EEE251

Logic Design and Circuits

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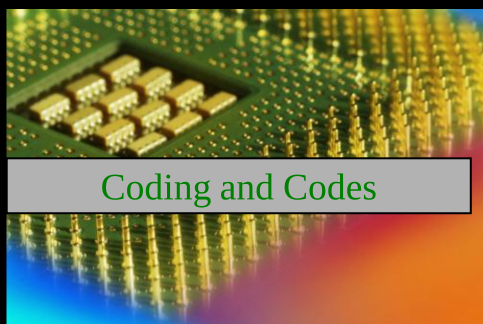

Coding and Codes

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Outline

- Numerical Codes
  - BCD Code (Binary Coded Decimal Code) - 8421 Code
  - Gray Code
  - Excess 3
  - 2 out of 5 Code
  - Parity Code
  - Aiken Code
  - Bar Code
- Alphanumeric Codes
  - ASCII Code
  - EBCDIC Code

Introduction

- Exchange process of visible, readable text, numbers and signs is called 'coding'
- 'Morse alphabet is a good example of coding.
- Coding process, can contain decimal numbers (0, 1, 2,...., 9) as well as alphabetic and alphanumeric information

Coding types and Benefits

- The advantages of coding :
  - Convenience of arithmetic calculations
  - Convenience of finding errors
  - Simplicity of correcting errors
  - Increase efficiency of memory porcesses
  - Convenience of understanding of information process
- If the codes are result of only numeric characters they are called **'numerical codes'** and if the codes are result of alphabetic and numeric characters they are called **'alphanumerical codes'**

Numeric Codes

- Coding System consisting of conversion of a decimal number into binary number system is called **'pure binary coding'**
- Examples of numeric Code Systems;
  - i- BCD code,
  - ii- Gray code,
  - iii- +3 code,
  - iv- Aiken code,
  - v- 2 out of 5 code,
  - vi- Bar code,

BCD Code (Binary Coded Decimal Code) - 8421 Code

- Coding system which every digit of decimal number represented by 4 digit in binary number system is called **'Binary Coded Decimal Code'** ismi verilir.
- **Example 1:** $(263)_{10} = (\qquad)_{BCD}$
- 2 6 3
- 0010 0110 0011
- $(263)_{10} = (001001100011)_{BCD}$
- Note: Be aware that it's not the representation of decimal number in binary number system

BCD Code (Binary Coded Decimal Code) - 8421 Code

- **Example :** $(\underline{1001}\ 0\underline{011}\ 0\underline{110})_{BCD} = (\quad)_{10}$

  – $(1001\ 0011\ 0110)_{BCD}$
- 9 3 6
- Then
  - » $(100100110110)_{BCD} = (936)_{10}$ is found

BCD Code (Binary Coded Decimal Code) - 8421 Code

- **Example :** $(\underline{1001}\ 0\underline{011}\ 0\underline{110})_{BCD} = (\quad)_{10}$

  – $(1001\ 0011\ 0110)_{BCD}$
- 9 3 6
- Is found. Then… ;
  - » $(100100110110)_{BCD} = (936)_{10}$

Gray Code

- Gray encoding method is a non-digit weight method of encoding
- It's impossible to use this method for arithmetic calculation because this coding method is a non-digit weight method
- It's mosly used for input/output units and Analog/digital converters

Summary

Gray code

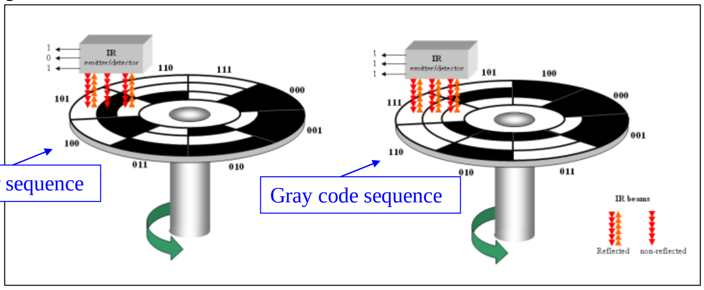
Gray code is an unweighted code that has a single bit change between one code word and the next in a sequence. Gray code is used to avoid problems in systems where an error can occur if more than one bit changes at a time.

