

19/07/23
Wednesday

Computer Organisation and Architecture

Number System Conversion:-

Octal \rightarrow Binary \rightarrow Hexadecimal
 $\leftarrow 3 \rightarrow 4 \rightarrow$

Conversion of Grey Code:-

1. $\begin{array}{c} \text{+} \\ 1001 \end{array} \rightarrow 1101$
 $\begin{array}{c} \text{+} \quad \text{+} \\ 1+0=1 \\ 0+0=0 \\ 0+1=1 \end{array}$

2. $0110 \rightarrow 0101$

$\begin{array}{l} 0+1=1 \\ 1+1=10 \text{ (1 - carry)} \\ 1+0=1 \end{array}$

3. $1010 \rightarrow 1111$
 $\begin{array}{l} 1+0=1 \\ 0+1=1 \\ 1+0=1 \end{array}$

4. $1011 \rightarrow 1110$

$\begin{array}{l} 1+0=1 \\ 0+1=1 \\ 1+1=10 \text{ (1 - carry)} \end{array}$

Homework:-

1. $(1\ 2\ 3\ 4)_8$ to Binary

$\begin{array}{c} 1 \\ 4\ 2\ 1 \\ 0\ 0\ 1 \end{array} \quad \begin{array}{c} 2 \\ 4\ 2\ 1 \\ 0\ 1\ 0 \end{array} \quad \begin{array}{c} 3 \\ 4\ 2\ 1 \\ 0\ 1\ 1 \end{array} \quad \begin{array}{c} 4 \\ 4\ 2\ 1 \\ 1\ 0\ 0 \end{array}$

$B-2$
 $D-10$
 $O-8$
 $Hd-16$

$(1\ 2\ 3\ 4)_8 = (001010\ 011100)_2$

$(1\ 2\ 3\ 4)_8$ to Binary

$\begin{array}{c} 1 \\ 4\ 2\ 1 \\ 0\ 0\ 1 \end{array} \quad \begin{array}{c} 2 \\ 4\ 2\ 1 \\ 0\ 1\ 0 \end{array} \quad \begin{array}{c} 3 \\ 4\ 2\ 1 \\ 0\ 1\ 1 \end{array} \quad \begin{array}{c} 4 \\ 4\ 2\ 1 \\ 1\ 0\ 0 \end{array}$

2. $(1CF)_{16}$ to Binary

1				C (12)				F (15)			
8	4	2	1	8	4	2	1	8	4	2	1
0	0	0	1	1	1	0	0	1	1	1	1

$$(1CF)_{16} = (000111001111)_2$$

3. $(11110000111)_2$ to Octa, decimal, hexadecimal

(i) Binary to octa

011110000111

0	1	1	1	1	0	0	0	0	1	1	1
4	2	1		4	2	1		4	2	1	
3				6				0			

$$(11110000111)_2 = (3607)_8$$

(ii) Binary to hexadecimal

011110000111

0	1	1	1	1	0	0	0	0	1	1	1
8	4	2	1		8	4	2	1		8	4
7					8					7	

$$(11110000111)_2 = (787)_{16}$$

(iii) Binary to decimal

$$\begin{array}{r} 2^{10} \quad 2^9 \quad 2^8 \quad 2^7 \quad 2^6 \quad 2^5 \quad 2^4 \quad 2^3 \quad 2^2 \quad 2^1 \quad 2^0 \\ 1 \quad 1 \quad 1 \quad 1 \quad 0 \quad 0 \quad 0 \quad 0 \quad 1 \quad 1 \quad 1 \end{array}$$

$$\begin{array}{r} 1 \times 2^0 = 1 \\ 1 \times 2^1 = 2 \\ 1 \times 2^2 = 4 \\ 1 \times 2^7 = 128 \\ 1 \times 2^8 = 256 \\ 1 \times 2^9 = 512 \\ 1 \times 2^{10} = 1024 \\ \hline 1927 \end{array}$$

