DIGITAL TECHNIQUES [DTE-313303]

Branch: CO / CW | Diploma Engineering Notes – K Scheme | Year: - Second (2nd)

Semester: - Third (3rd) | **Unit 1: Number System** | Marks: 08 Marks

⊛ Number system :- It is defined as → a method of → representing Numerical values → using a specific base or radix.

⊛ Base or Radix :- It is defined as → the number of unique digits → including zero → used to represent numbers in a positional Number system.

e.g. Binary uses only two digits → 0 & 1 → hence radix is 2.

⊛ Types of Number system :-

Parameters	Binary	octal	Decimal	Hexadecimal
1) Base or Radix	2	8	10	16
2) Largest value	1	7	9	F (15)
3) e.g.	0 to 1	0 to 7	0 to 9	0 to 9 & A to F

Note :- Largest value of a digit → is always → one less than the Base.

⊛ Conversion of Number system :-

Table 1 :- Rel^n between Decimal, Binary, octal & Hexadecimal.

Decimal (10)	Binary (2)				octal (8)	Hexadecimal (16)
	8	4	2	1		
0	0	0	0	0	0	0
1	0	0	0	1	1	1
2	0	0	1	0	2	2
3	0	0	1	1	3	3
4	0	1	0	0	4	4
5	0	1	0	1	5	5
6	0	1	1	0	6	6

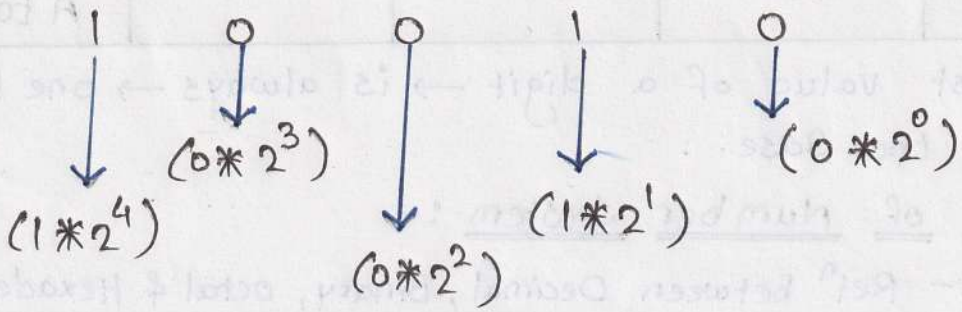
Decimal (10)	Binary (2)				Octal (8)	Hexadecimal (16)
	8	4	2	1		
7	0	1	1	1	7	7
8	1	0	0	0	9	8
9	1	0	0	1	11	9
10	1	0	1	0	12	A
11	1	0	1	1	13	B
12	1	1	0	0	14	C
13	1	1	0	1	15	D
14	1	1	1	0	16	E
15	1	1	1	1	17	F

A) Conversion from Binary (2), octal (8), Hexadecimal into Decimal (10) :-

A.1) Conversion of Binary (2) into Decimal (10).:-

a) Convert $(10010)_2 = (?)_{10}$

$\Rightarrow$



$= (1*2^4) + (0*2^3) + (0*2^2) + (1*2^1) + (0*2^0)$

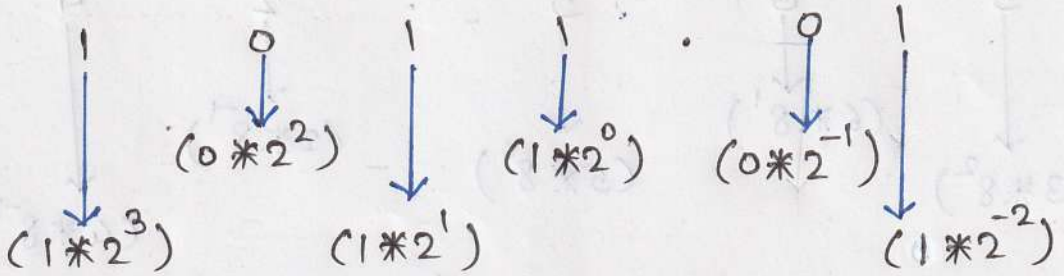
$= 16 + 0 + 0 + 2 + 0$

$= (18)_{10}$ --- final Ans.

$\therefore (10010)_2 = (18)_{10}$

b) Convert $(1011.01)_2 = (?.)_{10}$

$\Rightarrow$



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

$= (8 + 0 + 2 + 1) \cdot (0 + 0.25)$

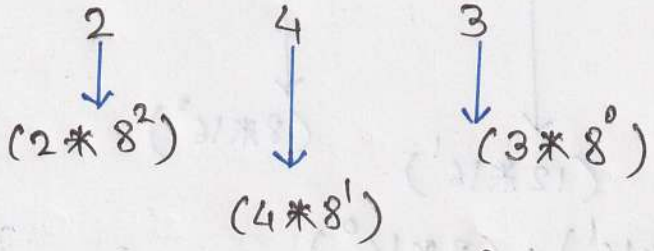
$= (11.25)_{10}$ ... (final Ans)

$\therefore (1011.01)_2 = (11.25)_{10}$

B) Convert octal (8) into Decimal (10) :-

a) Convert $(243)_8 = (?.)_{10}$

$\Rightarrow$



$= (2*8^2) + (4*8^1) + (3*8^0)$

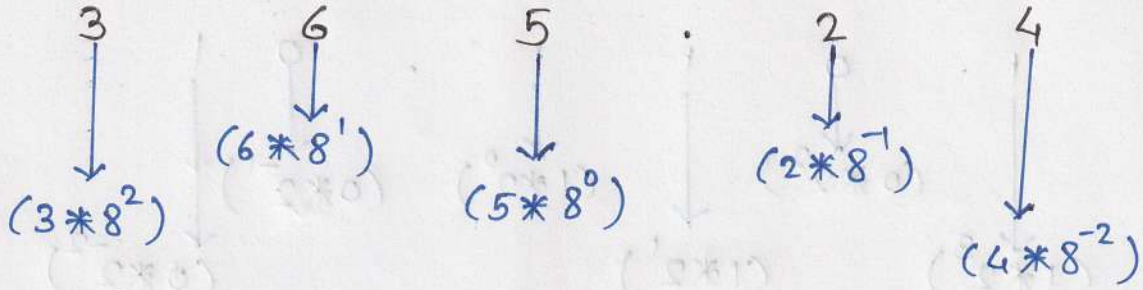
$= 128 + 32 + 3$

$= (163)_{10}$ --- (Final Ans.)

