It is the same of for ordinary full wave rectifier

$\eta = 81.2\%. \qquad if\ diode\ resistance\ is\ neglected.$

(*f*) Advantages:

1. No centre-tap is required on the transformer.
2. Much smaller transformers are required.
3. It is suitable for high-voltage applications.
4. It has less *PIV* rating per diode.

The obvious disadvantage is the need for twice as many diodes as for the centre-tapped transformer version.

Diode Applications

Diode Clipper and Clamper Circuits

These are diode wave-shaping circuits *i.e*. circuits meant to control the shape of the voltage and current waveforms to suit various purposes. Each performs the wave-shaping function indicated by its name. The output of the clipping circuit appears as if a portion of the input signal were clipped off. But clamper circuits simply lams (*i.e*. lift up or down) the input signal to a different dc level.

Clippers

A clipping circuit requires a minimum of two components *i.e*. a diode and a resistor. Often, dc battery is also used to fix the clipping level. The input waveform can be clipped at different levels by simply changing the battery voltage and by

interchanging the position of various elements. We will use an ideal diode which acts like a closed switch when forward-biased and as an open switch when reverse-biased.

Such circuits are used in radars and digital computers etc. when it is desired to remove signal voltages above or below a specified voltage level. Another application is in radio receivers for communication circuits where noise pulses that rise well above the signal amplitude are clipped down to the desired level.

Example:

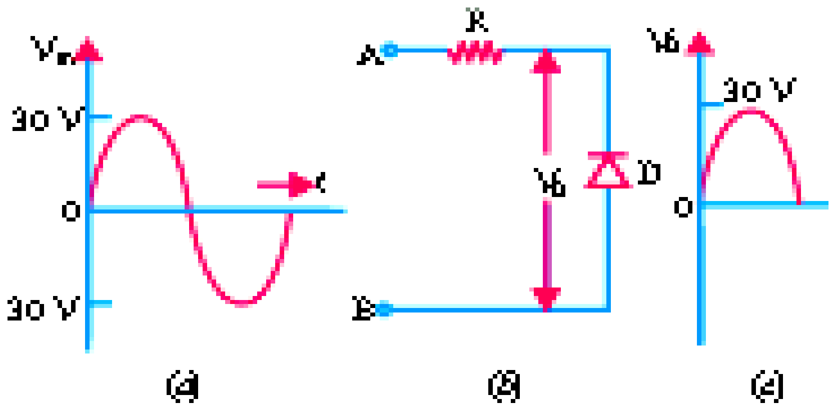
For the simple parallel clipper of Fig. below, find the shape of the output voltage. What will happen when diode and resistor are inter-changed?

Solution:

When positive half-cycle of the signal voltage is applied to the clipper *i.e*. when *A* is positive with respect to *B*, the diode *D* is reverse-biased. Hence, it acts as an open switch. Consequently, the entire input voltage appears across it.

During the negative half-cycle of the signal voltage when circuit terminal *B* becomes positive with respect to *A*, the diode is forward-biased. Hence, it acts like a closed switch (or short) across which no voltage is dropped.

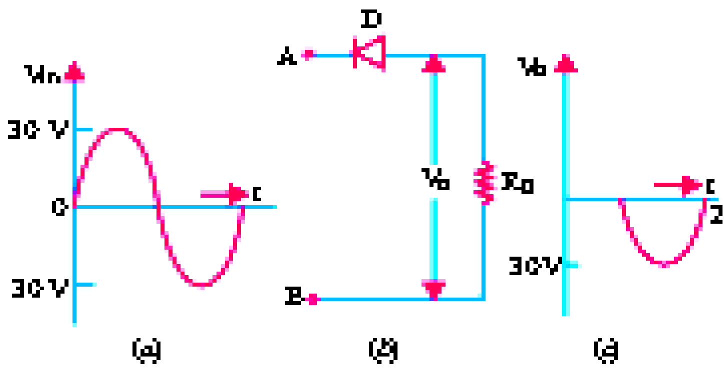
Hence, the wave-shape of V_0 is as shown in Fig. below (*c*). It is seen that the negative portion of the signal voltage has been removed. Hence, such a circuit is called a **negative clipper**.



