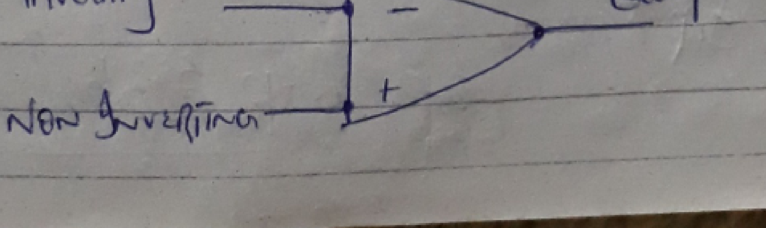
Image

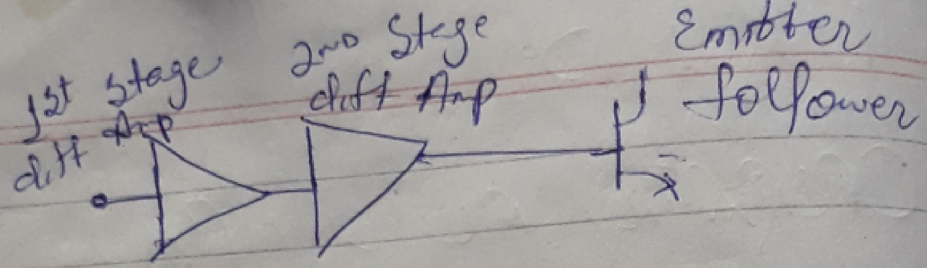
AFTER MID:

OPERATIONAL AMP:

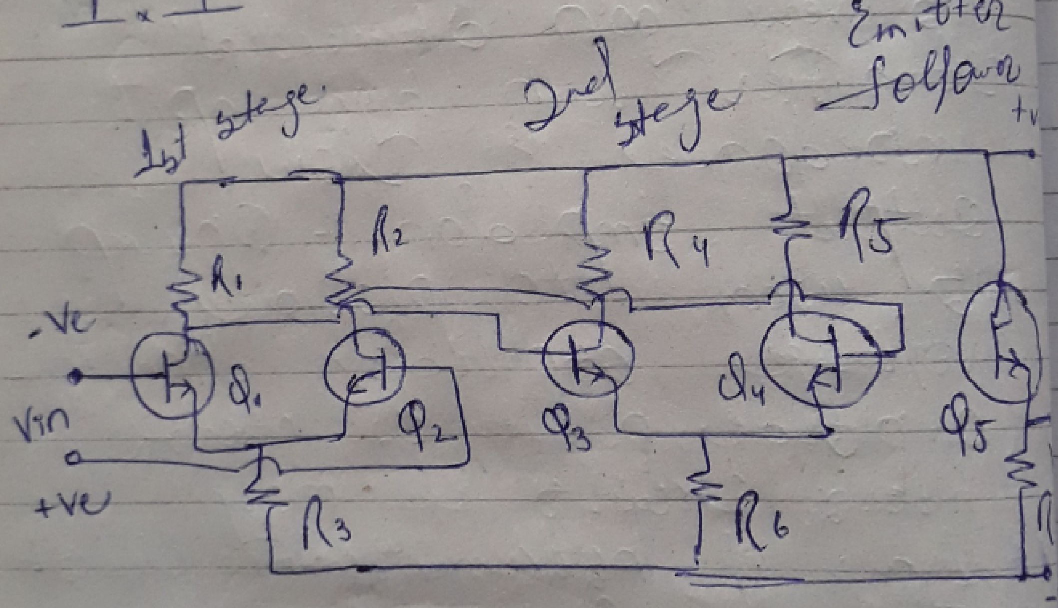
INTRODUCTION: An op-Amp is very high gain differential Amplifier with high input impedance & low output Impedance. Op-Amp is used to provide voltage amplitude changes (amplitude, polarity, Oscillators, filters circuits & many type of instrumentation ckts). An op-Amp contains a no of differential Amplifier stages to achieve very high voltage gain.

CONSTRUCTION:

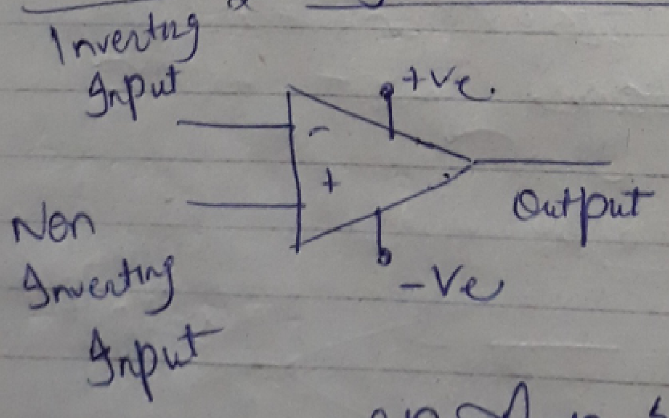




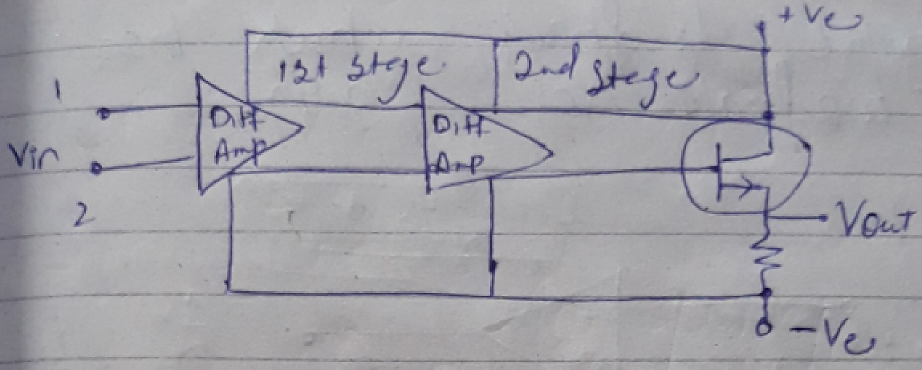
Op-AmP:



double Stage diff amp



Op Amp Symbol:

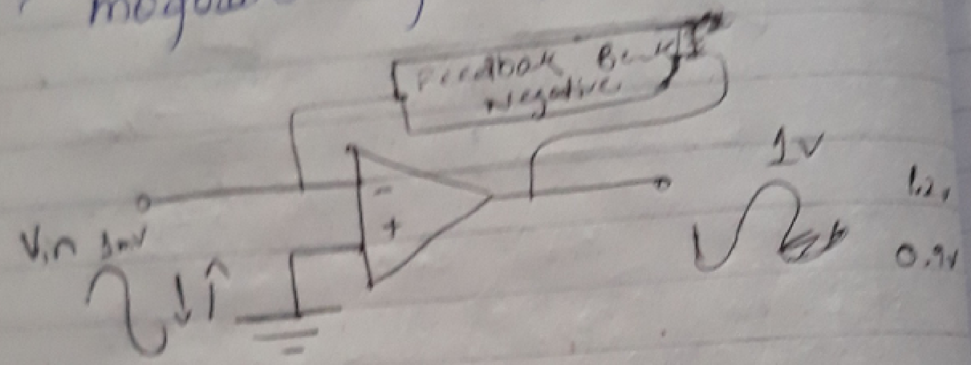


NEGATIVE FEEDBACK IN AN OP-AMP:

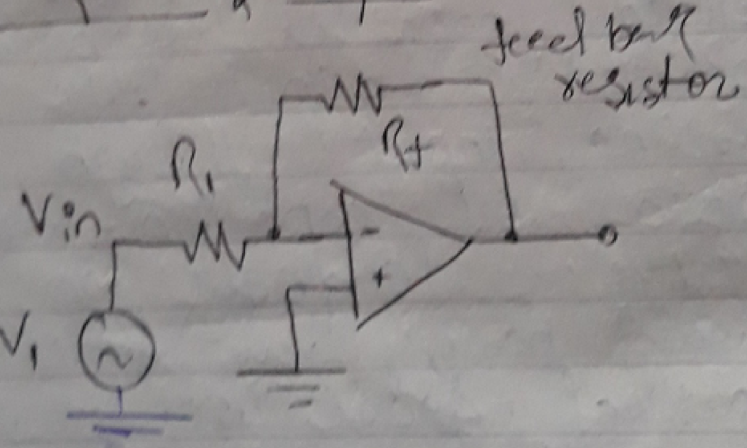
Almost all op-Amp ckts includes negative feedback from the output to the inverting input through resistor or capacitor. without negative feedback on op-amp would have very little practical ~~use~~ use.

NOTE:

An open loop op-Amp ckt has no negative feedback & extremely high gain. In close loop op-Amp ckt has negative feedback which has moderate value gain.



INVERTING AMP:



Signal V_1 is applied through resistor R_1 to the (–) input.

The output is then connected back to the same

(−) Minus input through Resistor R_f. The (+) input is connected to the ground. the output appear 180° out of phase with the input.

It is widely used constant gain multiplier ckt. The output is obtained by Multiplying the input by the fixed or constant gain, Set by the input Resistor R_1 & feedback resistor R_f. The output is also being inverted from the input. Mathematically It is represented as:

$$V_o = -\left(\frac{R_f}{R_1}\right) V_1$$

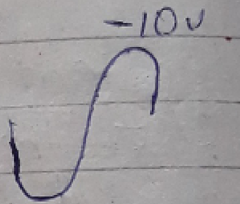
$$\boxed{A_v = -\frac{R_f}{R_1}}$$

PROB:

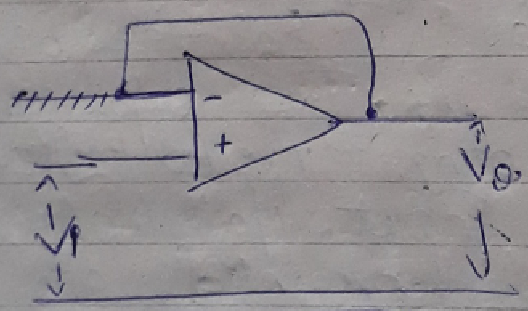
$R_1 = 100K$, $R_f = 500K$, $V_1 = 2v$

$V_0 = ?$

$\boxed{V_0 = -10v}$



Unity Follower:

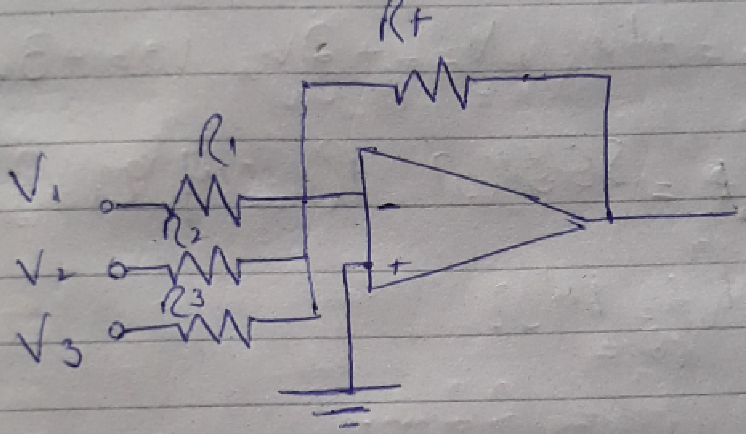


$\boxed{V_0 = V_1}$

The unity follower ckt as shown in fig provides gain of unity (1). with no polarity or phase reversal.

The output is the same polarity & magnitude as the input.

SUMMING AMPLIFIER:



$$V_o = -\left[\frac{R_f}{R_1}V_1 + \frac{R_f V_2}{R_2} + \frac{R_f V_3}{R_3}\right]$$

⇒ The ckt shown in fig is a three input summing amplifier which provides algebrically (adding) summing of three voltages.

PROB:

calculate the output voltage of an op-Amp summing Amp for the following sets of voltages & Resistors

$V_1 = +1V$, $V_2 = +2V$, $V_3 = +3V$

$R_1 = 500k\Omega$, $R_2 = 1M\Omega$, $R_3 = 1M\Omega$

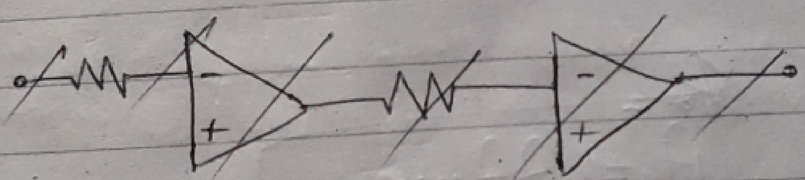
$R_f = 1M\Omega$

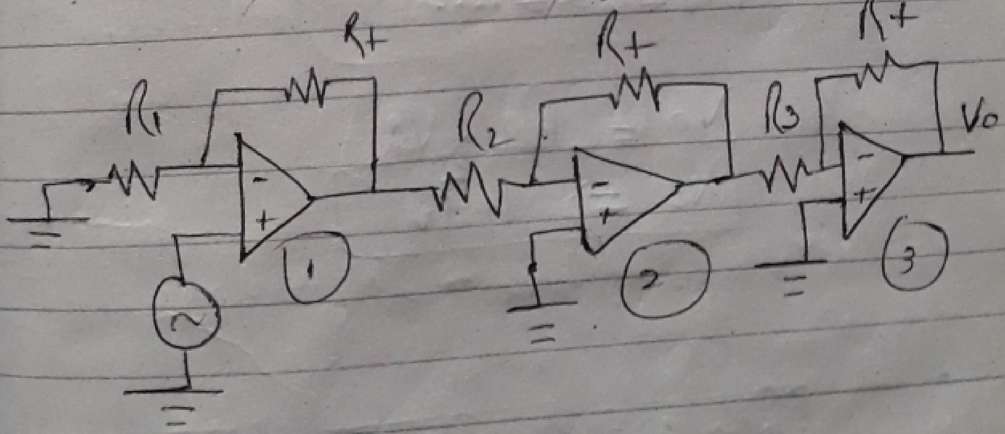
$$V_o = -\left[\frac{R_f}{R_1}V_1 + \frac{R_f}{R_2}V_2 + \frac{R_f}{R_3}V_3\right]$$

$$\boxed{V_o = -7V}$$

MULTISTAGE GAIN:

when a no of stages are connected in series, the overall gain is the product of the individual stage gain.





