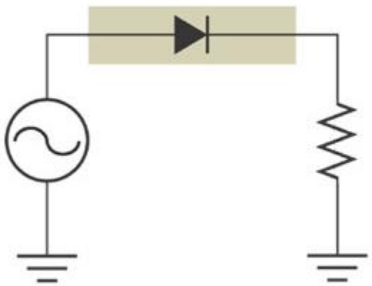
Ch. 4 Common Diode Applications

4.1 Clippers

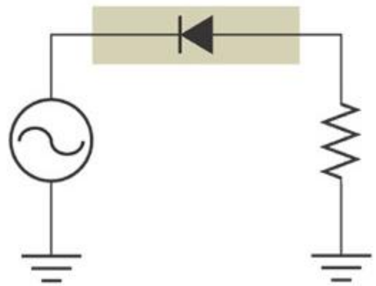
4.2 Clampers

4.1 Clippers

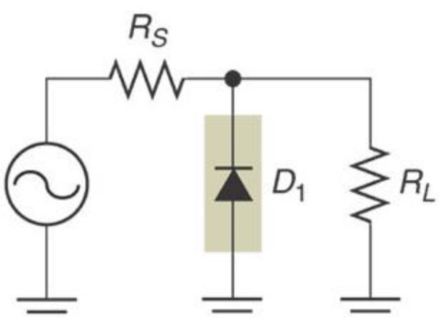
Clipper (or Limiter)
: A diode circuit used to eliminate some portion of a waveform



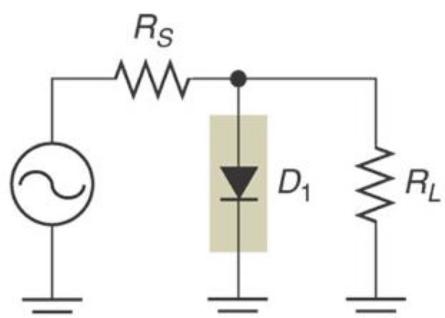
Negative series clipper



Positive series clipper



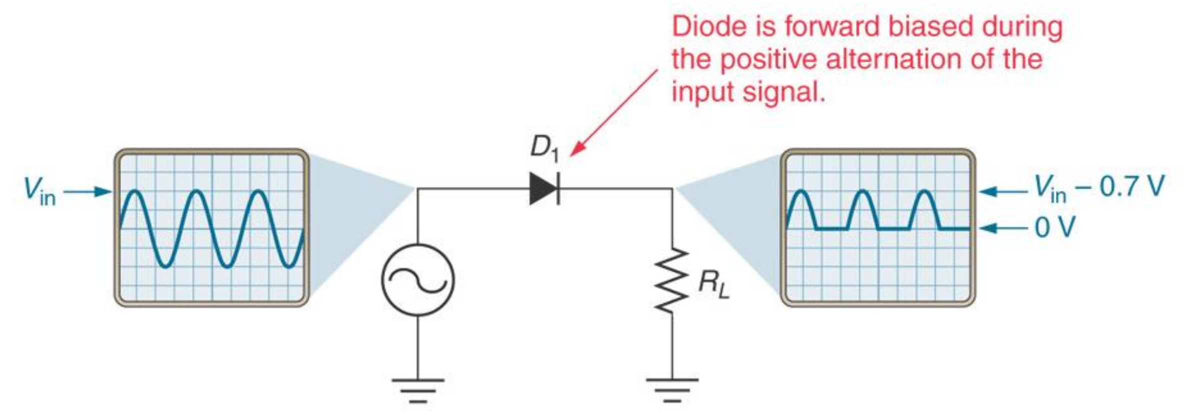
Negative shunt clipper



Positive shunt clipper

4.1.1 Series clippers

The series clipper has the same circuit operating characteristics as the **half-wave rectifier**, which provides an output when the diode is forward biased and no output when the diode is reverse biased



