3. Clippers:

Clipper is the network that has the ability to clip off a portion of the input signal without distorting the remaining part.

3.1 Series Clipper:

The diode is in the series with load as shown in Figure (3.1).

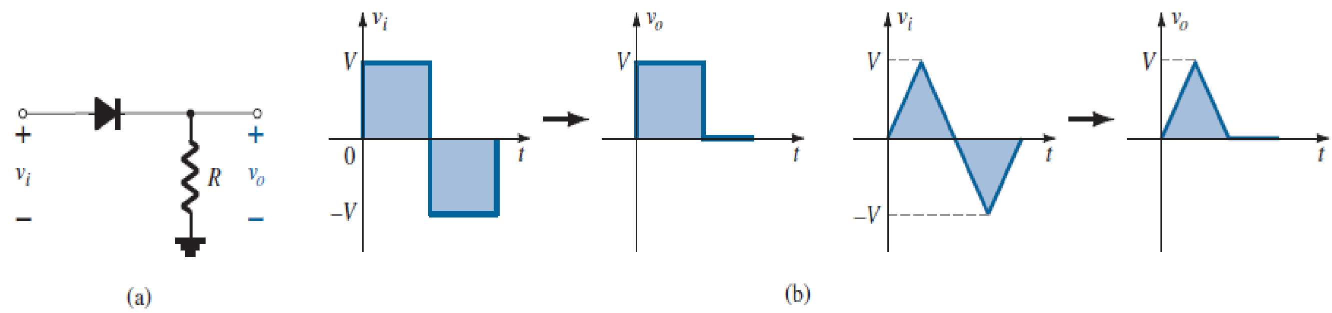
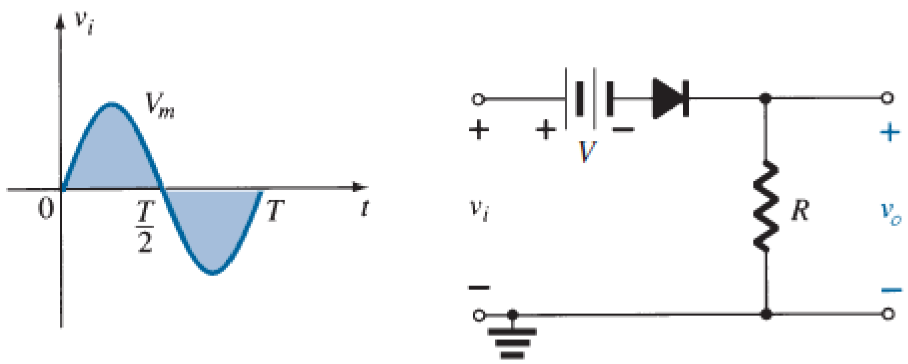


Figure (3.1): Series clipper.

The addition of a DC supply can have a clear effect on the output of a clipper.



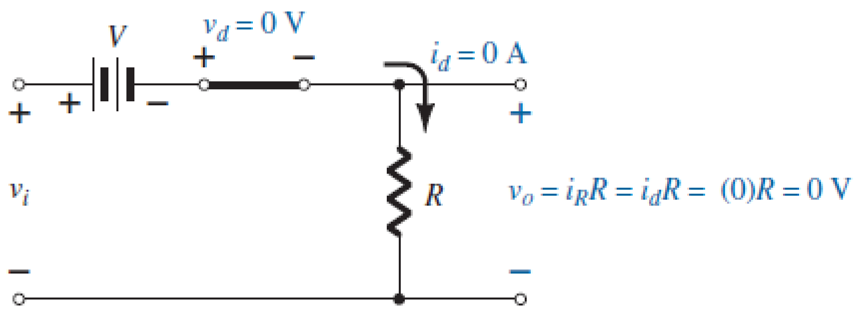
1. Determine the applied voltage (**transition voltage**) that will cause a change in state for the diode. Applying the condition:

