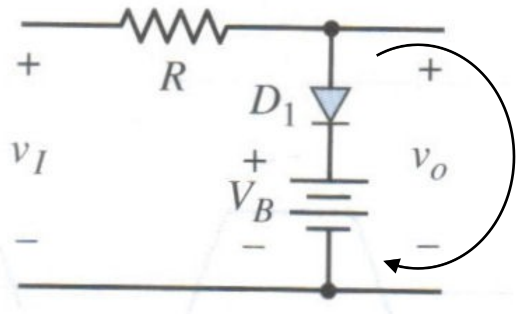
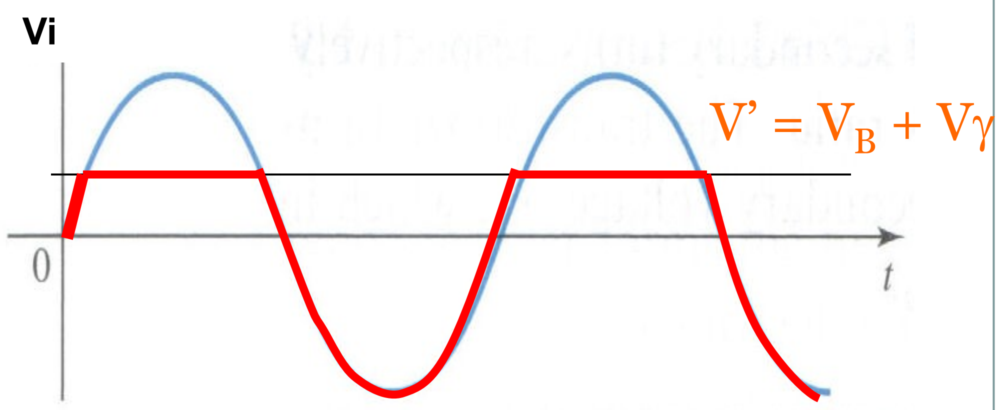
Semiconductor Diode

Clipper and Clamper Circuits

Clippers

- Clipper circuits, also called **limiter circuits**, are used to eliminate portion of a signal that are above or below a specified level – clip value.
- The purpose of the diode is that when it is turn on, it provides the clip value
- Clip value = V'. To find V', use KVL at L1
- The equation is : $V' - V_B - V\gamma = 0 \rightarrow V' = V_B + V\gamma$

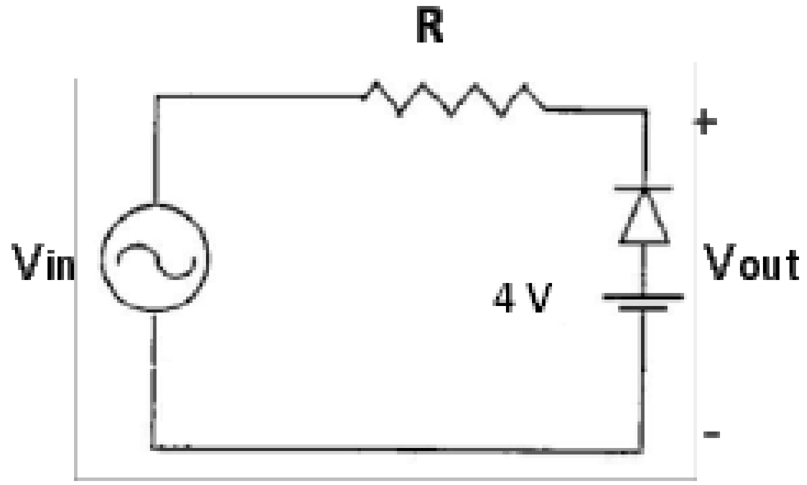




- Then, set the conditions
  - If **Vi > V'**, what happens? → diode conducts, hence Vo = V'
  - If **Vi < V'**, what happens? → diode off, open circuit, no current flow, Vo = Vi

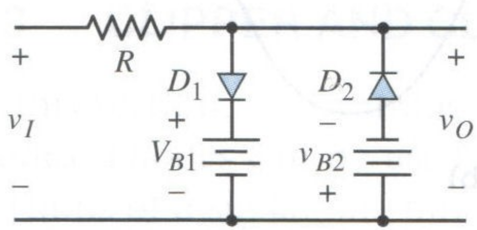
EXAMPLE

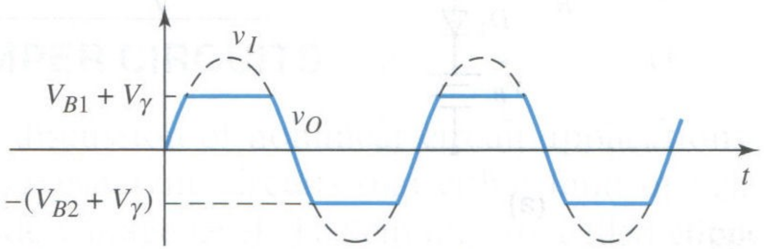
For the circuit shown below sketch the waveform of the output voltage, V_{out}. The input voltage is a sine wave where $V_{in} = 10 \sin \omega t$. Assume $V\gamma = 0.7$ V



Parallel Based Clippers

- Positive and negative clipping can be performed simultaneously by using a double limiter or a **parallel-based clipper**.



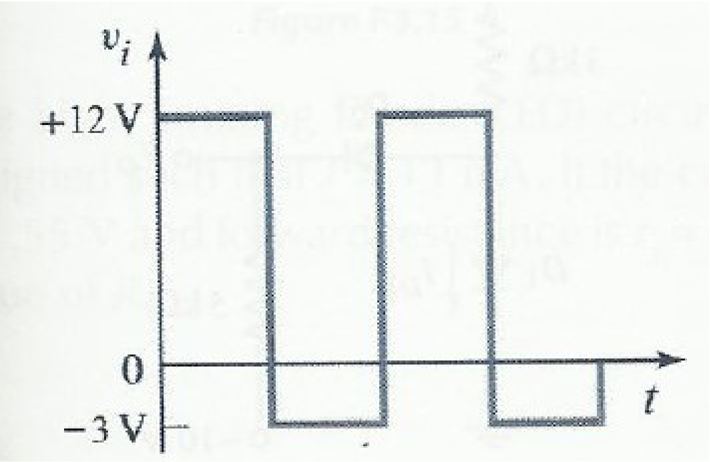


- The parallel-based clipper is designed with two diodes and two voltage sources oriented in opposite directions.
- This circuit is to allow clipping to occur during both cycles; negative and positive

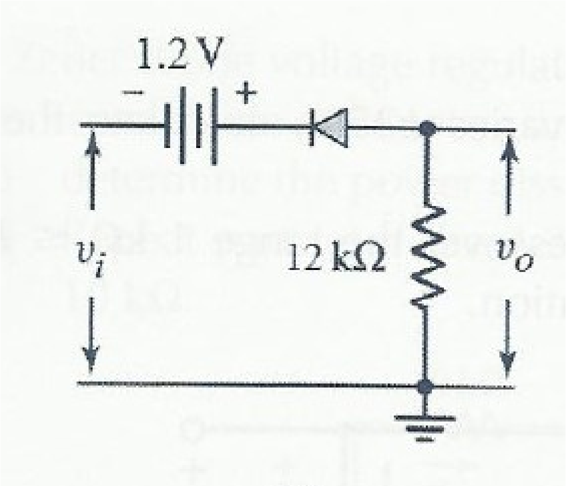
Clipper – Diode in Series

Problem 3.11

Figure P3.11(a) shows the input voltage of the circuit as shown in Figure P3.11(b). Plot the output voltage V_o of these circuits if $V\gamma = 0.7$ V



