Quaid-e-Awam University of Engineering, Science and Technology

بسم الله الرحمن الرحيم

In the name of Allah, the Most Merciful, the Most Kind

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BCS 103
Digital Logic & Computer Architecture

Lecture 7 and 8

Department of Computer Science

IN THE LAST LECTURE

Classification of binary codes

The codes are broadly categorized into following four categories.

- **Weighted Codes**
  - BCD (8421)
  - 6311
  - 2421
  - 642-3
  - 84-2-1

Done

- **Non-Weighted Codes**
  - Excess-3 Codes
  - Gray Codes
- **Alphanumeric Codes**
  - ASCII
  - EBCDIC
- **Error Detecting Codes (Parity)**

Today

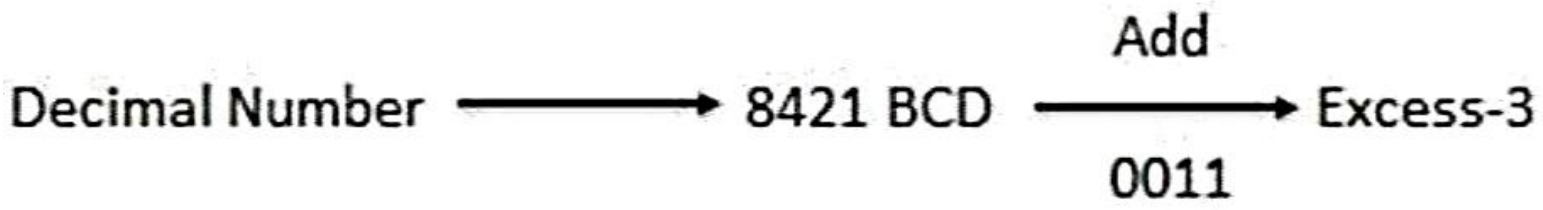
Non-Weighted Codes

In this type of binary codes, the positional weights are not assigned. The examples of non-weighted codes are:

- Excess-3 codes
- Gray codes

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,



Excess-3 code

Decimal	BCD 8 4 2 1	Excess-3 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

Advantage: This code has a vital role in arithmetic operations. It is because it resolves deficiencies which are encountered when we use the 8421 BCD code for adding two decimal digits whose sum is greater than 9.

Excess-3 code

Example-1 –**Convert decimal number 23 to Excess-3 code.**

So, according to excess-3 code we need to add 3 to both digit in the decimal number then convert into 4-bit binary number for result of each digit. Therefore,

= 23+33=56 =0101 0110 which is required excess-3 code for given decimal number 23.

Excess-3 code

Example-2 −**Convert decimal number 15.46 into Excess-3 code.**

According to excess-3 code we need to add 3 to both digit in the decimal number then convert into 4-bit binary number for result of each digit. Therefore,

= 15.46+33.33=48.79 =0100 1000.0111 1001 which is required excess-3 code for given decimal number 15.46.

Exercise

Convert BCD to Excess-3 Codes.

	BCD	Excess-3
1.	1010	
2.	1100	
3.	1011	
4.	1111	

Gray Codes

It is the non-weighted code and it is not arithmetic codes. That means there are no specific weights assigned to the bit position. It has a very special feature that, only one bit will change each time the decimal number is incremented. 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. Gray code cannot be used for arithmetic operation.

Gray Codes

The reflected binary code (RBC) or Gray code after Frank Gray, is an ordering of the binary numeral system such that two successive values differ in only one bit (binary digit).

For example, the representation of the decimal value "1" in binary would normally be "001" and "2" would be "010".

In Gray code, these values are represented as "001" and "011". That way, incrementing a value from 1 to 2 requires only one bit to change, instead of two.

Application of Gray code

- Gray codes are widely used to prevent spurious output from electromechanical switches
- To facilitate error correction in digital communications such as digital television and some cable TV systems.
- Gray code is popularly used in the shaft position encoders.

