Electronic Devices

Mid Term
Lecture - 05

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Reference book:

Electronic Devices and Circuit Theory (Chapter-2)

Robert L. Boylestad and L. Nashelsky , (11th Edition)

Objectives

- Be able to predict the output response of a clipper and clamper diode configuration.

CLIPPERS

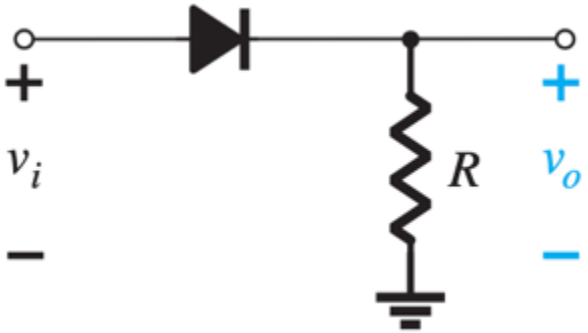
- Clippers are networks that employ diodes ***to "clip" away a portion of an input signal without distorting the remaining part*** of the applied waveform.

- The **half-wave rectifier** is an example of the simplest form of diode clipper- one resistor and a diode. Depending on the orientation of the diode, the positive or negative region of the applied signal is "clipped" off.

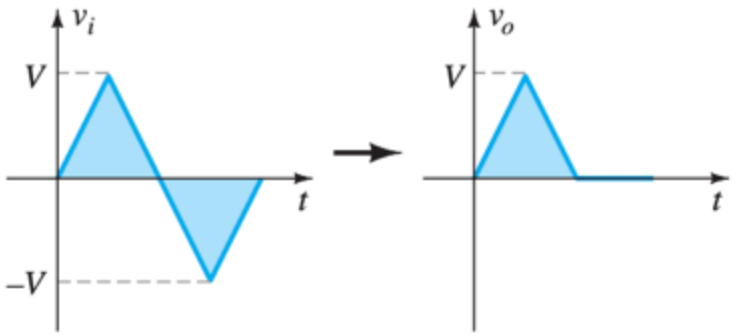
- There are two general categories of clippers: ***series and parallel***.

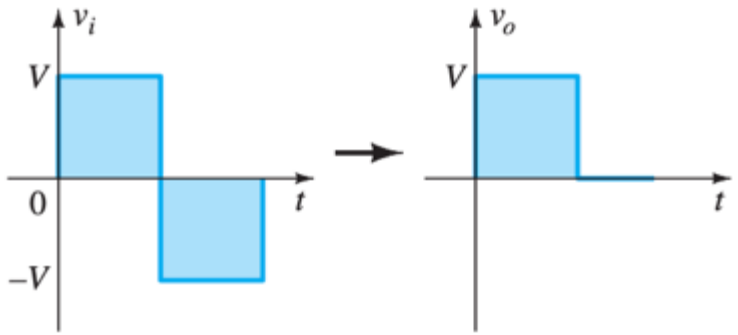
- The series configuration is defined as one where the ***diode is in series with the load***, whereas the parallel variety has the ***diode in a branch parallel to the load***.

CLIPPERS: SERIES



***Diode is in series with the load*.**





Series Clipper with a dc supply

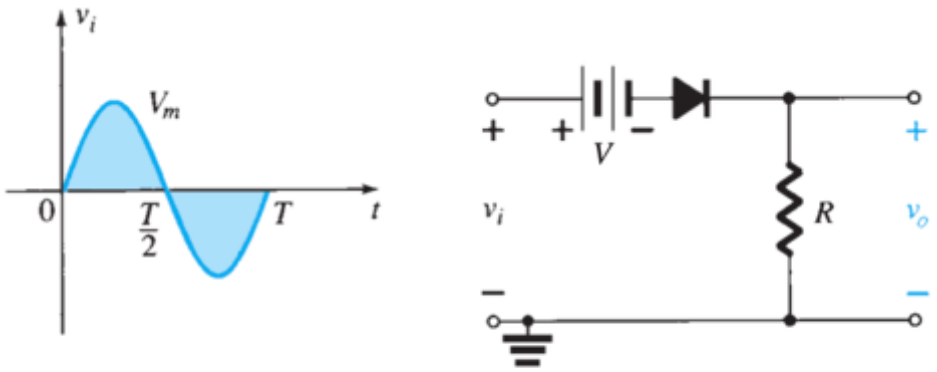


FIG. 2.69

Series clipper with a dc supply.

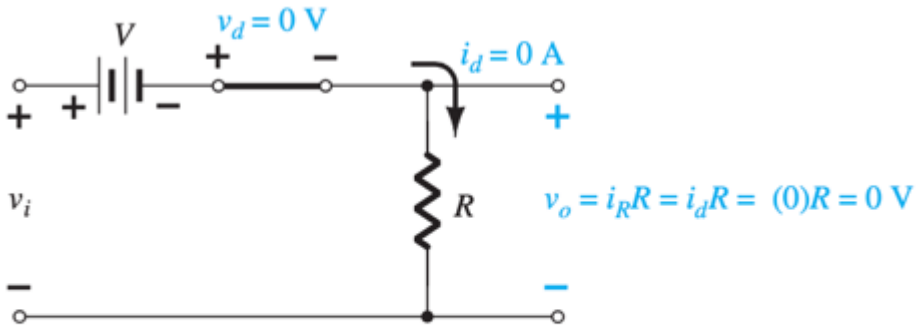


FIG. 2.70

Determining the transition level for the circuit of Fig. 2.69.

CLIPPERS: SERIES

Use transition voltage to define "on" and "off" regions

Draw the output waveform directly below the applied voltage using the same scales for the horizontal axis and the vertical axis.

