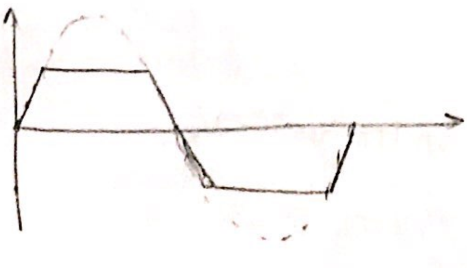
UNIT - II

Non - Linear Wave Shaping:-

The clipping circuit comprises of linear elements like resistors and non - linear elements like junction diodes and transistors. But it does not contain energy storage elements like capacitors. clipping circuits are used to select to a purpose of transmission that part of a signal wave form which lies above or below a certain reference voltage level. Thus, clipper circuit can remove certain portions of an arbitrary wave form near the +ve or -ve peaks. clipping voltage may be achieved either at one level or at two levels. ~~For exampe.~~ For example, a sinusoidal wave can be converted into a trapezoidal wave using two level clipper.



V_{R_1} & V_{R_2} are the reference voltage levels.

clipping circuits are also called as slices, amplitude selector or limiter classification:-

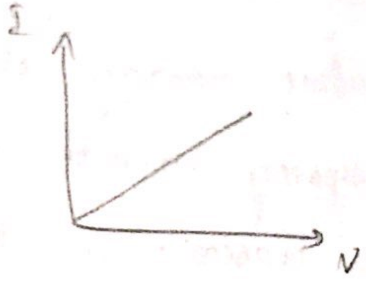
Practically, clippers are classified into two types

(1) shunt clippers.

(2) series clippers.

characteristics of ~~linear~~, ideal and practical diode

⇒ An ideal diode exhibits the following characteristics

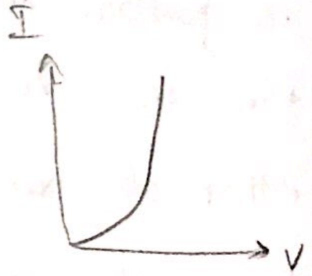


The forward resistance $R_f = 0$

The reverse resistance $R_r = \infty$

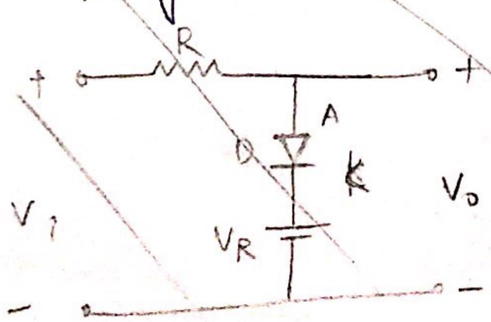
cut in voltage $V_\gamma = 0$

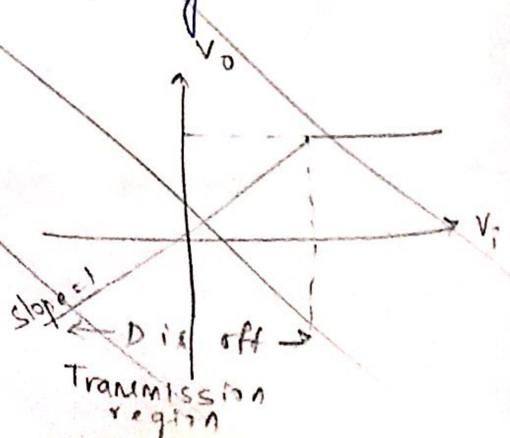
⇒ For practical diode, the forward resistance is of the order of a few ohms. The reverse resistance is quite large. Also, cut-in-voltage $V_\gamma = 0.2\,V$ (or) $0.6\,V$



Shunt clippers:·

clipping above the reference voltage V_R.

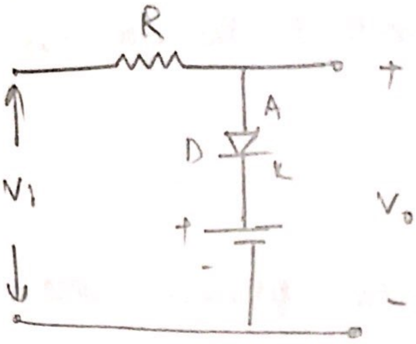




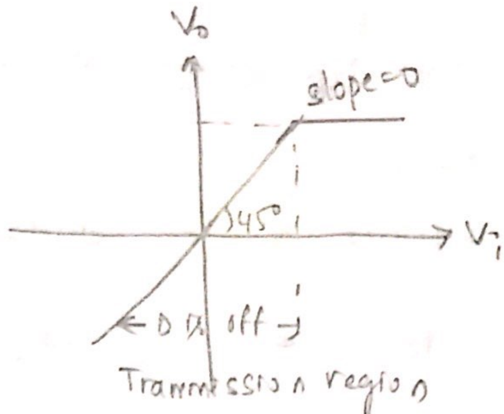
Transfer characteristic

Shunt clippers:-

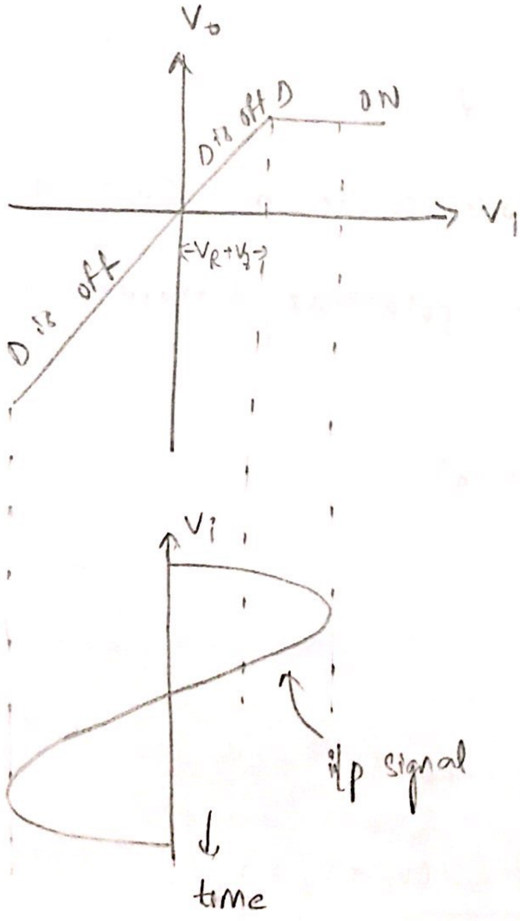
Shunt clipper clipping above the V_R.

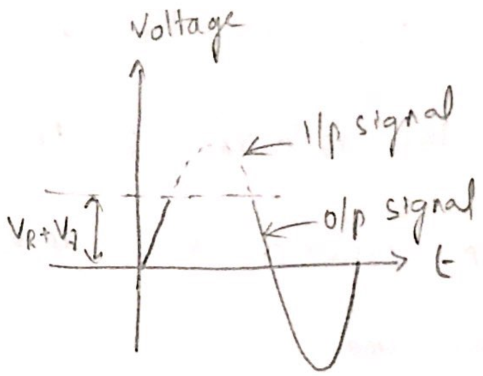


clipping above reference voltage



Transfer characteristic





D is the diode which is connected in series with battery V_R and this series combination forms a parallel path across the o/p voltage 'V_o'. 'V_R' represents the reference voltage 'R' is a current limiting resistance. Let 'V_o' denotes the o/p voltage when i/p voltage V_i which transmitted through the circuit

Working of the diodes-

For $V_i < V_R + V_\gamma$ the diode D is OFFed since it is reverse biased and hence doesnot conduct. So, no current flows and there is no voltage drop across Resistance R.

$\therefore V_o = V_i$ for $V_i < V_R + V_\gamma$.

For $V_i > V_R + V_\gamma$, the diode D is ON, since it is in forward bias and the potential barrier is overcome.

Let 'i' denotes the current

$$i = \frac{V_i - (V_R + V_\gamma)}{R + R_F}$$

The o/p voltage $V_o = V_i - iR$.

$$V_o = V_i - \left(\frac{V_i - (V_R + V_\gamma)}{R + R_F} \right) R$$

Neglecting R_F

$$V_o = \frac{V_i - (V_i - (V_R + V_\gamma))}{R} \times R$$

$$V_o = V_R + V_\gamma$$

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$V_o = V_i$ for ($V_i < V_R + V_\gamma$)

$V_o = V_R + V_\gamma$ for ($V_i > V_R + V_\gamma$).

Transfer characteristics :-

when $V_o = V_i$, then $\frac{V_o}{V_i} = 1$

$\therefore$ Slope = 1

when $V_o = V_R + V_\gamma$, then V_o is constant, since both V_R and V_γ are of fixed magnitude

$\therefore$ Slope = 0

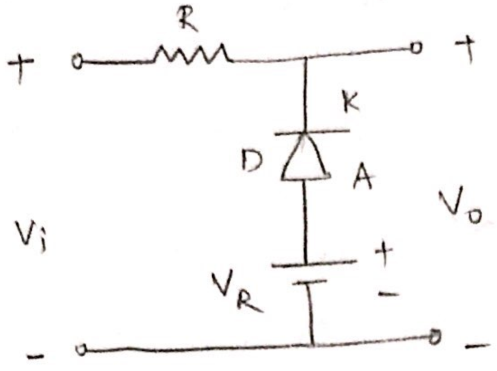
It is evident that $V_o = V_i$, when D is off, there's no clipping action and the i/p signal is transmitted without any alteration of wave shape.