P3.11(a)



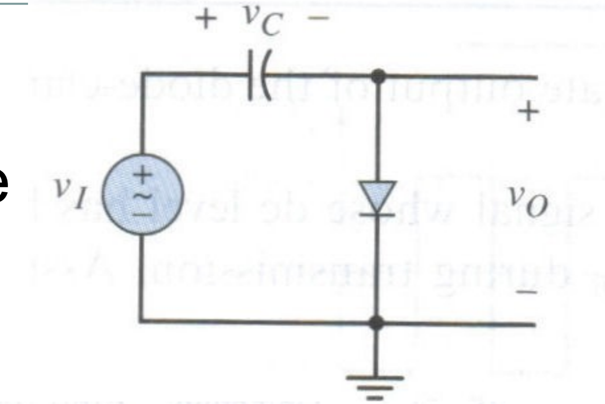
P3.11(b)

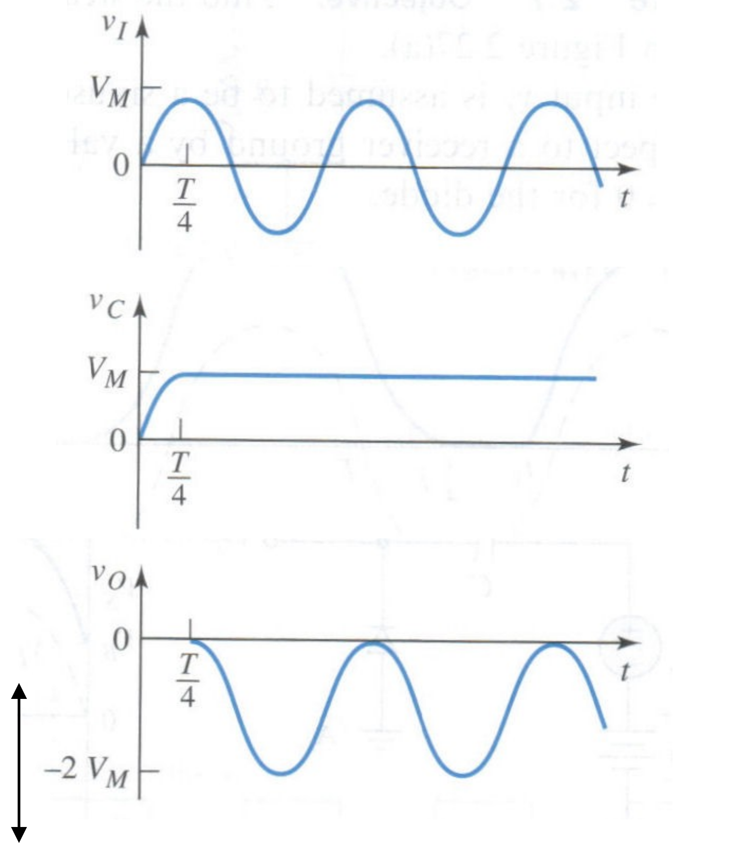
Clampers

- Clamping shifts the entire signal voltage by a DC level.
  - Consider, the sinusoidal input voltage signal, v_I.
  - 1st 90^0, the capacitor is charged up to the peak value of **Vi which is V_M.**
  - Then, as Vi moves towards the –ve cycle,
    - the diode is reverse biased.
    - Ideally, capacitor cannot discharge, hence Vc = V_M
  - By KVL, we get

$$v_O = -v_C + v_I = -V_M + V_M \sin \omega t$$

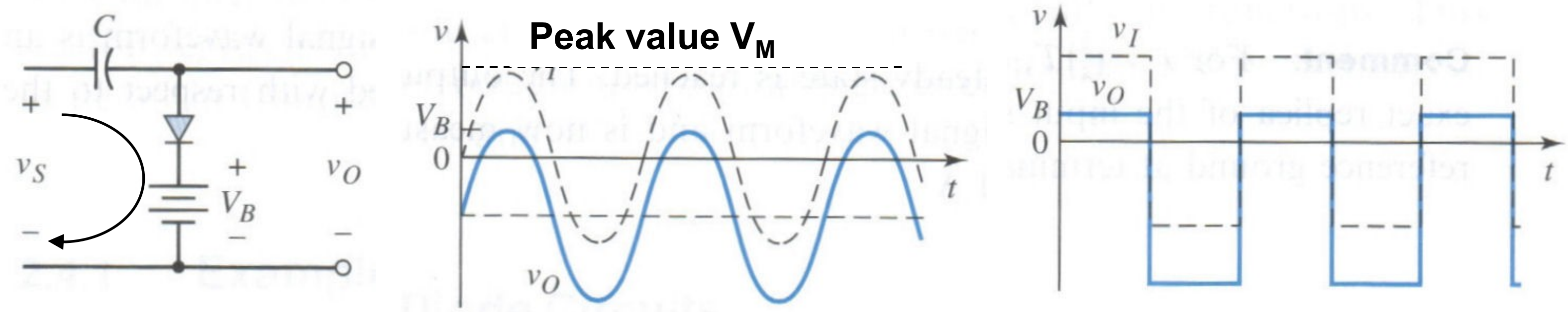
NOTE: The input signal is shifted by a dc level; and that the peak-to-peak value is the same





Clampers

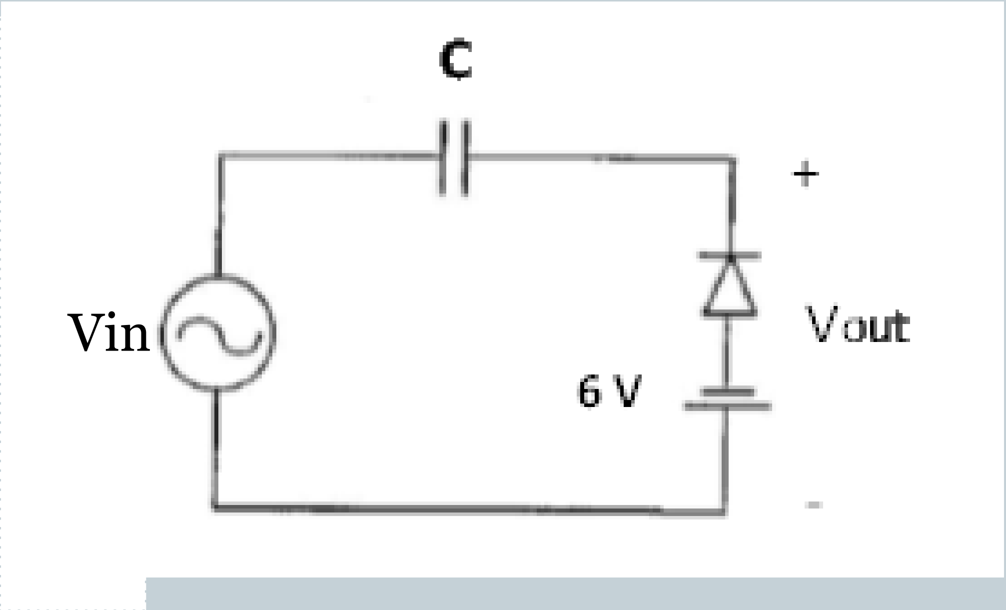
- A clamping circuit that includes an independent voltage source V_B.



