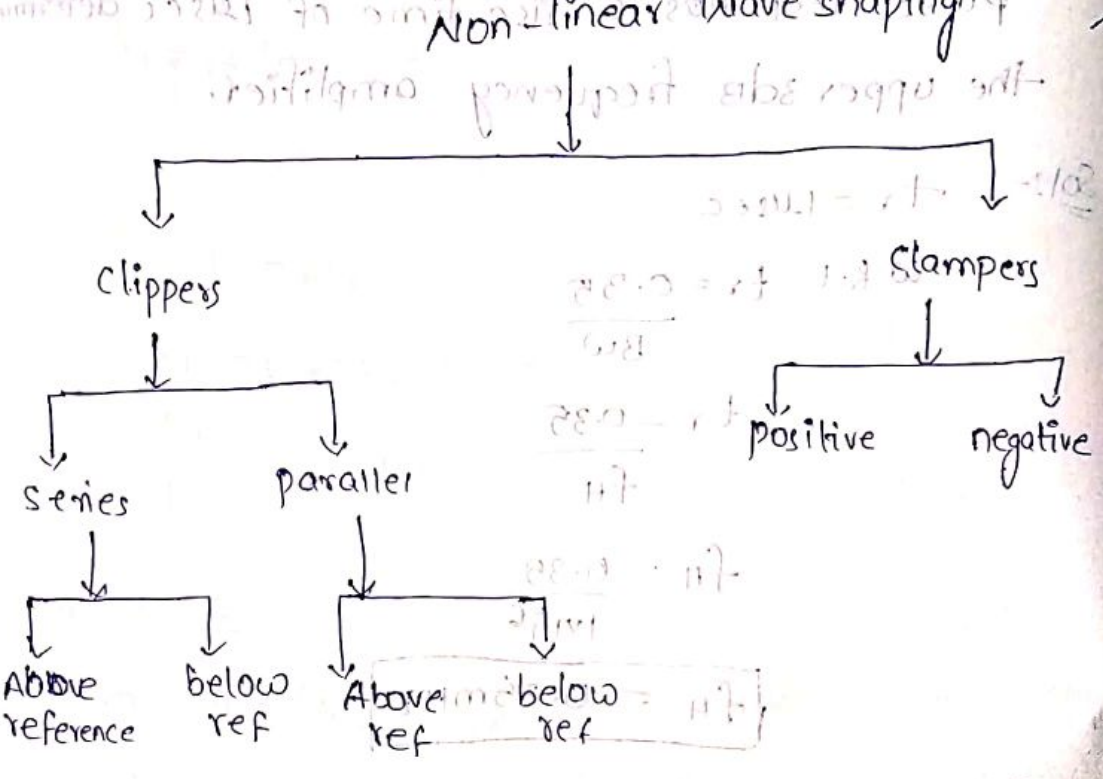
16/12/17

Non-linear Wave shaping

For a linear N/w if we add an additional element like (diode, transistor) then it is called as non-linear circuit.

For a non-linear N/w if i/p is sinusiodal then o/p is other than sinusiodal and this study is called non-linear wave shaping.



clippers:- A circuit which is used to remove unwanted information (portion) is called clippers.

clippers are also known as Amplitude slicers, Amplitude selector, limiters.

clampers:- clampers are the circuits which are used to shift the input waveform based on

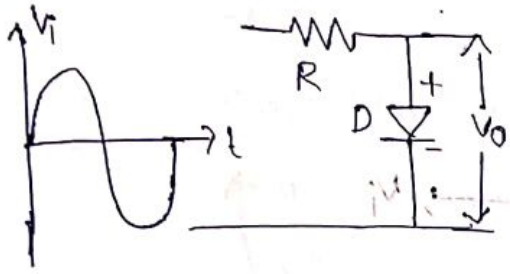
www.Jntufastupdates.com Scanned by CamScanner

reference levels.

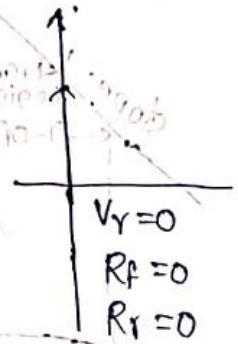
clampers are also called as level shifters (or) Dc restorers.

Shunt clippers :-

positive shunt clippers:

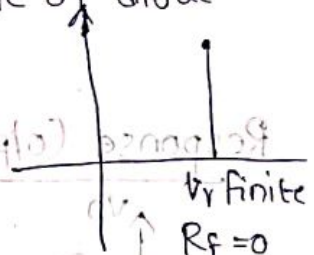


Ideal diode



which conducts at zero level.

p-sclice linear characteristic of diode.



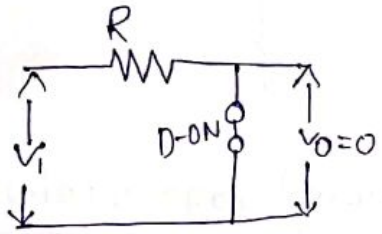
(1) $V_i > 0$, D-ON, $V_o = 0$

then slope = 0

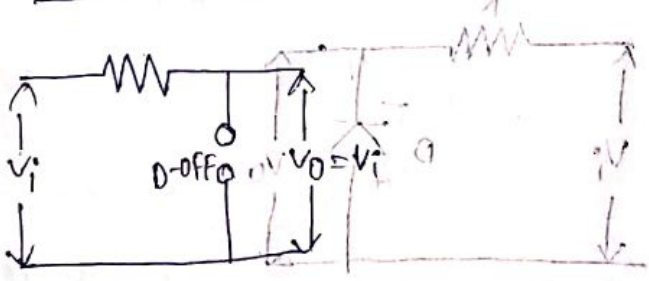
(2) $V_i < 0$, D-off, $V_o = V_i$

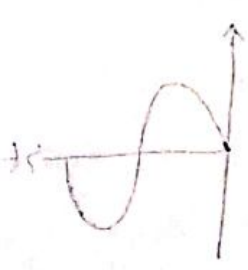
then slope = 1

Equivalent for $V_i > 0$:-



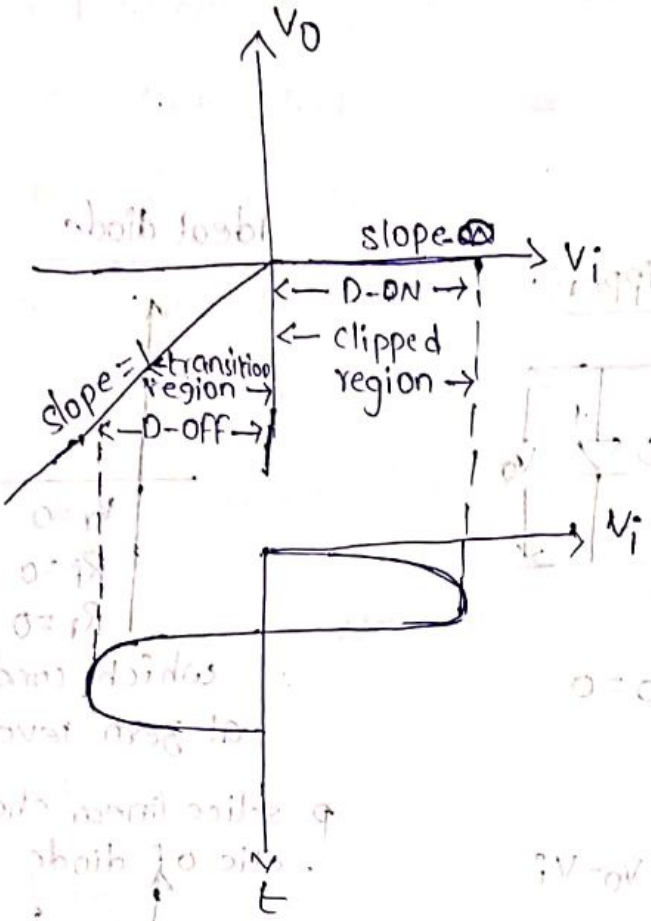
Equivalent for $V_i < 0$:-



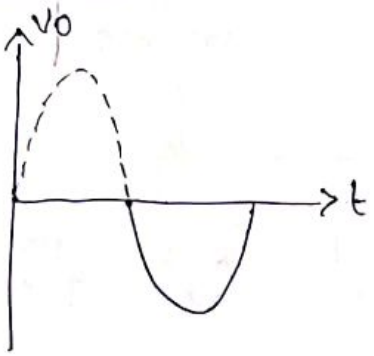


www.Jntufastupdates.com Scanned by CamScanner

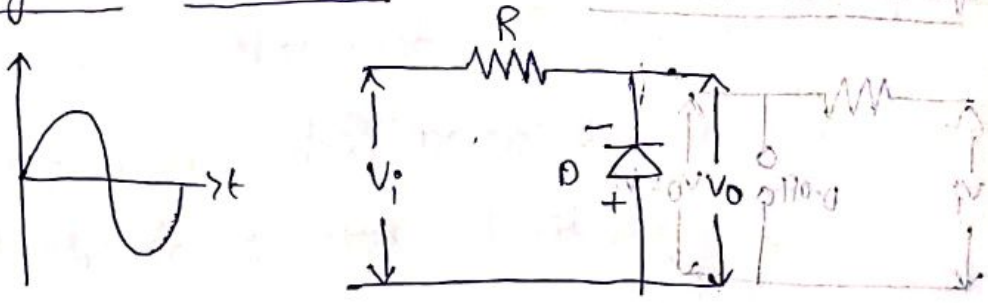
Transfer characteristic curve:-



Response (o/p):-



Negative shunt clipper:-

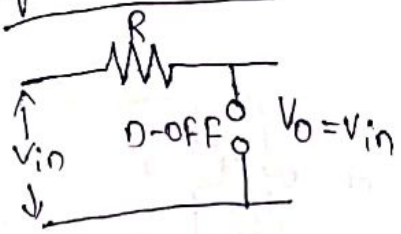


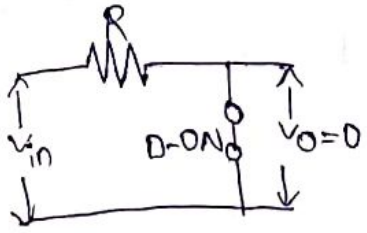
Vin > 0, D-OFF, Vout = Vin, slope = 1

Vin < 0, D-ON, Vout = 0, slope = 0

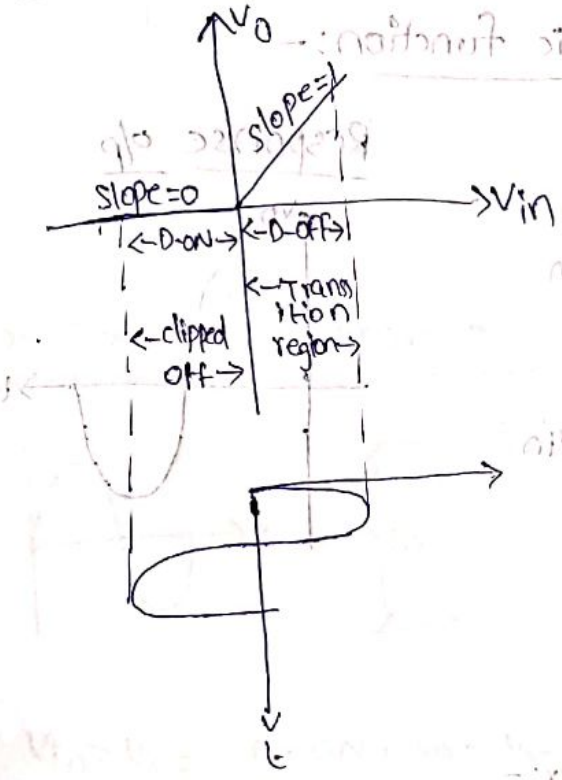
www.Jntufastupdates.com Scanned by CamScanner