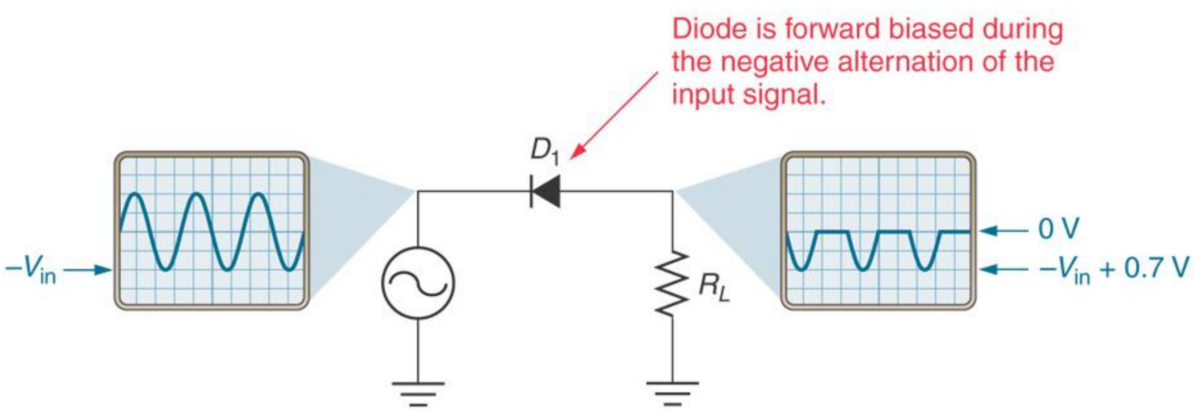
(a) Negative series clipper

1. Negative series clipper for $+V_{in}$

   $V_L = V_{in} - 0.7$ V

2. Negative series clipper for $-V_{in}$

   $V_L = 0$ V



(b) Positive series clipper

3. Positive series clipper for $+V_{in}$

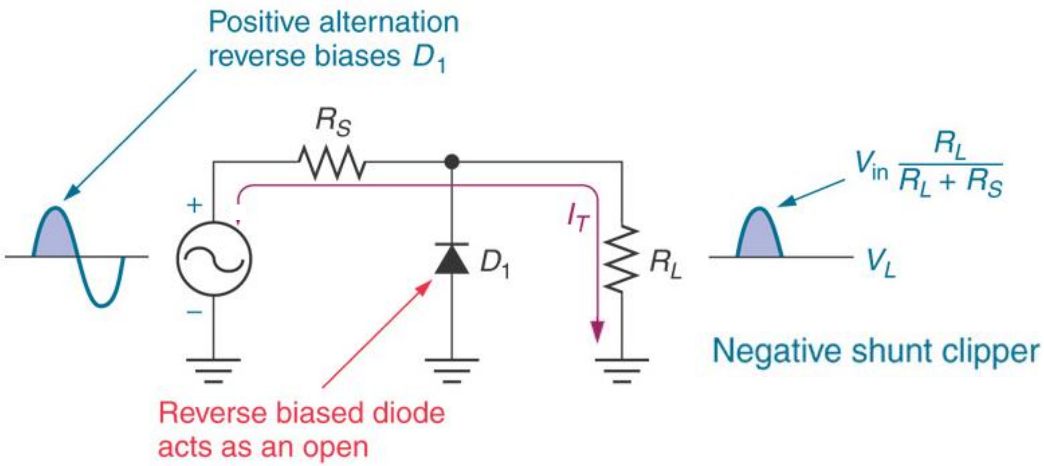
   $V_L = 0$ V

4. Negative series clipper for $-V_{in}$

   $V_L = -V_{in} + 0.7$ V

4.1.2 Shunt clippers

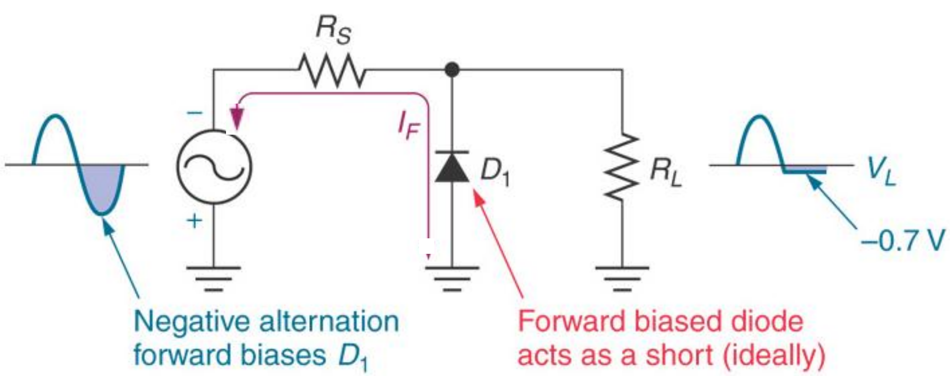
The shunt clipper provides an output when the diode is reverse biased and no output when the diode is forward biased



(a) Positive half-cycle operation

When the diode is reverse biased

$$V_L = \frac{R_L}{R_L + R_S} V_{in}$$



(b) Negative half-cycle operation

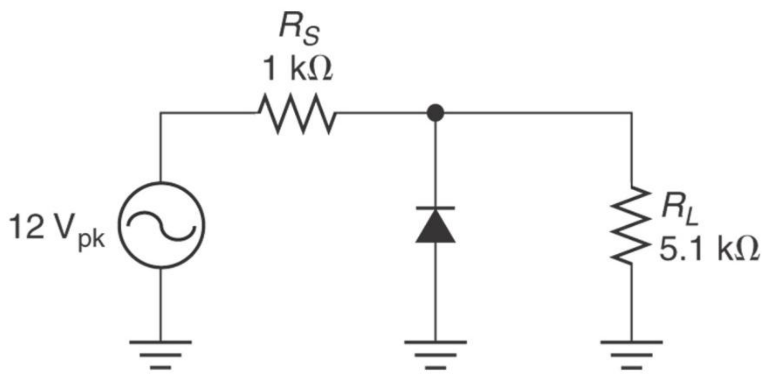
When the diode is forward biased

$$V_L = -V_F$$

$$V_{RS} = -V_{in} + 0.7V$$

EXAMPLE 4.1

Q. The negative shunt clipper shown in Figure 4.4 has a peak input voltage of +12V. What is the peak load voltage for the circuit?

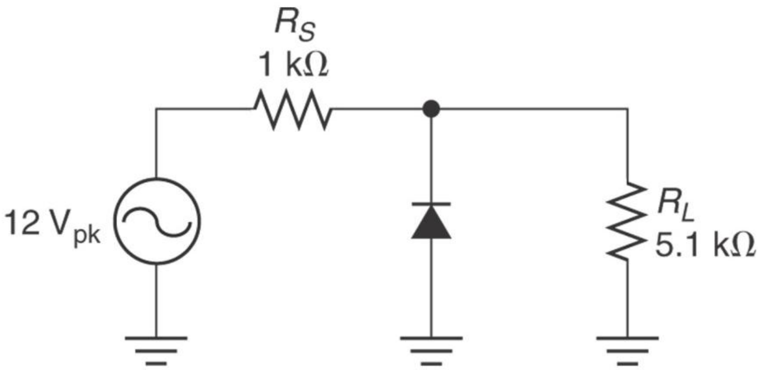


when the input is positive the diode is reverse biased and does not conduct.
Therefore, the peak load voltage is found as

$$V_L = \frac{R_L}{R_L + R_S} V_{in} = \frac{5.1k\Omega}{6.1k\Omega}(+12V_{pk}) = 10V_{pk}$$

EXAMPLE 4.2

Q. The circuit described in Example 4.1 has a -12V_{pk} input. Determine the values of V_L and V_{RS} for the circuit.



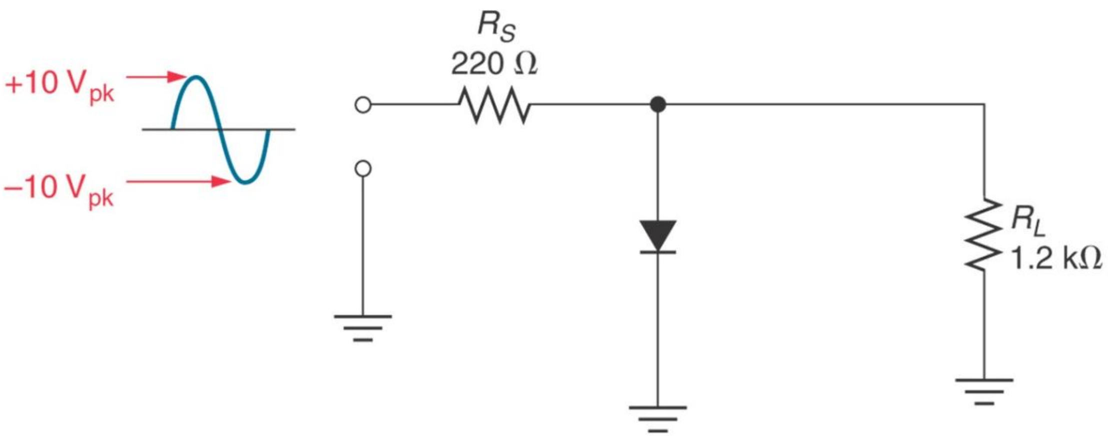
The load voltage: $V_L = -0.7V$

The voltage across the series resistor (Rs):

$$V_{RS} = -V_{in} + 0.7V = -12V_{pk} + 0.7V = -11.3V_{pk}$$

EXAMPLE 4.3

Q. The positive shunt clipper shown in the figure has the input waveform shown. Determine the value for V_L for each of the input alternations