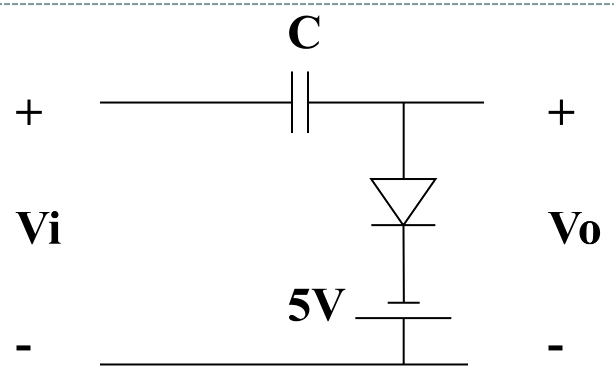
- **STEP 1**: Knowing what value that the capacitor is charged to. **<u>And from the polarity of the diode</u>**, we know that it is charged during positive cycle. Using KVL,
  - $\mathbf{V_C + V_B - V_S = 0 \rightarrow V_C = V_M - V_B}$
- **STEP 2**: When the diode is reversed biased and V_C is already a constant value
  - $\mathbf{V_O - V_S + V_C = 0 \rightarrow V_O = V_S - V_C}$.

EXAMPLE – clampers with ideal diode

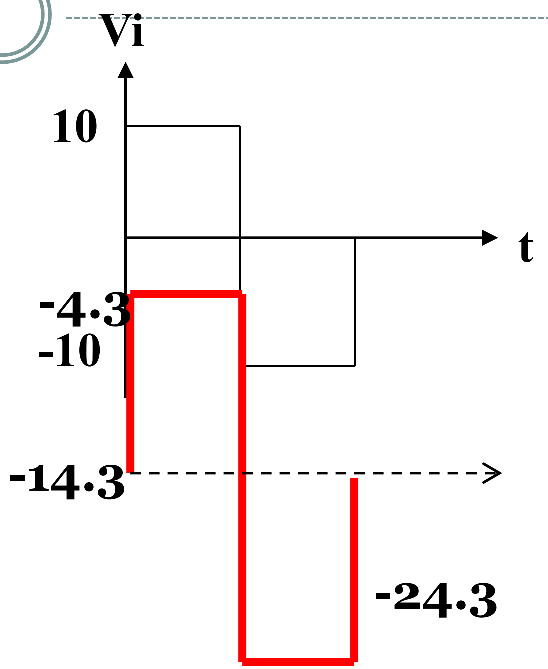
For the circuit shown in figure below, sketch the waveforms of the output voltage, V_{out}. The input voltage is a sine wave where V_{in} = 20 sin ωt. Assume ideal diodes.



What if the diode is non-ideal?



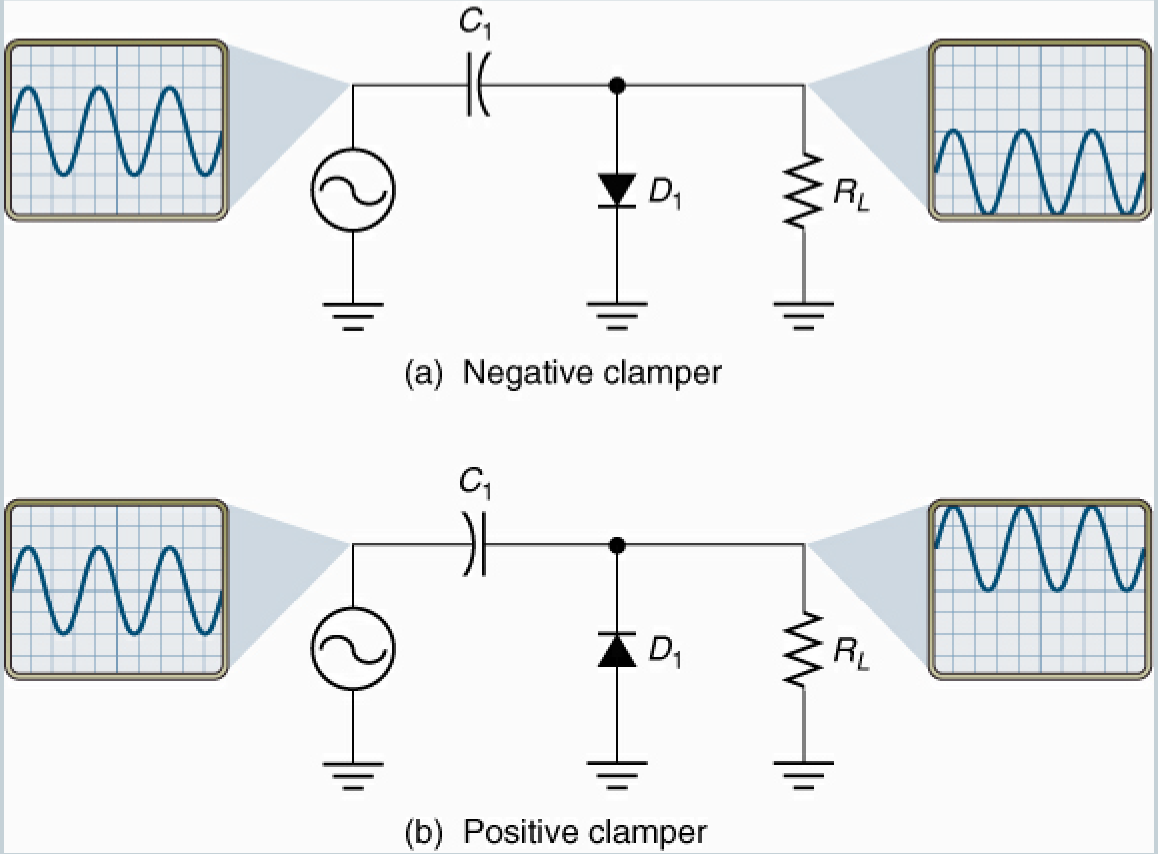
The diode is a non-ideal with Vγ = 0.7V



- **Step 1: $V_C + V\gamma - V_B - V_i = 0 \rightarrow V_C = 10 + 5 - 0.7 = 14.3V$**
- **Step 2: $V_O - V_i + V_C = 0 \rightarrow V_O = V_i - 14.3$.**