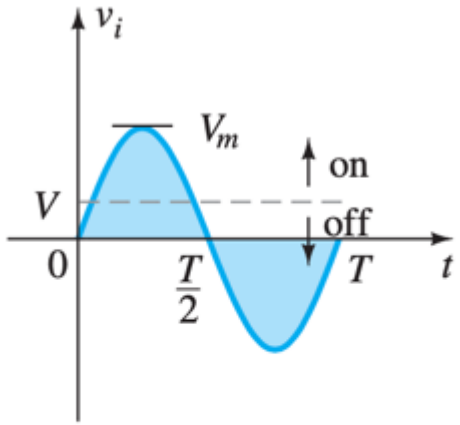


FIG. 2.71

Using the transition voltage to define the "on" and "off" regions.

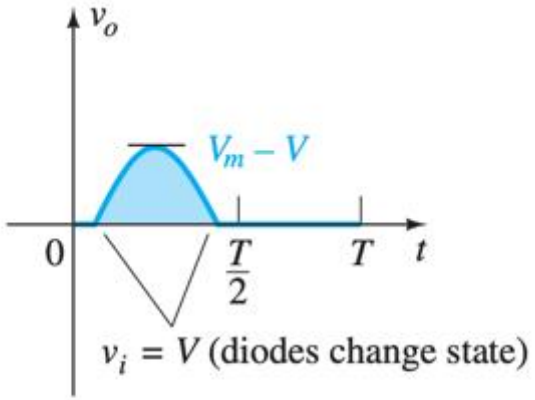


FIG. 2.73

Sketching the waveform of v_o using the results obtained for v_o above and below the transition level.

Negative half cycle clipped away in output waveform

CLIPPERS: SERIES

EXAMPLE 2.18 Determine the output waveform for the sinusoidal input of Fig. 2.74.

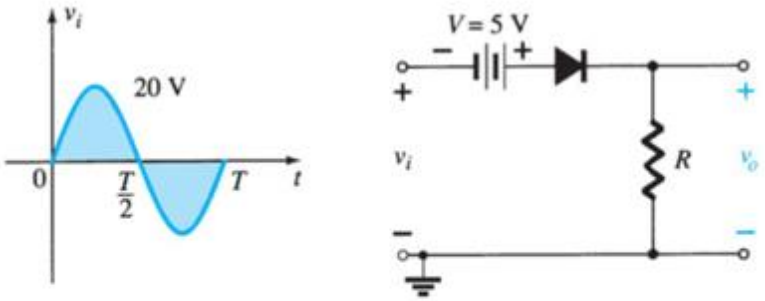
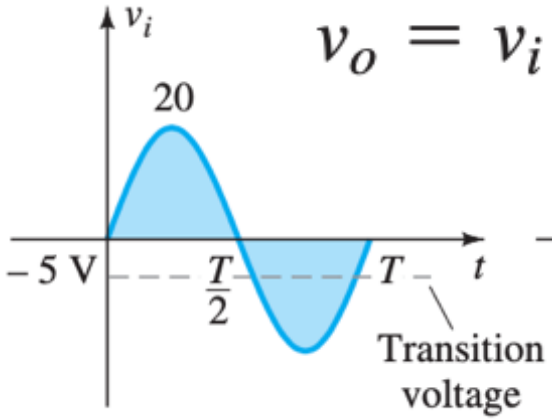
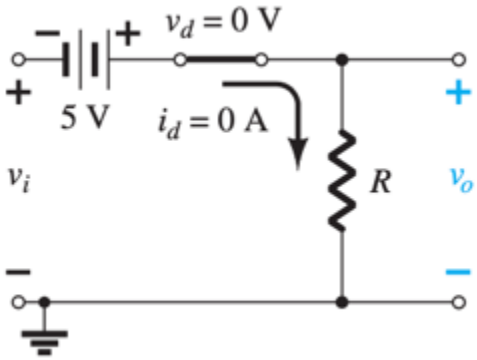


FIG. 2.74
Series clipper for Example 2.18.



$$v_o = v_i + 5\text{ V}$$

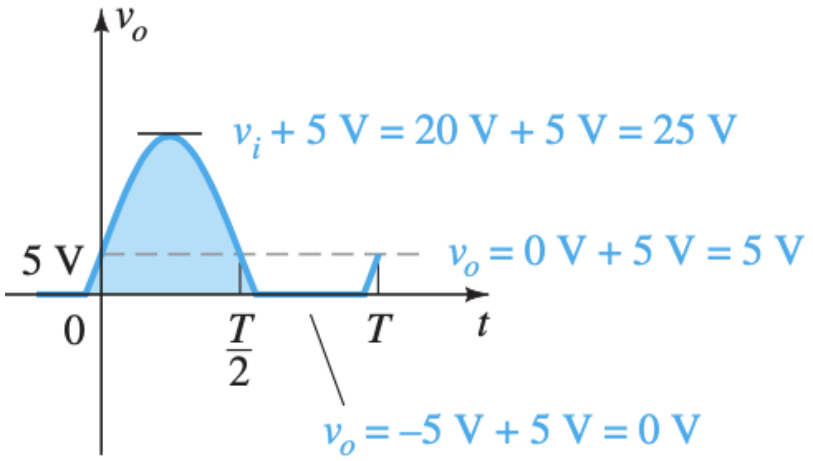
Determine transition level



$$v_i + 5\text{ V} = 0\text{ V}$$

$$v_i = -5\text{ V}$$

$$v_o = v_R = i_R R = i_d R = (0)\,R = 0\text{ V}$$



CLIPPERS: SERIES

EXAMPLE 2.19 Find the output voltage for the network examined in Example 2.18 if the applied signal is the square wave of Fig. 2.77.