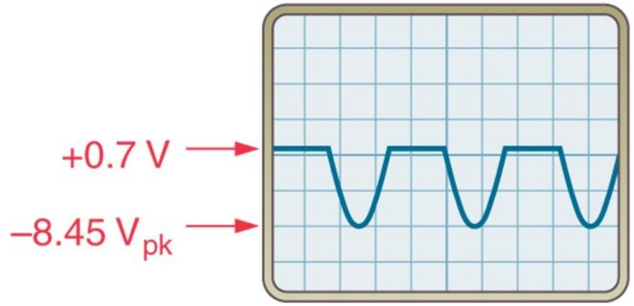


When the input is positive,

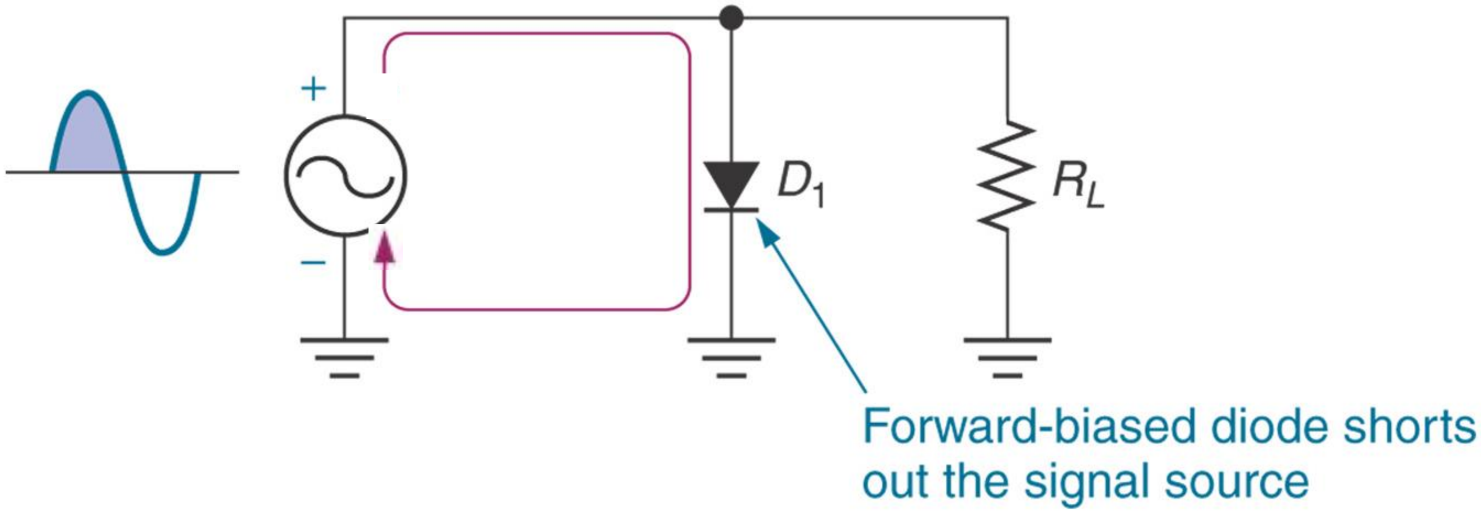
$$V_L = 0.7V$$
$$V_{RS} = -V_{in} + 0.7V = 10V_{pk} - 0.7V = 9.3V_{pk}$$

When the input is negative,

$$V_L = \frac{R_L}{R_L + R_S} V_{in} = \frac{1.2k\Omega}{1.42k\Omega}(-10V_{pk}) = -8.45V_{pk}$$



4.1.3 The role of R_S



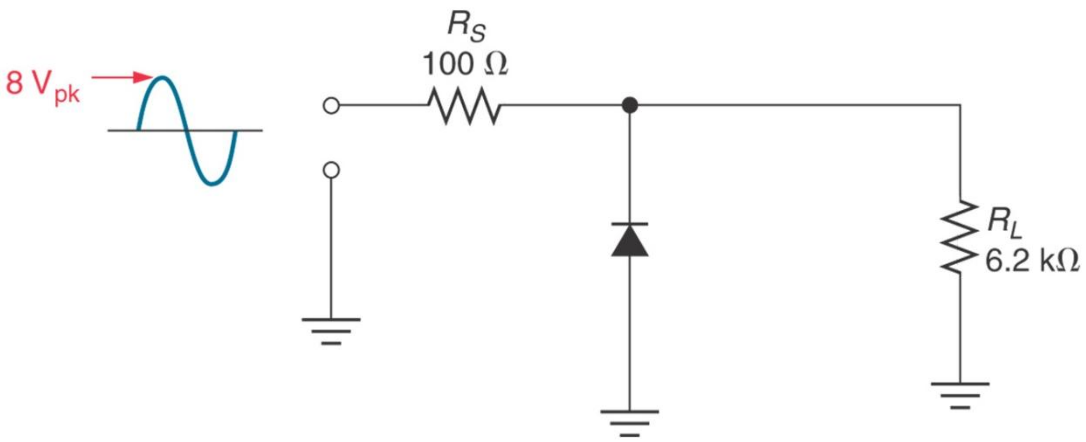
Without R_S in the circuit,

- The diode is destroyed by excessive forward current.
- One or more components in the signal source can be damaged by the excessive current demand of the conducting diode.

R_s is included in the shunt clipper as a current-limiting resistor.

EXAMPLE 4.4

Q. Determine the peak load voltage for the circuit shown in the figure. Assume that the diode is reverse biased.



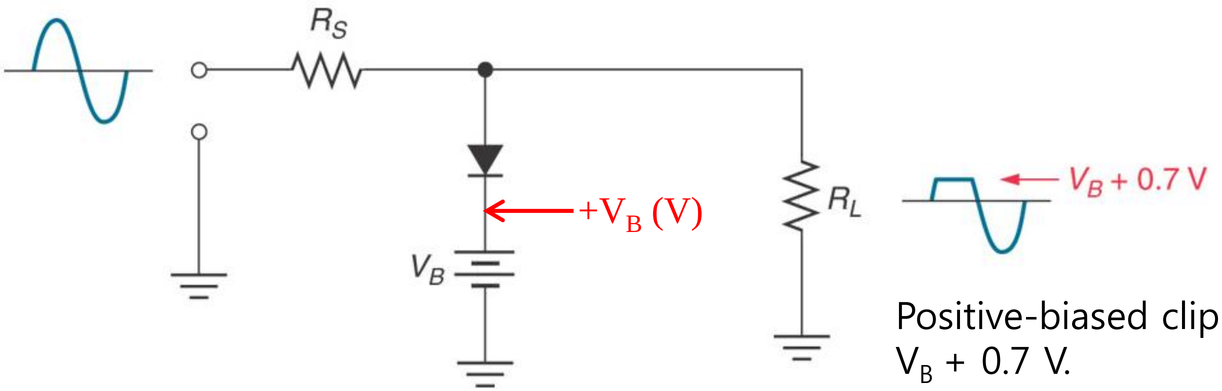
The peak load voltage is given by

$$V_L = \frac{R_L}{R_L + R_S} V_{in} = \frac{6.2k\Omega}{6.3k\Omega}(8V_{pk}) = 7.87V_{pk}$$

$$V_L \approx V_{in} \quad \text{if} \quad R_S << R_L$$

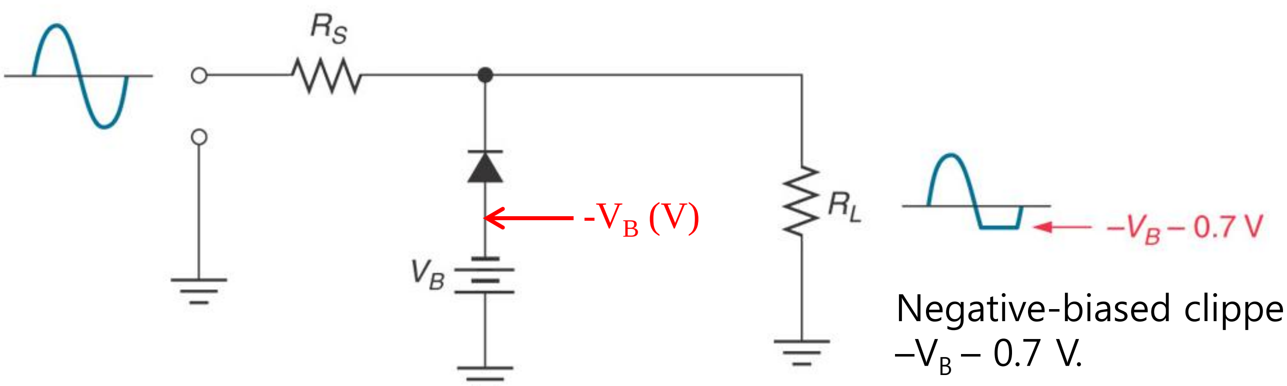
4.1.4 Biased Clippers

• A biased clipper uses a dc biasing source to set the limit on the output voltage.
• The additional bias voltage allows the circuit to clip the input waveforms at certain values other than V_F of 0.7 V



Positive-biased clipper clips its input signal at V_B + 0.7 V.

