- 2's complement :

1000	: -8	1100	: -4
1001	: -7	1101	: -3
1010	: -6	1110	: -2
1011	: -5	1111	: -1

— In signed magnitude and 1's comp. rep. we have two diff. rep. for +0 or -0 so there is comparision betn them and we need extra bits (space) for it.
While in 2's complement range is betn $+(2^{n-1}-1)$ to -2^{n-1} [-8 to +7].
(7) (-8)

→ In signed Magnitude representation, addition of two +ve numbers

$$\begin{array}{r} 0110 \rightarrow +6 \\ 0100 \rightarrow +4 \\ \hline 1010 \end{array}$$

negative

In two -ve numbers,

$$\begin{array}{r} 1010 \rightarrow -2 \\ 1011 \rightarrow -3 \\ \hline 10101 \end{array}$$

positive

→ we have two numbers $X(x_3x_2x_1x_0)$ & $Y(y_3y_2y_1y_0)$ and carry is $C_3C_2C_1C_0$, then sum is $S_3S_2S_1S_0$

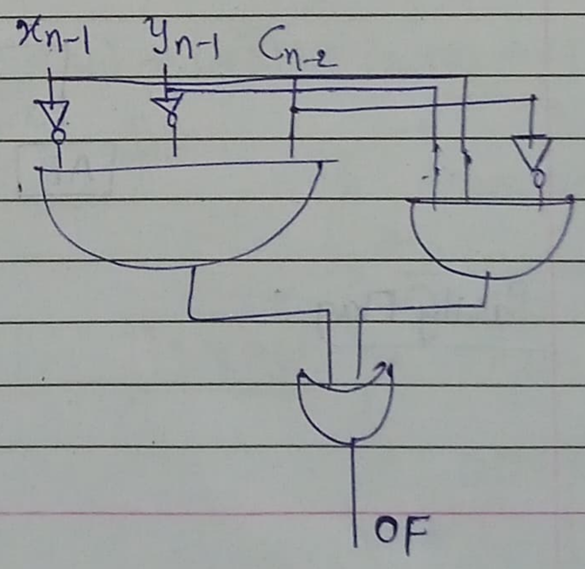
	C_3	C_2	C_1	C_0
	x_3	x_2	x_1	x_0
	0	1	1	0
+	y_3	y_2	y_1	y_0
	0	1	0	0
	1	0	1	0
	S_3	S_2	S_1	S_0

	x_3	y_3	C_2		S_3	C_3	Overflow flag (OF)
	0	0	0		0	0	0
(Two +ve)	0	0	1	(-ve)	1	0	1
	0	1	0		1	0	0
	0	1	1		0	1	0
	1	0	0		1	0	0
	1	0	1		0	1	0
(Two -ve)	1	1	0	(+ve)	0	1	1
	1	1	1		1	1	0

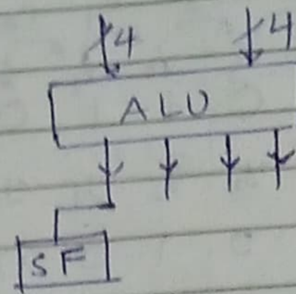
$$OF = x_3' y_3' C_2 + x_3 y_3 C_2'$$ (4 bit no.)

$$OF = x_{n-1}' y_{n-1}' C_{n-2} + x_{n-1} y_{n-1} C_{n-2}'$$ (n-bit no.)

