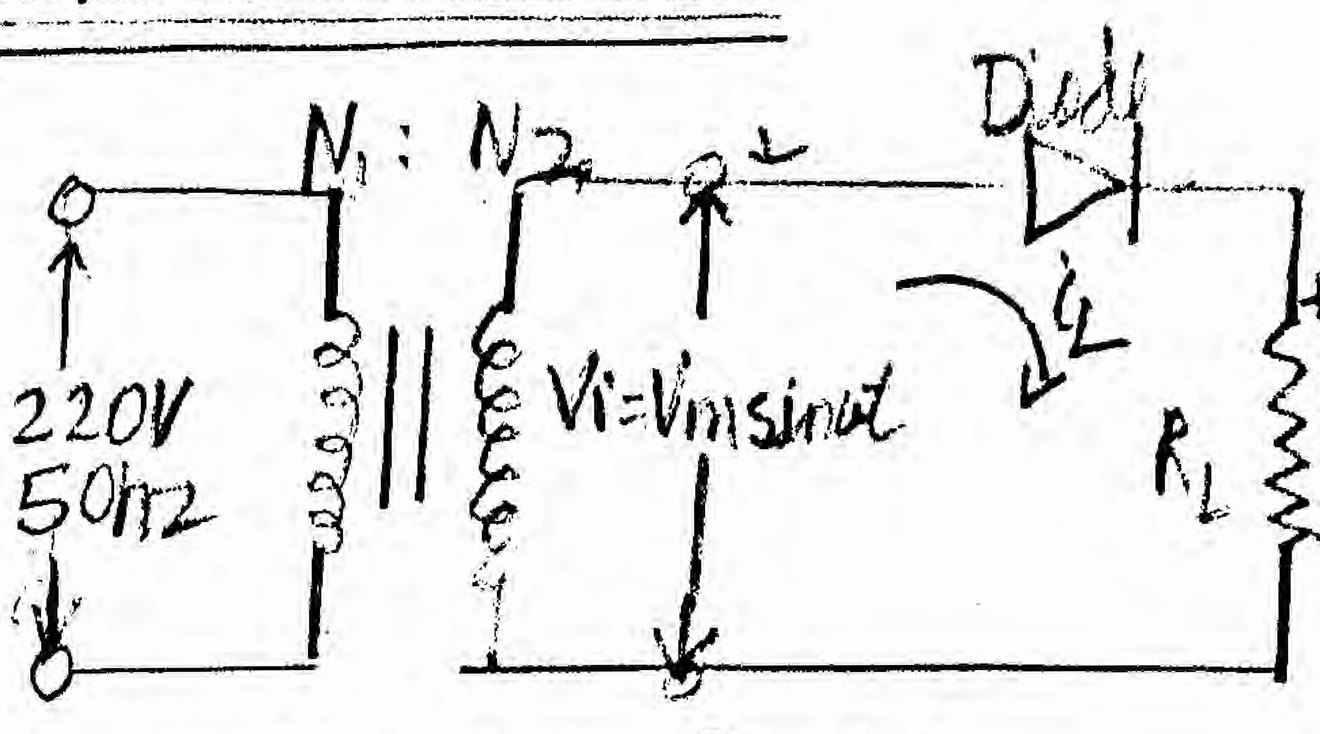
HALF-WAVE RECTIFIER

A Half wave rectifier transform AC voltage to DC voltage. It uses only one diode for the transformation. It allows only one half cycle of an AC voltage waveform to pass while blocking the other half cycle.

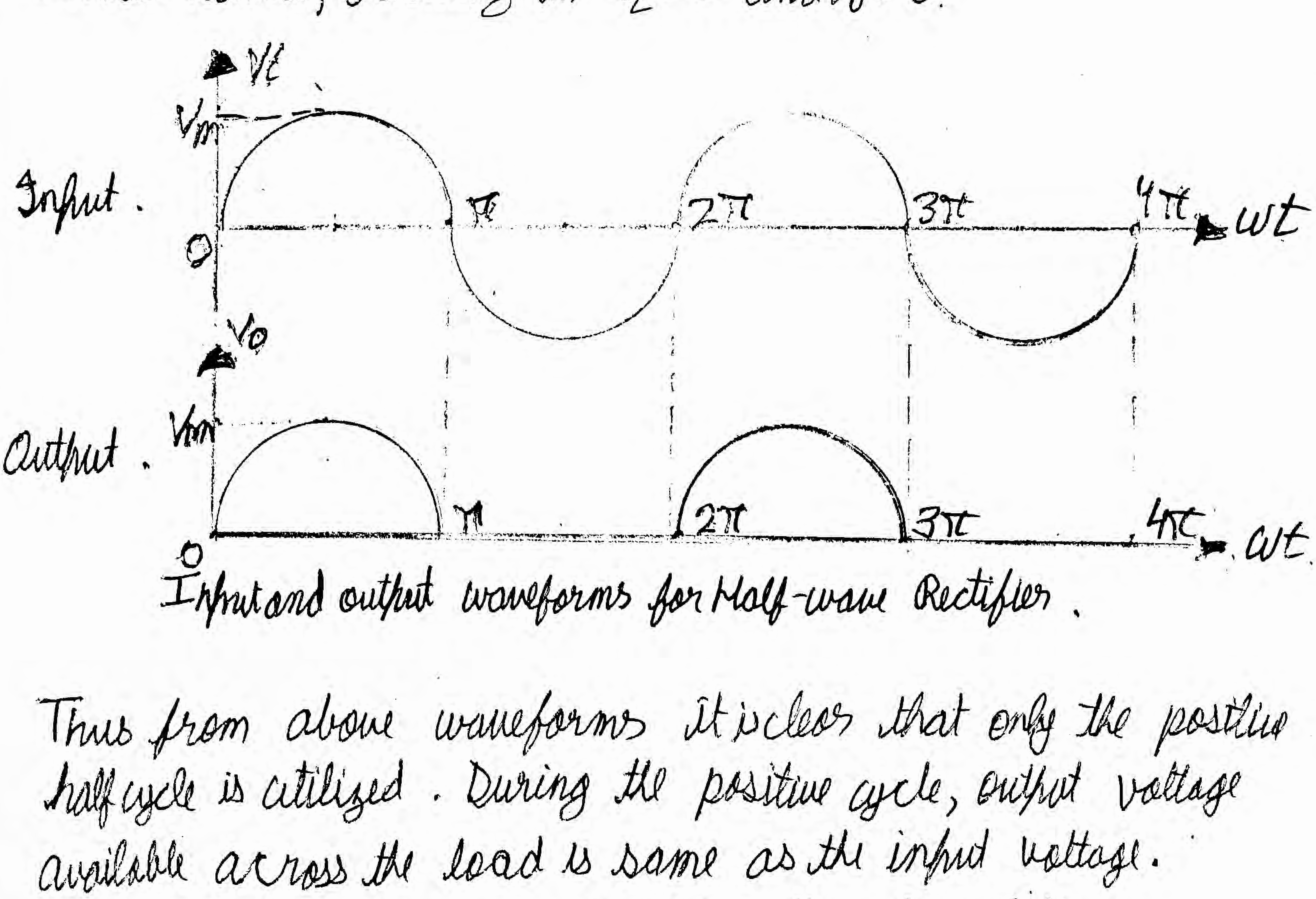


Half wave Rectifier

Working:-

① During the positive half-cycle of the input voltage, the diode is forward-biased, hence it conducts and a current i_L flows through the load Resistor R_L to produce output voltage V_o. (V drop for Si 0.7V and 0.3V for Ge) $V_{output} = V_{input}$

② During the negative half-cycle of the input ac voltage, the diode is reverse biased, resulting in $i_L = 0$ and $V_o = 0$.

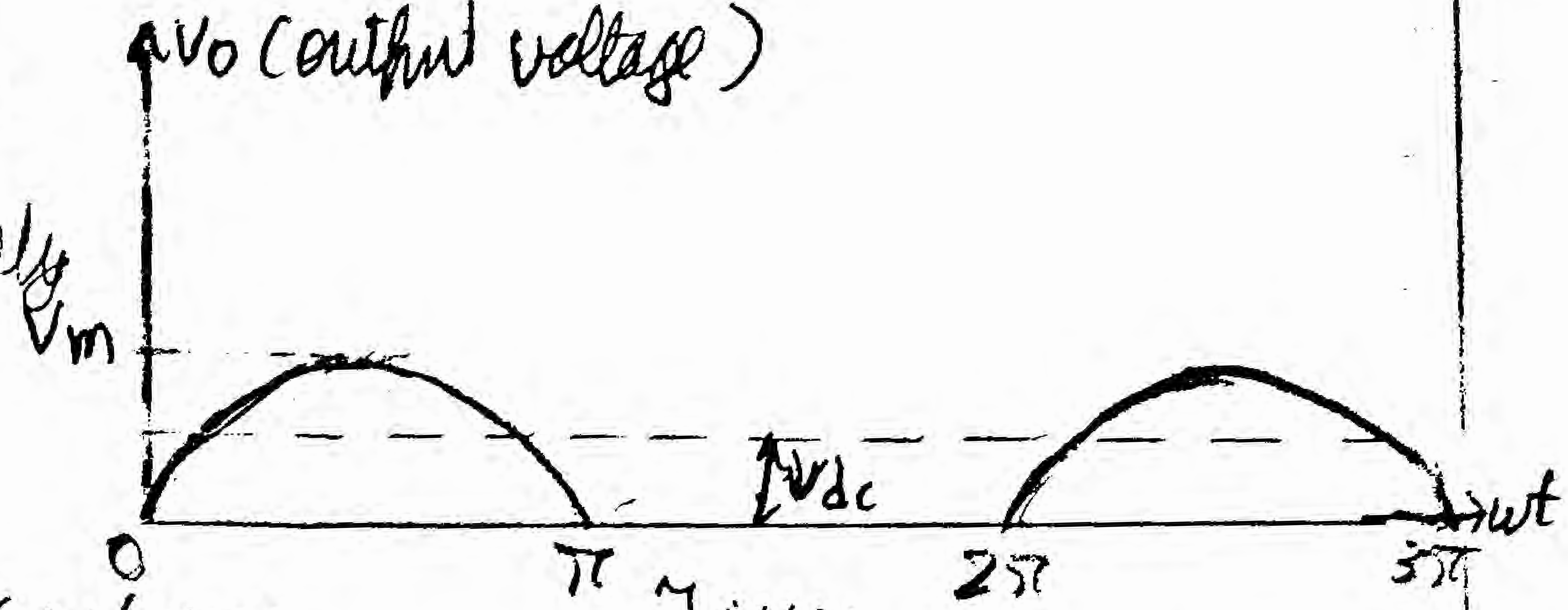


Input and output waveforms for Half-wave Rectifier.

Thus from above waveforms it is clear that only the positive half cycle is utilized. During the positive cycle, output voltage available across the load is same as the input voltage.
During negative cycle, no output voltage is available.
Output voltage is not a perfect d.c. It is unidirectional and pulsating voltage.

Average or DC values of Output Voltage & Load Current.

This figure shows the output voltage waveform, mathematically it can be written as,



Figure

$V_0 = V_m \sin\omega t$ for $0 \le \omega t \le \pi$

$= 0$ for $\pi \le \omega t \le 2\pi$.

$V_{avg} = V_{dc} = \dfrac{\text{Area under the curve over the full cycle}}{\text{Base}}$.

$$\text{Area} = \int_0^{2\pi} V_0 \cdot d(\omega t) = \int_0^{\pi} V_0\, d(\omega t) + \int_{\pi}^{2\pi} V_0\, d(\omega t)$$

$$= \int_0^{\pi} V_m \sin\omega t \cdot d(\omega t) + \int_0^{2\pi} 0 \cdot d\omega t$$

$$= V_m[-\cos\omega t]_0^{\pi} = 2V_m$$

$$V_{dc} = \frac{\text{Area}}{\text{Base}} = \frac{2V_m}{2\pi} = 0.318 V_m = V_{dc}$$

$$I_{avg} = I_{dc} = \frac{V_{avg}}{R_L} = \frac{V_m}{\pi} \times \frac{1}{R_L}$$

$$\Rightarrow I_{dc} = 0.318\, I_m$$

Peak Inverse Voltage: PIV represents the maximum voltage which a diode used in reverse bias must withstand.

For Half Wave Rectifier,

$$PIV = V_m.$$

Full Wave Rectifier

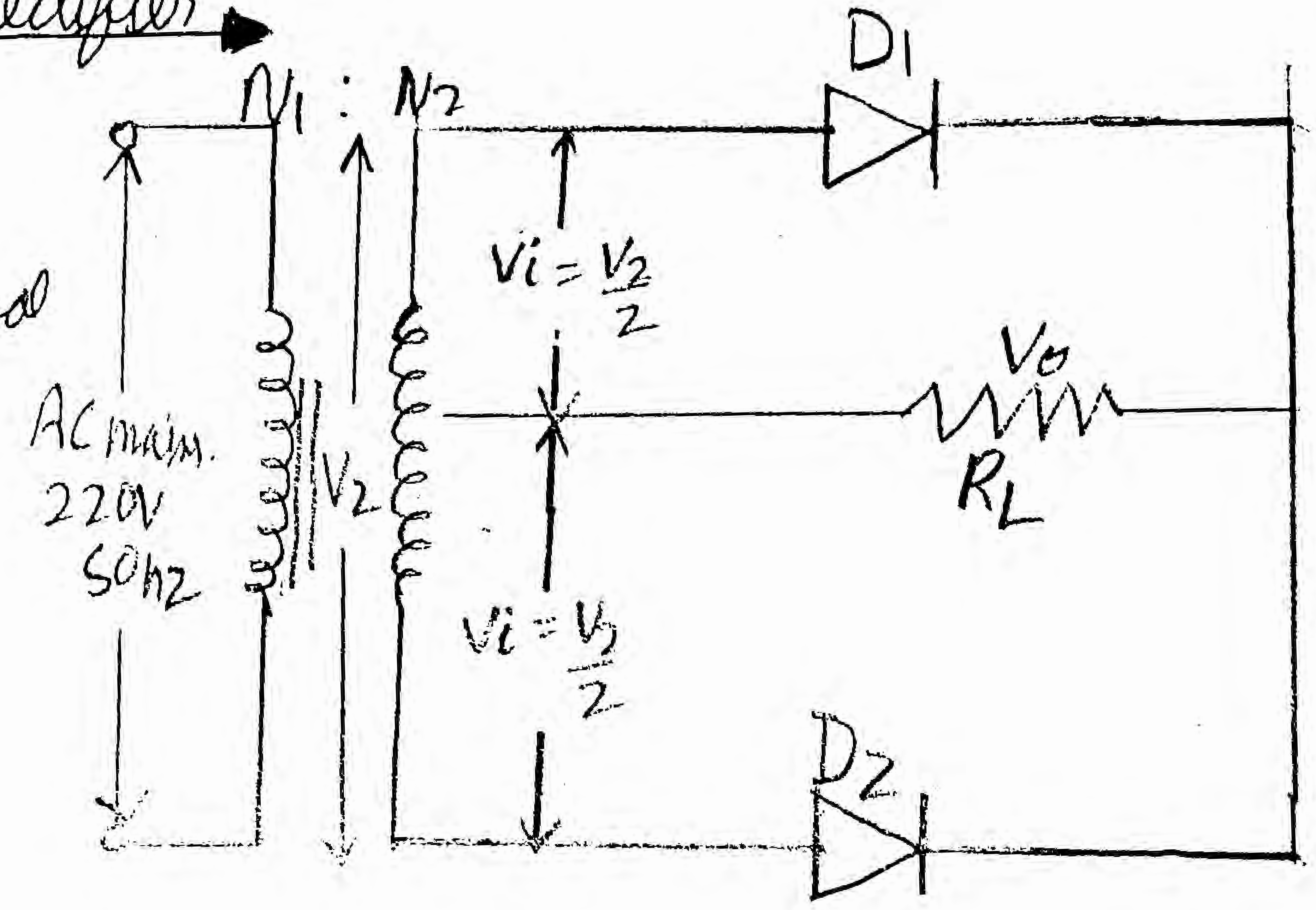
A full wave rectifier is that type of rectifier which utilizes both the half cycle of a.c. input voltage. There are two two types of full wave rectifier.