$$\boldsymbol{I_D = 0 \; at \; V_D = 0}$$

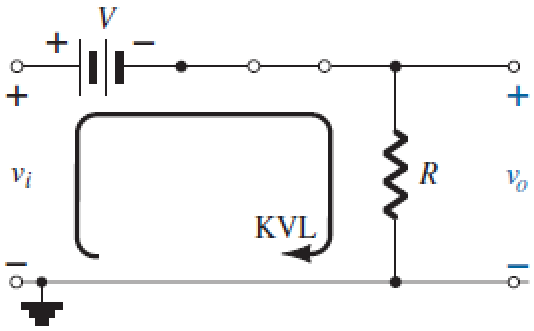
The level of V_i that will cause a transition in state is:

$$V_i = V_{DC}$$

For **an input voltage greater than V_{DC} volts** the diode is in the **short-circuit state**, while for **input voltages less than V_{DC} volts** it is in the **open-circuit state or (off state).**



2. Defined terminals and polarity of V_o when the diode is in the **short circuit state**, the output voltage V_o can be determined by using **KVL**.

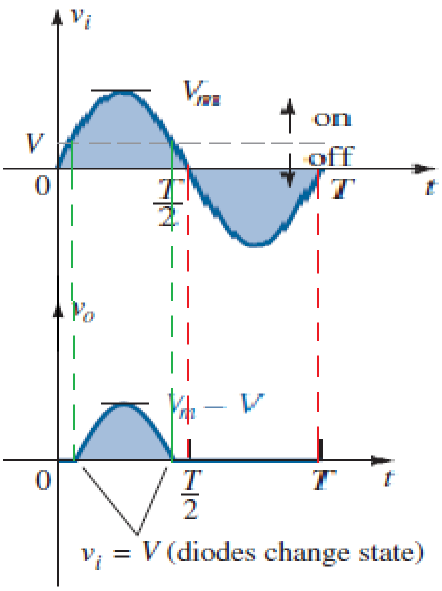


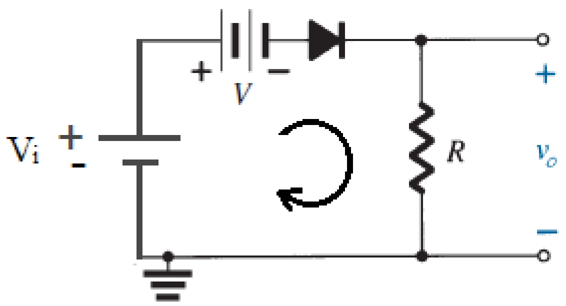
$$V_i - V - V_o = 0 \quad \text{(CW direction)}$$

$$\text{And } V_o = V_i - V$$

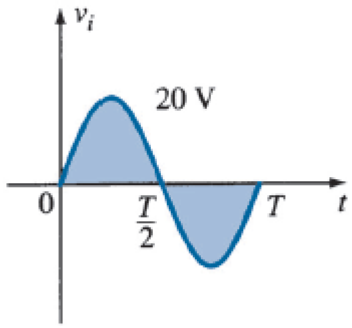
3. Sketch the input signals above the output and determine the output at instantaneous values of the input by using the formula for each case.

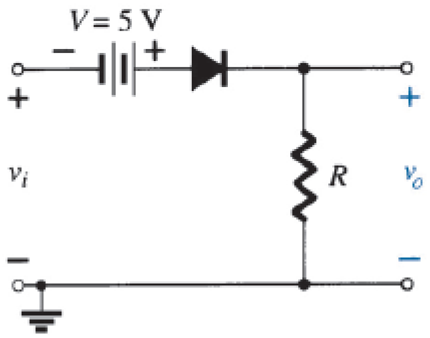
   Keep in mind that at an instantaneous value of V_i the input can be treated as a DC supply of that value and the corresponding DC (the instantaneous) value of the output determined.





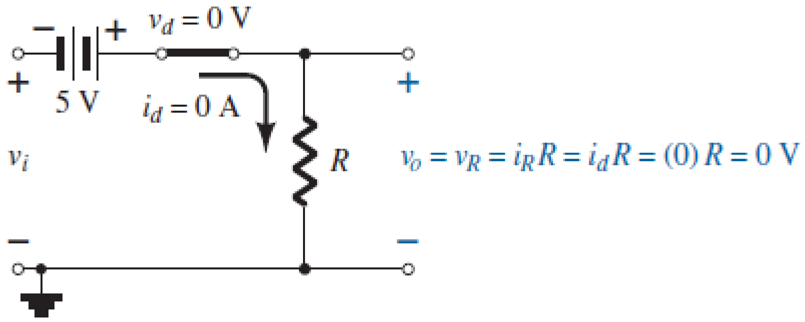
Example1: Determine the output waveform for the network of Figure below.