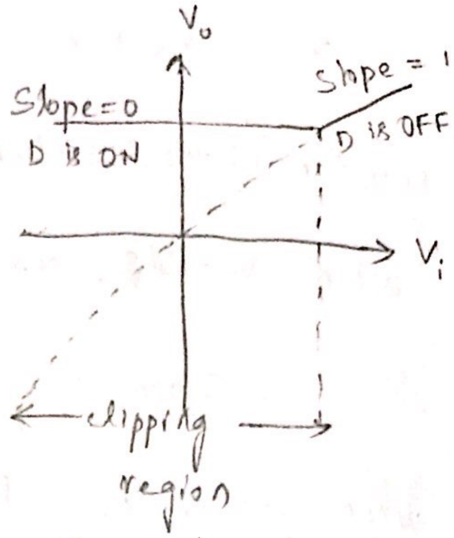
When D is ON, it is seen that V_o is constant and whatever the magnitude & instantaneous V_i, Hence there is clipping action for the portion of i/p signal greater than $V_R + V_\gamma$ is not transmitted.

In practice if $V_R >> V_\gamma$ we have $V_R + V_\gamma = V_R$ and V_R itself can be taken as level below which transmission occurs without clipping action but beyond which clipping really occurs

08/08/2017

b) Clipping Below the Reference Voltage V_R.

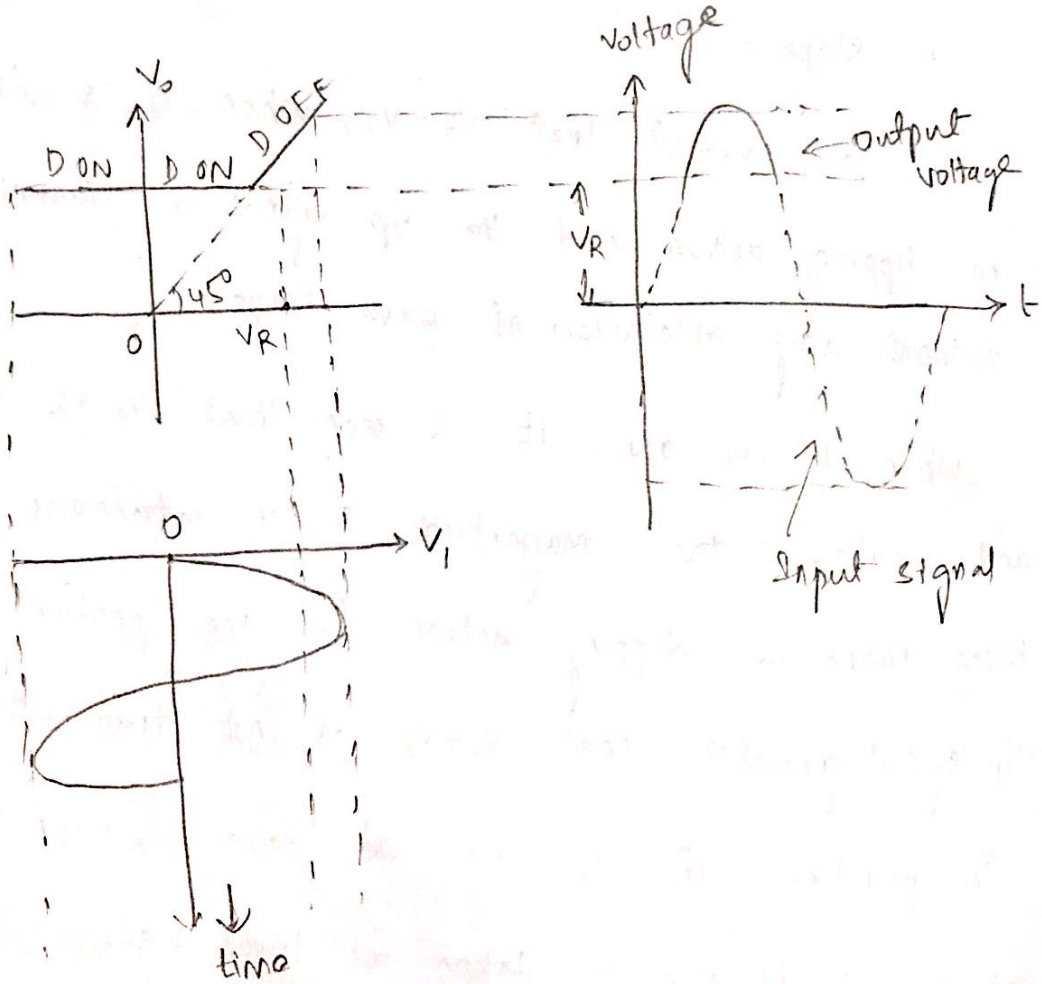




Transfer characteristic

$V_o = V_R$ for $V_i < V_R$ (D ON)

$V_o = V_i$ for $V_i > V_R$



let 'D' is an ideal diode so that $R_f = 0$ and $V_\gamma = 0$ and V_R is the reference voltage it is of fixed magnitude, V_i is the input voltage and V_o is the output voltage.

Working:-

For $V_i < V_R$, Diode is ON since V_R is greater than V_i, the diode gets forward Biased and conduction readily occurs. The ideal diode acts as short circuit and there is no voltage drop across the diode ~~and~~ Hence, $V_o = V_R$.

For $V_i > V_R$, Diode 'D' is OFF since it gets Reverse Biased there is no conduction and no voltage drop across 'R'. Therefore $V_o = V_i$.

Transfer characteristics :-

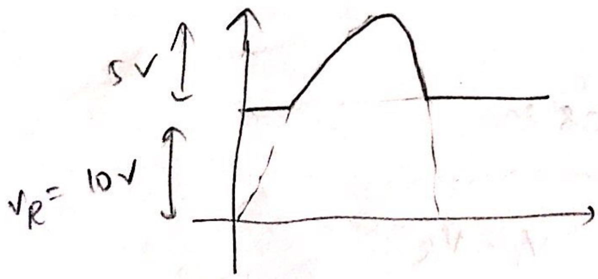
$V_o = V_R$ for $V_i < V_R$

$V_o = V_i$ for $V_i > V_R$

when $V_o = V_R$ the slope is zero and when (∵ V_R = constant) $V_o = V_i$ the slope is '1'.

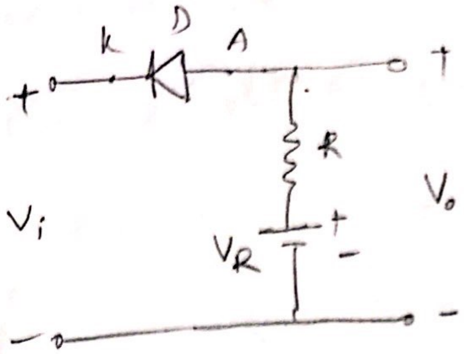
when the diode is 'ON' clipping action readily takes place since the output $V_o = V_R$ of constant magnitude. Thus for all values of $V_i < V_R$, the output voltage has the magnitude V_R (OR) The portion of the input voltage waveform below the reference voltage V_R is readily clipped. When the diode is OFF, we have $V_o = V_i$ and there is no clipping. Hence the portion of the input signal waveform lying above the reference voltage V_R is readily transmitted without attenuation.

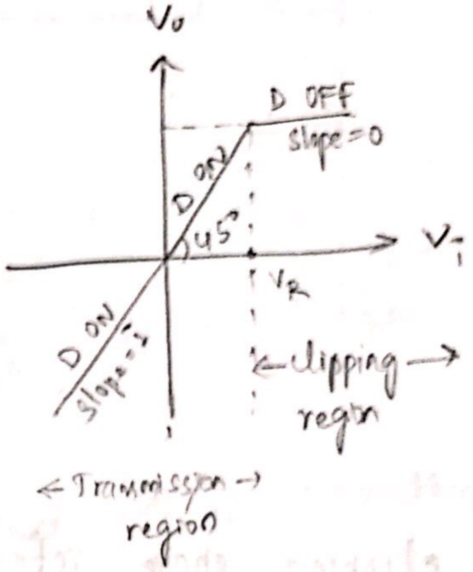
Ex:- Let the sine wave $E = 15 \sin \omega t$ be passed through the above clipper circuit. The output voltage has the waveform as follow if $V_R = 10V$



