April 4th

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Number System

A number system used in digital electronics

a) Decimal

- The decimal number system is a type of number system that has a base value equal to 10.

- Decimal number system are represented by one ten symbols i.e 0 to 9.

b) Binary

- The binary number system is a type of number system that has a base value equal to ~~2~~ ~~2~~ two (0 and 1)

- A computer understand information composed of only 0 and 1. When we type some letters or words data is processed by the computer in the form of 0 and 1.

c) Hexadecimal

- The hexadecimal number system is a type of number system that has base value equal to 10
0 1 2 3 4 5 6 7 8 9 A B C D E F.

d) Octal

- The octal number system is a type of number system that ~~has~~ has base value equal to 8.

Conversion in Number System

i) Binary to Decimal

a) $1011_2 \longrightarrow (11)_{10}$

1	0	1	1	Binary numbers
2^3	2^2	2^1	2^0	Weight.

$= 1\times 2^3 + 0\times 2^2 + 1\times 2^1 + 1\times 2^0$
$= 8 + 0 + 2 + 1$
$= 11$

b) $(10111)_2 \longrightarrow (23)_{10}$

1	0	1	1	1
2^4	2^3	2^2	2^1	2^0

$= 1\times 2^4 + 0\times 2^3 + 1\times 2^2 + 1\times 2^1 + 1\times 2^0$
$= 16 + 0 + 4 + 2 + 1$
$= 23$

c) $(1011 \cdot 11)_2 \longrightarrow (11.75)_{10}$

1	0	1	1	.	1	1
2^3	2^2	2^1	2^0		2^{-1}	2^{-2}

$= 1 \times 2^3 + 0 \times 2^2 + 1 \times 2^1 + 1 \times 2^0 + 1 \times 2^{-1} + 1 \times 2^{-2}$

$= 8 + 0 + 2 + 1 + \frac{1}{2} + \frac{1}{2^2}$

$= 10 + 0.5 + 0.25 + 1$

$= \cancel{10.75}\ 11.75$

d) $(101.01)_2 \longrightarrow (5.25)_{10}$

1	0	1	.	0	1
2^2	2^1	2^0		2^{-1}	2^{-2}

$= 1 \times 2^2 + 0 \times 2^1 + 1 \times 2^0 + 0 \times \frac{1}{2} + 1 \times \frac{1}{2^2}$

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$= 4 + 0 + 1 + 0 + 0.25$
$= 5.25$

ii) Octal to Decimal

a) $(14)_8 \rightarrow (12)_{10}$

Octal number	1	4
Weight	8^1	8^0

$= 1 \times 8^1 + 4 \times 8^0$
$= 8 + 4 \times 1$
$= 8 + 4$
$= 12.$

b) $(14.2)_8 \rightarrow (12.25)_{10}$.

Octal number	1	4	.	2
Weight	8^1	8^0	.	8^{-1}

$= 1 \times 8^1 + 4 \times 8^0 + \overset{1}{\cancel{2}} \times \frac{1}{\cancel{8}\,4}$

$= 8 + 4 + 0.25$
$= 12.25$

c) $(AE3)_{16} \rightarrow (2787)_{10}$

Hexadecimal	A	E	3
weight	16^2	16^1	16^0

$= A \times 16^2 + E \times 16^1 + 3 \times 16^0$
$= 10 \times 16^2 + \overset{14}{\cancel{15}} \times 16^1 + 3 \times 16^0$

$= 10 \times 256 + 15 \times 16 + 3 \times 1$

$= 2560 + 2240 + 3$

$= \cancel{2803}\ 2787$

Hexadecimals are used in the following :-

1) To define locations in memory.
2) To define colours on webpage.
3) To represent media acess control (MAC).address.
4) To display error messages.

Numericals.

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

1	0	1	1	0
2^4	2^3	2^2	2^1	2^0

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

$= 16 + 0 + 4 + 2 + 0$

$= 22.$

2) $(1011.011)_2 \rightarrow (11.375)_{10}$

1	0	1	1	.	0	1	1
2^3	2^2	2^1	2^0		2^{-1}	2^{-2}	2^{-3}

$= 1 \times 2^3 + 0 \times 2^2 + 1 \times 2^1 + 1 \times 2^0 + 0 \times \frac{1}{2} + \frac{1}{2^2} + \frac{1}{2^3}$

$= 8 + 0 + 2 + 1 + 0 + 0.25 + 0.125$

$= 11.375$

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3) $(A4F.3)_{16} \rightarrow (2639.1875)_{10}$.