$\therefore (243)_8 = (163)_{10}$

b) Convert $(365.24)_8 = (?.)_{10}$

$\Rightarrow$



$= (3*8^2) + (6*8^1) + (5*8^0) \cdot (2*8^{-1}) + (4*8^{-2})$

$= (192 + 48 + 5) \cdot (0.25 + 0.0625)$

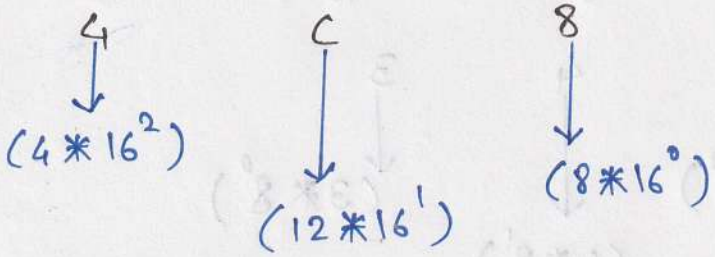
$= (245.3125)_{10}$ ---- (Final Ans.)

$\therefore (365.24)_8 = (245.3125)_{10}$

A-3) Convert Hexadecimal (16) into its Decimal (10) :-

a) Convert $(4C8)_{16} = (?.)_{10}$

$\Rightarrow$



$= (4*16^2) + (12*16^1) + (8*16^0)$

$= (1024 + 192 + 8)$

$= (1224)_{10}$ --- (Final Ans.)

$\therefore (4C8)_{16} = (1224)_{10}$

b) $(A26.48)_{16} = (?)_{10}$ Convert.

⇒

A 2 6 . 4 8

$(10*16^2) + (2*16^1) + (6*16^0) . (4*16^{-1}) + (8*16^{-2})$

$= (10*16^2) + (2*16^1) + (6*16^0) . (4*16^{-1}) + (8*16^{-2})$

$= (2560 + 32 + 6) . (0.25 + 0.03125)$

$= (2598.28125)_{10}$ --- (Final Ans.)

$\therefore (A26.48)_{16} = (2598.28125)_{10}$

B) Conversion from Binary (2), Decimal (10) & Hexadecimal (16) into octal (8). :-

B.1) Convert Binary (2) into octal (8) :-

a) Convert $(11010)_2 = (?)_8$

⇒ Extra Bit Added ← 0 1 1 0 1 0

3 2

$\therefore (11010)_2 = (32)_8$ --- (Final Ans.)

b) Convert $(1101.0011)_2 = (?)_8$

⇒ Extra Bit Added → 0 0 1 1 0 1 . 0 0 1 1 0 0

1 5 . 1 4

$\therefore (1101.0011)_2 = (15.14)_8$

Note :- Hence make a group of 3.

i) $8 = 2^3$

∴ for octal, make a group of Three (3).

ii) Grouping should be start from right to left.

iii) if Group of 3 is not Completed properlly then Extra Bits are get Added

iv) After Decimal, grouping is from left to Right.

B.2) Convert Decimal (10) into octal (8).

a) Convert $(2003)_{10} = (?.)_8$

⇒

8	2003	
8	850	3
8	31	2
8	3	7
	0	3

LSD ↑ MSD

$\therefore (2003)_{10} = (3723)_8$ --- final Ans.

i) 8 | 2003 → 850, remainder 3

ii) 8 | 850 → 31, remainder 2

iii) 8 | 31 → 3, remainder 7

iv) 8 | 3 → 0, remainder 3

b) Convert $(172.95)_{10} = (?.)_8$

⇒

8	172	
8	21	4
8	2	5
	0	2

LSD ↑ MSD

$\therefore (172.95)_{10} = (254.74631)_8$ --- final Ans.

$0.95 * 8 = 7.60$ → 7 (MSD)
$0.60 * 8 = 4.80$ → 4
$0.80 * 8 = 6.4$ → 6
$0.40 * 8 = 3.2$ → 3
$0.20 * 8 = 1.6$ → 1 (LSD)

B.3) Convert Hexadecimal (16) into octal (8) :-

a) Convert $(AF)_{16} = (?.)_8$

⇒ Step 1) Convert Hexadecimal $(AF)_{16}$ into Binary $(?.)_2$.

A ↓ 10 → (1010)
F ↓ 15 → (1111)

$\therefore (AF)_{16} = (1010\ 1111)_2$

Note :- $16 = 2^4$ ← Group size

Step 2) Convert Binary obtained into octal.

Extra Bit Added ←

0 1 0 1 0 1 1 1 1

2 5 7

$\therefore (Af)_{16} = (257)_8$ --- final Ans.

b) Convert $(498.25)_{16} = (?.)_8$

⇒ Step 1) Convert $(498.25)_{16}$ into $(?)_2$

4 9 8 . 2 5

(0100) (1001) (1000) (0010) (0101)

$\therefore (498.25)_{16} = (0100\ 1001\ 1000.0010\ 0101)_2$

Step 2) Convert Binary obtained into octal.

Extra Bit Added →

0100 1001 1000 . 0010 0101 0

2 2 3 0 . 1 1 2

$\therefore (498.25)_{16} = (2230.112)_8$ --- (final Ans.)

c) Conversion from octal (8), Decimal (10) and Hexadecimal into Binary (2) :-

c.1) Convert octal (8) into Binary (2) :-

a) Convert $(253)_8 = (?.)_2$

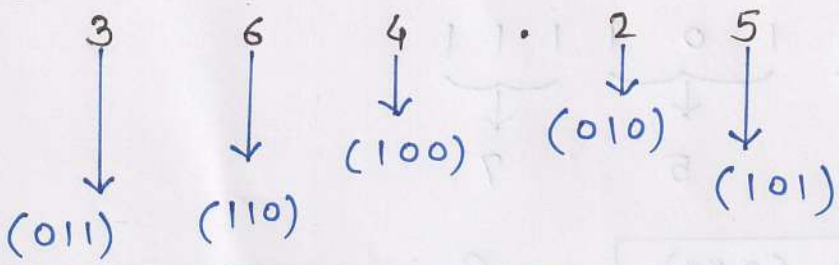
⇒ 2 5 3

(010) (101) (011)

$\therefore (253)_8 = (010\ 101\ 011)_2$ --- Final Ans.

b) Convert $(364.25)_8 = (?.)_2$

⇒



$\therefore (364.25)_8 = (011110100.010101)_2$ ---(Final Ans.)

