ASSIGNMENT NO. 02

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SEMESTER/YEAR: Sem-3 / 2022-23	**ROLL NO:** 015
DATE OF PERFORMANCE: / /2022	**DATE OF SUBMISSION:** / /2022
EXAMINED BY: Prof. G. B. Aochar	**EXPERIMENT NO: 2**

TITLE: Code Converters e.g. BCD to Excess-3 & Binary to Gray

PROBLEM STATEMENT: To study the design & implementation of

a) Binary to Gray code converter using logic gates
b) BCD to Excess-3 code converter using logic gates

PRE-REQUESITE:

Digital trainer kit, ICs- 74LS08, 74LS86, 74LS00, 74LS02, 7432, 7404 , Probs

THEORY:

There is a wide variety of binary codes used in digital systems. Some of these codes are binary-coded -decimal (BCD), Excess-3, Gray, octal, hexadecimal, etc. Often it is required to convert from one code to another. For example the input to a digital system may be in natural BCD and output may be 7-segment LEDs. The digital system used may be capable of processing the data in straight binary format. Therefore, the data has to be converted from one type of code to another type for different purpose. The various code converters can be designed using gates.

1) Binary Code:

It is straight binary code. The binary number system (with base 2) represents values using two symbols, typically 0 and 1.Computers call these bits as either off (0) or on (1). The binary code are made up of only zeros and ones, and used in computers to stand for letters and digits. It is used to represent numbers using natural or straight binary form.It is a weighted code since a weight is assigned to every position. Various arithmetic operations can be performed in this form. Binary code is weighted and sequential code.

2) Gray Code:

It is a modified binary code in which a decimal number is represented in binary form in such a way that each Gray- Code number differs from the preceding and the succeeding number by a single bit. (E.g. for decimal number 5 the equivalent Gray code is 0111 and for 6 it is 0101. These two codes differ by only one bit position i. e. third from the left.) Whereas by using binary code there is a possibility of change of all bits if we move from one number to other in sequence (e.g. binary code for 7 is 0111 and for 8 it is 1000). Therefore it is more useful to use Gray code in some applications than binary code.The Gray code is a non weighted code i.e. there are no specific weights assigned to the bit positions. Like binary numbers, the Gray code can have any no. of bits. It is also known as reflected code.

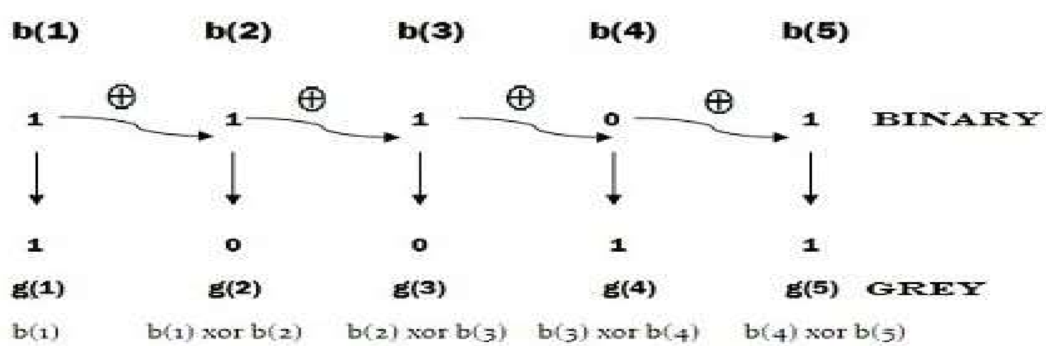
Applications:

1. Important feature of Gray code is it exhibits only a single bit change from one code word to the next in sequence. This property is important in many applications such as Shaft encoders where error susceptibility increases with number of bit changes between adjacent numbers in sequence.
2. It is sometimes convenient to use the Gray code to represent the digital data converted from the analog data (Outputs of ADC).
3. Gray codes are used in angle-measuring devices in preference to straight forward binary encoding.
4. Gray codes are widely used in K-map.