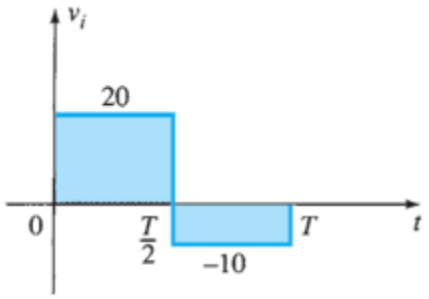
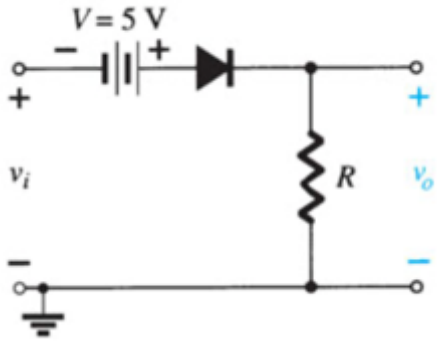


FIG. 2.77
Applied signal for Example 2.19.



For v_i = 20 V (0 --> $T/2$) the network results,

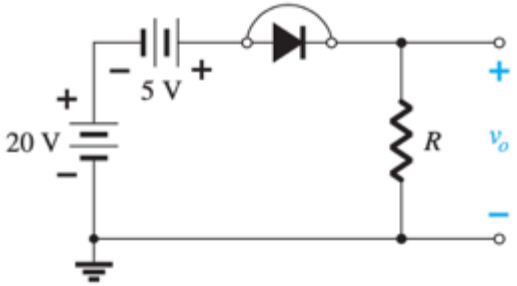


FIG. 2.78
v_o *at* $v_i = +20$ *V.*

The diode is in the short-circuit state.

$$v_o = 20V + 5V = 25V$$

For v_i = -10 V (T/2 --> T) the network results,

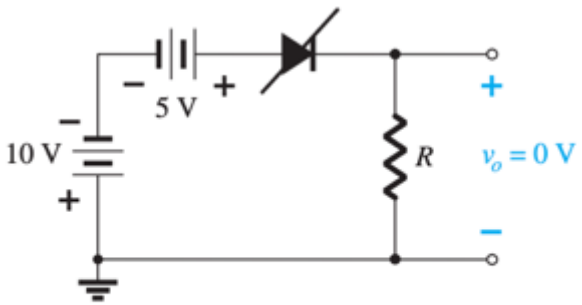


FIG. 2.79
v_o at $v_i = -10$ V.

The diode is in the "*off*" state.

$$v_o = i_R R = (0)R = 0 \text{ V}$$

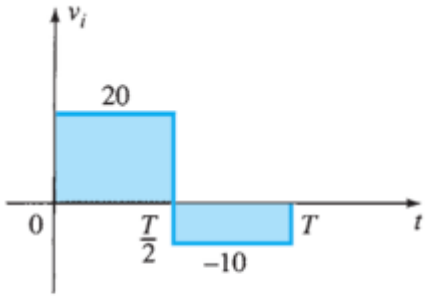


FIG. 2.77
Applied signal for Example 2.19.

The resulting output voltage corresponds to input voltage appears as:

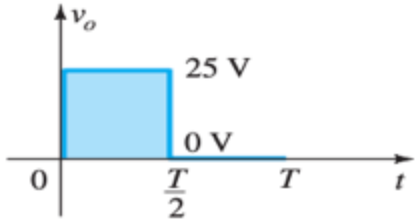
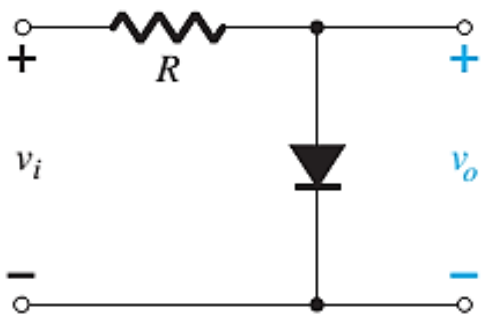
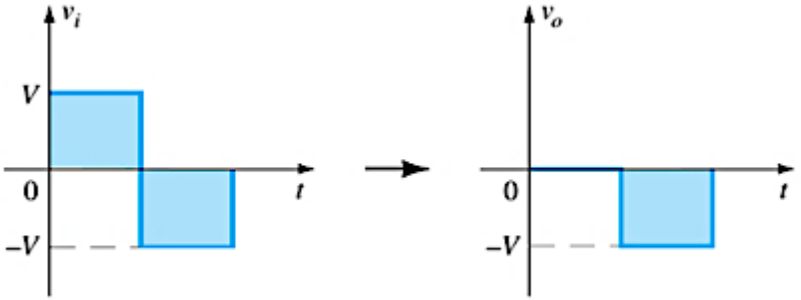


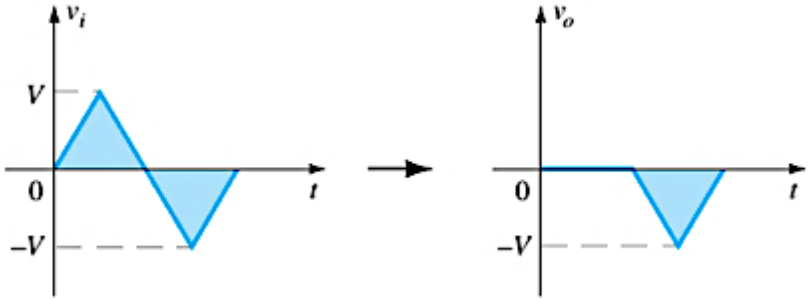
FIG. 2.80
Sketching v_o for Example 2.19.

CLIPPERS: PARALLEL



Diode in a branch parallel to the load.





CLIPPERS: PARALLEL

EXAMPLE 2.20 Determine v_o for the network of Fig. 2.82.

