

Digital Electronics

Number system :-

There are four number systems in arithmetic. They are :-

- 1) Decimal number system.
- 2) Binary number system.
- 3) Hexadecimal number system.
- 4) Octal number system.

General rule for representing numbers in any number system is.

$$a_n a_{n-1} \dots a_2 a_1 a_0 = a_n r^n + a_{n-1} r^{n-1} + \dots + a_2 r^2 + a_1 r^1 + a_0 r^0$$

Where, $a_n, a_{n-1}, \dots, a_0 \rightarrow$ Digits

$a_0 \rightarrow$ LSD - Least significant Digit

$a_n \rightarrow$ MSD - Most Significant Digit

$r \rightarrow$ Base of number system.

Conversions :-

Binary to Decimal conversion:-

i) $(11011)_2$

$$\begin{aligned}(11011)_2 &= 1 \times 2^5 + 1 \times 2^4 + 0 \times 2^3 + 1 \times 2^2 + 1 \times 2^1 + 1 \times 2^0 \\ &= 32 + 16 + 0 + 4 + 2 + 1 \\ &= \underline{(55)}_{10}\end{aligned}$$

ii) $(11101.1011)_2$

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

$$= 16 + 8 + 4 + 0 + 1 + \frac{1}{2} + 0 + \frac{1}{8} + \frac{1}{16}$$

$$= \underline{(29.6275)}_{10}$$

$$\text{iii) } (10110)_2 = 1 \times 2^4 + 0 \times 2^3 + 1 \times 2^2 + 1 \times 2^1 + 0 \times 2^0$$

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

$$= \underline{(22)}_{10}$$

$$\text{iv) } (10001101)_2 = 1 \times 2^7 + 0 \times 2^6 + 0 \times 2^5 + 0 \times 2^4 + 1 \times 2^3 + 1 \times 2^2 + 0 \times 2^1 + 1 \times 2^0$$

$$= 128 + 0 + 0 + 0 + 8 + 4 + 1$$

$$= \underline{(141)}_{10}$$

$$\text{v) } (10111.1011)_2 = 1 \times 2^4 + 0 \times 2^3 + 1 \times 2^2 + 1 \times 2^1 + 1 \times 2^0 + 1 \times 2^{-1} + 0 \times 2^{-2} + 1 \times 2^{-3} + 1 \times 2^{-4}$$

$$= 16 + 0 + 4 + 2 + 1 + \frac{1}{2} + 0 + \frac{1}{8} + \frac{1}{16}$$

$$= 23 + 0.5 + 0.125 + 0.0625$$

$$= \underline{(23.6875)}_{10}$$

$$\text{vi) } (0.011011)_2 = 0 \times 2^{-1} + 1 \times 2^{-2} + 1 \times 2^{-3} + 0 \times 2^{-4} + 1 \times 2^{-5} + 1 \times 2^{-6}$$

$$= 0 + \frac{1}{4} + \frac{1}{8} + 0 + \frac{1}{32} + \frac{1}{64}$$

$$= 0.25 + 0.125 + 0.03125 + 0.015625$$

$$= \underline{(0.421875)}_{10}$$

$$\text{vii) } (110111.101)_2 = 1 \times 2^5 + 1 \times 2^4 + 0 \times 2^3 + 1 \times 2^2 + 1 \times 2^1 + 1 \times 2^0 + 1 \times 2^{-1} + 0 \times 2^{-2} + 1 \times 2^{-3}$$

$$= 32 + 16 + 0 + 4 + 2 + 1 + 0.5 + 0 + 0.125$$

$$= \underline{(55.625)}_{10}$$

Decimal, Binary, Octal and Hexadecimal numbers.

Decimal.	Binary	Octal.	Hexadecimal.
0	0000	0	0
1	0001	1	1
2	0010	2	2
3	0011	3	3
4	0100	4	4
5	0101	5	5
6	0110	6	6
7	0111	7	7
8	1000	10	8
9	1001	11	9
10	1010	12	A
11	1011	13	B
12	1100	14	C
13	1101	15	D
14	1110	16	E
15	1111	17	F

* Convert $(475.25)_8$ to its decimal equivalent.

$$\begin{aligned}
 (475.25)_8 &= 4 \times 8^2 + 7 \times 8^1 + 5 \times 8^0 + 2 \times 8^{-1} + 5 \times 8^{-2} \\
 &= 256 + 56 + 5 + 2 \times \frac{1}{8} + 5 \times \frac{1}{64} \\
 &= (317.30813)_{10}
 \end{aligned}$$