(-2) Convert Decimal (10) into Binary (2) :-

a) Convert $(146)_{10} = (?.)_2$

⇒

2	146	
2	73	0
2	36	1
2	18	0
2	9	0
2	4	1
2	2	0
2	1	0
	0	1

LSB ↑ MSB

$\therefore (146)_{10} = (10010010)_2$

---Final Ans.

b) Convert $(2.45)_{10} = (?.)_2$

2	2	
2	1	0
	0	1

LSB ↑ MSB

$0.45 * 2 = 0.90 \quad 0$ (MSB)
$0.90 * 2 = 1.8 \quad 1$
$0.80 * 2 = 1.6 \quad 1$
$0.60 * 2 = 1.2 \quad 1$
$0.20 * 2 = 0.40 \quad 0$
$0.40 * 2 = 0.80 \quad 0$ (LSB)

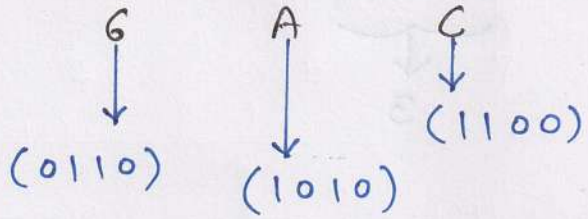
$\therefore (2.45)_{10} = (10.011100)_2$

---(Final Ans.)

C·3) Convert Hexadecimal (16) into Binary (2).

a) Convert $(6AC)_{16} = (?.)_2$

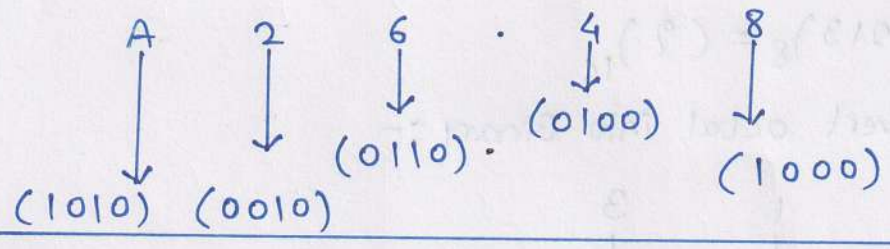
⇒



$\therefore (6AC)_{16} = (011010101100)_2$ ---(Final Ans.)

b) Convert $(A26.48)_{16} = (?.)_2$

⇒



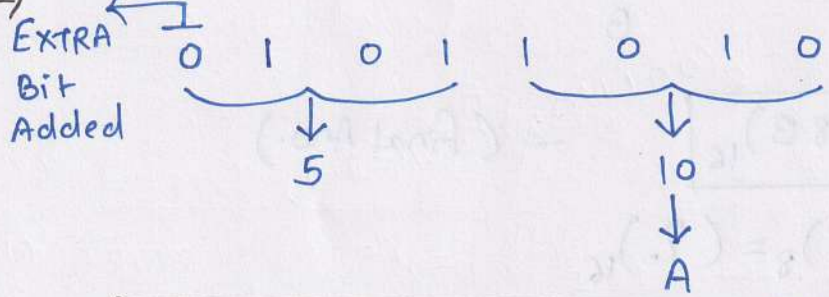
$\therefore (A26.48)_{16} = (101000100110.01001000)_2$ ---final Ans.

D) Conversion of Binary (2), Decimal (10), octal (8) into Hexadecimal (16) :-

D·1) Convert Binary (2) into Hexadecimal (16) :-

a) Convert $(1011010)_2 = (?.)_{16}$

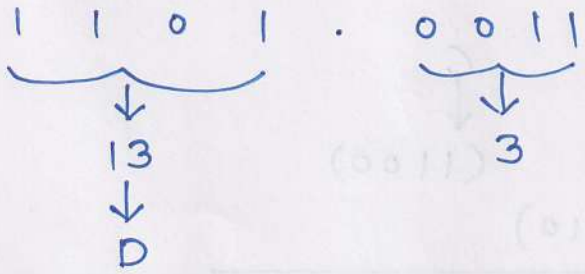
⇒



$\therefore (1011010)_2 = (5A)_{16}$ --- (final Ans.)

b) Convert $(1101.0011)_2 = (?.)_{16}$

⇒

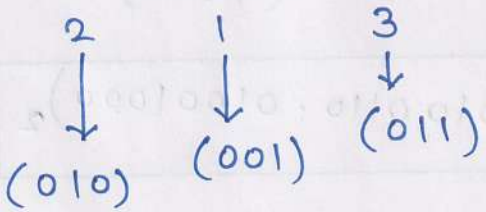


$\therefore (1101.0011)_2 = (D.3)_{16}$ ---(Final Ans.)