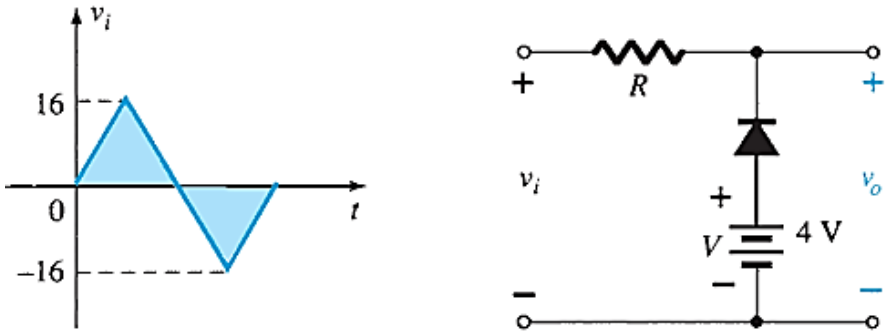


FIG. 2.82
Example 2.20.

Determine output across the series combination of the diode and the 4-V supply

Determine transition level of input voltage.

$$v_i = 4\,\text{V}$$

Condition:

- ***Replace circuit with short-circuit equivalent.***
- ***Diode current is 0 mA.***

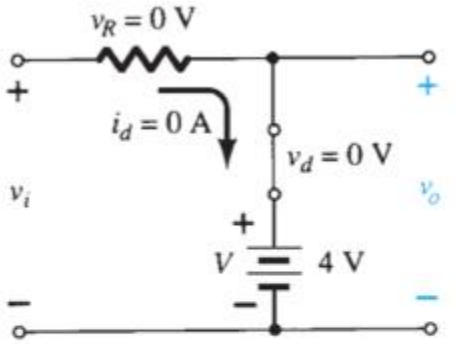


FIG. 2.83
Determining the transition level for Example 2.20.

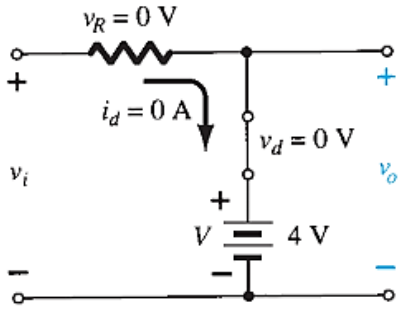


FIG. 2.83
Determining the transition level for Example 2.20.

For $v_i \geq 4V$, diode is **on**.

$$v_o = 4V$$

For $v_i < 4V$, diode is **off**.

$$v_o = v_i$$

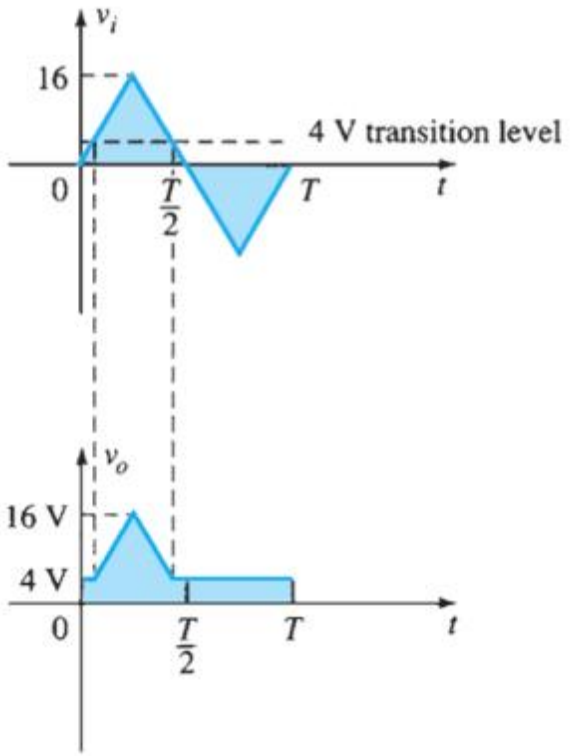
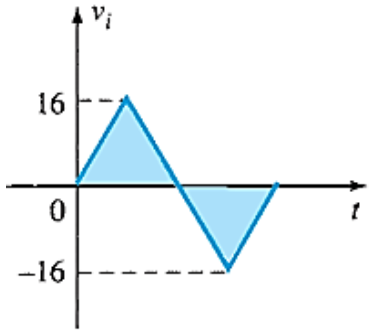
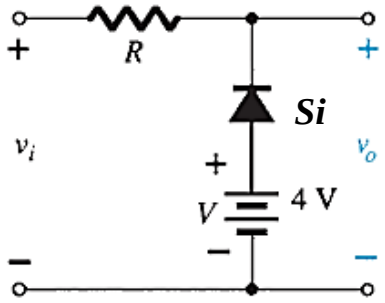


FIG. 2.84
Sketching v_o for Example 2.20.

CLIPPERS: PARALLEL

EXAMPLE 2.21 Repeat Example 2.20 using a silicon diode with $V_K = 0.7$ V.





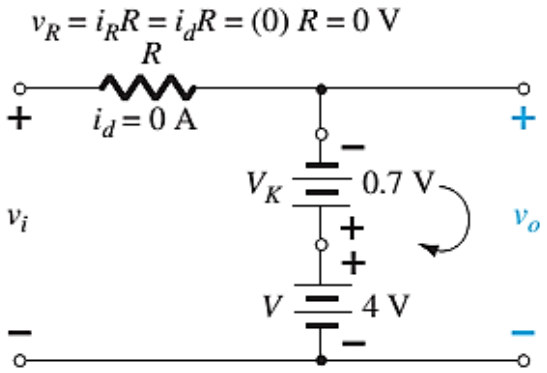


FIG. 2.85
Determining the transition level for the network of Fig. 2.82.

Determine transition level of input voltage.

