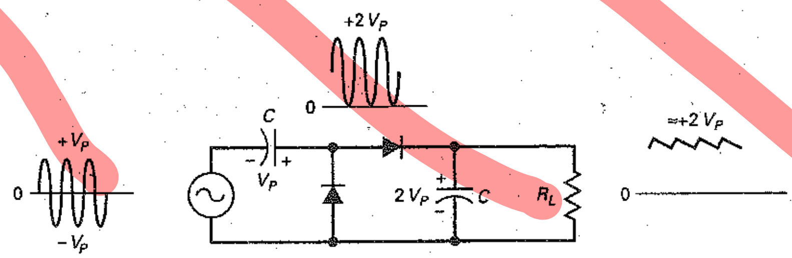
Figure 4-33 Peak-to-peak detector.



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 $2V_p$.

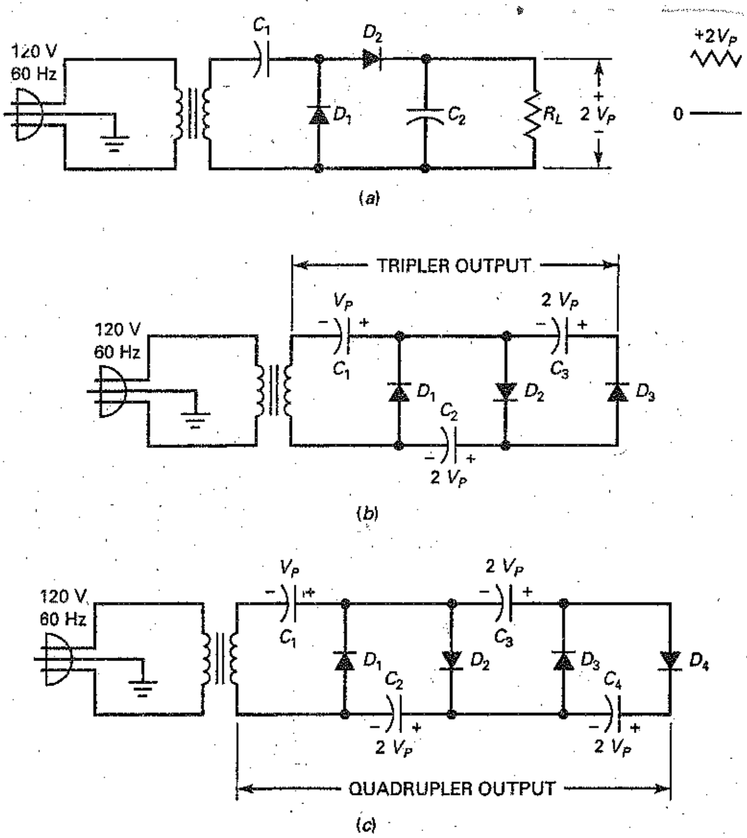
As usual, the *RC* time constant must be much greater than the period of the signal. By satisfying this condition, you get good clamping action and good peak detection. The output ripple will therefore be small.

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.*

Figure 4-34 Voltage multipliers with floating loads. (*a*) Doubler; (*b*) tripler; (*c*) quadrupler.



Voltage Doubler

Figure 4-34*a* is a *voltage doubler.* The configuration is the same as a peak-to-peak detector, except that we use rectifier diodes and operate at 60 Hz. The clamper section adds a dc component to the secondary voltage. The peak detector then produces a dc output voltage that is 2 times the secondary voltage.

Why bother using a voltage doubler when you can change the turns ratio to get more output voltage? The answer is that you don't need to use a voltage doubler at lower voltages. The only time you run into a problem is when you are trying to produce very high dc output voltages.

For instance, line voltage is 120 V rms, or 170 V peak. If you are trying to produce 3400 V dc, you will need to use a 1:20 step-up transformer. Here is where the problem comes in. Very high secondary voltages can be obtained only with bulky transformers. At some point, a designer may decide that it would be simpler to use a voltage doubler and a smaller transformer.

Voltage Tripler

By connecting another section, we get the *voltage tripler* of Fig. 4-34*b*. The first two sections act like a doubler. At the peak of the negative half cycle, D_3 is forward-biased. This charges C_3 to $2V_p$ with the polarity shown in Fig. 4-34*b*. The tripler output appears across C_1 and C_3. The load resistance can be connected across the tripler output. As long as the time constant is long, the output equals approximately $3V_p$.

Voltage Quadrupler

Figure 4-34*c* is a *voltage quadrupler* with four sections in *cascade* (one after another). The first three sections are a tripler, and the fourth makes the overall circuit a quadrupler. The first capacitor charges to V_p. All others charge to $2V_p$. The quadrupler output is across the series connection of C_2 and C_4. We can connect a load resistance across the quadrupler output to get an output of $4V_p$.