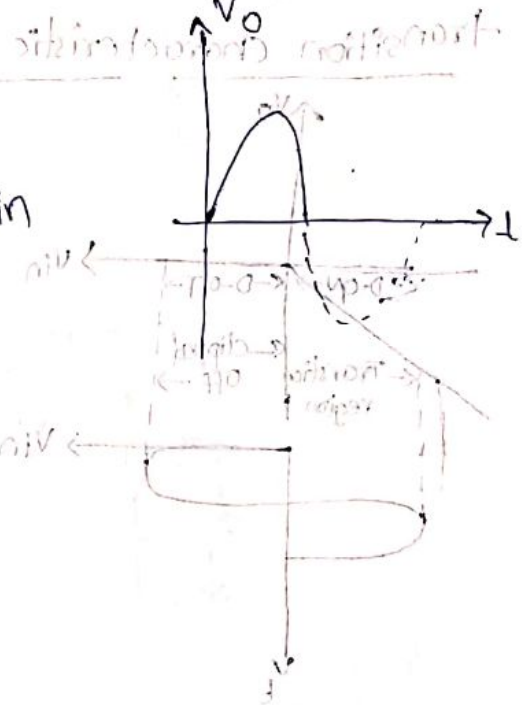
equivalent ckt



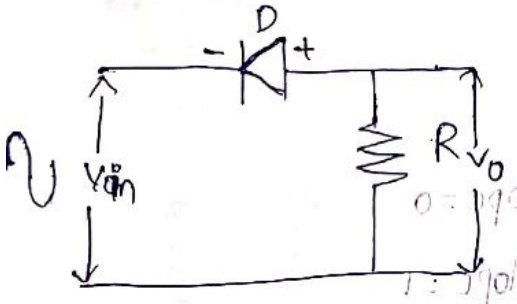


Transfer characteristics:-





series clipper (positive)

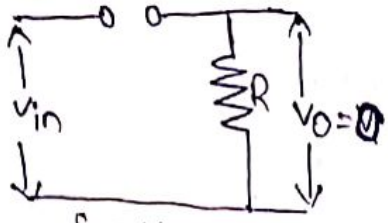


Vin > 0, D - OFF, Vout = 0, slope = 0

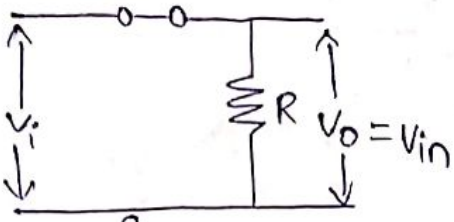
Vin < 0, D - ON, Vout = Vin, slope = 1

www.Jntufastupdates.com Scanned by CamScanner

Equivalent ckt

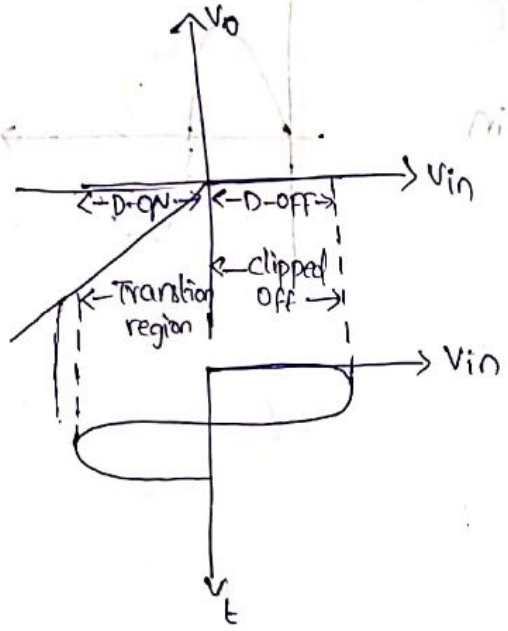


for $V_{in} < 0$

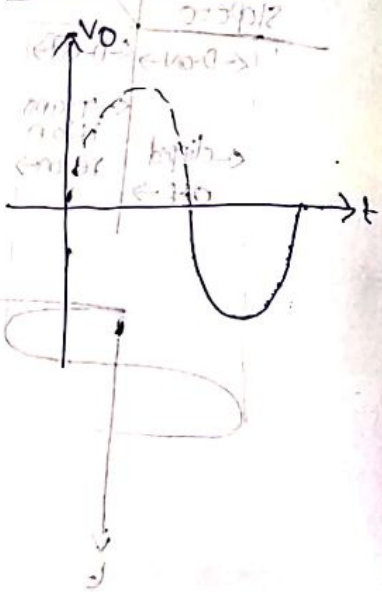


for $V_{in} > 0$

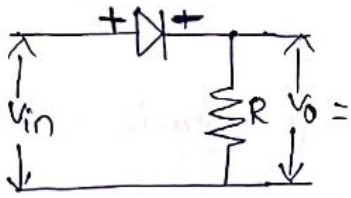
Transition characteristic function:-



Response o/p



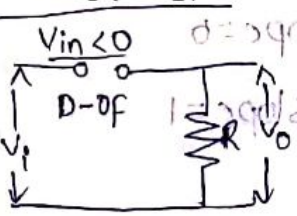
Series negative clipper:-



$V_{in} < 0$, D − OFF, $V_{out} = 0$, slope = 0

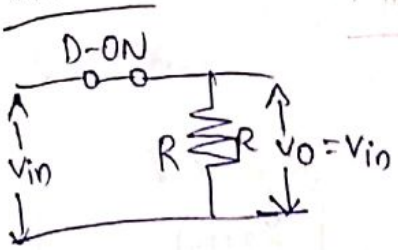
$V_{in} > 0$, D − ON, $V_{out} = V_{in}$, slope = 1

equivalent ckt

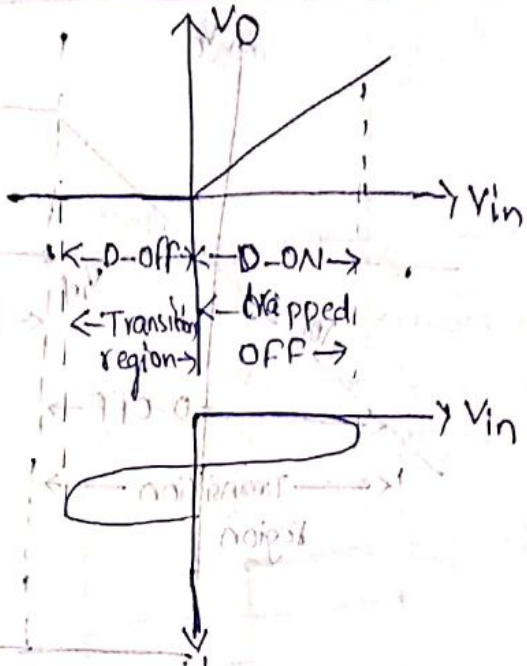


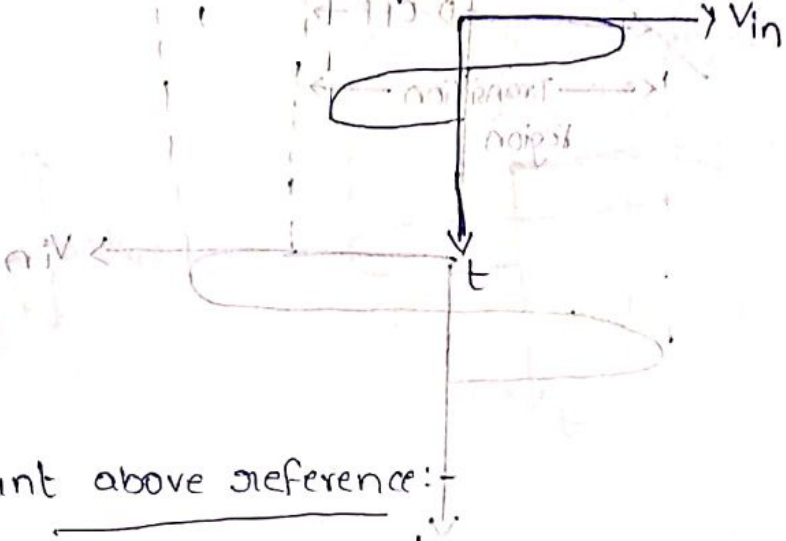
www.Jntufastupdates.com Scanned by CamScanner

$V_{in} > 0$

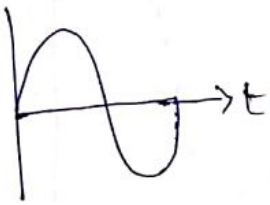


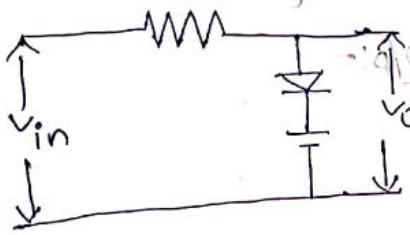
Transition characteristic





Positive shunt above reference:-



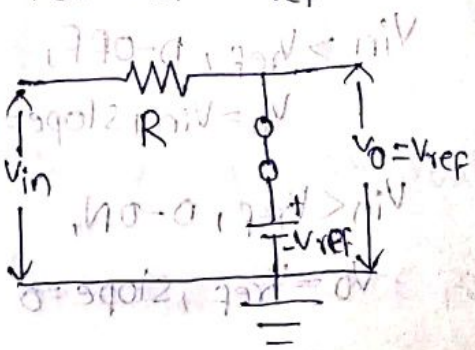


$V_{in} > V_{ref}$, D-ON , $V_O = V_{ref}$, slope = 0

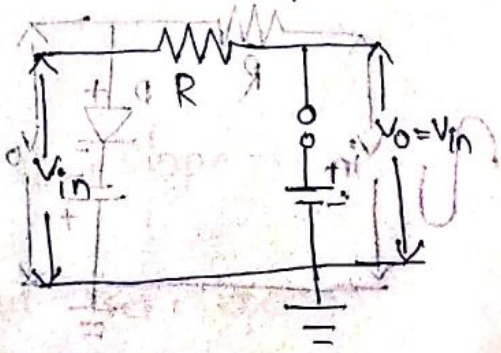
$V_{in} < V_{ref}$, D-OFF , $V_O = V_{in}$, slope = 1