$$(11110000111)_2 = (1927)_{10}$$

Sign magnitude

- Sign magnitude represents - MSD
- If number is positive, MSD is 0
- If number is negative, MSD is 1

$$\begin{array}{l} +6 \rightarrow 0110 \\ -6 \rightarrow 1110 \end{array}$$

Eg:

$$\begin{array}{l} +7 \rightarrow 0111 \\ -7 \rightarrow 1111 \end{array}$$

1's Complement

$$101010 \rightarrow 010101$$

2's Complement

$$\begin{array}{r} 101010 \rightarrow 010101 \\ \hline 010110 \end{array}$$

$$6 \rightarrow 110 \rightarrow 001$$

$$-6 \rightarrow 010$$

$$7 \rightarrow 111 \rightarrow 000$$

$$-7 \rightarrow 001$$

(C F)₁₆ to Binary

$$\begin{array}{cccccc} & C & & F & & \\ 1 & 1 & 0 & 0 & 1 & 1 \end{array}$$

$$\begin{array}{r}
 +7 \rightarrow 111 \\
 +4 \rightarrow 100 + \\
 \hline
 +11 \rightarrow 1011
 \end{array}$$

1 → Left as carry
0 → MSD, number is +ve

negative number - find 2's Complement

$$-7 \rightarrow \text{?}$$

$$+7 \rightarrow 0111$$

$$1's \text{ Complement} \rightarrow 0001 +$$

$$001 - 2's \text{ Complement}$$

$$-4 \rightarrow +4 \rightarrow 100$$

$$1's \text{ Complement} \rightarrow 011 +$$

$$\begin{array}{r}
 -7 \\
 -4 \\
 \hline
 -11
 \end{array}
 \rightarrow 4 \text{ bit (add 0)} \rightarrow 1000 \rightarrow 2's \text{ Complement}$$

$$\begin{array}{r}
 001 \\
 100 \\
 \hline
 0101 \\
 1 \\
 \hline
 110
 \end{array}$$

$$\begin{array}{r}
 001 \\
 100 \\
 \hline
 0101
 \end{array}$$

$$\begin{array}{r}
 1010 \\
 1 \\
 \hline
 1011
 \end{array}$$

(ii)

7 and -4

$$\begin{array}{r}
 8 \ 4 \ 2 \ 1 \\
 0 \ 1 \ 1 \ 1
 \end{array}$$

$$+7 \rightarrow 0111$$

$$-4 \rightarrow +4 \rightarrow 100$$

$$\begin{array}{r}
 001 \\
 100 \\
 \hline
 0101 \\
 1 \\
 \hline
 0110
 \end{array}$$

$$\begin{array}{r}
 11 \\
 011 \\
 1 \\
 \hline
 100
 \end{array}$$

$$\begin{array}{r}
 111 \\
 010 \\
 \hline
 1001
 \end{array}$$

$$\begin{array}{r}
 +7 \\
 -4 \\
 \hline
 3
 \end{array}$$

$$\begin{array}{r}
 111 \\
 100 \\
 \hline
 1011 \quad (+3) \\
 \downarrow \\
 +ve
 \end{array}$$

$$+12 \rightarrow 1100$$

$$-5 \rightarrow +5 \rightarrow 0101 \rightarrow \begin{array}{r} 010 \\ 1+ \\ \hline 011 \end{array}$$

$$12 \rightarrow 100$$

$$-5 \rightarrow 011$$

$$\begin{array}{r} 100 \\ +7 \quad 111 \\ \hline \end{array}$$

$$\begin{array}{r} -7 \rightarrow +7 \rightarrow 111 \\ +4 \rightarrow 100 \\ \hline \end{array}$$

$$5+5$$

$$\begin{array}{r} 0101 \\ 0101 \\ \hline 1010 \end{array}$$

$$\begin{array}{r} 1111 \\ 1101 \\ \hline \end{array}$$

$$1111$$

$$0101$$

$$1010 \rightarrow 1's \text{ Complement}$$

$$1011$$

$$\begin{array}{r} -5 \rightarrow 0101 \\ +3 \rightarrow 0011 \\ \hline \end{array}$$