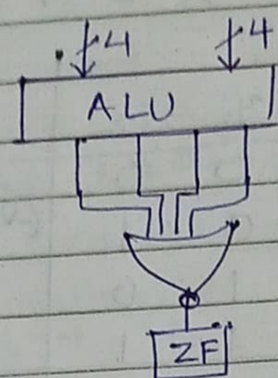
Logic Diagram :



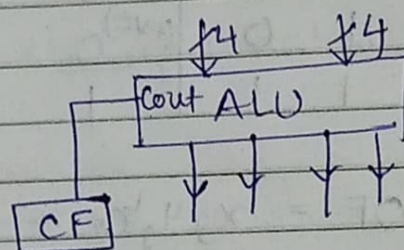
→ Sign Flag :



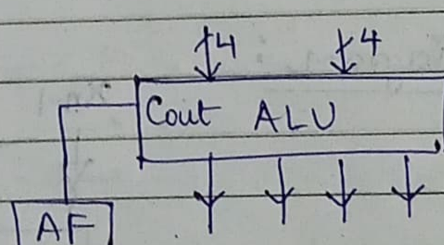
→ Zero flag :



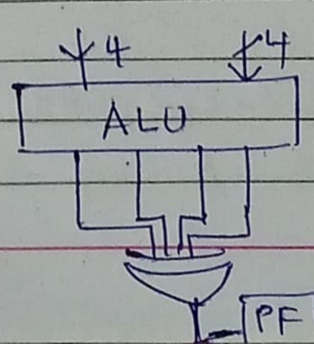
→ Carry flag :



→ Auxiliary flag :



→ Parity Flag :



(even parity)

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* Unsigned Numbers

+ve no.

2^7	2^6	2^5	2^4	2^3	2^2	2^1	2^0
0	0	0	0	0	1	0	0

8 bit no

2^3	2^2	2^1	2^0
0	1	0	0

4 bit no. (+ve)

want to copy

Since it is unsigned no. this should be 0.

- this is same for signed rep, 1's comp & 2's comp.

→ For (-ve) no. : (Signed magnitude rep.)

copy

[1000|0100] 8 bit no.

[1100] (-ve) 4 bit no

(-ve) no.

[magnitude won't be change]

extra 2's

1 1 0 0

weight -8 4 2 1 $= (-8\times1) + (4\times1) + (2\times0) + (1\times0)$

$= -4$ no.

In 2's complement :

1's complement → [1111|1100] [1100]

-7 +6 +5 +4 +3 +2

0000011
+ 1
0000100
(-4)

0011
+ 1
0100 -4

ex. 2

$$\begin{array}{cccc} 1 & 1 & 1 & 1 \\ -8 & 4 & 2 & 1 \end{array} = (-8\times1) + (4\times1) + (2\times1) + (1\times1)$$

$= \boxed{-1}$ in 2's comp.

$$\begin{array}{rcccc} & \cancel{1} & \cancel{1} & \cancel{1} & \cancel{1} \\ & \cancel{0} & \cancel{0} & \cancel{0} & \cancel{0} \\ + & & & & \cancel{1} \\ \hline & \cancel{0} & \cancel{0} & \cancel{0} & \cancel{1} \end{array}$$

~~1's comp~~

~~2's comp.~~

1 ← no.

$$\begin{array}{rcccc} & 0 & 0 & 0 & 1 \\ & 1 & 1 & 1 & 0 \\ + & & & & 1 \\ \hline & 1 & 1 & 1 & 1 \end{array}$$

1's com

ex. Binary Representation 127.25 (fixed point rep.)

$$\underbrace{\begin{array}{ccccccc} 1 & 1 & 1 & 1 & 1 & 1 & 1 \\ 2^6 & 2^5 & 2^4 & 2^3 & 2^2 & 2^1 & 2^0 \end{array}}_{\text{integer}} \, . \, \underbrace{\begin{array}{cc} 0 & 1 \\ 2^{-1} & 2^{-2} \end{array}}_{\text{fractional}}$$

00 – 0.00
01 – 0.25
10 – 0.50
11 – 0.75

↑ can only be represented

5 bit integer & 2 bit fractional
max. value can be represented = 31.75

31.705
0.02

— not possible to represent
If we want to rep. then we have to increase the fractional bit.

ex In floating point representation

Standard IEEE 754 provided format,

32 bit

↑	8 bits	23 bits
sign bit	Exponential part	Mantissa part

- Any no. we want to represent, $\rightarrow 2^{E} \cdot (1.M)$

$0.75 \longrightarrow 3 \times 2^{-2}$ (E)

Mantissa

- In general, $M \times B^{E}$ → Exp.