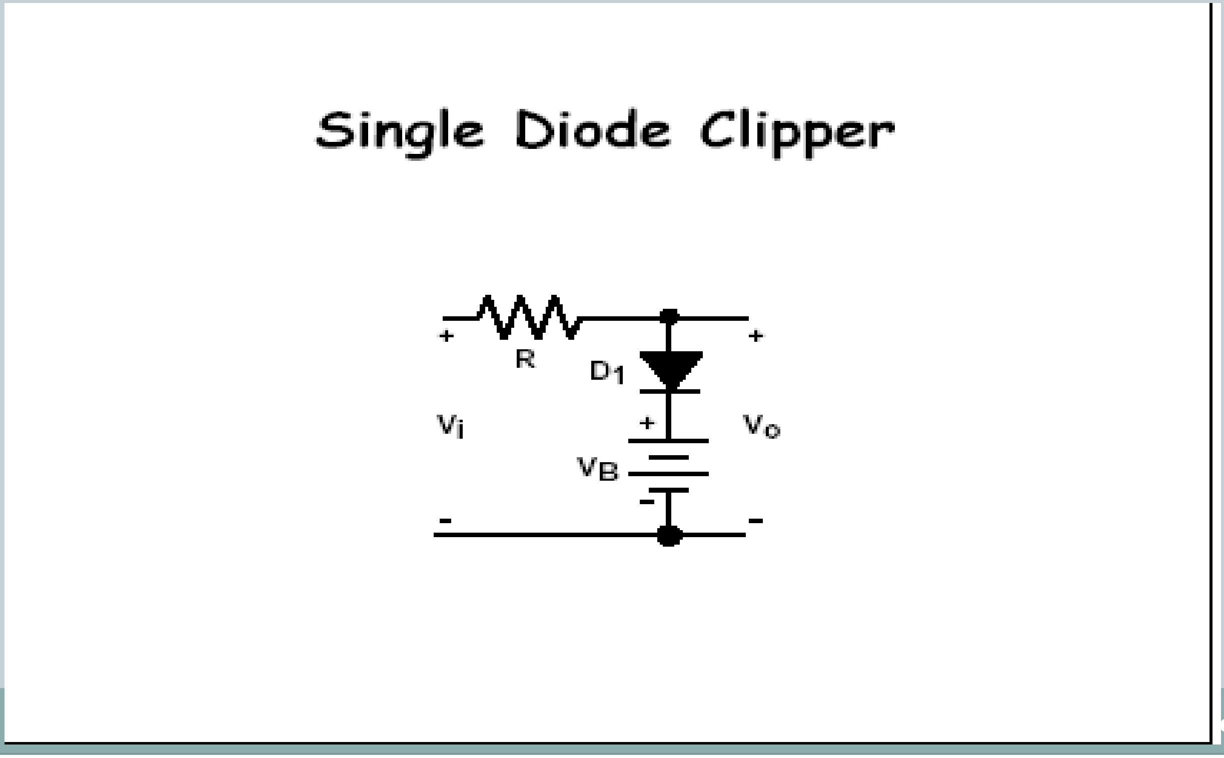
Diode Clampers

A clamper (or dc restorer) sets (or restores) the dc reference of a waveform.



Clipper Circuit

Clipper circuits have the ability to 'clip' off a portion of the input signal without distorting the remaining part of the alternating waveform.



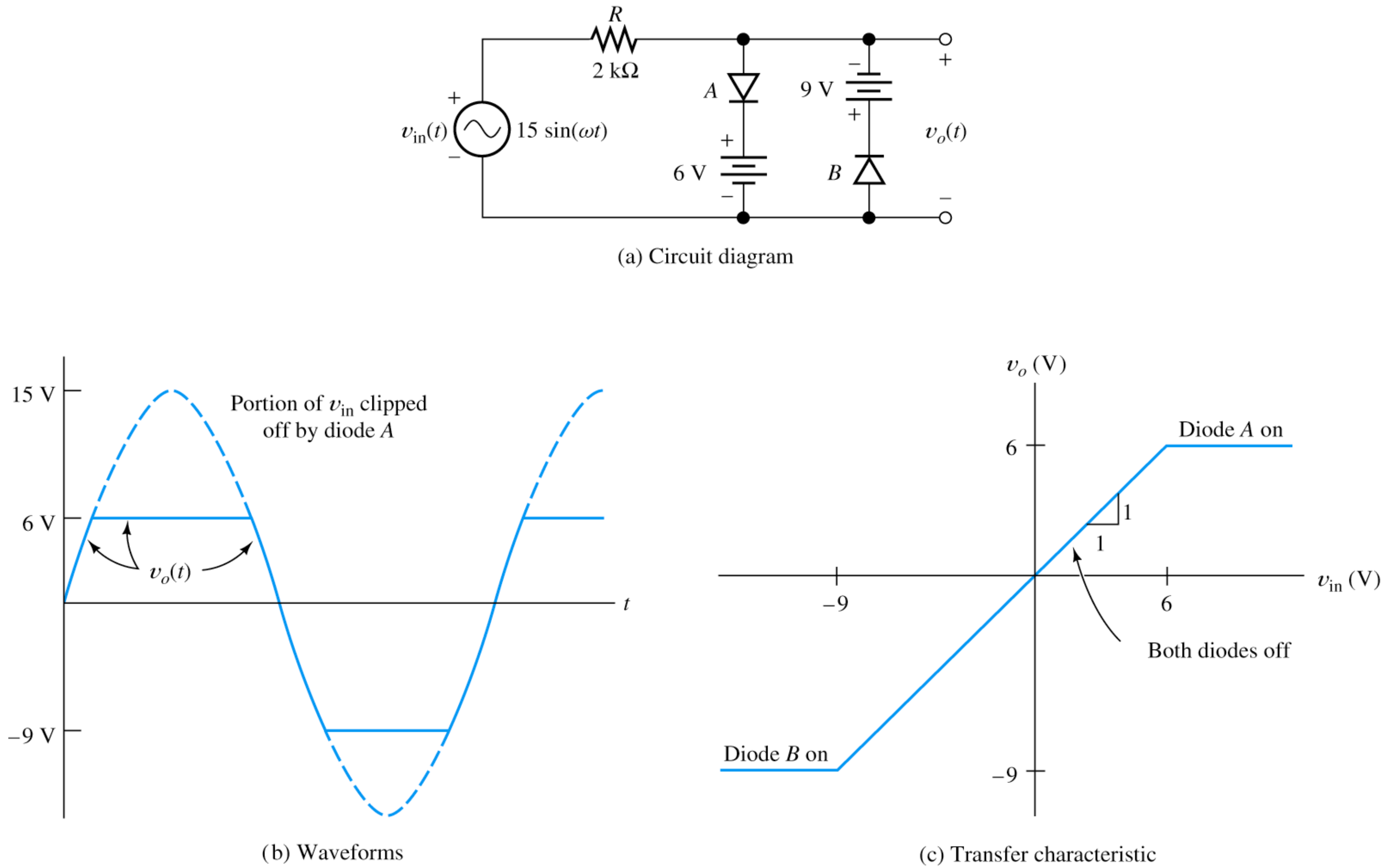


Figure 10.29 Clipper circuit.

Clamper Circuit

Clamper Circuit

The clamping network 'clamp' a signal to different dc level without altering the wave-shape.

The network will have a capacitor, a diode and a resistive element.

