

# UNIT II - ARITHMETIC OPERATIONS

## CONVERSIONS :-

Binary  $( )_2 \Rightarrow 0 \text{ - } 1$

Decimal  $( )_{10} \Rightarrow 0 \text{ - } 9$

Octal  $( )_8 \Rightarrow 0 \text{ - } 7$

Hexa decimal  $( )_{16} \Rightarrow 0 \text{ - } 9, A \text{ - } F$

(values fall inside)

(3 conversions each)

Hexa decimal: 

8	4	2	1
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0	0	0	0	0	1	0	1	0	10	A
0	0	0	1	1	1	0	1	1	11	B
0	0	1	0	2	1	1	0	0	12	C
0	0	1	1	3	1	1	0	1	13	D
0	1	0	0	4	1	1	1	0	14	E
0	1	0	1	5	1	1	1	1	15	F
0	1	1	0	6						
0	1	1	1	7						
1	0	0	0	8						
1	0	0	1	9						

Decimal  $\rightarrow$  Binary - divide by 2 & write the remainder

1.  $(25)_{10} \Rightarrow$

2	25	remainder
2	12	-1
2	6	-0
2	3	-0
1		-1

$= (11001)_2$   
(Binary form)

2.  $(25.75)_{10}$   
 $= (11001.11)_2$

$0.75 \times 2 = 1.50 \Rightarrow 1$  ( $\frac{1}{2} = 0.5$ )  
 $0.50 \times 2 = 1.00 \Rightarrow 1$   
 $0.00 \times 2 = 0.00 \Rightarrow 0$



Hexa decimal  $\rightarrow$  Decimal

$$(1AC)_{16} \\ = \underline{\underline{(428)_{10}}}$$

1 A C (numerical value of C)

$$\begin{aligned} & \rightarrow 12 \times 16^0 = 12 \\ & \rightarrow 10 \times 16^1 = 160 \\ & \rightarrow 1 \times 16^2 = 256 \\ & \hline & 428 \end{aligned}$$

Binary  $\rightarrow$  Octal

(Octal is 3 digit conversion from binary)

$$\begin{aligned} (01011101)_2 & \text{ (from table)} & | & (-11010) \\ & = \underline{\underline{(135)_8}} & & = \underline{\underline{(064)_8}} \end{aligned}$$

Decimal  $\rightarrow$  Octal

$$\begin{aligned} (302)_{10} & \quad \begin{array}{r} 8 \overline{) 302} \\ \underline{8 \quad 37} \quad -6 \\ \quad \quad \underline{4} \quad -5 \end{array} & | & (.75)_{10} = \underline{\underline{(0.6)_8}} \\ & = \underline{\underline{(456)_8}} & & \begin{aligned} & \cdot 75 \times 8 = 6.00 \\ & \cdot 00 \times 8 = 0 \end{aligned} \end{aligned}$$

Hexa decimal  $\rightarrow$  Octal (H  $\rightarrow$  B  $\rightarrow$  O)

$$\begin{aligned} (5D)_{16} & = \underline{01011101} \text{ binary} \rightarrow \text{octal} \\ & = \underline{\underline{(135)_8}} \end{aligned}$$

Binary  $\rightarrow$  Hexa decimal

$(01011101)_2 = (5D)_{16}$  (from table)

$(\cdot 11011111)_2 = (DF)_{16}$

Decimal  $\rightarrow$  Hexa decimal

$(428)_{10}$

$= (1AC)_{16}$

$$\begin{array}{r} 16 \overline{) 428} \\ \underline{16 \overline{) 26}} \phantom{-10} \\ \phantom{16} \underline{10} \phantom{-10} \\ \phantom{16} \phantom{10} \phantom{-10} \end{array}$$
 -12 (C)  $\uparrow$  (from table)  
 -10 (A)

Octal  $\rightarrow$  Hexa decimal (O  $\rightarrow$  B  $\rightarrow$  H)

