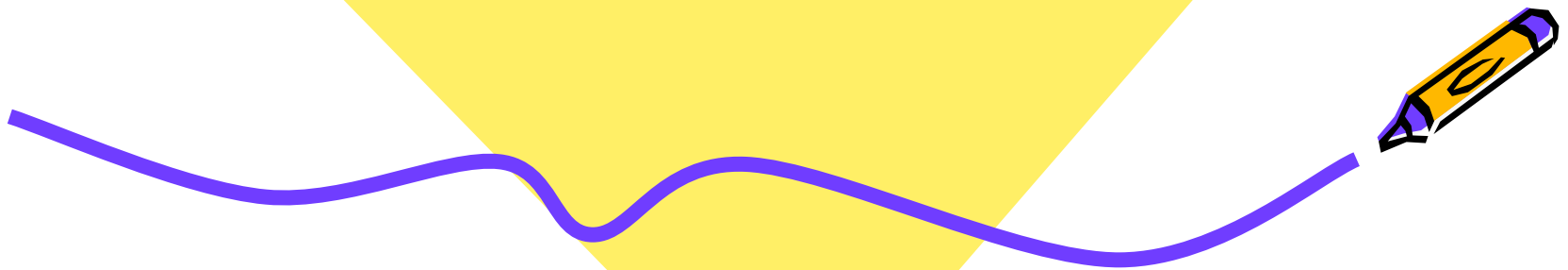# Logical Design

CS 221

Prof.Dr. Mohamed Osama Khozium

Binary Tools

Computers deals with the binary systems

through some tools (codes)….
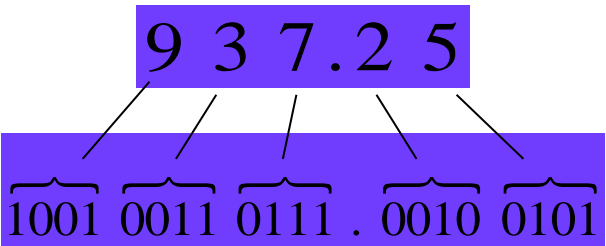
For examples BCD, Gray, and excess-3 code

We will discuss these three codes in the

following slides

Binary Codes

9 3 7 . 2 5

1001 0011 0111 . 0010 0101

Decimal Digit	8-4-2-1 Code (BCD)	Gray Code	Excees-3 Code
0	0000	0000	0011
1	0001	0001	0100
2	0010	0011	0101
3	0011	0010	0110
4	0100	0110	0111
5	0101	1110	1000
6	0110	1010	1001
7	0111	1011	1010
8	1000	1001	1011
9	1001	1000	1100

BCD (binary coded decimal)

Decimal Digit	8-4-2-1 Code (BCD)
0	0000
1	0001
2	0010
3	0011
4	0100
5	0101
6	0110
7	0111
8	1000
9	1001

BCD conversion

- Code = 4 bit
- No of combination = 2^4 = 16

Ex 1 : convert each of the following decimal to BCD code :

a) 35   b) 98   c) 170   d) 2469

BCD conversion

Solution

a) 35   3   5

          0011   0101

Then   35 →   00110101

b) 98   9   8

          1001   1000

Then   98 →   10011000

BCD conversion

c) 170   1   7   0

           0001   0111   0000

Then 170 → 000101110000

d) 2469   2   4   6   9

           0010   0100   0110   1001

Then 2469 → 0010010001101001

BCD conversion

Ex2 Convert each of the following BCD code to decimal :

a) 10000110   b) 001101010001

c) 10010100 01110000

Solution

a) Start from right and group each four digits

1000   0110

8   6

Then 10000110 → 86

BCD conversion

b) 001101010001

0011	0101	0001	
3	5	1	$\rightarrow$ 351

c) 1001   0100   0111   0000

    9   4   7   0

$\rightarrow$ 9470

BCD addition

1 – use binary addition rules

2 – if the 4-bit sum is greater than 9 then it is not a BCD valid number ....add 6(0110) to the 4-bit sum.

BCD addition

Add the following BCD numbers
a) 0011 + 0100
b) 001000111 + 00010101
c) 1001 + 0100
d) 00010110 + 00010101
e) 01100111 + 01010011

BCD addition

Solutions

a) $0011 \rightarrow$ 3

   + $0100 \rightarrow$ 4

_____

     $0111 \rightarrow$ 7

b) $00100011 \rightarrow$ 2 3

   + $00010101 \rightarrow$ 1 5

_____

    $00111000 \rightarrow$ 38   (each number < 9)

BCD addition

Solutions

c)   1001 →   9
  + 0100 →   4
_____

     1101 →   13 → invalid BCD number > 9
  + 0110 →   Add 6 (0110)

_____

     10011 →   0001 10011 → 13 in BCD

BCD addition

Solutions

d)   00010110 →   1   6

　　+ 00010101 →   1   5   6+5 = 11 > 9

_____

　　　00101011 →   1011 > 9 then add 6(0110)

　+　　　0110 →   Add 6 (0110)

_____

　　　00110001 →   0011 00001 → 31 in BCD

BCD addition

Solutions

e)   01100111 →   6 7

   + 01010011 →   5 3   6+5 = 11 > 9 & 7+3 > 9

_____

     1011 1010 →   1011 > 9 then add 6(0110)

  + 0110 0110 →   Add 6 (0110) & 6(0110)

_____

  1 0010 0000 →   0001 0010 0000→ 120

Gray Code

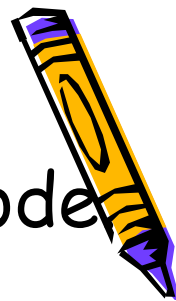| Decimal Digit	8-4-2-1 Code (BCD)	Gray Code
0	0000	0000
1	0001	0001
2	0010	0011
3	0011	0010
4	0100	0110
5	0101	1110
6	0110	1010
7	0111	1011
8	1000	1001
9	1001	1000

Gray Code

It is unweighted code and it is not arithmetic code

Binary to Gray Code

Convert the binary number 11000110 to Gray code

Sol.

Binary   1 + 1 + 0 + 0 + 0 + 1 + 1 + 0

                 ↓   ↓   ↓   ↓   ↓   ↓   ↓   ↓

Gray   1   0   1   0   0   1   0   1

Shortcut

The first number will be the same…the second number in gray = first + second in binary……… the third in gray = second + third in binary and go on …neglect carry.

Gray Code to binary

Convert the gray code number 10100101 to binary.

Sol.

Gray   1   0   1   0   0   1   0   1

           ↓   ↓   ↓   ↓   ↓   ↓   ↓   ↓

Binary   1 +0= 1 +1= 0+0= 0   0   1   1   0

Shortcut

The first number will be the same…the second number in binary = first (binary) + second (gray).. the third in binary = second (binary)+ third (gray) and go on …neglect carry.

Excess – 3 code

It is a digital code related to BCD derived by adding 3 to each decimal digit ...then converting the result to 4-bit binary ..

It is unweighted code.

Excess – 3 code

Convert each of the following decimal numbers to excess-3 code. a) 13 b) 430

a)   1   3

      + 3 + 3

      ‾‾‾‾‾‾‾‾
         4   6

      0100 0110 → excess-3 code

Excess – 3 code

a)

	4	3	0
+	3	+ 3	+ 3

$$\overline{}$$

	7	6	3

0111 0110 0011 → excess-3 code

Thank you

THANKS