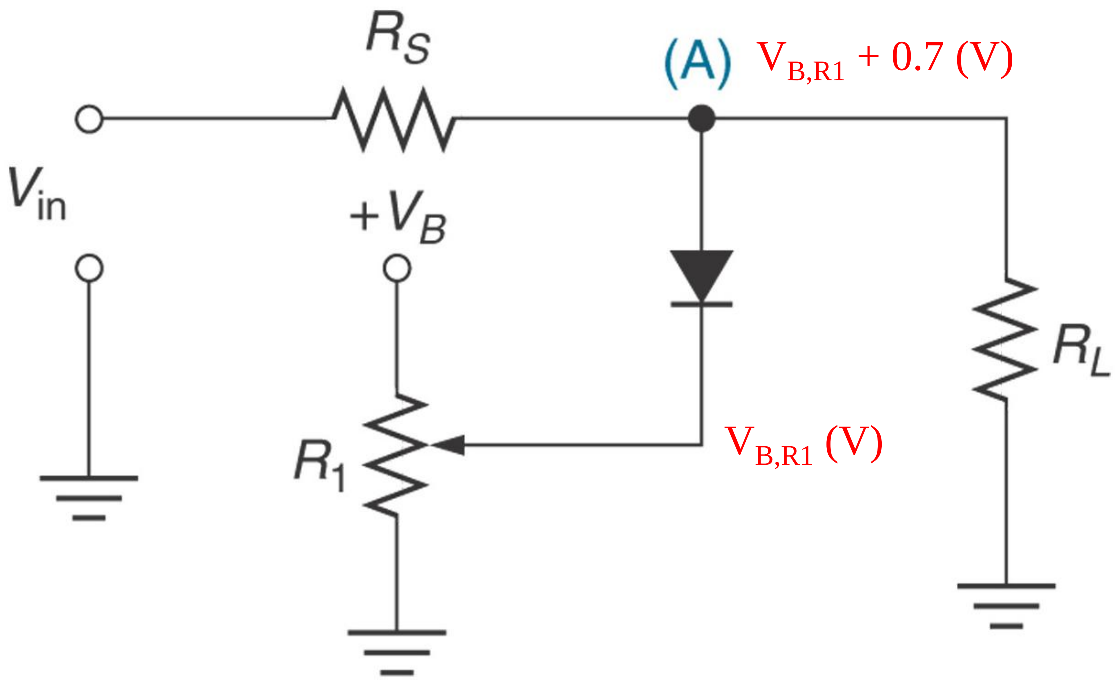
(a) Positive-biased clipper



Negative-biased clipper clips its input signal at $-V_B$ – 0.7 V.

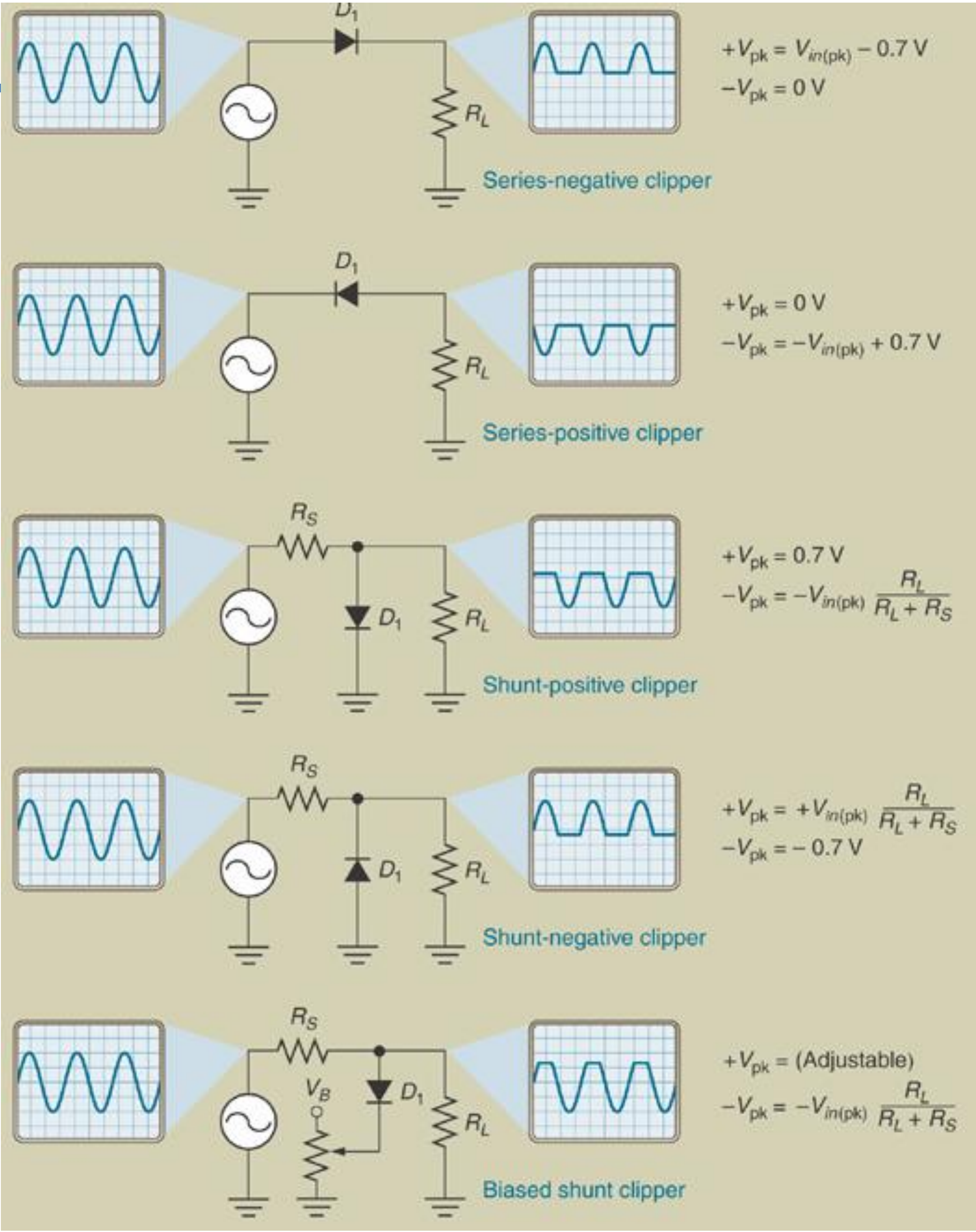
(b) Negative-biased clipper

4.1.4 Biased Clippers



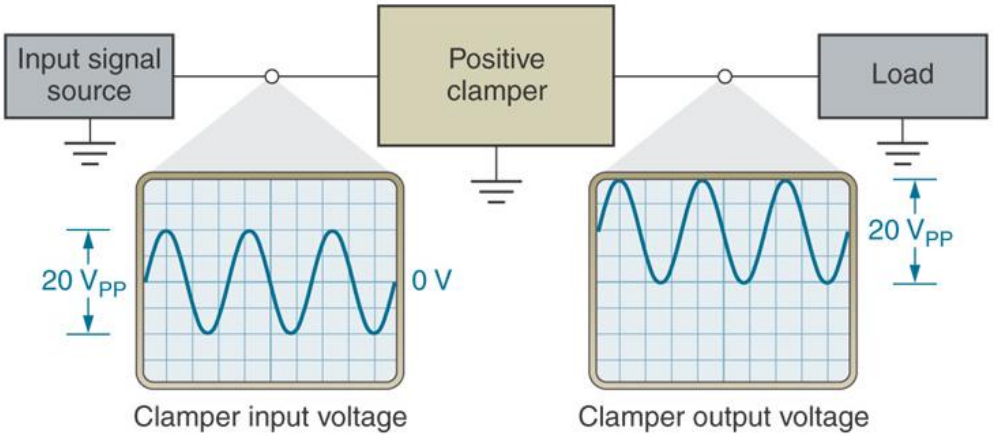
In practice, a potentiometer (R1) is used to provide an adjustable value of V_B.