$$\ominus 2$$

$$\begin{array}{r} 111 \\ 0101 \\ 001110 \\ \hline 10000 \end{array}$$

$$10000 + 1000$$

$$\begin{array}{r} 10010101 \rightarrow 10101 \\ 1011101 \\ \hline 11101 \end{array}$$

$$+12 \rightarrow 1100$$

$$-5 \rightarrow +5 \rightarrow \begin{array}{r} 0101 \\ 1+ \\ \hline 0101 \end{array}$$

$$\begin{array}{r} 1010 \\ 1+ \\ \hline 1011 \end{array}$$

$$\begin{array}{r} 1100 \\ 1011 \\ \hline \end{array}$$

$$\oplus 7 \quad 10111$$

$$\begin{array}{r} 0000 \\ 1+ \\ \hline 001 \end{array}$$

$$\begin{array}{r} 8 \quad 4 \quad 2 \quad 1 \\ 0 \quad 1 \quad 0 \quad 1 \end{array}$$

$$\begin{array}{r} 001 \\ 100 \\ \hline \end{array}$$

$$\oplus 3 \rightarrow \begin{array}{r} 101 \\ 101 \\ \hline \end{array}$$

$$\begin{array}{r} 010 \\ 1+ \\ \hline 011 \end{array}$$

$$1101$$

$$0010$$

$$0010 +$$

$$011$$

$$0011$$

$$111$$

$$1111$$

$$011$$

$$1010$$

$$+5 \rightarrow 0101$$

$$+3 \rightarrow 0011$$

$$+8$$

$$0011$$

$$111$$

$$1111$$

$$0011 +$$

$$10010$$

$$0 \rightarrow +ve$$

$$0 \rightarrow -ve$$

$$0001$$

$$8421$$

1. $5 + 5$

$$\begin{array}{r} 10101 \\ 0101 \\ 0101 \\ \hline 10100011 \end{array}$$

2. 1111
 -1101

$-1101 \rightarrow 0010$

$$\begin{array}{r} 0010 \\ \hline 0011 \end{array}$$

$$\begin{array}{r} 111 \\ 1111 \\ 0011 \\ \hline 10010 \end{array}$$

3. $-15 + 3$

$3 \rightarrow 0011$

8	4	2	1
1	1	1	1
0	1	0	1

$-15 \rightarrow 1111$

2's $1111 \rightarrow 0000$

$$\begin{array}{r} 0000 \\ 0001 \\ \hline 0001 \end{array}$$

$$\begin{array}{r} 11 \\ 0011 \\ 000110 \\ \hline 0100 \end{array}$$

$0100 \rightarrow 2's \text{ complement}$

$$\begin{array}{r} 11 \\ 1011 \\ 1 \\ \hline 1100 \end{array} \rightarrow \begin{array}{r} -15 \\ +3 \\ \hline -12 \end{array}$$

4. $-12 \rightarrow 1100$
 $+4 \rightarrow 0100$

-8

$1100 \rightarrow 0011$

$$\begin{array}{r} 0100 \\ \hline 0100 \end{array}$$

$$\begin{array}{r} 0100 \\ 0100 \\ \hline 1000 \end{array}$$

8	4	2	1
0	1	1	1
0	1	1	1

1000
 \downarrow
 -8

5. $-8 \rightarrow 1000 \rightarrow 0111$
 $-5 \rightarrow 0101 \rightarrow 1010$

$-13 \Rightarrow 1101$

$$\begin{array}{r} 1000 \\ 1011 \\ \hline 10011 \end{array}$$

100111000

$$\begin{array}{r} 10011 \\ 1010 \\ \hline 1011 \end{array}$$

12			
8	4	2	1
1	1	0	0

(-)