The disadvantage of Gray code is that it is not good for arithmetic operation

Binary To Gray Conversion

1. Record the most significant bit as it is.
2. EX-OR this bit to the next position bit, record the resultant bit.
3. Record successive EX-ORed bits until completed.
4. Convert 0011 binary to Gray.



Block Diagram:

Truth Table:

Binary				Gray Code			
b_3	b_2	b_1	b_0	g_3	g_2	g_1	g_0
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

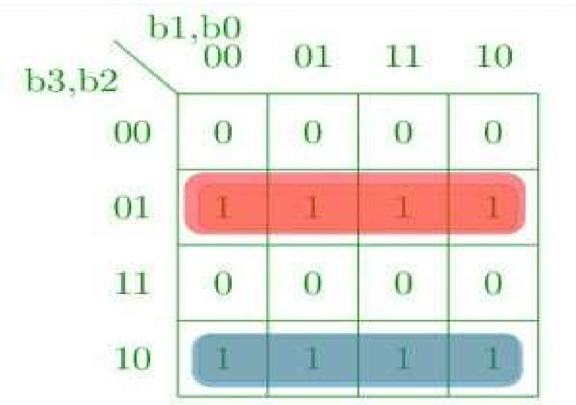
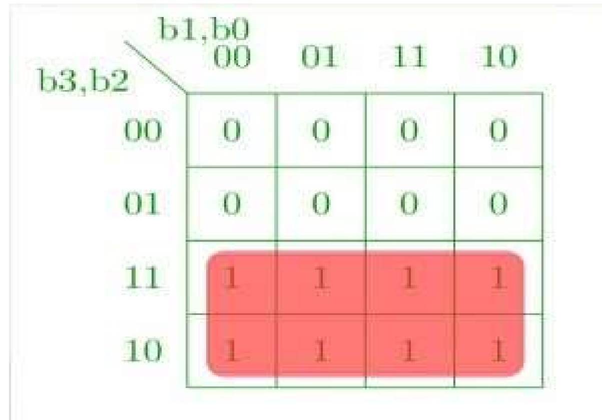
K-map

K-map for g0:

b3,b2 \ b1,b0	00	01	11	10
00	0	1	0	1
01	0	1	0	1
11	0	1	0	1
10	0	1	0	1

K-map for g1:

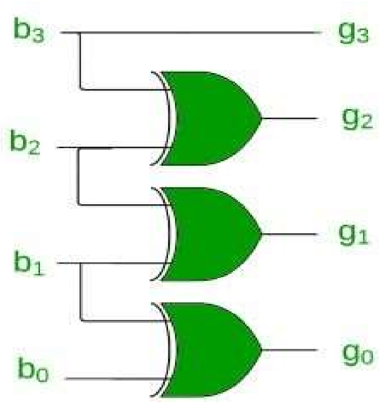
b3,b2 \ b1,b0	00	01	11	10
00	0	0	1	1
01	1	1	0	0
11	1	1	0	0
10	0	0	1	1

K-map for g2:	**K-map for g3:**
	

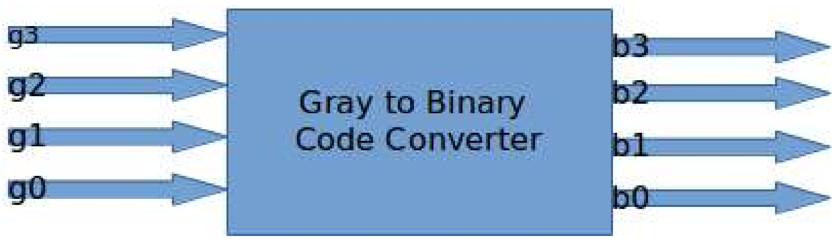
Corresponding minimized boolean expressions for gray code bits –

$$g_0 = b_0 b_1' + b_1 b_0' = b_0 \oplus b_1$$
$$g_1 = b_2 b_1' + b_1 b_2' = b_1 \oplus b_2$$
$$g_2 = b_2 b_3' + b_3 b_2' = b_2 \oplus b_3$$
$$g_3 = b_3$$