SERIES CLIPPERS :-

Clipping above the Reference voltage V_R :-

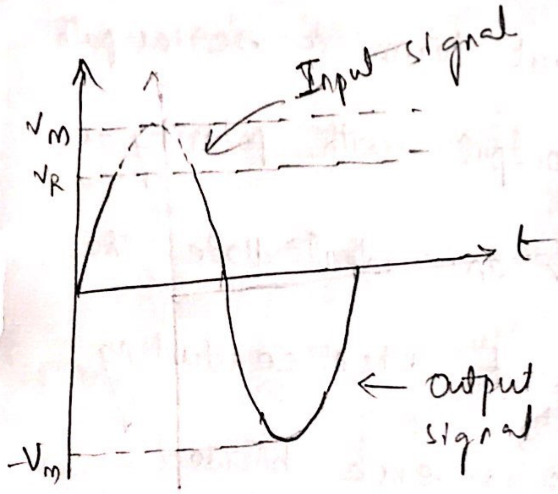




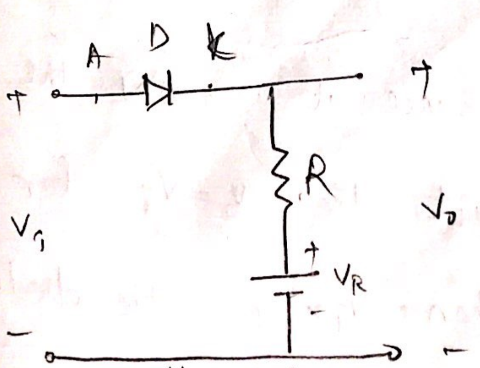
$V_o = V_i$ for $V_i < V_R$

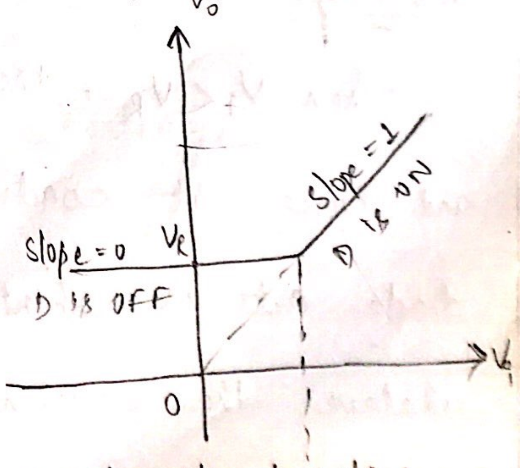
$V_o = V_R$ for $V_i > V_R$

Transfer characteristics



Clipping Below the reference voltage V_R :-

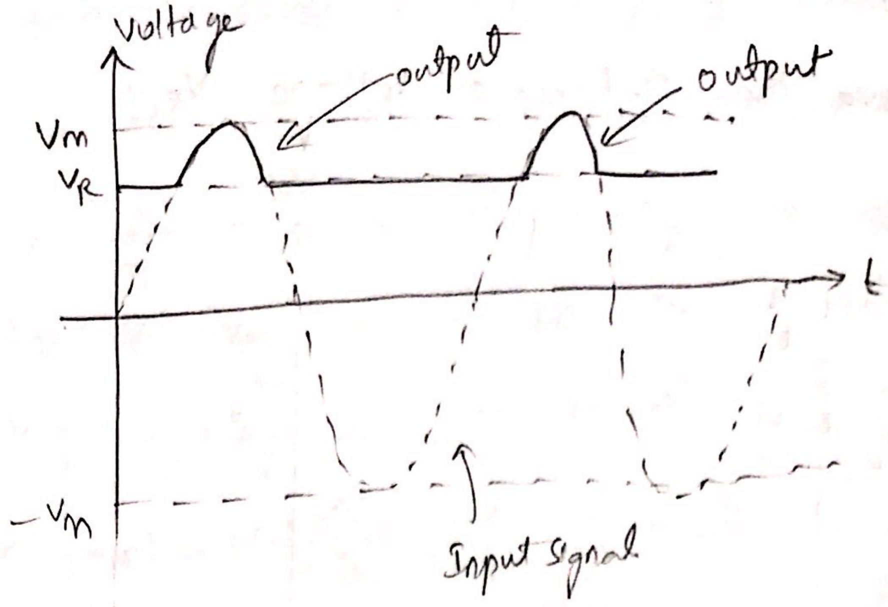




$V_o = V_R$ for $V_i < V_R$

$V_o = V_i$ for $V_i > V_R$

Transfer characteristics



clipping above reference voltage:-

Let 'D' is an ideal Diode, the diode that connected in the circuit forms a series path connecting the input and output with polarity as shown. Hence $R_f = 0$ for an ideal diode. The diode acts as short circuit when conducting and as open circuit when reverse biased.

working:-

when $V_i < V_R$, the diode is forward biased and hence it conducts, since it is ON the diode acts as short circuit the $V_o = V_i$ for whatever the current - when, $V_i > V_R$, the diode is reverse biased and hence it is OFF.

It acts as open circuit. since there is no conduction of diode.

Transfer characteristics :-

For $V_i < V_R$, $V_0 = V_i$, Therefore slope = 1.

for $V_i > V_R$, $V_0 = V_R$ Since V_R is of fixed magnitude Hence slope = 0.

An input signal is transmitted without attenuation untill $V_i = V_R$. for $V_i > V_R$ clipping occurs and portion of the waveform above V_R is clipped

clipping below the reference voltage :-

Let 'D' is an ideal diode, the diode that connected in the circuit forms a series path connecting the input and output with polarity as shown. Hence $R_f = 0$ for an ideal diode. The diode acts as short circuit. when reverse biased and open circuit when conducting.

Working:-

when $V_i < V_R$, the diode is reverse biased and hence it is OFF it acts as open circuit since there is no conduction of diode when $V_i \geq V_R$, the diode is forward biased & hence it is ON it acts as short circuit.

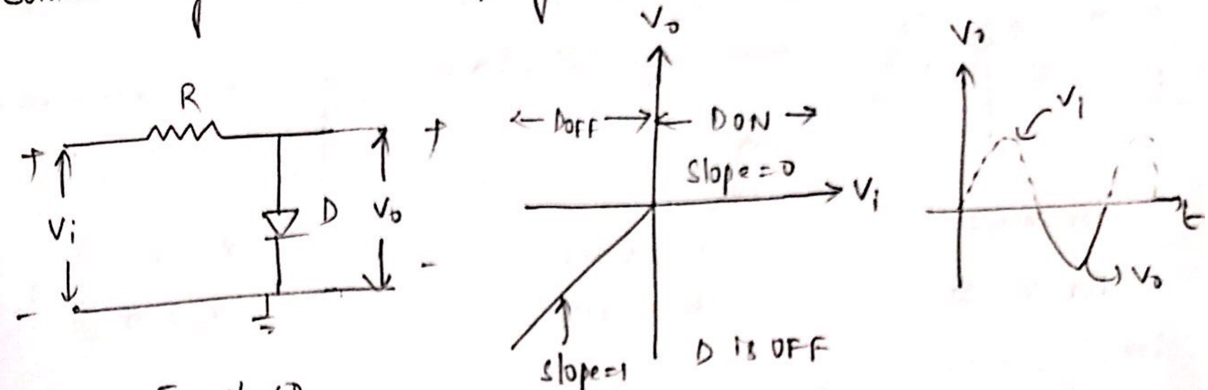
Transfer characteristics:-

For $V_i < V_R$, $V_o = V_R$ since V_R is of fixed voltage. Hence slope = 0. For $V_i > V_R$, $V_o = V_i$. Therefore slope = 1

An input signal is not transmitted until $V_i = V_R$. after it gets V_R. input signal is transmitted. Therefore signal below the reference voltage is clipped off.

Assignment - slicer:- (clipping at two levels)

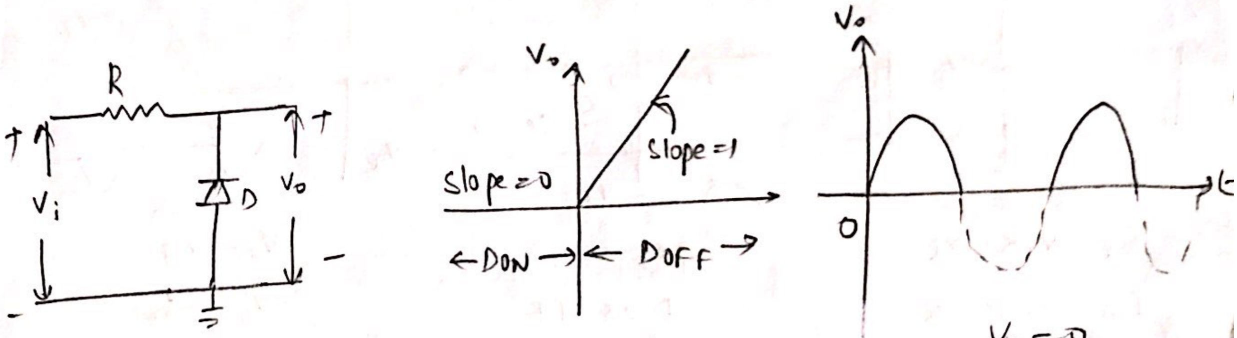
Some single ended clipping circuits



For $V_i < 0$ D is OFF

For $V_i > 0$ D is ON

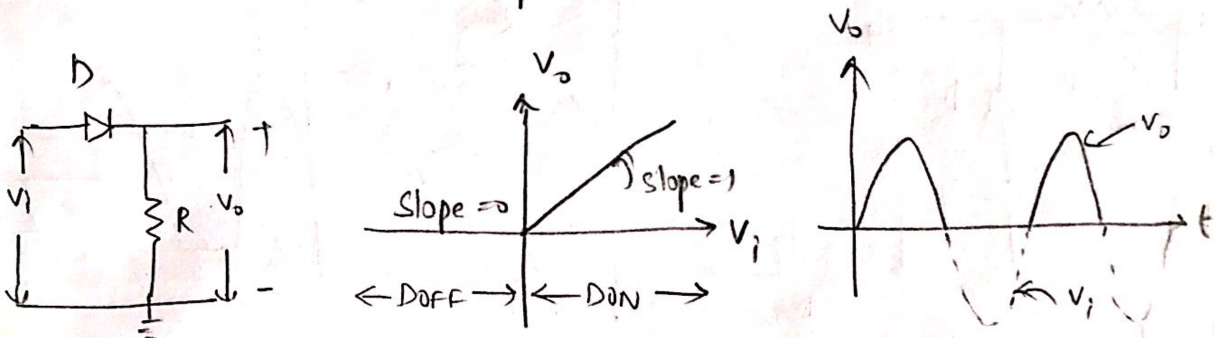
(a) shunt clipper, positive peak clipping without reference



For $V_i < 0$ D is ON $V_o = 0$

For $V_i > 0$ D is OFF $V_o = V_i$

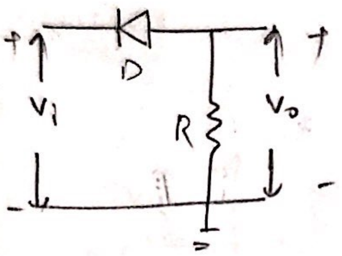
(b) shunt clipper, negative peak clipping without reference

