BCD ⇒ Binary Coded Decimal

Decimal	BCD_{8421}
0	0000
1	0001
2	0010
3	0011
4	0100
5	0101
6	0110
7	0111
8	1000
9	1001
	1010
	1011
	1100
	1101
	1110
	1111

these are unused and considered as error

By default $BCD = BCD_{8421}$

Decimal → BCD

$(3450)_{10} \rightarrow (?)_{BCD}$

Step: Convert each Decimal digit into its corresponding BCD Code.

3 → 0011, 4 → 0100, 5 → 0101, 0 → 0000

$(3450)_{10} \rightarrow (0011\ 0100\ 0101\ 0000)_{BCD}$

BCD → Decimal

$(1001011000100101)_{BCD} \rightarrow (?)_{10}$

Step: Start from LSB and make groups of 4 bits. Then figure out the corresponding Decimal Digits of that group.

MSB ... LSB

$(\underbrace{1001}_{9}\ \underbrace{0110}_{6}\ \underbrace{0010}_{2}\ \underbrace{0101}_{5})$

$= (9625)_{10}$

Ex:

$\Rightarrow (\underbrace{0101}_{5}\ \underbrace{1111}_{\text{error}}\ \underbrace{0101}_{5})_{BCD} = (?)_{10}$

⇒ Given number is not valid in BCD

Excess-3

Decimal	Excess-3
0	0011
1	0100
2	0101
3	0110
4	0111
5	1000
6	1001
7	1010
8	1011
9	1100
	1101
	1110
	1111
	0000
	0001
	0010

these are unused combinations

Decimal to Excess N

Step 1: Decimal digit + N

Step 2: Now find the binary of $(\text{Decimal digit} + N)_{10}$

BCD → Ex-3 ← N

$(3)_{10} \rightarrow (?)_{Ex3}$

$= 3+3 = (6)_{10} \rightarrow (?)_2$

$= 0110$

So, $(3)_{10} = (0110)_{Ex3}$

Signed Number Representation:

(i) sign & magnitude.

(ii) 1s complement.

(iii) 2s complement.

Sign & Magnitude

$+$	$= 0$
$-$	$= 1$

positive number :

$$+(14)_{10} = (?)_{s\&m}$$

Step 1 : $(14)_{10} = (1110)_2$

Step 2 : $+(14)_{10} = \underbrace{01110}$

$$\underbrace{\boxed{0}}_{\text{sign bit}}\ \underbrace{\boxed{1110}}_{\text{Magnitude of that number}}$$

negative number :

$$-(14)_{10} = (?)_{s\&m}$$

Step 1 : $-(14)_{10} = (1110)_2$

Step 2 : $-(14)_{10} = \underbrace{11110}$

$$\underbrace{\boxed{1}}_{\text{sign bit}}\ \underbrace{\boxed{1110}}_{\text{Magnitude of that number}}$$

1s Complement

Positive Number:

$+(15)_{10} = (?)_{1s}$

(i) 15 = 1111

(ii) +15 = 01111

sign bit

Negative Number:

$-(15)_{10} = (?)_{1s}$

(i) 15 = 1111

(ii) +15 = 01111

-15 = 10000

(i) Find the binary of the given number without sign.

(ii) Now find positive version of that number

(iii) Invert all the bits
(0 → 1
1 → 0)

2s Complement

Positive Number:

$+(15)_{10} = (?)_{1s}$

(i) 15 = 1111

(ii) +15 = 01111

sign bit

Negative Number:

$-(15)_{10} = (?)_{1s}$

(i) 15 = 1111

(ii) +15 = 01111

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

-15 = 10001

(i) Find the binary of the given number without sign.

(ii) Now find positive version of that number

(iii) Perform 1s complement.

(iv) Add 1 with the answer.

Range Formulas

	Formula
Sign & Magnitude	$-[(2^{n-1})-1]$ to $+[(2^{n-1})-1]$
1s complement	$-[(2^{n-1})-1]$ to $+[(2^{n-1})-1]$
2s complement	$-[(2^{n-1})]$ to $+[(2^{n-1})-1]$

Representing 0s

S&M:

+0 = 00
-0 = 10

two diff. representation of 0

1s:

+0 = 00
-0 = 11

two diff. representation of 0

2s:

+0 = 00

$$\begin{array}{r} {}^{1}\,{}^{1}11 \\ +1 \\ \hline \cancel{1}00 \end{array}$$

-0 = 00

+0 & -0 are same.
no space wastage.

we discard carry bit in 2s comp.

2s Complement

Addition: $A + B$

(i) Perform Binary addition

(ii) If you see a carry out → Discard it.

Subtraction: $A - B = A + (-B)$ [No direct sub operation]

(i) Take 2s complement of B.

(ii) Add the 2s complement of B. with A.

1s Complement

Addition: $A + B$

(i) Perform Binary addition

(ii) If you see a carry out → Add 1 to the result.

Subtraction: $A - B = A + (-B)$ [No direct sub operation]

(i) Take 1s complement of B.

(ii) Add the 1s complement of B. with A.

Overflow

Addition:

=> Add two same signed number

if (answer also has same sign):

No overflow

else

Overflow

=> Sub two same signed number

Never Over Flow.

=> Add two different signed number

Never Over Flow.

=> Sub two different number

$+A - (-B) = +A + B$ => rule 1

$-A - (+B) = -A + (-B)$ => rule 1