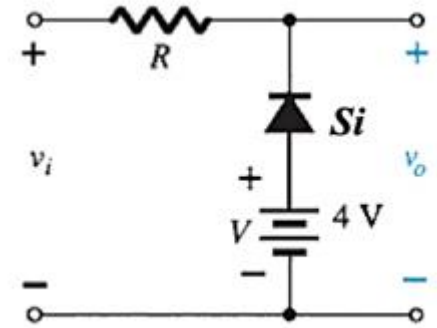
Condition:

- ***Replace circuit with diode equivalent circuit.***
- ***Diode current is 0 mA.***

Applying KVL around output loop in clockwise direction,

$$v_i + V_K - V = 0$$

$$v_i = V - V_K = 4\text{ V} - 0.7\text{ V} = \mathbf{3.3\text{ V}}$$



For $v_i > 3.3V$, I_D direction is counter-clockwise.
Diode is **off**.

$$\boldsymbol{v_o = v_i}$$

For $v_i \leq 3.3V$, I_D direction is counter-clockwise
Diode is **on**.

$$\boldsymbol{v_o = 4\,V\ - 0.7\,V = 3.3\,V}$$

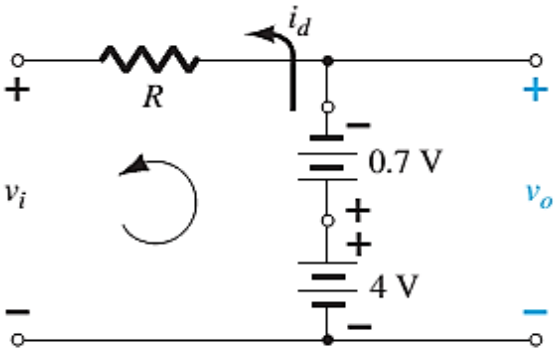


FIG. 2.86
Determining v_o for the diode of Fig. 2.82 in the "on" state.

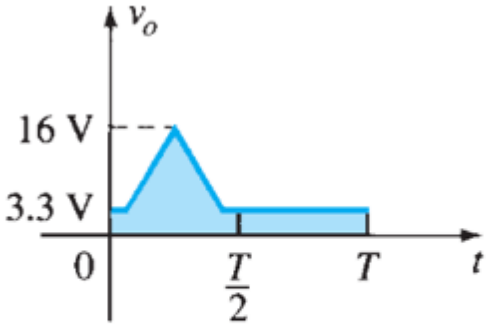
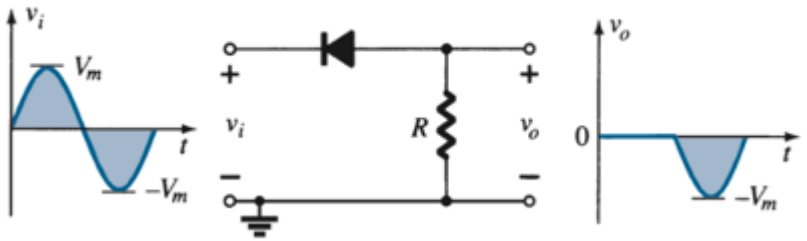


FIG. 2.87
Sketching v_o for Example 2.21.

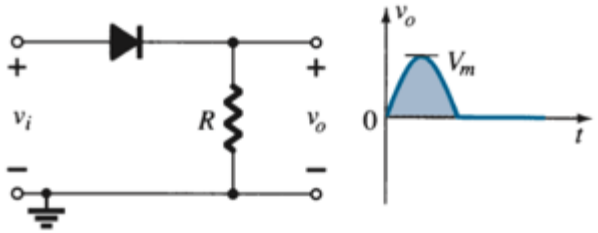
CLIPPERS

Simple Series clippers (Ideal Diodes) for the sinusoidal input

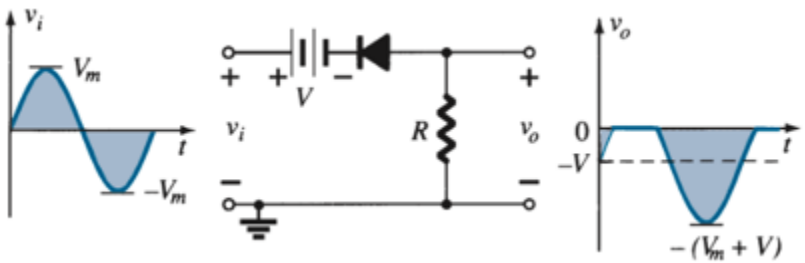
POSITIVE

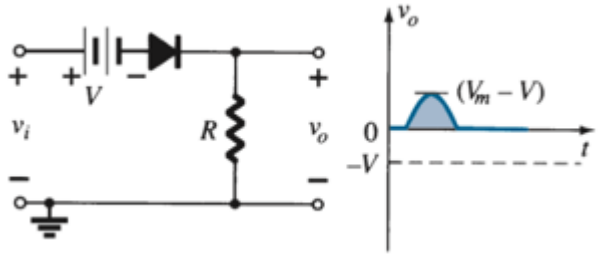


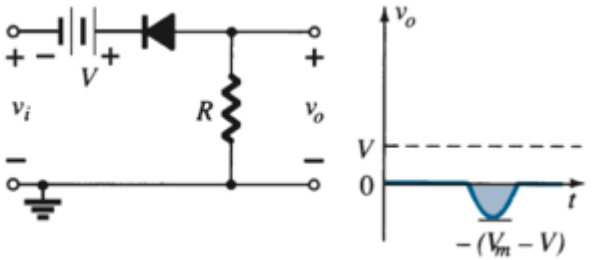
NEGATIVE

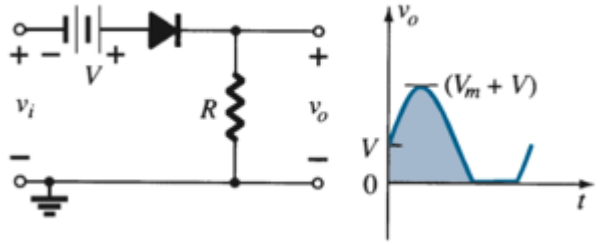


Biased Series Clippers (Ideal Diodes)





