



Al-Mustaqbal University  
College Of Engineering Technology  
Department Of Cyber Security Techniques Engineering  
Class: 1<sup>st</sup>  
Subject: Digital Logic Design  
Lecturer: Dr. Rami Qays Malik  
2<sup>nd</sup> term – Lecture: 3- Binary Codes

## **BINARY CODES**

### **INTRODUCTION:**

This lecture describes various popular Binary Code formats. In the coding, when numbers, letters or words are represented by a specific group of symbols, it is said that the number, letter or word is being encoded. The group of symbols is called as a code. The digital data is represented, stored and transmitted as group of binary bits. This group is also called as binary code. The binary code is represented by the number as well as alphanumeric letter

### **ADVANTAGES OF BINARY CODE:**

- ✓ Binary codes are suitable for the computer applications.
- ✓ Binary codes are suitable for the digital communications.
- ✓ Since only 0 & 1 are being used, implementation becomes easy.

### **1.BINARY CODED DECIMAL (BCD) CODE:**

In this code each decimal digit is represented by a 4-bit binary number. BCD is a way to express each of the decimal digits with a binary code. In the BCD, with four bits we can represent sixteen numbers (0000 to 1111).

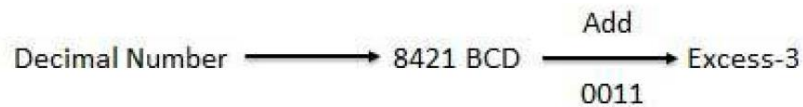
**Note:** But in BCD code only first ten of these are used (0000 to 1001). The remaining six code combinations i.e. 1010 to 1111 are invalid in BCD..



<b>DECIMAL</b>	<b>0</b>	<b>1</b>	<b>2</b>	<b>3</b>	<b>4</b>	<b>5</b>	<b>6</b>	<b>7</b>	<b>8</b>	<b>9</b>
<b>BCD</b>	<b>0000</b>	<b>0001</b>	<b>0010</b>	<b>0011</b>	<b>0100</b>	<b>0101</b>	<b>0110</b>	<b>0111</b>	<b>1000</b>	<b>1001</b>

## 2: EXCESS-3 CODE

The Excess-3 code is also called as XS-3 code. It is non-weighted code used to express decimal numbers. The Excess-3 code words are derived from the 8421 BCD code words adding  $(0011)_2$  or  $(3)_{10}$  to each code word in 8421. The excess-3 codes are obtained as follows:



### Example :

Decimal	BCD				Excess-3			
	8	4	2	1	BCD + 0011			
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

## 3. Gray Code:



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It has a very special feature that has only one bit will change, each time the decimal number is incremented as shown in fig. As only one bit changes at a time, the gray code is called as a unit distance code. The gray code is a cyclic code.

Decimal	BCD	Gray
0	0 0 0 0	0 0 0 0
1	0 0 0 1	0 0 0 1
2	0 0 1 0	0 0 1 1
3	0 0 1 1	0 0 1 0
4	0 1 0 0	0 1 1 0
5	0 1 0 1	0 1 1 1
6	0 1 1 0	0 1 0 1
7	0 1 1 1	0 1 0 0
8	1 0 0 0	1 1 0 0
9	1 0 0 1	1 1 0 1

### **CODES CONVERSION:**

This section describes conversion of various digital code formats to one another. there are many methods or techniques which can be used to convert code from one format to another. We'll demonstrate here the following:



- Binary to BCD Conversion
- BCD to Binary Conversion
- BCD to Excess-3
- Excess-3 to BCD
- Binary to Gray
- Gary to binary

## 1. BINARY TO BCD CONVERSION:

**Step 1** -- Convert the binary number to decimal.

**Step 2** -- Convert decimal number to BCD.

**Example** :Convert  $(11101)_2$  to BCD.

**Step 1** - Convert to Decimal

Binary Number:  $11101_2$

Calculating Decimal Equivalent:

**Step 1:**  $11101_2 = ((1 \times 16) + (1 \times 8) + (1 \times 4) + (0 \times 2) + (1 \times 1))_{10}$

$11101_2 = (16 + 8 + 4 + 0 + 1)_{10}$

$11101_2 = 29_{10}$

**Step 2** – Convert to BCD

Decimal Number:  $29_{10}$



Calculating BCD Equivalent: Convert each digit into groups of four binary digits equivalent.