When Diode and Resistor are Interchanged

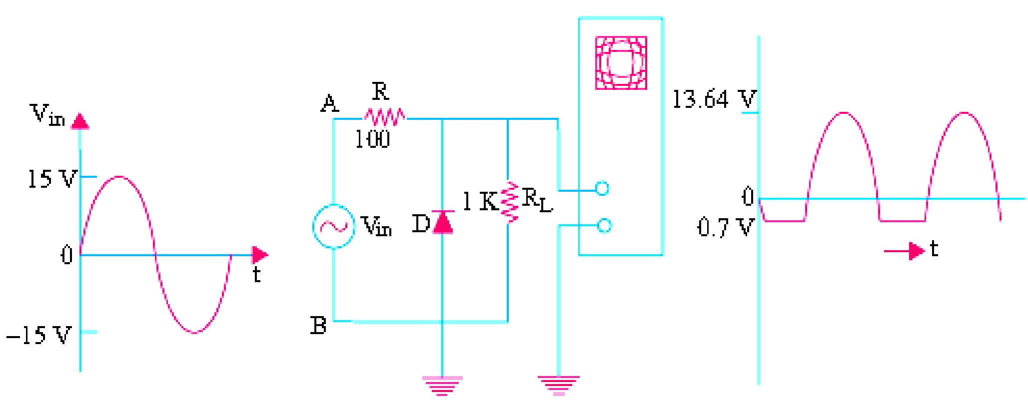
In this case, the circuit becomes as shown in Fig. below. Now, the output voltage *V*0 is that which is dropped across *R*. During the positive half-cycle of the signal voltage, *D* acts as an open switch. Hence, all applied voltage drops across *D* and none across *R*. So, there is no output signal voltage.

During the negative input half cycle, terminal *B* is positive and so it is forward-biases *B* which acts as a short. Hence, there is no voltage drop across *D*. Consequently, all the applied signal voltage drops across *R* and none across *D*. As a result, the negative half-cycle of the input signal is allowed to pass through the clipper circuit. Obviously, now the circuit acts as a **positive clipper.**



Example:

What would be the output waveform displayed by the oscilloscope in Fig. below? The silicon diode has a barrier voltage of 0.7 V.



Solution:

Consider the negative input half-cycle first *i.e.* when point *B* is positive with respect to point *A*. The diode starts conducting when applied voltage exceeds 0.7 V. Since *D* and *RL* are in parallel, voltage across them cannot exceed 0.7 V. Obviously, negative half-cycle beyond 0.7 V gets clipped. Hence, circuit behaves like a negative clipper.

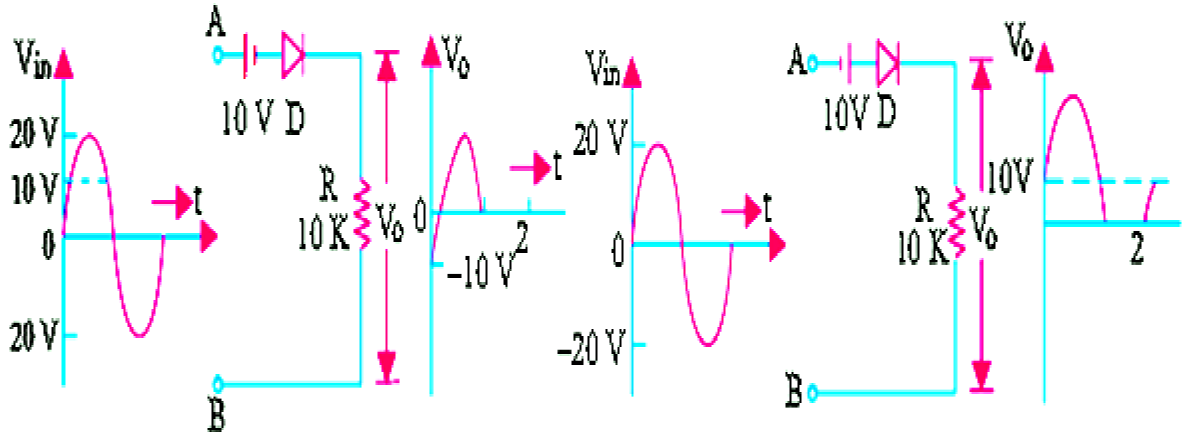
During the positive input half-cycle when point *A* is positive, diode becomes reverse-biased and hence, becomes open-circuited. The applied voltage drops across the resistors *R* and *RL* connected in series. The peak value of the output voltage is

$$V_p = 15 \times \frac{R_L}{R + R_L}$$

$$= 15 \times \frac{1}{1.1} = 13.64\,V.$$

Example:

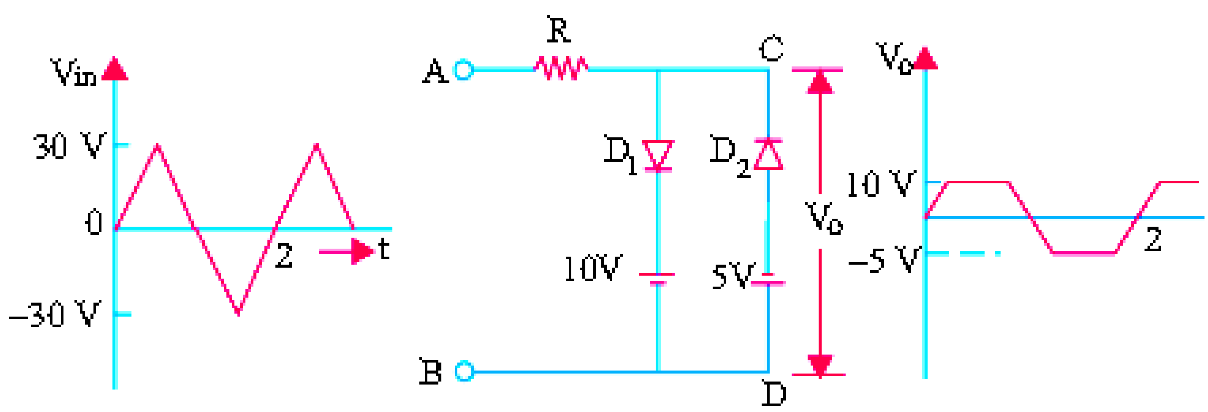
With the sine wave signal input of Fig. below (a) find the shape of the output signal V_0. (b) Find the shape of the output signal V_0. if battery connections are reversed and peak value of the output voltage.



(a) (b) (c) (a) (b) (c)

Example:

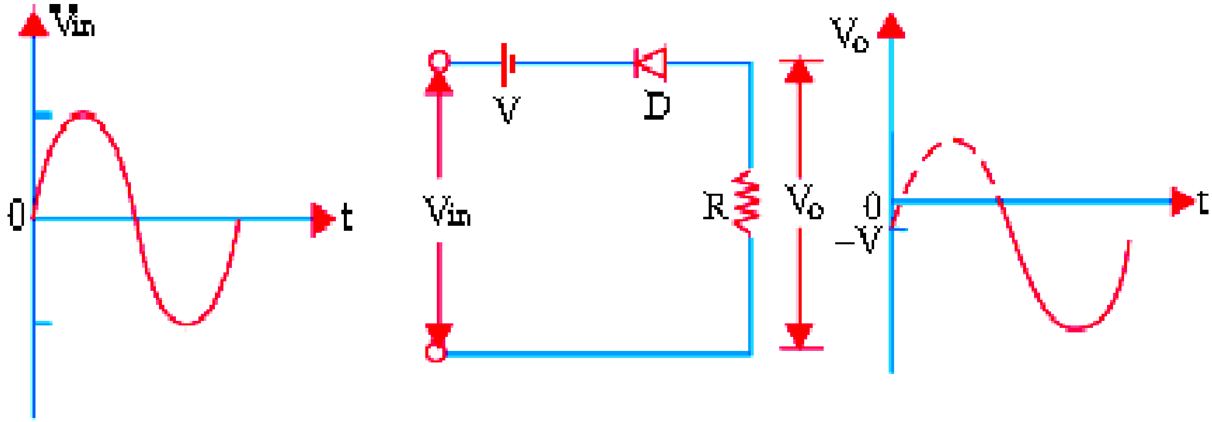
The triangular voltage of Fig. below (a) is applied to the biased parallel Clipper circuit of Fig. below (b). Find the wave-shape of the output voltage together with the maximum value of the output.