-12

$$\begin{array}{r} 101111 \\ \hline 1011 \end{array}$$

01100

$$\begin{array}{r} 01101 \\ \hline 841 \\ \star 13 \end{array}$$

magic again

$$\begin{array}{r} -9 \rightarrow 1001 \\ +5 \rightarrow 0101 \\ \hline -4 \end{array}$$

$$\begin{array}{r} 1001 \rightarrow 0110_1 + \\ \hline 0111 \end{array}$$

$$\begin{array}{r} 111 \\ 0111 \\ 0101 \\ \hline 1100 \end{array}$$

\rightarrow 2's Complement.

$$\begin{array}{r} 0011 \\ 1 \\ \hline 0100 \end{array} \Rightarrow \begin{array}{r} 8 \ 4 \ 2 \ 1 \\ 0 \ 1 \ 0 \ 0 \\ -4 \end{array}$$

$$\begin{array}{r} 1011 \\ 1100 \\ \hline 10111 \end{array} +$$

$$\begin{array}{r} 01000 \\ 1 \\ \hline 01001 \\ 8 \quad 9 \end{array}$$

$$\begin{array}{r} 9 \rightarrow 1001 \\ -5 \rightarrow 0101 \\ \hline 4 \end{array}$$

$$\begin{array}{r} -5 \rightarrow 0101 \\ 1010 \\ 1 \\ \hline 1011 \end{array}$$

$$\begin{array}{r} 8 \rightarrow 1000 \\ -3 \rightarrow 0011 \\ \hline 5 \end{array}$$

$$0011 \rightarrow 1100$$

$$\begin{array}{r} 1000 \\ 1101 \\ \hline 10101 \end{array}$$

$$\begin{array}{r} 11 \\ 1001 \\ 1011 \\ \hline 10100 \end{array} - + (4)$$

$$\begin{array}{r} 8 \\ -3 \\ \hline 5 \end{array}$$

$$15 \rightarrow 1111$$

$$\begin{array}{r} -8 \\ -2 \\ \hline -10 \end{array}$$

Internally Stored Instructions.
Application of workstations.

$$\begin{array}{r} 8 \ 4 \ 2 \ 1 \\ 5 \ 0 \ 1 \ 0 \ 1 \\ 9 \ 1 \ 0 \ 0 \ 1 \end{array}$$

$$\begin{array}{r} -5 \rightarrow 0101 \\ -4 \rightarrow 0100 \\ \hline -9 \end{array}$$

$$\begin{array}{r} 0101 \\ 1010 \\ 1 \\ \hline 1011 \end{array}$$

$$\begin{array}{r} 1011 \\ 1 \\ \hline 1100 \end{array}$$

Binary Coded decimal:-

1. Sum < 9 and carry = 0, Sum < 9 & Carry = 1, 6(0110)
 Sum > 9 & Carry = 0; add 6(0110)

①

$$\begin{array}{r} 5 \rightarrow 0101 \\ 3 \rightarrow 0011 \\ \hline 1000 \end{array} \quad 1000 = 8_{10}$$