$(135)_8$

$\rightarrow$  binary  $(001011101)_2$

$\downarrow$   
hexa  $(5D)_{16}$

	B	D	O	H
B	-	$\begin{matrix} \times 2^0 \\ \times 2^1 \\ \times 2^2 \end{matrix}$	table $\times 2^0$	$\times 2^0$
D	$\begin{matrix} 2L \text{ Heximal} \\ 2L \rightarrow \cdot \times 2 \end{matrix}$	-	$\begin{matrix} 8L \\ 8L \end{matrix} \times 2$	$\begin{matrix} 16L \\ 16L \end{matrix} \times 2$
O	table $\times 3$	$\begin{matrix} \rightarrow \times 8^0 \\ \rightarrow \times 8^1 \\ \rightarrow \times 8^2 \end{matrix}$	-	O $\rightarrow$ B $\rightarrow$ H
H	table $\times 4$	$\begin{matrix} \rightarrow \times 16^0 \\ \rightarrow \times 16^1 \\ \rightarrow \times 16^2 \end{matrix}$	H $\rightarrow$ B $\rightarrow$ C	-

# ADDITION & SUBTRACTION OF SIGNED NUMBERS

$$+ \Rightarrow 0$$

$$- \Rightarrow 1$$

$0 + 0 = 0$
$0 + 1 = 1$
$1 + 0 = 1$
$1 + 1 = 10$

8 4 2 1  
↑

7 bit digit representation:

$$+9 = \overset{+}{\boxed{0}} \overset{7 \text{ bit}}{0001001}$$

$$-9 = \overset{-}{\boxed{1}} 0001001$$

6 bit digit representation:

$$+9 = \overset{+}{\boxed{0}} \overset{6 \text{ bit}}{001001}$$

$$-9 = \overset{-}{\boxed{1}} 001001$$

1's complement:

$$(\overline{0001001}) = \underline{\underline{1110110}} \quad (0 \rightarrow 1 / 1 \rightarrow 0)$$

2's complement:

$$(\overline{0001001}) = \underline{\underline{1110111}} \quad (\bar{2} \text{ last digit add } 1) \text{ right most bit.}$$

$$(\underline{\underline{1110111}}) + 1 = \underline{\underline{1111000}}$$

$$\begin{array}{r} 1110111 \\ + 1 \\ \hline 1111000 \end{array}$$

Addition:

$$+98 \Rightarrow \overset{1}{0} 10011000$$

$$+87 \Rightarrow \begin{array}{r} 01000011 \\ \hline 10001111 \end{array}$$

$$+70 \Rightarrow 001110000$$

$$+46 \Rightarrow \begin{array}{r} 001000110 \\ \hline 010110110 \end{array}$$

$$\begin{array}{r} +9 \\ -7 \\ \hline +2 \end{array}$$

$$\begin{array}{r} -9 \\ +7 \\ \hline -2 \end{array}$$

$$\begin{array}{r} 2 \overline{) 70} \\ \underline{25} \phantom{0} \\ 2 \overline{) 45} \phantom{0} \\ \underline{27} \phantom{0} \\ 2 \overline{) 18} \phantom{0} \\ \underline{24} \phantom{0} \\ 2 \overline{) 4} \phantom{0} \\ \underline{2} \phantom{0} \\ 1 \phantom{0} \end{array} \quad \begin{array}{r} 2 \overline{) 46} \\ \underline{23} \phantom{0} \\ 2 \overline{) 23} \phantom{0} \\ \underline{21} \phantom{0} \\ 2 \overline{) 2} \phantom{0} \\ \underline{2} \phantom{0} \\ 0 \phantom{0} \end{array} \quad \begin{array}{r} 1000110 \\ 0101110 \\ \hline 1110100 \end{array}$$