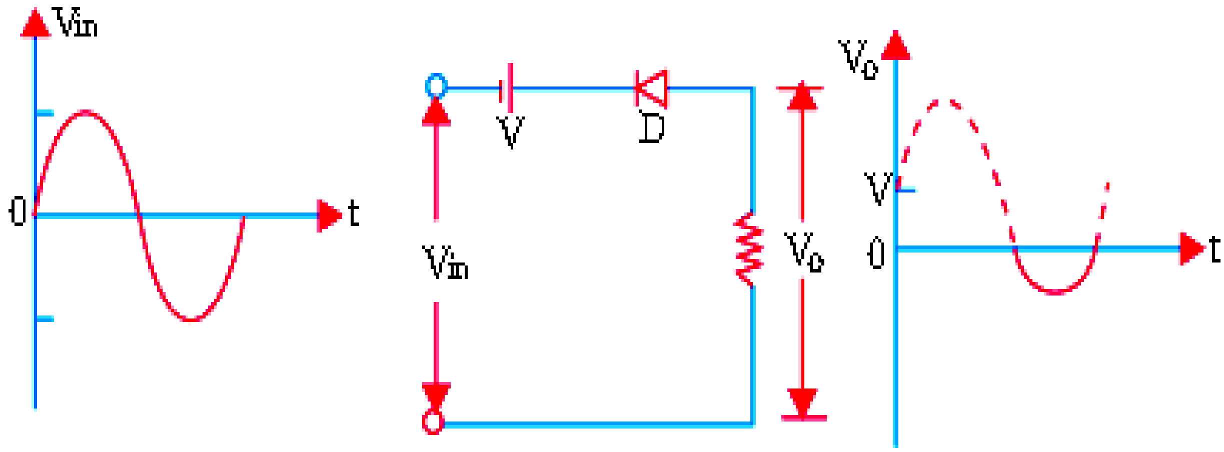


(a) (b) (c)

(a) Biased Series Clippers

Consider the wave form shown below, and then the output voltage of the biased series circuits will be as shown below:

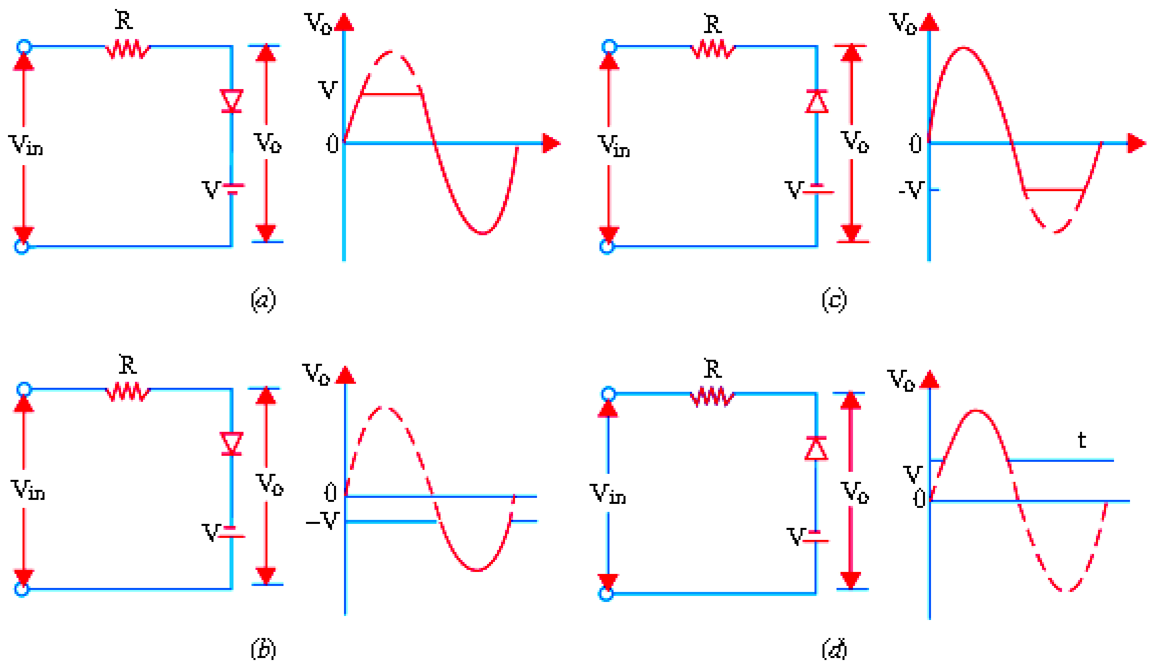




(b) Biased Parallel Clippers

The waveforms of the output voltage are as shown below:

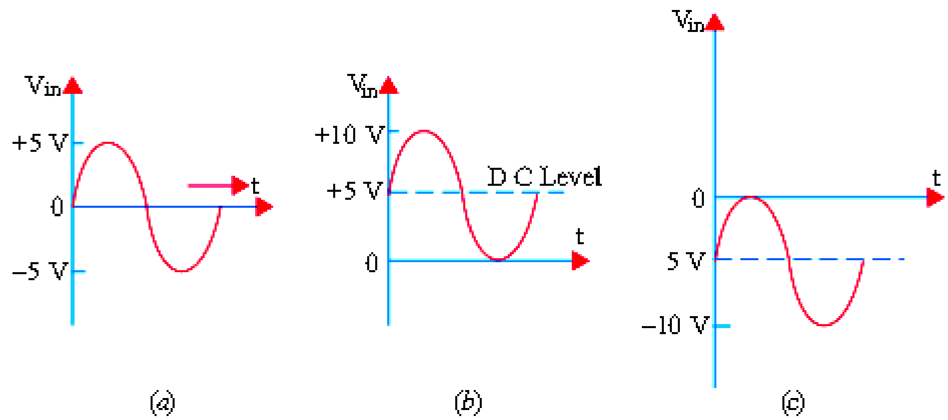
Clipping has been changed by changing the battery and diode connections.



Clampers

To put it simply, clamping is the process of introducing a dc level into an ac signal. Clampers are also sometimes known as dc restorers.

By way of illustration, consider the signal shown in Fig. below (*a*). It is a sine wave with equal of ± 5 V about 0 V.



A clamper circuit has a minimum requirement of three elements, diode**,** capacitor and resistor. Also it needs a dc battery. Following additional points regarding clamper circuits are worth keeping in mind.

1. Both R and C affect the waveform.

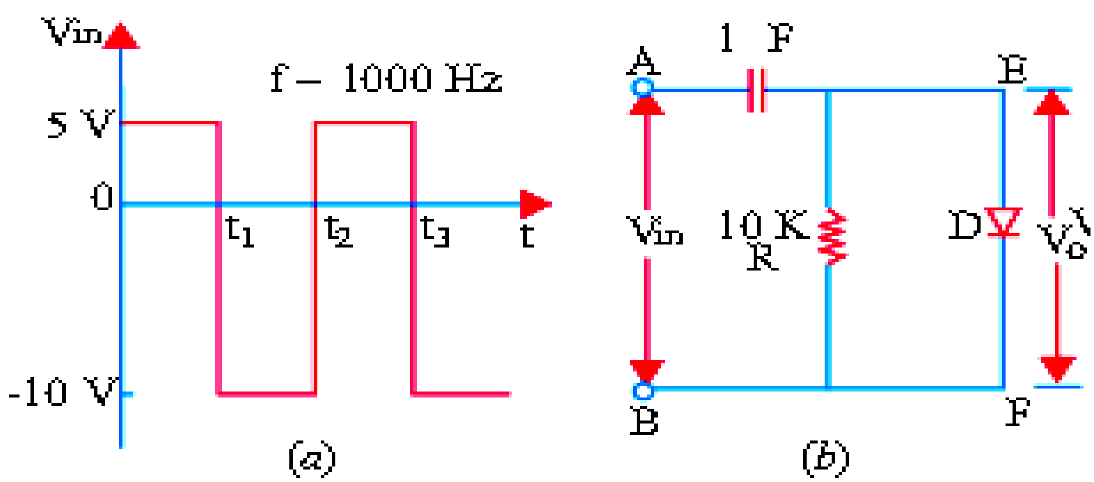
2. Values of R and C should produce a time constant (τ= CR) which is large enough to ensure that capacitor remains almost fully charged during the time-period of the signal. In other words, time constant $\tau \gg T/2$ where T is the time-period of the input signal. For good clamping action, the RC time constant should be at least ten times the time-period of the input signal voltage.