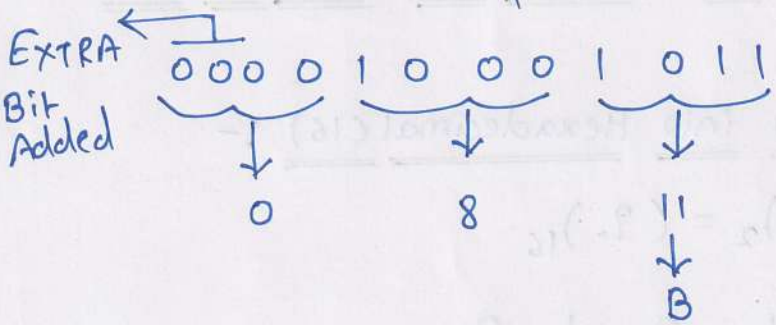
D.2) Convert octal (8) into Hexadecimal (16). :-

a) Convert $(213)_8 = (?)_{16}$

⇒ Step 1) Convert octal into Binary :-



Step 2) Convert Binary obtained into Hexadecimal

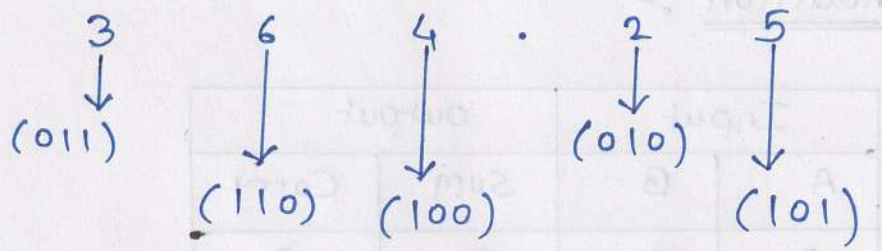


$\therefore (213)_8 = (08B)_{16}$ --- (Final Ans.)

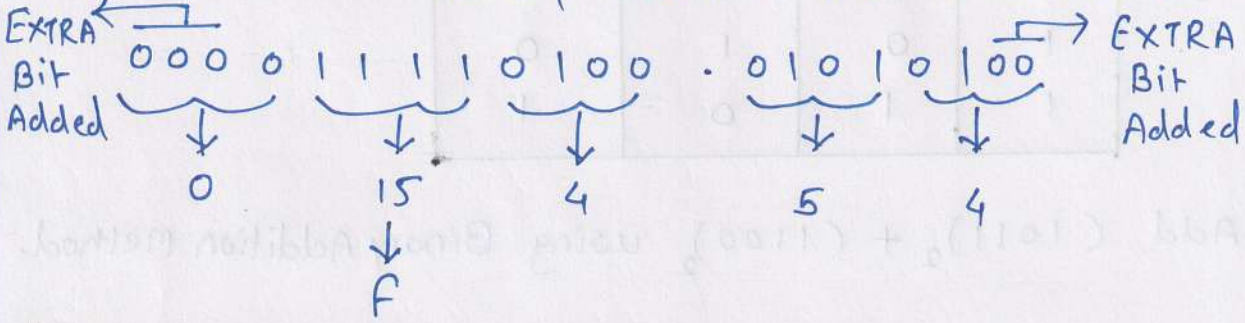
b) Convert $(364.25)_8 = (?.)_{16}$

⇒ Step 1) Convert octal into Binary

⇒



Step 2:- Convert Binary obtained into Hexadecimal.



$\therefore (364.25)_8 = (0f4.54)_{16}$ --- (Final Ans.)

D.3) Convert Decimal into Hexadecimal :-

a) Convert $(146)_{10} = (?.)_{16}$

⇒

16	146	
16	9	2
	0	9

LSD ↑ MSD

$\therefore (146)_{10} = (92)_{16}$ --- Final Ans.

b) Convert $(172.25)_{10} = (?.)_{16}$

⇒

16	172	
16	10	12 → C
	0	10 → A

LSD ↑ MSD

$0.25 * 16 = 4.0 \rightarrow 4$ (MSD)

$0.00 * 16 = 0.0 \rightarrow 0$ (LSD)

$\therefore (172.25)_{10} = (AC.40)_{16}$ --- Final Ans.

⊛ Binary Addition :-

Input		Output	
A	B	SUM	Carry
0	0	0	0
0	1	1	0
1	0	1	0
1	1	0	1

Q.1 Add $(1011)_2 + (1100)_2$ using Binary Addition Method.

⇒

$$\begin{array}{cccccc} & 1 & 0 & 1 & 1 & \rightarrow 11 \\ + & & & & & + \\ 1 & 1 & 1 & 0 & 0 & \rightarrow 12 \\ \hline 1 & 0 & 1 & 1 & 1 & \rightarrow 23 \end{array}$$

$$\therefore (1011)_2 + (1100)_2 = (10111)_2$$

⊛ Binary Multiplication :-

Input		output
A	B	Y = A * B
0	0	0
0	1	0
1	0	0
1	1	1

Q.2 Multiply $(9)_{10}$ by $(8)_{10}$

⇒ $(9)_{10} = 1001$

$(8)_{10} = 1000$

⇒

$$
\begin{array}{rcccccccl}
 & & 1 & 0 & 0 & 1 & & & \leftarrow (9)_{10} \\
* & & 1 & 0 & 0 & 0 & & & \leftarrow (8)_{10} \\
\hline
 & & 0 & 0 & 0 & 0 & & & \\
 & 0 & 0 & 0 & 0 & X & & & \\
 & 0 & 0 & 0 & 0 & X & X & & \\
1 & 0 & 0 & 1 & X & X & X & & \\
\hline
1 & 0 & 0 & 1 & 0 & 0 & 0 & \leftarrow & (72)_{10}
\end{array}
$$

$\therefore (9)_{10} * (8)_{10} = (1001000)_2 = (72)_{10}$ ----(Final Ans.)

✱ Binary Division :-

Q.3 Perform the Division $(1111101)_2 \div (101)_2$

⇒

$$
\begin{array}{r}
11001 \\
\hline
101 \;)\; 1111101 \\
-\;\; 101 \\
\hline
\;\; 101 \\
-\;\; 101 \\
\hline
\;\;\; 001 \\
-\;\; 000 \\
\hline
\;\;\;\; 010 \\
-\;\;\; 000 \\
\hline
\;\;\;\;\; 101 \\
-\;\;\; 101 \\
\hline
\;\;\;\;\; 000
\end{array}
$$

$\therefore (1111101)_2 \div (101)_2 = (11001)_2$ ---(Final Ans.)

✱ Binary Subtraction :-

Input		Output	
A	B	Diff	Borrow
0	0	0	0
0	1	1	1
1	0	1	0
1	1	0	0

Q.4 Subtract Decimal numbers $(38)_{10}$ and $(29)_{10}$ by Converting them into Binary.

⇒

$(38)_{10} \Rightarrow$ 1 0 0 1 1 0

$-$ $(29)_{10} \Rightarrow$ -1 $\underset{-1}{1}$ 1 1 $\underset{-1}{0}$ 1

$(9)_{10}$ ← 0 0 1 0 0 1

$\therefore (38)_{10} - (29)_{10} = (9)_{10}$ --- (Final Ans.)