(i) Centre-Tap full wave Rectifier. (ii) Fullwave Bridge Rectifier.

Centre-Tap Fullwave Rectifier

The voltage b/w one end of secondary and centre-tap is equal to half of the secondary voltage.

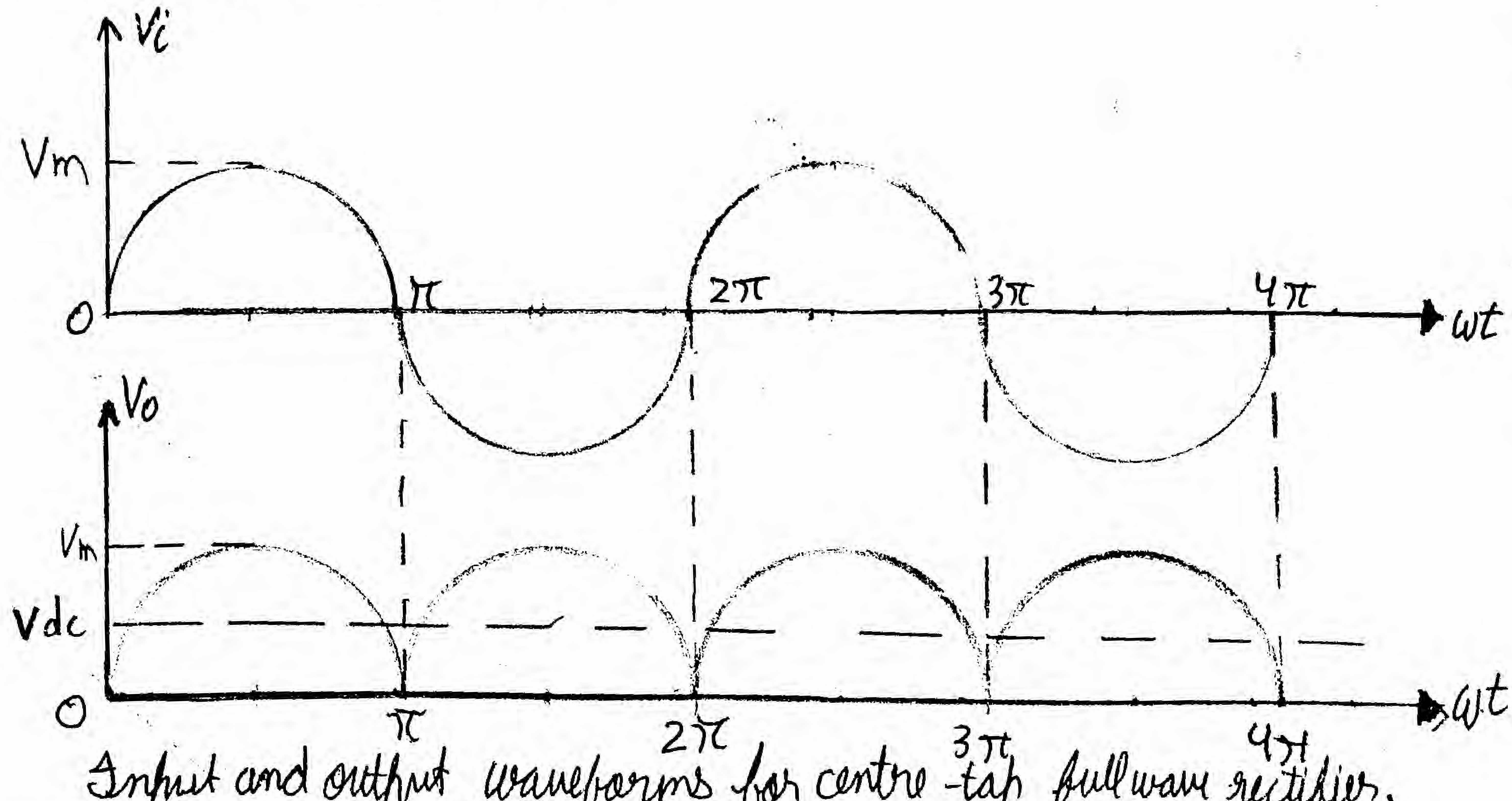
$V_i = \frac{V_2}{2}$



Working.

(1) During positive half cycle of the input voltage D_2 is reversed biased & D_1 forward biased.

(2) During negative half cycle of the input voltage D_1 is reversed biased & D_2 is forward biased.



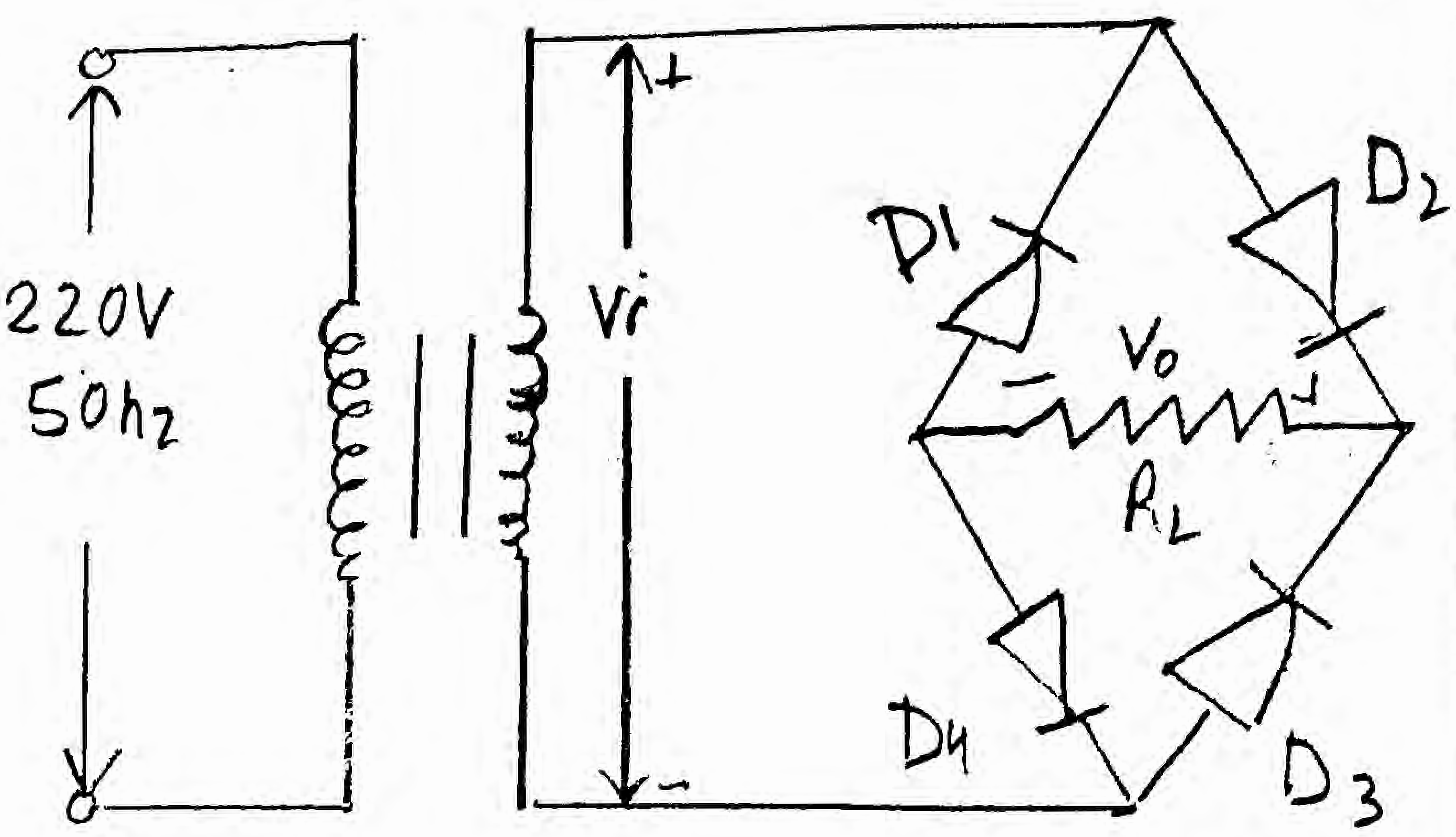
Input and output waveforms for centre-tap fullwave rectifier.

PIV of a Diode in Centre - Tapped Full Wave Rectifier.

$$PIV = 2V_m$$

Full Wave Bridge Rectifier

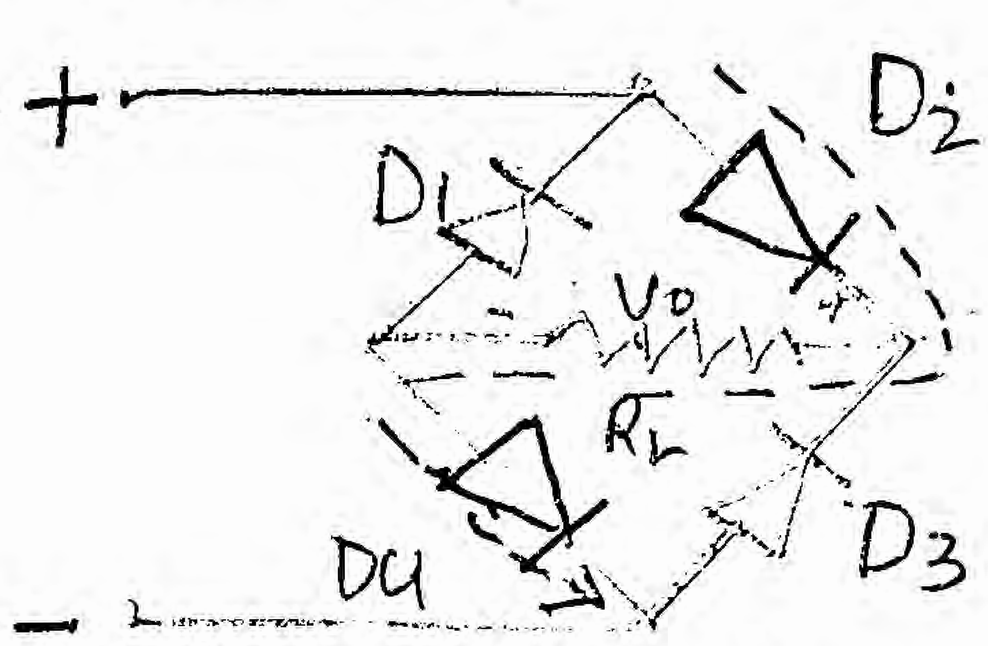
It uses four diodes which are connected across the secondary of the transformer.



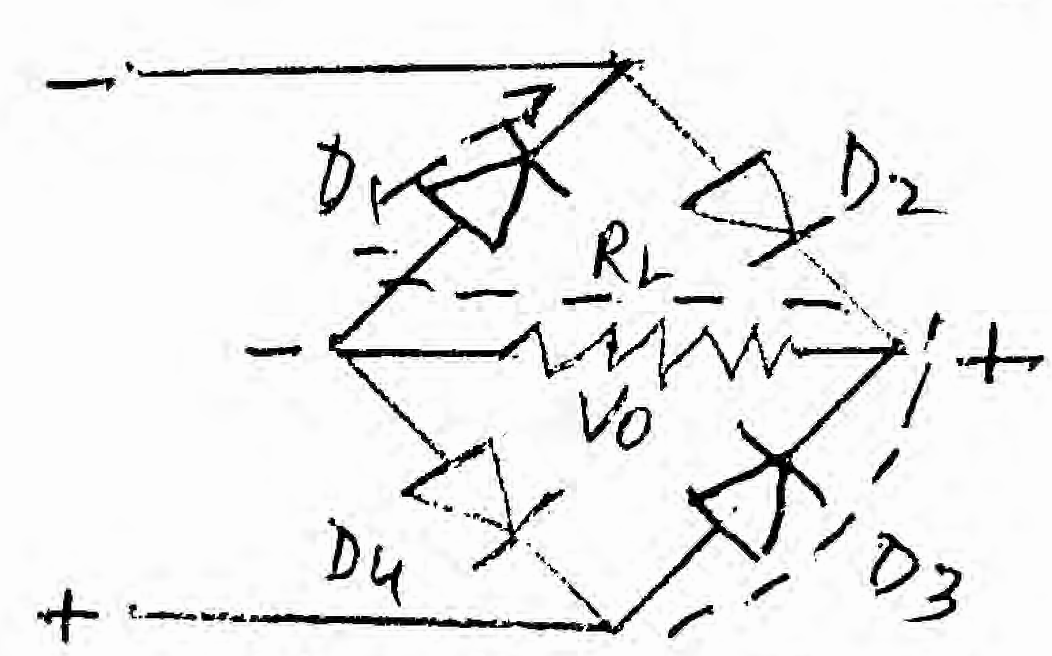
Working

① During positive half cycle. D_2 & D_4 conducts.

② During negative half cycle D_3 & D_1 conducts



Positive halfcycle



Negative halfcycle.

