Digital System Design

Lecture 5

Binary Codes

Objectives:

1. **Binary codes types.**
2. **BCD code (8421 code).**
3. **Alphanumeric codes.**
4. **Excess-3 and Gray code.**
5. **Parity method for error detection.**

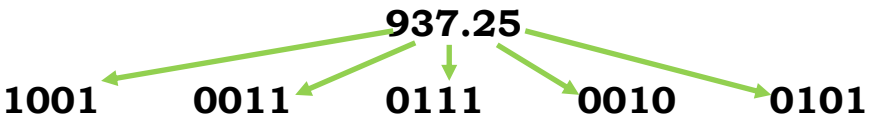
1. Binary codes types:

- ✓ **Weighted codes**
  - BCD (8421)
  - 6311
  - 2421
  - 642-3
  - 84-2-1
- ✓ **Non_ Weighted codes**
  - Excess-3
  - Gray
- ✓ **Alphanumeric codes.**
  - EBCDIC
  - ASCII
- ✓ **Error detection codes (Parity).**
  - ➢ Weighted codes and non-weighted codes are used to represent the ***decimal numbers***.
  - ➢ Alphanumeric codes are used to represent the ***numeric and nonnumeric data (characters)***.
  - ➢ Error detection codes are used to ***detect the errors during the data transmission.***
  - ➢ Weighted codes use ***4 binary digits to represent (0-9) decimal numbers.***

2. BCD code (8421 code)

- ***Simplest form***: each decimal digit is replaced by its binary equivalent.

Example1: 937.25 is represented by



(937.25)= $(1001\,0011\,0111.0010\,0101)_{BCD}$

- This representation is referred to as ***"Binary-Coded-Decimal"*: BCD** or more explicitly as **8-4-2-1(8421 code).**

> Note:
> The result is quite different than that obtained by converting the number as a whole into binary.

Example 2:

854_{10} = $100001010100_{(BCD)}$

- BCD is ***inefficient,*** e.g. to represent **999** and **999999** bits needed:
  - **10 and 20 in binary numbers**
  - **12 and 24 for BCD code.**

Decimal numbers	8421(BCD)	6311	642-3
0	0000	0000	0000
1	0001	0001	0101
2	0010	0011	0010
3	0011	0100	1001
4	0100	0101	0100
5	0101	0111	1011
6	0110	1000	0110
7	0111	1001	1101
8	1000	1011	1010
9	1001	1100	1111

Example 3: convert 0110100000111001(BCD) to its decimal equivalent.

Solution:

Divide the BCD number into four-bit groups and convert each to decimal:

0110 1000 0011 1001

↓ ↓ ↓ ↓

6 8 3 9

0110100000111001(BCD) = 6839_{10}

- BCD is used in interfacing between a digit device and a human being, e.g. digital voltmeter (DVM).

Example 4: Convert the following decimal and binary numbers to BCD.

a) 5648_{10}
b) 10001101_2

Solution:

a) 5648_{10} =0101 0110 0100 1000
b) 10001101_2=141_{10}=**0001 0100 0001**

Example 5: convert the BCD number 011111000001 to its decimal equivalent.

$0111\ 1100\ 0001_{BCD}$ = error

↓

Doesn't exist in the BCD Code

3. Alphanumeric codes

- ✓ A complete alphanumeric code would include the ***26 lowercase characters, 26 uppercase characters, 10 numeric digits, etc.***
- ✓ There are ***many choices of codes sets*** to represent alphanumeric characters and several control characters.
- ✓ ***Two*** well accepted code sets are used for information coding:
  - **EBCDIC code: *extended binary coded decimal interchange code.***
  - **ASCII Code: *American standard code for information interchange:*** The ASCII code is a ***seven-bit code***, and so it has 2^7 =128 possible code groups.

Example: Write the ASCII code for the message: The email is

Answer:

1010100 1101000 1100101 1100101 1101101 1100001 1101001 1101100 1101001 1110011

Character	ASCII	EBCDIC	Character	ASCII	EBCDIC
Space	010 0000	0100 0000	A	100 0001	1100 0001
!	010 0001	0101 1010	B	100 0010	1100 0010
"	010 0010	0111 1111	C	100 0011	1100 0011
#	010 0011	0111 1011	D	100 0100	1100 0100
$	010 0100	0101 1011	E	100 0101	1100 0101
%	010 0101	0110 1100	F	100 0110	1100 0110
&	010 0110	0101 0000	G	100 0111	1100 0111
'	010 0111	0111 1101	H	100 1000	1100 1000
(	010 1000	0100 1101	I	100 1001	1100 1001
)	010 1001	0101 1101	J	100 1010	1101 0001
*	010 1010	0101 1100	K	100 1011	1101 0010
+	010 1011	0100 1110	L	100 1100	1101 0011
,	010 1100	0110 1011	M	100 1101	1101 0100
-	010 1101	0110 0000	N	100 1110	1101 0101
.	010 1110	0100 1011	O	100 1111	1101 0110
/	010 1111	0110 0001	P	101 0000	1101 0111
0	011 0000	1111 0000	Q	101 0001	1101 1000
1	011 0001	1111 0001	R	101 0010	1101 1001
2	011 0010	1111 0010	S	101 0011	1110 0010
3	011 0011	1111 0011	T	101 0100	1110 0011
4	011 0100	1111 0100	U	101 0101	1110 0100
5	011 0101	1111 0101	V	101 0110	1110 0101
6	011 0110	1111 0110	W	101 0111	1110 0110
7	011 0111	1111 0111	X	101 1000	1110 0111
8	011 1000	1111 1000	Y	101 1001	1110 1000
9	011 1001	1111 1001	Z	101 1010	1110 1001

Alphanumeric codes: ASCII and EBCDIC Codes