equivalent ckt :-

for $V_{in} > V_{ref}$

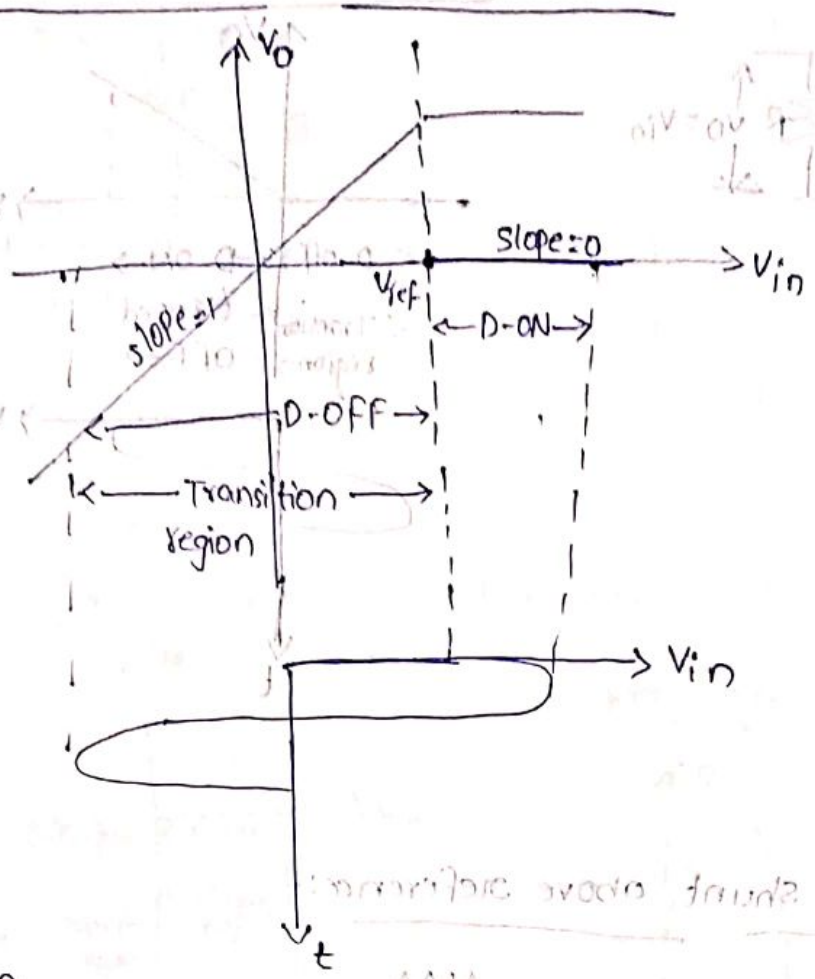


for $V_{in} < V_{ref}$

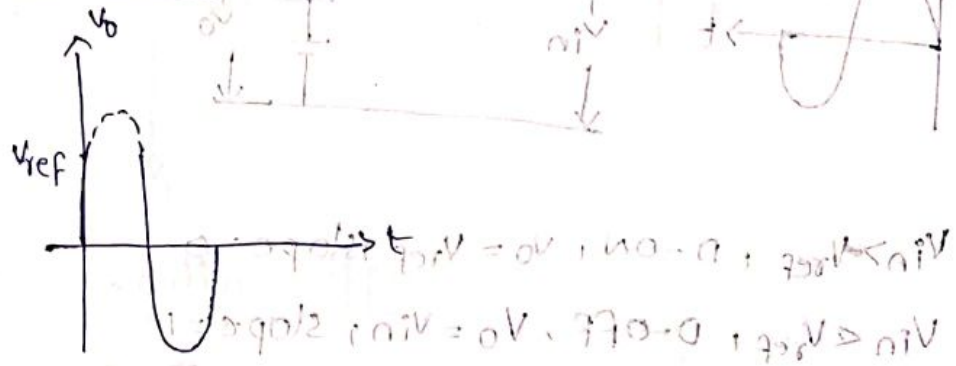


www.Jntufastupdates.com Scanned by CamScanner

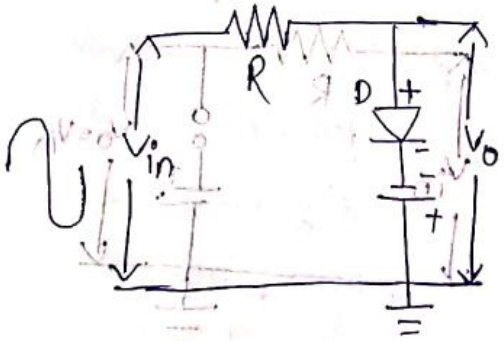
Transfer characteristic function:-



Response o/p:-



Shunt positive below reference level



$V_{in} > V_{ref}$, D-OFF,

$V_o = V_{in}$, slope = 1

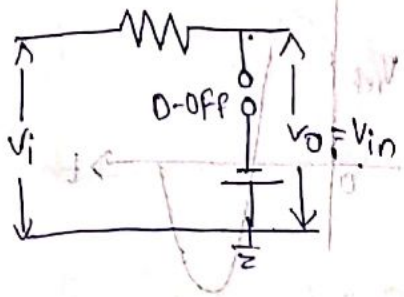
$V_{in} < V_{ref}$, D-ON,

$V_o = V_{ref}$, slope = 0

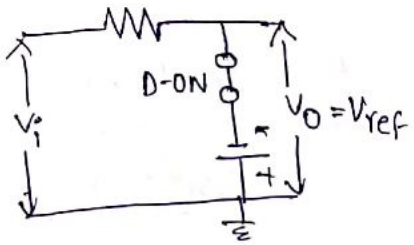
 Scanned by CamScanner

equivalent circuit:-

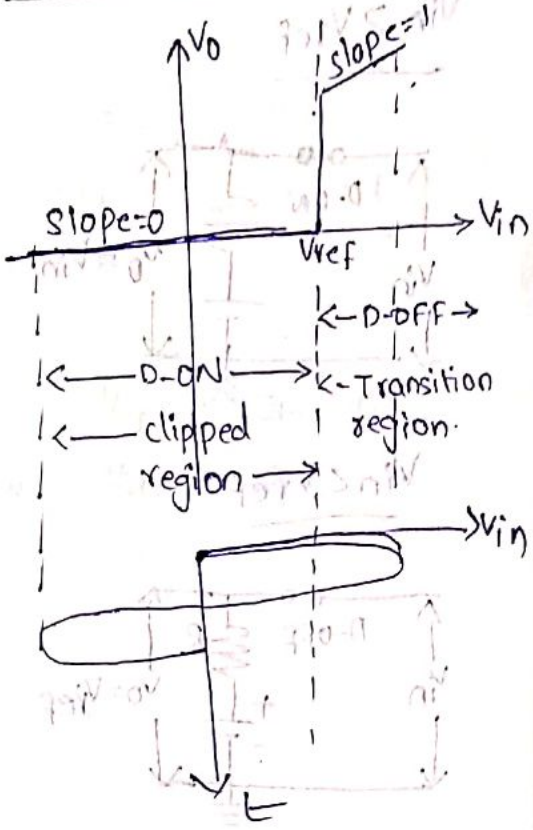
$V_{in} > V_{ref}$



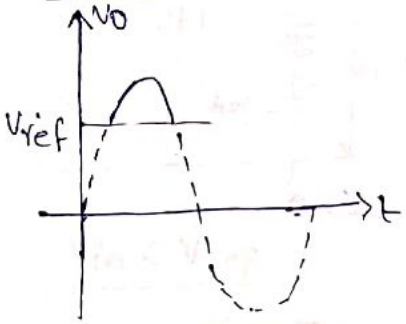
$V_{in} < V_{ref}$



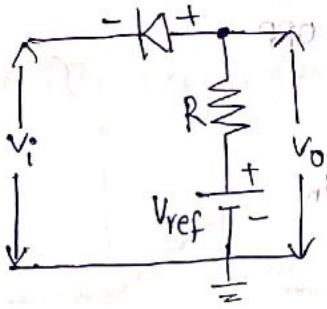
Transfer characteristic



Response



Series positive above reference level:-



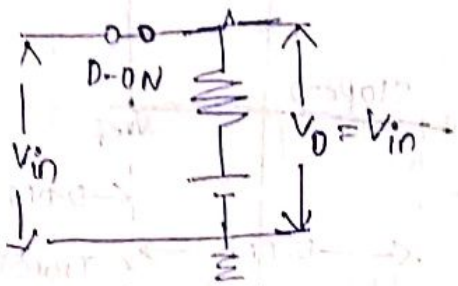
$V_{in} > V_{ref}$, D-ON , $V_{out} = V_{in}$, slope = 1

$V_{in} < V_{ref}$, D-OFF , $V_{out} = V_{ref}$, slope = 0

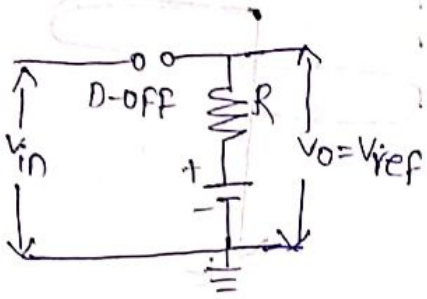
www.Jntufastupdates.com Scanned by CamScanner

Equivalent circuit

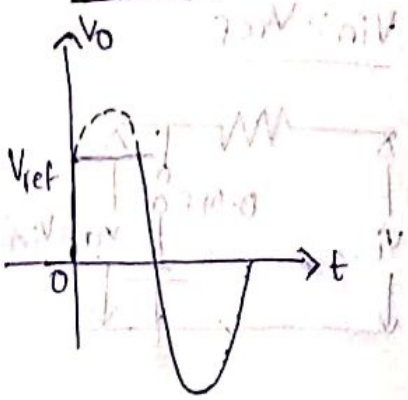
$V_{in} > V_{ref}$



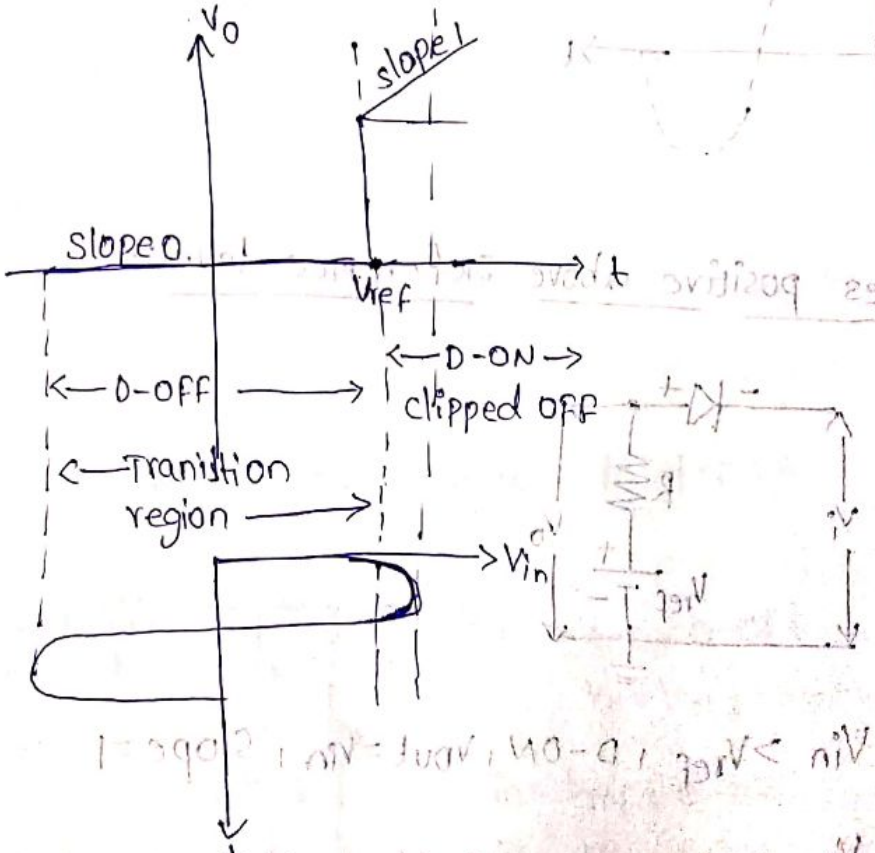
$V_{in} < V_{ref}$



Response

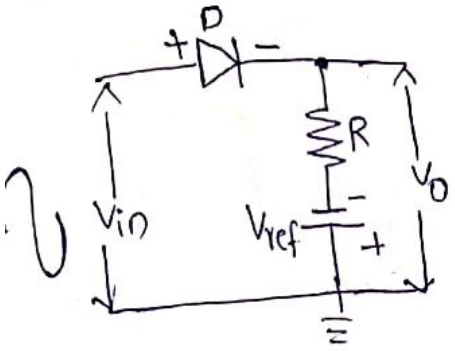


Transfer characteristic:-



www.Jntufastupdates.com Scanned by CamScanner

series -ve clipper below ref level:-

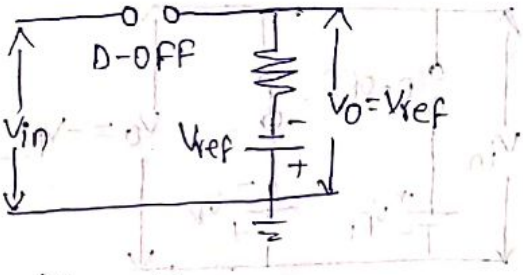


$V_{in} > V_{ref}$, D – OFF , $V_{out} = V_{ref}$, slope = 0

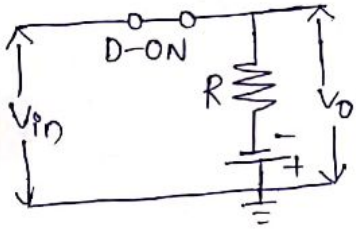
$V_{in} < V_{ref}$, D – ON , $V_{out} = V_{in}$, slope = 1