* $(9B2.1A)_{16} = (?)_{10}$.

$$\begin{aligned}
 &= 9 \times 16^2 + B(11) \times 16^1 + 2 \times 16^0 + 1 \times 16^{-1} + A(10) \times 16^{-2} \\
 &= 2304 + 176 + 2 + 1 \cdot \frac{1}{16} + 10 \cdot \frac{1}{256} \\
 &= 2304 + 176 + 2 + 0.0625 + 0.039 \\
 &= (2482.1)_{10}
 \end{aligned}$$

$$\begin{aligned}
 * (3102.12)_4 &= (?)_{10} \\
 &= 3 \times 4^3 + 1 \times 4^2 + 0 \times 4^1 + 2 \times 4^0 + 1 \times 4^{-1} + 2 \times 4^{-2} \\
 &= 192 + 16 + 0 + 2 + \frac{1}{4} + (2) \cdot \frac{1}{16} \\
 &= (210.375)_{10}.
 \end{aligned}$$

$$\begin{aligned}
 * (614.15)_7 &= (?)_{10} \\
 &= 6 \times 7^2 + 1 \times 7^1 + 4 \times 7^0 + 1 \times 7^{-1} + 5 \times 7^{-2} \\
 &= 294 + 7 + 4 + \frac{1}{7} + 5 \cdot \frac{1}{49} \\
 &= 294 + 7 + 4 + 0.142857 + 0.102 \\
 &= (305.24486)_{10}.
 \end{aligned}$$

Decimal to Binary conversion.

$$\begin{aligned}
 * (29)_{10} &= (?)_2 \\
 &= \underline{(11101)}_2.
 \end{aligned}$$

$$\begin{array}{r}
 2 \overline{) 29} \\
 2 \overline{) 14} - 1 \\
 2 \overline{) 7} - 0 \\
 2 \overline{) 3} - 1 \\
 1 - 1
 \end{array}
 \begin{array}{l}
 \text{LSD} \\
 \uparrow \\
 \text{MSD}
 \end{array}$$

$$* (25.375)_{10} = (?)_2.$$

$$\begin{array}{r}
 2 \overline{) 25} \\
 2 \overline{) 12} - 1 \\
 2 \overline{) 6} - 0 \\
 2 \overline{) 3} - 0 \\
 1 - 1
 \end{array}
 \begin{array}{l}
 \text{LSD} \\
 \uparrow \\
 \text{MSD}
 \end{array}$$

$$\frac{0.375 \times 2}{0.750} = 0.$$

$$\frac{0.750 \times 2}{1.5} = 1.$$

Decimal to Octal conversion.

$$* (416.12)_{10} = (?)_8$$

$$\begin{array}{r} 8 \overline{) 416} \\ 8 \overline{) 52} - 6 \\ 6 - 4 \end{array} \quad \uparrow$$

$$\frac{0.12 \times 8}{0.96} = 0.$$

$$\frac{0.96 \times 8}{7.68} = 7$$

$$\frac{0.68 \times 8}{5.44} = 5$$

$$\frac{0.44 \times 8}{3.52} = 3$$

$$\frac{0.52 \times 8}{4.16} = 4 \quad \downarrow$$

$$(416.12)_{10} = (640.07534)_8$$

$$* (3964.63)_{10} = (7574.50243)_8$$

$$* (469)_{10} = (725)_8$$

Decimal to Hexadecimal conversion.

$$* (3509)_{10} = (?)_{16}$$

$$\begin{array}{r} 16 \overline{) 3509} \\ 16 \overline{) 219} - 5 \\ 16 \overline{) 13} - 11 \\ 0 - 13 \end{array} \quad \uparrow \begin{array}{l} B \\ D \end{array}$$

$$(3509)_{10} = (DB5)_{16}$$

$$* (2604.10546875)_{10} = (?)_{16}.$$

The whole number part is converted by repeated division by 16.

$$\begin{array}{r} 16 \overline{) 2604} \\ 16 \overline{) 162} \quad - 12(C) \\ \hline 10(A) - 2 \end{array}$$

$$(2604)_{10} = (A2C)_{16}.$$

* The fraction part is converted by repeated multiplication by 16 and by keeping track of the integer.

$$\begin{array}{r} 0.10546875 \times 16 \\ \hline 1.6875. \end{array}$$

- 1.

$$\begin{array}{r} 0.6875 \times 16 \\ \hline 11.00. \end{array}$$

- 11(B).

$$\begin{array}{r} 0.00 \times 16 \\ \hline 00. \end{array}$$

$$(0.10546875)_{10} = (.1B)_{16}.$$

$$(2604.10546875)_{10} = (A2C.1B)_{16}.$$

Binary to Octal.

octal number.	Binary equivalent
0	0 0 0
1	0 0 1
2	0 1 0
3	0 1 1
4	1 0 0
5	1 0 1
6	1 1 0
7	1 1 1

* For binary to octal conversion of whole numbers group the given binary number in groups of three starting from the right most [LSB] and replace each group by the octal number shown in above table.

