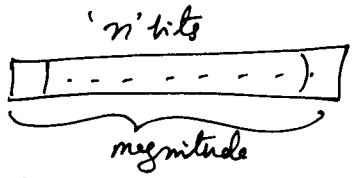
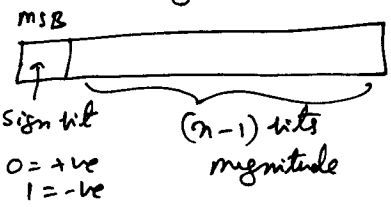
Signed Binary numbers:-

(a) un signed numbers →



(b) Signed numbers →



(i) signed magnitude form
(ii) 1's complement form
(iii) 2's complement form.

* In all the 3 forms, +ve number representation is same.

ex:- Represent $+51_{10}$ & -51_{10} in all the 3 forms of signed number representation.

sol:

	signed magnitude form	1's comp form	2's comp form
$+51_{10}$	0 0110011	0 0110011	0 0110011
-51_{10}	1 0110011	1 1001100	1 1001101

(1's) (2's)

16 | 51
16 | 3 - 3
0 - 3

33_{16}
0011 0011$_2$

ex:- Determine the decimal equivalent of the following signed numbers in all the 3 forms. 01011, 101010, 111111

sol:

	sign magnitude	1's form	2's form
01011	+11	+11	+11
101010	−10	−10101 = −21	−10110 = −22
111111	−31	−00000 = −0	−00001 = −1

→ Addition & subtraction using 2's complement form:-

1) +29 → 0 0011101
+19 → + 0 0010011
0 0 11 1010 = 48_{10}

16 | 19
16 | 1 - 3
0 - 1
1 3
00010011$_2$

16 | 29
16 | 1 - 13
0 - 1
1 D$_{16}$
0001 1101$_2$

(2) $+28 \xrightarrow{2's}$ 0001 1100

$-19 \xrightarrow{2's}$ + 1110 1101

(1) 0000 1001

EOC ×

↓

+9

16 | 19

1-3

1 3

↓ ↓

0001 0011

↓ 2's

1110 1101

16 | 28

1-12

1 C

↓ ↓

(0001 1100)$_2$

(3) $+19 \longrightarrow$ 0001 0011

$-43 \longrightarrow$ 1101 0101

1110 1000

no EOC

↓ 2's

$-00011000 = -24$

16 | 43

2-11

2 B

↓ ↓

(0010 1011)

↓ 2's

1101 0101

(4) $-57 \longrightarrow$ 11 000 111

$-33 \longrightarrow$ 1101 1111

(1) (1) 0 100 110

EOC ×

↓

+166 ← wrong.

sign bit

∴ -ve number

2's ↓

1011 010

↓

$-$ 90

16 | 33

2-1

2 1

0010 0001

↓ 2's

1101 1111

16 | 57

3-9

3 9

↓ ↓

0011 1001

↓ 2's

1100 0111

Binary coded decimal (BCD):-

→ A string of 4 bits is known as nibble.

→ BCD means each decimal digit is represented by a nibble.

→ many BCD codes have been proposed eg 8421, 2421, 5211 etc

→ out of these 8421 code is the most prominent BCD code.

→ when one refers to BCD code it always means 8421 code.

→ Even though 16 numbers (2^4) can be represented with 4 bits, only 10 of these are used and remaining 6 are invalid in BCD code.

→ BCD is used in pocket calculators, electronic counters, digital voltmeters, digital clocks etc.

→ Early versions of computers also used BCD code but discarded as it is slow and more complicated than binary.

ex:- express the following numbers in BCD code (a) 90 (b) 1507 (c) 38.2

sol:-

90	1507	38.2
1001 0000	0001 0101 0000 0111	0011 1000 . 0010

BCD Addition:-

steps:- 1. Add 2 numbers using binary addition

(i) If 4 bit sum is ≤ 9 → It is valid BCD

(ii) If 4 bit sum is > 9 → Invalid BCD
Add 6 to the 4 bit sum to skip 6 invalid states. If carry is generated in this operation add to the next nibble.

