Unit 1 Fundamentals of Digital Systems and logic families

→ Number System & Codes ?

1. Binary Number System
2. Decimal Number System
3. Octal Number System
4. Hexadecimal Number System

1. Binary Number System :-

Base = 2 OR Radix r = 2

0 to (r - 1) 0 to (2 - 1) 0 to 1 = 2 digits

2. Decimal Number System :-

Base = 10 OR Radix r = 10

0 to (r - 1) 0 to (10 - 1) 0 to 9 = 10 digits

3. Octal Number System :-

Base = 8 OR Radix r = 8

0 to (r - 1) 0 to (8 - 1) 0 to 7 = 8 digits

4. Hexadecimal Number System :-

Base = 16 OR Radix r = 16

0 to (r - 1) 0 to (16 - 1) 0 to 9, A, B, C, D, E, F = 16 digits

$\Rightarrow$ Binary Number System :-

$$\begin{array}{ccccccccc} & & 0 & 1 & 0 & 0 & 1 & \leftarrow & \text{Position} \\ & & \uparrow & \uparrow & \uparrow & \uparrow & \uparrow & & \\ 2^n & \dots & 2^4 & 2^3 & 2^2 & 2^1 & 2^0 & \leftarrow & \text{Weight} \end{array}$$

$0 \times 2^4 + 1 \times 2^3 + 0 \times 2^2 + 0 \times 2^1 + 1 \times 2^0$

$0 + 8 + 0 + 0 + 1$

9 Ans

* Binary to Decimal :-

1. $(10110)_2 \rightarrow (22)_{10}$

Ans $(1 \times 2^4) + (0 \times 2^3) + (1 \times 2^2) \times (1 \times 2^1) + (0 \times 2^0)$

$16 + 0 + 4 + 2 + 0$

22 Ans

2. $(10101.11)_2 \rightarrow (21.75)_{10}$

Ans $(1 \times 2^4) + (0 \times 2^3) + (1 \times 2^2) + (0 \times 2^1) + (1 \times 2^0)$

$16 + 0 + 4 + 0 + 1$

21 Ans

$(1 \times 2^{-1}) + (1 \times 2^{-2})$

$\frac{1}{2} + \frac{1}{4} \Rightarrow \frac{3}{4} \Rightarrow .75$ Ans

* Octal to Decimal :-

1. $(562)_8 \rightarrow (370)_{10}$

Ans $(5\times8^2) + (6\times8^1) + (2\times8^0)$
$(5\times64) + (6\times8) + (2\times1)$
$320 + 48 + 2$
$(370)_{10}$ Ans

2. $(562.13) \rightarrow (370.171875)_{10}$

Ans $(5\times8^2) + (5\times8^1) + (2\times8^0) \cdot (1\times8^{-1}) + (3\times8^{-2})$
$(5\times64) + (5\times8) + (2\times1) \quad \cdot \frac{1\times8}{8\times8} + \frac{3}{64} \Rightarrow \frac{11}{64}$
$320 + 48 + 2$
$370 \quad \cdot 171875$
$(370.171875)_{10}$
Ans

* Decimal to Binary :-

1. $(21.75)_{10} \rightarrow (10101.11)_2$

Ans $21 = 10101$

$0.75\times2 = 1.5$
$0.5 \times 2 = 1.0$

$(10101.11)_2$
Ans

2. $(19)_{10} \rightarrow (10011)_2$

Ans

2	19	1
2	9	1
2	4	0
2	2	0
	1	

$(10011)_2$ Ans

* Hexadecimal Number:-

↳ Each significant position in hexadecimal number has positional weight

1. $(268)_{16} \rightarrow \cancel{(512)_{10}}\ (616)_{10}$

Ans $(2 \times 16^2) + (6 \times 16^1) + (8 \times 16^0)$

$512 + 96 + 8$

$(616)_{10}$ Ans

2. $A(32)_{16} \rightarrow (2610)_{10}$

Ans $(A \times 16^2) + (3 \times 16^1) + (2 \times 16^0)$

$(10 \times 16^2) + (3 \times 16^1) + (2 \times 16^0)$

$2560 + 48 + 2$

$(2610)_{10}$ Ans

→ Arithmatic operation :-

↳ Arithmatic operation in a computer are done using binary number and not decimal number and these take place in its arithmatic unit

* Binary Arithmatic :-

↳ The arithmatic rules for addition, subtraction, multiplication and de division of binary number.