②

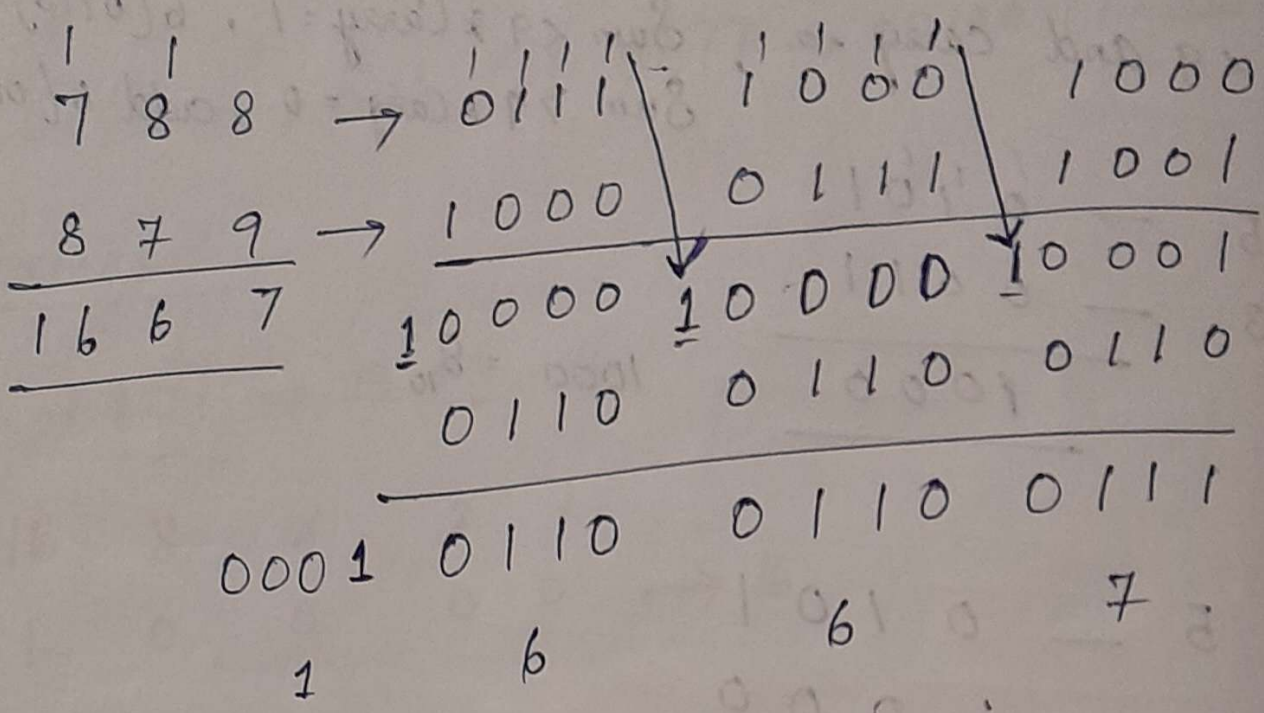
$$\begin{array}{r} 5 \rightarrow 0101 \\ 8 \rightarrow 1000 \\ \hline 11101 \\ + 0110 \\ \hline 13 \rightarrow 110011 \end{array}$$

③

$$\begin{array}{r} 235 \rightarrow 0010 \quad 0011 \quad 0101 \\ 852 \rightarrow 1000 \quad 0101 \quad 0010 \\ \hline 11010 \quad 1000 \quad 0111 \\ 0110 \\ \hline 0001 \quad 0000 \quad 1000 \quad 0111 \\ \hline 1 \quad 0 \quad 8 \quad 7 \end{array}$$