equivalent ckt

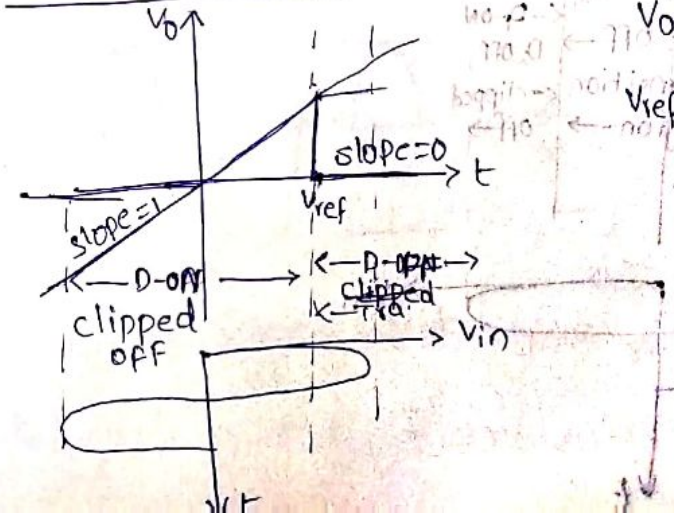
$V_{in} > V_{ref}$



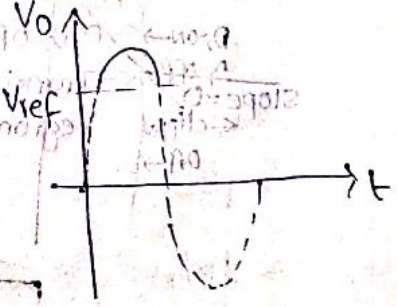
$V_{in} < V_{ref}$



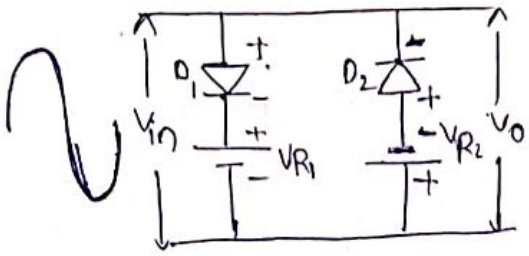
transfer characteristic



Response



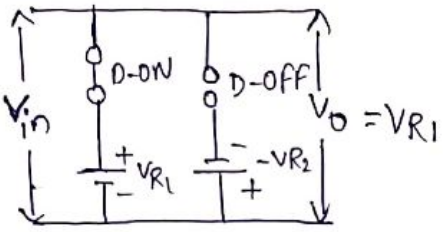
Double ended clippers:

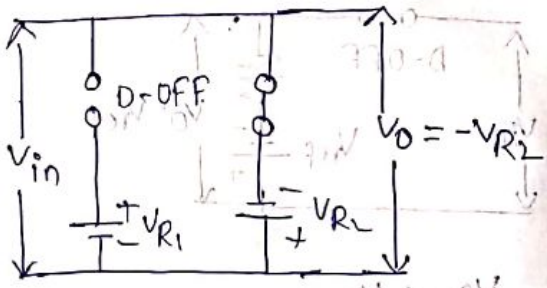


$V_{in} > V_{R1}$ = D_1 ON, D_2 OFF $\Rightarrow V_o = V_{R1}$, slope = 0

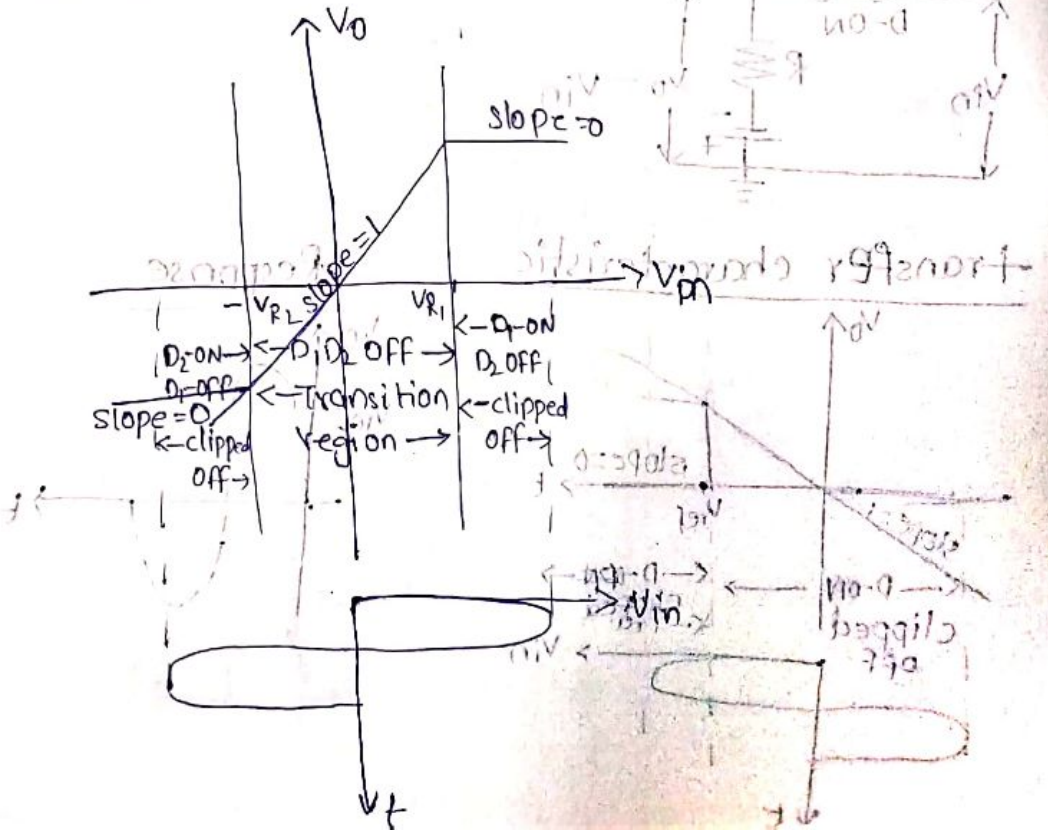
$V_{in} < -V_{R2}$ = D_2 ON, D_1-OFF $\Rightarrow V_o = -V_{R2}$, Slope = 0

$-V_{R2} < V_{in} < V_{R1}$, D_1, D_2 OFF $\Rightarrow V_o = V_{in}$, slope = 1



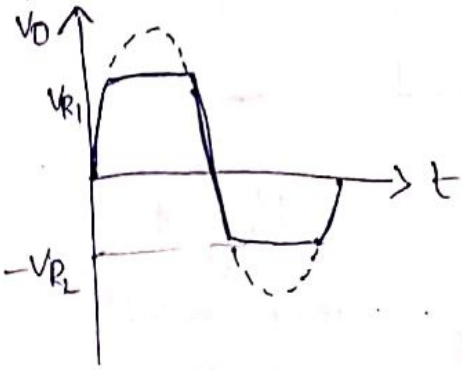


Transfer characteristic



www.Jntufastupdates.com Scanned by CamScanner

Response O/p:-





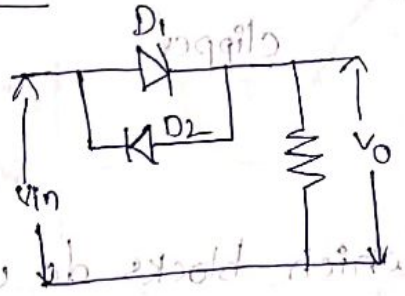
The double ended clippers, are also called as sin wave to square wave convertor.

If $V_i >> V_{R_1} + (-V_{R_2})$ then the output is [sem] symmtric square wave for $V_{R_1} = V_{R_2}$.

Noise clippers:-

- series
- shunt

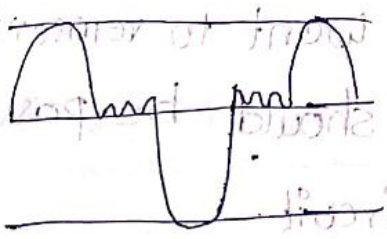
Series



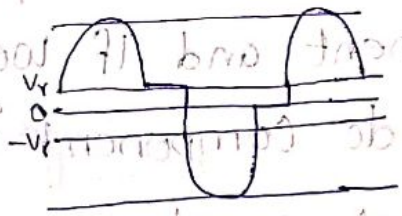
$V_{in} > V_r$, D_1 – ON, D_2 – OFF $\Rightarrow V_O = V_{max} - V_r$

$V_{in} < -V_r$, D_1 – OFF, D_2 – ON $\Rightarrow V_O = -(V_{max} - V_r)$

$-V_r < V_{in} < V_r$, D_1, D_2 – OFF, $V_O = 0$



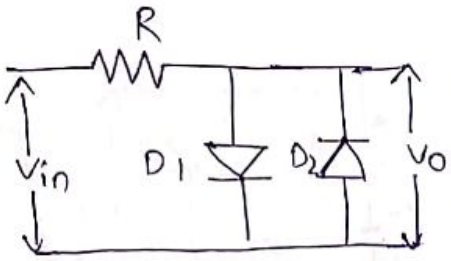
i/p signal with noise



o/p of series noise clipper

www.Jntufastupdates.com Scanned by CamScanner

Noise Shunt clippers:-

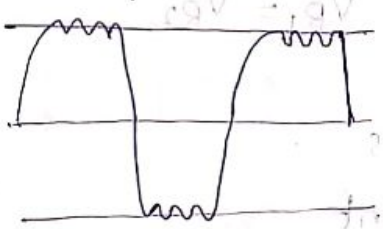




$V_{in} > V_r$, D_1-ON, D_2-OFF $\Big\}$ $V_o = V_r$

$V_{in} < -V_r$, D_1-OFF, D_2-ON $\Big\}$ $V_o = -V_r$

$-V_r < V_{in} < V_r$, D_1, D_2 -OFF ; $V_o = V_{in}$



i/p with noise



o/p of shunt noise clipper

Clampers:-

* Capacitor is device which blocks dc when ever your [av] i/p is having dc level when it is passed to a capacitor. It loses it's dc component and if we want to reinsert that last dc component it should be passed through a clamper circuit.

