# NUMBER SYSTEMS.

Binary coded decimal

| DECIMAL | OCTAL | HEX | BINARY | BCD | |
|---------|-------|-----|--------|-----|---|
| Base 10 | Base 8 | BASI6 | BASE2 | BCD 4 bits | |
| 0 | 0 | 0 | 0000 | 0000 | |
| 1 | 1 | 1 | 0001 | 0001 | |
| 2 | 2 | 2 | 0010 | 0010 | |
| 3 | 3 | 3 | 0011 | 0011 | |
| 4 | 4 | 4 | 0100 | 0100 | |
| 5 | 5 | 5 | 0101 | 0101 | |
| 6 | 6 | 6 | 0110 | 0110 | |
| 7 | 7 | 7 | 0111 | 0111 | |
| 8 | 10 | 8 | 1000 | 1000 | |
| 9 | 11 | 9 | 1001 | 1001 | |
| 10 | 12 | A | 1010 | x xxx | 0001 0000 |
| 11 | 13 | B | 1011 | | 0001 0001 |
| 12 | 14 | C | 1100 | | 0001 0010 |
| 13 | 15 | D | 1101 | | |
| 14 | 16 | E | 1110 | | |
| 15 | 17 | F | 1111 | | |
| 16 | 20 | 10 | 10000 | xxxx | |

$$3\ 2\ 1\ 0 \leftarrow \text{posindex}$$
$$2756_{10} = (2\times10^3) + (7\times10^2) + (5\times10^1) + (6\times10^0).$$

$$3\ 2\ 1\ 0$$
$$7235_{16} = (7\times16^3) + (2\times16^2) + (3\times16^1) + (5\times16^0)$$

## Conversion from HEX, OCTAL, BINARY to DECIMAL

(i) HEX to DEC :

$$1235_{16} = (1\times16^3) + (2\times16^2) + (3\times16^1) + (5\times16^0)$$
$$= 4096 + 512 + 48 + 5 = 4661$$

## Octal to Dec:

$$2254_8 = (2 \times 8^3) + (3 \times 8^2) + (5 \times 8^1) + (4 \times 8^0)$$

$$= 1024 + 192 + 40 + 4 = 1260_{10}$$

$$\begin{array}{r} 64 \\ \times 8 \quad 3 \\ \hline 572 \\ \times 2 \\ \hline 1024 \end{array}$$

$$\begin{array}{r} 64 \\ 3 \\ \hline 192 \\ 44 \\ \hline 236 \\ 1024 \\ \hline 1260 \end{array}$$

## Binary to Dec:

$$\overset{6\,5\,4\,3\,2\,1\,0}{1101101} = (1 \times 2^6) + (1 \times 2^5) + (1 \times 2^3) + (1 \times 2^2) + (1 \times 2^0)$$

$$= 64 + 32 + 8 + 4 + 1$$

$$= 109_{10}$$

$$\begin{array}{r} 64 \\ 45 \\ \hline 109 \end{array}$$

## DEC TO HEX

$$257_{10} \rightarrow HEX$$

$$16\,\overline{)257}$$
$$16\,\overline{)16}\ R1$$
$$1\ R0$$

$$257_{10} = 101_{16} \quad \checkmark$$

$$(1 \times 16^2) + (1 \times 16^0) = 257$$

## DEC to OCTAL

$$347_{10} \rightarrow Octal$$

$$8\,\overline{)347}$$
$$8\,\overline{)43}\ R3$$
$$5\ R3$$

$$347_{10} \Rightarrow 533_8$$

## DEC to BINARY.

$233_{10} \rightarrow$ Binary.

```
2) 233
  2) 116 R1
    2) 58 R0
     2) 29 R0
       2) 14 R1
         2) 7 R0
           2) 3 R1
              1-R1
```

$233_{10} = 11101001_2$.

## BINARY TO OCTAL.

Group binary bits into groups of 3 fm RHS.

eg $01010110_2 \rightarrow$ 001   010   110

                  ↓      ↓     ↓

                  1      2     6

added Zeros to fill up gap.

## OCTAL → BINARY

∴ Octal to Binary → reverse process i.e write in binary each digit using 3 bits.

$126_8 \rightarrow$     1      2     6

                  ↓      ↓     ↓

                 001   010   110

```
2) 10
 2) 5 R0
  2) 2 R1
     1 r0
```

## HEX TO ~~DEC~~ BINARY.

(i) Write out each digit using 4 ~~binary~~ bits. (ii)

eg $2A43_{16} \rightarrow$    2      A     4    3

                      ↓      ↓     ↓    ↓

                   0010   1010   0100   0011

$\Rightarrow 2A43_{16} \rightarrow 0010101001000011_2$.

Convert (i) 17CD$_{Hex}$ to Binary
(ii) 174$_8$ to BINARY.

## Binary to Hex.

① Group the binary bits into groups of 4 from RHS. ② Convert each group into Hex equivalent.

e.g

$$0010\ 1001\ 0010\ 0111\ 1011$$

↓   ↓   ↓   ↓   ↓
2   9   2   7   B$_{16}$

Exercises: Convert (i) $10110101_2$ to OCTAL
(ii) $101101110_2$ to HEX

## BINARY ARITHMETIC

### Binary addition :
Use 5-bit notation to add 10 to 6 in binary

(i)   10 ⟶   01010
    + 6      00110 +
    ─────    ──────
     16 ⟶   10000

(ii)   use 7 bits

      $5\not{4}$ ⟶   0101001
     +$\not{7}2$     1001011 +
      ──────        ─────────
      $\not{8}\not{9}$   1 0000100
      129

overflow if max No. of bits is 7

2 | 78
2 | 36 r0
2 | 18 r1
2 | 9 r0
2 | 4 r1
2 | 2 r0
  | 1 r0

32
16
48
 8
56

## BCD - Binary Coded Decimal.

In BCD the decimal digits 0,1,2,3,4,5,6,7,8,9 are represented in Binary using 4 binary bits.
for instance

Dec 3 = 0011 in BCD    and 6$_{10}$ = 0110$_{BCD}$

and 9$_{10}$ = 1001$_{BCD}$.

## HEX ADDITION

$$\begin{array}{r} 5AA \\ + \; B27 \\ \hline 10CB \end{array}$$

Perform the following operations in HEX

(i) $CDF + O1D = CFC$
(ii) $7AE + 8FD = 10AB$
(iii) $7AE + 9FE = 11AC$

~~stopped~~
~~BINARY~~ SUBTRACTION

Binary

$$\begin{array}{r} 10101 \\ - \; 01101 \\ \hline 00000 \end{array}$$

$$\begin{array}{r} 11 \\ - \; 6 \\ \hline 5 \end{array} \longrightarrow \begin{array}{r} 1011 \\ 0110 \\ \hline 0101 \end{array}$$

HEX:

(a)
$$\begin{array}{r} C\,37 \\ - \; 7B5 \\ \hline 482 \end{array}$$

FEED
$- CDF$

$\dfrac{19}{7}$

A 10
B 11
C 12

(b)
$$\begin{array}{r} BC1 \\ 9FE \\ \hline 1C3 \end{array}$$

CDF − BED

$\dfrac{11}{16}$
$\dfrac{27}{12}$
$\dfrac{15}{}$