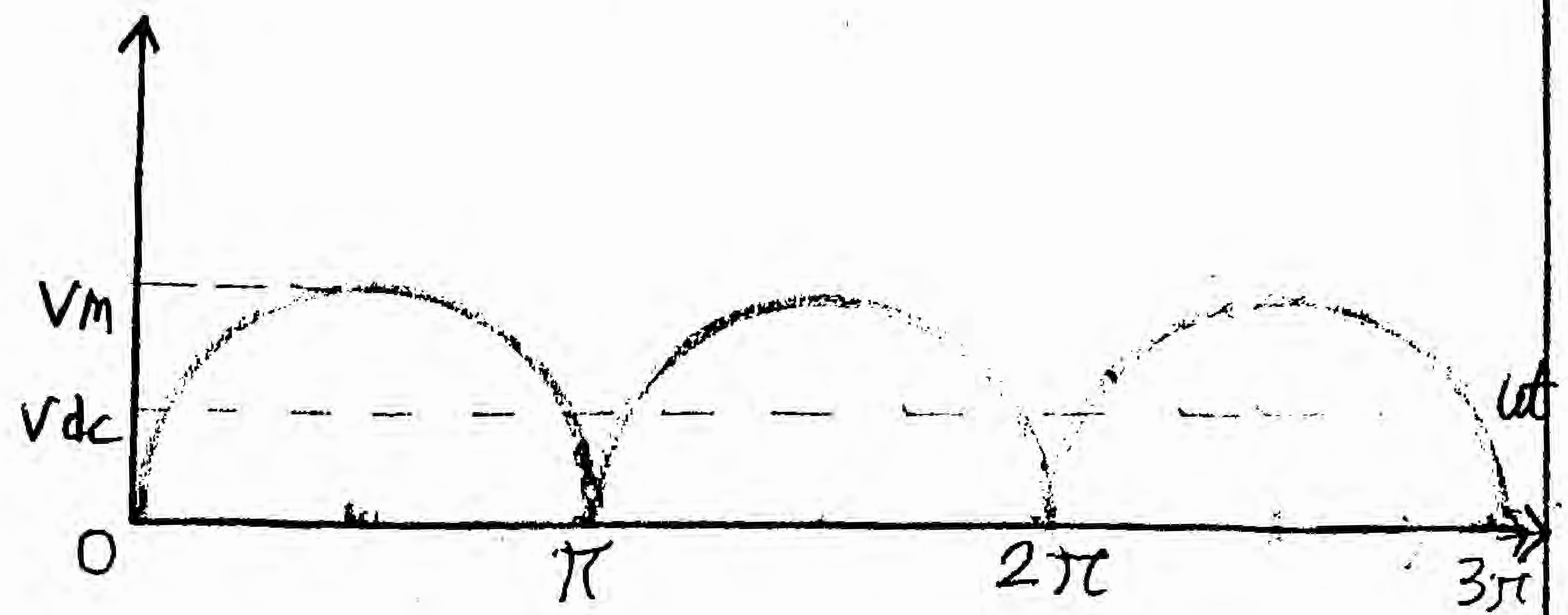
Input and output waveforms: Same as Centre-tapped fullwave rectifier.

A fluctuating, unidirectional output voltage is developed across load.

Peak Inverse Voltage : $PIV = V_m$.

Average or DC value of Output Voltage and Load Current for a Fullwave Rectifier:

From the figure, we can write.



$$V_0 = \begin{cases} V_m \sin\omega t & \text{for } 0 \le \omega t \le \pi \\ -V_m \sin\omega t & \text{for } \pi \le \omega t \le 2\pi \end{cases}$$

$$V_{avg} = V_{dc} = \frac{\text{Area under the curve}}{\text{base}}$$

$$\text{Area} = \int_0^{2\pi} V_0 \cdot d(\omega t) = \int_0^{\pi} V_0\, d(\omega t) + \int_{\pi}^{2\pi} V_0\, d(\omega t)$$

$$= \int_0^{\pi} V_m \sin\omega t \cdot d(\omega t) + \int_{\pi}^{2\pi} -V_m \sin\omega t \cdot d(\omega t) = [-V_m \cos\omega t]_0^{\pi} + [V_m \cos\omega t]_{\pi}^{2\pi}$$

$$= V_m[1+1+1+1] = 4V_m$$

$$V_{dc} = \frac{4 \cdot V_m}{2\pi} = \frac{2V_m}{\pi} = 0.636\,V_m = V_{dc}$$

$$I_{dc} = \frac{V_{dc}}{R_L} = \frac{2V_m}{\pi R_L} = \frac{2I_m}{\pi} = 0.636\,I_m = I_{dc}$$

Efficiency of a Rectifier; $\eta = \frac{\text{DC power delivered to load}}{\text{AC input from transformer}}$

$$\eta = \frac{P_{dc}}{P_{ac}}$$

$$P_{dc} = I^2_{dc} \times R_L$$

$$P_{ac} = I^2_{rms}(R_L + R_F)$$

R_L = load Resistance.
R_F = Forward Res. of diode.

$$\boxed{\eta = \frac{I^2_{dc} \times R_L}{I^2_{rms}(R_L + R_F)}}$$

I Efficiency of Half Wave Rectifier.

$I_{dc} = \frac{I_m}{\pi}$ $\qquad I_{rms} = \frac{I_m}{2}$

$$\eta = \frac{(I_m/\pi)^2 \times R_L}{\left(\frac{I_m}{2}\right)^2 \times (R_L + R_F)} = \frac{4}{\pi^2} \times \frac{R_L}{R_L + R_F} = \frac{0.406}{1 + \frac{R_F}{R_L}}$$

$(R_L >> R_F)$

$\eta_{max} = 0.406 \Rightarrow 40.6\%$

II Efficiency of Full-Wave Rectifier.

$I_{dc} = \frac{2 I_m}{\pi}$ $\qquad I_{rms} = \frac{I_m}{\sqrt{2}}$

$$\eta = \frac{8}{\pi^2} \times \frac{R_L}{R_L + R_F} = \frac{0.812}{1 + \frac{R_F}{R_L}}$$

$(R_L >> R_F)$

$\eta = 0.812 \Rightarrow 81.2\%$

"Full wave Rectifier is twice as Effective as a half wave Rectifier"

Clipper Circuits

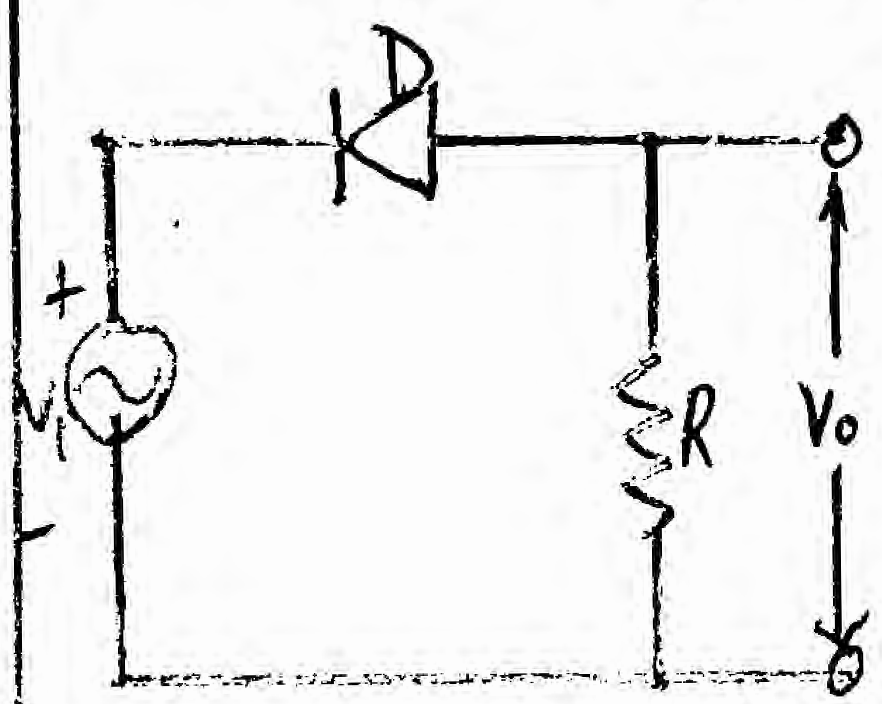
A clipper is a circuit with which the waveform is shaped by removing or clipping a portion of the applied input signal waveform without distorting the remaining part.

Clipper circuits may be classified as:

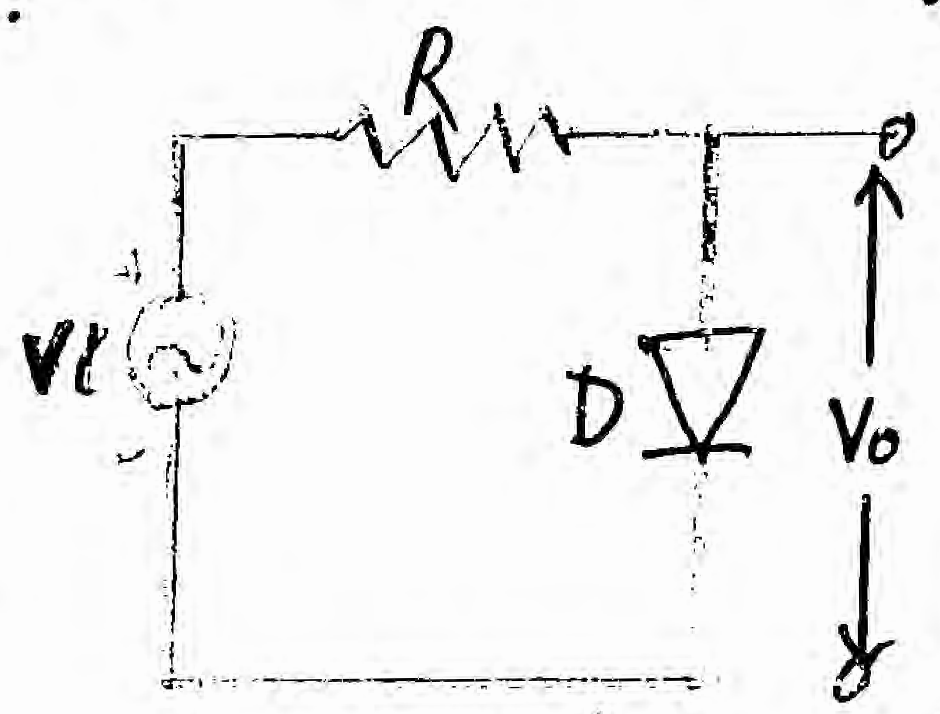
(i) Positive clipper (ii) Megative Clipper (iii) Biased Clipper.

Positive clipper:

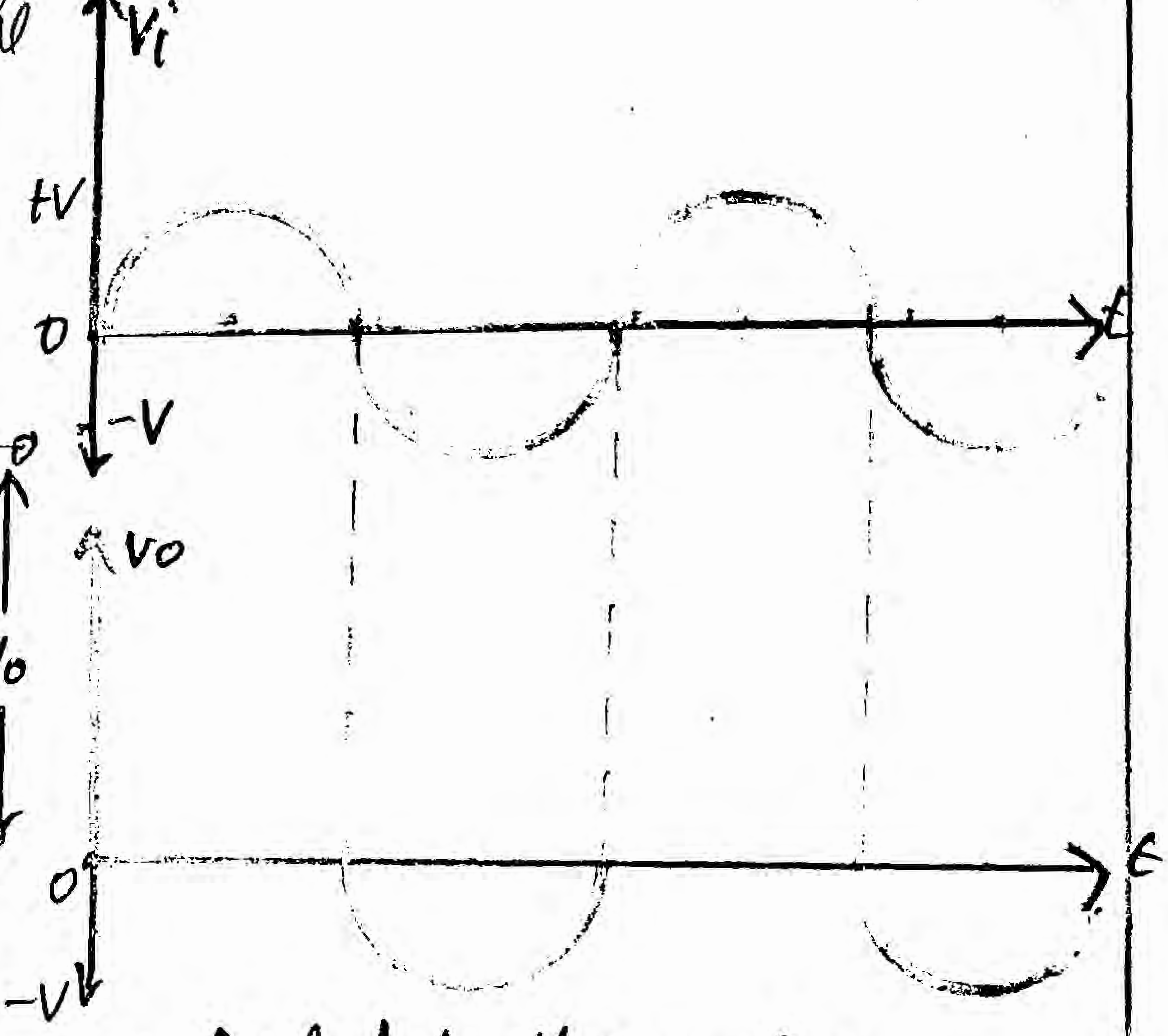
It removes the positive half cycles of the input voltage waveforms. It can be classified into following two waves.