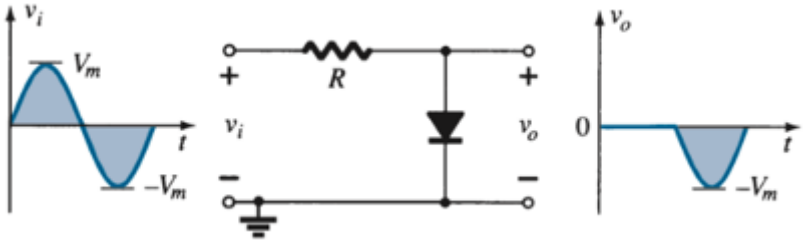




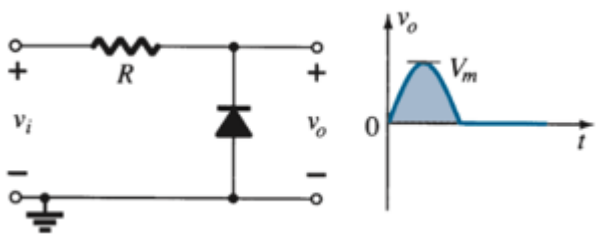
CLIPPERS

Simple Parallel clippers (Ideal Diodes) for the sinusoidal input

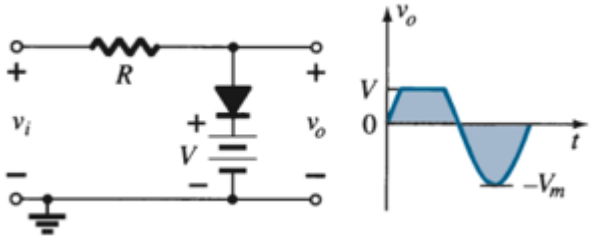
POSITIVE

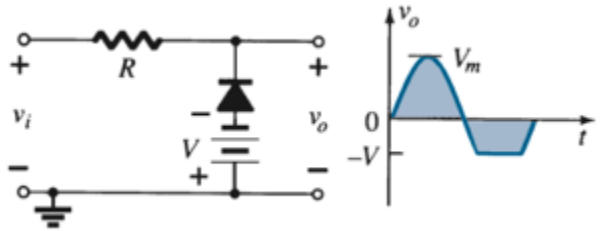


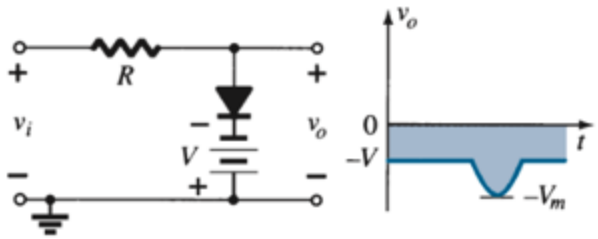
NEGATIVE

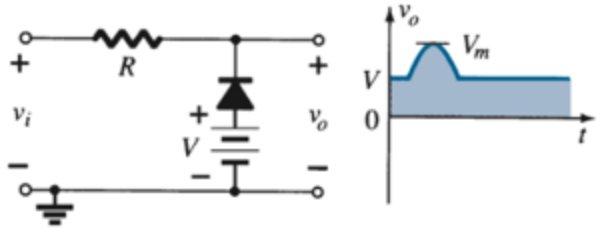


Biased Parallel Clippers (Ideal Diodes)



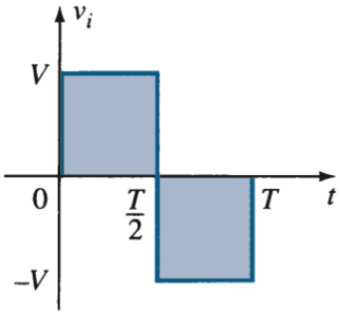


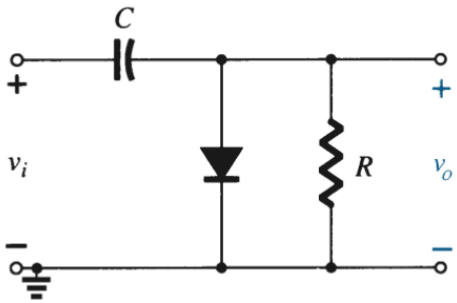


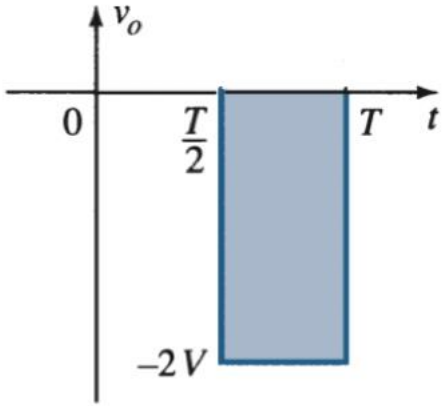


CLAMPERS

A clamper is a network constructed of a diode, a resistor, and a capacitor that shifts a waveform to a different dc level without changing the appearance of the applied signal.







The output signal is clamped to 0 V for the interval 0 to *T*/2 but maintains the same total swing (2*V*) as the input.

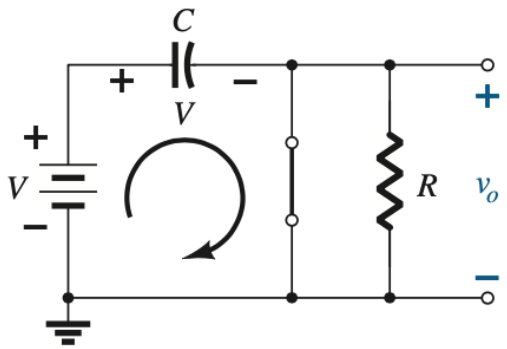
CLAMPERS

Step 1: Start the analysis by examining the response of the portion of the input signal that will **forward bias the diode.**

Step 2: During the period that the diode is in the **"on" state**, assume that the **capacitor will charge up instantaneously** to a voltage level determined by the surrounding network.