## Addition Algorithm:

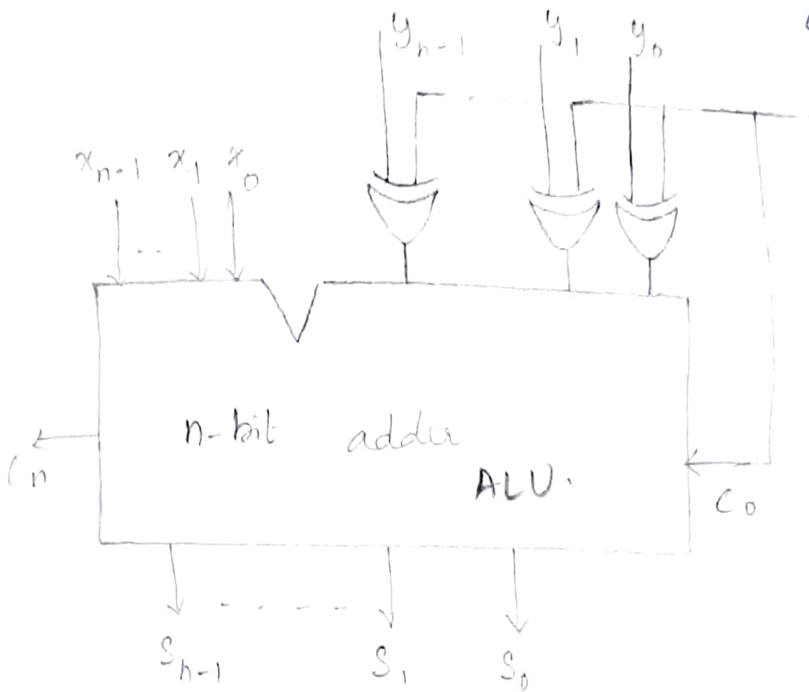
- \* When the sign of two no.s are identical add the values and attach the same sign to the result.
- \* If the sign of the two inputs are different subtract the smaller no. from the larger no. and represent the sign of the larger value (no.).
- \* If the given two values are opposite signs and if the values are same subtract the two values and consider the sign of the result as positive value.

## Subtraction Algorithm:

- \* To subtract positive / negative no.s just (inverse) change the sign of 2<sup>nd</sup> no.  $\leftarrow$  perform addi. oper.

\*

# Add / Subtraction Control - Logic <sup>Block</sup> diagram of Binary Adder / Subtractor



17/9/22

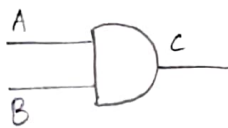
## Logic Gates

Gates

Expression + Logic Circuit

Truth Table

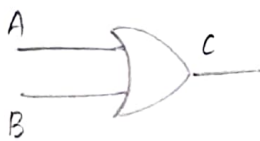
AND



$$C = A \cdot B$$

A	B	C
0	0	0
0	1	0
1	0	0
1	1	1

OR



$$C = A + B$$

A	B	C
0	0	0
0	1	1
1	0	1
1	1	1

NOT



$$C = \bar{A}$$

A	C
0	1
1	0

12/10/22

# ADDITION OF UNSIGNED BINARY No.

Addition :

1) 70 & 46

$$\begin{array}{r}
 1000110 \\
 0101110 \\
 \hline
 1110100
 \end{array}$$

$$\begin{array}{r}
 2|70 \\
 2|35 -0 \\
 2|17 -1 \\
 2|8 -1 \\
 2|4 -0 \\
 2|2 -0 \\
 1 -0
 \end{array}$$

$$\begin{array}{r}
 2|46 \\
 2|23 -0 \\
 2|11 -1 \\
 2|5 -1 \\
 2|2 -1 \\
 1 -0
 \end{array}$$

2) +47 & -34

$$\begin{array}{r}
 +47 \\
 -34 \\
 \hline
 +13
 \end{array}$$

$$\begin{array}{r}
 2|34 \\
 2|17 -0 \\
 2|8 -1 \\
 2|4 -0 \\
 2|2 -0 \\
 1 -0
 \end{array}$$

$$\begin{array}{r}
 2|47 \\
 2|23 -1 \\
 2|11 -1 \\
 2|5 -1 \\
 2|2 -1 \\
 1 -0
 \end{array}$$

$$\begin{array}{r}
 100010 \\
 1's \ 011101 \\
 \hline
 +1 \\
 \hline
 2's \ 011110
 \end{array}$$

$$\begin{array}{r}
 101111 \\
 1's \ 010000 \\
 \hline
 +1 \\
 \hline
 2's \ 010001
 \end{array}$$

cause +47 only.