(iii) If carry generates from nibble → Add 6 to the 4 bit sum and if carry is generated add to the next nibble.

ex:-

1) $3_{10} = 0011_{BCD}$

$+\ 4_{10} = 0100_{BCD}$

$+7 \qquad 0111$

2) $6_{10} \qquad 0110_{BCD}$

$+\ 5_{10} \qquad 0101_{BCD}$

$11_{10} \qquad 1011 > 9$ invalid BCD

$+6 \rightarrow 0110$

$1\ 0001$

$\downarrow \quad \downarrow$

$1\ \ 1_{10}$

3) $9_{10} \qquad 1001_{BCD}$

$8_{10} \qquad 1000_{BCD}$

$17_{10} \qquad 10001 \leftarrow$ carry is generated.

$+6 \quad 0110$

10111

$\downarrow \quad \downarrow$

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

4) $15 \rightarrow 0001\ 0101$

$17 \rightarrow 0001\ 0111$

$32 \qquad 0010\ 1100$

$+\ 0110$

$0011\ 0010$

$\downarrow \quad \downarrow$

$3 \quad 2$

5) $18 \qquad 0001\ 1000$

$+08 \qquad 0000\ 1000$

$26 \qquad 0010\ 0000$ as carry is generated add $+6$

$+\ 0110$

$0010\ 0110$

$\downarrow \quad \downarrow$

$2 \quad 6$

eg: How many BCD corrections are required in the following BCD addition.

0100	0010	0110	BCD
0101	0111	0100	BCD
1001	1001	1010 *	
–	–	+ 0110	
1001	1010 *	0000	
–	0110	–	
1010 *	0000	0000	
+ 0110	–	–	
1 0000	0000	0000	
↓	↓	↓	↓
1	0	0	0

correction is done 3 times.

BCD Subtraction:-

method 1:- using 1's comp form.

decade result	sign of total result	
	+(EAC=1)	− (EAC=0)
	Transfer true result of adder 1	Transfer 1's comp of result of adder 1
$C_n = 1$	0000 is added in adder 2	1010 added in adder 2
$C_n = 0$	1010 is added in adder 2	0000 is added in adder 2

ex:-

$$\begin{array}{r} 835 \\ -274 \\ \hline +561 \end{array}$$

$$\begin{array}{rrrr} & 1000 & 0011 & 0101 \\ - & 0010 & 0111 & 0100 \\ \hline & 1101 & 1000 & 1011 \end{array}$$

$$\begin{array}{rrrr} & 1000 & 0011 & 0101 \\ & 1101 & 1000 & 1011 \\ \hline (1) & 0101 & 1011 & 0000 \\ & & & \downarrow \\ & & & 1 \\ \hline & 0101 & 1100 & 0001 \end{array}$$

EOC = +ve

Transfer true O/P of adder 1

$$\begin{array}{rrrr} & 0101 & 1100 & 0001 \\ + & 0000 & 1010 & 0000 \\ \hline & 0101 & (1)0110 & 0001 \end{array}$$

neglect C_n

$$[5 \quad 6 \quad 1]_{10}$$

$$\begin{array}{rrrr} 429 \xrightarrow{1's} & 0100 & 0010 & 1001 \\ -476 \xrightarrow{1's} & 1011 & 1000 & 1001 \\ \hline -47 & & & \end{array}$$

$$\begin{array}{rrrr} & 1111 & 1010 & 0010 \\ & & & 1 \\ \hline & 1111 & 1011 & 0010 \end{array}$$

as EOC ⇒ -ve

transfer 1's comp

$$\begin{array}{rrrr} & 0000 & 0100 & 1101 \\ + & 0000 & 0000 & 1010 \\ \hline & 0000 & 0100 & (1)0111 \end{array}$$

neglect C_n

$$-(0 \quad 4 \quad 7)_{10}$$

ex:- 983 − 748 = 235

7	4	8
0111	0100	1000

1001	1000	0011
1's → 1000	1011	0111
(1) 0001	0011	1010
EOC then → 1		1
0010	0011	1011] copy result

0010	0011	1011
+ 0000	0000	1010
0010	0011	(1) 0101

(1) ← Cn is neglected.