Steps	Decimal	Number Conversion
Step 1	$29_{10}$	$0010_2 1001_2$
Step 2	$29_{10}$	$00101001_{BCD}$
Result = $(11101)_2 = (00101001)_{BCD}$		

## 2. BCD TO BINARY CONVERSION:

**Step 1** -- Convert the BCD number to decimal.

**Step 2** -- Convert decimal to binary.

Example:

Convert  $(00101001)_{BCD}$  to Binary.

**Step 1** – Convert to Decimal: Calculating Decimal Equivalent: Convert each four digit into a group and get decimal equivalent or each group.

**Step 1**  $(00101001)_{BCD} = 0010_2 1001_2$

$(00101001)_{BCD} = 29_{10}$

**Step 2** – Convert to Binary: Used long division method for decimal to binary conversion.



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$$29 / 2 \quad 14 \quad 1$$

$$14 / 2 \quad 7 \quad 0$$

$$7 / 2 \quad 3 \quad 1$$

$$3 / 2 \quad 1 \quad 1$$

$$1 / 2 \quad 0 \quad 1$$

Decimal Number:  $29_{10} =$  Binary Number:  $11101_2$

Result :  $(00101001)_{BCD} = (11101)_2$

### 3. BCD TO EXCESS-3:

**Step 1** -- Convert BCD to decimal.

**Step 2** -- Add  $(3)_{10}$  to this decimal number.

**Step 3** -- Convert into binary to get excess-3 code

Example:

Convert  $(1001)_{BCD}$  to Excess-3.

**Step 1** – Convert to Decimal

$$(1001)_{BCD} = 9_{10}$$

**Step 2** – Add 3 to Decimal

$$(9)_{10} + (3)_{10} = (12)_{10}$$

**Step 3** – Convert to Excess-3

$$(12)_{10} = (1100)_2$$

Result

$$(1001)_{BCD} = (1100)_{XS-3}$$



### 4. EXCESS-3 TO BCD CONVERSION:

**Step 1** -- Subtract  $(0011)_2$  from each 4 bit of excess-3 digit to obtain the corresponding BCD code.

Example

convert  $(10011010)_{XS-3}$  to BCD.

Given XS-3 number = 1 0 0 1 1 0 1 0

Subtract  $(0011)_2 = 0 0 1 1 0 0 1 1$

$(10011010)_{XS-3} = (01100111)_{BCD}$

### 5. Gray To Binary Conversion:

**Step1:** The MSB in the left is the MSB in binary number. In other word they are The same.

**Step2:** Add the first digit of the binary number to the second digit in Gary code, the carry is ignored , in other word , take XOR operation between them .

Example: Convert the Gary code 11011 to binary number?

<b>Gray code</b>	<b>→</b>	<b>1</b>		<b>1</b>		<b>0</b>		<b>1</b>		<b>1</b>
		↓ ↗		↓ ↗		↓ ↗		↓ ↗		↓
<b>Binary Number</b>	<b>→</b>	<b>1</b>		<b>0</b>		<b>0</b>		<b>1</b>		<b>0</b>

Then  $(11011)_G = (10010)_2$

### 6. Binary To Gray Conversion:

**Step1:** The MSB digit in Gary code is the same as corresponding digit in the binary number.



**Step2:** going from left to right , add each adjacent pair of binary digit to get the next Gray digits , regardless carries .

**Example:** Convert the following binary number 100110 to Gray code?

**Binary Number** → 1 0 0 1 1 0

**Gray Code** → 1 1 0 1 0 1

Then  $(100110)_2 = (110101)_G$

### **EXERCISE :**

1- convert the BCD code  $(1001010100000100)_{BCD}$  to decimal number

2- convert the gray code 11011 to binary number