-34 : 0101111

+47 : 1011110

[overflow must be taken as sign] .

10001101  
(sign of '0')



3)  $-62 \text{ e } +32$

$$\begin{array}{r} -62 \\ +32 \\ \hline -30 \end{array}$$

$$\begin{array}{r} 2 \overline{) 62} \\ 2 \overline{) 31} -0 \\ 2 \overline{) 15} -1 \\ 2 \overline{) 7} -1 \\ 2 \overline{) 3} -1 \\ 1 -1 \end{array}$$

$$\begin{array}{r} 2 \overline{) 32} \\ 2 \overline{) 16} -0 \\ 2 \overline{) 8} -0 \\ 2 \overline{) 4} -0 \\ 2 \overline{) 2} -0 \\ 1 -0 \end{array}$$

$$\begin{array}{r} -62 \quad 1000010 \quad 111110 \\ +32 \quad 0100000 \quad 13000001 \\ \hline 1100010 \quad +1 \\ \hline 25000010 \end{array}$$

$$1000000$$

4)  $-55 \text{ e } -61$

$$\begin{array}{r} -55 \\ -61 \\ \hline -116 \end{array}$$

$$\begin{array}{r} 2 \overline{) 55} \\ 2 \overline{) 27} -1 \\ 2 \overline{) 13} -1 \\ 2 \overline{) 6} -1 \\ 2 \overline{) 3} -0 \\ 1 -1 \end{array}$$

$$\begin{array}{r} 2 \overline{) 61} \\ 2 \overline{) 30} -1 \\ 2 \overline{) 15} -0 \\ 2 \overline{) 7} -1 \\ 2 \overline{) 3} -1 \\ 1 -1 \end{array}$$

$$\begin{array}{r} -55 \quad 1001001 \\ -61 \quad 1000011 \\ \hline 10001100 \end{array}$$

$$\begin{array}{r} 110111 \\ 13001000 \\ \hline +1 \\ 25001001 \end{array}$$

$$\begin{array}{r} 111101 \\ 13000010 \\ \hline +1 \\ 25000011 \end{array}$$

128 64 32 16 8 4 2 1

$$\begin{array}{r} -128 \\ +8 \\ +4 \\ \hline -116 \end{array}$$

13/10/02

+80 & -72

$$\begin{array}{r} +80 \\ -72 \\ \hline 8 \end{array}$$

$$\begin{array}{r} 2 \overline{)80} \\ \underline{2(40)} -0 \\ 2 \overline{)40} \\ \underline{2(20)} -0 \\ 2 \overline{)20} \\ \underline{2(10)} -0 \\ 2 \overline{)10} \\ \underline{2(5)} -0 \\ 2 \overline{)5} \\ \underline{2(2)} -1 \\ 1 -0 \end{array}$$

1010000

$$\begin{array}{r} 2 \overline{)72} \\ \underline{2(36)} -0 \\ 2 \overline{)36} \\ \underline{2(18)} -0 \\ 2 \overline{)18} \\ \underline{2(9)} -0 \\ 2 \overline{)9} \\ \underline{2(4)} -1 \\ 2 \overline{)4} \\ \underline{2(2)} -0 \\ 1 -0 \end{array}$$

$$\begin{array}{r} 01001000 \\ 0110111 \\ \hline +1 \\ \hline 0111000 \end{array}$$

$$\begin{array}{r} +80 \\ -72 \\ \hline 01010000 \\ 10111000 \\ \hline 100001000 \end{array} \checkmark$$