Digital circuit



Gray to Binary Code Conversion:



Truth Table:

Gray Code				Binary			
g_3	g_2	g_1	g_0	b_3	b_2	b_1	b_0
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

Kmap:

K-map for b0:

g3,g2 \ g1,g0	00	01	11	10
00	0	1	0	1
01	1	0	1	0
11	0	1	0	1
10	1	0	1	0

K-map for b1:

g3,g2 \ g1,g0	00	01	11	10
00	0	0	1	1
01	1	1	0	0
11	0	0	1	1
10	1	1	0	0

K-map for b2:

g3,g2 \ g1,g0	00	01	11	10
00	0	0	0	0
01	1	1	1	1
11	0	0	0	0
10	1	1	1	1

K-map for b3:

g3,g2 \ g1,g0	00	01	11	10
00	0	0	0	0
01	0	0	0	0
11	1	1	1	1
10	1	1	1	1

Corresponding Boolean expressions

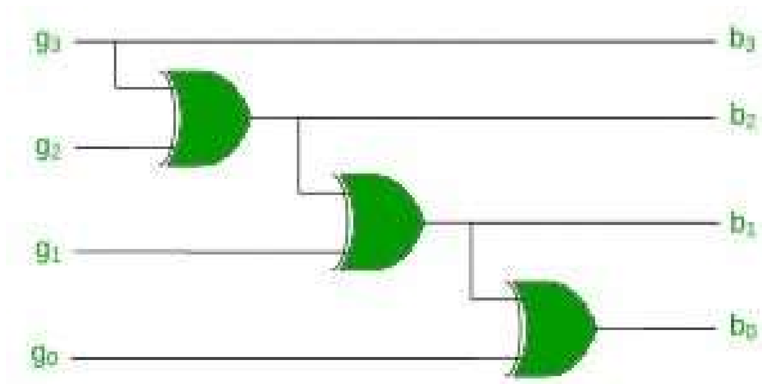
$3=3$

$2=3\oplus2$

$1=3\oplus2\oplus1$

$0=3\oplus2\oplus1\oplus0$

Digital circuit



3) BCD Code:

Binary Coded Decimal (BCD) is used to represent each of decimal digits (0 to 9) with a 4-bit binary code. For example $(23)_{10}$ is represented by 0010 0011 using BCD code rather than$(10111)_2$ This code is also known as 8-4-2-1 code as 8421 indicates the binary weights of four bits(2^3, 2^2, 2^1, 2^0). It is easy to convert between BCD code numbers and the familiar decimal numbers. It is the main advantage of this code. With four bits, sixteen numbers (0000 to 1111) can be represented, but in BCD code only 10 of these are used. The six code combinations (1010 to 1111) are not used and are invalid.

Applications: Some early computers processed BCD numbers. Arithmetic operations can be performed using this code. Input to a digital system may be in natural BCD and output may be 7-segment LEDs. It is observed that more number of bits are required to code a decimal number using BCD code than using the straight binary code. However in spite of this disadvantage it is very convenient and useful code for input and output operations in digital systems.

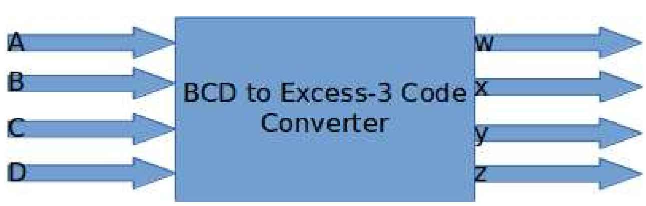
Fig. 3 BCD Coded Decimal Representation

4) EXCESS-3 Code:

Excess-3, also called XS3, is a non weighted code used to express decimal numbers. It can be used for the representation of multi-digit decimal numbers as can BCD.The code for each decimal number is obtained by adding decimal 3 and then converting it to a 4-bit binary number. For e.g. decimal 2 is coded as 0010 + 0011 = 0101 in Excess-3 code.