Clipper summary



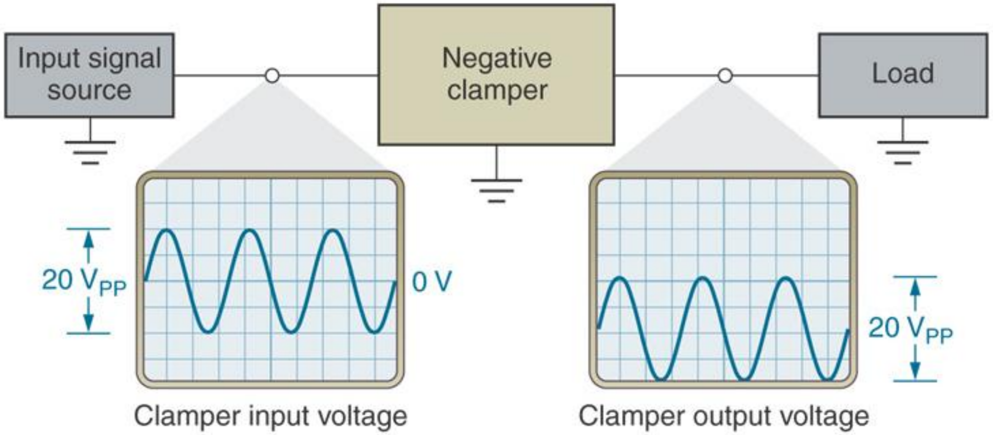
4.3 Clampers (DC Restorers, Shifters)

A clamper is a circuit designed to shift a waveform either above or below a given reference voltage without distorting the waveform



(a)

Positive clamper
A circuit that shifts an entire input signal above a dc reference voltage.

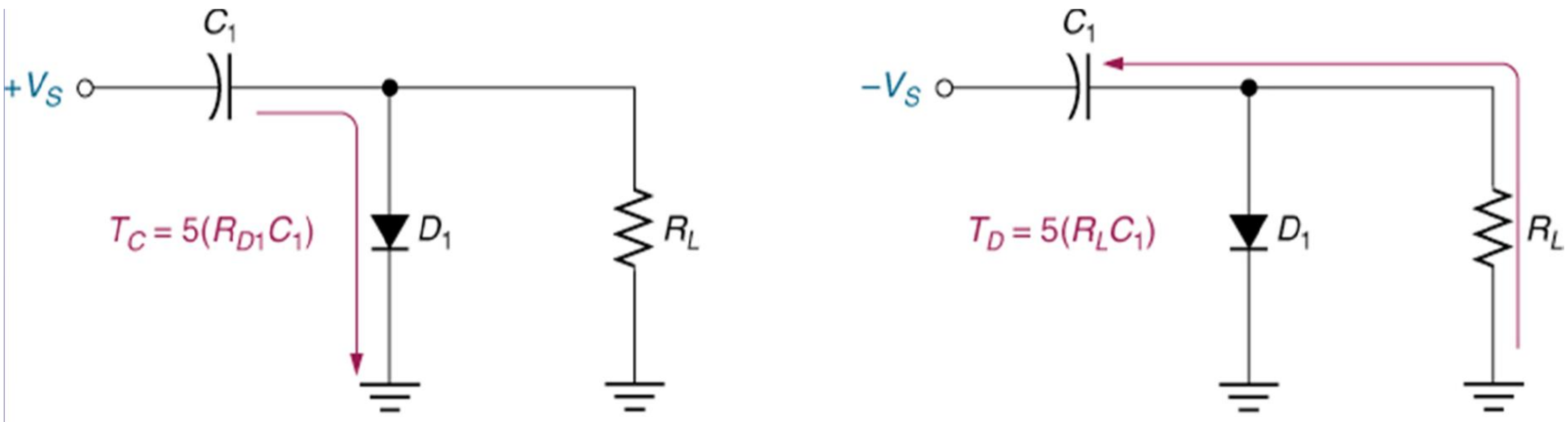


(b)

Negative clamper
A circuit that shifts an entire input signal below a dc reference voltage.

4.3.2 Clamper Operation

- The clamper is similar to a shunt clipper connected with a capacitor in series.
- Like the capacitive power supply filter, the clamper works on the basis of switching time constants (시상수).



(a) Capacitor charge circuit

(b) Capacitor discharge circuit

$\tau = R_{D1}C_1$ $\ll$ $\tau = R_LC_1$

total charge time:

$$T_C = 5(R_{D1}C_1)$$

$\sim \mu sec$

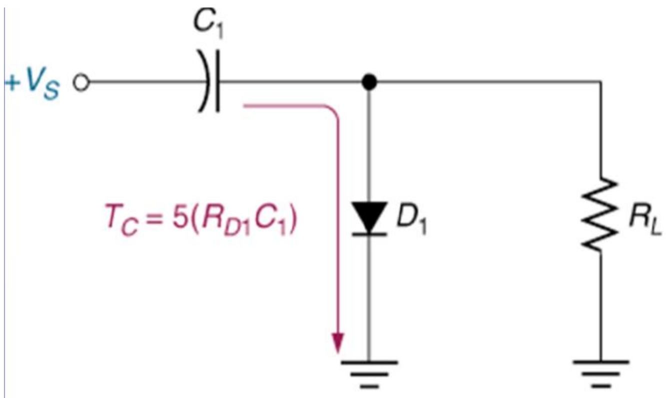
total discharge time:

$$T_D = 5(R_LC_1)$$

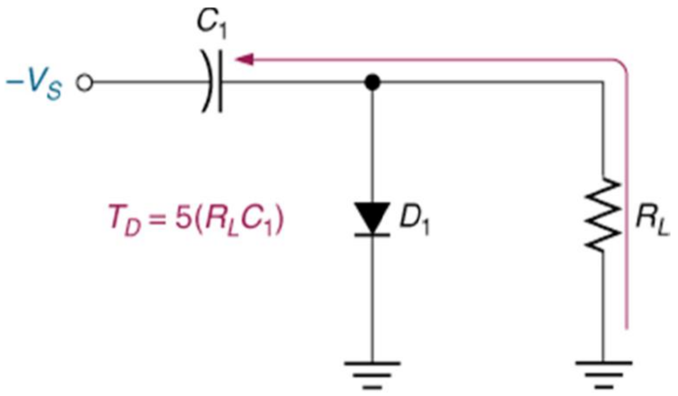
$\sim msec$

EXAMPLE 4.5

Determine the capacitor charge and discharge times for the circuit represented in the figure. Assume that the forward resistance of the diode is 10 Ω, R_L = 10 kΩ, and C_1 =1 μF.