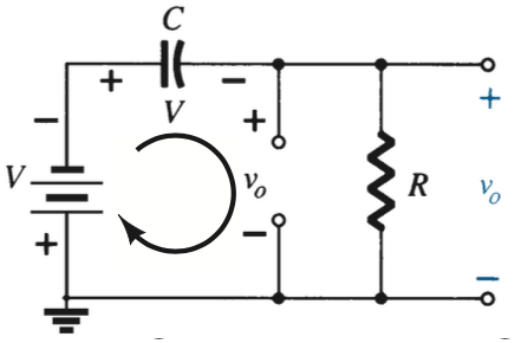
Step 3: Assume that during the period when the diode is in the **"off" state** the **capacitor holds on to its established voltage level**.

For the interval 0 -> $T/2$:



$$v_o = 0$$
$$v_c = V$$

For the interval T/2 -> T :



$$-V - V - v_o = 0$$
$$v_o = -2V$$

Step 4: Throughout the analysis, maintain a continual awareness of the location and defined polarity for v_o to ensure that the proper levels are obtained.

Step 5: Check that the total swing of the output matches that of the input.

The output signal maintains the same total swing ($2V$) as the input.

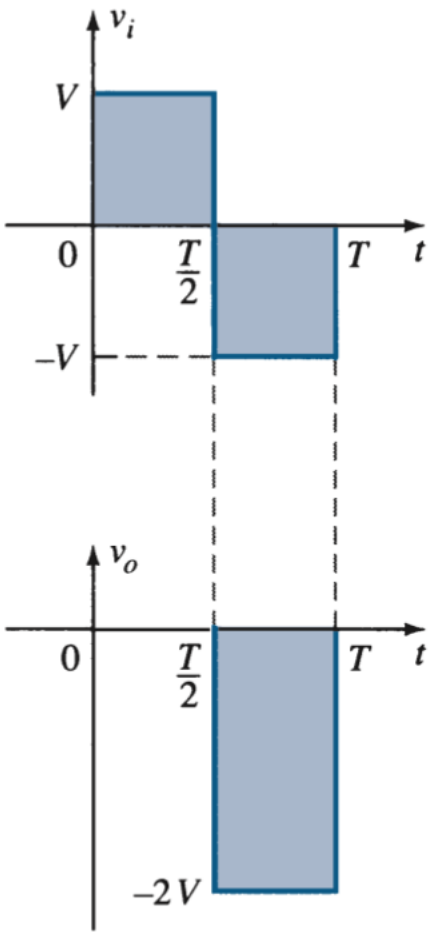


FIG. 92
Sketching v_o for the network of Fig. 91.

CLAMPERS

EXAMPLE 2.22 Determine v_o for the network of Fig. 2.93 for the input indicated.

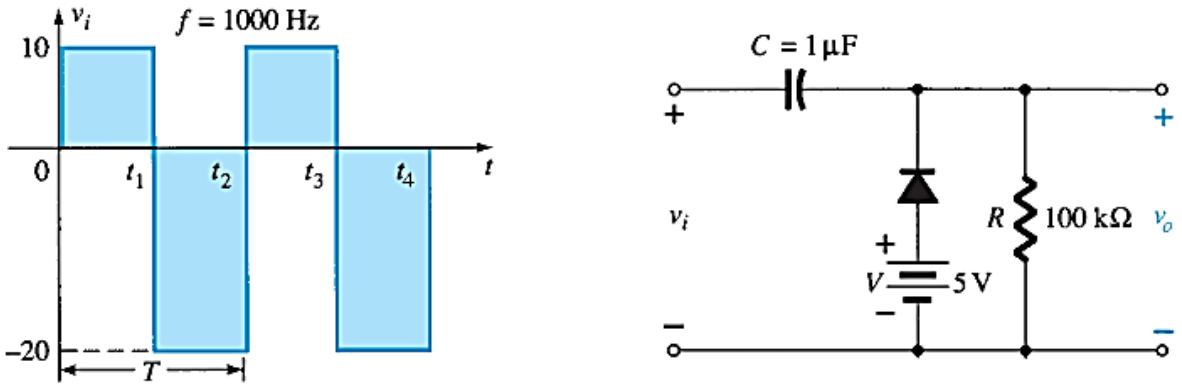
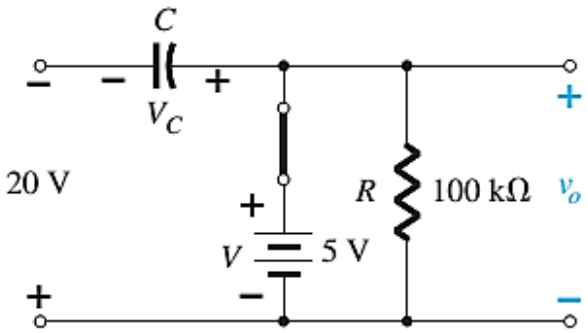


FIG. 2.93
Applied signal and network for Example 2.22.

From t_1 to t_2 period of the input signal the diode will be forward biased.