A	4	F	3
16^2	16^1	16^0	16^{-1}

$= 10 \times 16^2 + 4 \times 16^1 + 15 \times 16^0 + 3 \times 16^{-1}$

$= 2560 + 64 + 15 + 3 \times 0.0625$

$= 2560 + 64 + 15 + 0.1875$

$= 2,639.1875$.

Memory units.

1) 1 Nibble = 4 bits.

2) 1 byte = 8 bits

3) 1 KB = 1024 bytes.

4) 1 MB = 1024 KB.

5) 1 GB = 1024 MB

6) 1 TB = 1024 GB

7) 1 PB = 1024 TB

8) 1 EB = 1024 PB

9) 1 ZB = 1024 EB

10) 1 YB = 1024 ZB.

Exabyte (EB)
Zettabyte (ZB)
Yottabyte (YB)

Any number system to binary system.

To convert any number system into Binary number system the integer and the fractional parts of the number should be considered separately.

Q.1. $(13)_{10} \rightarrow (?)_2$

1	3

		R
2	13	1
2	6	0
2	3	1
	1	

$\therefore (13)_{10} \rightarrow (1101)_2$

Q.2. $(1101)_2 \rightarrow (?)_{10}$

1	1	0	1	Binary number
2^3	2^2	2^1	2^0	Weight.

$= \cancel{1+?}\ 1 \times 2^3 + 1 \times 2^2 + \cancel{1}0 \times 2^1 + 1 \times 2^0$

$= 8 + 4 + 0 + 1$

$= 13$

$\therefore (1101)_2 \rightarrow (13)_{10}$

Q.3. $(13.25)_{10} \rightarrow (?)_2$

		R
2	13	1
2	6	0
2	3	1
	1	

$0.25 \times 2 = 0.5$ 0

$0.5 \times 2 = 1$ 1

$(1101.01)_2$

1	1	0	1	.	0	1
2^3	2^2	2^1	2^0		2^{-1}	2^{-2}

$= 1\times 2^3 + 1\times 2^2 + 0\times 2^1 + 1\times 2^0 + 0\times 2^{-1} + 1\times 2^{-2}$

$= 8+4+0+1+0+1\times\frac{1}{2^2}$

$= 8+4+0+1+0+0.25$

$= 13.25$

$\therefore (1101.25)_2 \rightarrow (13.25)_{10}$.

Q.N.4 $(16.73)_{10} \rightarrow (\ ?\ )_2$.

$(10000.10111)_2$

1	0	0	0	0	.	1	0	1	1	1
2^5	2^4	2^3	2^1	2^0		2^{-1}	2^{-2}	2^{-3}	2^{-4}	2^{-5}

$= 1\times 2^5 + 0\times 2^4 + 0\times 2^3 + 0\times 2^1 + 0\times 2^0 +$
$1\times 2^{-1} + 1 0\times 2^{-2} + 1\times 2^{-3} + 1\times 2^{-4} +$
1×2^{-5}

$= 32+0+0+0+0+1\times\frac{1}{2}+$

		R
2	16	0
2	8	0
2	4	0
2	2	0
	1	

$0.73\times 2 = 1.46$	1
$0.46\times 2 = 0.92$	0
$0.92\times 2 = 1.84$	1
$0.84\times 2 = 1.68$	1
$0.68\times 2 = 1.3$	1

$\therefore (16.73)_{10} \rightarrow (10000.10111)_2$.

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Octal number to Binary number.

Q.1. $(540)_8 \rightarrow (?)_2$.

421	421	421
5	4	0
101	100	000

$(540)_8 \rightarrow (101\ 100\ 000)_2$.

Q.2. $(352)_8 \longrightarrow (?)_2$.

421	421	421
3	5	2
011	101	010

$(352)_2 \longrightarrow (011\ 101\ 010)_2$.

Q.3. $(352.563)_8 \longrightarrow (?)_2$.

421	421	421	421	421	421
3	5	2	5	6	3
011	101	010	101	110	~~000~~ 011

$\therefore (352.563)_8 \longrightarrow (011101\ 010.101\ 110\ 011)_2$

Hexadecimal to Binary System.

A = 10
B = 11
C = 12
D = 13
E = 14
F = 15

Q.N.1. $(852)_{16} \rightarrow (?)_2$.