+ (2 3 5)

387 − 649 = −262

6	4	9
0110	0100	1001

0011	1000	0111
1's → 1001	1011	0110
1100	0011	1101
1		
use EOC ⇒ -ve number 1101	0011	1101] copy 1's comp.

0010	1100	0010
+ 0000	1010	0000
0010	(1) 0110	0010

↳ Cn neglected

− (2 6 2)

method 2:-

9's complement form.

ex:

$$\begin{array}{r} 983 \\ -748 \\ \hline 235 \end{array} \xrightarrow{9's} \begin{array}{r} 983 \\ +251 \\ \hline (1)234 \\ \text{EOC} \rightarrow 1 \\ \hline +235 \end{array}$$

1001	1000	0011
0010	0101	0001
1011	1101	0100
+ 0110	0110	0000
(1) 0010	0011	0100
EOC →		1
0010	0011	0101
+ 2	3	5

ex:

$$\begin{array}{r} 429 \\ -476 \\ \hline -47 \end{array} \xrightarrow{9's} \begin{array}{r} 429 \\ +523 \\ \hline 952 \end{array}$$

↗ no EOC

952 ↓ 9's − 047

0100	0010	1001
+ 0101	0010	0011
1001	0100	1100
		+ 0110
1001	0101	0010
9	5	2

↗ no EOC

↓ 9's

− 0 4 7

ex:-

$$\begin{array}{r} 679.6 \\ -885.9 \\ \hline -206.3 \end{array} \xrightarrow{9's} \begin{array}{r} 679.6 \\ +114.0 \\ \hline 793.6 \end{array}$$

↗ no EOC

793.6 ↓ 9's − 206.3

0110	0111	1001	· 0110
+ 0001	0001	0100	· 0000
0111	1000	1101	· 0110
		+ 0110	
0111	1001	0011	· 0110
7	9	3	· 6

↓ 9's

− 206 · 3

305·5 → 305·5

−168·8 —9's→ +831·1

136·7 ① 136·6

→ 1

+136·7

0011 0000 0101 · 0101

1000 0011 0001 · 0001

1011 0011 0110 · 0110

+0110

① 0001 0011 0110 · 0110

EOC → +1

0001 0011 0110 · 0111

→ + 1 3 6 · 7

147·8 → 147·8

−206·7 —9's→ +793·2

−58·9 → 941·0

no EOC ↓ 9's

−058·9

0001 0100 0111 · 1000

0111 1001 0011 · 0010

1000 1101 1010 · 1010

+0110 +0110 · 0110

· 0000

1001 0100 0001

9 4 1 · 0

↓ 9's

− 0 5 8 · 9

Method 3:-

10's complement form:-

342.7 → 342.7

−108.9 —10's→ 891.1

233.8 ① 233.8

EOC ↓

× +233.8

0011 0100 0010 · 0111

1000 1001 0001 · 0001

1011 1101 0011 · 1000

0110 0110

① 0010 0011 0011 · 1000

EOC

↑

neglect +2 3 3 · 8

206.4 → 206.4

−507.6 —10's→ 492.4

−301.2 ↑ 698.8

no EOC ↓ 10's

−301.2

0010 0000 0110 · 0100

0100 1001 0010 · 0100

↑ 0110 1001 1000 · 1000

no EOC ↓

6 9 8 · 8

↓ 10's

−301.2

983 − 748 = 235

983 → 10's → 252

(1) 235 (EOC)

↓

+ 235

1001 1000 0011

0010 0101 0010

1011 1101 0101

+0110 0110 —

0010 0011 0101

(1) EOC neglect + 2 3 5

429 − 476 = −47

429 → 10's → 524

953

↑ as EOC ↓ 10's

−047

0100 0010 1001

0101 0010 0100

1001 0100 1101

+0110

1001 0101 0011

↑ as EOC 9 5 3

↓ 10's

− 0 4 7