	1	0	1	0
1	1	0	1	1	0	1	1
1	1	1	0	1	0	0	1
1	1	1	1	1	0	0	0

Table 1: Truth Table of Binary to Gray Code Conversion

Gray to Binary Code Conversion

This gray to binary conversion method also uses the working concept of binary to gray code conversion. The following example with step by step procedure may help to know the conversion concept of gray code to binary code.

To change gray to binary code, take down the MSB digit of the gray code number, as the primary digit or the MSB of the binary code is similar to the gray digit. To get the next straight binary bit, look at the primary digit or the MSB digit of gray code and the second digit then note down 0 if they are similar to each other and 1 if they are different next to the primary bit of binary number. Do the same thing with the next gray bit and third bit then note down the product next to the 2nd bit of binary code. Similarly, follow this procedure until the final gray bit as well as note down the outcomes to generate the corresponding binary number. The truth table of gray to binary code conversion can be seen at Table (2).

Gray Code				Binary Code			
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	0	0	0	1	1
0	0	1	1	0	0	1	0
0	1	0	0	0	1	1	1
0	1	0	1	0	1	1	0
0	1	1	0	0	1	0	0
0	1	1	1	0	1	0	1
1	0	0	0	1	1	1	1
1	0	0	1	1	1	1	0
1	0	1	0	1	1	0	0
1	0	1	1	1	1	0	1
1	1	0	0	1	0	0	0
1	1	0	1	1	0	0	1
1	1	1	0	1	0	1	1
1	1	1	1	1	0	1	0

Table 2: Truth Table of Gray To Binary Code Conversion

The DB06 Code Conversion Panel shown in Figure 1 is a compact, ready to use logic board that will be used in this experiment. It is useful for students to study and understand the code conversion techniques binary to gray and gray to binary and verify them.
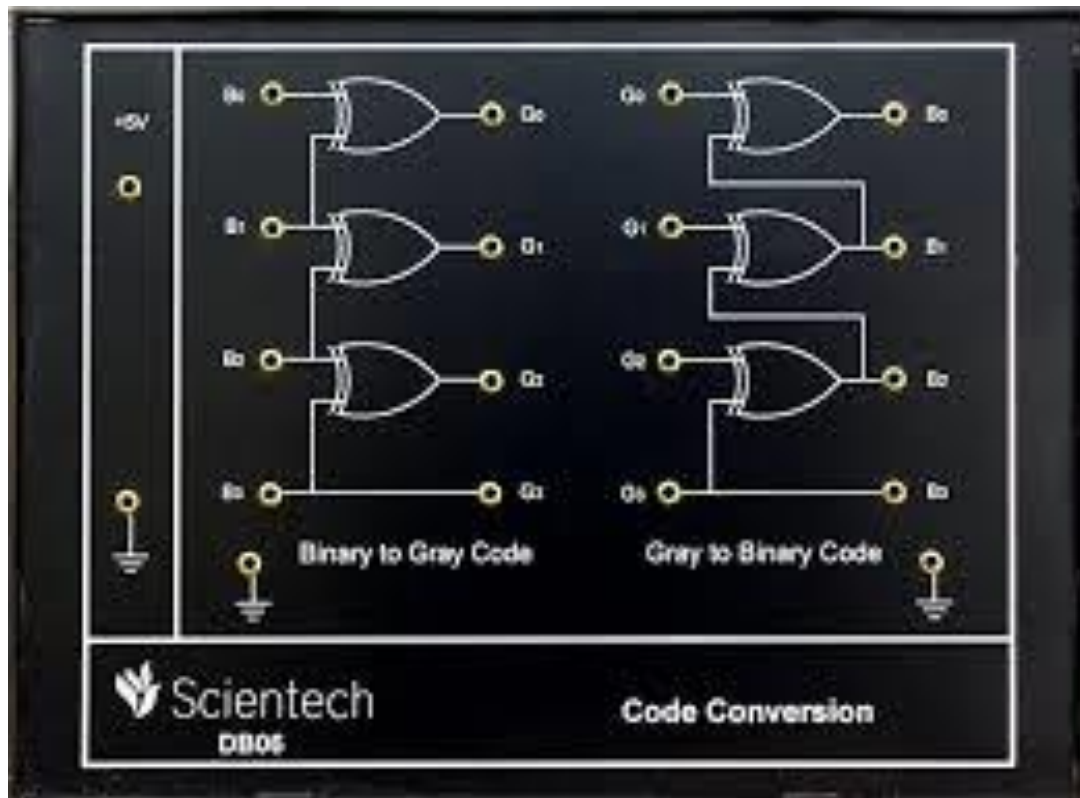
Figure 1: DB06 Code Conversion Panel

2. Experiments:

2.1 Exercise 1: Binary to Gray Code Conversion:

1. Place the DB06 panel shown in Figure 1 on the trainer.

2. To provide power to the board, connect +5 V pin from the trainer on the left side to +5V pin on the DB06 using a wire.

3. Connect GND pin from the trainer on the left side to ground symbol pin on the DB06.

4. Connect the input switches which are pins no. D0, D1, D2 and D3 on the bottom of the trainer to B0, B1, B2, and B3 pins of the binary to gray code circuit on the left of the panel respectively.

5. Connect the pin no. G0, G1, G2, and G3 of binary to gray code circuit on the left side of the panel to the output pin no. 0, 1, 2, and 3 of the 8-bit LED Display on the right side of the trainer respectively, in order to display the gray code from the binary inputs.

6. Make sure all your connections are right then turn on the power supply.

7. Turn D3 switch to position 1 and keep D0, D1 and D2 switches at position 0 then observe the output on 8-bit LED display (green light indicates 0 and red light indicates 1).

8. Observe the output for different input combination as shown in truth table of binary to gray code conversion on Table (1).

9. Verify Truth Table on Table (1).

2.2 Exercise 2: Gray to Binary Code Conversion:

1. Turn off the power supply and keep no. 1 through 3 of exercise 1 connections the same and take of the others.

2. Connect the input switches which are pins no. D0, D1, D2 and D3 on the bottom of the trainer to G0, G1, G2, and G3 pins of the gray to binary code circuit on the right of the panel respectively.

3. Connect the pin no. B0, B1, B2, and B3 of gray to binary code circuit on the right side of the panel to the output pin no. 0, 1, 2, and 3 of the 8-bit LED Display on the right side of the trainer respectively, in order to display the binary number from the gray inputs.

4. Make sure all your connections are right then turn on the power supply.

5. Turn D3 switch to position 1 and keep D0, D1 and D2 switches at position 0 then observe the output on 8-bit LED display (green light indicates 0 and red light indicates 1).

6. Observe the output for different input combination as shown in truth table of gray to binary code conversion on Table (2).

7. Verify Truth Table on Table (2).

3. Discussion:

1. Convert the gray code 01011001 to decimal number and show your work.

2. Convert the gray code 00101101 to binary number and show your work.

3. Design a 8-bit binary to gray code conversion circuit using logic gates and verify your design.

4. Design a 8-bit gray to binary code conversion circuit using logic gates and verify your design.