8421	8421	8421
8	5	2
1000	0101	0010

$(852)_{16} \rightarrow (1000\ 0101\ 0010)_2$

Binary to Hexadecimal

8421

Q.1 $(\underbrace{1000}_{8}\underbrace{0101}_{5}\underbrace{0010}_{2})_2 \rightarrow (?)_{16}$.

8 5 2

$\therefore (1000\ 0101\ 0010)_2 \rightarrow (852)_{16}$.

Octal

421

Q.2 $(\underbrace{001}_{1}\underbrace{010}_{2}\underbrace{000}_{0}\underbrace{011}_{3})_2 \rightarrow (?)_8$. [If there is only one number left at the beginning we should add 0 infront]

1 2 0 3

$\therefore (001010000011)_2 \rightarrow (1203)_8$.

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Q.3. $(101 \quad 000 \quad 0011^{01})_2 \longrightarrow (?)_8$

421

001 010 000 011 · 010

1 2 0 3 2

$(001\ 010\ 000\ 011)_2 \longrightarrow (1203.2)_8$

Binary Operations.

Imp

1) $\begin{array}{r} 0 \\ +\ 0 \\ \hline 0 \end{array}$

2) $\begin{array}{r} 0 \\ +\ 1 \\ \hline 1 \end{array}$

3) $\begin{array}{r} 1 \\ +\ 0 \\ \hline 1 \end{array}$

4) $\begin{array}{r} 1 \\ +\ 1 \\ \hline 10 \end{array}$

carry

Imp

5) $\begin{array}{r} 1 \\ 1 \\ +\ 1 \\ \hline 11 \end{array}$

carry.

Binary Operations.

The automatic operations in digital computers are performed on Binary numbers only. The hexa-decimal representation is used only for entering information into the computers.

Use of complements to represent Negative number.

Today, computer systems performed subtraction using complemented number. This is done because this is economical.

Imp

a) 1's complement. (opposite - उल्टो) $\begin{bmatrix} 0 \rightarrow 1 \\ 1 \rightarrow 0 \end{bmatrix}$

Q.N.1 Find 1's complement of $(1011)_2$.

$(1\ 0\ 1\ 1)_2$.

$\downarrow\ \downarrow\ \downarrow\ \downarrow$

$0\ 1\ 0\ 0$

1's complement of $(1011)_2 \rightarrow (0100)_2$.

~~b) 2's complement~~

b) 2's complement. [formula → 2's complement = 1's complement + 1]

Q.N.2 Find 2's complement of $(1011)_2$

$(1\ 0\ 1\ 1)_2$

$\downarrow\ \downarrow\ \downarrow\ \downarrow$

$0\ 1\ 0\ 0$

$$\begin{array}{r} 0100 \\ +\ 1 \\ \hline 0101 \end{array}$$

$\therefore$ 2's complement of ~~(0101 to~~ $(1011)_2 \longrightarrow (0101)_2$.

Useful for checking answers in Exam

$1\ 0\ 1\ 1 \longrightarrow$ keep it constant

$0\ 1\ 0\ 1$

Subtraction.

Small no − big no [case 1]

- There is no carry.
- take 2's complement of answer and put (−) negative sign.

big no − small no [case 2]

- There is always a carry.
- Remove carry

Q.N 1) Subtract 1011_2 from 1100_2.

$= (1100)_2 - (1011)_2$.

$= (1100)_2 + (2\text{'s complement of } (1011)_2)$

$= (1100)_2 + \begin{pmatrix} 0100 \\ +1 \end{pmatrix}_2$

$= (1100)_2 + (0101)_2$.

$= 0001$.

$$\begin{array}{r} 1\ 1\ 0\ 0 \\ +\ 0\ 1\ 0\ 1 \\ \hline 1)0\ 0\ 0\ 1 \end{array}$$

Remove.

Q.N.2. Find 1's and 2's complement of.

a) $(1010101)_2$

Solution:

1's complement of $(1010101)_2$ is $(0101010)_2$

2's complement of 1010101 is

$$
\begin{array}{r}
0101010 \\
+\ 1 \\
\hline
\cancel{010} \\
0101011
\end{array}
$$

b) $(0111000)_2$

Solution:

1's complement of (0111000) is $(1000111)_2$

2's complement of $(0111000)_2$ is ~~01110~~

$$
\begin{array}{r}
1000111 \\
+\ 1 \\
\hline
1001000
\end{array}
$$

Q.N.1 $(1745.246)_8 \longrightarrow (?)_{16}$.