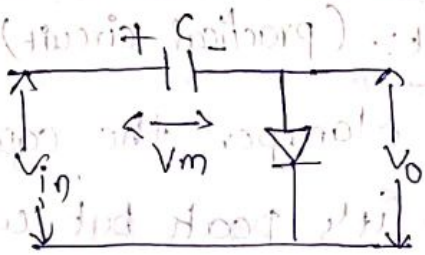
* A clamper is a one which is used to restore dc level. hence it is called dc level inserter.

www.Jntufastupdates.com Scanned by CamScanner

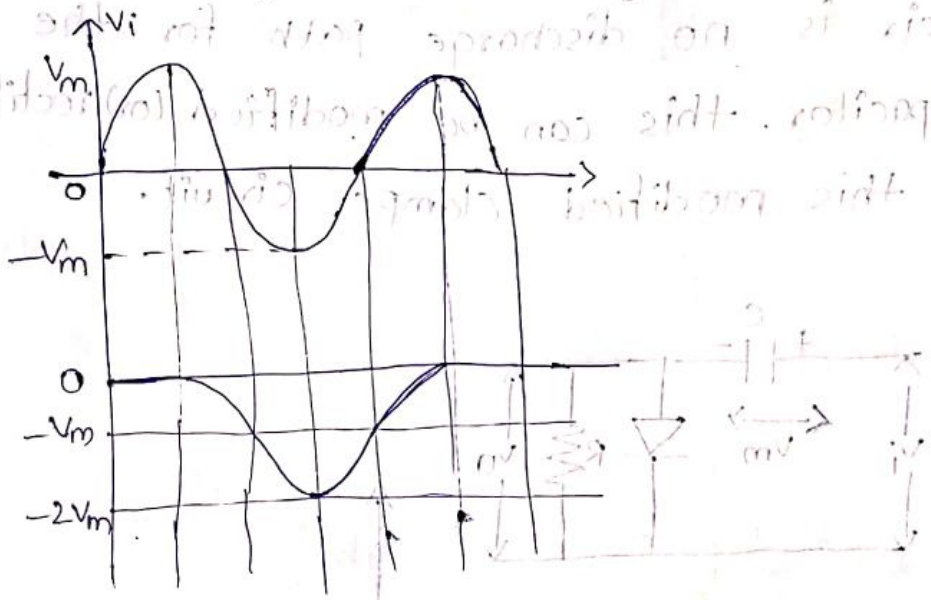
clamper

- Negative (Positive peak clamper)
- positive (Negative peak clamper)

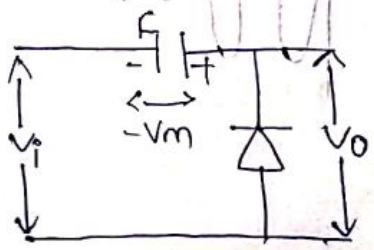
Negative clamper (positive peak clamper):-



$V_o = V_i - V_m$



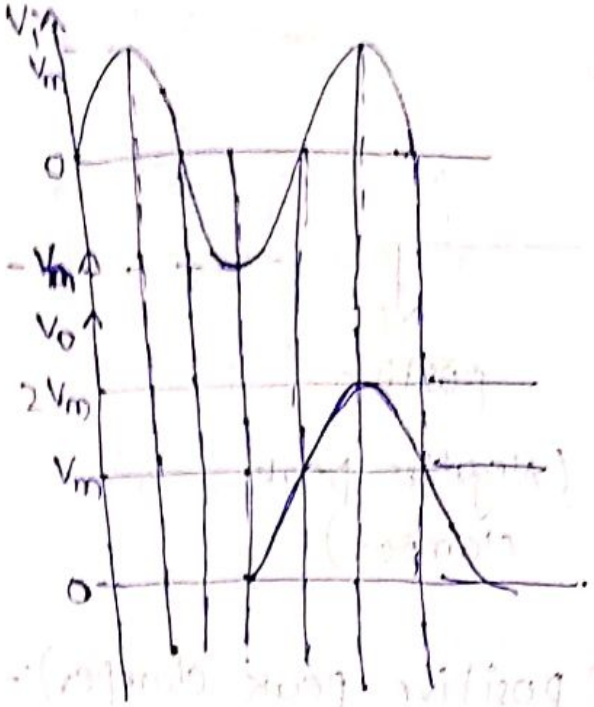
positive clamper (Negative peak clamper):-



$V_i = -V_m$; D-ON

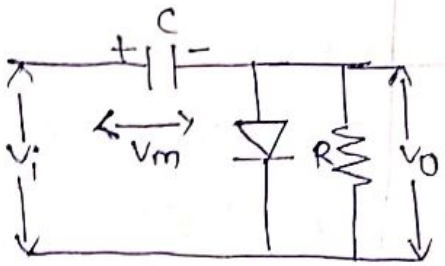
$V_o = V_i - (-V_m)$

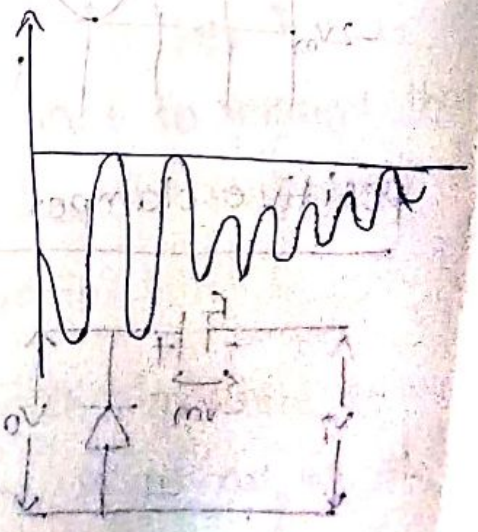
www.Jntufastupdates.com Scanned by CamScanner



Modified clamper circuit:-(practical circuit)

In positive (or) -ve' clamper the capacitor can store voltages to it's peak but when -ever i/p voltage falls below it's maximum their is no discharge path for the capacitor. this can be modified (or) rectified in this modified clamper circuit.





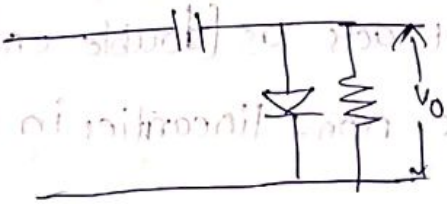
www.Jntufastupdates.com Scanned by CamScanner

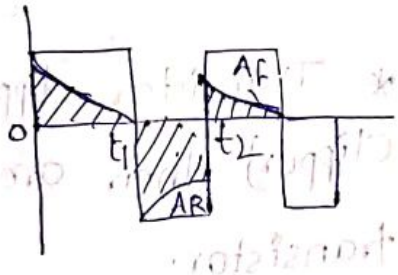
* To have modified clamper circuit and to create a discharge path for a capacitor. a resistor (R) is shunted to the diode.

clamping theorem:-

clamping theorem states that under steady state condition the area under forward bias condition is equal to area under reverse bias condition. that is

$$\frac{A_f}{AR} = \frac{R_f}{R}$$





Charge lost in F·B

$$q_1 = \int_0^{t_1} i_1(t)\,dt$$

$$= \int_0^{t_1} \frac{V_f(t)}{R_f}\,dt$$

$$= \frac{1}{R_f}\int_0^{t_1} V_f(t)\,dt$$

$$q_1 = \frac{1}{R_f} A_f$$

Charge lost in R·B

$$q_2 = \int_{t_1}^{t_2} i_2(t)\,dt$$

$$= \int_{t_1}^{t_2} \frac{V_r(t)}{R}\,dt$$

$$= \frac{1}{R}\int_{t_1}^{t_2} V_r(t)\,dt$$

$$q_2 = \frac{1}{R} A_r$$

www.Jntufastupdates.com Scanned by CamScanner

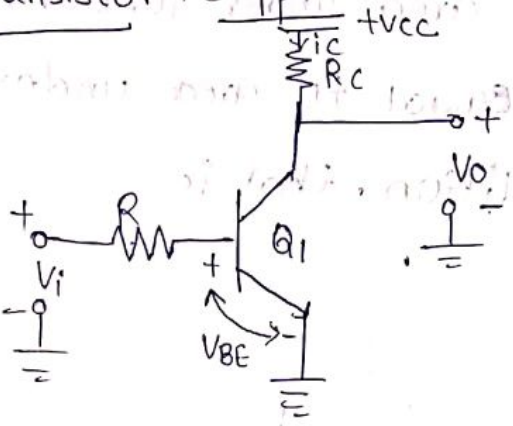
under steady state

$$v_1 = v_2$$

$$\frac{A_f}{R_f} = \frac{A_r}{R}$$

$$\boxed{\frac{A_f}{A_r} = \frac{R_f}{R}}$$

Transistor clipper:-



* Transistor clipper ckt acts as [double ended clipper] their are two non-linearities in a transistor.

1) when it moves from cut-off to active region.

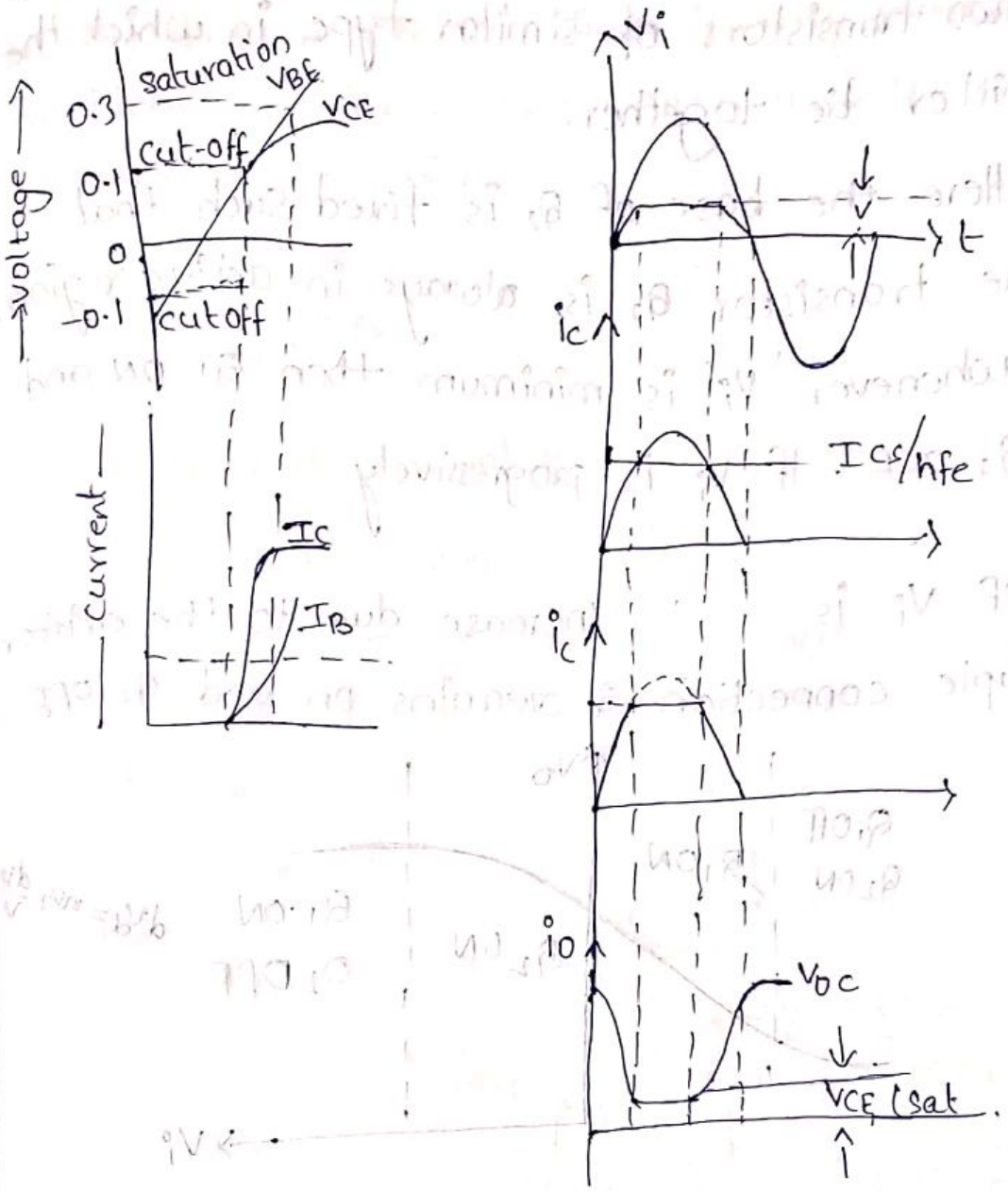
2) when it moves from Active to saturation region.

