



Experiment No.4

BCD to Excess-3 Code Conversion and Vice Versa

1. Introduction

1.1 Objective:

To study of binary-coded decimal (BCD) to Excess-3 code and vice versa conversion.

1.2 Components:

1. ST2611 Digital Circuit Development Platform trainer with power supply cord
2. DB07 – BCD to Excess-3 Code Conversion
3. Set of wires

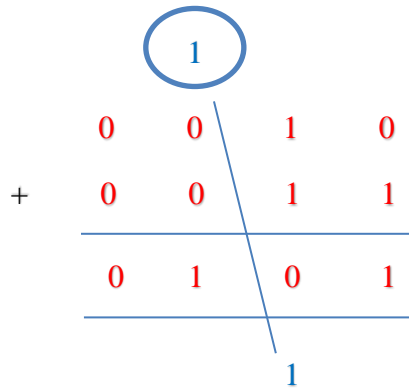
1.3 Theory:

The term BCD refers to representing the ten decimal digits in binary forms; where each decimal digit is represented by 4-bits. The Excess-3 system is a non-weighted code used to express decimal numbers. It is another important binary code which is particularly significant for arithmetic operations as it overcomes the shortcomings encountered while using the 8421 BCD code to add two decimal digits whose sum exceeds 9. The Excess-3 system simply adds 3 to each number to make the codes look different. The BCD to Excess-3 system is formed by adding 0011 to each BCD value as in Table (1) while Excess-3 code to BCD system is formed by subtracting 0011 from each Excess-3 value as in Table (2).

BCD to Excess-3 Code Conversion

As it is clear by the name, a BCD digit can be converted to its corresponding Excess-3 code by simply adding 3 to it. We can do that, either by taking the binary number, add 0011 to it as we did in experiment 2, and get the result or by converting the binary number to its corresponding decimal number, add 3 to it then convert it back to binary.

Let's take the following example, if we need to convert the binary number 0010 to Excess-3 code, we need to add 0011 to the number and find the result:



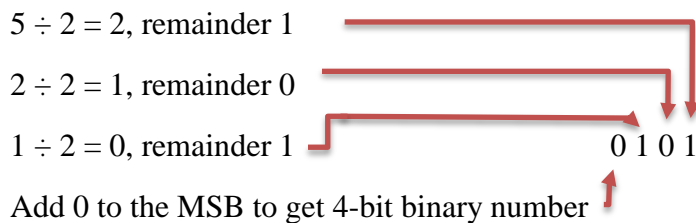
The result from the above example is 0101. Now, let's solve the same problem by converting the binary number to decimal number, add 3, then convert it to binary again.

Step 1:

$$\begin{array}{r}
 0010 \\
 2^3 \ 2^2 \ 2^1 \ 2^0 \\
 8 \ 4 \ 2 \ 1 \\
 0 + 0 + 2 + 0 = 2
 \end{array}$$

Step 2: $2 + 3 = 5$

Step 3:



From the truth table in Table (1), we see the conversion of 4-bit binary numbers to its corresponding Excess-3 code. B0 – B3 represents the BCD number where B0 is the LSB and B3 is the MSB. E0 – E3 represents the Excess-3 code where E0 is the LSB and E3 is the MSB.

Decimal Numerals	BCD Input				Excess-3 Output			
Decimal	B3	B2	B1	B0	E3	E2	E1	E0
0	0	0	0	0	0	0	1	1
1	0	0	0	1	0	1	0	0
2	0	0	1	0	0	1	0	1
3	0	0	1	1	0	1	1	0
4	0	1	0	0	0	1	1	1
5	0	1	0	1	1	0	0	0
6	0	1	1	0	1	0	0	1
7	0	1	1	1	1	0	1	0
8	1	0	0	0	1	0	1	1
9	1	0	0	1	1	1	0	0

Table 1: Truth Table of BCD Input to Excess-3 Output Conversion

Excess-3 to BCD Code Conversion

In order to convert a number from Excess-3 to BCD code, we need to opposite the previous process by subtracting 3 or 0011 from the given number. Again, we can do it either by taking the binary number, subtracting 0011 from, and get the result or by converting the binary number to its corresponding decimal number, subtract 3 then convert it back to binary.

Let's take another example, if we need to convert the Excess-3 number 0111 to BCD code, we need to subtract 0011 from the number and find the result:

$$\begin{array}{r} 0111 \\ - 0011 \\ \hline 0100 \end{array}$$

The result from the above example is 0100. Now, solving the same problem by converting the binary number to decimal number, subtract 3, then convert it to binary again.