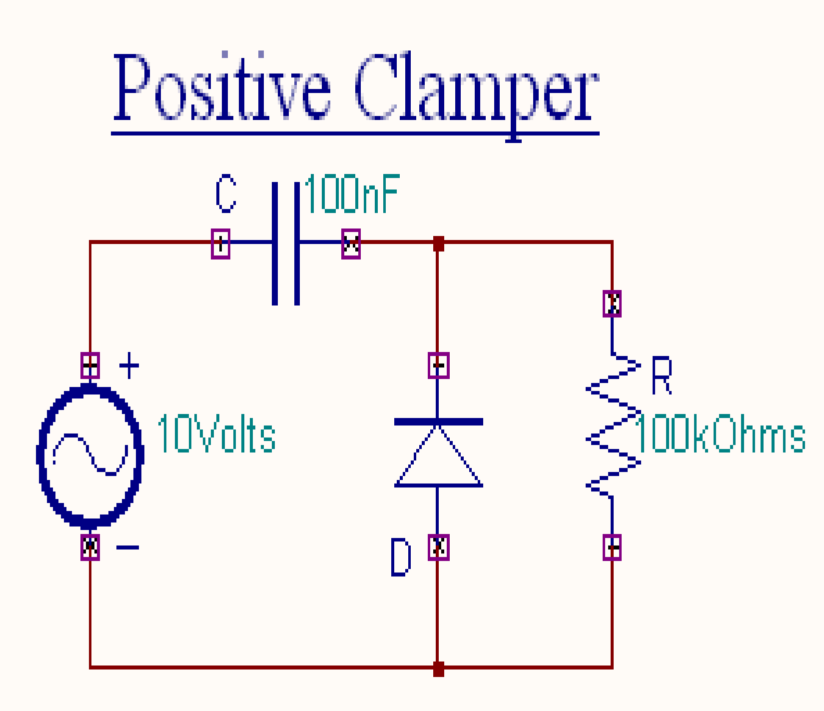
The magnitude of R and C must be chosen such that the time constant $t = RC$ is large enough to ensure that the voltage across the capacitor does not discharge significantly during the interval the diode is non-conducting

Used in TV receivers as a DC restorer

Diode :- Clamper

POSITIVE CLAMPER

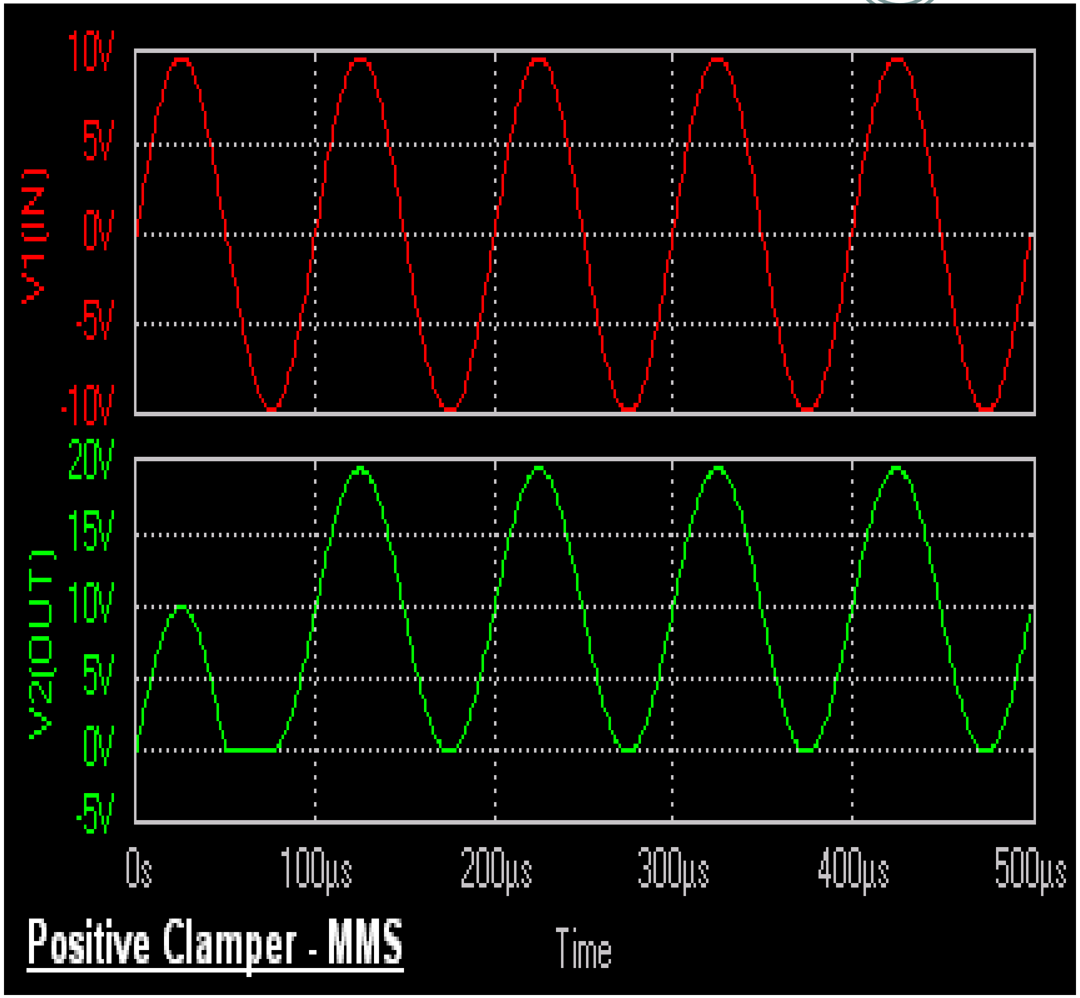
The circuit for a positive clamper is shown in the figure. During the negative half cycle of the input signal, the diode conducts and acts like a short circuit. The output voltage $V_o \Rightarrow 0$ volts . The capacitor is charged to the peak value of input voltage V_m. and it behaves like a battery. During the positive half of the input signal, the diode does not conduct and acts as an open circuit. Hence the output voltage $V_o \Rightarrow V_m + V_m$ This gives a positively clamped voltage.