XOR Gate

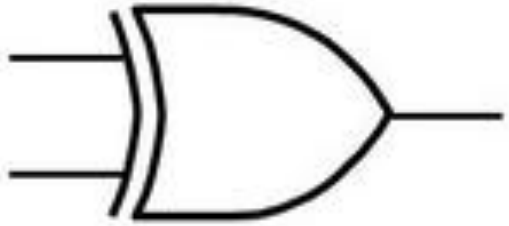
Truth Table

XOR

X	Y	X ⊕ Y
0	0	0
0	1	1
1	0	1
1	1	0

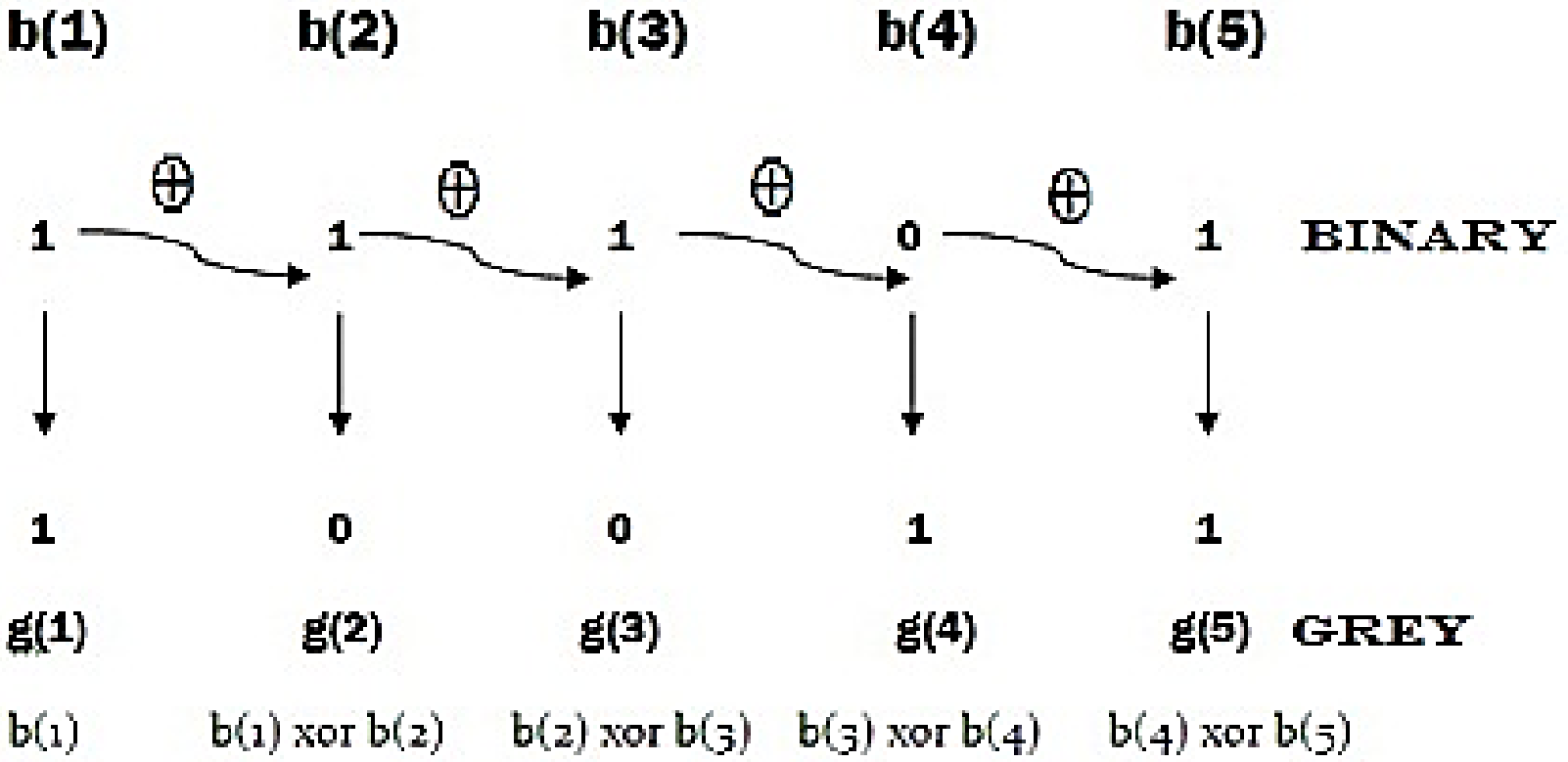
Exclusive OR (XOR)

XOR Symbol



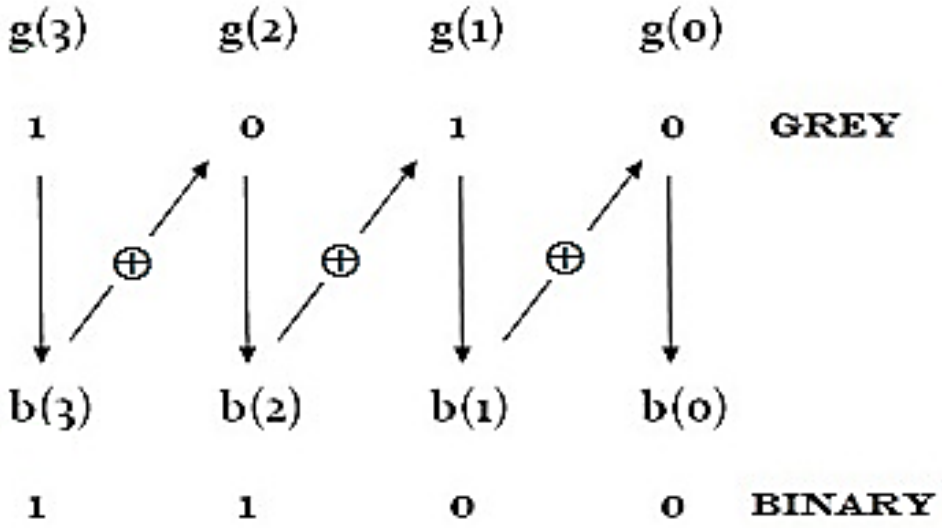
Binary to Grey Code Conversion

Convert the binary 11101_2 to its equivalent Grey code



Grey Code to Binary Conversion

Convert the Grey code 1010 to its equivalent Binary



i.e $b(3) = g(3)$

$b(2) = b(3) \oplus g(2)$

$b(1) = b(2) \oplus g(1)$

$b(0) = b(1) \oplus g(0)$

Gray Codes

Convert from Binary to Gray code

Decimal	Binary	Gray Code
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

Do your self

Thanks