4-11 Clampers

The diode clamp, which was discussed in the preceding section, protects sensitive circuits. The **clamper** is different, so don't confuse the similar-sounding names. A clamper adds a dc voltage to the signal.

Positive Clamper

Figure 4-30*a* shows the basic idea for a positive clamper. When a positive clamper has a sine-wave input, it adds a positive dc voltage to the sine wave. Stated another way, the positive clamper shifts the ac reference level (normally zero) up to a dc level. The effect is to have an ac voltage centered on a dc level. This means that each point on the sine wave is shifted upward, as shown on the output wave.

Figure 4-30*b* shows an equivalent way of visualizing the effect of a positive clamper. An ac source drives the input side of the clamper. The Thevenin voltage of the clamper output is the superposition of a dc source and an ac source. The ac signal has a dc voltage of V_p added to it. This is why the entire sine wave of Fig. 4-30*a* has shifted upward so that it has a positive peak of $2V_p$ and a negative peak of zero.

Figure 4-31*a* is a positive clamper. Ideally, here is how it works. The capacitor is initially uncharged. On the first negative half cycle of input voltage, the diode turns on (Fig. 4-31*b*). At the negative peak of the ac source, the capacitor has fully charged and its voltage is V_p with the polarity shown.

Slightly beyond the negative peak, the diode shuts off (Fig. 4-31*c*). The R_LC time constant is deliberately made much larger than the period T of the signal. We will define *much larger* as at least 100 times greater:

$$\textbf{Stiff clamper: } R_LC > 100T \tag{4-19}$$

For this reason, the capacitor remains almost fully charged during the off time of the diode. To a first approximation, the capacitor acts like a battery of V_p volts. This is why the output voltage in Fig. 4-31*a* is a positively clamped signal. Any clamper that satisfies Eq. (4-19) is called a *stiff clamper.*

GOOD TO KNOW

Clampers are commonly used in analog television receivers for the purpose of restoring the dc component of the video signal prior to its being fed to the picture tube.

Figure 4-30 (*a*) Positive clamper shifts waveform upward; (*b*) positive clamper adds a dc component to signal.

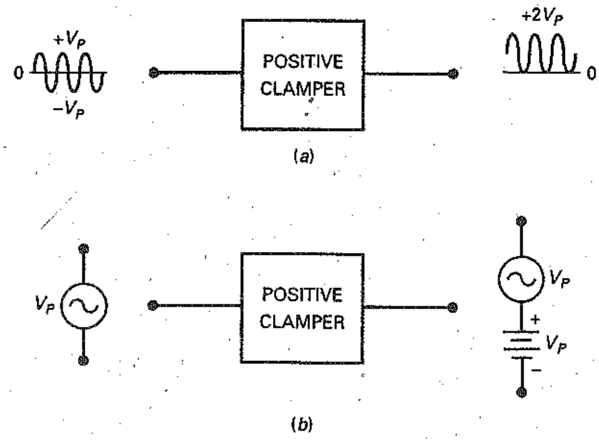
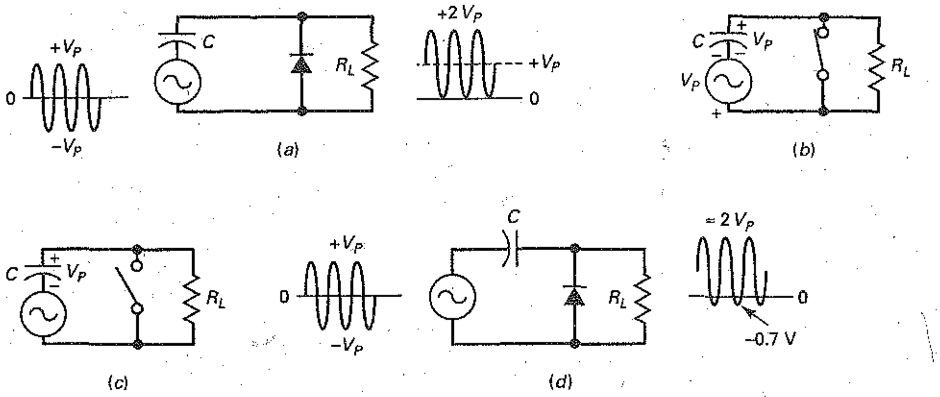


Figure 4-31 (*a*) Ideal positive clamper; (*b*) at the positive peak; (*c*) beyond the positive peak; (*d*) clamper is not quite perfect.