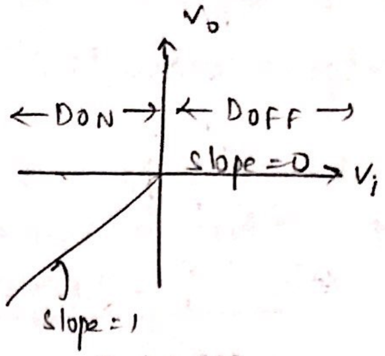


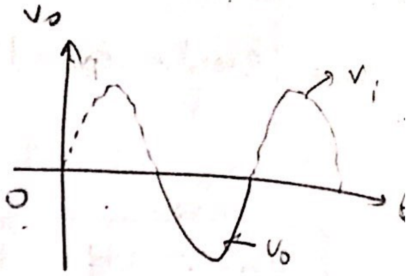
For $V_i < 0$ D is OFF $V_o = 0$

For $V_i > 0$ D is ON $V_o = V_i$

(c) series clipping, negative peak clipping without reference

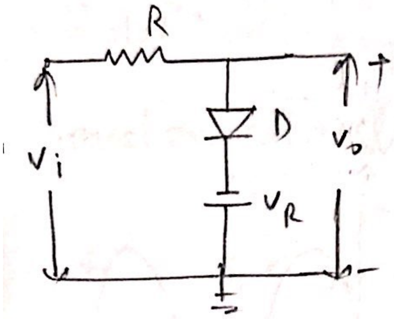


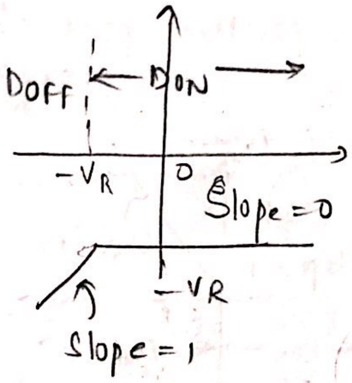


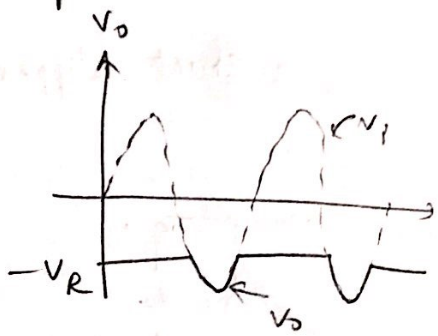


for $V_i < 0$	D is ON	$V_o = V_i$
for $V_i > 0$	D is OFF	$V_o = 0$

(d) series clipper, positive peak clipping without reference.

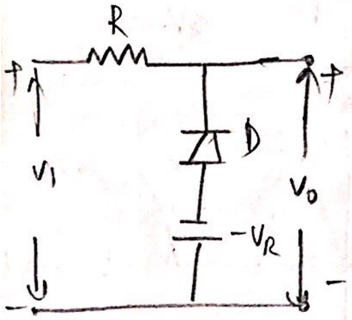


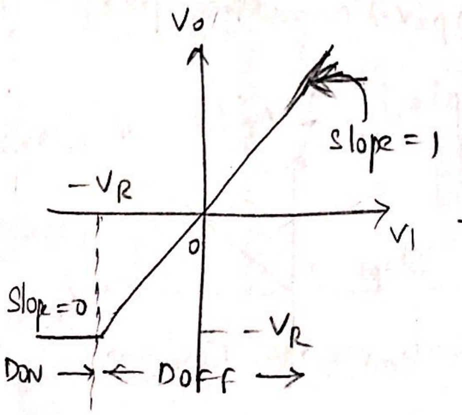


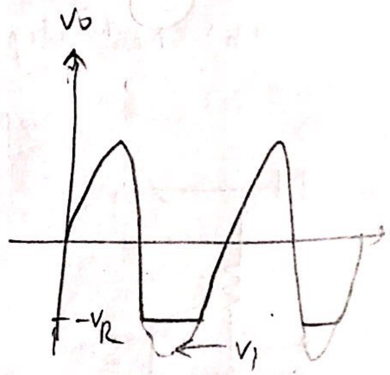


for $V_i < -V_R$	D is OFF	$V_o = V_i$
For $V_i > -V_R$	D is ON	$V_o = -V_R$

(e) shunt clipper, negative base clipping above reference level

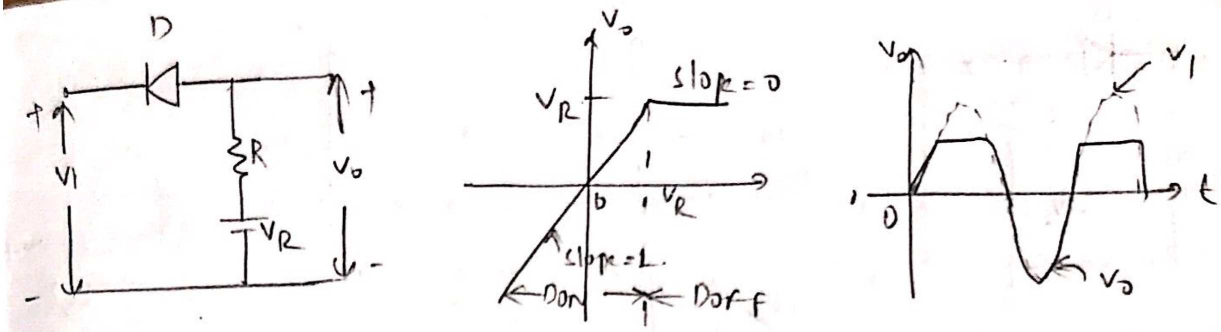






for $V_i < -V_R$	D is ON	$V_o = -V_R$
for $V_i > -V_R$	D is OFF	$V_o = V_i$

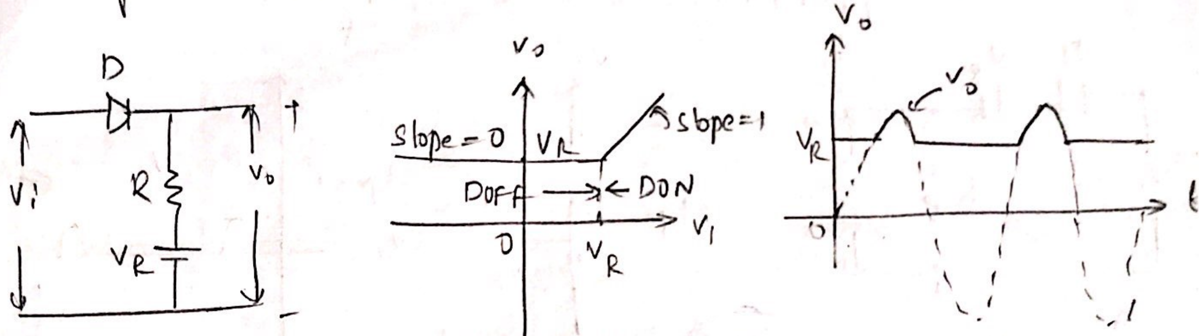
(f) shunt clipper, negative base clipping below reference level



for $V_i < V_R$ D is ON $V_o = V_i$

for $V_i > V_R$ D is OFF $V_o = V_R$

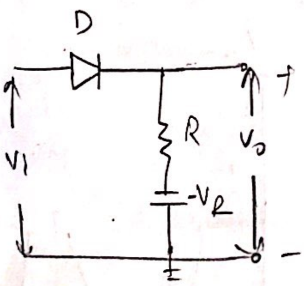
(g) series clipper, positive base clipping above reference level

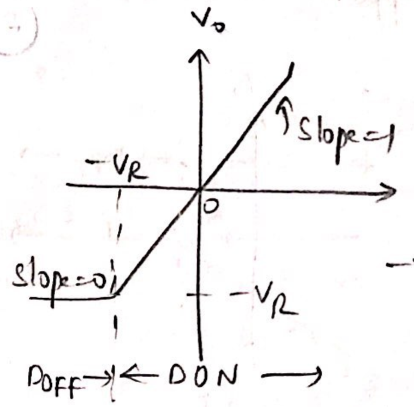


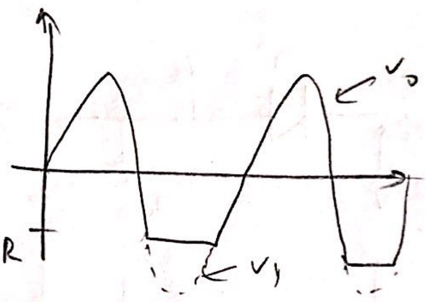
for $V_i < V_R$ D is OFF $V_o = V_R$

for $V_i > V_R$ D is ON $V_o = V_i$

(h) series clipper, positive base clipping above reference level







for $V_i < -V_R$ D is OFF $V_o = -V_R$

for $V_i > -V_R$ D is ON $V_o = V_i$

(i) Series clipper, negative base clipping above reference level

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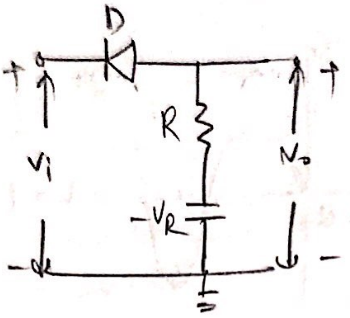
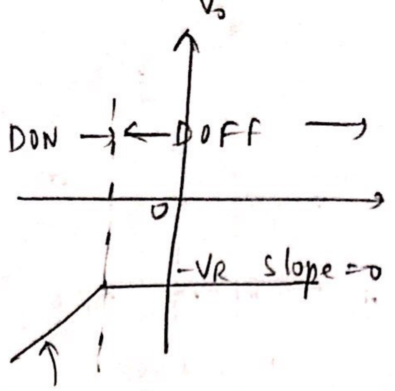
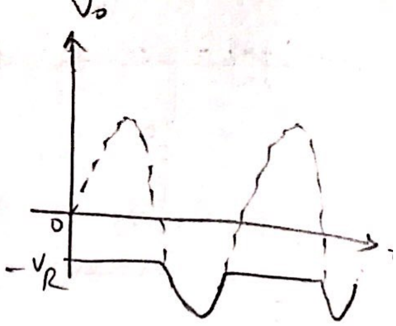