(a) Capacitor charge circuit



(b) Capacitor discharge circuit

charge time:

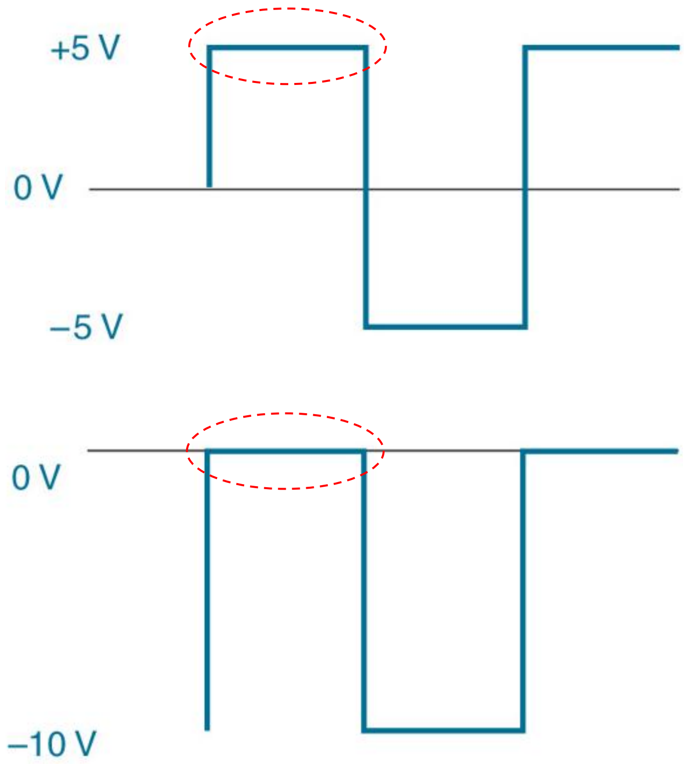
$$T_C = 5(R_{D1}C_1) = 5(10\Omega \times 1\mu F) = 50\mu s$$

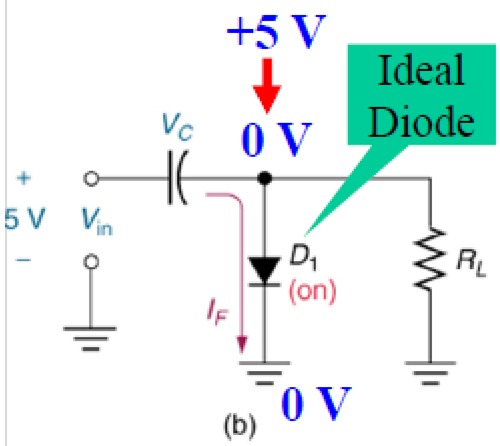
discharge time:

$$T_D = 5(R_LC_1) = 5(10k\Omega \times 1\mu F) = 50ms$$

the difference is significant!

4.3.2 Clamper Operation (1)





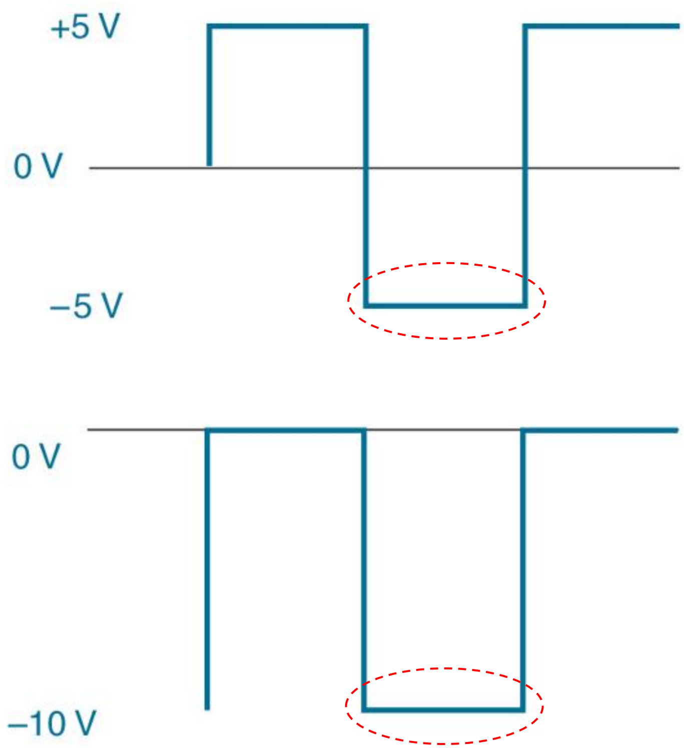
When the input goes to its positive peak (+5V), D1 is forward biased.

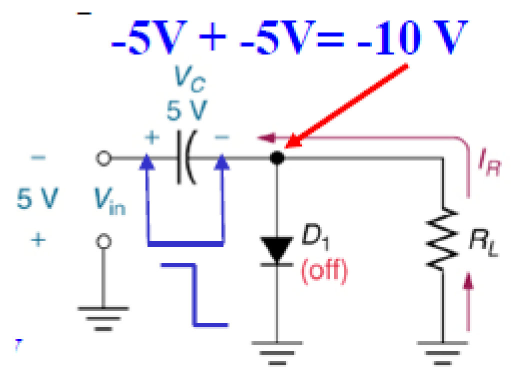
There forms a low-resistance current path for charging C_1.

Then C_1 is rapidly charged to the full value (5V).

With the applied voltage dropped across C_1, the load voltage has a positive peak value of 0 V.

4.3.2 Clamper Operation (2)





When the input goes to its negative peak (+5V), D1 is reverse biased.

There forms a high-resistance current path for discharging C_1.

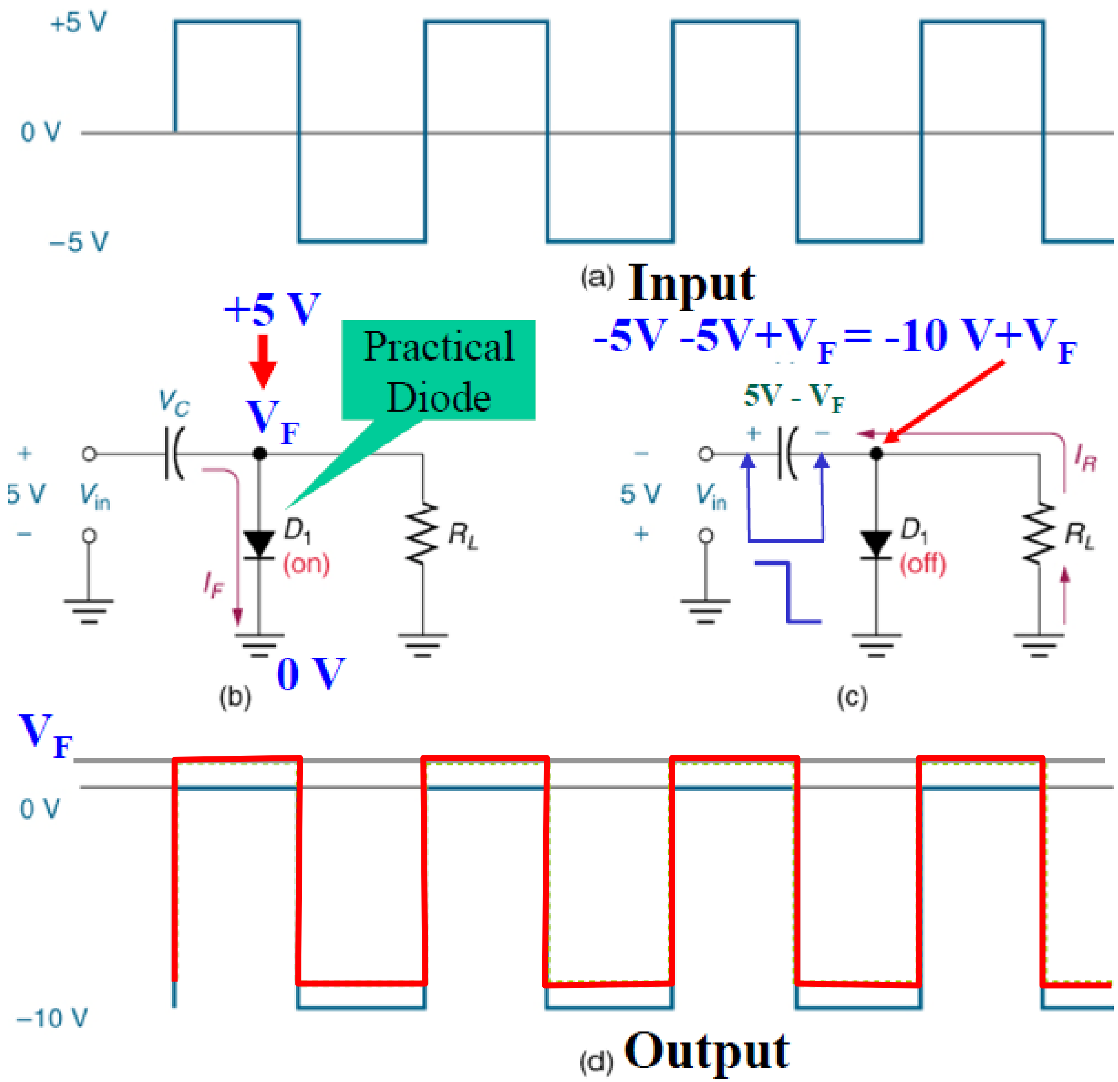
Then C_1 is very slowly discharged.