Solution:

Substituting $\mathbf{I_D = 0}$ at $V_D = 0$ for the **transition voltage**, we obtain the network of Figure below.



$$V_i + V - V_D - V_o = 0 \;\Rightarrow V_i + 5v - 0 - 0 = 0$$

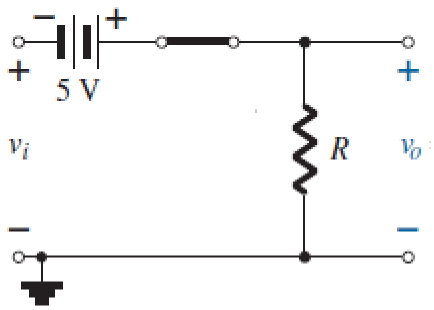
$$\therefore V_i = -5v$$

For **voltages greater than transition voltage**, the diode is in the **short-circuit state** as shown in Figure below.

$$V_i + V - V_D - V_o = 0$$

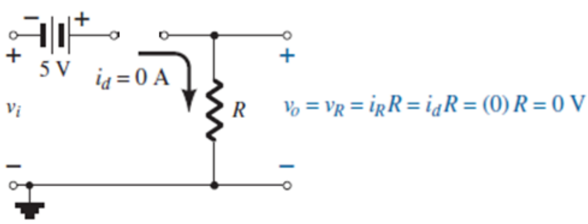
$$V_i + 5 - 0 - V_o = 0$$

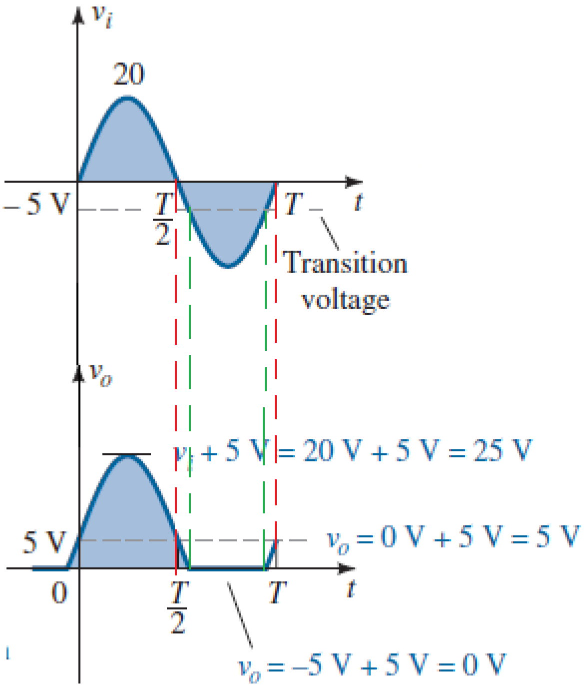
$$\therefore V_o = V_i + 5$$



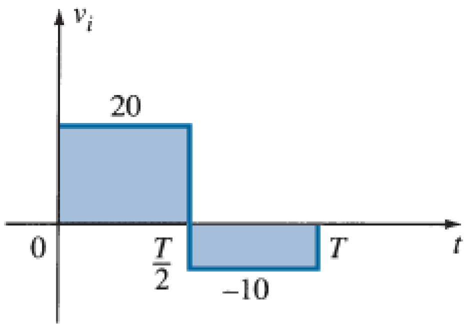
For **voltages less than transition voltage**, the diode will enter its **open-circuit state**,

$$V_o = 0v$$

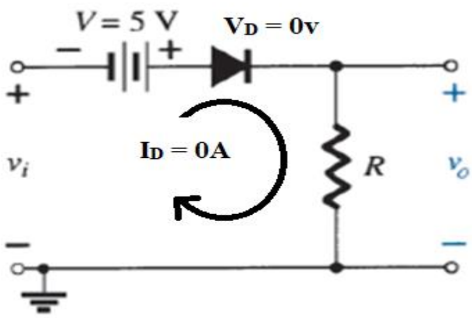




Example2: Find the output voltage for the network examined in Example1 if the applied signal is the square wave of Figure below.