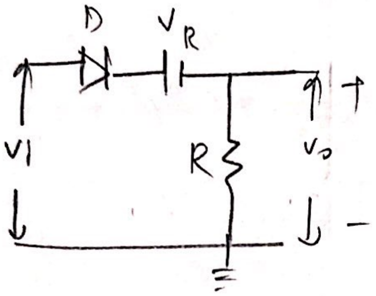


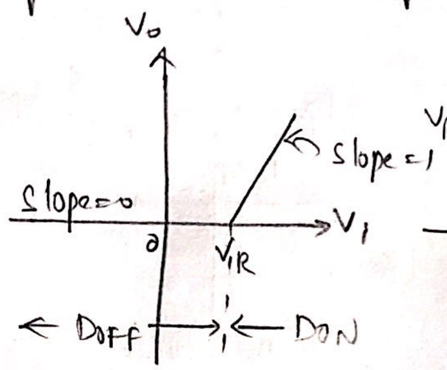


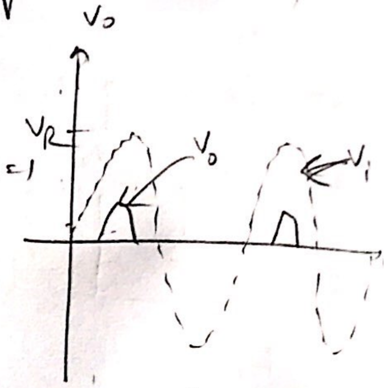
for $V_i < -V_R$ — D is ON — $\therefore V_o = V_i$

for $V_i > -V_R$ — D is OFF — $V_o = -V_R$

(j) series clipper, negative base clipping above refcrence level



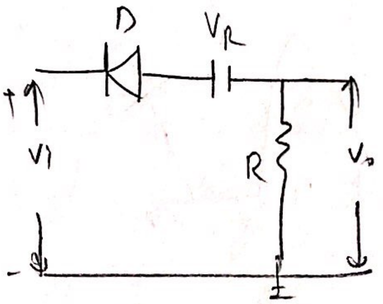


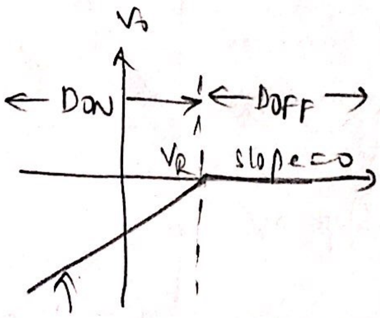


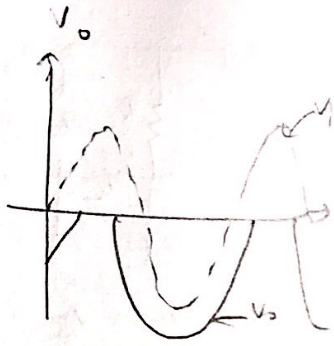
for $V_i < V_R$ — D is OFF — $\therefore V_o = 0$

for $V_i > V_R$ — D is ON — $V_o = V_i - V_R$

(k) series clipper (Biased,



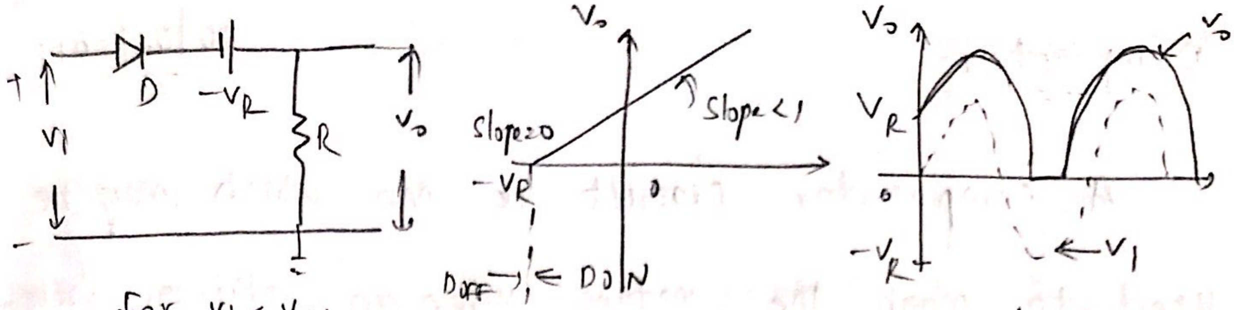




for $V_i < V_R'$ — D is ONN — $V_o = V_i - V_R$

for $V_i > V_R'$ — D is OFF — $V_o = 0$

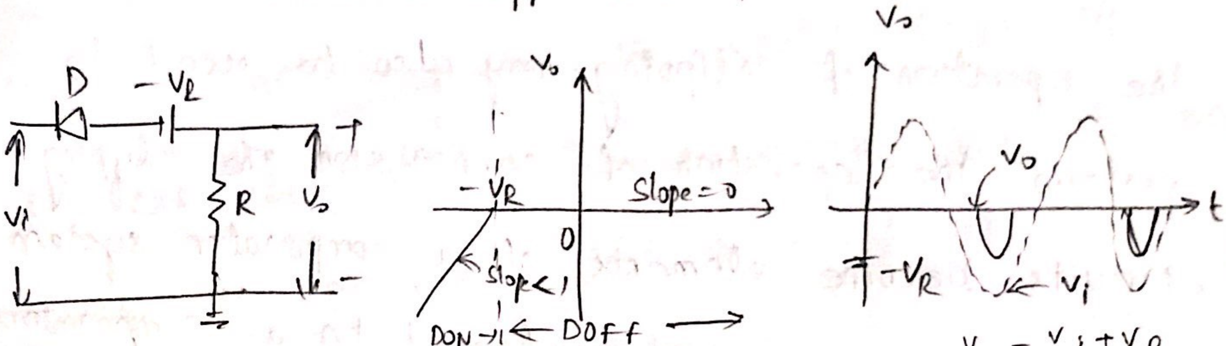
(l) series clipper (Biased,



for $V_1 < V_R$, D is OFF $V_o = 0$

for $V_1 > -V_R$, D is ON $V_o = V_i + V_R$

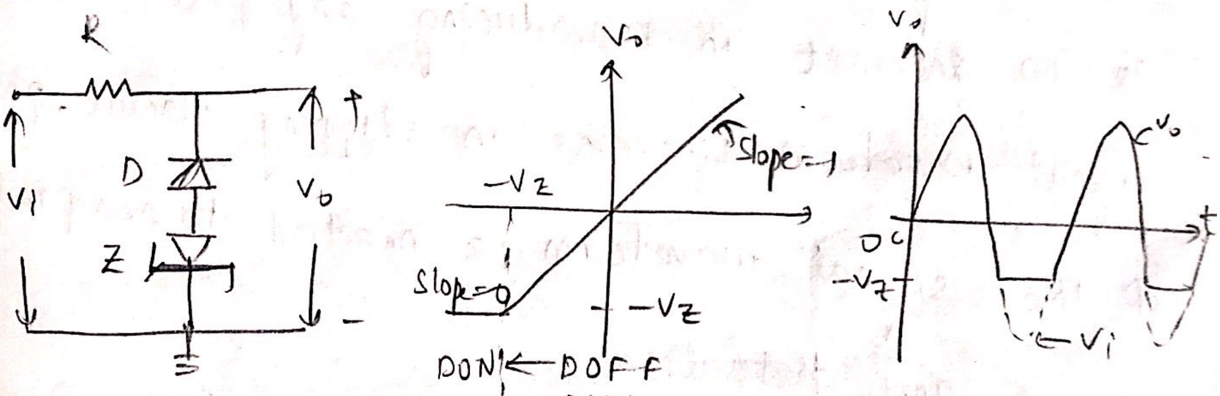
(m) series clipper (Biased)



for $V_1 < -V_R$, D is ON $V_o = V_i + V_R$

for $V_i > -V_R$, D is OFF $V_o = 0$

(n) series clipper (Biased)



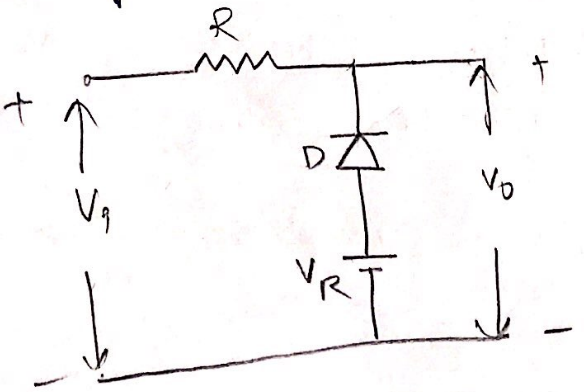
for $V_1 < -V_Z$, D is ON, Z breaks $V_o = -V_Z$

for $V_i > -V_Z$ D is OFF, Z is OFF $V_o = V_i$

(o) shunt clipper using zener diode, negative clipping comparator:-

10/08/2017

A comparator circuit is one which may be used to mark the instant. when an arbitrary wave-form attains some particular reference level The Non-linear circuit which can be used to perform the operation of clipping may also be used to perform the operation of comparision. The clipping circuits become elements of a comparator system. and are usually simply referred to as comparators. The Distinction between comparator circuits and the clipping circuits is that in a comparator there is no interest in reproducing any part of the signal waveform. whereas in clipping circuit, part of the signal waveform is needed to be reproduced without any distortion.