Solution:

Octal to Binary.

421

1	7	4	5	2	4	6
001	111	100	101	010	100	110

$\therefore (1745.246)_8 \longrightarrow (001\ 111\ 100\ 101 \cdot 010\ 100\ \overset{110}{})_2$.

Binary to Hexadecimal

8421.

$(001\ 111\ 100\ 101\ .\ 010\ 100\ \overset{110}{})_2 = (\ ?\ )_{16}$.

8421.

(001111100101.010100110)

$(3E5.530)_{16}$.

\# Binary to Octal (3) / hexa (4)
(group)

A → 10
B → 11
C → 12
D → 13
E → 14
F → 15.

Example

~~Q.1. $(001100000)_2 \rightarrow (?)_8$.~~

~~421~~

~~001100000~~

~~1 4 0~~

Q.1. $(101100000.111000)_2 \rightarrow (?)_{16}$.

Solution;

8421.

$\underbrace{0001}_{1}\ \underbrace{0110}_{6}\ \underbrace{0000}_{0}\ .\ \underbrace{1110}_{E}\ \underbrace{0000}_{0}$

1 6 0 . E 0

$(160.E0)_{16}$.

111 100

Q.N.1 $01011_2 - 11100_2$

$= 01011_2 + (2\text{'s complement of } 11100_2)$

2's complement of 11100_2

$= 1\text{'s complement of } 11100_2 + 1$

$$
\begin{array}{r}
\scriptstyle 11 \\
00011 \\
+\ 1 \\
\hline
00100
\end{array}
$$

$= 01011_2 + 00100_2$

$= 01111$

$$
\begin{array}{r}
01011 \\
+\ 00100 \\
\hline
01111
\end{array}
$$

∴ Since, there is no carry. So, 2's complement of 01111_2 is 1's complement of $01111 + 1$.

$$
\begin{array}{r}
10000 \\
+\ 1 \\
\hline
10001
\end{array}
$$

$= -(10001)_2$

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Q.1. $(10101)_2 - (10111)_2$.

$= (10101)_2 + (2\text{'s complement of } 10111_2)$

$= 2\text{'s complement of } 10111_2$

$= 1\text{'s complement of } 10111_2 + 1$.

$$
\begin{array}{r}
01000 \\
+\ 1 \\
\hline
01001
\end{array}
$$

$= (10101)_2 + (01001)_2$.

$= (11110)_2$.

$$
\begin{array}{r}
1 \\
10101 \\
+\ 01001 \\
\hline
11110
\end{array}
$$

∴ Since, there is no carry. so, 2's complement of $(11110)_2$ is 1's complement of $(11110 + 1)_2$.

$$
\begin{array}{r}
1 \\
00001 \\
+\ 1 \\
\hline
00010
\end{array}
$$

∴ $-(00010)_2$.

Q.N.2 $(10101)_2 - (00111)_2$.

$= (10101)_2 + (2\text{'s complement of } \cancel{101}\ 00111_2)$.

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2's complement of 00111_2

= 1's complement of $00111_2 + 1$

$$= \begin{array}{r} \cancel{11000_2} \\ \cancel{+1} \\ \hline \cancel{00001} \end{array} \qquad \begin{array}{r} 11000 \\ +1 \\ \hline 11001 \end{array}$$

$$\begin{array}{r} {}^{1} \\ 10101 \\ +11001 \\ \hline 101110 \end{array}$$

carry

$= (10101)_2 + (11001)_2$.

$= (101110)_2$

∴ Since, there is carry the answer is $(01110)_2$.

Q.N.3. $(10011)_2 - (11100)_2$

$= (10011)_2 + (2\text{'s complement of } 11100_2)$

2's complement of 11100_2

= 1's complement of $11100_2 + 1$

$$= \begin{array}{r} {}^{1\,1} \\ 00011 \\ +1 \\ \hline 00100 \end{array}$$

$= (10011)_2 + (00100)_2$.

$= (10111)_2$.

$$\begin{array}{r} 10011 \\ +\ 00100 \\ \hline 10111 \end{array}$$

∴ Since, there is no carry. So, 2's complement of $(10111)_2$ is 1's complement of $(10111 + 1)_2$.

$$\begin{array}{r} 01000 \\ +1 \\ \hline 01001 \end{array}$$

$= -(01001)_2$