Since the input voltage and V_C have the same polarity, the load voltage has a peak value of -10 V.

Here capacitor plays a role of dc battery for the time being of $\tau = CR_L$

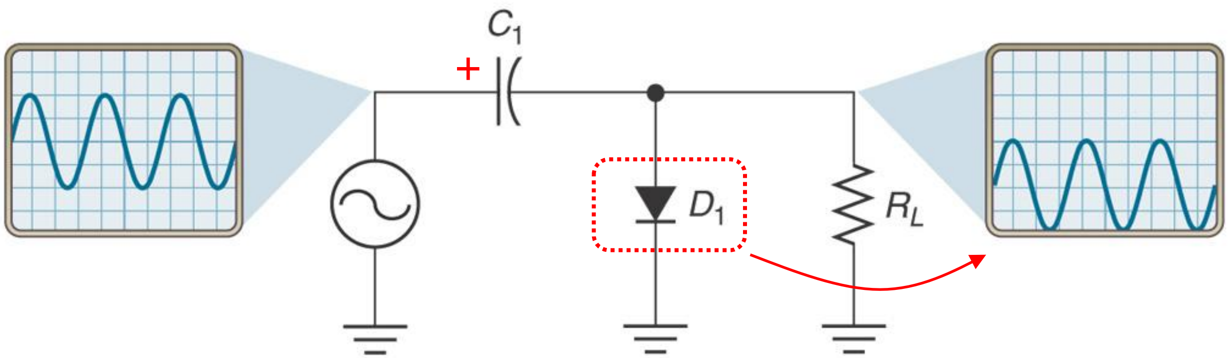
4.3.2 Clamper Operation (3)

Using the practical diode model with V_F = +0.7 V,

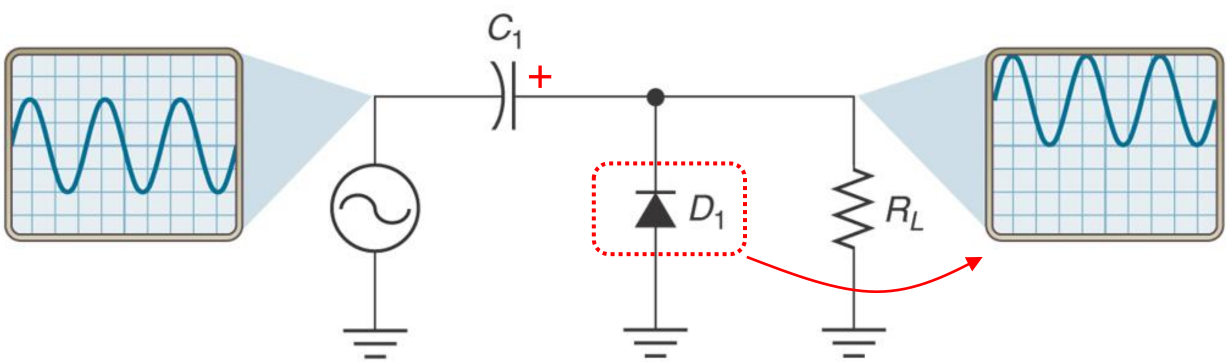


4.3.3 Negative Clampers vs Positive Clampers

The direction of the diode is opposite with each other.



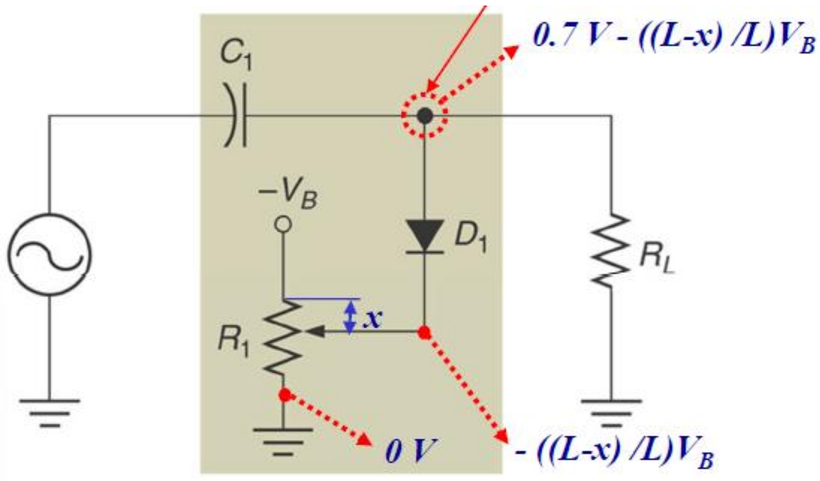
(a) Negative clamper



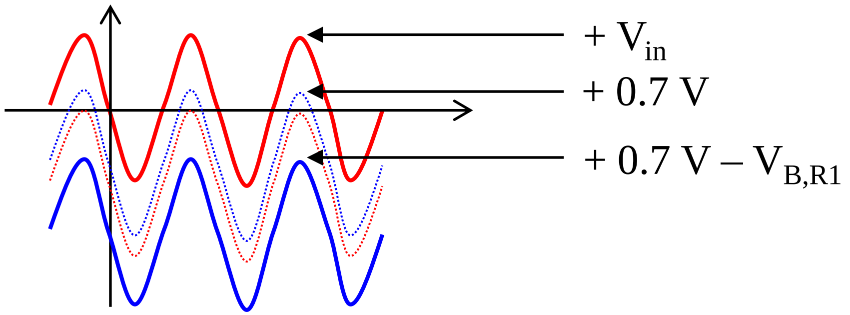
(b) Positive clamper

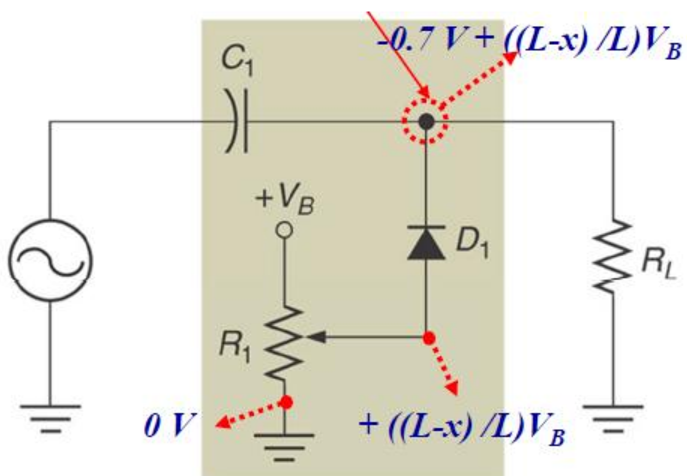
4.3.4 Biased Clampers

A *biased clamper* allows a waveform to be shifted above (or below) a dc reference other than 0 V. By varying the potentiometer setting of R_1, the circuit reference voltage can be varied between approximately 0 V and the value of V_B.