Solution:

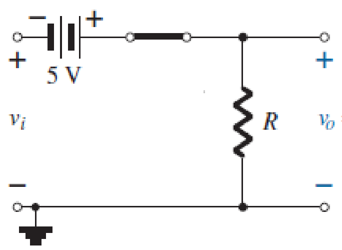


Substituting $\mathbf{I_D = 0}$ at $V_D = 0$ for **the transition voltage**:

$V_i + V - V_D - V_o = 0 \Rightarrow V_i + 5v - 0 - 0 = 0$

$\therefore V_i = -5v$

For **voltages greater than transition voltage**, the diode is in the **short-circuit state** as shown in Figure below.



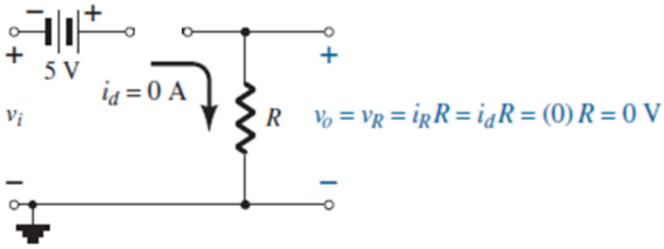
$V_i + V - V_D - V_o = 0$

$V_i + 5 - 0 - V_o = 0$

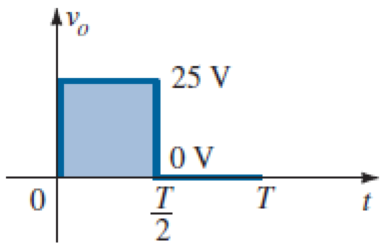
$\therefore V_o = V_i + 5$

For **voltages less than transition voltage**, the diode will enter its **open-circuit state**,

$V_o = 0v$



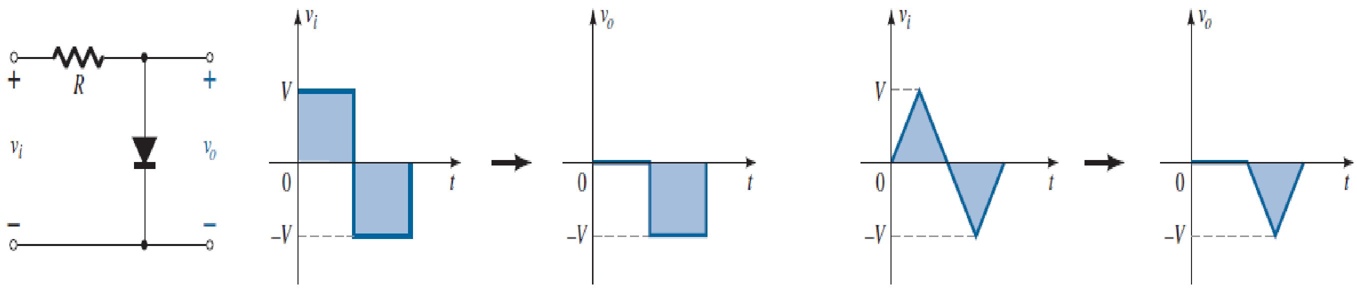
The resulting output voltage appears in Figure below.



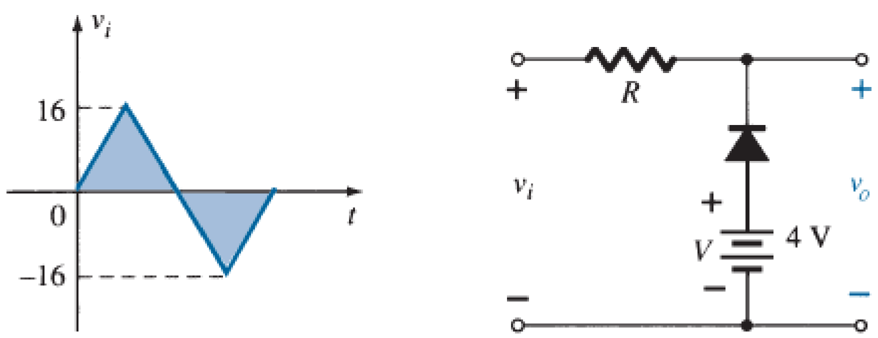
Note: The clipper not only clipped off 5volt from the total swing but raised the DC level of the signal by 5volt.