* For conversion of fraction part, make group of three starting with the left most bit.

$$1) (101111)_2 = (?)_8 \quad \begin{array}{c} \leftarrow \\ 101, 111 \\ 5 \quad 7 \end{array}$$

$$\therefore (101111)_2 = (57)_8$$

$$2) (1110.01101)_2 = (?)_8$$

whole number

001, 110

add

1, 6.

fraction part

011. 010

3 2. add.

$$(1110.01101)_2 = (16.32)_8$$

Octal numbers to binary.

* To convert octal to binary, simply replace each octal number by its equivalent.

$$\Rightarrow (724)_8 = (?)_2.$$

$$\begin{array}{ccc} 7 & 2 & 4 \\ 111 & 010 & 100. \end{array}$$

$$\therefore (724)_8 = (111010100)_2.$$

$$2) (365.217)_8 = (?)_2 = (011110101.010001111)_2$$

$$3) (0.506)_8 = (?)_2 = (0.101000110)_2.$$

NUMBER SYSTEM.

1) Convert

$$i) (284.65)_{10} = (?)_8 = (?)_{16}.$$

Integer part.

$$\begin{array}{r|l} 16 & 284 \\ \hline 16 & 17 \\ \hline & 1 \end{array} \quad \begin{array}{l} 12 \\ 1 \end{array} \quad \begin{array}{l} \uparrow \text{LSD} \\ \downarrow \text{MSD} \end{array}$$

Fraction part :

$$\begin{array}{l} \frac{0.65 \times 16}{10.4} \rightarrow 10 = A \\ \frac{0.4 \times 16}{6.4} \rightarrow 6 \\ \frac{0.4 \times 16}{6.4} \rightarrow 6 \end{array} \quad \begin{array}{l} \uparrow \text{MSD} \\ \downarrow \text{LSD} \end{array}$$

$$(284.65)_{10} = (11C.A66)_{16}.$$

$$\neq (11C.A66)_{16} = 000,100,011,100 \cdot 101,001,100,110.$$

$$(11C.A66)_{16} = (0434.5146)_8.$$

$$\therefore (284.65)_{10} = (434.5146)_8 = (11C.A66)_{16}.$$

ii) Convert $(ABFE)_{16} = (?)_2 = (?)_{10}.$

$$(ABFE)_{16} = (1010 \ 1011 \ 1111 \ 1110)_2.$$

$$(ABFE)_{16} = (10 \times 16^3) + (11 \times 16^2) + (15 \times 16^1) + (14 \times 16^0)$$

$$(ABFE)_{16} = (44030)_{10}.$$

$$(ABFE)_{16} = (1010101111111110)_2 = (44030)_{10}.$$

$$2) i) (532.65)_{10} = (?)_{16} = (?)_2$$

June - 03, 4M

Integer part -

$$\begin{array}{r} 16 \overline{) 532} \text{ - 4} \quad \uparrow \text{LSD} \\ 16 \overline{) 33} \text{ - 1} \\ \quad 21 \text{ - 1} \\ \hline \text{MSD} \end{array}$$

$$(2114)_{16}$$

Fraction part -

$$\begin{array}{r} 0.65 \times 16 \rightarrow 10 \quad \text{MSD} \\ 10.4 \cdot \\ 0.4 \times 16 \rightarrow 6 \\ 6.4 \cdot \\ 0.4 \times 16 \rightarrow 6 \quad \downarrow \text{LSD} \\ 6.4 \cdot \\ (0.A66)_{16} \end{array}$$

$$\therefore (532.65)_{10} = (2114.A66)_{16}$$

$$(2114.A66)_{16} = (0010 \ 0001 \ 0100 \cdot 1010 \ 0110 \ 0110)_2$$

$$\therefore (532.65)_{10} = (2114.A66)_{16} = (0010 \ 0001 \ 0100 \cdot 1010 \ 0110 \ 0110)_2$$

$$ii) (ABCD)_{16} = (?)_2 = (?)_8$$

$$(ABCD)_{16} = (1010 \ 1011 \ 1100 \ 1101)_2$$

$$(1,010,101,1 \ 11,00 \ 1,101)_2 = (125715)_8$$

$$(ABCD)_{16} = (1010 \ 1011 \ 1100 \ 1101)_2 = (125715)_8$$

3) a) perform the following.