3. It is advantageous to first consider the condition under which the diode becomes forward biased.

4. For all clamping circuits, voltage swing of the input and output wave forms is the same.

Example:

The input signal of Fig. below (a) is applied to the clamper circuit shown in Fig. below (b). Draw the waveform of the output voltage V_0. How will it change if R is 100 Ω?



Solution:

As seen, time-period of the input signal is T = 1/1000 second = 1 ms

T/2 = 0.5 ms.

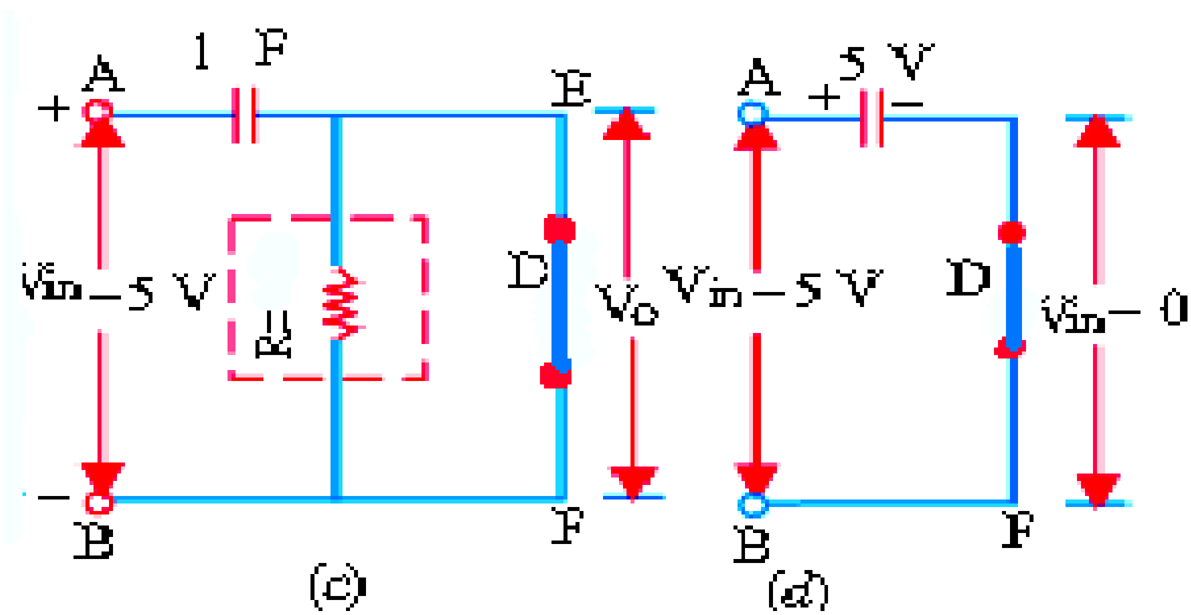
τ = 1 × 10−6 × 10 × 103 = 10 ms

τ » T/2. Hence, once charged, the capacitor will have hardly any time to discharge by the time signal polarity reverses.

We consider the two half cycles of the input signal separately:

(*a*) Positive Input Half-cycle

When positive half-cycle of the input signal voltage is applied to the clamper circuit, its terminal *A* becomes positive with respect to terminal *B*. Hence, *D* acts like a short as shown in Fig. below(*c*). A steady positive voltage of 5 V remains applied to *A* for 0.5 ms. at the same time, *R* is also shorted out because it is in parallel with *D*. Hence, C will rapidly charge to 5 V. Being across a short, $V_0 = 0$ during positive half-cycle as shown below.