3.2 Parallel Clipper:

The diode is in the parallel to the load as shown in the Figure (3.2).



Example3: Determine the output waveform for the network of Figure below.



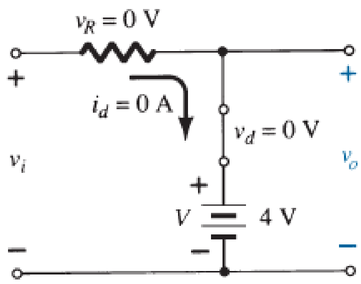
Solution:

The condition $\mathbf{I_D = 0A}$ at $V_D = 0v$ has been imposed.

The result is:

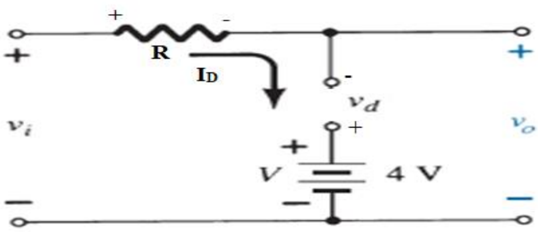
$V_i - V_R + V_D - V = 0 \Rightarrow V_i - 0 + 0 - 4v = 0$

$\therefore V_i(transition) = 4v$



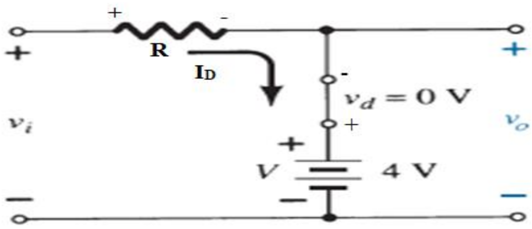
For **voltages greater than transition voltage,** the diode is in the **open-circuit state** as shown in Figure below.

$V_o = V_i$

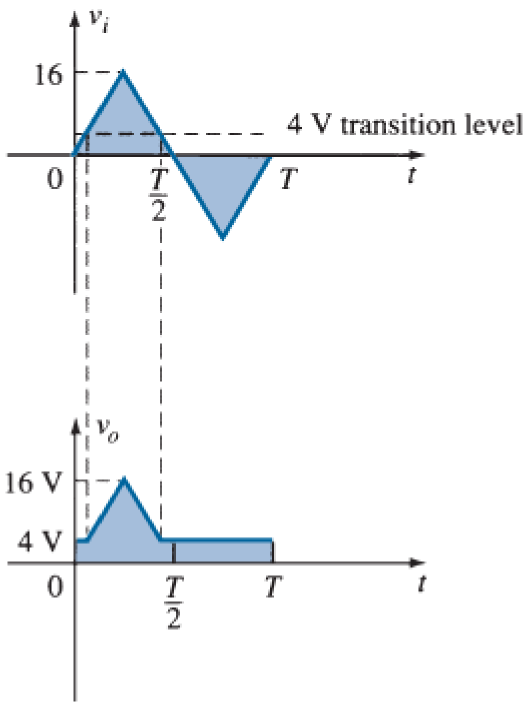


For **voltages less than transition voltage,** the diode will enter its **short-circuit state**,

$V_o = V - V_D = 4v - 0 = 4v$



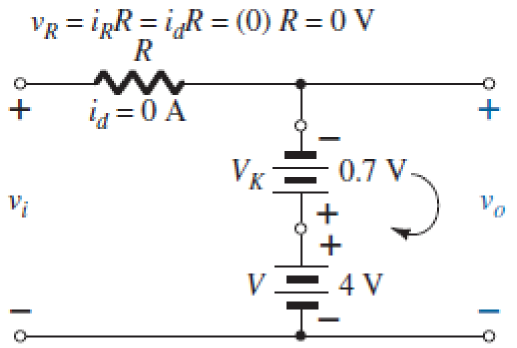
Completing the sketch of V_o results in the waveform of Figure below.