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

Summary

Gray code

A shaft encoder is a typical application. Three IR emitter/detectors are used to encode the position of the shaft. The encoder on the left uses binary and can have three bits change together, creating a potential error. The encoder on the right uses gray code and only 1-bit changes, eliminating potential errors.



Conversion of Binary Numbers into Gray Coded Numbers

- To convert a binary number in the form of Gray-coded number, it's assumed there is a zero on the left of the highest bit and every bit is added to the next one and written
- This process continuoes until all digits are finished. Resulting number is Gray Coded number.
- **Example :** $(101110101)_2$ = ($)_{Gray}$
- 0 1 0 1 1 1 0 1 0 1 ___Binary Number
- Başlama biti
- 1 1 1 0 0 1 1 1 1 Gray coded Number
- The answer is;
- $(101110101)_2 = (111001111)_{Gray}$

Conversion of Binary Numbers into Gray Coded Numbers

- **Example :** $(1000101)_2$ = ($)_{Gray}$
- 0 1 0 0 0 1 0 1 Binary Number
-
- 1 1 0 0 1 1 1 Gray coded Number
- The answer is;
- $(1000101)_2 = (1100111)_{Gray}$

- **Example :** $(101110101)_2$ = ($)_{Gray}$
- 0 1 0 1 1 1 0 1 0 1 Binary Number
-
- 1 1 1 0 0 1 1 1 1 Gray coded Number
- The answer is;
- $(101110101)_2 = (111001111)_{Gray}$

Conversion of Gray Coded Numbers Into Binary Numbers

- To convert a Gray-coded number in the form of a binary number system, the digit at far left is taken to down and added to next bit. Resulting number is also added to the next bit and it goes on for every bit.

- **Example :** $(111001111)_{GRAY}$ = ($)_2$

- 1 1 1 0 0 1 1 1 1 Gray coded Number
- 1 0 1 1 1 0 1 0 1 binary Number
- The answer is;
- $(111001111)_{GRAY} = (101110101)_2$

Conversion of Gray Coded Numbers Into Binary Numbers

- **Example :** $(1100111)_{GRAY} = (\quad)_2$

1	1	0	0	1	1	1	Gray coded Number
1	0	0	0	1	0	1	binary Number

The answer is;

$(1100111)_{GRAY} = (1000101)_2$.

Conversion of Gray Coded Numbers Into Binary Numbers

- **Example :** $(111001111)_{GRAY} = (\quad)_2$

1	1	1	0	0	1	1	1	1	Gray coded Number
1	0	1	1	1	0	1	0	1	binary Number

The answer is;

$(111001111)_{GRAY} = (101110101)_2$.

Excess 3 Code:

- +3 code, is related to BCD code and used for certain artihmetic calculations for it's convenience instead of the BCD code
- The equivalent of a decimal number in +3 code system is found by adding 3 to it's digits' binary equivalent.
- **Example :** $(48)_{10} = (\quad)_{+3}$
- 4 8
- + 3 + 3
- 7 11
- 0111 1011
- $(48)_{10}=(01111011)_{+3}$

+3 Code

Example : $(10100110)_{+3} = (\quad)_{10}$

$(10100110)_{+3}$ 1010 0110 = $(10\ 6)_{+3}$

Then subtract 3 from each digit;

$$\begin{array}{rr} 10 & 6 \\ -\ 3 & -\ 3 \\ \hline 7 & 3 \end{array}$$

$(73)_{10}$

$(10100110)_{+3}=(73)_{10}$

+3 Code

Example : $(10100110)_{+3} = (\quad)_{10}$

$(10100110)_{+3}$ 1010 0110 = $(10\ \ 6)_{+3}$

$$\begin{array}{r} 10 \\ -\ 3 \\ \hline 7 \end{array} \qquad \begin{array}{r} 6 \\ -\ 3 \\ \hline 3 \end{array}$$

$(73)_{10}$,

$(10100110)_{+3}=(73)_{10}$

2 out of 5 Code

- Decimal numbers represented by 5 bit binary number where there is allways 2 ones in it
- Digit weights are '7 4 2 1 0'