Note :- i) Subtraction always starts from LSB (Rightside) & it get performed Coloumn by Coloumn.

ii) 1's Complement and 2's Complement is used for Subtraction specially for Negative Numbers.

⊛ 1's Complement :-

1) Def^n :- It is obtained by → inverting all bits → of given number

2) e.g. :- obtain 1's Complement of $(1011\ 0010)_2$

⇒

1 0 1 1 0 0 1 0 ← Given number

↓ ↓ ↓ ↓ ↓ ↓ ↓ ↓

0 1 0 0 1 1 0 1 ← 1's Complement

⊛ Binary Subtraction using 1's Complement :-

Steps to be followed for subtraction $(A)_2 - (B)_2$ using 1's Complement.

Step 1 :- Convert $(B)_2$ [Negative Number] to it's 1's Complement.

Step 2 :- Add $(A)_2$ & 1's Complement of Negative Number $(B)_2$ using Binary Addition.

Step 3 :- if Carry = 1, then add 1 to the result obtained in step 2. and get the final result.

Step 4 :- if Carry = 0, then the result obtained is in Negative form (Not True) i.e. in 1's Complement form. So Convert it into True form by inverting all bits of result obtained and get final Result.

Q.1 perform $(7)_{10} - (3)_{10}$ using 1's Complement method.

⇒ **Step 1 :-** Convert Negative Number $(3)_{10}$ into its 1's Complement

$(3)_{10} \Rightarrow (0\ 1\ 1)_2$

1's Complement of $(3)_{10} \Rightarrow (1\ 0\ 0)_2$

Step 2 :- Add $(7)_{10}$ with 1's Complement of Negative Number.

$(7)_{10} \Rightarrow$ 1 1 1

1's Complement of $(3)_{10} \Rightarrow$ + 1 0 0

Carry → [1]

0 1 1

Step 3 :- Here, Carry=1 is obtained. Then add this Carry 1 to the LSB of result obtained in Step 2.

```
  0 1 1   ← result obtained in step 2
+     1   ← Add 1 to the LSB.
-------
  1 0 0   ← final Result.
```

$\therefore (7)_{10} - (3)_{10} = (100)_2 = (4)_{10}$ --- (final Ans.)

Q.2. Perform $(4)_{10} - (9)_{10}$ using 1's Complement Method.

⇒ **Step 1 :-** Convert Negative Number $(9)_{10}$ into its 1's Complement.

$(9)_{10} \Rightarrow (1\ 0\ 0\ 1)_2$

1's Complement of $(9)_{10} \Rightarrow (0\ 1\ 1\ 0)_2$

Step 2 :- Add $(4)_{10}$ to the 1's Complement of Negative Number.

$(4)_{10} \Rightarrow 0\ 1\ 0\ 0$

1's Complement of $(9)_{10} \Rightarrow +\ 0\ 1\ 1\ 0$

Carry → [0] $1\ 0\ 1\ 0$

Step 3 :- Here, Carry = 0. It means result is Negative & in it's Complement form. Therefore, invert all the bits of result obtained in step 2.

```
1 0 1 0
↓ ↓ ↓ ↓
0 1 0 1   ← final result.
```

$\therefore (4)_{10} - (9)_{10} = (0101)_2 = (-5)_{10}$ --- (final Ans.)

⊛ 2's Complement :-

i) Def^ :- 2's Complement of Binary Number is obtained by Adding 1 to the LSB of 1's Complement of that Number.

ii) That is, **2's Complement = 1's Complement + 1**

iii) e.g. obtain 2's Complement of $(10110010)_2$

⇒ Step 1 :- obtain 1's Complement of given number

1 0 1 1 0 0 1 0 ← Given Number

0 1 0 0 1 1 0 1 ← Inverting all bits (1's complement)

Step 2 :- Add 1 to the 1's Complement obtained in step 1.

```
  0 1 0 0 1 1 0 1
+               1
-----------------
  0 1 0 0 1 1 1 0   ← 2's Complement
```

∴ 2's Complement of $(10110010)_2$ is $(01001110)_2$

⊛ Binary Subtraction using 2's Complement :-

Steps to be followed for subtraction $(A)_{10} - (B)_{10}$ using 2's Complement

Step 1 :- Convert Negative Number $(B)_{10}$ to it's 2's Complement

Step 2 :- Add $(A)_{10}$ to the 2's Complement of $(B)_{10}$ & get the result.

Step 3 :- if Carry = 1, then the result is positive & in its True form. (Note :- Carry is discarded)

Step 4 :- if Carry = 0, then the result is Negative & in its 2's Complement form. In this case, perform following steps.

Step A) Subtract 1 from the result obtained in step 2.

Step B) Invert all the bits of step A) result obtained.

Q.1 Perform $(1010)_2 - (101)_2$ using 2's Complement method.

⇒ **Step 1 :-** obtain 2's Complement of Negative Number $(101)_2$

Extra bit Added →

```
  0 1 0 1
  ↓ ↓ ↓ ↓
  1 0 1 0   ← 1's Complement
+       1   ← Add 1
-----------
  1 0 1 1   ← 2's Complement of given number
```

Step 2 :- Add $(1010)_2$ into 2's Complement of given number.

```
    1 0 1 0
+   1 0 1 1
-----------
1 | 0 1 0 1
```

Carry → 1

Step 3 :- Since Carry = 1, then the result is in its True form.
Hence, Carry is Discarded.

$$\therefore (1010)_2 - (101)_2 = (0101)_2 \quad \text{... (Final Ans.)}$$

Q.2 Perform $(11011)_2 - (11100)_2$ using 2's Complement method.