$$A = A_1 \cdot A_2 \cdot A_3$$

$$A = \left(\frac{R_f}{R_1} + 1\right)\left(\frac{-R_f}{R_2}\right)\left(\frac{-R_f}{R_3}\right)$$

PROB:

calculate the o/p voltage using the ckt shown in (Fig - i) for resistor components

$R_f = 470 K\Omega$., $R_1 = 4.3 K\Omega$
$R_2 = 33 K\Omega$ & $R_3 = 33 K\Omega$

$V_1 = 80 \mu V$

Multistage Gain - $V_0 = ?$

$\cancel{V_0} =$
$\boxed{A_v = 22....}$

$V_0 = A_v \times V_i$

$\boxed{V_0 \Rightarrow 1.7 V}$

One stage

$$V_{o_1} = \left(1 + \frac{R_f}{R_i}\right) \times V_1$$
$$= 8.8 mV$$

$$10 = 1 + \frac{R_f}{R_1}$$

PROB:

$$\left(1+\frac{R_f}{R_4}\right) = 10$$

Fig: i) Show the connection of an LM-124 quad op-amp as a three stage amplifier with gain of +10, -18 & -27. Use 270KΩ Feedback resistor for all three ckts. What o/p voltage will result for an input of 150μV.

$$\boxed{V_o = A_1 \times A_2 \times A_3 \times V_i}$$

$$A_1 = 1 + \frac{R_f}{R_1}$$

$$\therefore \boxed{R_1 = 30K\Omega}$$

$$A_2 = \frac{-R_f}{R_2}$$

$$\therefore \boxed{R_2 = 15K\Omega}$$

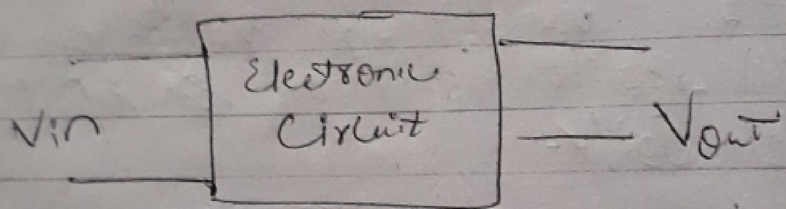
$$\therefore \boxed{R_3 = 10K\Omega}$$

Google Scholar

Smart Grid:

$\therefore \boxed{V_0 = 0.729}$ ✓

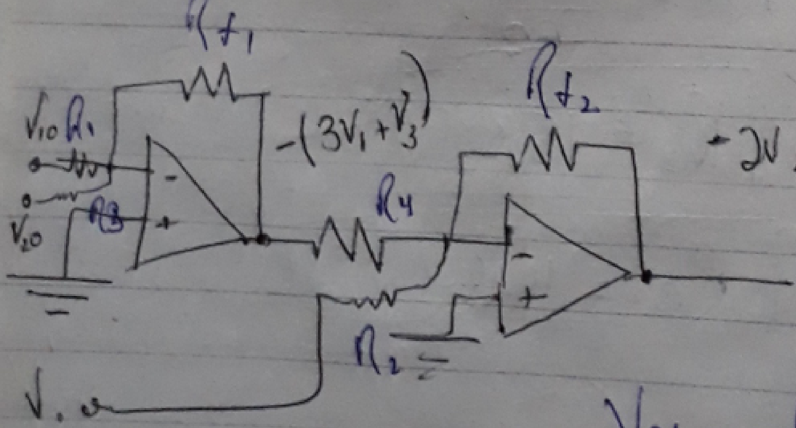
— x — x — x — x —



Design Electronic ckt that produce the derive output for given input voltages.

$V_{in} = [V_1, V_2, V_3]$

$V_{out} = [3V_1 - 2V_2 + V_3$



$-2V_2 + 3V_1 + V_3$

$V_{o1} = -\left(\frac{R_f V_1}{R_1} + \frac{R}{R_3}\right.$

$\cancel{\left(-\frac{R_f}{R_i}\right) + \left(1+\frac{R_f}{R_i}\right) + \left(1+\frac{R_f}{R_s}\right)}$