Desimal Sayı	5'te 2 Kodlu Sayı
	7 4 2 1 0
0	1 1 0 0 0
1	0 0 0 1 1
2	0 0 1 0 1
3	0 0 1 1 0
4	0 1 0 0 1
5	0 1 0 1 0
6	0 1 1 0 0
7	1 0 0 0 1
8	1 0 0 1 0
9	1 0 1 0 0

2 out of 5 Code

Example : $(6)_{10} = (\quad)_{2\text{ out of }5}$

$(6)_{10} = (01100)_{2\text{ out of }5}$

Example : $(0101010100)_{2\text{ out of }5} = (\quad)_{10}$

(01010 10100)

5 9

Then, $(0101010100)_{2\text{ out of }5} = (59)_{10}$ is found

Parity Code

- Transportation of information in binary number system is a frequently encountered phenomenon
- During the transportation, sometimes noise occurs and distorts the information
- The most common and easiest method to detect errors is **parity code method**
- In this method in order to detect errors parity bit is added to BCD coded number to it's right or left side

Parity Code

- Parity bit indicates that whether ones and zeros even or odd
- There are two types of parity bits: **even parity and odd parity**
- **Even parity;** the value of parity bit is selected to make total of ones even (including parity bit)
- If the total of ones is odd then ‘1’ is added as parity bit
- If the total of ones is eve then ‘0’ is added as parity bit

Even Parity Code

Example : Add even parity bit to $(1000011)_2$

In the given number (1000011) total of ‘1’ is odd. To make it even we have to add ‘1’ as parity bit

The answer is;

(**1**1000011)

Example : Add even parity bit to $(1000001)_2$

In the given number total of ‘1’ is even. To keep it even we have to add ‘0’ as parity bit

‘**0**1000001’

Odd Parity Code

- **Odd parity code;** same logic is valid for this method as well. The only difference is that the total of ones in coded information should be odd

Example : Add odd parity bit to $(1000001)_2$

'1000001' Total number of '1' is even. To make it odd we have to add '1' as parity bit

'**1**1000001'

Example : Add odd parity bit to $(1000011)_2$

Total number of '1' is odd. To keep it odd we have to add '0' as parity bit;
'**0**1000011'

Summary

Parity Method

The parity method is a method of error detection for simple transmission errors involving one bit (or an odd number of bits). A parity bit is an "extra" bit attached to a group of bits to force the number of 1's to be either even (even parity) or odd (odd parity).

Example The ASCII character for "a" is 1100001 and for "A" is 1000001. What is the correct bit to append to make both of these have odd parity?

Solution The ASCII "a" has an odd number of bits that are equal to 1; therefore the parity bit is 0. The ASCII "A" has an even number of bits that are equal to 1; therefore the parity bit is 1.

Summary

ASCII

ASCII is a code for alphanumeric characters and control characters. In its original form, ASCII encoded 128 characters and symbols using 7-bits. The first 32 characters are control characters, that are based on obsolete teletype requirements, so these characters are generally assigned to other functions in modern usage.

In 1981, IBM introduced extended ASCII, which is an 8-bit code and increased the character set to 256. Other extended sets (such as Unicode) have been introduced to handle characters in languages other than English.

ASCII Code

Example: What is the meaning of the binary coded ASCII message below?

1001000 1000101 100110 1010000

Find the hexadecimal equivalent of each 7 bit

48 45 4C 50

Find the characters from the table;

48=H, 45=E, 4C=L, 50=P

The answer is, HELP

ASCII Code

Example: Find ASCII code information for word **'DIGITAL'**.

D = 100 0100
I = 100 1001
G = 100 0111
I = 100 1001
T = 100 0100
A = 100 0001
L = 100 1100

Selected Key Terms

Alphanumeric Consisting of numerals, letters, and other characters

ASCII American Standard Code for Information Interchange; the most widely used alphanumeric code.

Parity In relation to binary codes, the condition of evenness or oddness in the number of 1s in a code group.

Quiz

1. An example of an unweighted code is

   a. binary

   b. decimal

   c. BCD

   d. Gray code

Quiz

2. An example of an alphanumeric code is

   a. hexadecimal

   b. ASCII

   c. BCD

   d. CRC

Quiz

3. An example of an error detection method for transmitted data is the

a. parity check

b. CRC

c. both of the above

d. none of the above