(a) Series positive clipper



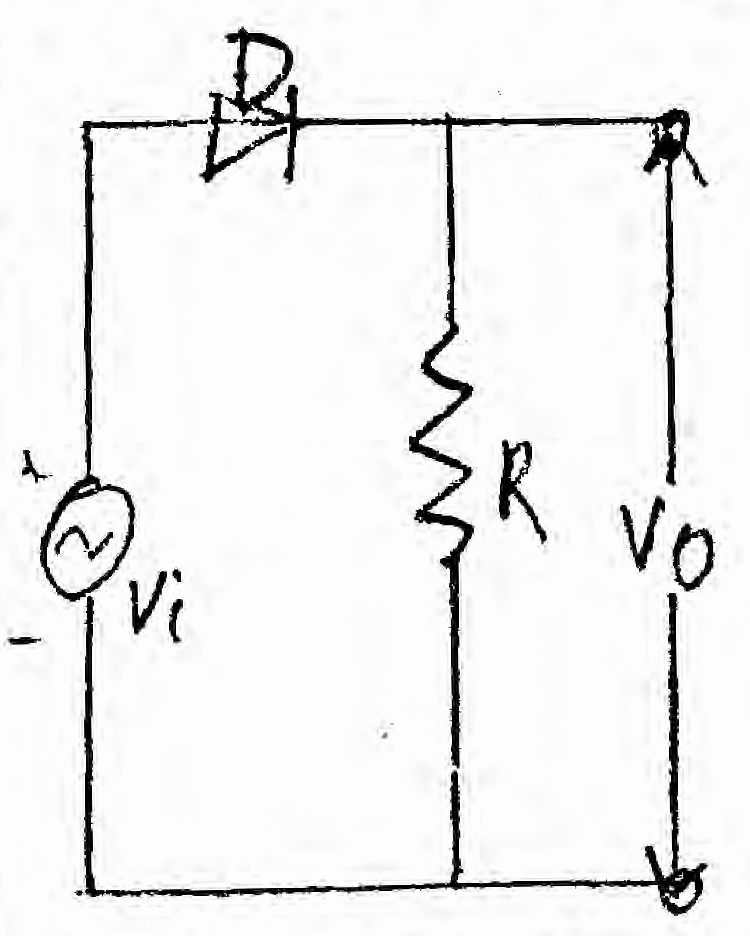
(b) Shunt Positive clipper.



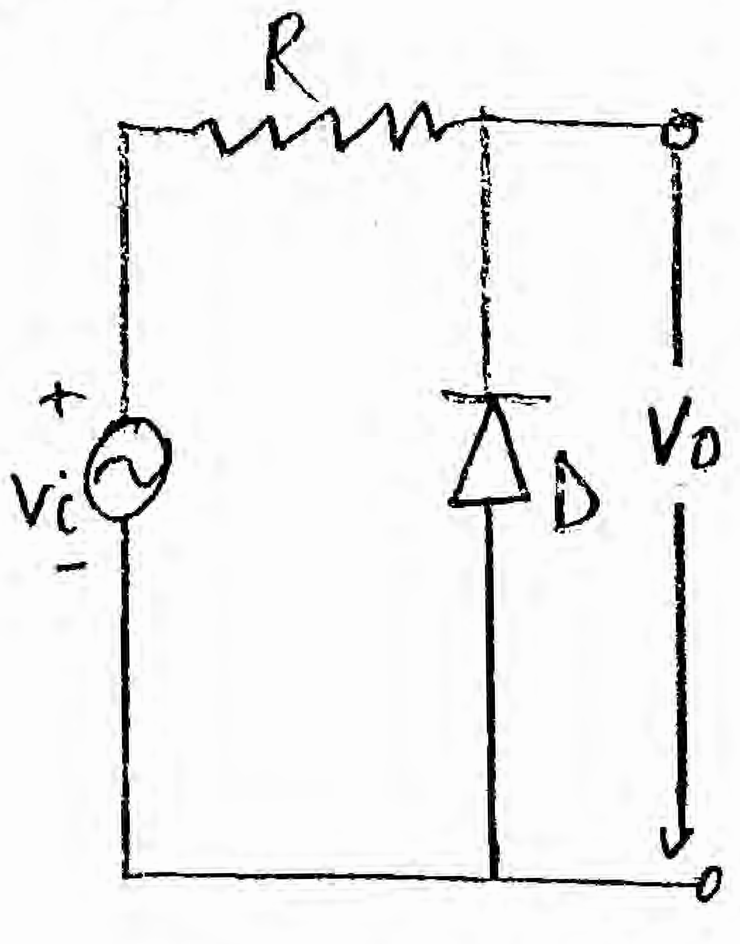
(c) Input / output waveforms.

Negative Clipper:

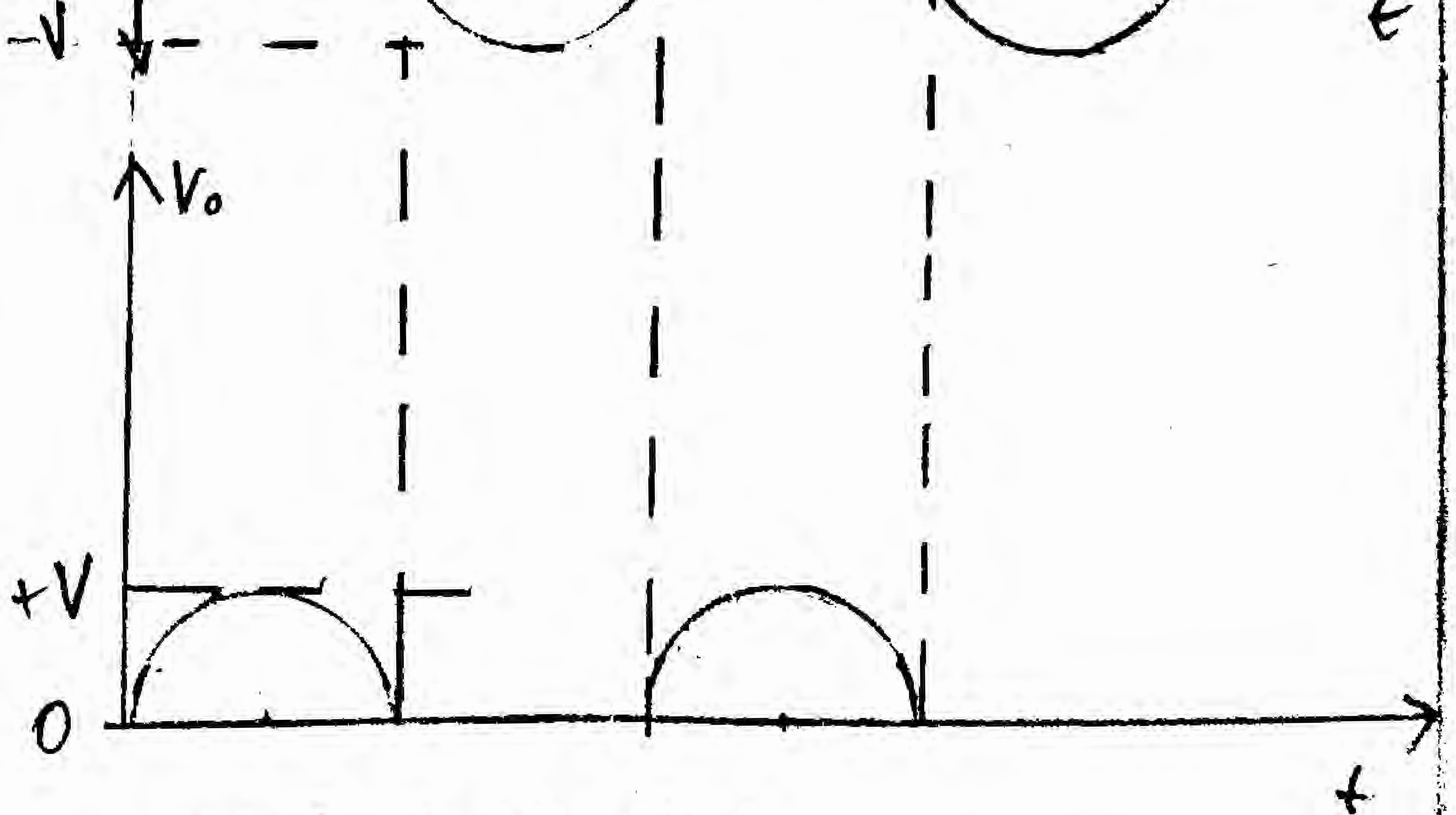
A negative clipper removes the negative half cycles of the input voltage waveforms:



(a) Series negative clipper



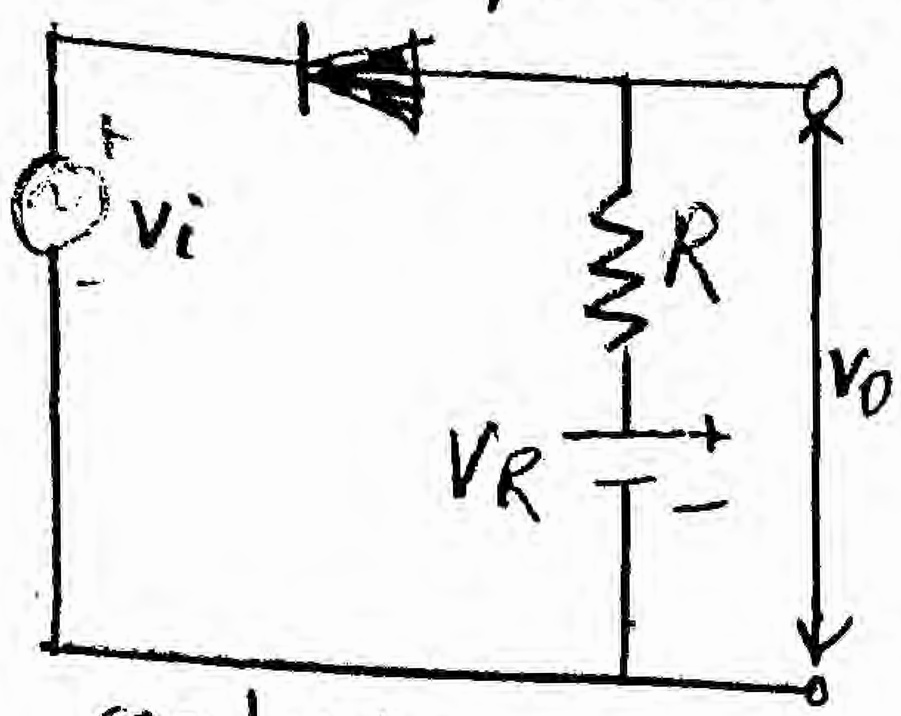
(b) Shunt negative clipper.



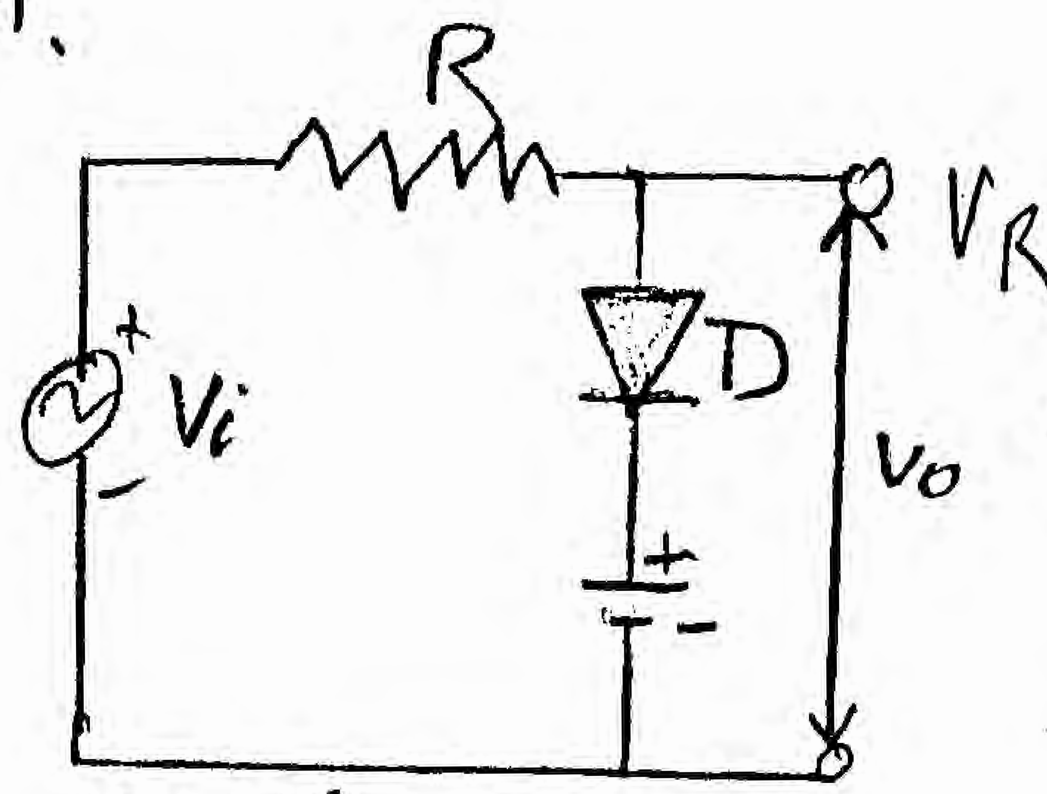
(c) Input/output waveform

Biased Clipper.

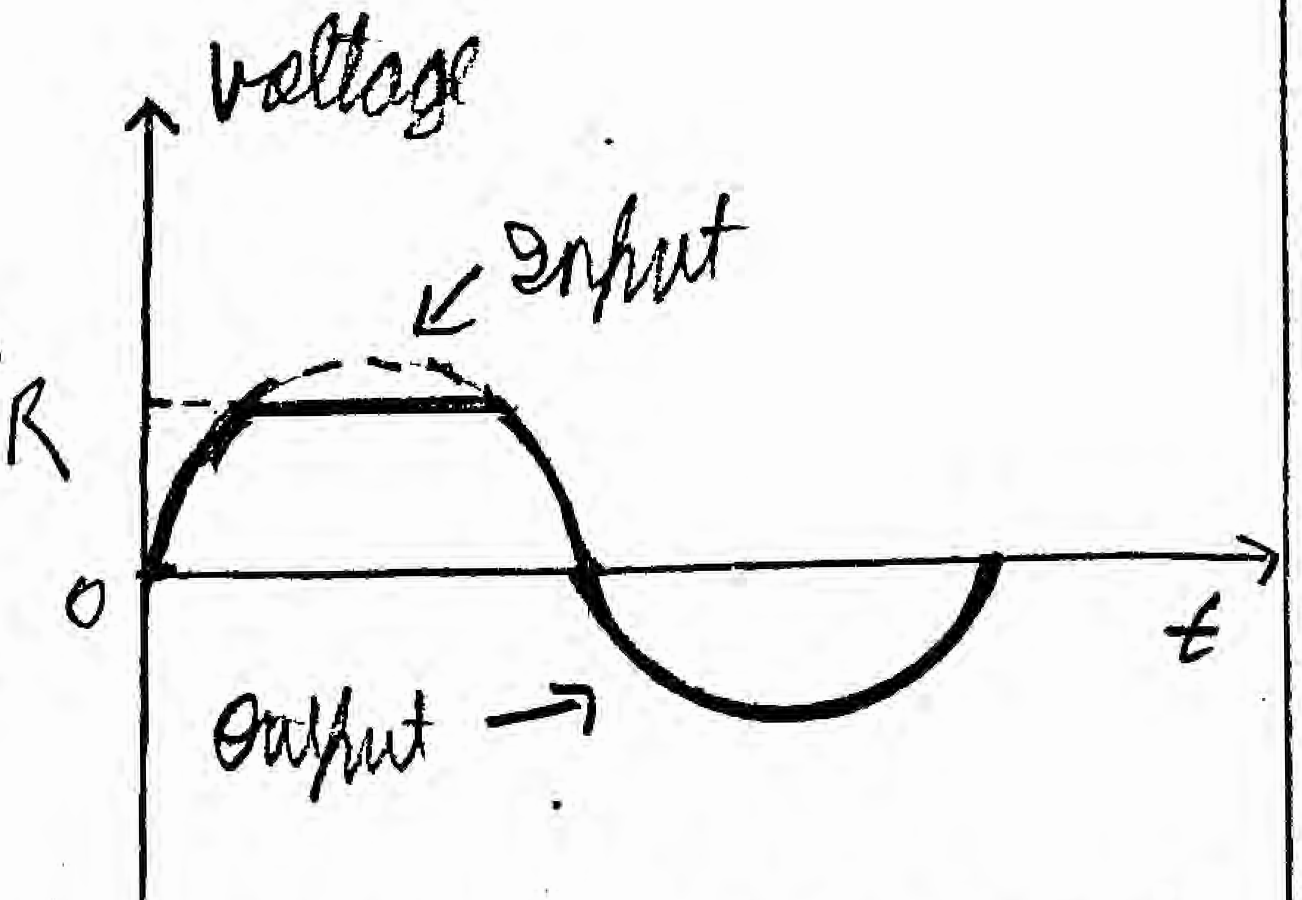
(i) Biased positive clipper.