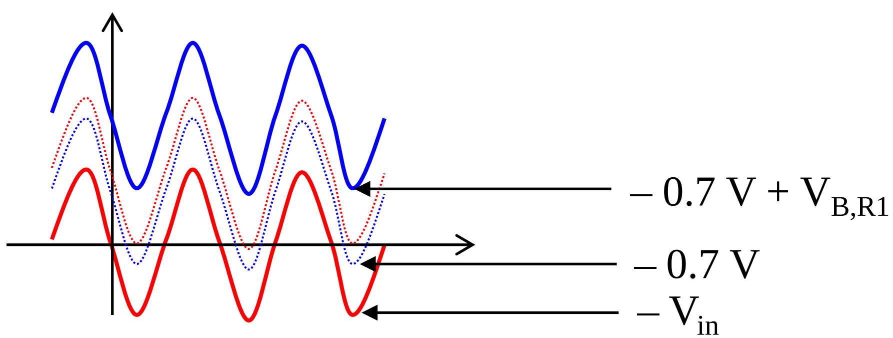


(a) Negative-biased clamper



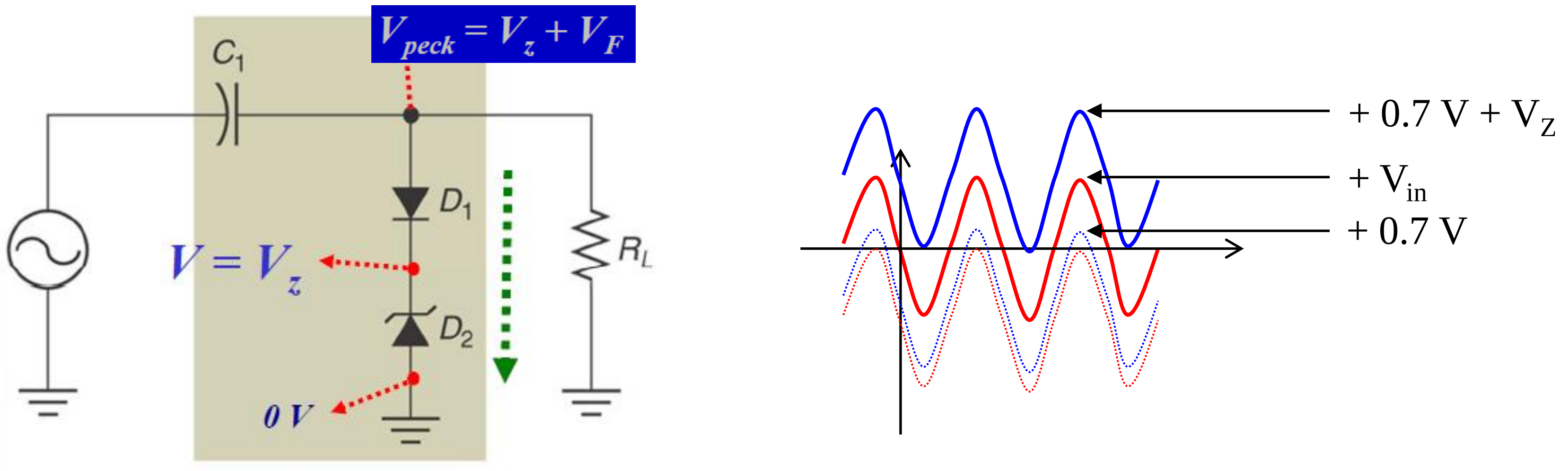


(b) Positive-biased clamper

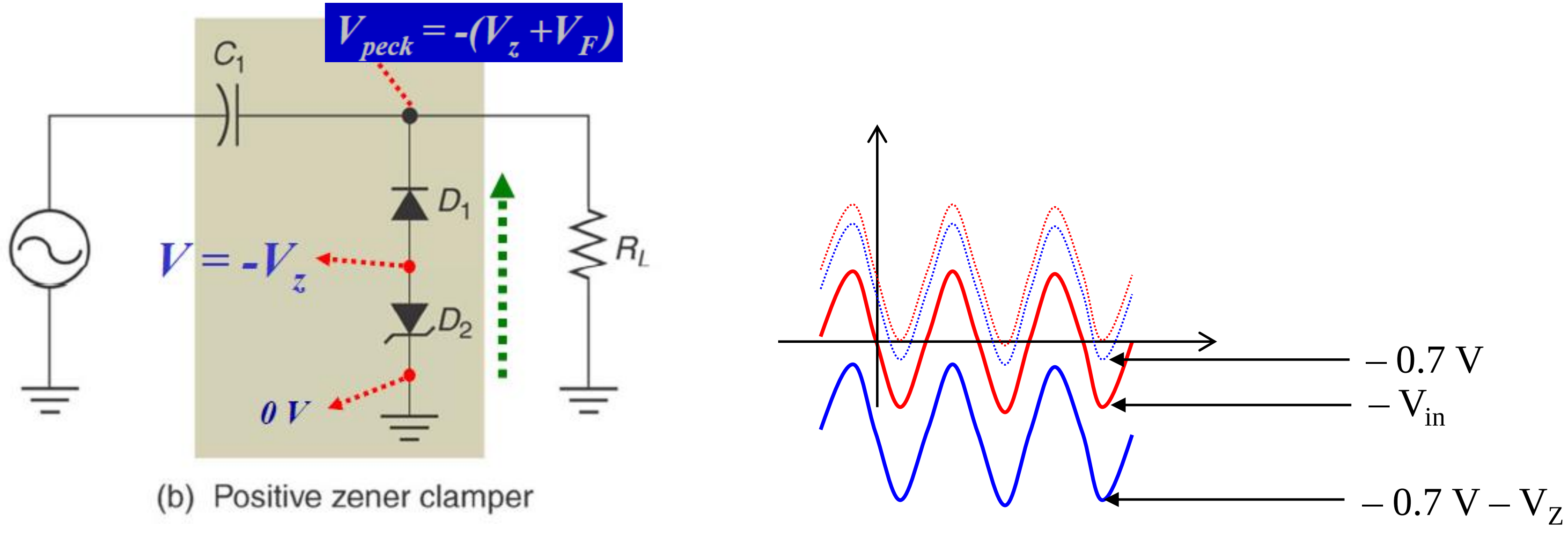


4.3.4 Biased Clampers

The *zener clamper* uses a zener diode to set the circuit dc reference voltage. For example, the dc reference voltage for each zener clamper in Figure 4.4 has a value of $V_Z \pm 0.7$ V.



(a) Negative zener clamper



(b) Positive zener clamper