This is self complementing code which means 1's complement of the coded number yields 9's complement of the number itself. Self complementing property of this helps considerably in performing subtraction operation in digital systems, so this code is used for certain arithmetic operations.

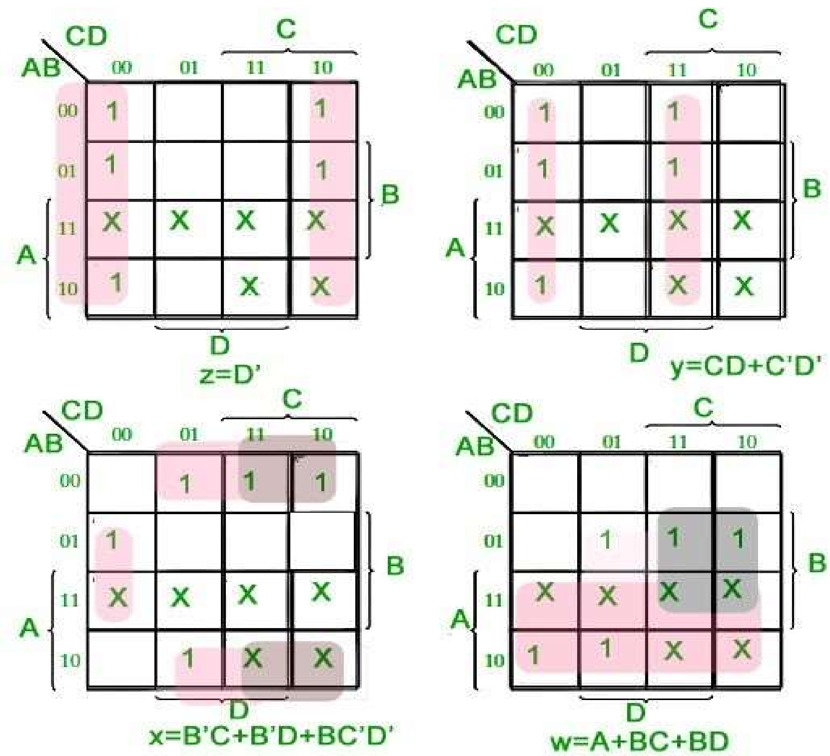
BCD to Excess-3 Code Conversion



Truth Table:

BCD(8421)				Excess-3			
A	B	C	D	w	x	y	z
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