$(-2V_2) \cdot (3V_1) \cdot (V_3)$

$R_{f_1} = 10K, \quad R_1 = 3.3K\Omega, \quad R_3 = 10K$

$V_{o2} = -\left(3V_1 + V_2\right)$

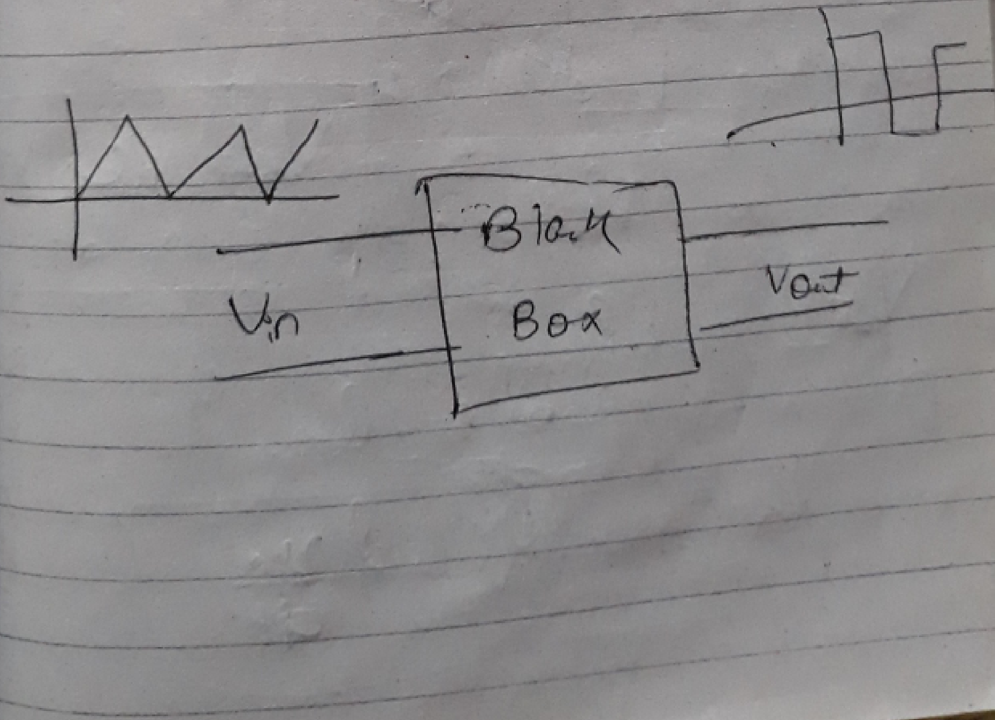
$R_{f_2} = 10K$

$\frac{R_{f_2}}{R_4} = 1$

$R_{f_2} = R_4 = 10K\Omega$

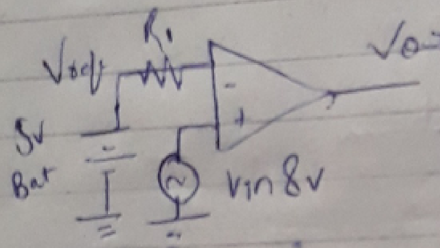
$R_2 \Rightarrow 5K\Omega$

$\boxed{V_{o2} = -2V_2 + 3V_1 + V_3}$



Op-Amp:

COMPARATOR:



Application

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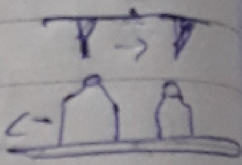
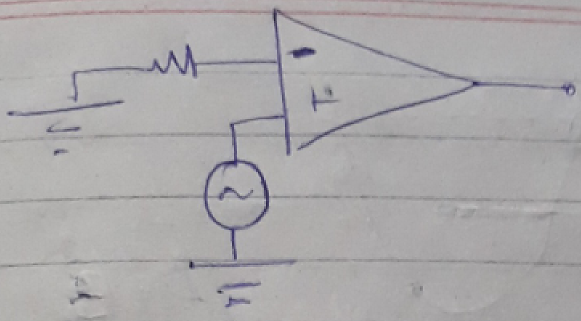


Def:

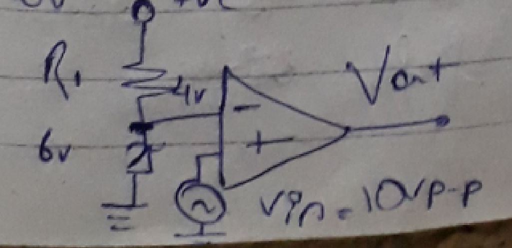
Remember that an op-amp is made of differential amp. & the open loop gain is extremely high. If the voltage diff b/w the two inputs is more than few millivolts, the output swings into saturation at 1 or the other of two power supply voltage. The inverting input is grounded.



Thus shown in fig(1). Then the signal on the non-inverting input swings slightly positive, the output goes all the way to the value of the positive power supply. when the signal swings slightly negative the output goes to the value of negative supply voltage.

NOTE:

Thus the o/p changes value when the input cross 0.



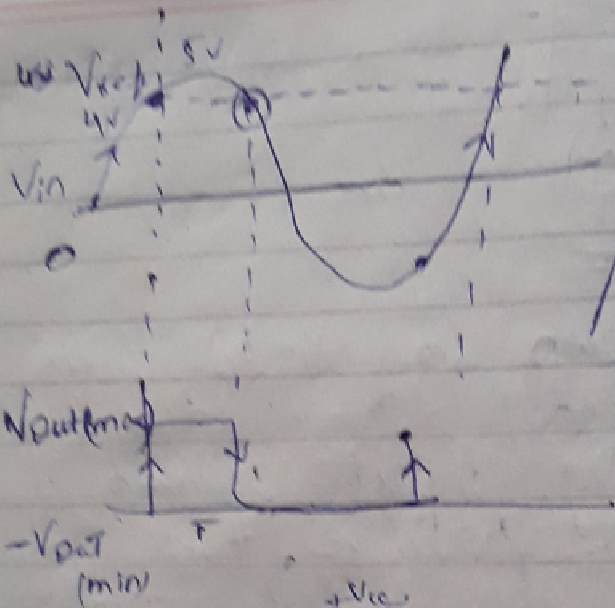


fig 3

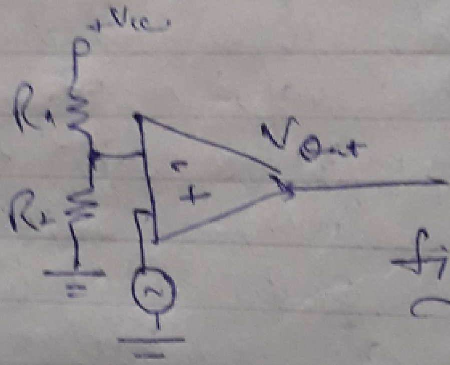


fig 5

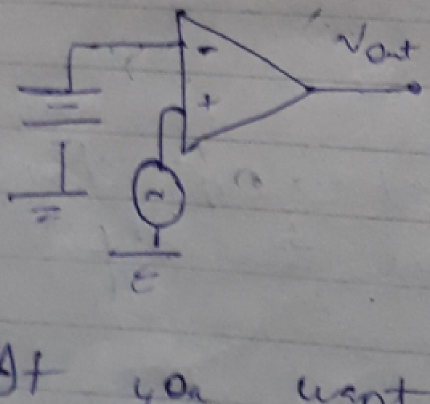


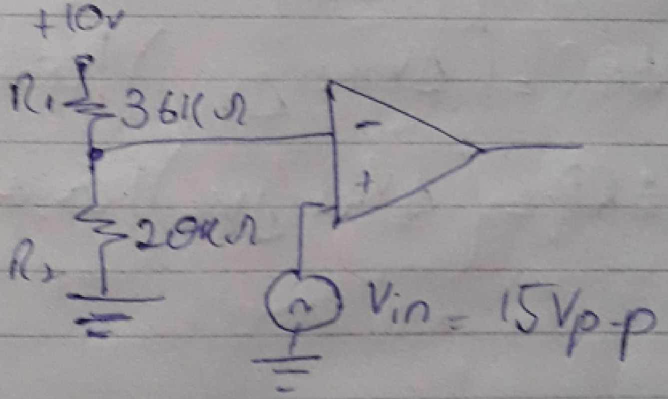
fig 4

If you want to detect a voltage w.r.t other

$$V_{ref} = \left(\frac{R_2}{R_1+R_2}\right)V_{cc}$$

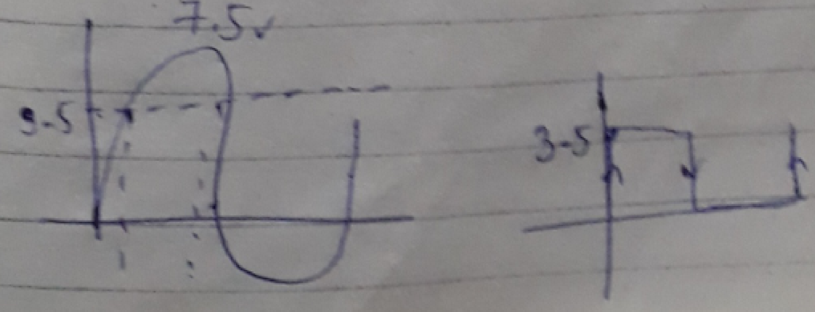
$$\Rightarrow \left(\frac{20K}{36K+20K}\right)10$$

than zero, all we have to do is to establish a reference voltage on the inverting input as shown in fig (2), (4), (5). when the input cross the reference value the output swing as shown in fig (3).