(a) Series

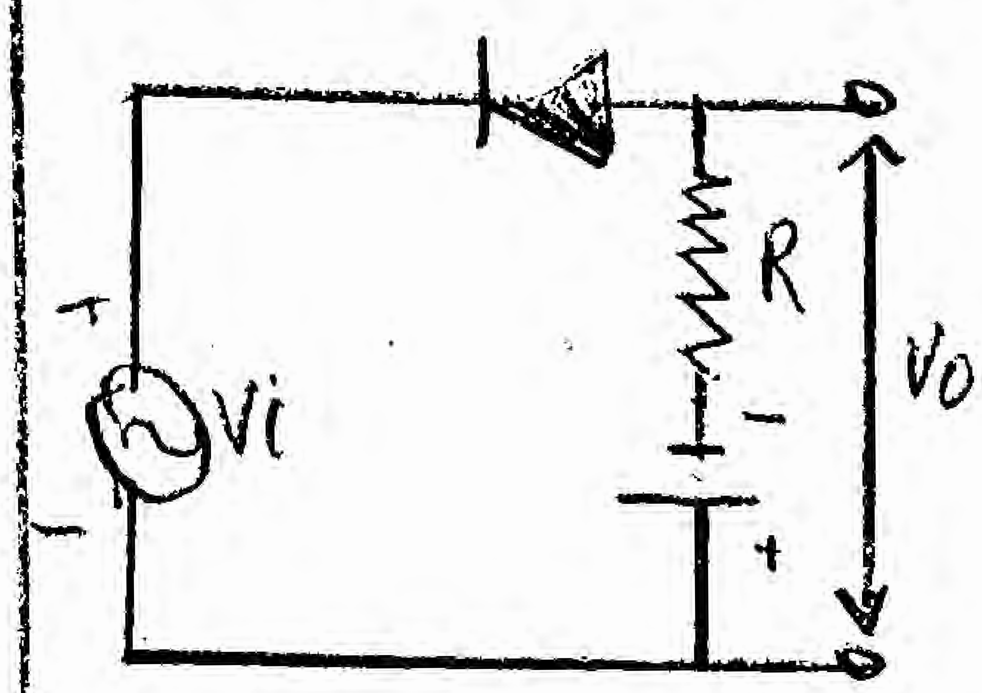


(b) Shunt

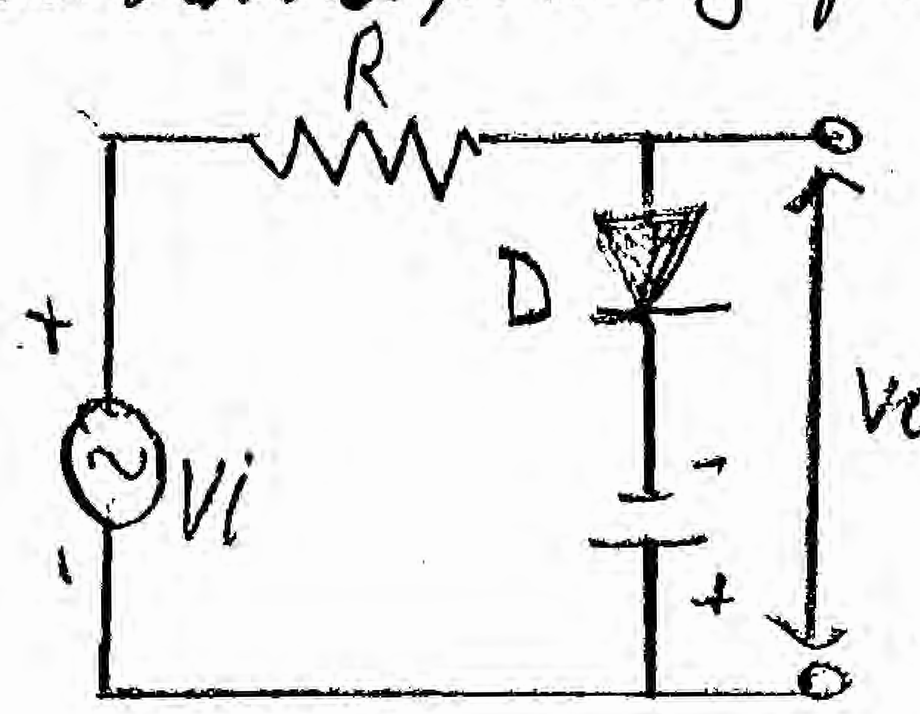


(c) Input / output signal waveform.

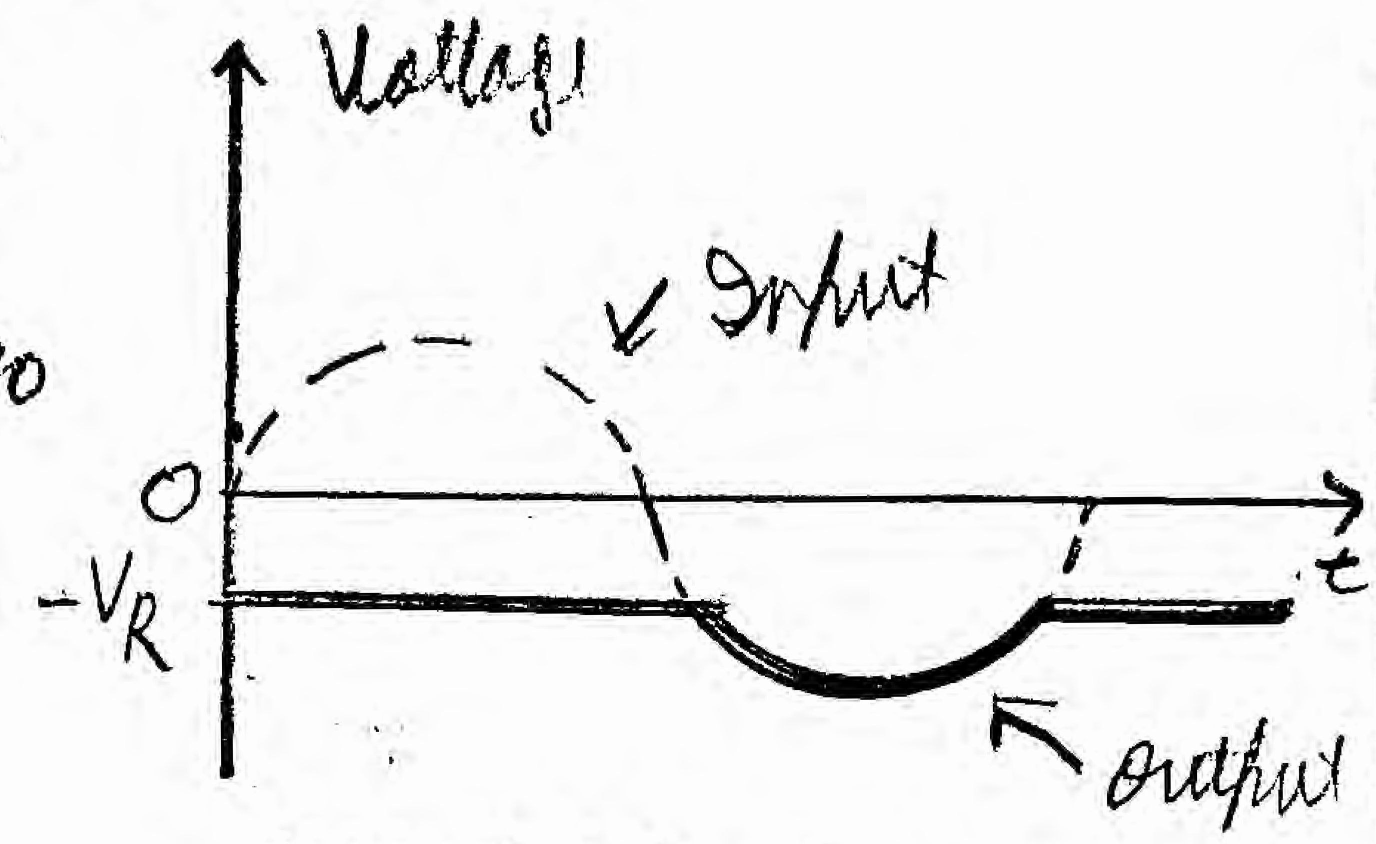
(ii) Biased positive clipper with reverse polarity of the battery



(a) Series.

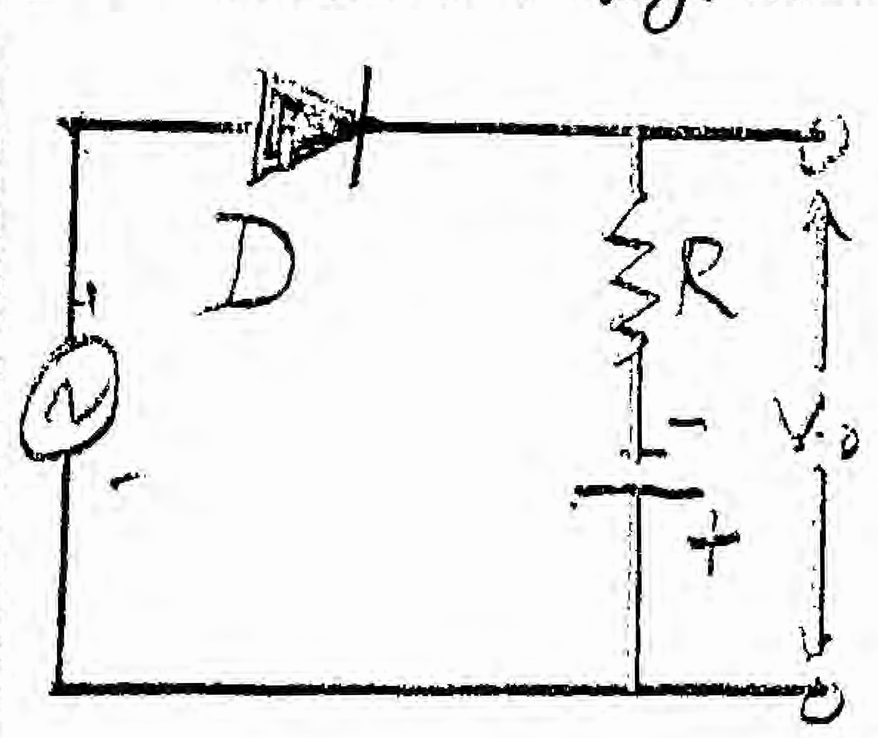


(b) Shunt.

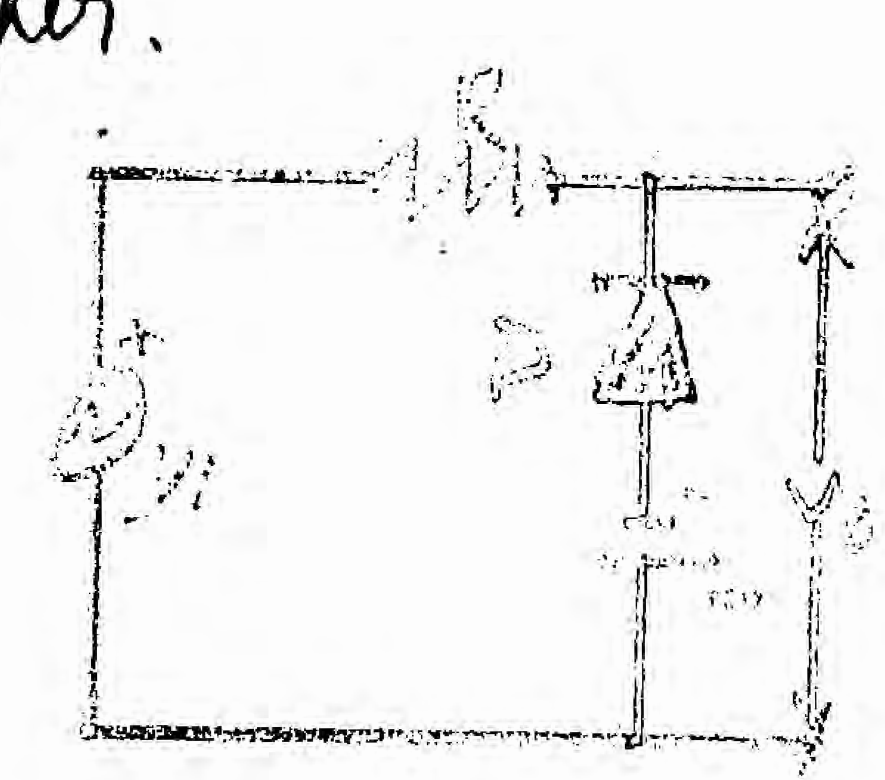


(c) Input / output waveform.