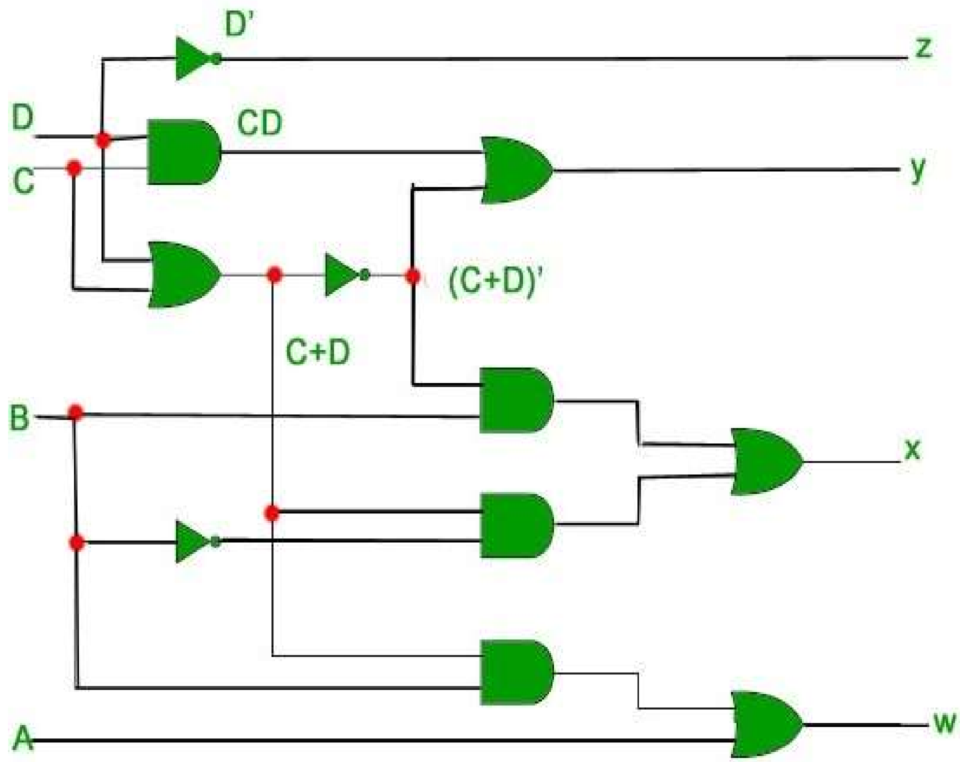
Kmap



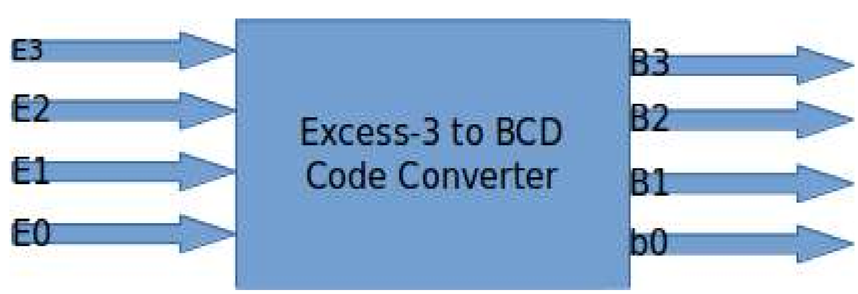
Corresponding Boolean expressions:

$$w = A + BC + BD$$
$$x = B'C + B'D + BC'D'$$
$$y = CD + C'D'$$
$$z = D'$$

Digital Circuit



Excess-3 to BCD code Conversion



Truth Table:

EXCESS-3 INPUT				BCD OUTPUT			
E3	E2	E1	E0	B3	B2	B1	B0
0	0	0	0	X	X	X	X
0	0	0	1	X	X	X	X
0	0	1	0	X	X	X	X
0	0	1	1	0	0	0	0
0	1	0	0	0	0	0	1
0	1	0	1	0	0	1	0
0	1	1	0	0	0	1	1
0	1	1	1	0	1	0	0
1	0	0	0	0	1	0	1
1	0	0	1	0	1	1	0
1	0	1	0	0	1	1	1
1	0	1	1	1	0	0	0
1	1	0	0	1	0	0	1
1	1	0	1	X	X	X	X
1	1	1	0	X	X	X	X
1	1	1	1	X	X	X	X

Kmap

K-map for B3:

E3E2 \ E1E0	00	01	11	10
00	X	X	0	X
01	0	0	0	0
11	1	X	X	X
10	0	0	1	0

B3 = ((E0E1) + E2) E3

K-map for B2:

E3E2 \ E1E0	00	01	11	10
00	X	X	0	X
01	0	0	1	0
11	0	X	X	X
10	1	1	0	1

B2 = $\overline{E2E1}$ + $\overline{E2E0}$ + E2E1E0

K-map for B1:

E3E2 \ E1E0	00	01	11	10
00	X	X	0	X
01	0	1	X	1
11	0	X	X	X
10	X	1	0	1

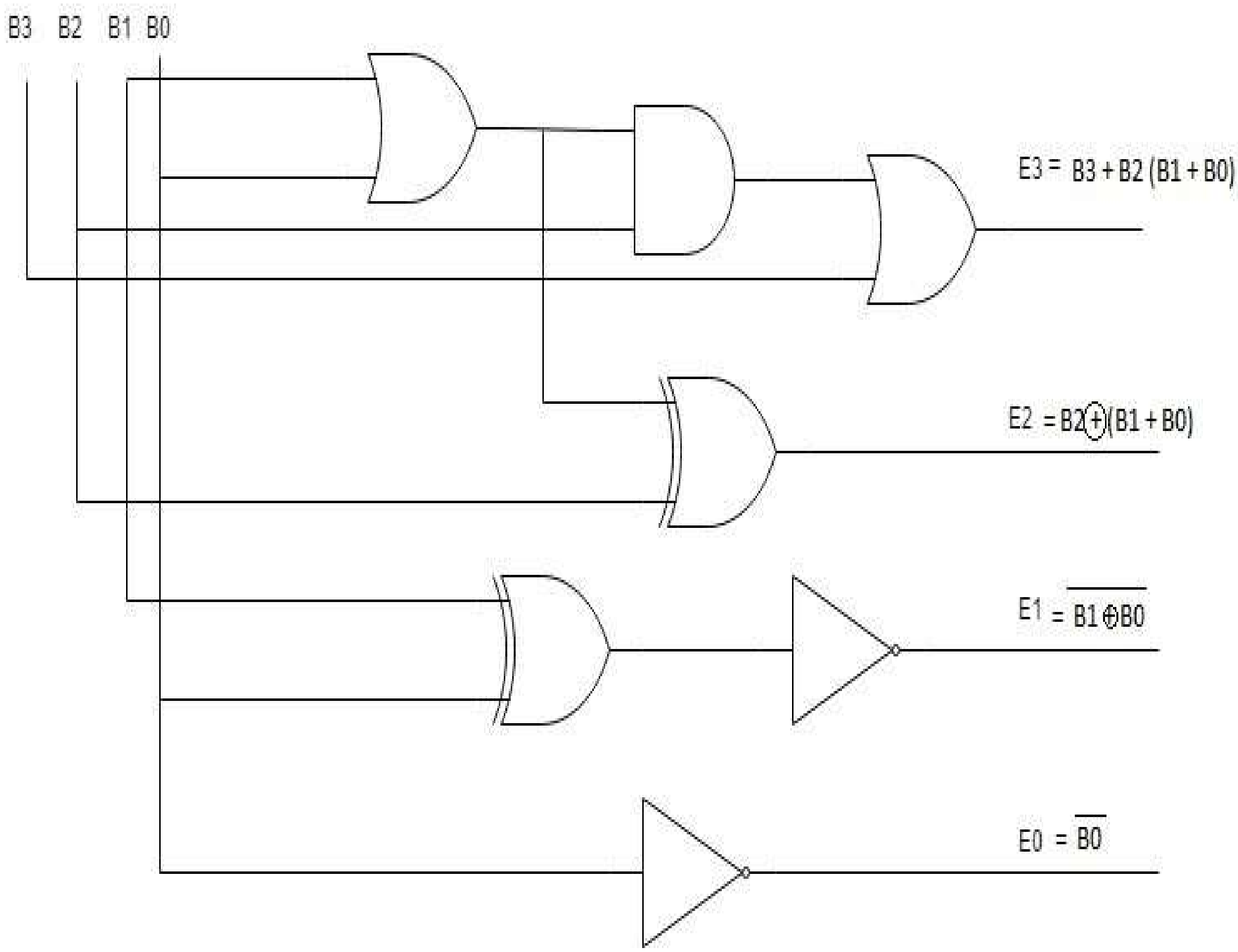
$B1 = E1 \oplus E0$

Kmap for B0:

E3E2 \ E1E0	00	01	11	10
00	X	X	0	X
01	1	0	0	1
11	1	X	X	X
10	1	0	0	1

$B0 = \overline{E0}$

Digital circuit



QUESTIONS:

1. What is difference between binary to BCD number syatem?
2. What are properties of Gray code?
3. What are properties of Excess-3 code?
4. What is non-weighted code?
5. Whay gray code called unit distance code?
6. Applications of Gray code.