$$V_{ref} = \left(\frac{R_2}{R_1+R_2}\right)\times 10$$

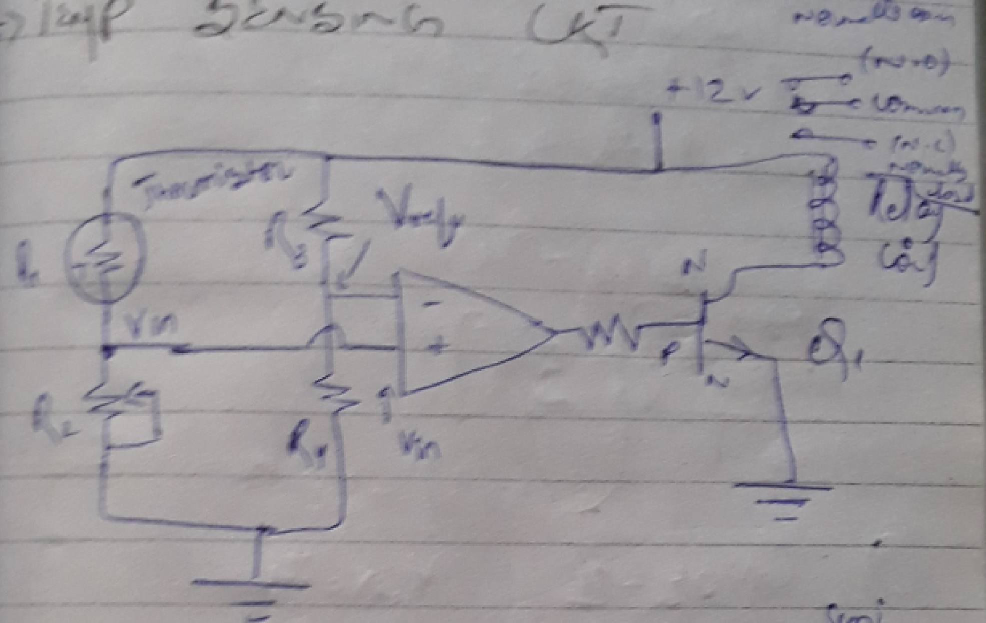
$$V_{ref} \Rightarrow \boxed{3.5\,v}$$



THERMISTOR → Temp Sensing

COMPARATOR: (APPLICATION)

⇒ Temp Sensing CKT



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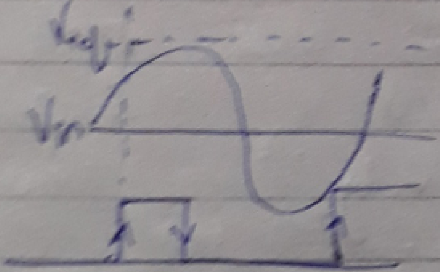
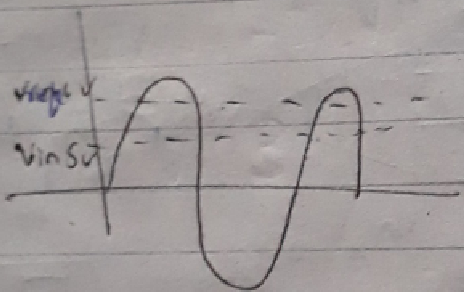


Temp ↑
resis ↓
Conduc ↑

Saturation:
e.Switch

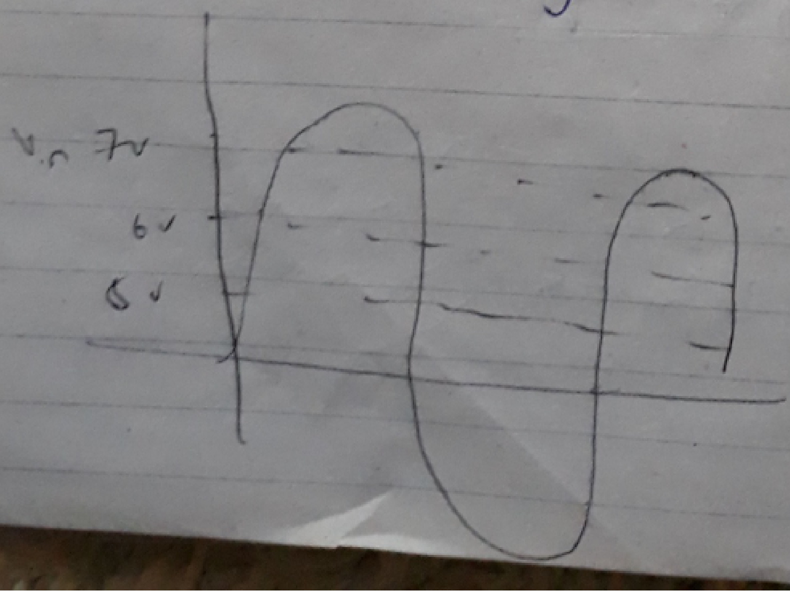
(ii) Case-I $\boxed{V_{in} = 5V}$

Temp ↓
Resistence ↑
conductivity ↓



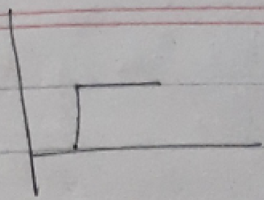
(iii) CASE - II $V_{in} = 7V$

Temp ↑
Resistence ↓
Conductivity ↑

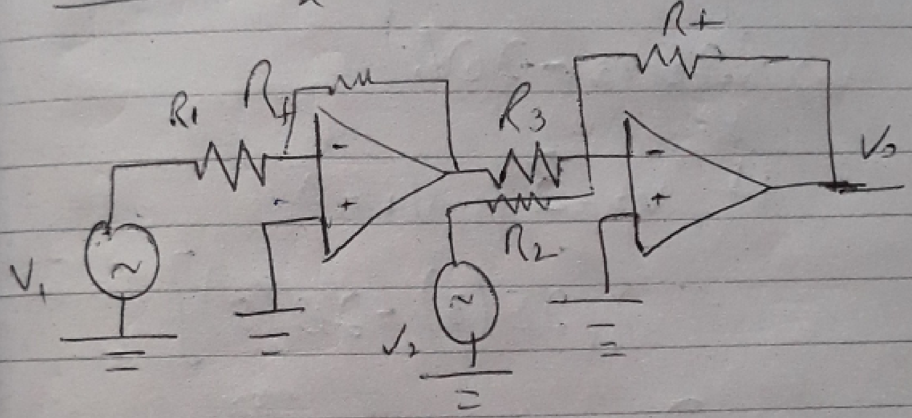


$-\frac{R_f}{R_1} V_1$ $\quad -\left\{ -\frac{R_f}{R_3} V_1 - \frac{R_f V_2}{R_2} \right.$