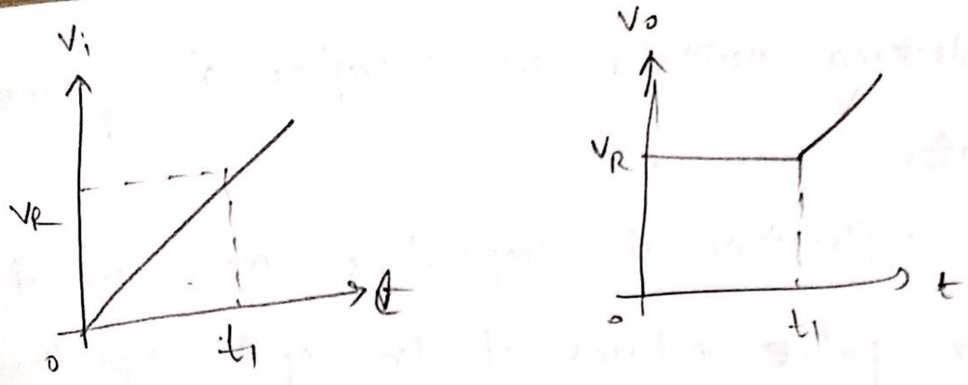


Fig shows the circuit diagram of a diode comparator as long as the input voltage V_i is less than the Reference voltage V_R. The Diode D is ON. and the output is fixed at V_R.

when $V_i > V_R$, the diode is OFF and hence $V_o = V_i$. The break occurs at $V_i = V_R$ at time $t = t_1$. This circuit can be used to mark the instant at which the input voltage reaches a particular reference level V_R.

Comparators may be non-regenerating or regenerating. clipping circuits fall into the category of Non-regenerating comparators.

In Regenerative comparators feedback is employed to obtain an infinite forward gain. (unity loop gain). The ~~symmet.~~ schmitt trigger.

and blocking oscillator are examples of regenerative comparators.

→ Most applications of comparators make use of step or pulse natures of the input. Operational amplifier and tunnel diodes may also be used as comparators.

Applications of Voltage comparators:-

(1) In accurate time measurements.

(2) In pulse time modulation.

(3) As timing makers generated from a sine wave

(4) In phase meters.

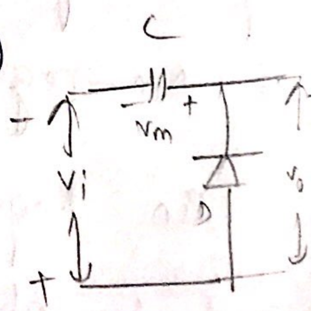
(5) In Amplitude distribution analysers to obtain square wave from a sine wave

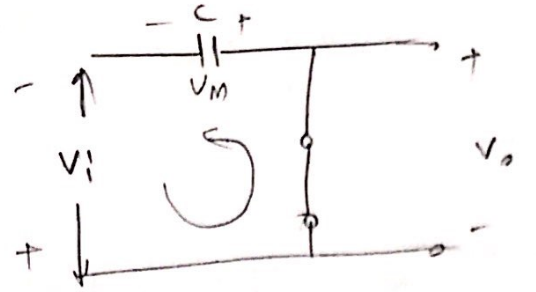
(6) In Analog to Digital converters.

Clampers:-

Consider $V_i < 0$ (Negative cycle)

Diode will be forward biased and acts as short circuit. The capacitor start charging to Diode to Vm





Applying KVL,

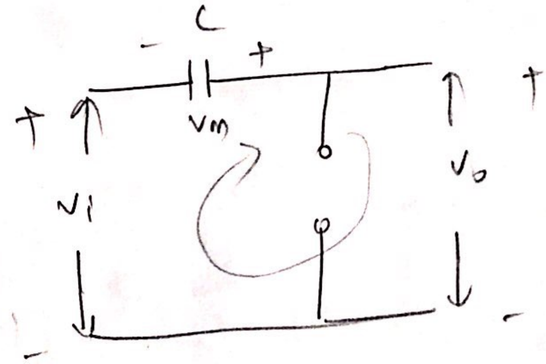
$$V_m - V_i = 0$$

$$V_m = V_i$$

and $V_o = 0$.

Consider $V_i > 0$ (positive Half cycle).

Diode will be reverse biased and acts as ~~reference~~ open circuit. Applying KVL to below circuit,



$$V_o - V_i - V_m = 0$$

$$V_o = V_i + V_m \quad (\because V_m = V_i \text{ from above})$$

$$= V_i + V_i$$

$$= 2V_i$$

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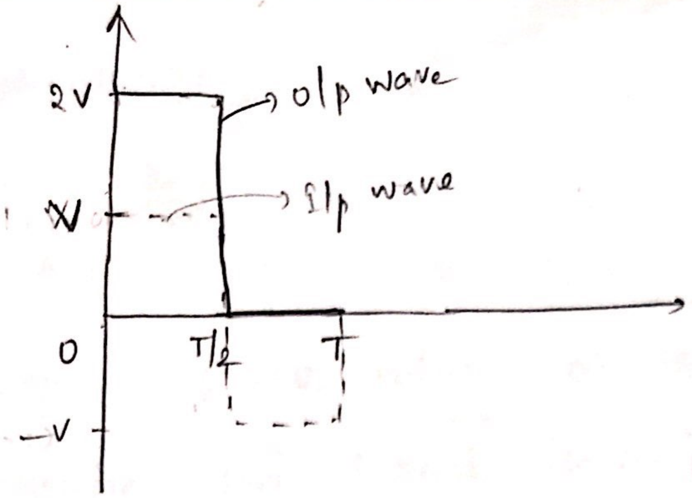
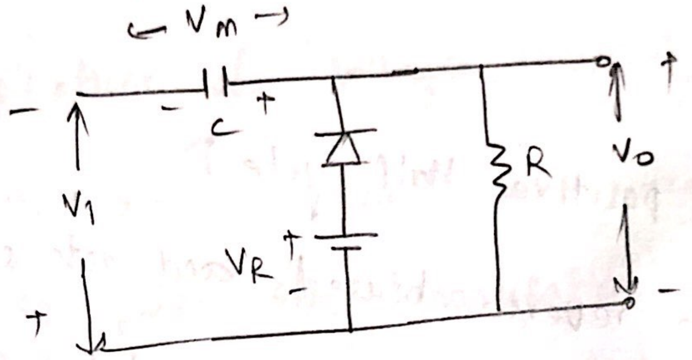
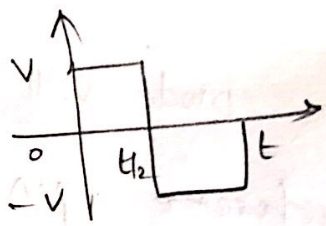


16/08/2017

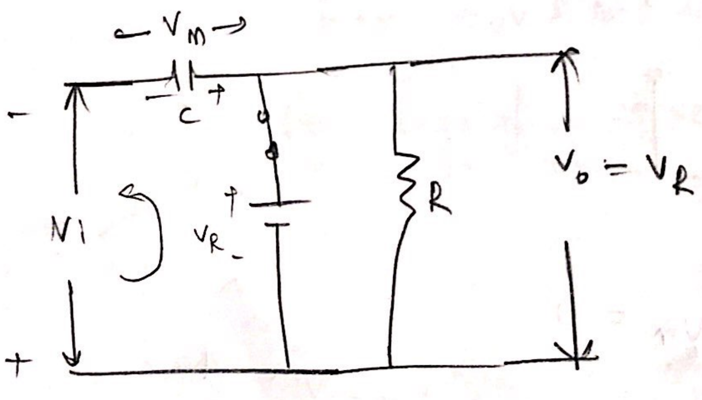
Biased clamper circuit





Negative Half cycle :-

$\frac{t}{2}$ to t :-



Apply KVL,

$$V_m - V_i - V_R = 0.$$

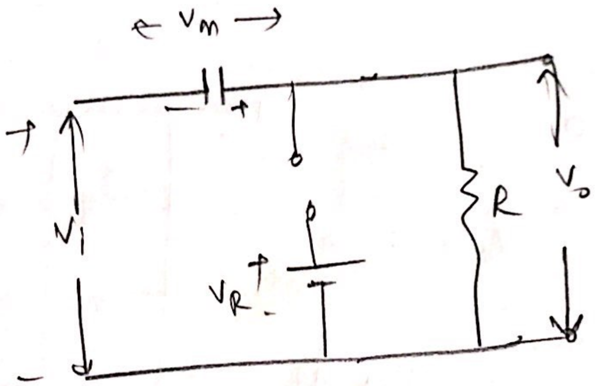
$$V_m = V_i + V_R$$

$V_m = V + V_R$

$V_o = V_R$

Positive Half cycle:

0 to $\frac{t}{2}$:



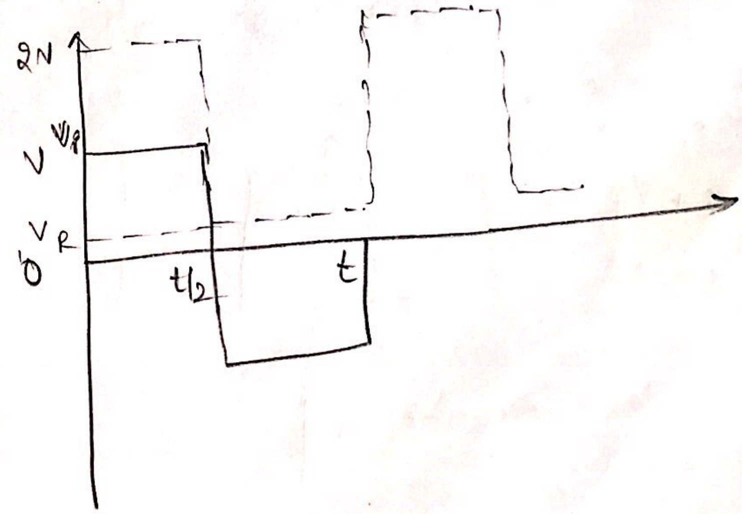
Apply KVL,

$V_o - V_i - V_m = 0$

$V_o = V_i + V_m$

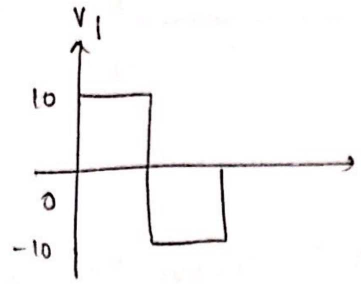
$V_o = V + V + V_R$

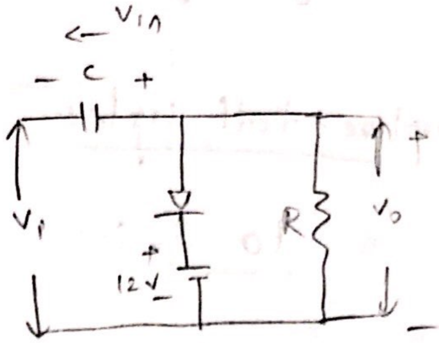
$V_o = 2V + V_R.$



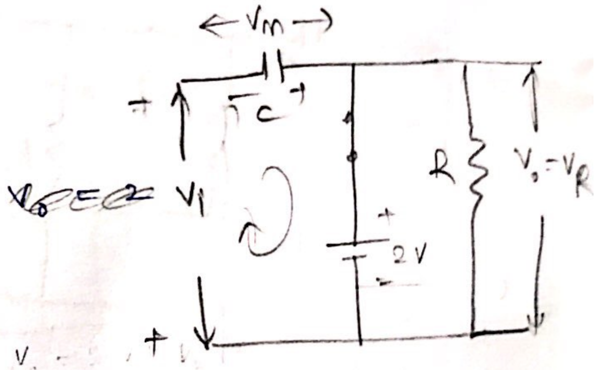
Problem:-

1) Sketch the o/p waveform of the circuit shown in fig





For positive half cycle



Apply $V_i - V_m - 2 = 0$

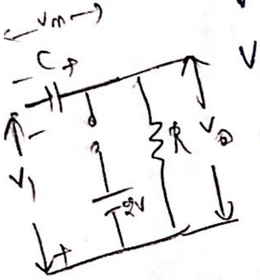
$V_m = V_i - 2$

$= 10 - 2$

$V_m = 8 \ V$

$\therefore V_o = 2 \ V$

For Negative Half cycle

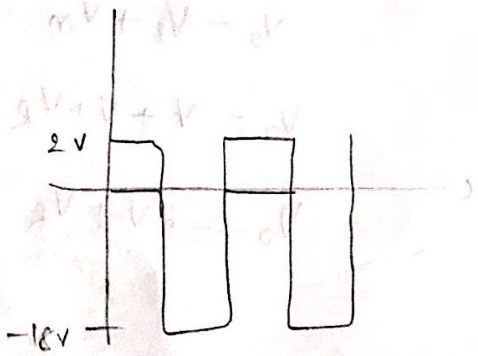


$V_i + V_o + V_m = 0$

$V_o = -V_i - V_m$

$= -10 - 8$

$= -18 \ V$

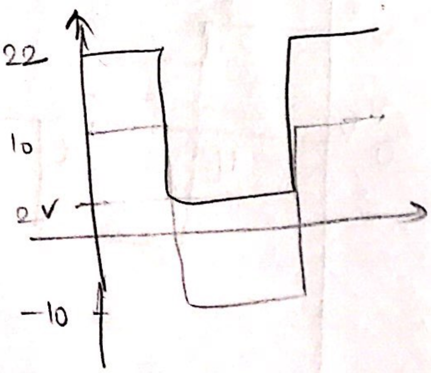


$V_o = V_R = 2 V$

$V_o = 2V + V_R$

$= 2 \times 10 + 2$

$= 22$



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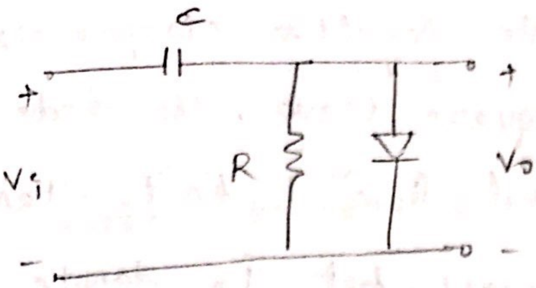
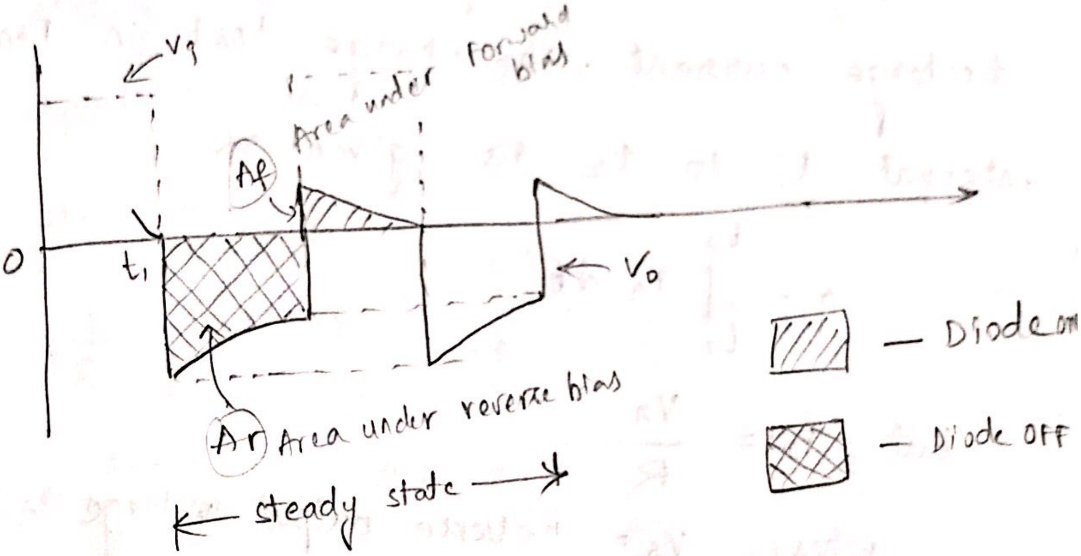
CLAMPING CIRCUIT THEOREM :-

17/08/2017





The theorem states that under steady state condition the ratio of the area under output curve in the forward direction (Diode is ON) to the area under the output curves in the reverse direction (Diode is OFF) is given as

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

where R_f = Forward resistance of Diode.

R_r = Resistance of Diode in reverse bias

PROOF :-

Let us consider simple negative clamper circuit. Let the input be a square wave, the diode is off during the interval from t_1 to t_2. Hence, the capacitor 'c' discharges. Let i_r denote the discharge current. The charge lost in time interval t_1 to t_2 is given as

$$q = \int_{t_1}^{t_2} i_r \, dt$$

but $i_r = \frac{V_r}{R}$

where V_r = Reverse output voltage

$$\therefore q = \int_{t_1}^{t_2} \frac{V_r}{R} \, dt.$$

$$q = \frac{1}{R} \int_{t_1}^{t_2} V_r \, dt \quad \rightarrow (i)$$

In the interval t_2 to t_3, the diode is ON. Hence the capacitor charges and regains the lost charge. Let i_f denote the charging current. The charge regain is given by

$$q' = \int_{t_2}^{t_3} i_f \, dt$$

but $i_f = \frac{V_f}{R_f}$

$$q' = \int_{t_2}^{t_3} \frac{V_f}{R_f} \, dt$$

$$q' = \frac{1}{R_f} \int_{t_2}^{t_3} V_f \, dt$$

where V_f is the forward o/p voltage

At steady state, we have the charge lost is equal to the charge regain

i.e., $q = q'$

$$\frac{1}{R} \int_{t_1}^{t_2} V_r \, dt = \frac{1}{R_f} \int_{t_2}^{t_3} V_f \, dt.$$

But $\int_{t_1}^{t_2} V_r \, dt = A_r$ and

$\int_{t_2}^{t_3} V_f \, dt = A_f$ from the fig

$$\frac{1}{R} (A_r) = \frac{1}{R_f} (A_f)$$

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

where A_f = Area under the o/p curve in the forward direction with Diode 'D' ON

A_r = Area under the o/p curve in the reverse direction with Diode 'D' OFF.