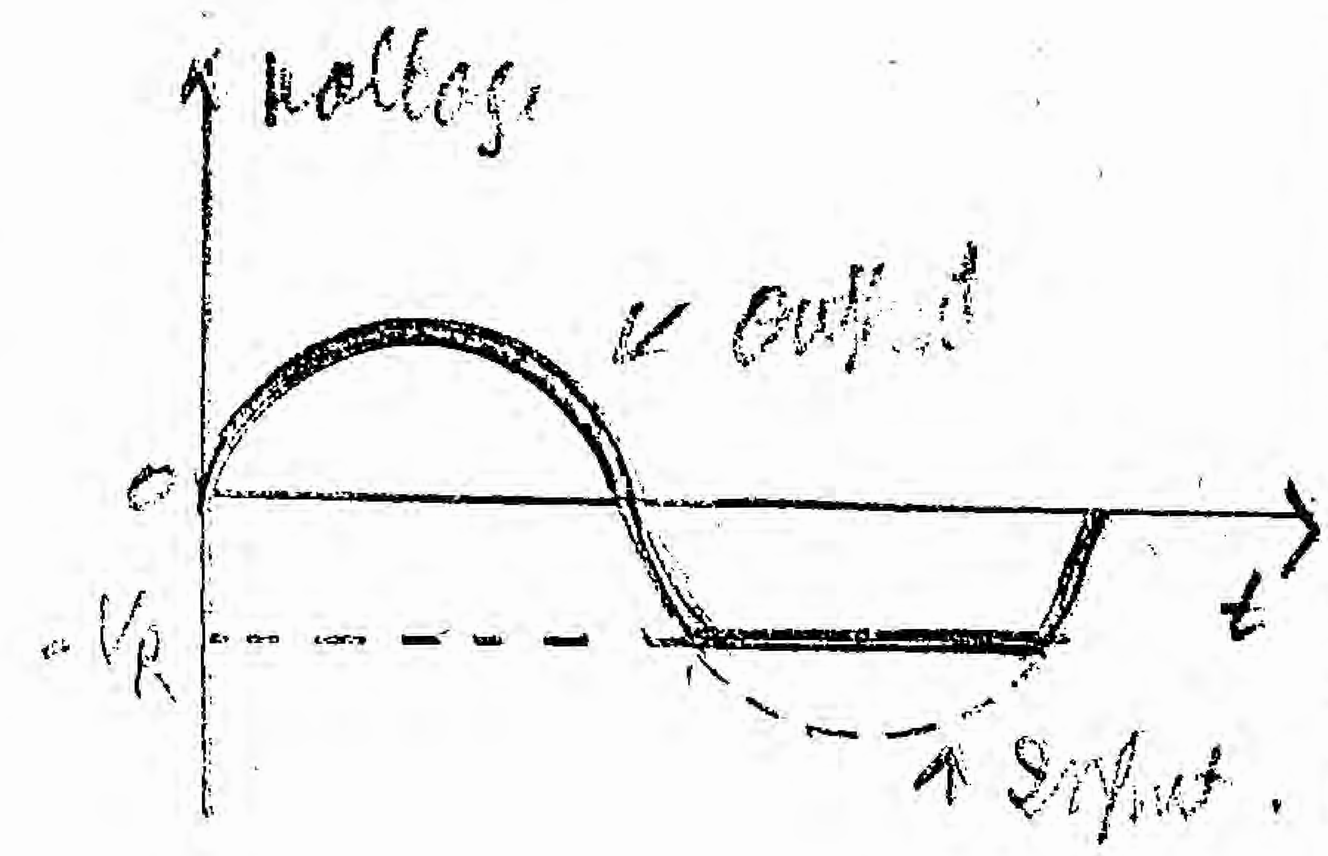
(iii) Biased Negative clipper.



(a) Series

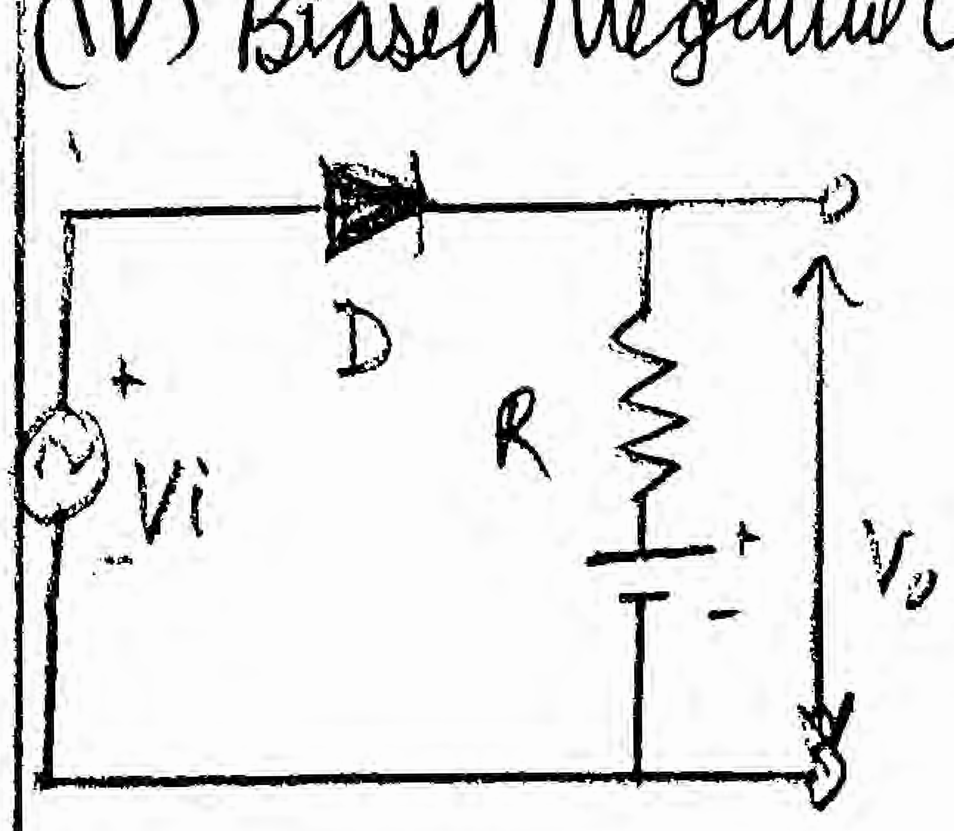


(b) Shunt.

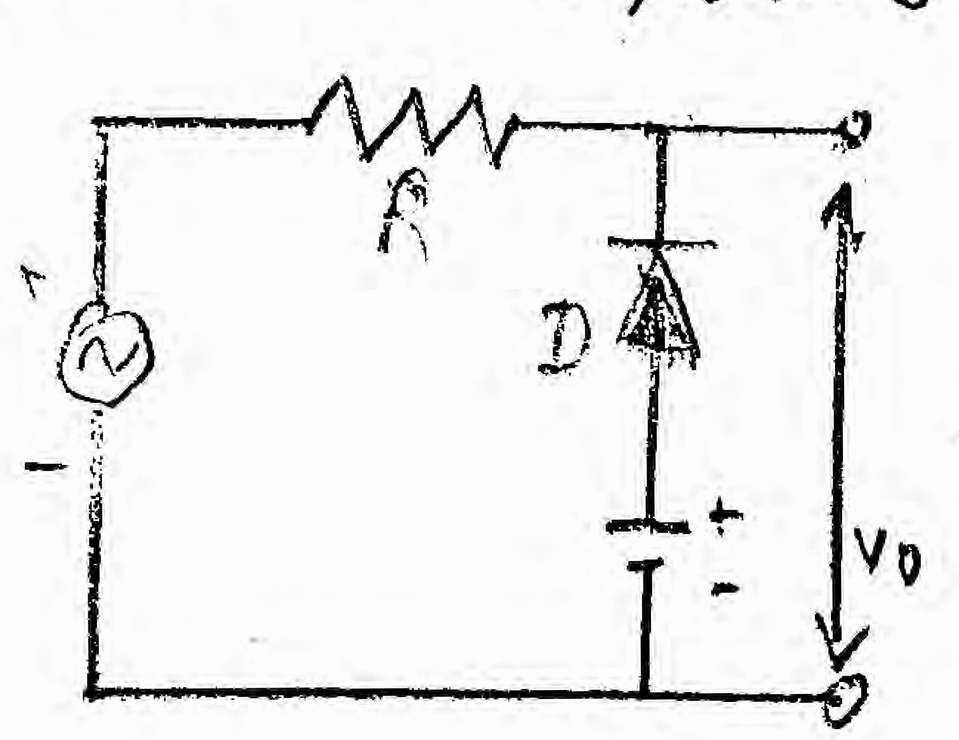


(c) Input / output waveform.

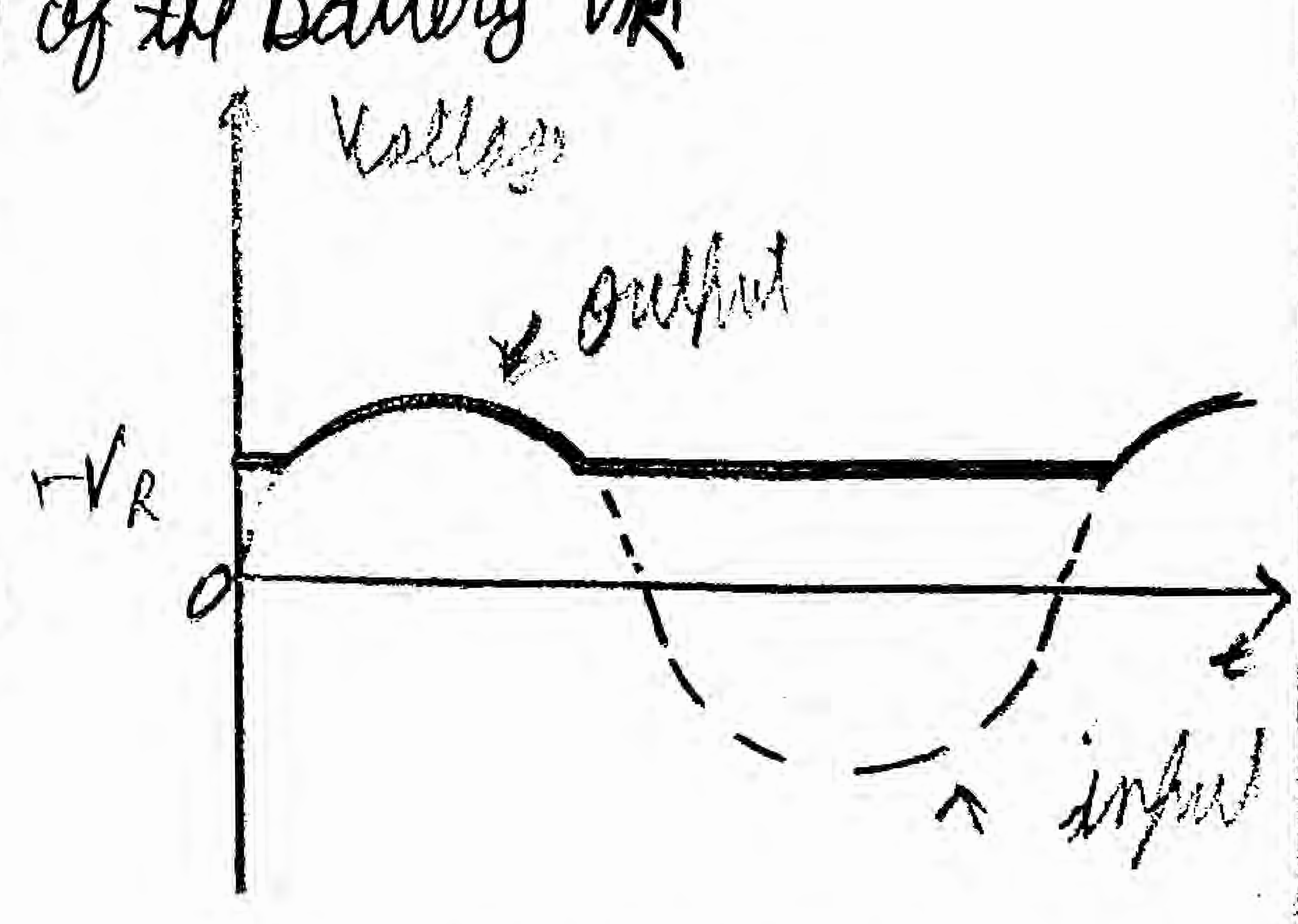
(iv) Biased Negative clipper with reverse polarity of the battery V_R



(a) Series



(b) Shunt



(c) Input/output waveform

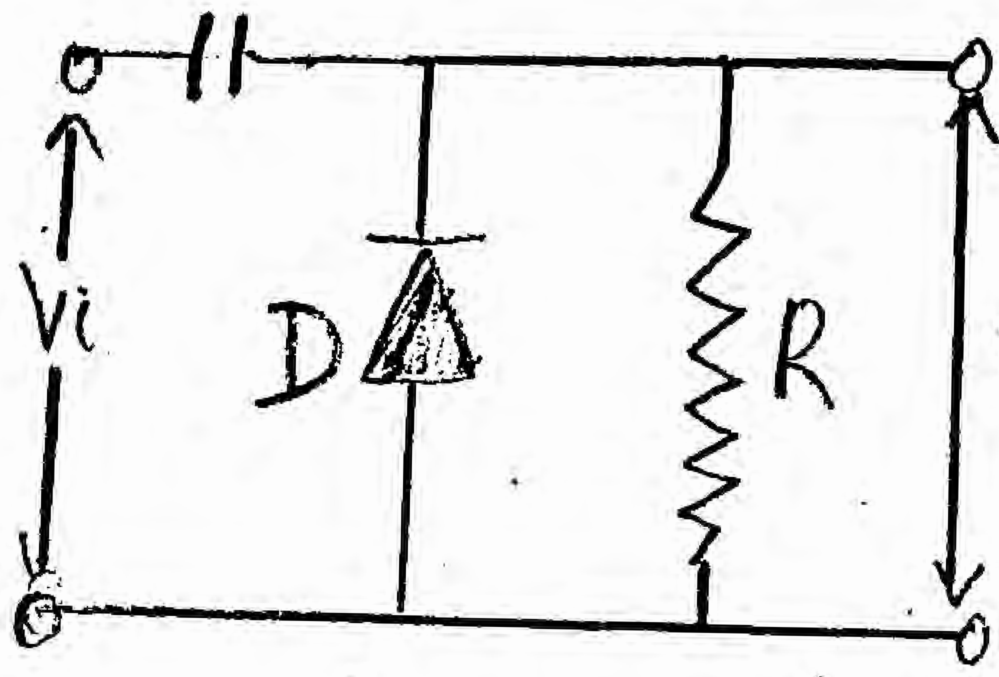
CLAMPERS

Clamping circuit shifts or clamps a signal to a different D.C. level. In other words, clamping circuits introduces a d.c. level to an a.c. signal. It is also known as d.c. strorus.

Clamping circuits are of three types.

(i) Positive Clamper (ii) Negative Clamper (iii) Biased Clamper.