1. Addition operation :-

0 + 0 = 0
0 + 1 = 1
1 + 0 = 0
1 + 1 = 0 (Carry = 1)

2. Substraction Operation :-

0 - 0 = 0
0 - 1 = 1
1 - 0 = 0
1 - 1 = 0
10 - 1 = 1 (2 - 1)

3. Multiplication operation :-

0 × 0 = 0
0 × 1 = 0
1 × 0 = 0
1 × 1 = 1

* Binary Addition :-

↳ Two binary number added in a same way as a two decimal number are added

1 1010 and 1111

```
   1 1
   1 0 1 0      -     10
 + 1 1 1 1           +15
 1 1 0 0 1            25    Ans
```

* Binary Subtraction :-

↳ Binary substraction is also carry out in the same way as decimal number are subtracted

1. 1101 and 1001

```
   1 1 0 1       13
 - 1 0 0 1      - 9
   0 1 0 0        4    Ans
```

* Binary Multiplication:

1. 1011 and 1101

```
            1 0 1 1          11
          x 1 1 0 1        x 13
          ---------        ----
          1 0 1 1            33
        0 0 0 0 0           110
      1 0 1 1 0 0          ----
    1 0 1 1 0 0 0           143
    -------------
  1 0 0 0 1 1 1 1
```

10001111 => 143 Ans

2. 1001101 and 1001

```
              1 0 0 1 1 0 1         77
        x           1 0 0 1      x   9
        -------------------      -----
              1 0 0 1 1 0 1        693
            0 0 0 0 0 0 0 0
          0 0 0 0 0 0 0 0 0
        1 0 0 1 1 0 1 0 0 0
        -------------------
        1 0 1 0 1 1 0 1 0 1
```

1010110101 → 693 Ans

3. $(1001.11)_2$ and $(111.01)_2$

```
                                1
                                8
        100111                 39
      × 11101                  29
      100111                 1 351
     000000×                  78×
    100111××                 11.31
   100111×××
  100111××××
 1000110.1011
```

1000110.1011 → 11.31 Ans

* Binary Division :-

1. 11001 ÷ 101

```
         101     ← Ans
   101 | 10001
         101
         00101
           101
           000
```

→

→ Rules for 1's Compliment :-

↳ Determine the 1's Compliment of the smaller number
↳ Add this to the larger number
↳ Remove the carry and add it to the result this carry is called end arround carry.

Ex :-

```
  010011
+ 101100   1's Compliment
  111111
```

Ex :- Subtract $(1010)_2$ from $(1111)_2$

```
  1111
- 1010
  0101
```

```
   1010
   ① ① ①
+  0101   1's Compliment
   1111
```

End Around Carry

```
 ①0100
+    1
  0101  - Ans
```

→ Rules for Subtraction of a larger number from a smaller number :-

↳ Determine the 1's Compliment of larger number
↳ Add to the smaller number
↳ The answer is the 1's Compliment of the true result and is opposite sign.

Ex:- Subtract $(1010)_2$ from $(1000)_2$

Ans

1010
0101 1's Compliment

  0101
+ 1000
  1101
  0010 1's Compliment
  ↑ Ans

→ 2's Compliment :-

↳ It is a way of representing negative number in binary

↳ Rules for 2's Complement

↳ Find the 1's compliment
↳ Add 1 to the result

Ex:- Find 2's compliment of (1010)

Ans

  1010
  0101 1's Complement
+   1
  0110 2's Complement

0110 = 6
– Ans

→ 9's Complement :-

↳ 9's Complement of a decimal number can be found by subtracting each digit in number from 9's Complement of decimal digit 0-9

Decimal Digit	9's Complement
0	9
1	8
2	7
3	6
4	5
5	4
6	3
7	2
8	1
9	0

Ex:- Find the 9's Complement of each of the following numbers
a. 19 b. 146 c. 469 d. 4397

Ans

$$\underbrace{\begin{array}{r} 99 \\ -\ 19 \\ \hline 80 \end{array} \quad \begin{array}{r} 999 \\ 146 \\ \hline 853 \end{array} \quad \begin{array}{r} 999 \\ 469 \\ \hline 530 \end{array} \quad \begin{array}{r} 9999 \\ 4397 \\ \hline 5602 \end{array}}_{\text{9's Complement}}$$

→

→ 10's Compliment :-

↳ The 10's Complement of Decimal number is equal to 9's Complement + 1.

