Digital Systems
18B11EC213

Module 1: Boolean Function Minimization Techniques and Combinational Circuits-5

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Codes

- Computers and other digital circuits process data in the binary formats.
- Various binary codes are used to represent data which may be numeric, alphabets or special characters.
- A user should be very careful about the codes being used while interpreting information available in the binary format.

Cont..

- Commonly Used Codes:

- ❑ Straight Binary Code
- ❑ Binary Coded Decimal (BCD)
- ❑ Excess-3 Code
- ❑ Gray Code
- ❑ Hexadecimal Code
- ❑ Octal Code
- ❑ Alphanumeric Codes

Cont..

- Straight Binary Code

❖ This code is used to represent numbers using natural (straight) binary form as discussed earlier.

Example:

The straight binary code (representation) of $(65)_{10}$ is 1000001

Cont..

- Binary Coded Decimal (BCD)

❖ In this code, each digit of a decimal number (0 to 9) is represented by its 4-bit binary equivalent.

❖ It is a weighted code.

❖ The weights in the BCD code are 8, 4, 2, 1. Therefore, it is also known as 8421 code.

Examples:

$(23)_{10} = (0010\ 0011)_{BCD}$

$(921)_{10} = (1001\ 0010\ 0001)_{BCD}$

$(25.89)_{10} = (0010\ 0101.1000\ 1001)_{BCD}$

Cont..

Representation of $(185)_{10}$ in BCD and straight Binary forms:

$(185)_{10} = (0001\ 1000\ 0101)_{BCD}$

$= (10111001)_2$

The BCD representation of $(185)_{10}$ has 12 bits, but the straight binary code needs only 8 bits.

Cont..

- Excess-3 Code

❖ This code is obtained from the corresponding value of BCD code by adding three to each coded number.

❖ It is not a weighted code.

❖ The code is self complementing in nature, i.e., 1’s complement of the coded number yields 9’s complement of the number itself.

Cont..

Example-1:

$(5)_{10}$ is coded as 0101 + 0011 = 1000 in excess-3 code.

$\Rightarrow (5)_{10} = (1000)_{\text{Excess-3}}$

Example-2:

$(39)_{10} = (0110\ 1100)_{\text{Excess-3}}$

Example-3:

$(395)_{10} = (0110\ 1100\ 1000)_{\text{Excess-3}}$

Cont..

Example-4: Self complementing property

$(34)_{10} = (0110\ 0111)_{Excess\text{-}3}$

1's complement of the coded number $(0110\ 0111)_{Excess\text{-}3}$ is $(1001\ 1000)_{Excess\text{-}3}$

9's complement of the given number $(34)_{10}$ is $(65)_{10}$, which has the Excess-3 code representation as

$(1001\ 1000)_{Excess\text{-}3}$

Cont..

- Gray Code

❖ In gray code, each number differs from its preceding and succeeding numbers by only one bit.

❖ It is not a weighted code.

Cont..

Decimal number	Binary code	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

Cont..

- Binary to Gray Code Conversion

- Start with the most significant bit (MSB) of the binary number. The MSB in the gray code is the same as corresponding digit in binary number.
- Starting from MSB to LSB, perform XOR operation between each adjacent pair of binary digits to get the next gray code digit.

0 XOR 0 = 0

0 XOR 1 = 1

1 XOR 0 = 1

1 XOR 1 = 0

Cont..

Example-1:

$(5)_{10} = (101)_2$

101	Binary code
111	Gray code

Example-2: Convert $(101110)_2$ to gray code.

101110	Binary code
111001	Gray code

Cont..

➢ Gray to Binary Code Conversion

- The MSB in the binary code is the same as the corresponding digit in the gray code.
- Perform the XOR operation between the generated binary digit and the next significant bit of the gray code.

Cont..

Example: Convert the gray code 100101 to binary.

100101	Gray code
111001	Binary code

Cont..

- Hexadecimal Code

Example: Represent $(27)_{10}$ in hexadecimal code.

$(27)_{10} = (11011)_2$

Make the group of 4 bits from RHS.

Hexadecimal code is 0001 1011

Cont..

- Octal Code

Example: Represent $(27)_{10}$ in octal code.

$(27)_{10} = (11011)_2$

Make the group of 3 bits from RHS.

Octal code is 011 011

Cont..

- Alphanumeric Codes

- In many situations, digital systems are required to handle data that may consist of numerals, letters and special characters.
- If we use an n-bit binary code, we can represent 2^n elements using this code, therefore to represent 10 digits 0 to 9 and 26 alphabets A to Z, we need a minimum of 6 bits ($2^6 = 64$).
- Frequently, there is a need to represent more than 64 characters, including the lower case letters and the special control characters for the transmission of the digital information.

Cont..

- ❖ The American Standard Code for Information Interchange (ASCII) is a well-known alphanumeric code.
- ➢ Details of ASCII Code:
- The ASCII code uses 7 bits to code 128 characters.
- It contains 94 graphic characters that can be printed:
  26 upper case letters (A to Z)
  26 lower case letters (a to z)
  10 numerals (0 to 9)
  32 special printable characters (such as %, *, $)
- Also contains 34 non-printing characters used for various control functions (such as NUL, SOH, STX)
- The control characters are used for routing data and arranging the printed text into a prescribed format.

References

- M. M. Mano, *Digital Logic and Computer Design*, 5th ed., Pearson Prentice Hall, 2013.
- R. P. Jain, *Modern Digital Electronics*, 4th ed., Tata McGraw-Hill Education, 2009.