Positive Clamper



Working:

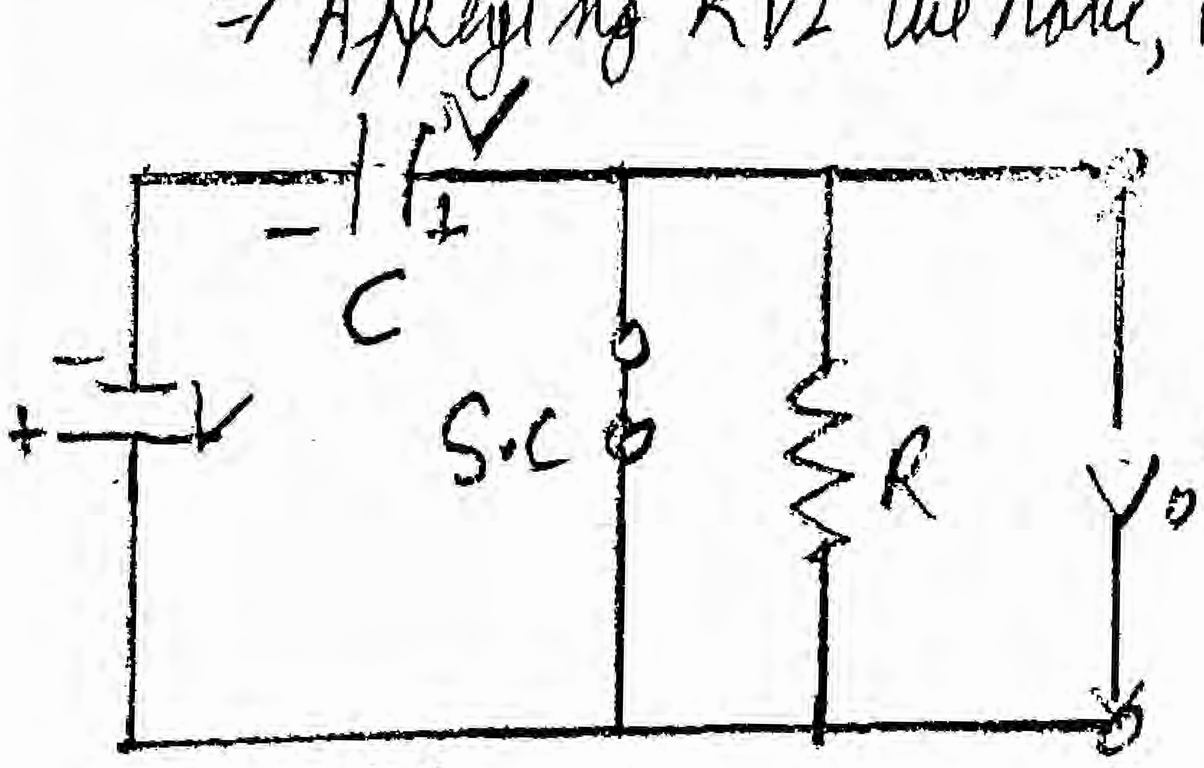
(i) During the negative half cycle, the diode is forward biased and behaves as a short circuit.

(ii) Since the charging time constant CR_F is quite small, the capacitor is charged to V volts very quickly. During this period the output is across the short circuit diode. Hence $V_0 = 0$.

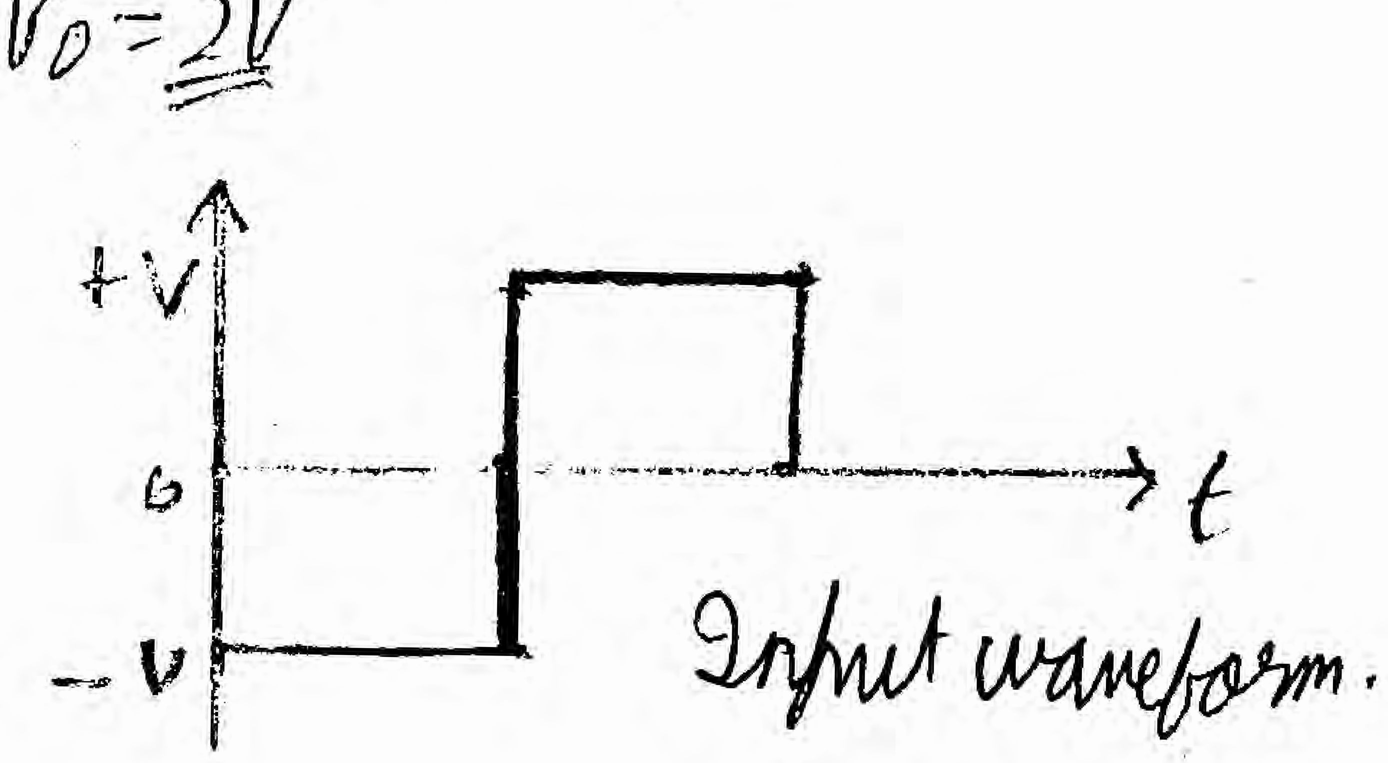
(iii) During positive half cycle, diode is ~~forward~~ reverse biased acts as open circuit. Now capacitor works as a battery and it should discharge through resistor R.

(iv) But since the discharging time constant (RC) is very large, the capacitor remains almost fully charged to V volt during the off time of diode.

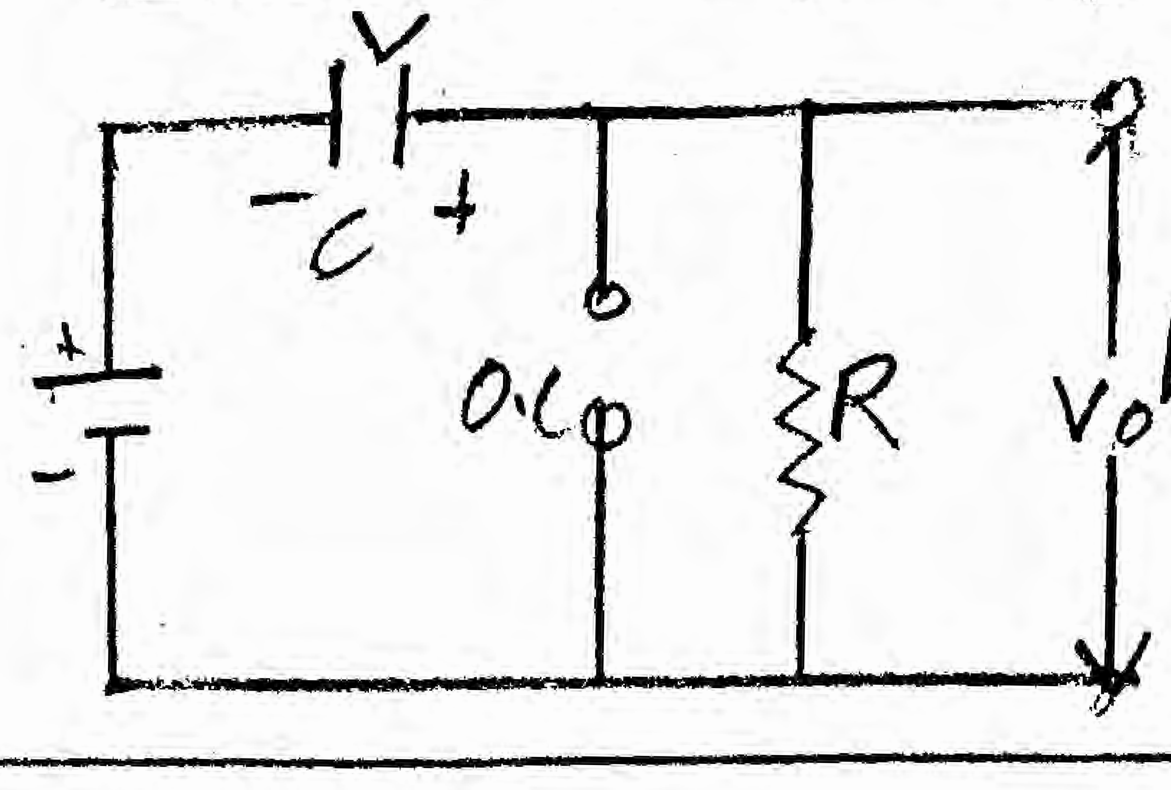
⇒ Applying KVL we have, $V + V - V_0 = 0 \Rightarrow V_0 = 2V$



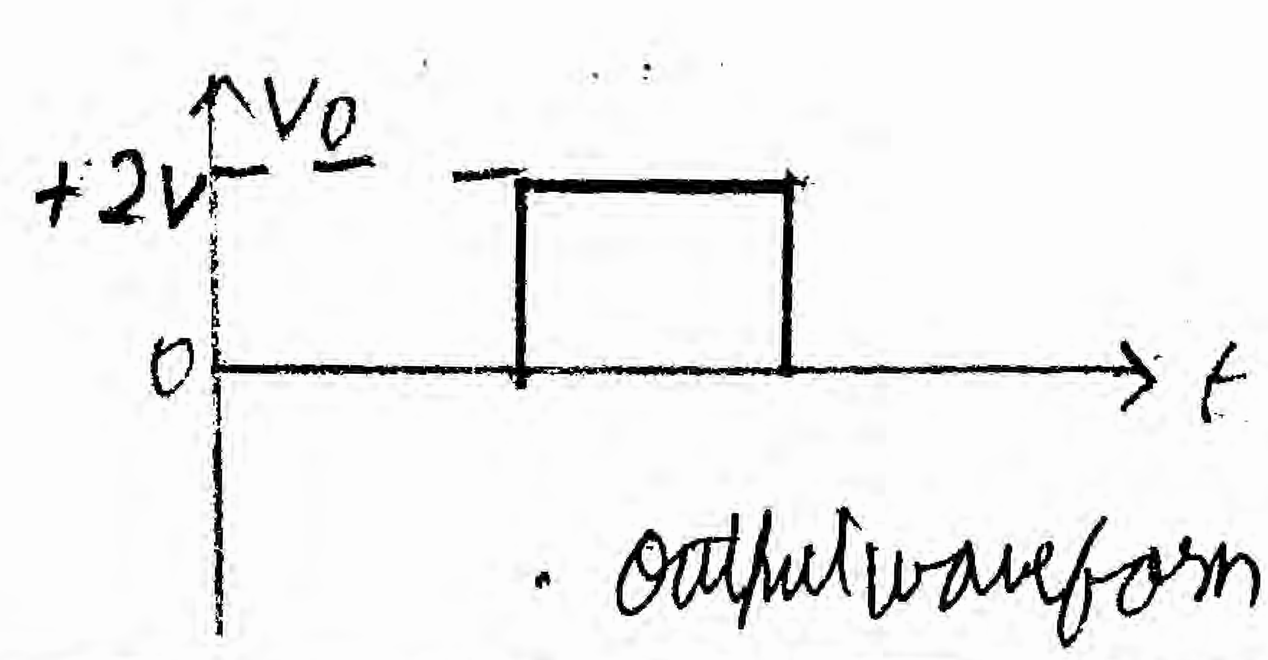
Negative cycle.



Input waveform.

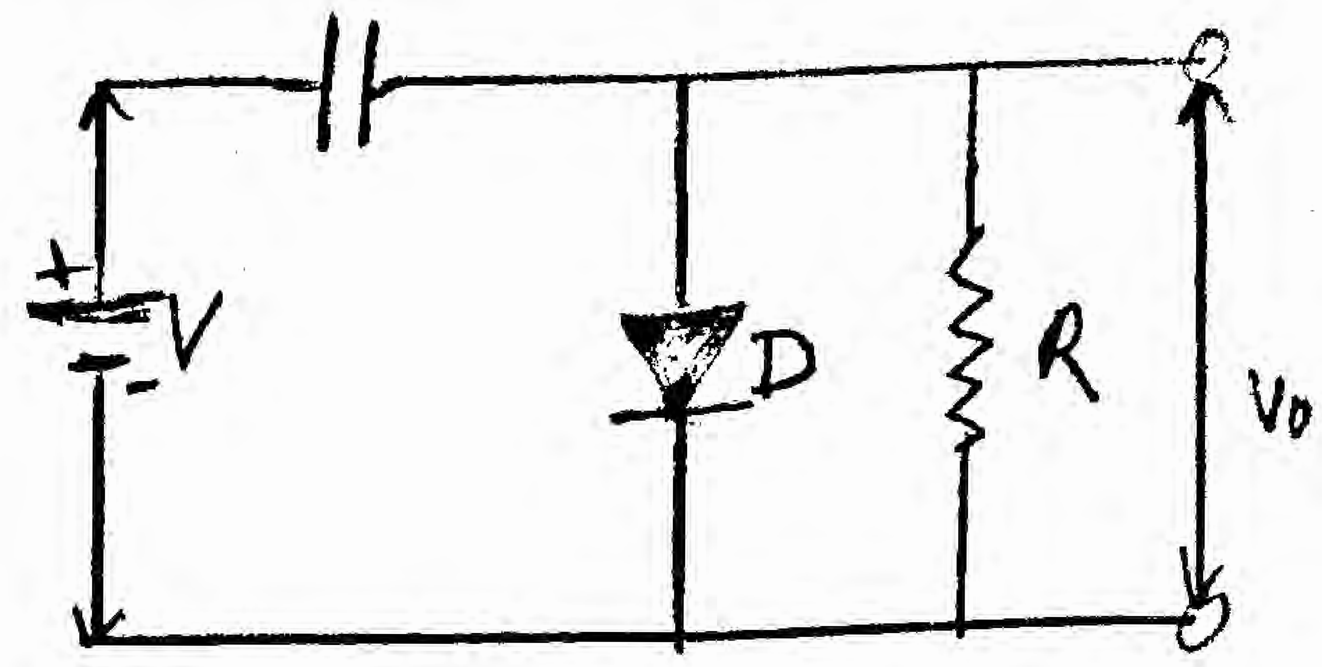


Positive cycle.



Output waveform.

Negative Clamper:



Working:

① During the positive half cycle of the input signal, the diode is forward biased, so it acts as short-circuit.

② The capacitor charges to V, Hence output across the S.C diode is,

$V_0 = 0$.