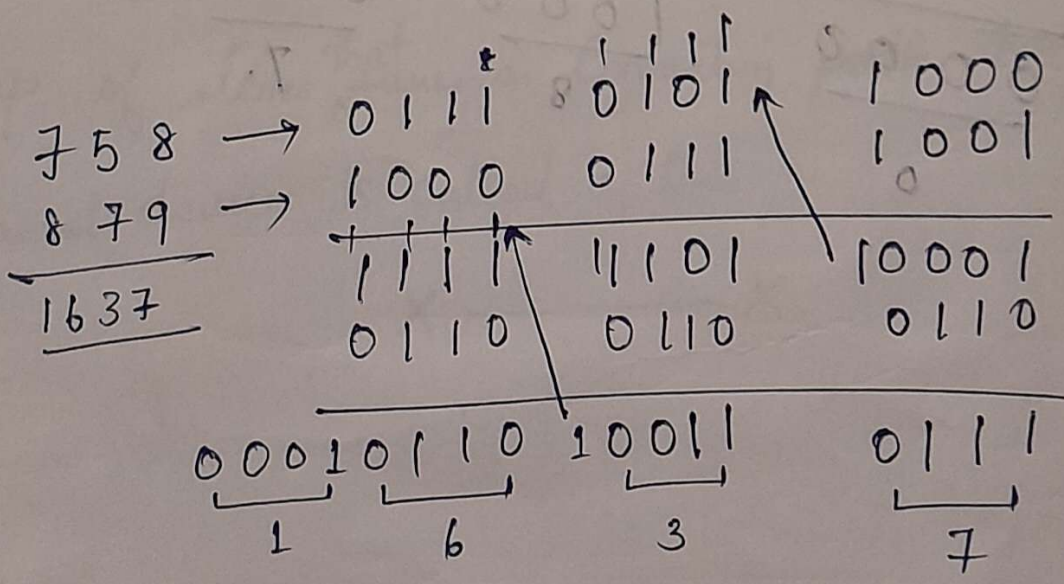
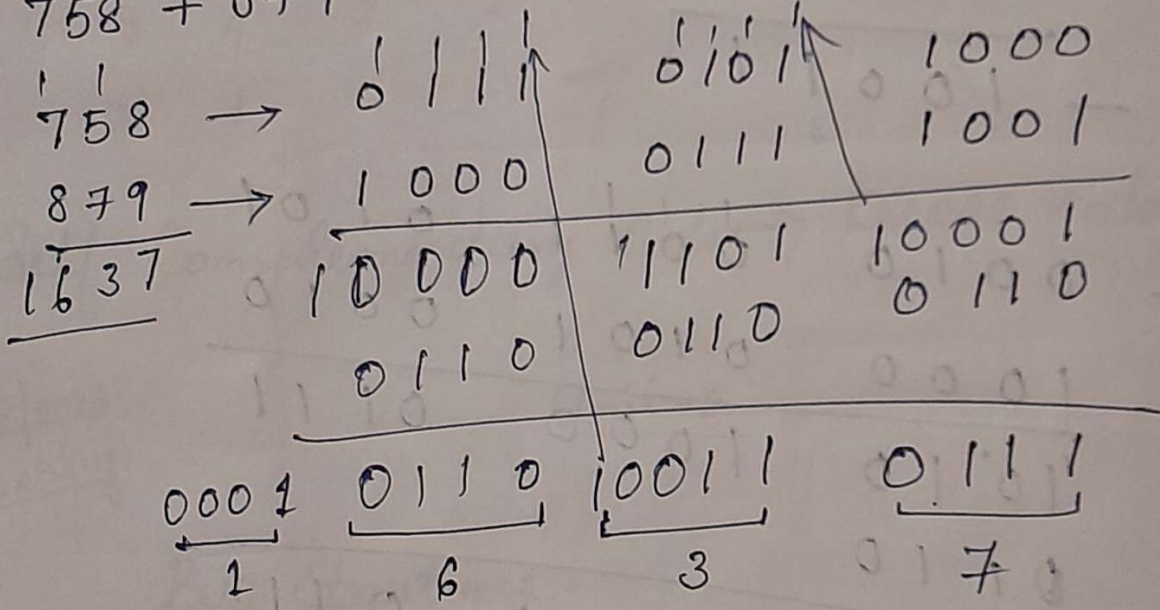
2.

788 + 879



3.

758 + 879



238
999
999
999

BCD Subtraction

1. $695 - 238$

9's Complement of 238 $\rightarrow 999 - 238 = 761$

$$\begin{array}{r} 999 \\ - 238 \\ \hline 761 \\ + 8 \\ \hline 695 \\ - 238 \\ \hline 457 \end{array}$$

~~695~~
~~9's complement~~
~~of 238 $\rightarrow 796$~~

695 \rightarrow	0110	1001	0101
761 \rightarrow	0111	1001	0110
<hr/>	<hr/>	<hr/>	<hr/>
6	1101	1111	0101
9	0110	0110	0001
5			
<hr/>	<hr/>	<hr/>	<hr/>
10	011	10101	0110
1	1		
<hr/>	<hr/>	<hr/>	<hr/>
0100	01001	0111	
<hr/>	<hr/>	<hr/>	<hr/>
4	5	7	