$$i) (57.6)_8 = (?)_2 = (?)_{16}$$

Jan - 04, 6M

$$(57.6)_8 = (101 \ 111 \cdot 110)_2 = (2F.C)_{16}$$

$$ii) (193)_{16} = (?)_8 = (?)_{10}$$

$$(193)_{16} = 0001 \ 1001 \ 0011$$

$$(193)_{16} = (623)_8$$

$$(193)_{16} = (1 \times 16^2) + (9 \times 16^1) + (3 \times 16^0) = (403)_{10}$$

$$(57.6)_8 = (2F.C)_{16} = (403)_{10}$$

$$4) \text{ convert } i) (526.44)_8 = (?)_2 = (?)_{10}$$

June -04, 6M

$$(526.44)_8 = (101010110.100100)_2$$

$$(526.44)_8 = (5 \times 8^2) + (2 \times 8^1) + (6 \times 8^0) + (4 \times 8^{-1}) + (4 \times 8^{-2})$$

$$(526.44)_8 = (342.5625)_{10}$$

$$(526.44)_8 = (101010110.100100)_2 = (342.5625)_{10}$$

$$ii) (48350)_{10} = (?)_{16} = (?)_8$$

16	48350	14	↑ LSB
16	3021	13	
16	188	12	
	11 (B)		

MSD.

$$(48350)_{10} = (BCDE)_{16}$$

8	48350		↑ LSD
8	6043	6	
8	755	3	
8	94	3	
8	11	6	
	1	3	

MSD.

$$(BCDE)_{16} = (1011 \ 1100 \ 1101 \ 1110)_2$$

$$= (136336)_8$$

OR.

$$(48350)_{10} = (136336)_8$$

$$(48350)_{10} = (BCDE)_{16} = (136336)_8$$

4) Carryout the following conversion.

Jan-05, 6M

i) $(F9AC.508B)_{16} = (?)_{10}$.

$F=15, A=10, E=12, D=13$.

$$\begin{aligned}(F9AC.508B)_{16} &= (15 \times 16^3) + (9 \times 16^2) + (10 \times 16^1) + (12 \times 16^0) + \\ &\quad (5 \times 16^{-1}) + (13 \times 16^{-2}) + (8 \times 16^{-3}) + (11 \times 16^{-4}) \\ &= (63916.36532)_{10}\end{aligned}$$

ii) $(457.248)_{16} = (?)_{10}$.

$$\begin{aligned}&= (4 \times 8^2) + (5 \times 8^1) + (7 \times 8^0) + (2 \times 8^{-1}) + \\ &\quad (4 \times 8^{-2}) + (8 \times 8^{-3})\end{aligned}$$

$$(457.248)_{16} = (303.32226)_{10}$$

5) convert i) $(2AB.8)_{16} = (?)_{10} = (?)_8$

June-05, 4M

$$(2AB.8)_{16} = (?)_{10} + 10 \times 16^1 + (11 \times 16^0) + (8 \times 16^{-1})$$

$$(2AB.8)_{16} = (683.5)_{10}$$

$$= 001,010,101,011.100,0$$

$$= 1 \quad 2 \quad 5 \quad 3 \quad . \quad 4 \quad 0$$

$$(2AB.8)_{16} = (1253.40)_8$$

$$(2AB.8)_{16} = (683.5)_{10} = (1253.40)_8$$

$$ii) (764.352)_8 = (?)_{16} = (?)_2$$

$$(764.352)_8 = 111\ 100\ 100.011\ 101\ 010.$$

$$= 1F4.75.$$

$$(764.352)_8 = (1F4.75)_{16}$$

$$(764.352)_8 = (1F4.75)_{16} = (111110100.011101010)_2.$$

6) Convert the following

Jan-06, 4M

$$i) (101010.101)_2 = (?)_{10}$$

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

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

$$(101010.101)_2 = (42.625)_{10}$$

$$ii) (7034)_8 = (?)_{10}$$

$$= (7 \times 8^3) + (0 \times 8^2) + (3 \times 8^1) + (4 \times 8^0)$$

$$(7034)_8 = (3612)_{10}$$

$$iii) (2616)_{10} = (?)_{16}$$

$$(2616)_{10} = (A38)_{16}$$

$$\begin{array}{r} 16 \overline{) 2616} \\ 16 \overline{) 163} \rightarrow 8, \uparrow \text{LSD} \\ \quad 10 \rightarrow 3 \\ \quad (A) \text{ } \rightarrow \text{MSD} \end{array}$$