Mantissa Base

- Exponetial part, 8 bit can be represented

$2^{8-1} - 1 = 2^{7} - 1 = 127$

Excess -127 code

$0 \longrightarrow 01111111$

$1 \longrightarrow 1 + 127 = 128$

10000000

32-bit = single precision
64-bit = double precision

64-bit :

↑	11 bits	52 bits
sign bit	Exp.	Mantissa

$2^{11-1} - 1 = 2^{10} - 1 = 1023$ (Excess-1023 code).

Binary no : 0.011×2^{1}

0.11×2^{0}

1.1×2^{-1} → normalized number form.

11.0×2^{-2}

eg Represent $+1.1 \times 2^{-1}$ in 32-bit

sign bit = 0

exp. part = number + 127

$127 + (-1) = 126$

0	01111110	1000 ----

Hex : 3F400000

eg 2.5 & −100.25 in 32-bit format

(i) 2.5 → Binary 10.1 = 1.01×2^{1}

0	10000000	01000 ---

Hex : 40200000

(ii) −100.25 → Binary 1100100.01

$= 1.10010001 \times 2^{6}$

1	10000101	1001000100 ...

Hex : C2C88000

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→ Min exp. value : $1-127 = -126$
Max. exp value : $254-127 = 127$

① → when exp. is 000 - - - 0
Mantissa is 00 - - 0
$N = (-1)$

In general,

$$\boxed{N = (-1)^{sign} \cdot 2^{E-127} \cdot (1.M)}$$

② → when exp is 111 - - - 1
Mantissa $\neq 0$
N = NAN

③ → when exp is 111 - - - 1
Mantissa = 0
$N = -\infty$ to $+\infty$

④ → sign bit = 0, exp. = 1, Mantissa = 0
$\boxed{N = -2^{-126}}$ (Minimum Number)

$1-127$

$[2^{-126}(1.M)]$

⑤ → Maximum number $= 2^{127}(1.\underset{2^{-1}}{1}1111 - - \underset{2^{-23}}{1})$

$= 2^{127}(1 + 0.1111 - - - 1)$

$= 2^{127} \cdot \left(1 + \frac{1}{2} + \frac{1}{2^2} + - - - + \frac{1}{2^{23}}\right)$

$= 2^{+127}\left[\frac{1-(1/2)^{24}}{1-(1/2)}\right]$

$$= \boxed{2^{127} \cdot \left(2 - \left(\frac{1}{2}\right)^{23}\right)}$$

Denormalized Form

sign = x
exp. = 00000000
Mantissa = 0.M

$$N = (-1)^{sign} \cdot 2^{E-126} (0.M)$$

$$\text{Minimum no.} = (-1)^{sign} \cdot 2^{-126} (0.\overset{2^{-1}}{0}\overset{2^{-2}}{0}00 \ldots \overset{2^{-23}}{0})$$

$$= (-1)^{sign} \cdot 2^{-126} \cdot 2^{-23}$$

$$= 2^{-149}$$

eg. ~~C2C88000~~

D3D88000

$1\,\underbrace{10100111}\,101100010000000$

sign bit = 1
exp bit = 10100111 $\longrightarrow \left.\begin{array}{r} 128 \\ +\ 32 \\ +\ 7 \end{array}\right]$ 167
Mantissa = 101100010...

$$\text{Minimum no.} = (-1)^1 \cdot 2^{167-127} (1.\overset{2^{-1}}{1}0\overset{2^{-3}}{1}\overset{2^{-4}}{1}000\overset{2^{-8}}{1}0\ldots)$$

$$\cancel{= -2^{+118}}$$

$$= (-1)^1 \cdot 2^{40} (1 + 0.6914)$$

$$= -1.0995 \times 10^{12} \times 1.6914$$

$$= \boxed{-1.85969 \times 10^{12}}$$