Ex :- Find the 10's Complement of each of the following numbers

a. 9 b. 46 c. 437 d. 739

Ans

$$\begin{array}{r} 9 \\ -\ 9 \\ \hline 0 \\ +\ 1 \\ \hline 1 \end{array} \qquad \begin{array}{r} 99 \\ -\ 46 \\ \hline 53 \\ +\ 1 \\ \hline 54 \end{array} \qquad \begin{array}{r} 999 \\ -\ 437 \\ \hline 562 \\ +\ 1 \\ \hline 563 \end{array} \qquad \begin{array}{r} 999 \\ -\ 739 \\ \hline 260 \\ +\ 1 \\ \hline 261 \end{array}$$

10's Complement

Ex :- Subtract the following Number (Smaller Number of 10's Complement)

a. 9-4 b. 20-09 c. 69-32

Ans

$$\begin{array}{r} 9 \\ -\ 4 \\ \hline 5 \end{array} \qquad \begin{array}{r} 9 \\ +\ 5 \\ \hline 15 \end{array}$$ 10's Complement of 4, 15 Ans

$$\begin{array}{r} 20 \\ -\ 09 \\ \hline 11 \end{array} \qquad \begin{array}{r} 20 \\ +\ 91 \\ \hline 111 \end{array}$$ 10's Complement of 09, 111 Ans

$$\begin{array}{r} 69 \\ -\ 32 \\ \hline 37 \end{array} \qquad \begin{array}{r} 69 \\ +\ 68 \\ \hline 137 \end{array}$$ 10's Complement of 32, 137 Ans

Drop Carry OR Omit Carry

Ex:- Find the 10's Complement of following number
347 - 265

Ans

```
  347        999         347
- 265      - 265       + 735   10's Complement of 265
  082        734        1082
           +   1          ↑ omit carry
             735
```

Ex:- Subtraction of 9's Complement of following number
a. 18-06   b. 34-49   c. 39-23

Ans

```
  18       99        18
- 06     - 06        93
  12       93       111
                   +  1
                     12 Ans
```

```
  34       99        34
- 49     - 49        50
- 15       50        84
                   - 99   Again 9's Complement
                   - 15 Ans
```

```
  39       99        39
- 23       23        76
  16       76       115
                   +  1
                     16 - Ans
```

→ Representation of Signed Data :-

- Magnitude
  - Unsigned
  - Signed
    - +ve → 0
    - -ve → 1
- Complement
  - 1's Complement
  - 2's Complement

↳ Binary Numbers are represented with a separate sign bit and the remaining 7 bit along with the magnitude.

↳ In an 8 bit binary number the MSB is the sign bit and the remaining 7 bit corresponds to magnitude

Example:-	Sign	Magnitude
+36	0 +ve	0100100 7bit 32+4 → 36
-49	1 -ve	0110001 7bit 32+16+1 → 49

→ Binary Code Decimal (BCD):-

↳ Binary Code Decimal number is a combination of four binary digits that represent decimal number and it is also called as 8421 code

↳ The 8421 is a type of binary coded decimal. It has 4 bits and represent the decimal digits 0 to 9.

↳ To express any decimal number in BCD each decimal digit should be replaced by the approate four bit code

Decimal	Binary	BCD Code
0	0000	0000
1	0001	0001
2	0010	0010
3	0011	0011
4	0100	0100
5	0101	0101
6	0110	0110
7	0111	0111
8	1000	1000
9	1001	1001
10	1010	0001 0000
11	1011	0001 0001
12	1100	0001 0010
13	1101	0001 0011
14	1110	0001 0100
15	1111	0001 0101
16	10000	0001 0110