Theoretically, we can add sections indefinitely, but the ripple gets much worse with each new section. Increased ripple is another reason why **voltage multipliers** (doublers, triplers, and quadruplers) are not used in low-voltage power supplies. As stated earlier, voltage multipliers are almost always used to produce high voltages, well into the hundreds or thousands of volts. Voltage multipliers are the natural choice for high-voltage and low-current devices like the cathode-ray tube (CRT) used in television receivers, oscilloscopes, and computer monitors.

Variations

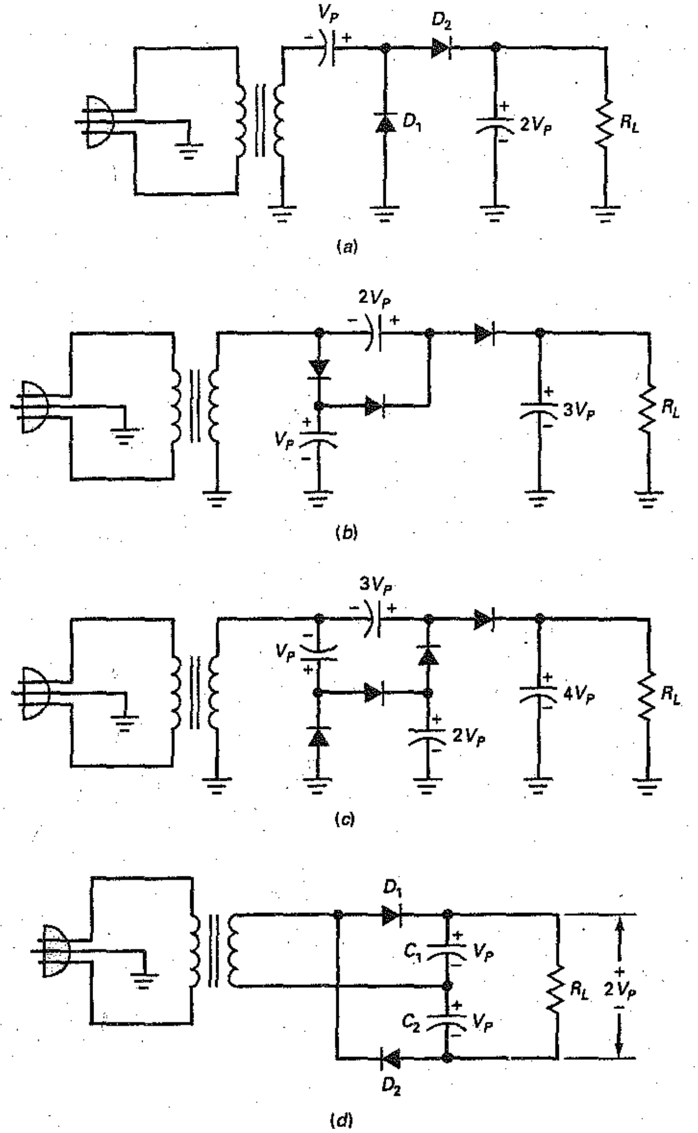
All of the voltage multipliers shown in Fig. 4-34 use load resistances that are *floating*. This means that neither end of the load is grounded. Figure 4-35*a*, *b*, and *c* shows variations of the voltage multipliers. Figure 4-35*a* merely adds grounds to Fig. 4-34*a*. On the other hand, Fig. 4-35*b* and *c* are redesigns of the tripler (Fig. 4-34*b*) and quadrupler (Fig. 4-34*c*). In some applications, you may see floating-load designs used (such as in the CRT); in others, you may see the grounded-load designs used.

Full-Wave Voltage Doubler

Figure 4-35*d* shows a full-wave voltage doubler. On the positive half cycle of the source, the upper capacitor charges to the peak voltage with the polarity shown. On the next half cycle, the lower capacitor charges to the peak voltage with the indicated polarity. For a light load, the final output voltage is approximately $2V_p$.

The voltage multipliers discussed earlier are half-wave designs; that is, the output ripple frequency is 60 Hz. On the other hand, the circuit of Fig. 4-35*d* is called a *full-wave voltage doubler* because one of the output capacitors is being charged during each half cycle. Because of this, the output ripple is 120 Hz. This ripple frequency is an advantage because it is easier to filter. Another advantage of the full-wave doubler is that the PIV rating of the diodes need only be greater than V_p.

Figure 4-35 Voltage multipliers with grounded loads, except full-wave doubler. (*a*) Doubler; (*b*) tripler; (*c*) quadrupler; (*d*) Full-wave doubler.



Summary

SEC. 4-1 THE HALF-WAVE RECTIFIER

The half-wave rectifier has a diode in series with a load resistor. The load voltage is a half-wave output. The average or dc voltage out of a half-wave rectifier equals 31.8 percent of the peak voltage.

SEC. 4-2 THE TRANSFORMER

The input transformer is usually a step-down transformer in which the voltage steps down and the current steps up. The secondary voltage equals the primary voltage divided by the turns ratio.