64 32 16 8 4 2 1

-64 & +32

$$\begin{array}{r} -64 \\ +32 \\ \hline -32 \end{array}$$

$$\begin{array}{r} 2 \overline{)64} \\ \underline{2(32)} -0 \\ 2 \overline{)32} \\ \underline{2(16)} -0 \\ 2 \overline{)16} \\ \underline{2(8)} -0 \\ 2 \overline{)8} \\ \underline{2(4)} -0 \\ 2 \overline{)4} \\ \underline{2(2)} -0 \\ 1 -0 \end{array}$$

$$\begin{array}{r} 1000000 \\ 0111111 \\ \hline +1 \\ \hline 1000000 \end{array}$$

$$\begin{array}{r} 2 \overline{)32} \\ \underline{2(16)} -0 \\ 2 \overline{)16} \\ \underline{2(8)} -0 \\ 2 \overline{)8} \\ \underline{2(4)} -0 \\ 2 \overline{)4} \\ \underline{2(2)} -0 \\ 1 -0 \end{array}$$

1000000

$$\begin{array}{r} -64 \\ +32 \\ \hline 11000000 \\ 00100000 \\ \hline 11100000 \end{array} \checkmark$$

64 32 16 8 4 2 1

+38 & -47

$$\begin{array}{r} +38 \\ -47 \\ \hline -9 \end{array}$$

$$\begin{array}{r} 2 \overline{)38} \\ \underline{2(19)} -0 \\ 2 \overline{)19} \\ \underline{2(9)} -1 \\ 2 \overline{)9} \\ \underline{2(4)} -1 \\ 2 \overline{)4} \\ \underline{2(2)} -0 \\ 1 -0 \end{array}$$

100110

$$\begin{array}{r} 2 \overline{)47} \\ \underline{2(23)} -1 \\ 2 \overline{)23} \\ \underline{2(11)} -1 \\ 2 \overline{)11} \\ \underline{2(5)} -1 \\ 2 \overline{)5} \\ \underline{2(2)} -1 \\ 1 -0 \end{array}$$

$$\begin{array}{r} 1011111 \\ 0100000 \\ \hline +1 \\ \hline 0100001 \end{array}$$

$$\begin{array}{r} +38 \\ -47 \\ \hline 01001110 \\ 10100001 \\ \hline 1110111 \end{array} \checkmark$$

32 16 8 4 2 1

32  
16  
8  
4  
2  
1

(1.) (+) o/p Sum.

A  $\Rightarrow$  Augend.

B  $\Rightarrow$  Addend.

(2.) (-) o/p Difference.

A  $\Rightarrow$  Minuend

B  $\Rightarrow$  Subtrahend

(3.) (\*) o/p Product.

A  $\Rightarrow$  Multiplicand

B  $\Rightarrow$  Multiplier

(4.) (/) o/p Remainder Quotient.

A  $\Rightarrow$  Divident

B  $\Rightarrow$  Divisor

### SUBTRACTION OF UNSIGNED BINARY No.

1. 45  $\div$  27

$$\begin{array}{r} 45 \\ \underline{27} \end{array}$$

$$\begin{array}{r} 2 \overline{)45} \\ \underline{22} \quad -1 \\ \underline{21} \quad -0 \\ \underline{25} \quad -1 \\ \underline{22} \quad -1 \\ \underline{1} \quad -0 \end{array}$$

101101

$$\begin{array}{r} 2 \overline{)27} \\ \underline{23} \quad -1 \\ \underline{26} \quad -1 \\ \underline{23} \quad -0 \\ \underline{1} \quad -1 \end{array}$$

11011

(-)

$$\begin{array}{r} 0101101 \\ \underline{0010111} \\ \hline 0010010 \\ \hline \end{array}$$

Exp. 32 16 8 4 2 1