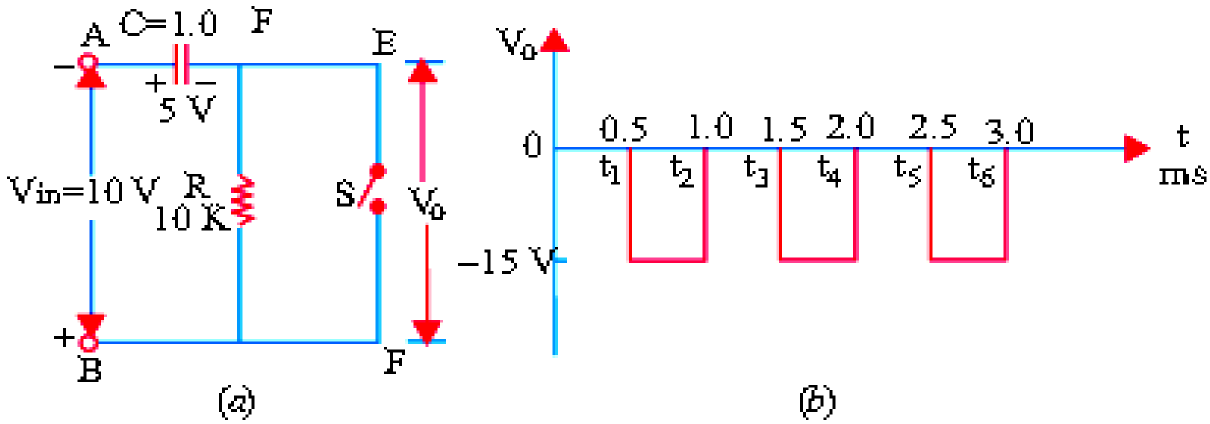
(*b*) Negative Input Half-cycle

In this case, terminal *B* becomes positive and so reverse-biases *D* by 10 V. Hence, *D* acts like an open switch as shown below. Now, *R* and *C* get connected in series

so that their τ= RC = 10 ms. as stated earlier, capacitor will take a time of 5τ = 50 ms to get fully discharged. But the input signal will allow it just 0.5 ms during which to discharge. Obviously, C would hardly get discharged in this extremely short time interval of 0.5 ms. hence, it can be assumed to be still fully charged with the original polarity during this negative half-cycle.

The output voltage V_0 across the 'open' will be = voltage from $E \rightarrow A \rightarrow B \rightarrow F$ –

= 5 + 10 = 15 V – with E negative the waveform of the output voltage is shown in Fig. below (b). It has same frequency as that of the input signal. However, it has been clamped down in the negative region. It is seen that voltage swing of both input and output circuits is the same $i.e.$ 15 V.

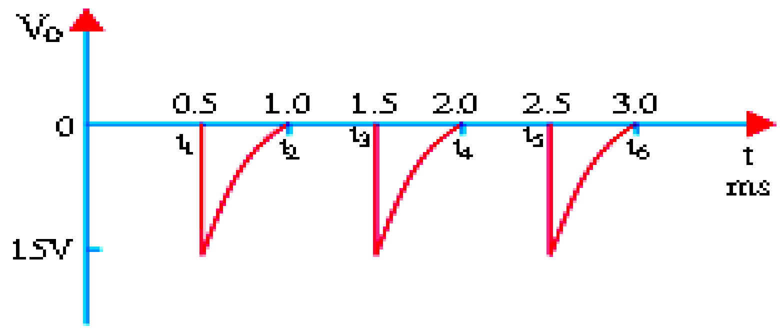


When R = 100Ω

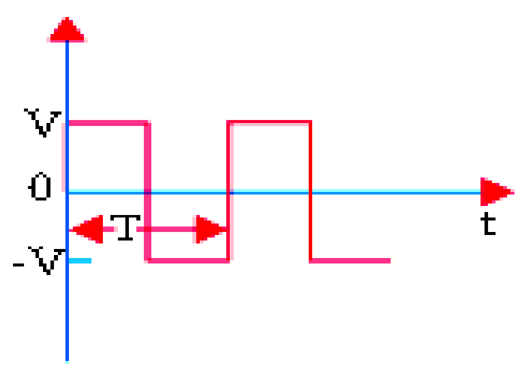
Now, τ= 100 × 1 × 10−6 ms = 0.1 ms. hence, the capacitor which is almost instantaneously charged to +5 V during the positive input half-cycle, will be

almost completely discharged during the negative half cycle because, now, 5 τ (full discharge time) equals the half time-period (0.5 ms) of the signal.