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Transistor as a switch:-

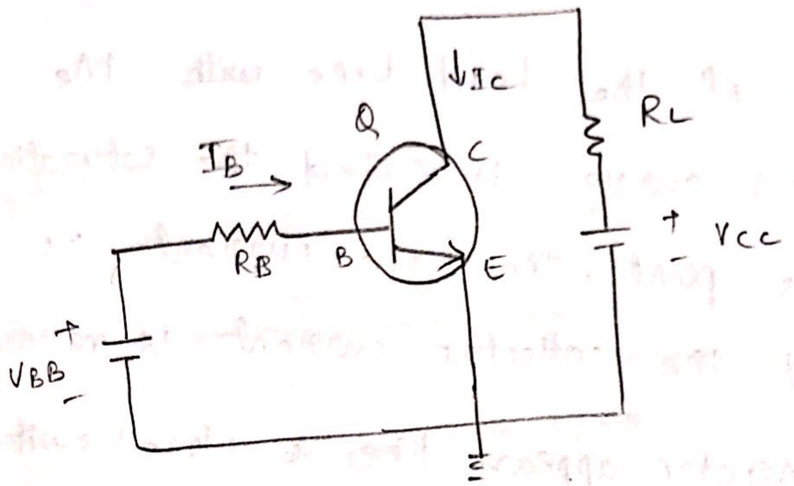
A Transistor can be used as a switch. it has three regions of operation when both Emitter base and collector base junction are reverse biased. the transistor operates in cutoff region. and it acts as OFF (or) open switch.

when the Emitter Base junction is forward biased and collector Base junction is reverse biased. It operates in the active region. it acts as an amplifier.

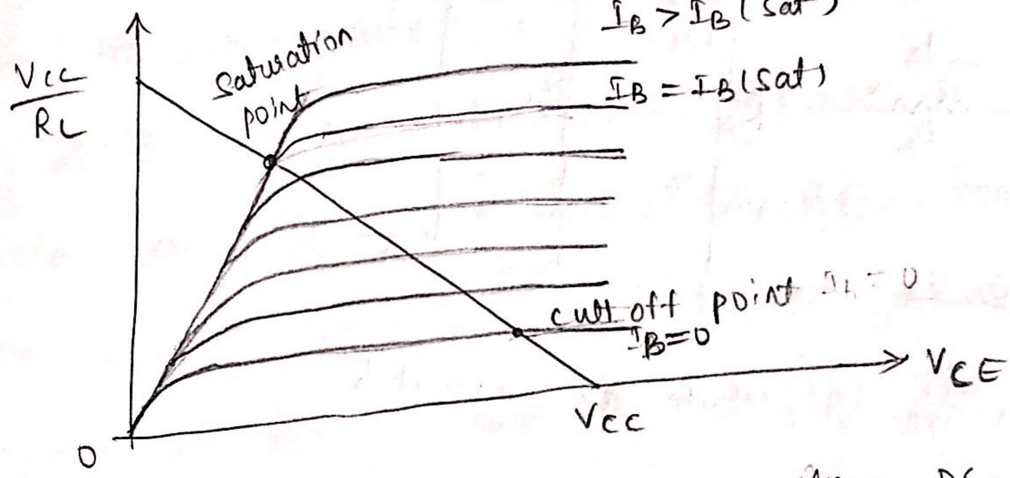
when Both the Emitter base and collector base junctions are Forward biased. It operates in the saturation region and acts as a closed switch.

when the transistor is switched from cuttoff to saturation and from saturation to cuttoff with negligible active region. The transistor is operated as a switch. when the transistor is in saturation, junction voltages are very small but the operating currents are large.

when the transistor is in cuttoff, the currents are zero except small leakage current but the junction voltages are large.



Transistor used as a switch.



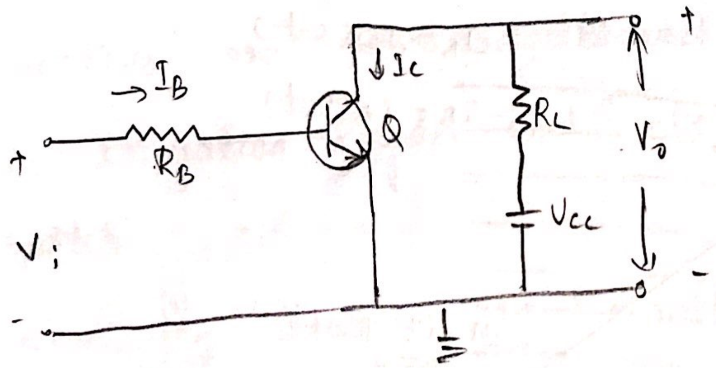
output characteristics with load line DC.

From the output characteristics, the region below the $I_B = 0$ curve, is cutt-off region.

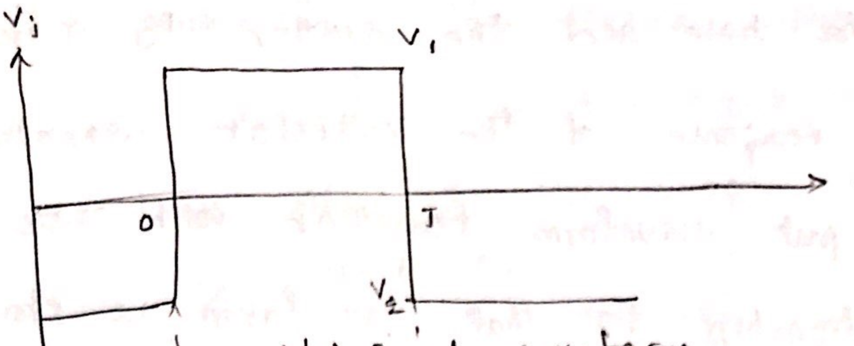
⇒ The intersection of the load line with $I_B = 0$ curve is the cuttoff point. At this point the Base current $I_B = 0$ and collector current is negligible. The transistor appears like an open switch.

⇒ The intersection of the Load Line with the $I_B = I_B(sat)$ curve is called the saturation point. At this point, the base current is $I_B(sat)$. and the collector current is maximum. and the transistor appears like a closed switch.

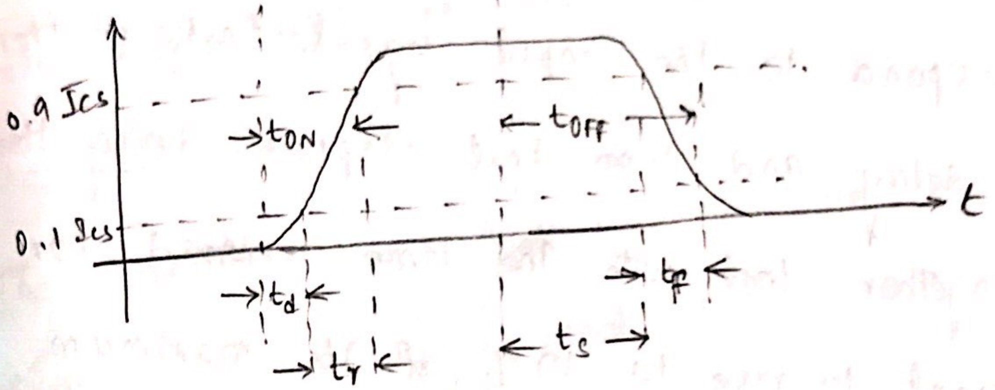
Transistor switching times :- 21/08/17



(a) Transistor acts as a switch.



(b) Input waveform



(c) The response of collector current V_s time

The transistor acts as a switch it is either in cutoff or in saturation. Consider the behaviour of the transistor as it makes transition from one state to the other. The circuit is driven by a pulse waveform shown in fig. (b). The pulse waveform makes transitions between the voltage levels V_2 and V_1. At V_2, the transistor is at cuttoff and at V_1 the transistor is in saturation. The input waveform V_i is applied

between the base and the emitter to a resistor
R_B. The response of the collector current I_c
to the input waveform together with its
time relationship to that waveform is shown
in fig(c). The collector current does not immedia-
tely respond to the input signal instead there
is a delay and time that elapses during this
delay together ~~that~~ with the time required for
the current to rise to 10% of its maximum
(saturation) values is called the delay time 't_d'.
The current waveform has a non-zero rise time 't_r'
which is the rise time required for the current
from 10% to 90% of I_{cs} (collect current satur-
ation point). The total turn on time (t_r) is
the sum of the delay time and the rise
time.

$$\text{ie, } t_{ON} = t_d + t_r.$$

When the input signal returns to its initial
stage the collector current again fails to

respond immediately the interval which elapses between the transition of the input waveform and the time when I_C has dropped to 90% of I_{CS} is called the storage time t_s.

The storage interval is ~~caused~~ followed by the fall time (t_f) which is the time required for I_C to fall from 90% to 10% of I_{CS}.

The turnoff time t_{off} is defined as the sum of the storage and fall time.

$$t_{off} = t_s + t_f$$

The Delay Time :-

There are three factors that contribute to the delay time.

(1) There is a delay which results from the fact that when the driving signal is applied to the transistor input, a non-zero time is required to charge up the junction capacitance so that the transistor may be plot from cuttoff to the active region.

(2) Even when the transistor has been plot to the point where 'minority carriers have begun to cross the emitter junction into the base, a non-zero time is required before these carrier can cross 'the base region to the collector junction and be recorded as collector current. Finally, the non-zero time is required before the collector current can rise to 10% of its maximum value.

Rise time and Fall time :-

The Rise time and fall time are due to the fact that if a base current step is used to saturate the transistor or to return it from saturation into cuttoff the collector current must travels the active region. The collector current increases or decreases along an exponential team.

Q.

storage time:

The failure of the transistor to respond to the trailing edge of the driving pulse for the time interval 't_s'. results from the fact that a transistor in saturation has a saturation charge of excess minority carriers stored in the base. The transistor cannot respond until the saturation excess charge has been removed.

Emitter coupled clipper:-