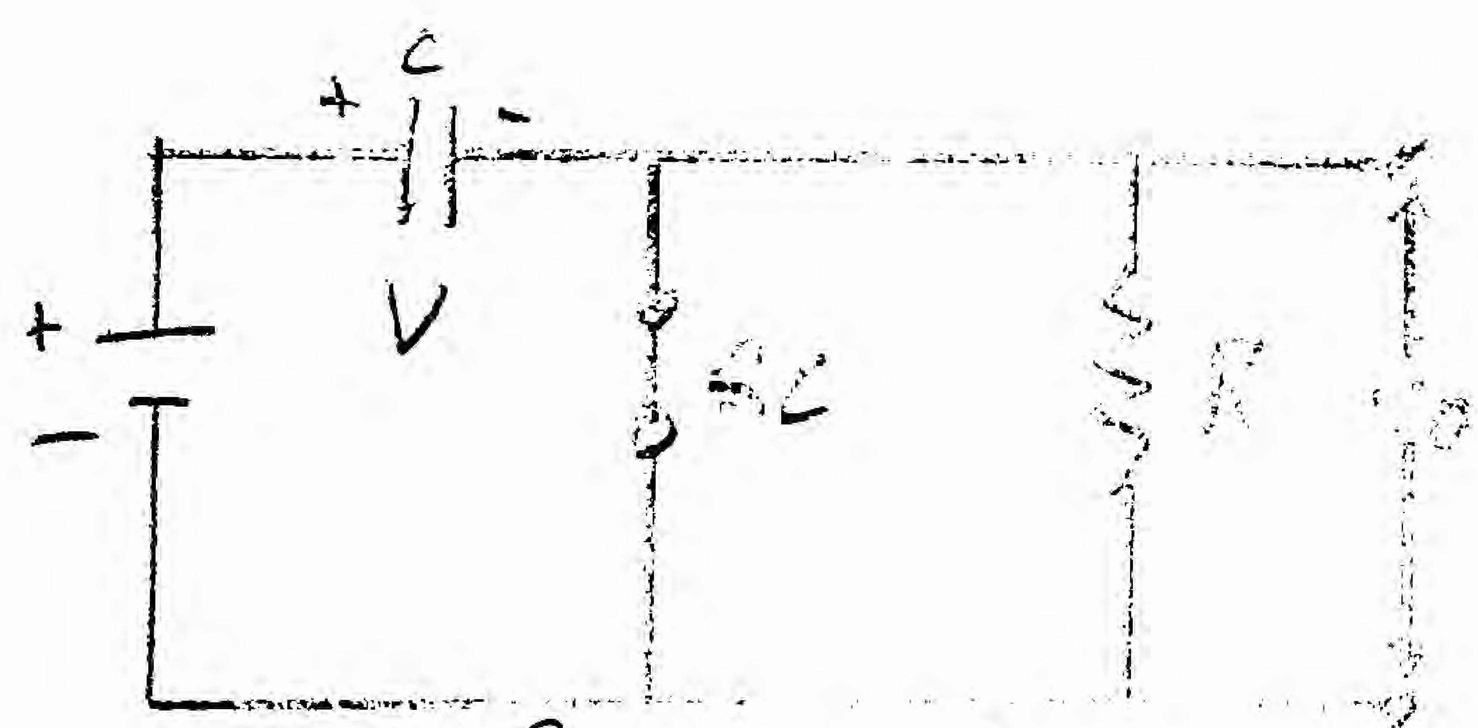
③ During negative half cycle, diode acts as open circuit.

④ Capacitor remains almost fully charged to V volts during the off-time of the diode,

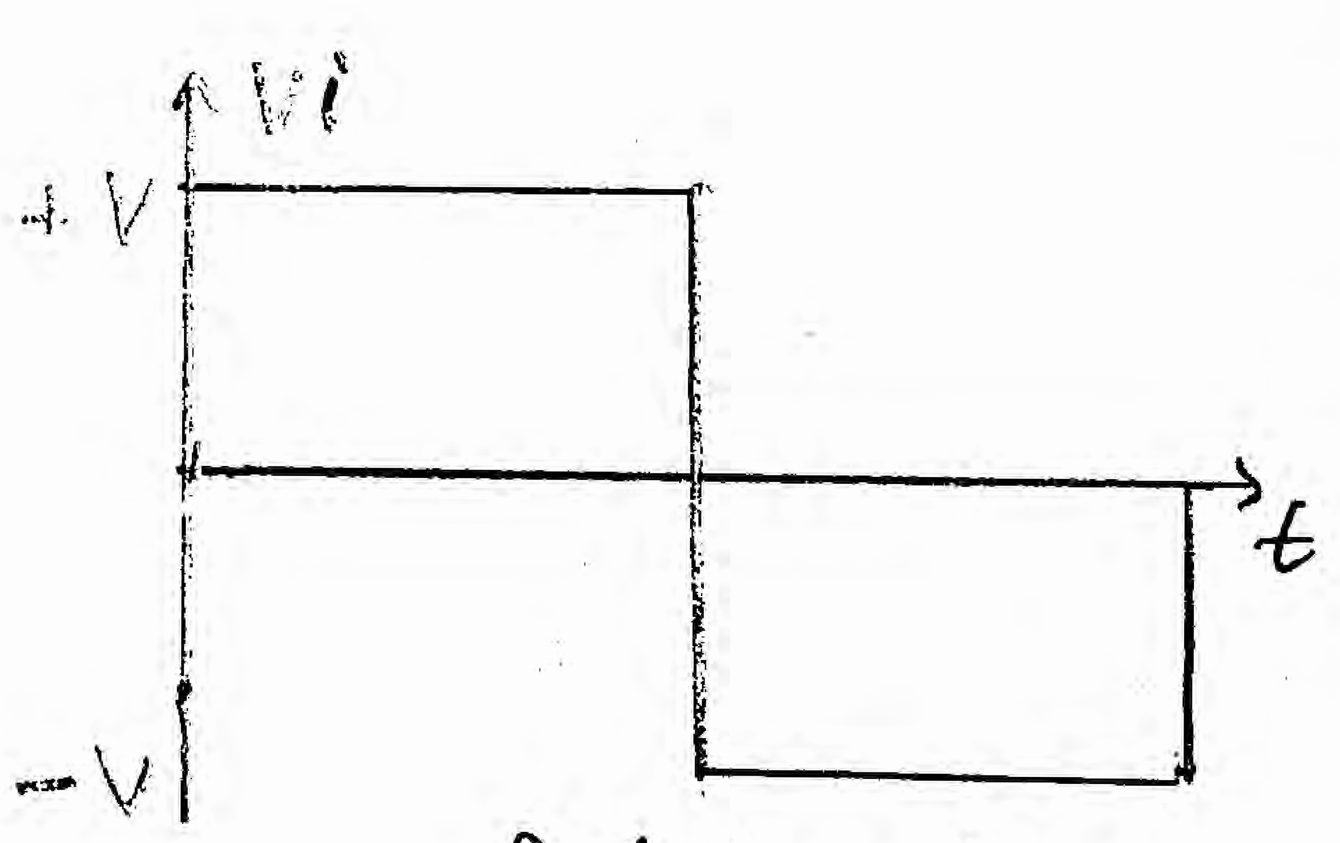
Applying KVL to the circuit,

$$-V - V - V_0 = 0$$

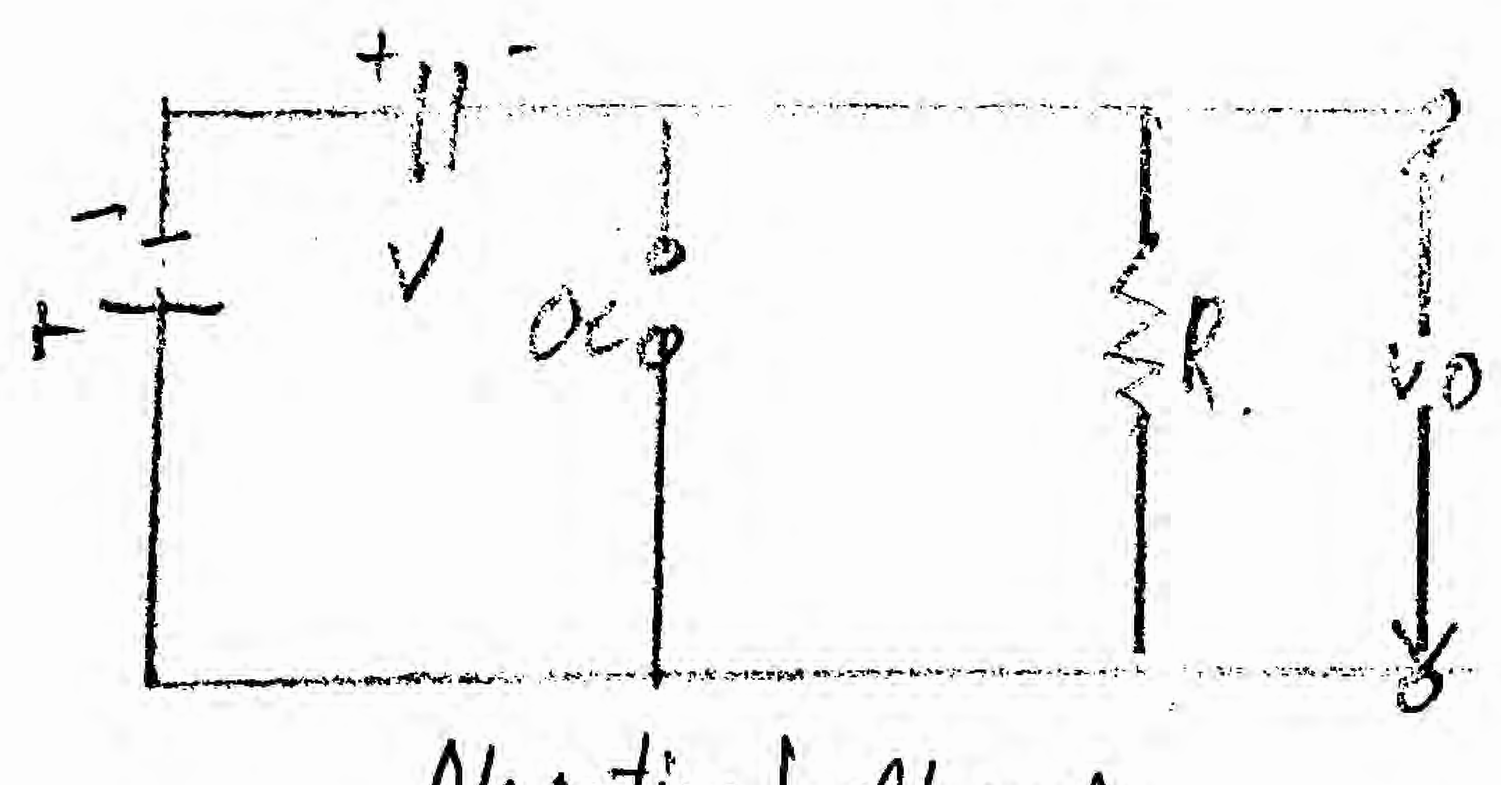
$$V_0 = -2V$$



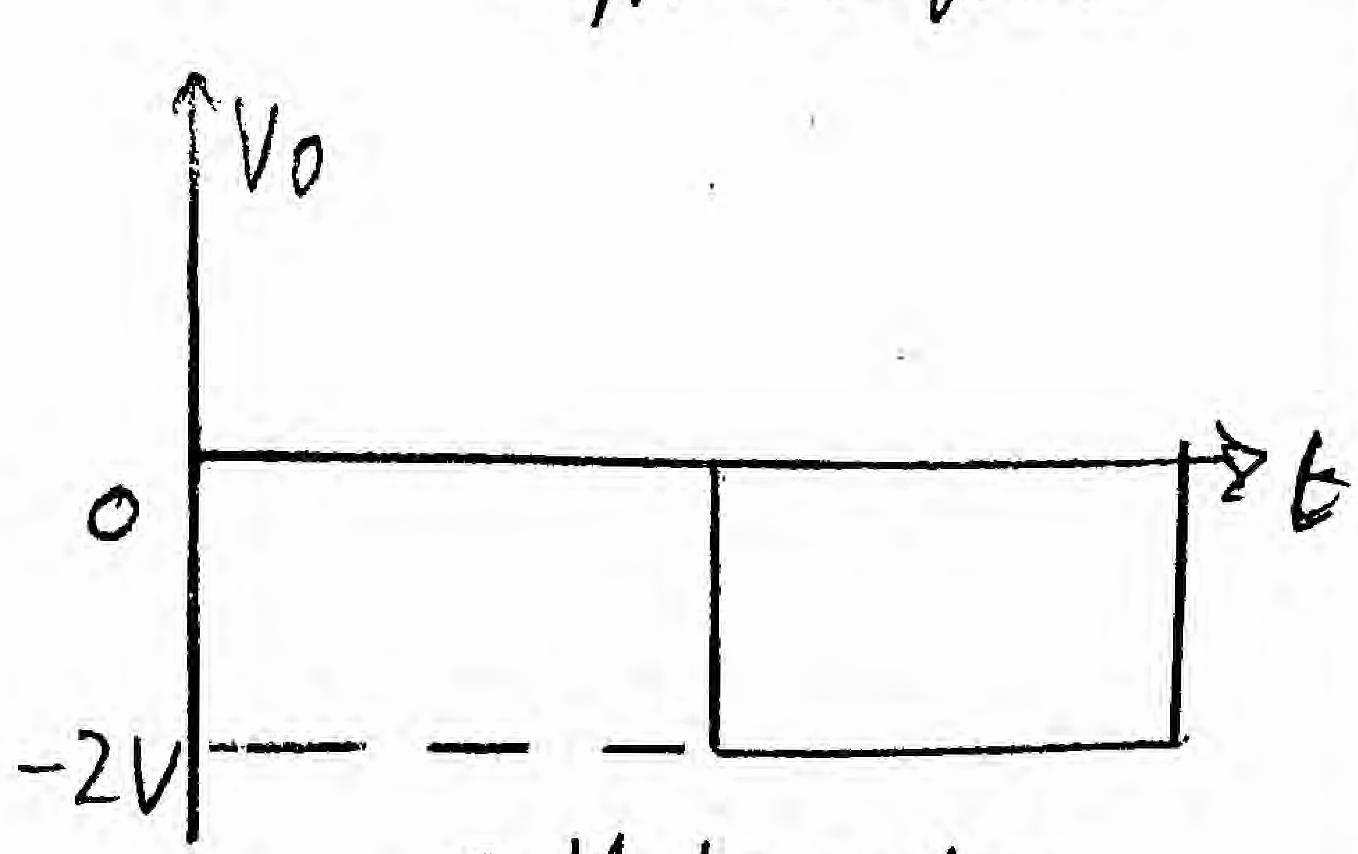
Positive half cycle.



Input waveform.



Negative half cycle.



Output waveform