⇒ **Step 1 :-** obtain 2's Complement of $(11100)_2$

```
  1 1 1 0 0
  ↓ ↓ ↓ ↓ ↓
  0 0 0 1 1   ← 1's Complement
+       1 1
-----------
  0 0 1 0 0   ← 2's Complement
```

Step 2 :- Add $(11011)_2$ with 2's Complement of Negative Number.

```
  1 1 0 1 1
+ 0 0 1 0 0
-----------
  1 1 1 1 1
```

Carry is → [0]

Step 3 :- Since the Carry is Zero, then the result is in Complement form. So,

Step a) Subtract 1 from result obtained in step 2.

```
  1 1 1 1 1
-       1
-----------
  1 1 1 1 0   ← 1's Complement
```

Step b) Invert all the 5 bits obtained above.

```
  1 1 1 1 0
  ↓ ↓ ↓ ↓ ↓
  0 0 0 0 1   ← final Result.
```

$$\therefore (11011)_2 - (11100)_2 = (00001)_2$$

✱ **Codes :-**

A) **BCD [Binary Coded Decimal]**

i) **Def^n :-** In this code, each decimal digit is represented by 4-bit (Binary) Number.

ii) e.g.

Decimal	0	1	2	3	4	5	6	7	8
BCD	0000	0001	0010	0011	0100	0101	0110	0111	1000

Note :- only first Ten Numbers, i.e. 0000 to 1001 ⇒ Valid BCD Codes and remaing Six i.e. 1010 to 1111 ⇒ Invalid BCD Codes.

Q.1 Convert the following into BCD

a) 35 b) 174 c) 2479

⇒ a) $35 \Rightarrow$

3 → 0011, 5 → 0101

$\therefore (35)_{10} = (0011\ 0101)_{BCD}$

b) $174 \Rightarrow$

1 → 0001, 7 → 0111, 4 → 0100

$\therefore (174)_{10} = (0001\ 0111\ 0100)_{BCD}$

c) $2479 \Rightarrow$

2 → 0010, 4 → 0100, 7 → 0111, 9 → 1001

$\therefore (2479)_{10} = (0010\ 0100\ 0111\ 1001)_{BCD}$

B) Gray Codes :-

1) Def^n :- In this Code, only one bit will change → each time → when the decimal number is incremented by 1.

2) As only one bit changes at a time → hence the gray code is called as "Unit Distance Code"

3) Gray Code is Non-weighted Code and also a Cyclic Code.

4) Gray Code exhibits reflective property.

5) Gray code is popularly used in shaft position Encoders.

Decimal Number	Binary Number				Gray Code			
	B_3	B_2	B_1	B_0	G_3	G_2	G_1	G_0
					B_3	$B_3 \oplus B_2$	$B_2 \oplus B_1$	$B_1 \oplus B_0$
0	0	0	0	0	0	0	0	0
1	0	0	0	1	0	0	0	1
2	0	0	1	0	0	0	1	1
3	0	0	1	1	0	0	1	0
4	0	1	0	0	0	1	1	0
5	0	1	0	1	0	1	1	1
6	0	1	1	0	0	1	0	1
7	0	1	1	1	0	1	0	0
8	1	0	0	0	1	1	0	0
9	1	0	0	1	1	1	0	1
10	1	0	1	0	1	1	1	1
11	1	0	1	1	1	1	1	0
12	1	1	0	0	1	0	1	0
13	1	1	0	1	1	0	1	1
14	1	1	1	0	1	0	0	1
15	1	1	1	1	1	0	0	0

✱ **Gray to Binary Conversion :-**

Step 1) MSB of Gray and Binary are same. (i.e. $G_3 = B_3$)

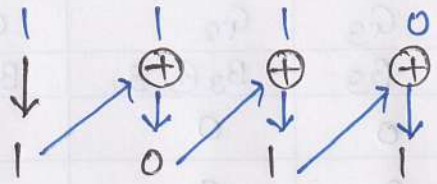
Step 2) Add Binary MSB to next Bit of Gray code. and Note down the result.

Step 3) Continues the process until LSB is reached.

Q.1 Convert 1110 Gray to Binary.

⇒

Gray Code



$\therefore (1110)_{Gray} = (1011)_{Binary}$ --- (final Ans.)

⊛ Binary to Gray Conversion :-

Step 1> MSB of Binary and Gray are same. So write it directly. $G_3 = B_3$ [Ex-OR Gate]

Step 2> perform,

$G_2 = B_3 \oplus B_2$

$G_1 = B_2 \oplus B_1$

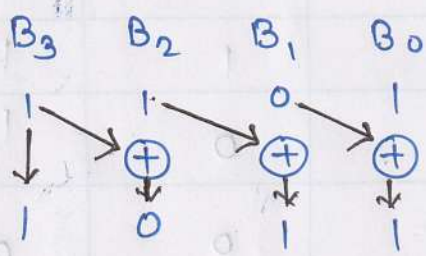
$G_0 = B_1 \oplus B_0$

AND Note Down the Result.

A	B	Y
0	0	0
0	1	1
1	0	1
1	1	0

Q.1 Convert $(1101)_2 = (?)_{Gray}$

⇒



$\therefore (1101)_2 = (1011)_{Gray}$

⊛ Excess-3 Code :-

i) It is also called as "XS-3".

ii) It is Non-weighted Code.

iii) This code is obtained by Adding $(0011)_2$ or $(3)_{10}$ to each individual Code.

Q.1 obtain XS-3 Code for $(428)_{10}$

⇒

4	2	8	
0 1 0 0	0 0 1 0	1 0 0 0	← Binary-4-bits (BCD)
+ 0 0 1 1	0 0 1 1	0 0 1 1	← Add $(3)_{10}$
0 1 1 1	0 1 0 1	1 0 1 1	

$\therefore (428)_{10} = (0111\ 0101\ 1011)_{\text{Excess-3}} = (7\ 5\ 11)$

Decimal No.	BCD 8	4	2	1	EXCESS-3 Code (Add $(0011)_2$)				
0	0	0	0	0	0	0	1	1	3
1	0	0	0	1	0	1	0	0	4
2	0	0	1	0	0	1	0	1	5
3	0	0	1	1	0	1	1	0	6
4	0	1	0	0	0	1	1	1	7
5	0	1	0	1	1	0	0	0	8
6	0	1	1	0	1	0	0	1	9
7	0	1	1	1	1	0	1	0	10
8	1	0	0	0	1	0	1	1	11
9	1	0	0	1	1	1	0	0	12

Note :- Excess-3 is a sequential code because each succeeding code is 1 binary number greater than its preceding code.