$$iv) (934)_{10} = (?)_8$$

$$(934)_{10} = (1646)_8$$

$$\begin{array}{r} 8 \overline{) 934} \\ 8 \overline{) 116} - 6 \uparrow \text{LSD} \\ 8 \overline{) 14} - 4. \\ \quad 1 - 1 \\ \quad \text{MSD} \end{array}$$

$$(A38)_{16} = (10 \times 16^2) + (3 \times 16^1) + (11 \times 16^0)$$

$$A=10, B=11$$

$$(A38)_{16} = (2619)_{10}$$

$$ii) (2F3)_{16} = (?)_{10}$$

$$F=15$$

$$= (2 \times 16^2) + (15 \times 16^1) + (3 \times 16^0)$$

$$(2F3)_{16} = (755)_{10}$$

10) solve.

June-08, 6M

$$i) (0.7642)_{10} = (?)_{12}$$

$$0.7642 \times 2$$

$$1.5284 \rightarrow 1$$

$$0.5284 \times 2$$

$$1.0568 \rightarrow 1$$

$$0.0568 \times 2$$

$$0.1136 \rightarrow 0$$

$$0.1136 \times 2$$

$$0.2272 \rightarrow 0$$

$$0.2272 \times 2$$

$$0.4544 \rightarrow 0$$

$$0.4544 \times 2$$

$$0.9088 \rightarrow 0$$

$$0.9088 \times 2$$

$$1.8176 \rightarrow 1$$

$$0.8176 \times 2$$

$$1.6352 \rightarrow 1$$

MSD

LSD

$$(0.7642)_{10} = (0.11000011)_2$$



$$\text{ii) } (AD6CB)_{16} = (?)_8$$

$$= (1010 \ 1101, 0110 \ 1100 \ 1011)_2$$

$$(AD6CB)_{16} = (255 \ 3313)_2$$

$$\text{iii) } (11011.1011)_2 = (?)_8$$

$$= \underset{3}{11}, \underset{3}{011}. \underset{5}{101}, \underset{4}{1}$$

$$(11011.1011)_2 = (33.54)_8$$

$$\text{iv) } (1011.11001)_2 = (?)_{10}$$

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

$$+ (1 \times 2^{-2}) + (0 \times 2^{-3}) + (0 \times 2^{-4}) + (1 \times 2^{-5})$$

$$= (13.78125)_{10}$$

$$(1011.11001)_2 = (13.78125)_{10}$$

ii) Convert $(10110011010)_2$ into octal decimal & hexadecimal.

$$(10110011010)_2 = (?)_8 = (?)_{10} = (?)_{16}$$

June-09, 8M

$$\rightarrow \underset{2}{10}, \underset{6}{110}, \underset{3}{011}, \underset{2}{010} = (2632)_8$$

$$\rightarrow \underset{5}{101}, \underset{9}{1001}, \underset{A}{1010} = (59A)_{16}$$

$$\rightarrow (1 \times 2^{10}) + (0 \times 2^9) + (1 \times 2^8) + (1 \times 2^7) + (0 \times 2^6) + (0 \times 2^5)$$

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

$$= (1434)_{10}$$

$$\therefore (10110011010)_2 = (2632)_8 = (59A)_{16} = (1434)_{10}$$



12) convert the following binary numbers to decimal numbers.

Jan - 10, 5M

$$\text{i) } (1101)_2 = (1 \times 2^3) + (1 \times 2^2) + (0 \times 2^1) + (1 \times 2^0) \\ = (13)_{10}.$$

$$\text{ii) } (10001)_2 = (1 \times 2^4) + (0 \times 2^3) + (0 \times 2^2) + (0 \times 2^1) + (1 \times 2^0) \\ = (17)_{10}.$$

$$\text{iii) } (10101)_2 = (1 \times 2^4) + (0 \times 2^3) + (1 \times 2^2) + (1 \times 2^1) + (0 \times 2^0) + (1 \times 2^0) \\ = (21)_{10}.$$