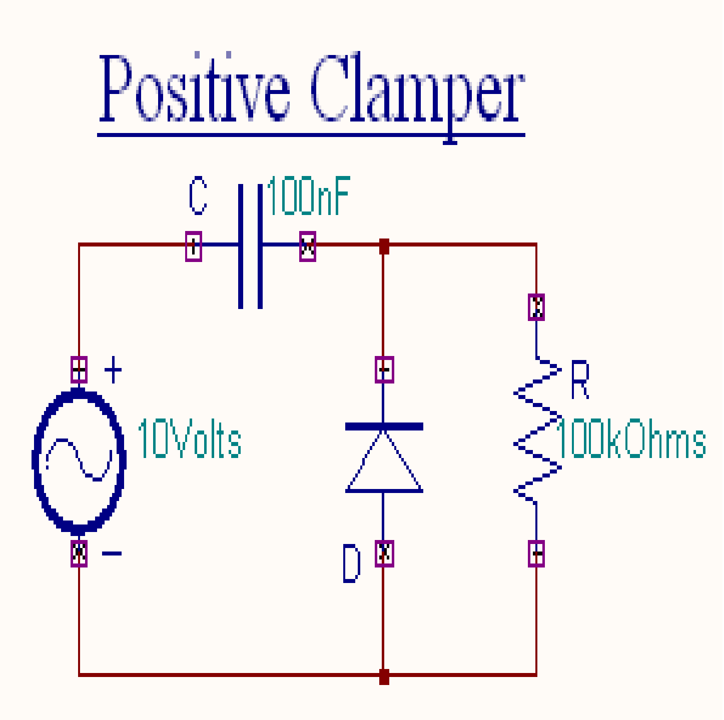


$$V_o \Rightarrow V_m + V_m = 2\,V_m$$

Diode :- Clamper

Positive Clamper

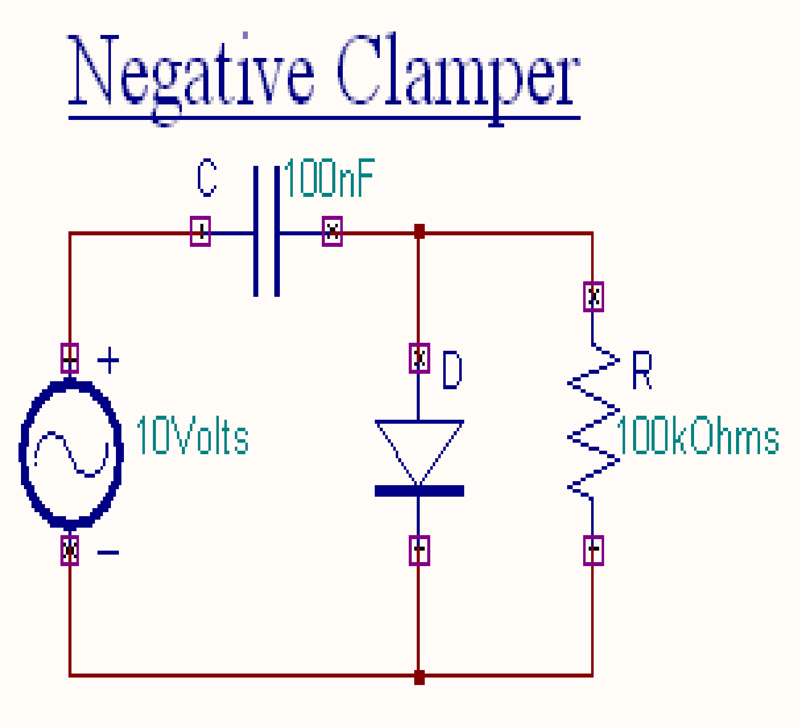




Diode :- Clamper

Negative Clamper

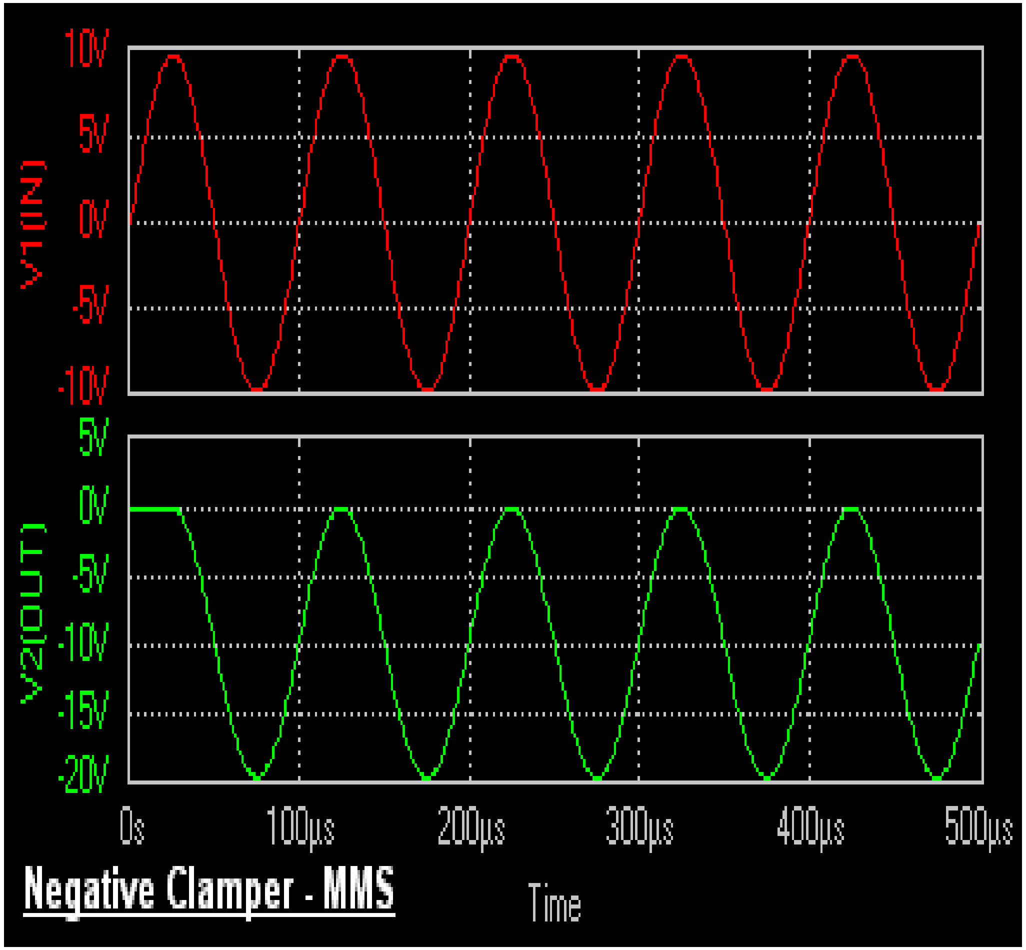
During the positive half cycle the diode conducts and acts like a short circuit. The capacitor charges to peak value of input voltage V_m. During this interval the output *Vo* which is taken across the short circuit will be zero During the negative half cycle, the diode is open. The output voltage can be found by applying KVL.