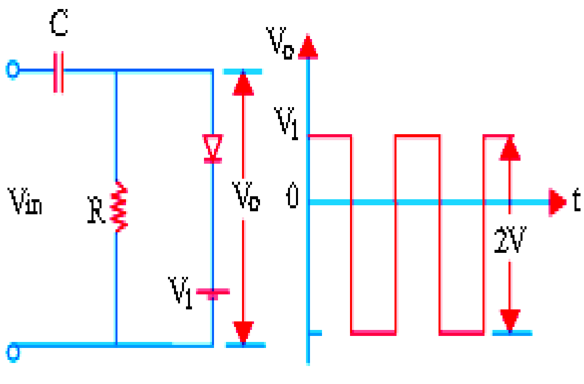
Hence, in this case, V_0 would be momentarily equal to – 15 V at the beginning of the negative half-cycle but will fall off to almost 0 V before the signal reverses its polarity (Fig. below). As seen, υ_0 consists of voltage spikes of amplitude –15 V.



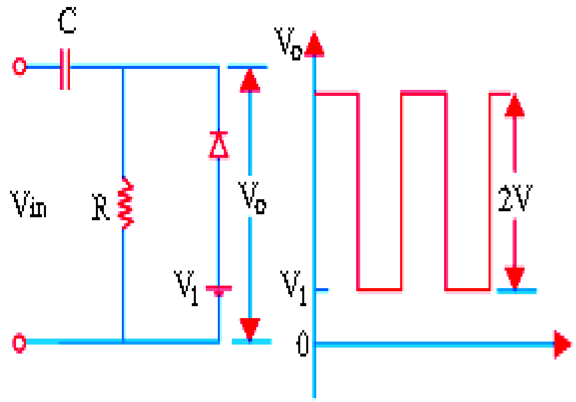
In the following clamping circuits, it would be assumed that the amount of the time $5\tau = 5\ RC \gg T/2$ where T is the time-period of the input signal. For all circuits, we will take the same input signal shown below with a peak value of V. We will also take note of the change in the output waveform when diode connections are reversed.



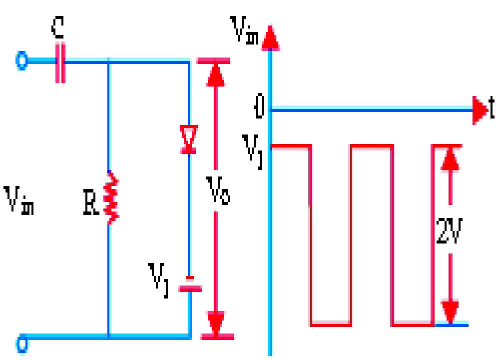
Input signal


C
Vin
R
V1
Vo
V1
0
t
2V

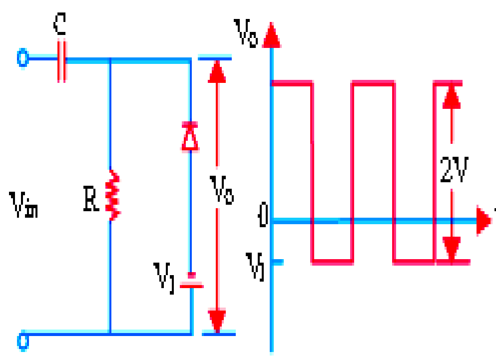
(a) (b)


C
Vin
R
V1
Vo
V1
0
t
2V

(a) (b)


C
Vin
R
V1
Vo
Vin
0
t
V1
2V

(a) (b)


C
Vin
R
V1
Vo
Vo
0
t
V1
2V

(a) (b)