✱ ASCII :- [American Standard Code for Information Interchange]

i) It is universally Accepted Alphanumeric Code.

ii) ASCII has 128 characters and symbols.

iii) ASCII is a 7-bit code as we need 7-bit to represent 128 characters.

iv) First 32 ASCII characters are → Nongraphic Commands which are never prited or displayed as they are used only for Control purpose.

v) Remaining characters are graphic symbols which can be displayed or printed.

vi) In detail, ASCII Code set Consist
- 94 printable characters
- 32 Control symbol
  - Space
  - Delete

✱ Applications of Codes :-

i) Data Representation :- Codes like Binary, BCD, ASCII are used to represent numbers, special characters, and Alphabets in Digital system.

ii) Digital Communication :- Codes are used to transmitting data between Computers and digital devices.

iii) Computer processing :- ASCII Code is used for storing and processing text data in Computers.

iv) Data storage :- Binary Codes are used for storing information in memory devices like RAM.

v) Arithmatic operation :- BCD and Excess 3 Codes are used in digital arithmatic operations such as addition & subtraction.

vi) Error Detection and Correction :- Gray Code and other coding Technique helps in reducing errors.

vii) Display System :- BCD Code is widely used in Calculators, digital clocks.

viii) position Encoder & Counter :- Gray code is used in shaft Encoders and Counters.

✱ BCD Addition :-

Assume that, two 4-Bit numbers A & B are being Added.

Add Two BCD Numbers A & B

Sum ≤ 9, Carry = 0	Sum ≤ 9, Carry = 1	Sum > 9, Carry = 0
↓	↓	↓
Ans. is Correct & NO Correction is required.	Add $(6)_{10}$ or $(0110)_2$ to get Correct Ans.	Add $(6)_{10}$ or $(0110)_2$ to get Correct Ans.

Q.1 Add $(57)_{10}$ & $(26)_{10}$ in BCD

$\Rightarrow (57)_{10} \Rightarrow$ 0101 0111

$(26)_{10} \Rightarrow$ 0010 0110

Valid BCD → 0111 1101 ← Invalid BCD

\+ 0000 0110

0 D D D 0011

↓8 ↓3

Q.2 Add $(83)_{10}$ & $(34)_{10}$ in BCD

$\Rightarrow (83)_{10} \Rightarrow$ 1000 0011

$(34)_{10} \Rightarrow$ 0011 0100

Invalid BCD → 1011 0111 ← Valid BCD

\+ 0110 0000

[1] ↓ 0001 0111

↓ ↓ ↓

1 1 7

$\therefore (57)_{10} + (26)_{10} = (83)_{10} = (1000\ 0011)_2$ --- final Ans.

$\therefore (83)_{10} + (34)_{10} = (117)_{10}$
$= (0001\ 0001\ 0111)_2$ ... final Ans.

⊛ BCD Subtraction using 9's Complement Method :-

Note :- i) 9's Complement of BCD Number can be obtained by subtracting it from 9.

ii) e.g. Decimal Digit = 02 & it's 9's Complement is $9 - 2 = 7$

Steps to perform BCD Subtraction using 9's Complement

$$(A)_{BCD} - (B)_{BCD}$$

Step 1 :- obtain 9's Complement of Number $(B)_{BCD}$ i.e. Negative Number.

Step 2 :- Add $(A)_{BCD}$ & 9's Complement of $(B)_{BCD}$.

Step 3 :- if Carry = 1, then add this Carry to sum obtained in step 2.

Step 4 :- if Carry = 0, then the result is Negative & hence take 9's Complement of result obtained.

Q.1 Perform $(7)_{10} - (3)_{10}$ using 9's

⇒ Step 1 :- obtain 9's Complement of Negative Number $(3)_{10}$

$\therefore (9)_{10} - (3)_{10} = (6)_{10}$

Add $(7)_{10}$ with 9's Complement of Negative Number.

$(7)_{10} \Rightarrow$ 0 1 1 1

$(6)_{10} \Rightarrow$ 0 1 1 0

1 1 0 1

Invalid BCD → ∴ Add $(0110)_2$

Q.2 Perform $(52)_{10} - (89)_{10}$ using 9's

⇒ Step 1 :- obtain 9's Complement of Negative Number $(89)_{10}$

$\therefore (99)_{10} - (89)_{10} = (10)_{10}$

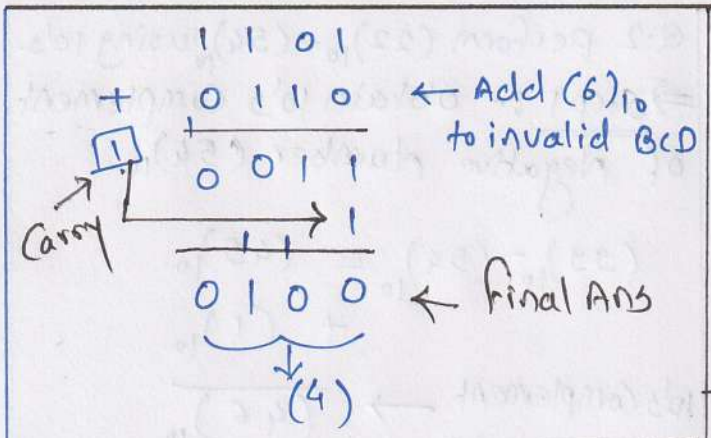
Add $(52)_{10}$ with 9's Complement of Negative Number

$(52)_{10} \Rightarrow$ 0101 0010

$(10)_{10} \Rightarrow$ 0001 0000

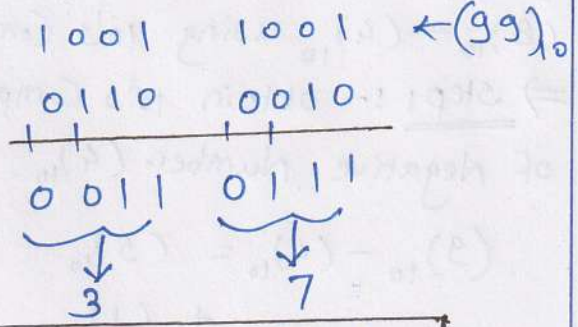
Carry → 0 | 0110 0010

Since, the Carry = 0, then the result is Negative. Take 9's



$\therefore (7)_{10} - (3)_{10} = (0100)_2 = (4)_{10}$

$\therefore$ Take 9's Complement



$\therefore (52)_{10} - (89)_{10} = (37)_{10}$

--- Final Ans.