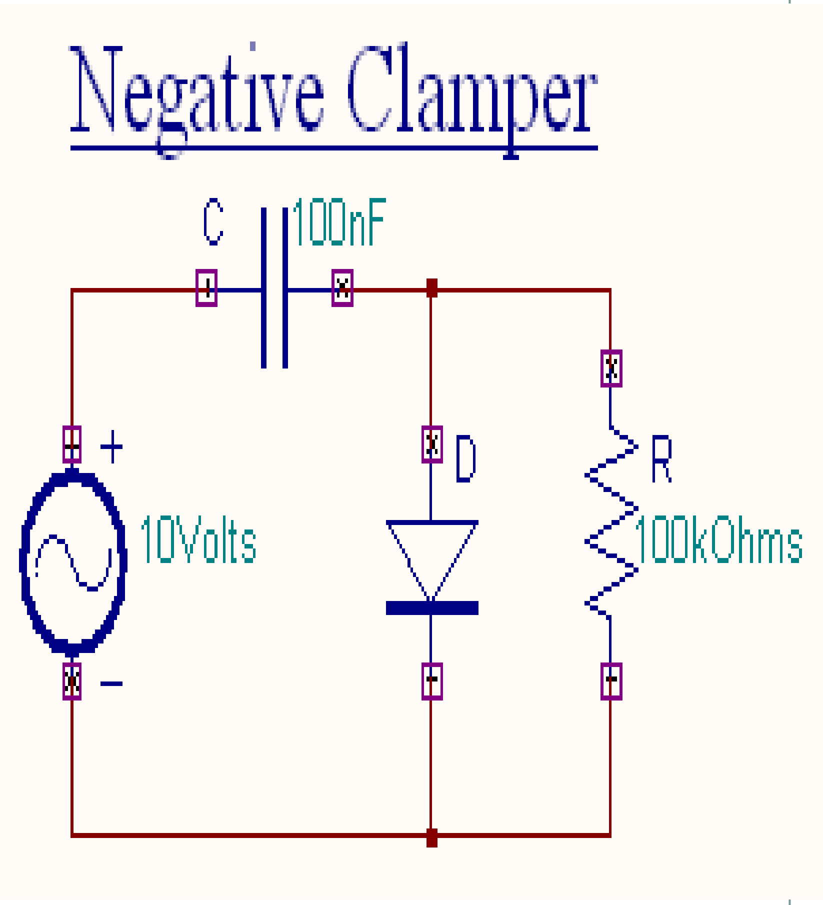


$$-V_m - V_m - V_o = 0 \qquad V_o = -2V_m$$

Diode :- Clamper

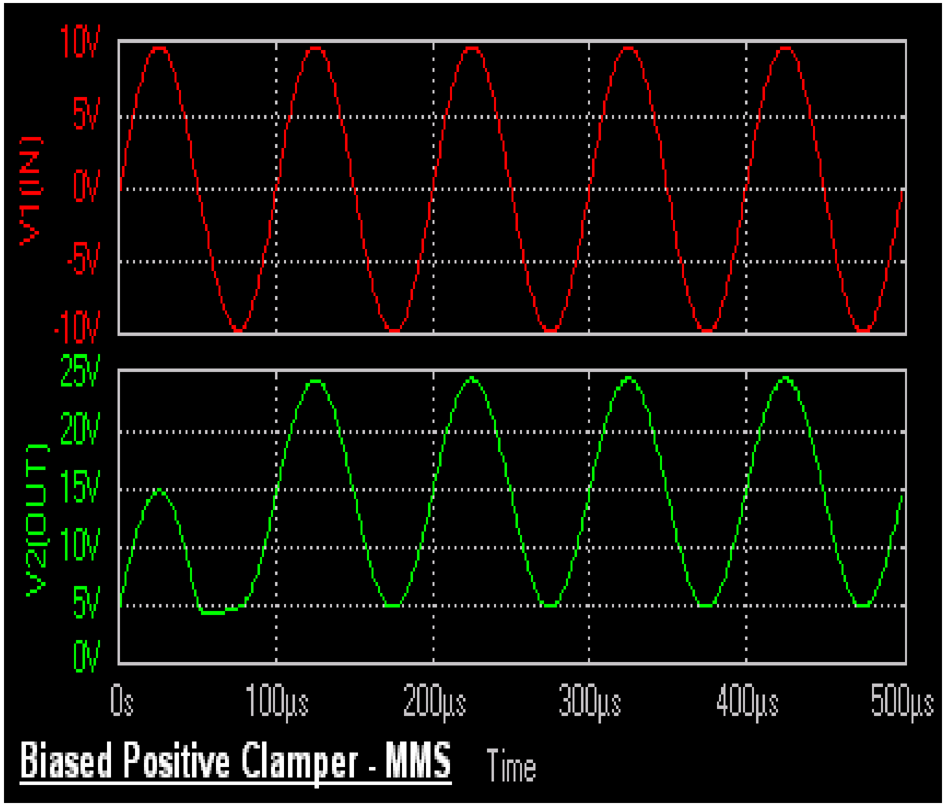
Negative Clamper

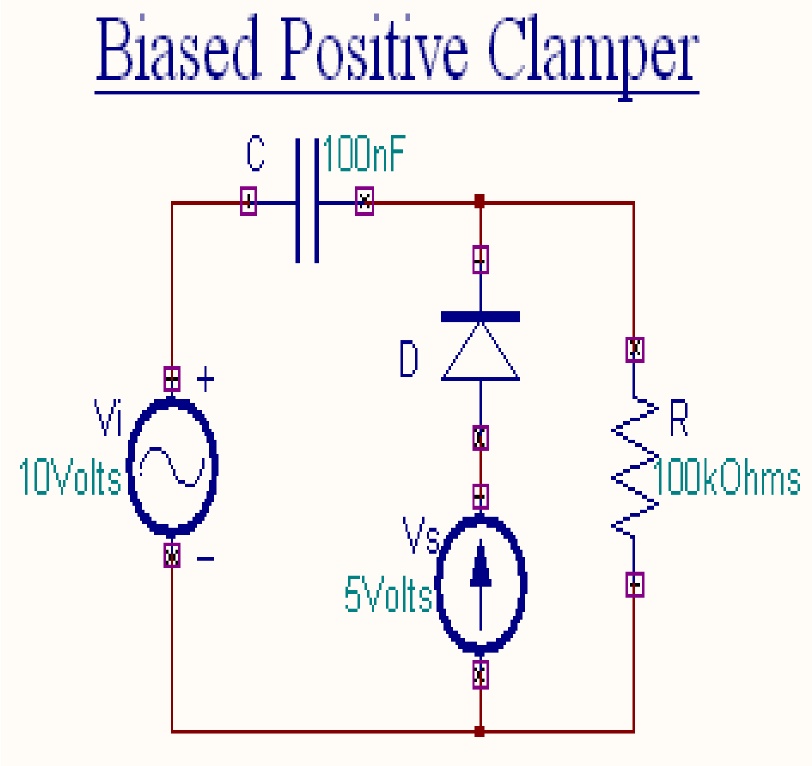




Diode :- Clamper

Biased Clamper





Diode :- Clamper

The circuit of a positively biased clamper is shown in the figure. During the negative half cycle of the input signal the diode is forward biased and acts like a short circuit. The capacitor charges to $V_i + V_s$. Applying the KVL to the input side

$$-V_i + V_c - V_s = 0$$

$$V_c = V_s + V_i$$

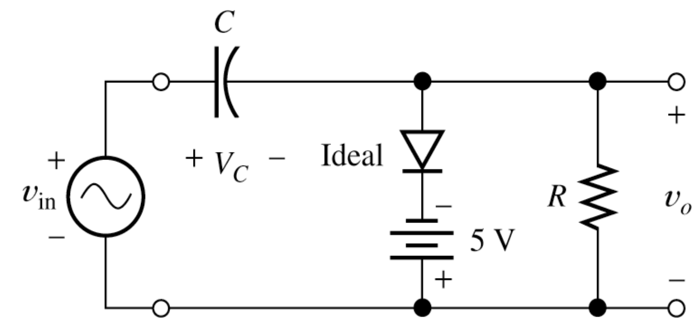
During the positive half cycle of the input signal, the diode is reverse biased and it acts as an open circuit. Hence V_s has no effect on V_o. Applying KVL around the outside loop.