$-V_1$



VOLTAGE SUBTRACTION:



$$V_o = \frac{-R_f}{R_3}\left(-\frac{R_f}{R_1} \times V_1\right) + \frac{R_f}{R_2} V_2$$

$$\Rightarrow -\left[\frac{-R_f V_2}{R_2} - \frac{R_f}{R_3}\frac{R_f}{R_1} V_1 \right]$$

Determine the ~~cor~~ value of V_o with the components:

$R_2 = 50k\Omega$

$R_1 = 100k\Omega$

$R_3 = 500k\Omega$

$V_o = ?$

$R_f = 1M\Omega$

$$\Rightarrow \left(\frac{R_f}{R_2} V_2 - \frac{R_f}{R_2} \times \frac{R_f V_1}{R_1} \right)$$

$$\Rightarrow \left(\frac{1\times10^6}{50K} V_2 - \frac{1M\Omega}{500K} \times \frac{1M}{100K} V_1 \right)$$

$$\Rightarrow (20V_2 - 20V_1)$$

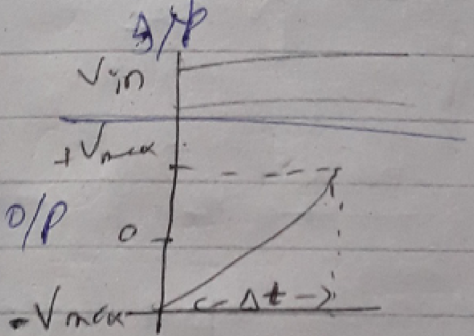
If $V_2 = 3$, $V_1 = 5$

$$\Rightarrow [20(3) - 20(5)]$$

• SLEW RATE: If we apply square wave at the input of op-amp, at the rising & falling transition of the square wave, the voltage changes infinitely fast & when they are fast op-amp can't change rapidly.

Result:

There should be slightly non-vertical slope produced on the o/p. This can be measured by slew rate (change in voltage over the change in time)



$$\frac{\Delta V}{\Delta t}$$

PROB: The output of an op-amp changes from 2.5v to 12.3v in a time of 2.8 μs. Find slew rate.

$$= \frac{\Delta V}{\Delta t} = 3.5 \times 10^{6}$$

$$= 3.5 V/\mu sec$$

REPEAT PROBLEM:

$V_1 = 1.3V$

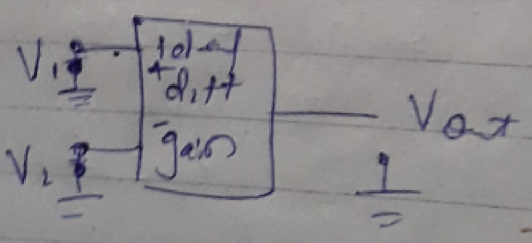
$V_2 = 6.9V$

$\Delta t = 3.1 \mu sec$

$$\frac{\Delta V}{\Delta t} \Rightarrow 1.80 V/\mu sec$$

• DIFFERENTIAL GAIN:

$A_{iv} \Rightarrow$ differential input gain.



Here V_1 & V_2 are the two inputs while V_{out} is the single ended output. each signal is measured w.r.t Ground. In a ideal diff amplifier, the output voltage is proportional to the difference between the two inputs signals. This means we can write $V_{OUT} = A_{id}(V_1 - V_2)$ - A_{id} is the gain with which diff amp amplifies the difference b/w the two input signals. Hence it is called differential gain of the differential amplifier so A_{id} = differential Gain.

$V_{id} = (V_1 - V_2)$ = diff in voltage in I/Ps

$$\boxed{V_{OUT} = A_{id} V_{id}}$$

$$\boxed{A_{id} = \frac{V_{OUT}}{V_{iD}}}$$

Generally it is expressed in db

$$\boxed{A_{id} = 20 \log(A_{id})} \text{ (in db)}$$

COMMON MODE GAIN A_{CM}:

If we apply two input voltages which are equal in all the respect to the differential amp. that is $V_1 = V_2$ then ideally o/p voltage

$$V_{out} = (V_1 - V_2) A_{id}$$ must be zero

It's not only depends on the diff voltage but also depends on the average common lvl of two inputs. Such average lvl of the two input signal is called common mode signal & it's denoted by V_{cm}

$$V_{cm} = \frac{V_1 + V_2}{2} \qquad V_{out} = A_{cm} V_{cm}$$

$$A_{cm} = \frac{V_{out}}{V_{cm}}$$

The output not practically zero due to the mismatched of the internal ckt

COMMON MODE REJECTION RATIO (CMRR):

when the same voltage is applied to both the inputs, the differential amp is set to be operated in common mode configuration - Many disturbance signals, noise signals appear as common input signal to both the input terminal of the differential amp. The ability of differential amp is to reject common mode signal is express by ratio called common mode rejection ratio. & is denoted by CMRR & mathematically:-

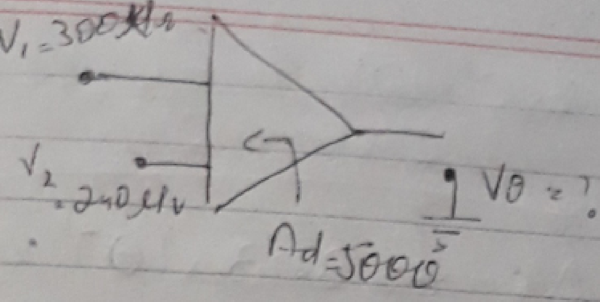
$$CMRR = \frac{A_{id}}{A_{cm}}$$

$$CMRR \text{ in } db = 20 \log \left| \frac{A_{id}}{A_{cm}} \right|$$

o/p voltage can be expressed as in terms of CMRR

$$\boxed{V_{OUT} = A_{id} V_{id} + A_{cm} V_{cm}}$$

PROB



$V_{out} = \cancel{A}_{id}\cancel{V}_{id}$

CMRR
(i) 100
(ii) 10^5

Determine the output voltage of diff amp for the input voltages of 300μv & 240μv. The diff gain of an amp is 5000 & the value of CMRR is 100 & 10^5 respectively:

$$\boxed{V_{cm} = 2.7 \times 10^{-4}}$$

$V_{out} = A_{id} V_{id} + A_{cm} V_{cm}$

$\Rightarrow (5000)(V_1 - V_2) + A_{cm}\left(\frac{V_1 + V_2}{2}\right)$

$$\boxed{V_{id} = 60 \times 10^{-6}}$$

$CMRR = \frac{5000}{A_{cm}} \Rightarrow 5$

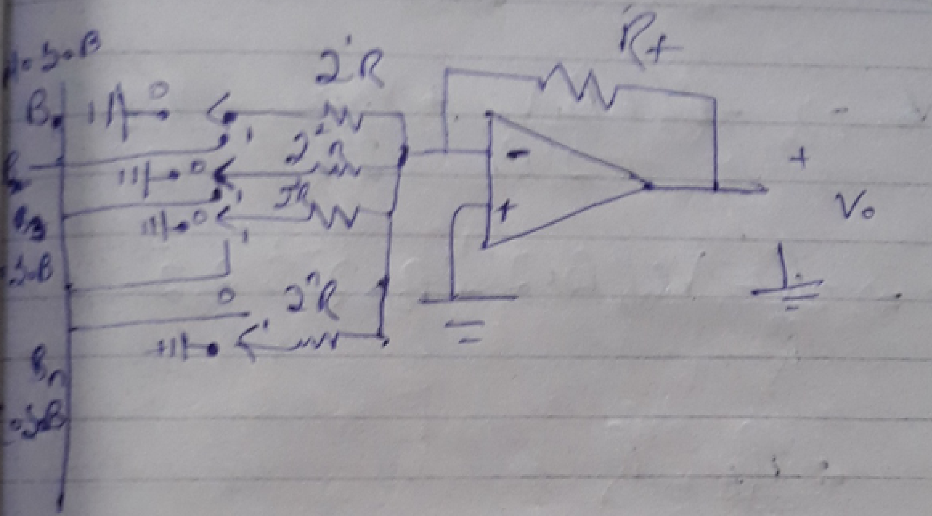
$$\boxed{A_{vm} = 5.0 \times 10^{1}}$$

$$\boxed{V_{out} \Rightarrow 3.13 \times 10^{-1}\ V}$$

$$\boxed{V_{OUT} = 313\ mV}$$

why | How | ... | Rigg

DIGITAL TO ANALOG CONVERTER:



It consists of parallel binary weighted resistor

BINARY WEIGHTED RESISTOR (DAC):

Binary weighted Resistor (Bank) & a feedback resistor Rf. The switch position decided the binary word [i.e. B_1, B_2 & B_3]

$\cancel{V_R}$

$$\cancel{\Rightarrow \left(\frac{-R_f B_1}{2^1 R_1} - \frac{R_f B_2}{2^2 R_2} - \frac{R_f B_3}{2^3 R_3}\right)}$$

$$V_o \Rightarrow -R_f \left(\frac{B_1 V_R}{2^1 R_1} + \frac{V_R B_2}{2^2 R} + \frac{V_R B_3}{2^3 R}\right.$$

$$V_o \Rightarrow \frac{-R_f}{R} V_R \left(B_1 2^{-1} + B_2 2^{-2} + B_3 2^{-3} + \ldots\right.$$

$$\because R_f = R$$

$$\Rightarrow -V_R \left[B_1 2^{-1} + B_2 2^{-2} + B_3 2^{-3} + \ldots B_n\right.$$

$$B_1 = 0, \; B_2 = 0, \; B_3 = 1$$

$$\Rightarrow -V_R \left[0 \times 2^{-1} + 0 \cdot 2^{-2} + 1 \times 2^{-3}\right]$$

$$\boxed{V_o \Rightarrow \frac{-V_R}{8}}$$

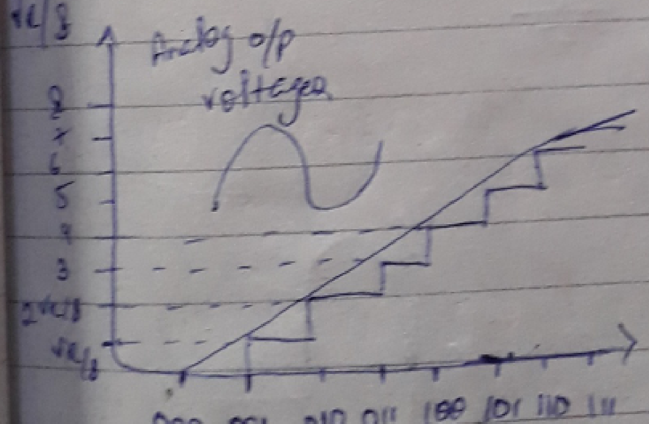
$\frac{V_R}{4} + \frac{V_R}{8}$

$\frac{V_R}{2} + \frac{V_R}{4} + \frac{V_R}{8}$ $\frac{4V_R + 2V_R + V_R}{8}$ $\frac{2V_R +}{8}$ $\frac{3V_R}{8}$

ANALOG O/P

DIGITAL INPUTS ⟹

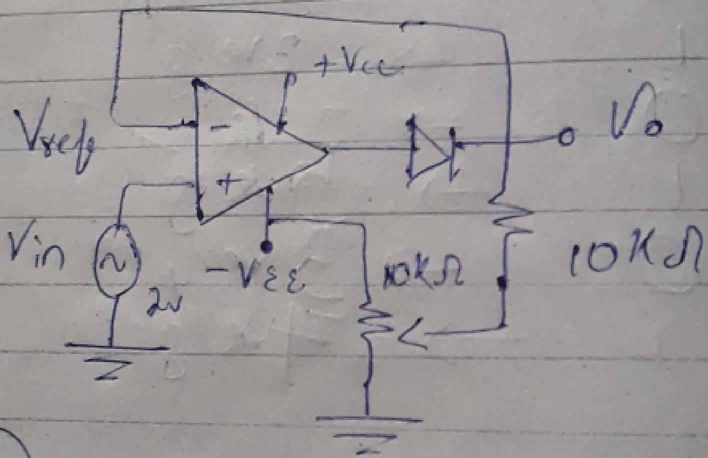
B_1	B_2	B_3		Analog o/p
0	0	0	→	0
0	0	1	→	$-V_R/8$
0	1	0	→	$-V_R/4$
0	1	1	→	$-3V_R/8$
1	0	0	→	$-V_R/2$
1	0	1	→	$-5V_R/8$
1	1	0	→	$-3V_R/4$
1	1	1	→	$-7V_R/8$