* Their is a linearity blw I_C and I_B rather than V_{BE}.

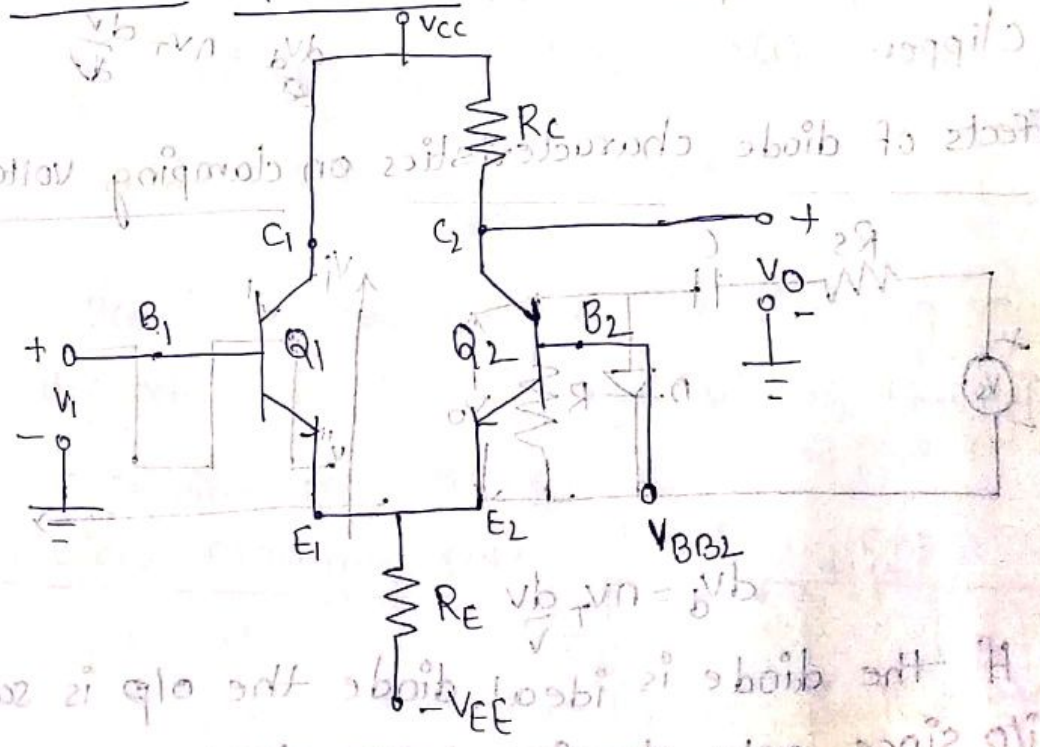
* whenever transistor operates in active region faithful application is done.

$$I_B = \frac{V_I - V_r}{R}$$

www.Jntufastupdates.com Scanned by CamScanner



Emitter coupled clipper



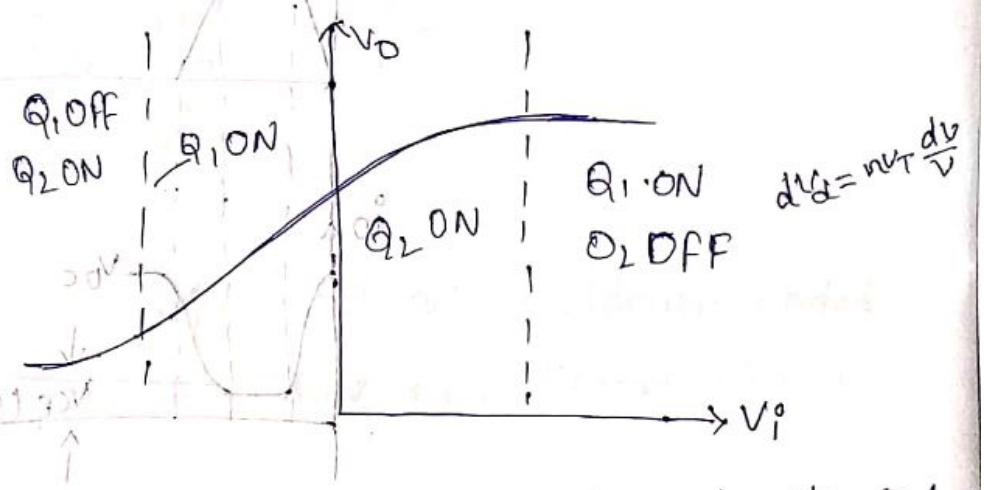
www.Jntufastupdates.com Scanned by CamScanner

Two transistors of similar type in which the emitter tie together.

Here the base of Q_2 is fixed such that the transistor Q_2 is always in active region.

* Whenever 'V_i' is minimum then Q_1 ON and Q_2 OFF. If V_i is progressively

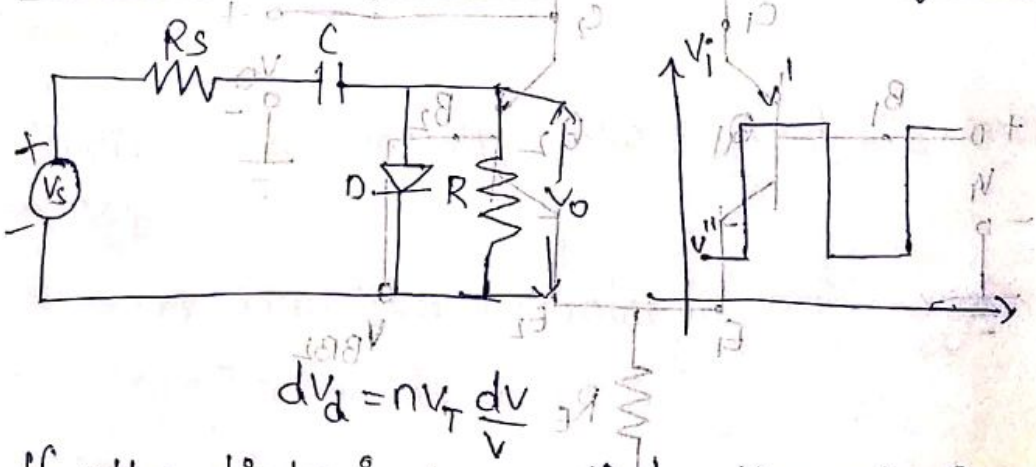
* If V_i is increase due to the emitter couple connection Q_1 remains on and Q_2 OFF.



* Emitter coupled clipper acts as double ended clipper.

$$\frac{dV_d}{\text{@}} = nV_T \frac{dv}{v}$$

Effects of diode characteristics on clamping voltage:-



$$dV_d = nV_T \frac{dv}{v}$$

If the diode is ideal diode the o/p is same as i/p since only clamping takes place.

www.Jntufastupdates.com Scanned by CamScanner

→ If the diode is practical diode it may consume 0.7 for silicon, 0.3 for Ge and it may effect the VI characteristics of diode.

We know that

$$I = I_0 e^{V_0/\eta V_T}$$

↓

Basic diode equation

where V_0 = o/p voltage

I_0 = Reverse saturation current

V_T = Voltage equivalent temp.

let $V_0 = V_{C1}$

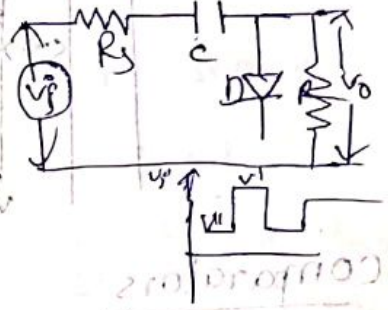
$I_0 = I_{C1}$

then

$$I_{C1} = \frac{V}{R} = I_0 e^{(V_{C1}/\eta V_T)}$$

$$\frac{V}{RI_0} = e^{V_{C1}/\eta V_T}$$

$$\log_e\left(\frac{V}{RI_0}\right) = V_{C1}/\eta V_T$$

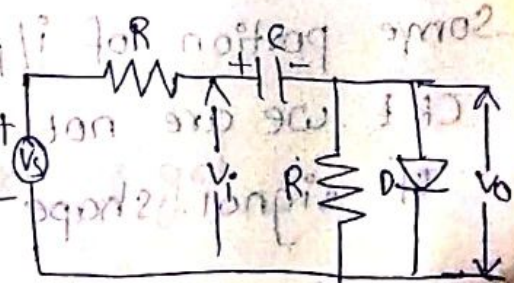


$$\eta V_T \log_e\left(\frac{V}{RI_0}\right) = V_{C1} \longrightarrow (1)$$

$$d V_{C1} = \eta V_T \left(\frac{dv}{I_0 R}\right) \longrightarrow (2)$$

Based on equ(1) & (2) the clamping voltage is dependent on i/p voltage 'v'. i.e, the effect of clamping loop voltage.

Practical clamping ckt:-



www.Jntufastupdates.com Scanned by CamScanner

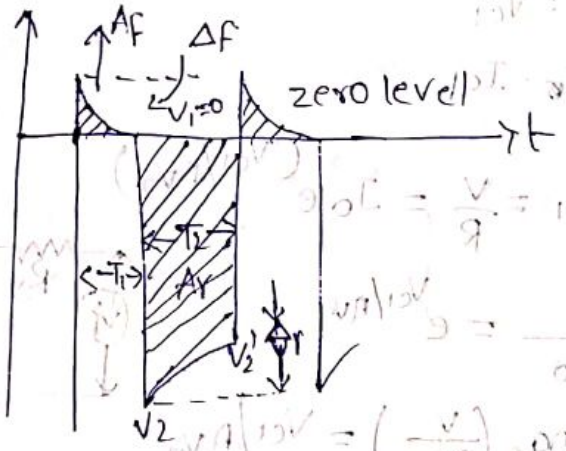
when diode conducts the o/p gets multiplied by $\frac{R_f}{R_f+R_s}$.

when diode reverse biased the o/p gets multiplied by $\frac{R}{R+R_s}$

→ so, for practical clamper ckts C value must be choosen such that as large as possible to have flat lines.

In F.W Bias — $(R_f+R_s)C << T_1$

In R.W Bias — $(R+R_s)C >> T_2$.