Example4: Repeat Example3 using a silicon diode with V_T = 0.7 V.

Solution:

The **transition voltage** can first be determined by applying the condition **I_D = 0 A** at V_D = 0.7 V and obtaining the network of Figure below.



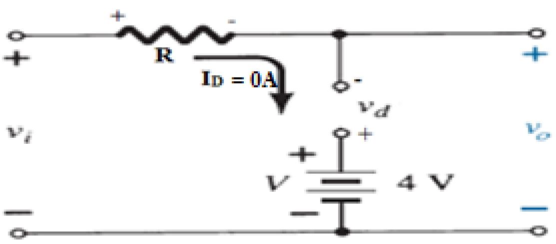
Applying Kirchhoff's voltage law around the output loop in the clockwise direction, we find:

$V_i - V_R + V_D - V = 0 \;\Rightarrow V_i - 0 + 0.7v - 4v = 0$

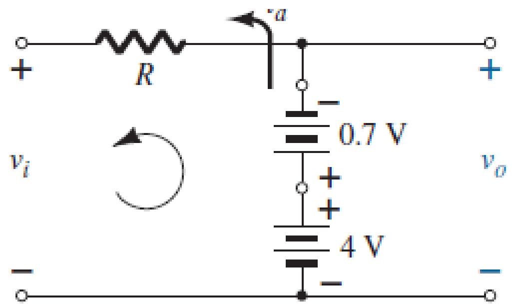
$\therefore V_i(transition) = 4v - 0.7v = 3.3v$

For **input voltages greater than 3.3 volts**, the diode will be an **open circuit** and:

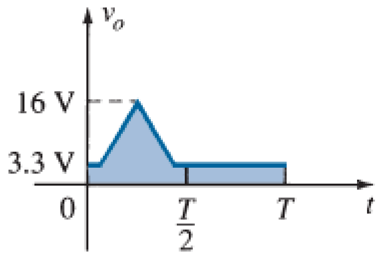
$V_o = V_i$



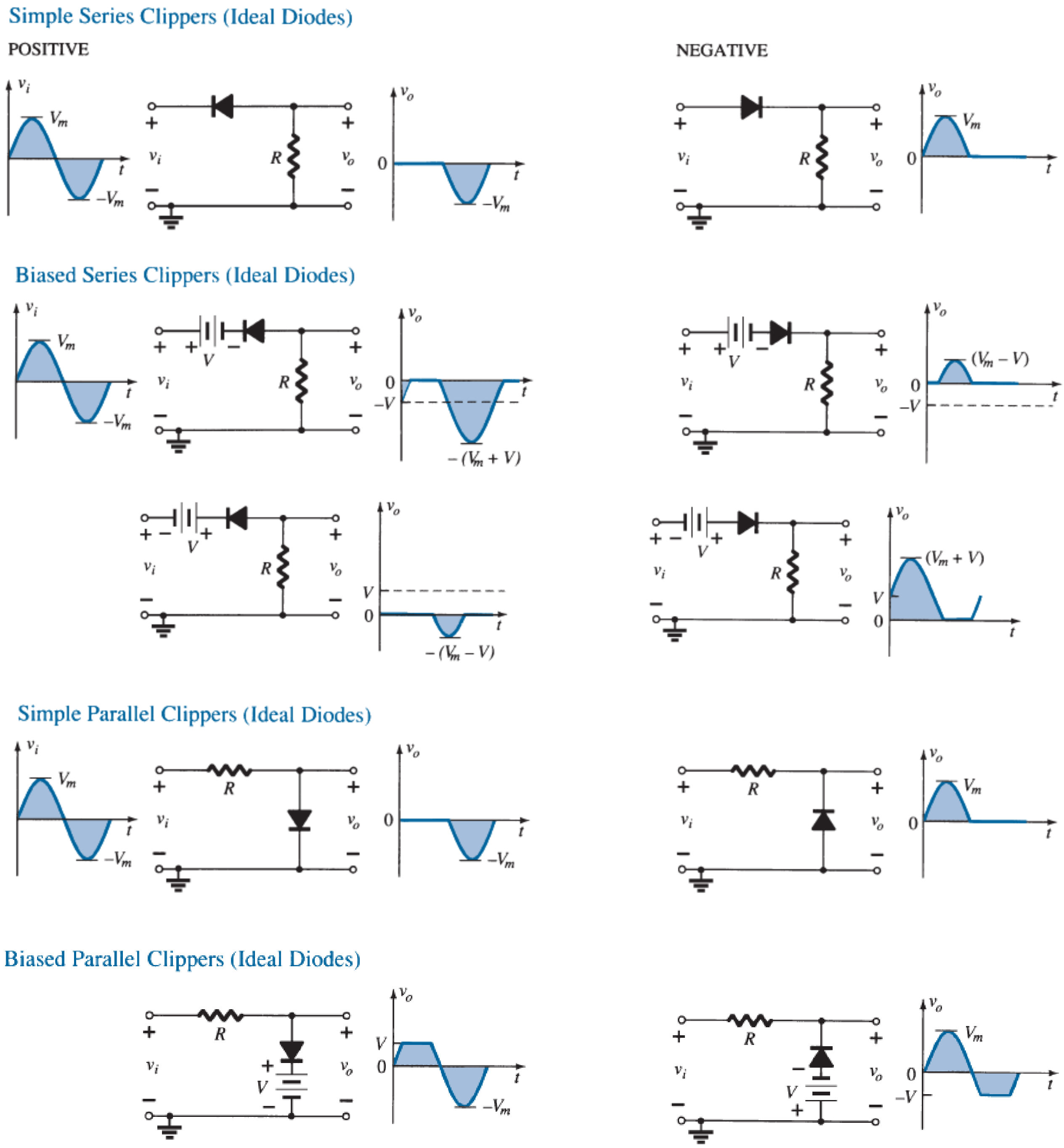
For **input voltages less than 3.3 volts**, the diode will be in the (**on state**) as shown in Figure below: $V_o = 4v - 0.7v = 3.3v$