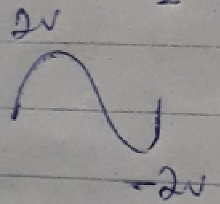


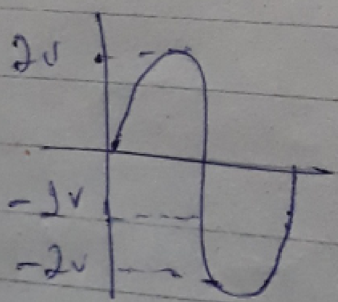
Digital inputs code

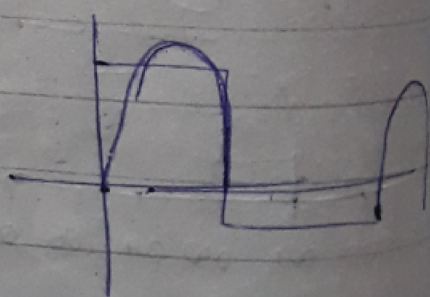
OP-AMP BASED CLIPPER

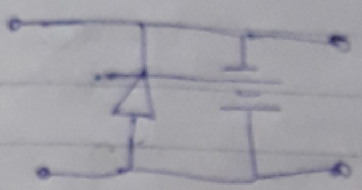
- NEGATIVE CLIPPER:

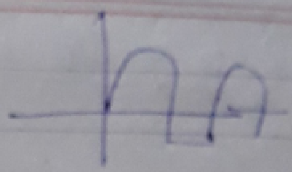




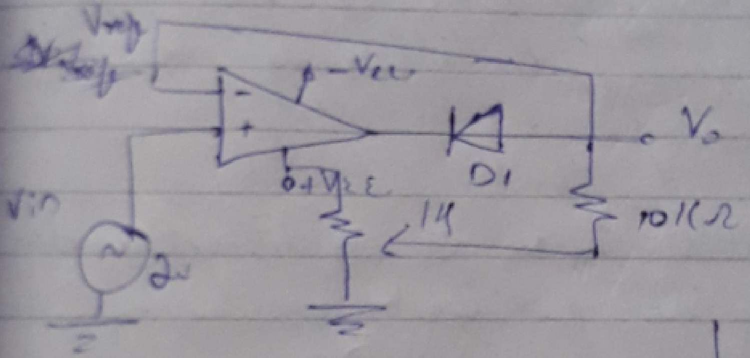


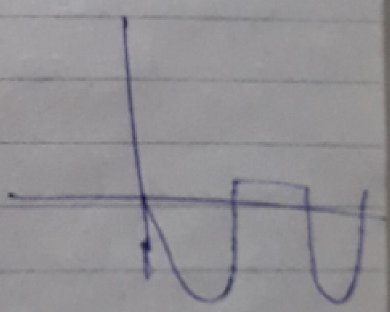






Positive Clipper:

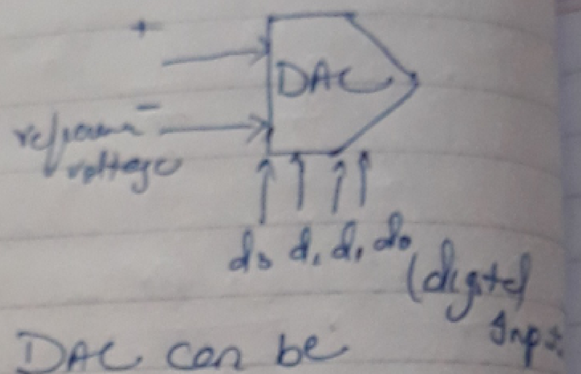




DAC

→ RESOLUTION:

KSB



"Resolution of DAC can be defined in following two diff ways:-

(i) Resolution is the no of different analog voltage value that can be provided by DAC for an n-bit DAC

Resolution $= 2^n$

Hence the resolution of 4-bit DAC is $2^4 = 16$ & 3-bit DAC is $2^3 = 8$

Therefore resolution increases with the increase in no of bits.

(ii) Resolution is defined as the ratio of change in analog output voltage resulting from a change of LSB with digital input

3/11/23

Resolution $= \frac{V_{FS}}{2^{n}-1}$

V_{FS} = Full scale voltage.

n = number of digital inputs.

PROB: ~~A~~ 4bit DAC has an o/p voltage range 0-5v. calculate its resolution using both the definition of resolution.

- Resolution $= \frac{V_{FS}}{2^n-1} \Rightarrow \frac{5}{15} \Rightarrow 0.33$ v.

Thus an input change of one L.S.B causes the output to change by 0.33v

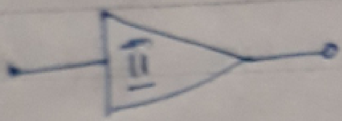
- THRESHOLD:

The min voltage required to on the transistor is called threshold voltage.

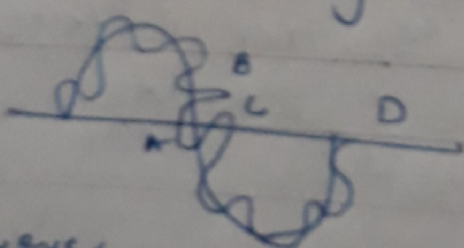
- SCHMITT TRIGGER:

The schmitt trigger

is logic input type that provide threshold voltage lvl for rising & falling edge. this is useful bcz it can avoid the error's when we have noisy input signals from which we want to get square wave signal



The schmitt trigger comparator has two voltage reference called the upper threshold point (UTP) & lower threshold point (LTP). bcz the comparator is so sensitive any noise in the signal can cause false detec as shown in the fig:



Sine wave

distorted by noise.

The True sine crosses
crosses zero volt at point D.
however the noise voltages case
the waveform to cross zero at
point A B C - The comparator will
detect all three crossing but
only one crossing should be counted.
The sol to the problem is
to give the comparator two reference
levels called the threshold points.
for a zero lvl the UPT the
positive voltage lvl & the LTP
is a negative voltage lvl-

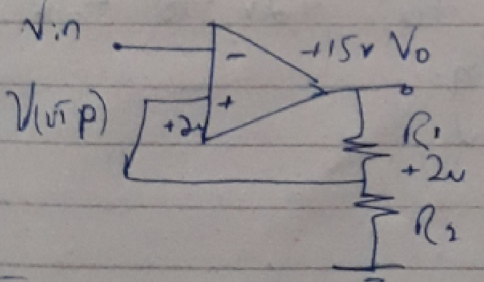


Fig (2)

In fig(1) The input voltage begins to swing
+ve, nothing happen until the input
voltage reach to +2v value of (UTP).
The comparator detect this crossing

Ex the output switches to max -ve voltage -15v - bcz the output switches to -ve value the feedback loop places a negative ref voltage of -2v on the non inverting input equals to the voltage drop at R_2, this changes the Ref voltage level of the comparator.

The input signal. It the noise in the signal cause the input to cross slightly ~~zero volt~~ above or below +2v it will not effect the output bcz the ref level has change to +2v to -2v shown in the fig.