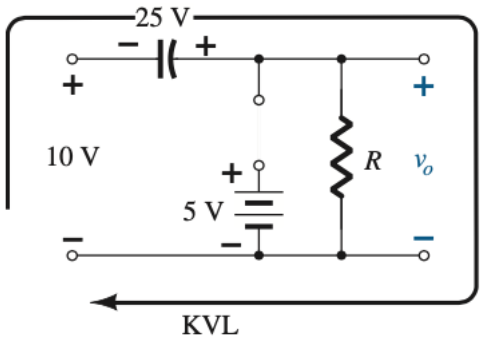


$$v_o = 5\,V$$

$$-20\text{ V} + V_C - 5\text{ V} = 0$$

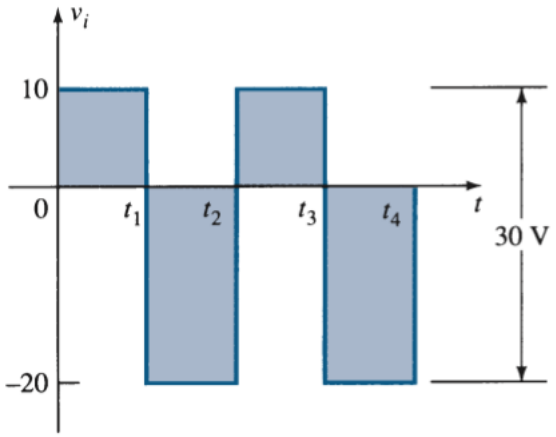
$$V_C = 25\text{ V}$$

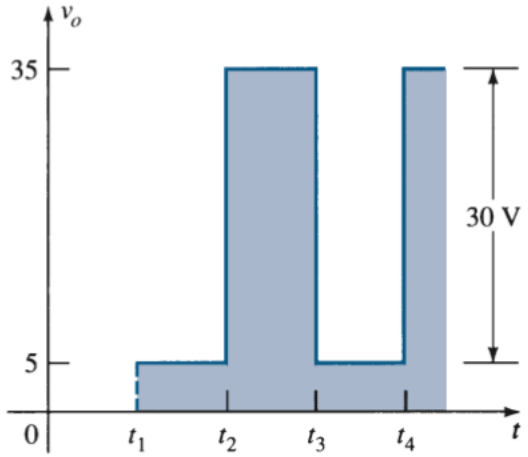
From t_2 to t_3 period of the input signal the diode will be reverse biased



$$+10\text{ V} + 25\text{ V} - v_o = 0$$

$$v_o = 35\text{ V}$$



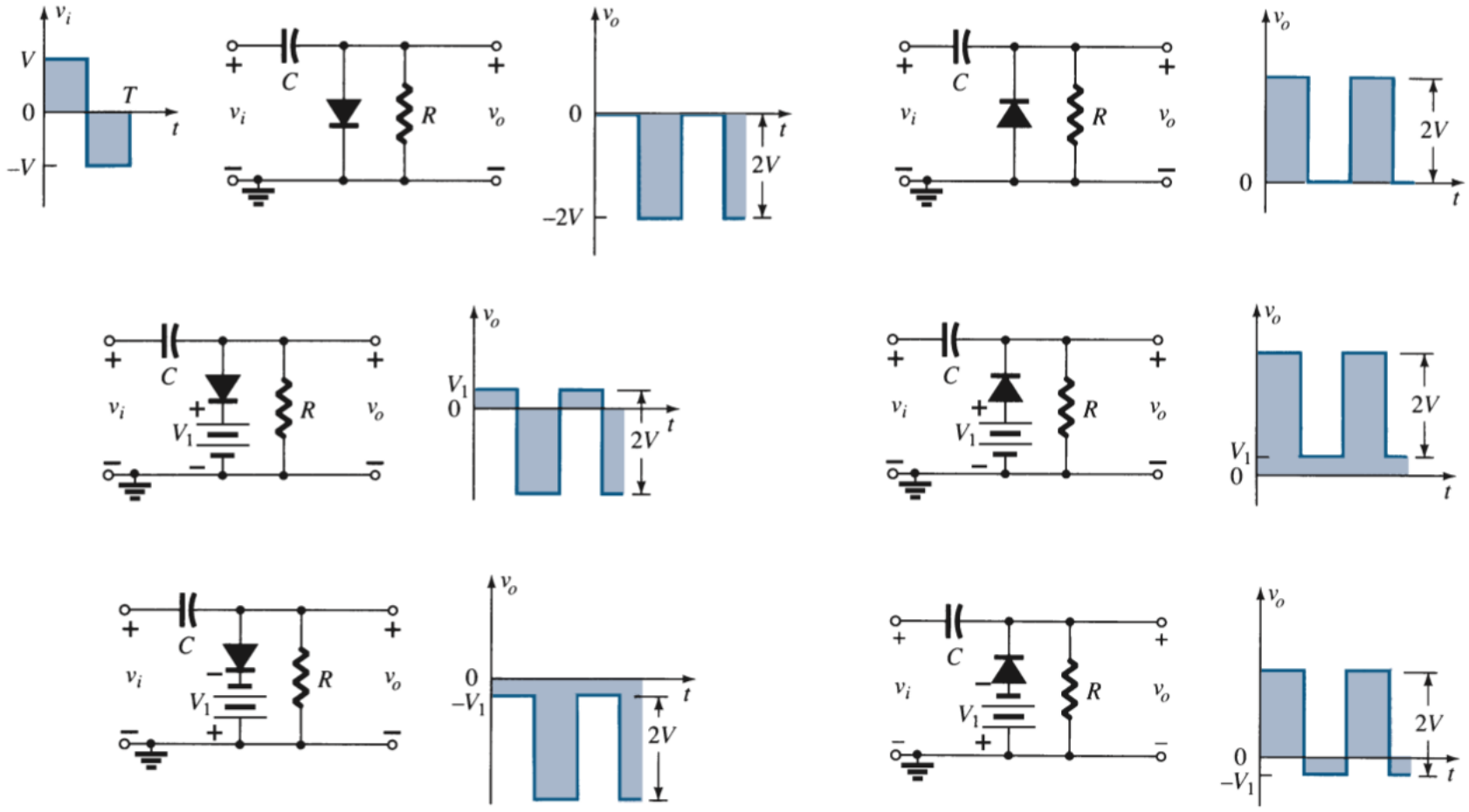


The output swing of 30 V matches the input swing.

- *See Example 2.23*

Clamping Networks

Clamping circuits with ideal diodes ($5\tau = 5RC \gg T/2$).



Thank You