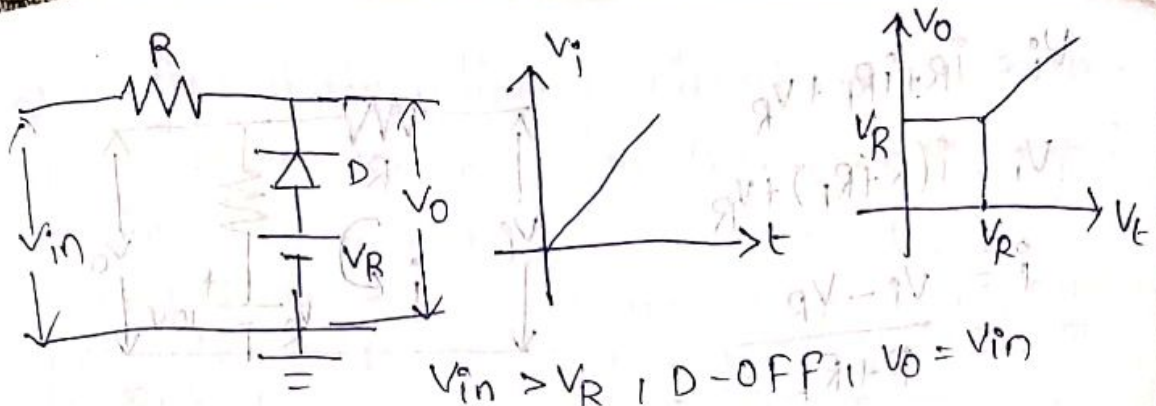
Comparators:-

A ckt which is used to mark when an orbitary wave form attains same reference level is called comparator.

→ comparators can be generated based on clipper ckts.

→ In clippers we may have to reproduce some portion of i/p signal but in comparator ckt we are not intrested in the reproduction of signal shape at the o/p.

www.Jntufastupdates.com Scanned by CamScanner



$V_{in} > V_R$, D-OFF, $V_o = V_{in}$

$V_{in} < V_R$, D-ON, $V_o = V_R$

Applications:-

1. Analog to digital convertor.
2. pulse time modulators.
3. To obtain square wave from sin wave
4. Accurate time measurment.

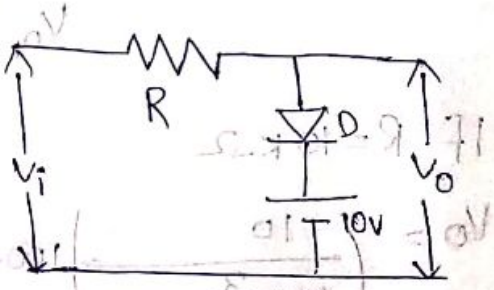
problems on clippers:-

1) From the diode clipping ckt shown below assume $V_R = 10V$, $V_i = 20\sin\omega t$, $R_f = 100\Omega$, $R_r = \infty$, $V_r = 0$, neglect all capacitance. draw to scale i/p & o/p waveforms and lable the max is min values if

(i) $R = 100\Omega$

(ii) $R = 1K\Omega$

(iii) $R = 10K\Omega$



Sol:- If $V_{in} > V_R$, D-ON,

Apply KVL to the ckt we get

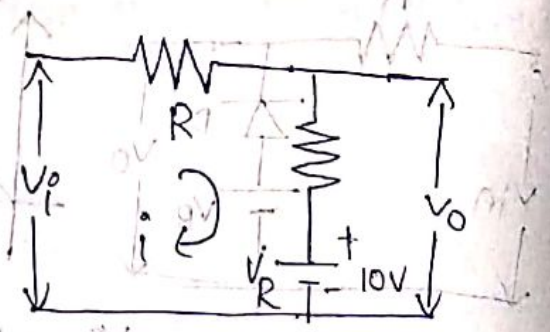
www.Jntufastupdates.com Scanned by CamScanner

$V_i = iR + iR_f + V_R$

$V_i = i(R+R_f) + V_R$

$i = \frac{V_i - V_R}{R+R_f}$

$= \frac{20-10}{R+100} = \frac{10}{R+100} \longrightarrow (1)$



The o/p voltage can be given as

$V_o = iR_f + V_R \longrightarrow (2)$

Put (1) in (2)

$= \left(\frac{10}{R+100}\right) R_f + 10$

$= \left(\frac{10}{R+100}\right) 100 + 10$

if $R = 100$ $V_o = \left(\frac{10}{100+100}\right) 100 + 10$ $\boxed{V_o = 15V}$

If $R = 1K\Omega$ $V_o = \left(\frac{10}{1K\Omega+100}\right) 100 + 10$

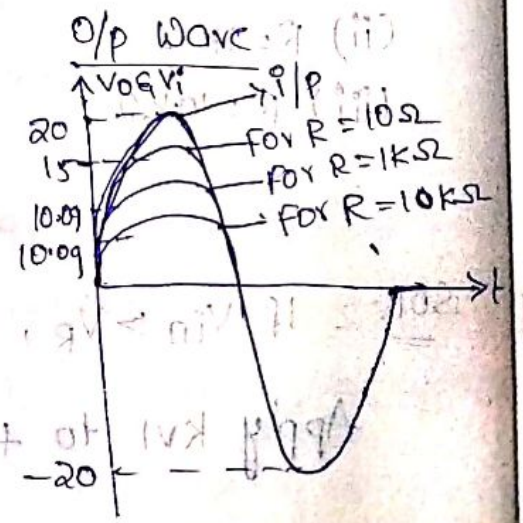
$= \left(\frac{10}{1100}\right) 100 + 10$

$V_o = 10.91\ V$

If $R = 10K\Omega$

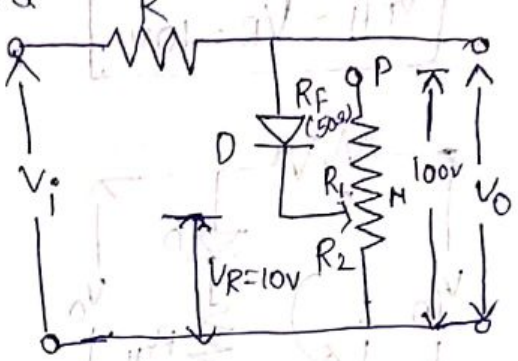
$V_o = \left(\frac{10}{10\times10^3+100}\right) 100 + 10$

$V_o = 10.09V$



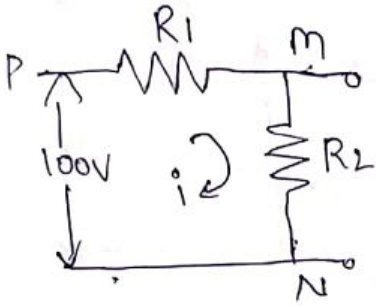
www.Jntufastupdates.com Scanned by CamScanner

2) In the diode clipping circuit shown below $V_i = 20\sin\omega t$, $V_R = 10V$, the Reference voltage is obtained from a tab on a 10kΩ, divider connected to a 100V source. Neglect all capacitance, the diode forward resistance is 50Ω. $R_R = \infty$, $V_\gamma = 0$. Draw i/p & o/p waveforms.



A) $V_i = 20\sin\omega t$

$R_1 + R_2 = 10k\Omega$



$V_i = i(R_1 + R_2)$

$100 = i(10k\Omega) \Rightarrow \boxed{i = 0.01mA}$

$V_{R_2} = iR_2$

$V_{R_2} = 10V$

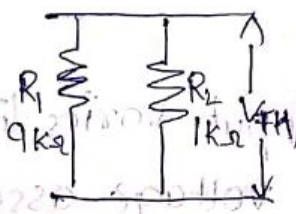
$10 = 0.1mA\,(R_2)$

$R_2 = \frac{10}{0.1mA} = 1k\Omega$

$\therefore R_1 + R_2 = 10k\Omega$

$R_1 = (10 - 1)\,k\Omega$

$R_1 = 9k\Omega$



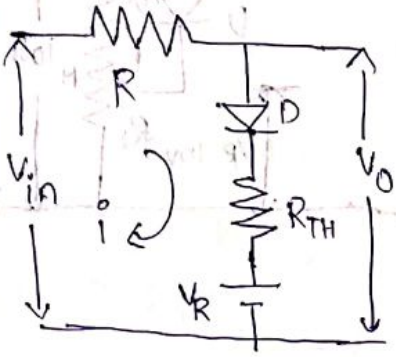
$R_{TH} = R_1 \| R_2 = \frac{R_1 R_2}{R_1 + R_2}$

www.Jntufastupdates.com Scanned by CamScanner

$= \frac{(1 \times 9)\,K\Omega}{10\,K\Omega}$

$R_{TH} = 0.9K\Omega$

$V_{TH} = V_R = 10V$



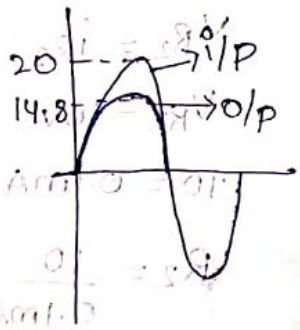
Apply KVL.

$V_{in} = i(R + R_f + R_{TH}) + V_R$

$20 = i(1K\Omega + 50\Omega + 0.9K\Omega) + 10$

$i = \frac{20-10}{1.95K\Omega}$

$i = \frac{10}{1.95K\Omega} = \boxed{5.12mA}$



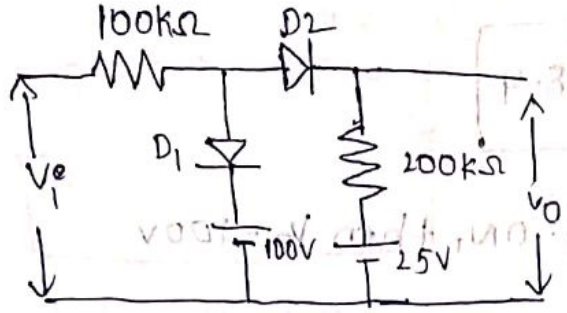
$V_O = i(R_f + R_{TH}) + V_R$

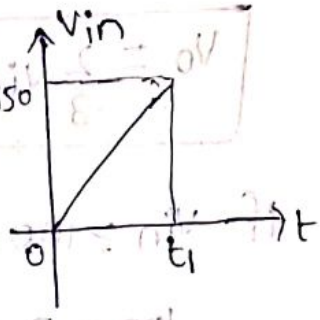
$= 5.12mA(50\Omega + 0.9K\Omega) + 10$

$\boxed{V_O = 14.87 \text{ volts}}$

3) For the following circuit input varies linearly from 0 to 150 v. sketch output voltage assume ideal diodes

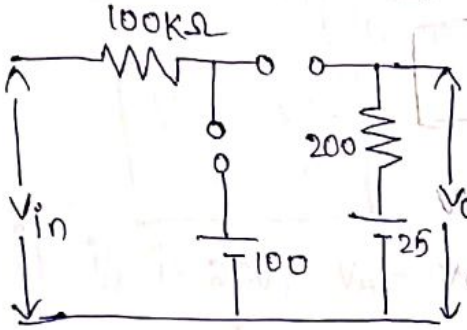
www.Jntufastupdates.com Scanned by CamScanner