⊛ BCD Subtraction using 10's Complement Method :-

Note :- 10's Complement is obtained by Adding 1 to the 9's Complement.

$\therefore$ 10's Complement = 9's Complement + 1

e.g. obtain 10's Complement of $(2)_{10}$

⇒ Step 1 :- obtain 9's Complement of $(2)_{10}$

$\therefore (9)_{10} - (2)_{10} = (7)_{10}$

Step 2 :- Add (1) to the 9's Complement obtained.

$\therefore (1)_{10} + (7)_{10} = (8)_{10}$

Steps to perform BCD Subtraction using 10's Complement

$(A)_{BCD} - (B)_{BCD}$

Step 1 :- obtain 10's Complement of $(B)_{BCD}$ i.e. Negative Number

Step 2 :- Add $(A)_{BCD}$ to the 10's Complement of $(B)_{BCD}$.

Step 3 :- if Carry = 1 → then the answer is positive & in its true form. Hence, Discard the Carry.

Step 4 :- if Carry = 0 → then the answer is Negative. So take 10's Complement to get the answer.

Q.1 Perform the subtraction $(8)_{10} - (4)_{10}$ using 10's Complement

⇒ Step 1 :- obtain 10's Complement of Negative Number. $(4)_{10}$.

$(9)_{10} - (4)_{10} = (5)_{10} + (1)_{10}$

10's Complement ⟶ $(6)_{10}$

Step 2 :- Add $(8)_{10}$ with 10's Complement of Negative Number

$(8)_{10} \Rightarrow$ 1000

$(6)_{10} \Rightarrow$ 0110

1110 ← Invalid BCD

+ 0110 ∴ Add $(0110)_2$

1 0100 ← Carry Discarded

$\therefore (8)_{10} - (4)_{10} = (0100)_2 = (4)_{10}$

--- Final Ans.

For practice,

i) Perform $(3)_{10} - (8)_{10}$ using 10's Complement Method.

ii) perform $(54)_{10} - (22)_{10}$ using 10's Complement Method.

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Q.2 perform $(22)_{10} - (54)_{10}$ using 10's.

⇒ Step 1 :- obtain 10's Complement of Negative Number $(54)_{10}$.

$(99)_{10} - (54)_{10} = (45)_{10} + (1)_{10}$

10's Complement ⟶ $(46)_{10}$

Step 2 :- Add $(22)_{10}$ with 10's Complement of Negative Number

$(22)_{10} \Rightarrow$ 0010 0010

+ 0100 0110

Carry 0 ← Valid

0110 1000 ← Valid

Since Carry is Zero, therefore the result is Negative & Take 10's Complement form.

Step 3 :- Take 10's Complement

1001 1001

− 0110 1000

0011 0001

3 1

+ 1 ← Add 1

0011 0010

3 2

$\therefore (22)_{10} - (54)_{10} = -(32)_{10}$

$= (0011\ 0010)_2$

--- (Final Ans.)

DIGITAL TECHNIQUES [DTE-313303]

Branch: CO / CW | QUESTION BANK | Year: - Second (2nd)

Semester: - Third (3rd) | Unit 1: Number System | Marks: 08 Marks

Q.1) 02 Marks Question.

a) write the Base of following Number systems. Decimal, Binary, octal and Hexadecimal ---(S-25)

b) write features of "Binary" & "octal" numbers in terms of following points ---(W-25)

i) Base / Radix ii) Symbol / character used iii) one example

c) List the Advantages of BCD Codes ---(W-24)

d) List the octal and Hexadecimal numbers for decimal number 0 to 15. ---(W-23)

e) Convert i) $(159)_{10} = (\quad)_8$ ---(S-23)

ii) $(380)_{10} = (\quad)_{16}$

f) Convert i) $(53)_{10} = (\quad)_{BCD}$ ---(S-23)

ii) $(34)_{10} = (\quad)_{Excess-3}$

g) Convert i) $(100111)_2 = (\text{Gray})$

ii) $(11010)_2 = (\text{2's Complement})$

h) Perform $(12)_{10} - (10)_{10}$ using 1's Complement Method.

i) Perform $(4)_{10} - (7)_{10}$ using 9's Complement Method.

j) obtain 2's Complement of i) $(7)_{10}$ ii) $(10110)_2$

k) List Application of Codes. (Any 4)

l) Develop the table for 4-bit Gray code

m) Develop the table for 4-bit Excess-3 code.

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Q.2) 04 Marks Question

a) Convert the following ---(S-25)

i) $(429)_{10} = (?.)_{BCD}$ ii) $(2.45)_{10} = (?.)_2$

iii) $(AF)_{16} = (?.)_8$ iv) $(1011010)_2 = (?.)_{16}$

b) perform $(85)_{10} - (98)_{10}$ using 2's Complement Method ---(W-25)

c) Convert the following ---(W-24)

i) $(A26.48)_{16} = (?.)_{10}$ ii) $(172.95)_{10} = (?.)_8$

iii) $(0101\ 0011)_{BCD} = (?.)_2$

d) perform $(10110)_2 - (11010)_2$ using 2's Complement.

e) Convert the following ---(S-25)

i) $(5C7)_{16} = (?.)_{10}$ ii) $(2598)_{10} = (?.)_{16}$

iii) $(10110)_2 = (?.)_{10} = (?.)_{16}$

f) Perform BCD Addition on following Decimal Nos. ---(W-25)

i) $(3485)_{10} + (1357)_{10} = (?.)_{BCD}$

ii) $(485)_{10} + (326)_{10} = (?.)_{BCD}$

g) Perform $(9)_{10} - (4)_{10}$ using 10's Complement method.

h) Convert given number system with proper steps. ---(W-25)
Hexadecimal to Binary and further to octal no.

i) $(4F)_{16} = (?.)_2 = (?.)_8$

ii) $(A72E)_{16} = (?.)_2 = (?.)_8$

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