$$V_i + V_c - V_o = 0 \qquad \therefore \quad V_o = V_i + V_c$$

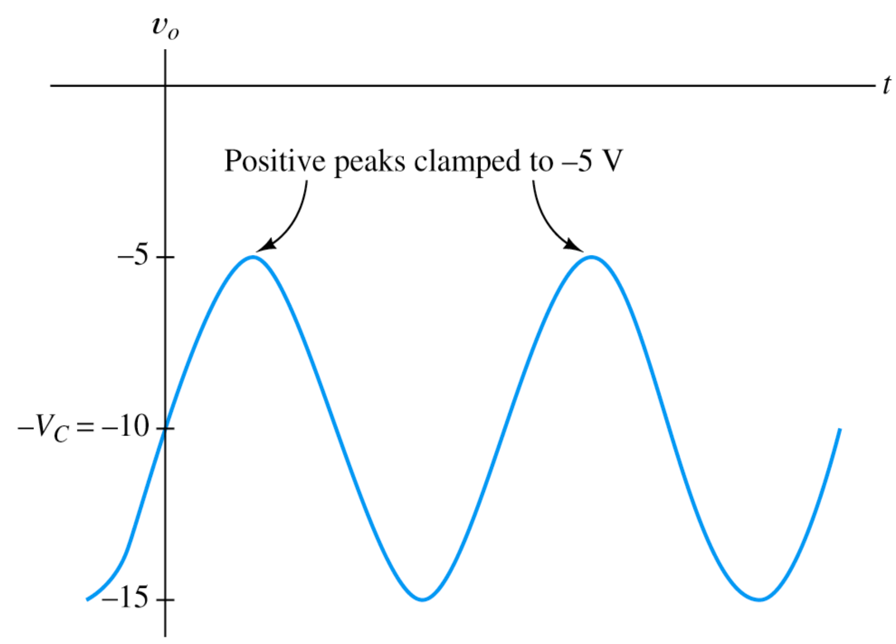
How Does A Clamp Circuit Work?

•In the positive half cycle C gets charged through D to 10V (peak of sine wave + 5 V) with the straight plate of C at a higher potential. D Clips the output to a maximum of -5V.

•In the negative half cycle D is reverse biased. The output can reach a minimum of –15V ($-V_C$ + negative peak of sine wave).



(a) Circuit diagram



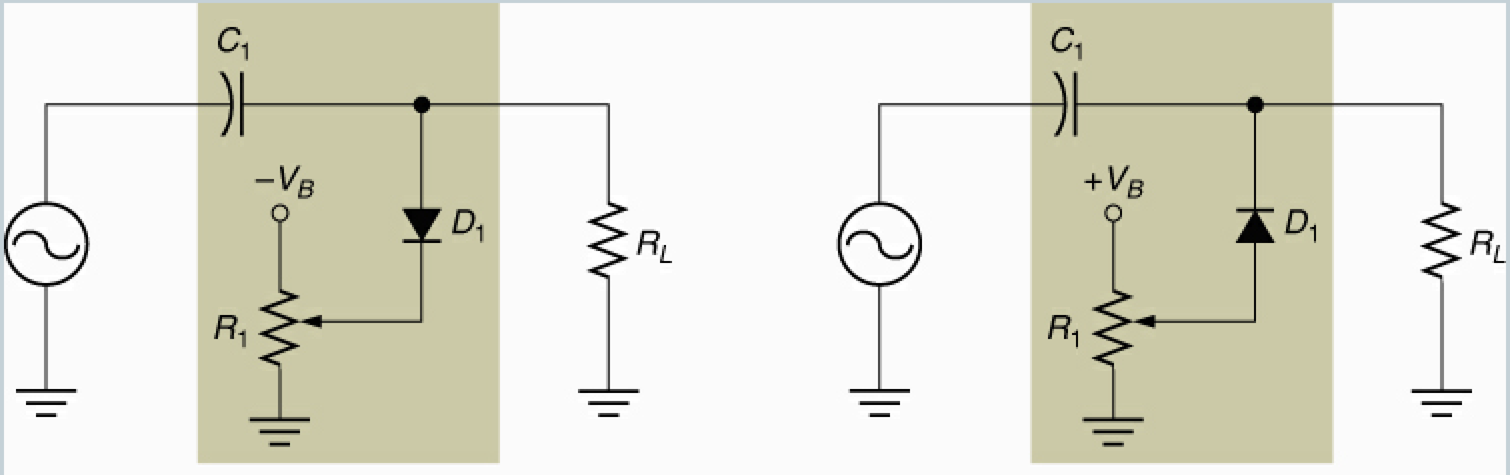
(b) Output waveform for $v_{in} = 5 \sin(\omega t)$

Figure 10.33 Example clamp circuit.

Biased clampers

Biased clampers allow a waveform to shifted above or below a dc reference other than 0 V.

- The dc reference is determined by the biasing voltage (V_B) and the setting of the potentiometer (R_1).

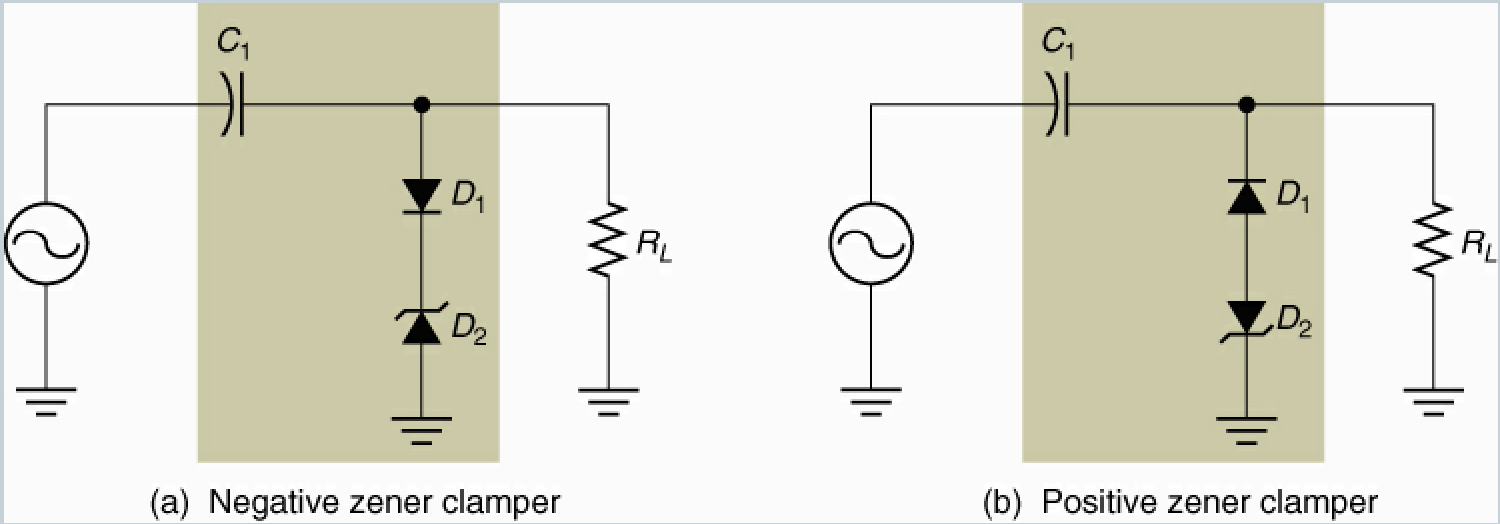


(a) Negative-biased clamper

(b) Positive-biased clamper

Zener clampers

The diodes in (a) are in a common-cathode configuration.
The diodes in (b) are in a common-anode configuration.



Thank You