The resulting output waveform appears in Figure below note that the only effect of V_T was to drop the (on state) level to 3.3v from 4v.



A variety of series and parallel clippers with the resulting output for the sinusoidal input are provided in Figure (3.3).



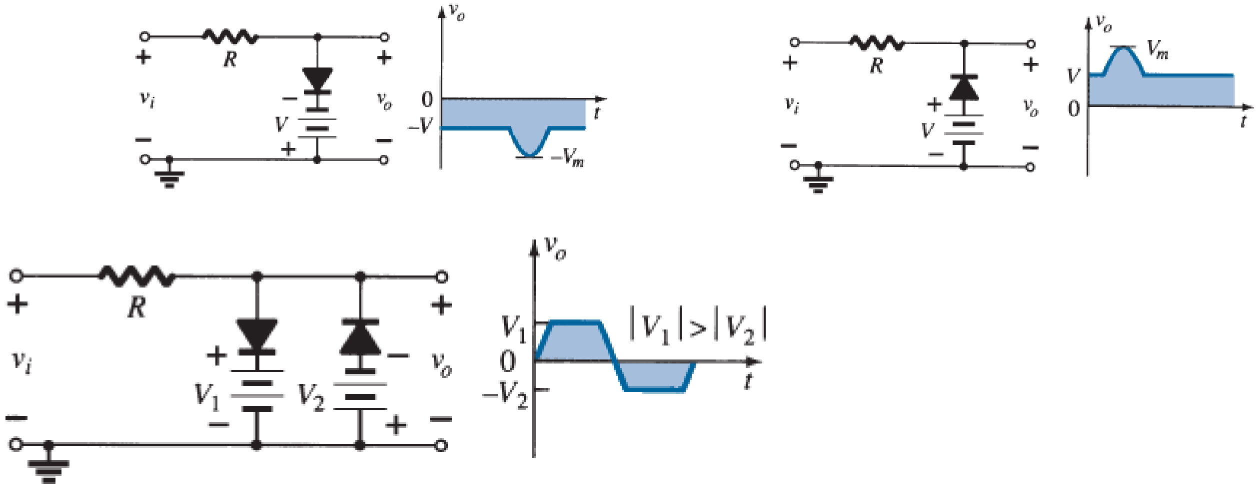


Figure (3.3): Clipping Circuits.