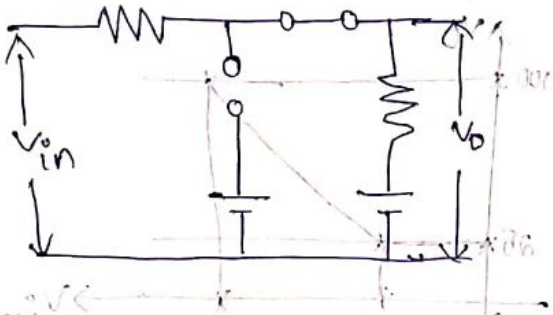




$V_{in} < 0$, D_1 & D_2 = OFF, $V_o = 25V$

$V_{in} > 0$, D_1 - OFF, D_2 - ON, $V_o = 25V$





Apply KVL to above n/w

$$V_{in} = i(100k\Omega + 200k\Omega) + 25$$

$$V_{in} = i(300k\Omega) + 25$$

$$\boxed{i = \frac{V_{in} - 25}{300k\Omega}}$$

$$V_o = i(200k\Omega) + 25$$

$$V_o = \left(\frac{V_{in} - 25}{300k\Omega}\right) 200k\Omega + 25$$

$$V_o = \frac{V_{in} 200k\Omega}{300k\Omega} - \frac{25(200k\Omega)}{300k\Omega} + 25$$

$$V_o = \frac{2}{3} V_{in} - 25 \times \frac{2}{3} + 25$$

www.Jntufastupdates.com Scanned by CamScanner

$$V_o = \frac{2}{3}V_{in} + 8.4$$

If $V_{in} \geq 100$, D_1 – ON, then $V_o = 100V$

$$100 = \frac{2}{3}V_{in} + 8.4$$

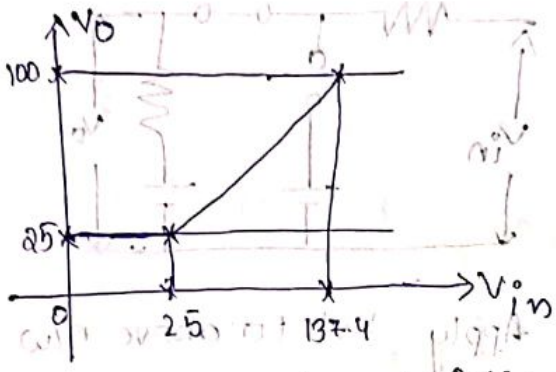
$$V_{in} = 100 - 8.4 \times \frac{3}{2}$$

$$V_{in} = 137.4V$$

$V_{in} = 0$, $V_o = 25V$

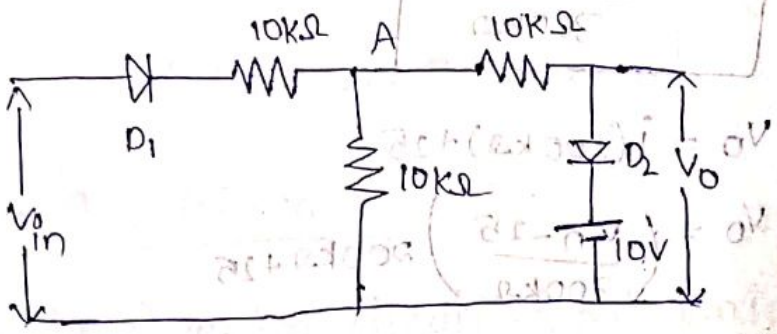
$V_{in} = 25$, $V_o = 25V$

$V_{in} = 137.4$, $V_o = 100V$



Transfer characteristics

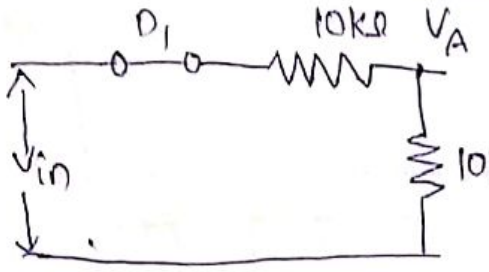
4) For the circuit shown below sketch output voltage. If input voltage is 20 sin ωt.



A) $V_{in} < 0$, D_1 & D_2 – OFF, $V_o = 0$

$V_{in} > 0$, D_1 – ON

www.Jntufastupdates.com Scanned by CamScanner



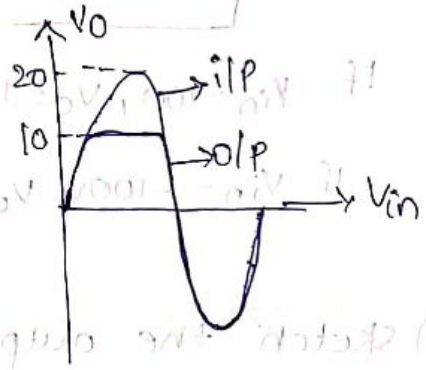
$$V_A = V_{in}\left(\frac{R_2}{R_1+R_2}\right)$$

$$= V_{in}\left(\frac{10K\Omega}{10+10K\Omega}\right)$$

$$\boxed{V_A = \frac{V_{in}}{2}}$$

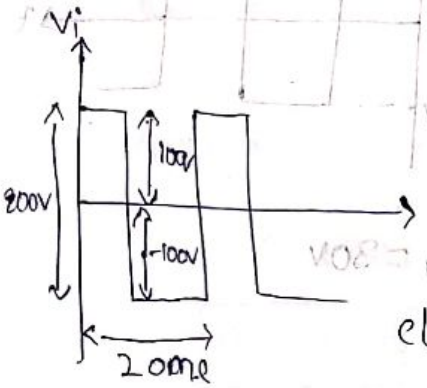
if i/p is 20V, $V_A = 10V$ then D_2 – conducts, $V_0 = 10V$

$V_0 = \cdot$

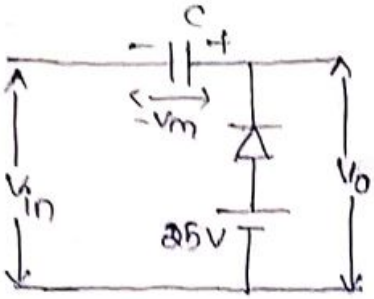


5 Problems of clampers:-

1)



The design of a positive clamper with a potential



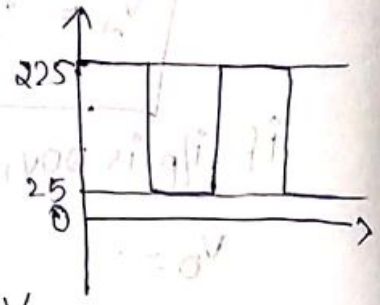
In the above ckt, the diode 'D' gets forward biased. If input is -100v and the capacitor charges to its P.

$-V_m = -125$

$V_m = 125$

$V_o = V_{in} + V_m$

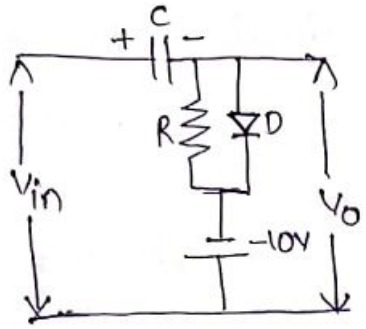
$\boxed{V_o = V_{in} + 125}$

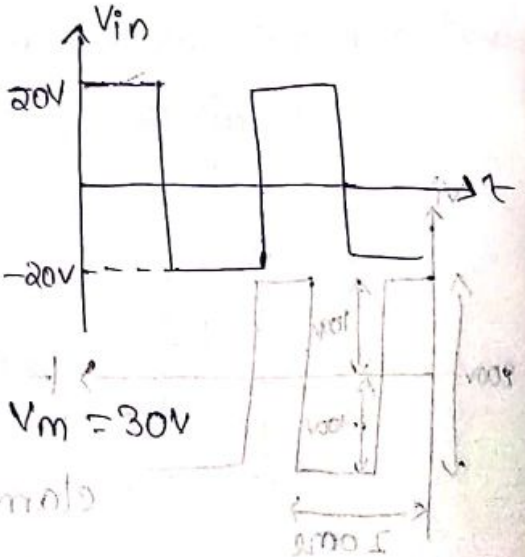


If $V_{in} = 100$, $V_o = 100 + 125 = 225V$

If $V_{in} = -100V$, $V_o = -100 + 125 = 25V$

2) Sketch the output waveform that we would expert from the ckt shown below when the i/p is ±20V square wave.





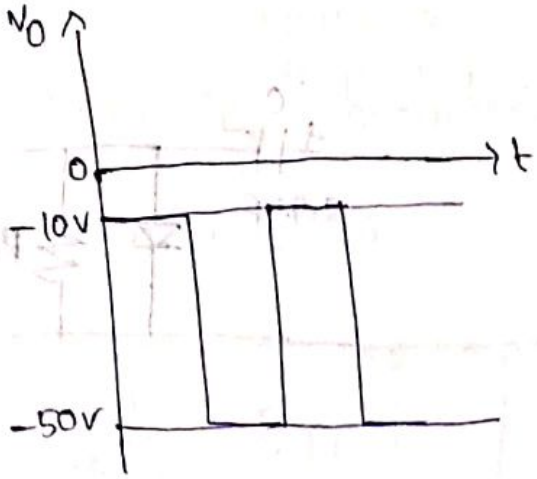
wkt $\boxed{V_o = V_{in} - V_m}$ $V_m = 30V$

$V_o = V_{in} - 30V$

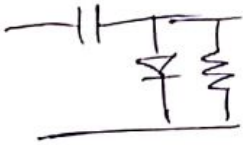
If $V_{in} = 20$, $V_o = 20 - 30 = -10V$

$V_{in} = -20$, $V_o = -20 - 30 = -50V$

www.Jntufastupdates.com Scanned by CamScanner



Desiging of clamping circuit:



$$\left.\begin{matrix} R_f \\ R_r \end{matrix}\right\} R = \sqrt{R_f \times R_r}$$

Let $RC = 25T$

$$C = \frac{25T}{R}$$

$$\boxed{C = \frac{25}{fR}}$$

P) Design a diode clamper to restore the button peaks (Negative peak) of the i/p signal to the zero level, use silicon diode with $R_f = 50\Omega$, $R_r = 400k\Omega$, the frequency of i/p is 5~~00~~kHz.

Sol:- $R_f = 50\Omega$

$R_r = 400k\Omega$

$f = 5KHz$

WKT $R = \sqrt{R_f \times R_r}$

$$= \sqrt{50 \times 400 \times 10^3}$$

$$\boxed{R = 4.47K\Omega}$$

let $RC = 20T$

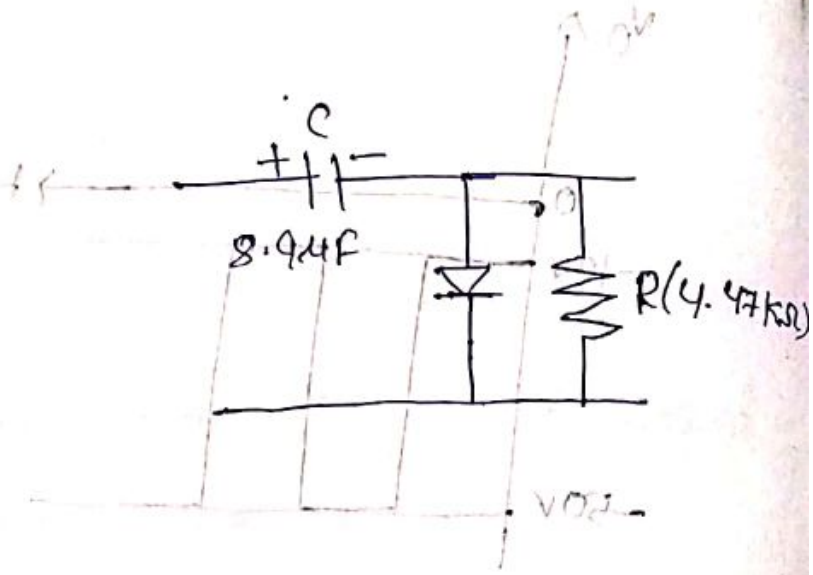
$$C = \frac{20T}{R}$$

www.Jntufastupdates.com Scanned by CamScanner

$$C = \frac{20}{fR}$$

$$= \frac{20}{5\times10^{3}\times4.47\times10^{3}}$$

$$\boxed{C = 8.94\mu F}$$



www.Jntufastupdates.com Scanned by CamScanner