The idea is similar to the way a half-wave rectifier with a capacitor-input filter works. The first quarter cycle charges the capacitor fully. Then, the capacitor retains almost all of its charge during subsequent cycles. The small charge that is lost between cycles is replaced by diode conduction.

In Fig. 4-31*c*, the charged capacitor looks like a battery with a voltage of V_p. This is the dc voltage that is being added to the signal. After the first quarter cycle, the output voltage is a positively clamped sine wave with a reference level of zero; that is, it sits on a level of 0 V.

Figure 4-31*d* shows the circuit as it is usually drawn. Since the diode drops 0.7 V when conducting, the capacitor voltage does not quite reach V_p. For this reason, the clamping is not perfect, and the negative peaks have a reference level of −0.7 V.

Negative Clamper

What happens if we turn the diode in Fig. 4-31*d* around? We get the negative clamper of Fig. 4-32. As you can see, the capacitor voltage reverses, and the circuit becomes a negative clamper. Again, the clamping is less than perfect because the positive peaks have a reference level of 0.7 V instead of 0 V.

As a memory aid, notice that the diode points in the direction of shift. In Fig. 4-32, the diode points downward, the same direction as the shift of the sine wave. This tells you that it's a negative clamper. In Fig. 4-31*a*, the diode points up, the waveform shifts up, and you have positive clamper.

Figure 4-32 Negative clamper.

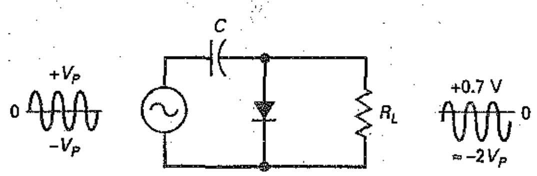
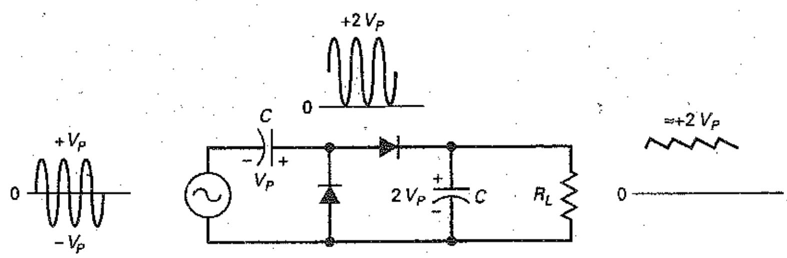


Figure 4-33 Peak-to-peak detector.



Both positive and negative clampers are widely used. For instance, television receivers use a clamper to change the reference level of video signals. Clampers are also used in radar and communication circuits.

A final point. The less than perfect clipping and clamping discussed so far are no problem. After we discuss op amps, we will look again at clippers and clampers. At that time, you will see how easy it is to eliminate the barrier-potential problem. In other words, we will look at circuits that are almost perfect.

Peak-to-Peak Detector

A half-wave rectifier with a capacitor-input filter produces a dc output voltage approximately equal to the peak of the input signal. When the same circuit uses a small-signal diode, it is called a **peak detector.** Typically, peak detectors operate at frequencies that are much higher than 60 Hz. The output of a peak detector is useful in measurements, signal processing, and communications.

If you cascade a clamper and a peak detector, you get a *peak-to-peak detector* (see Fig. 4-33). As you can see, the output of a clamper is used as the input to a peak detector. Since the sine wave is positively clamped, the input to the peak detector has a peak value of $2V_p$. This is why the output of the peak detector is a dc voltage equal to $2V_p$.

As usual, the RC time constant must be much greater than the period of the signal. By satisfying this condition, you get good clamping action and good peak detection. The output ripple will therefore be small.

One application is in measuring nonsinusoidal signals. An ordinary ac voltmeter is calibrated to read the rms value of an ac signal. If you try to measure a nonsinusoidal signal, you will get an incorrect reading with an ordinary ac voltmeter. However, if the output of a peak-to-peak detector is used as the input to a dc voltmeter, it will indicate the peak-to-peak voltage. If the nonsinusoidal signal swings from −20 to + 50 V, the reading is 70 V.

4-12 Voltage Multipliers

A peak-to-peak detector uses small-signal diodes and operates at high frequencies. By using rectifier diodes and operating at 60 Hz, we can produce a new kind of power supply called a *voltage doubler.*