Step 1:

$$\begin{array}{cccc} 0 & 1 & 1 & 1 \\ 2^3 & 2^2 & 2^1 & 2^0 \\ 8 & 4 & 2 & 1 \\ 0 + 4 + 2 + 1 = 7 \end{array}$$

Step 2: $7 - 3 = 4$

Step 3:

$4 \div 2 = 2$, remainder 0
 $2 \div 2 = 1$, remainder 0
 $1 \div 2 = 0$, remainder 1

0 1 0 0

Add 0 to the MSB to get 4-bit binary number

So, from both methods, we can get the same answer. The truth table of Excess-3 to BCD code conversion of 4-bit binary numbers is shown in Table (2).

Decimal Numerals	Excess-3 Input				BCD Output			
Decimal	E3	E2	E1	E0	B3	B2	B1	B0
3	0	0	1	1	0	0	0	0
4	0	1	0	0	0	0	0	1
5	0	1	0	1	0	0	1	0
6	0	1	1	0	0	0	1	1
7	0	1	1	1	0	1	0	0
8	1	0	0	0	0	1	0	1
9	1	0	0	1	0	1	1	0
10	1	0	1	0	0	1	1	1
11	1	0	1	1	1	0	0	0
12	1	1	0	0	1	0	0	1

Table 2: Truth Table of Excess-3 Input to BCD Output Conversion

2. Experiments:

2.1 Exercise 1: Convert BCD Number to Excess-3 Code

1. Place the DB07 panel as 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 DB07 using a wire.
3. Connect GND pin from the trainer on the left side to ground symbol pin on the DB07.
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 on the left of the panel respectively.
5. Connect the pins no. E0, E1, E2, and E3 on the right side of the panel to the output pins 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 Excess-3 code from the binary - coded decimal inputs.
6. Make sure all your connections are right then turn on the power supply.
7. Turn D1 and D2 switches to position 1 while keep D0 and D3 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 the truth table of BCD to Excess-3 code conversion on Table (1).
9. Verify Truth Table on Table (1).

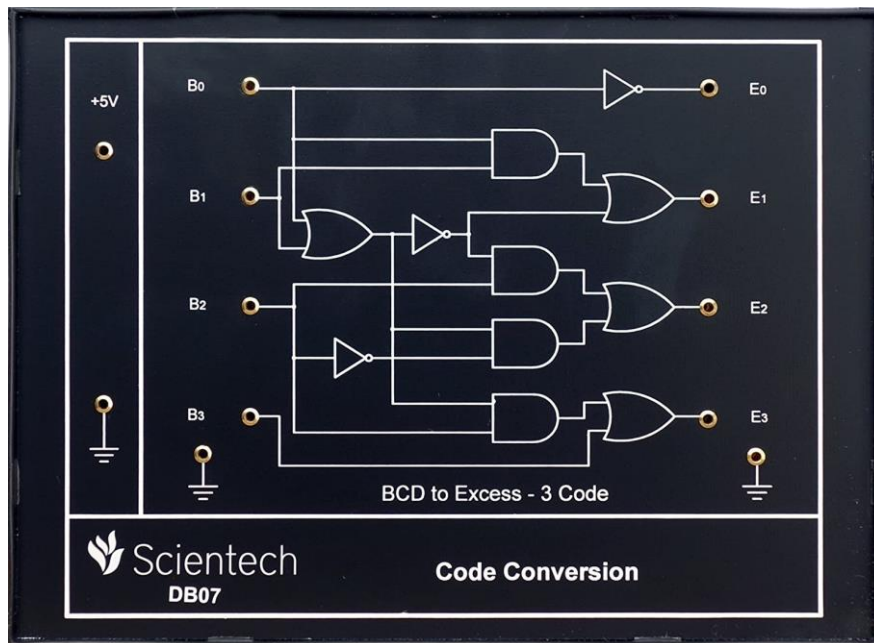


Figure 1: DB07 Code Conversion Panel (BCD to Excess-3 Code)

2.2 Exercise 2: Convert Excess-3 Number to BCD Code

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 E0, E1, E2, and E3 pins on the right of the panel respectively.
3. Connect the pins no. B0, B1, B2, and B3 on the left side of the panel to the output pins 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 BCD number from the Excess-3 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 Excess-3 number to binary coded decimal code conversion on Table (2).
7. Verify Truth Table on Table (2).

3. Discussion:

1. What is Excess-3 Codes?
2. Why use Excess-3 Codes?
3. Write the Excess-3 code for 1011.
4. Write the BCD code for 1111.