Test Equipment Scene

By Leslie Solomon

USING DIODES IN POWER SUPPLIES

ACCORDING to my mail, the piece of equipment that most people want to build for their test bench is a power supply. They usually want a supply that is well-filtered, regulated, has a variable output voltage level, and can be used to power a wide variety of equipment.

Questions most often asked about designing a supply involve the rectifier diodes and how to keep them from burning out. The confusion seems to lie in interpreting the diode specifications—particularly the peak inverse voltage (PIV).

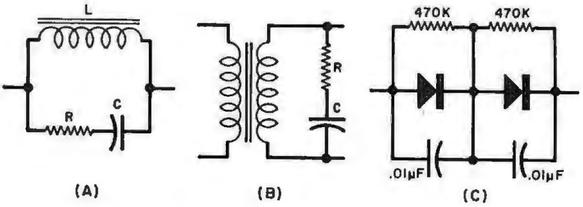
There are two ways to apply voltage to a diode—the right way (forward) and the wrong way (reverse). The right way is what is normally seen in a circuit and the wrong way is hardly ever seen, but is important to take it into consideration. For example, if we want a positive output from a simple half-wave rectifier, we would connect the diode anode to one end of the transformer secondary and the diode cathode to the positive lead of the filter capacitor. The other end of the transformer is then the common and is connected to the negative terminal of the filter capacitor. Now, when power is applied, the diode conducts on the positive half cycles and is reverse biased on the negative halves. But there is more to the story than that.

When the diode is properly biased, it conducts and allows the positive half cycles to put a charge on the filter capacitor, making the positive end more and more positive. On the negative half cycle, the diode anode is reverse biased, but the cathode is also reverse biased by the positive voltage on the capacitor. Therefore, the *total* voltage across the diode is not just the transformer voltage, but the transformer voltage plus the capacitor voltage. In fact, this voltage is 2.828 times the actual rms value. If the transformer supplies 35 volts rms, then the actual voltage across the diode can reach about 99 volts. If a center-tapped transformer and two diodes are used in a conventional full-wave rectifier/filter circuit, the voltage across the diode would be 1.414 times the rms (50 volts in our example).

So, it can be seen that the PIV rating of the diode must be carefully observed. (It is given in the specifications.) Using just any silicon rectifier is providing an invitation to disaster.

Choke-Input Filters. If a choke-input filter is used, it must be kept in mind that, when the diode switches through the zero point of the voltage cycle, the current in the inductor goes to zero. This sudden drop in current causes a large back emf across the diode. (This is how ignition and horizontal-sweep circuits work.) In this case, you must use a diode having a higher PIV and also use the circuit shown at A across the inductor. The approximate value of the transient-suppressing capacitor can be found from $C = (L \times I^2)/10E^2$, where C is in microfarads, L is the maximum choke inductance in henries, I is the maximum current through the choke in amperes, and E is the maximum dc supply in kilovolts. The series resistor should be equal to the load impedance connected across the supply.

Another source of damaging transients is the power transformer itself. Power-line transients and the result-



(A) (B) (C)

ing abrupt changes in the magnetizing current in the transformer can cause damage in voltage-sensitive solid-state components. The circuit shown at B is one way to reduce these transients. The approximate value of the capacitor can be found from $C = (15 \times E \times I)/e^2$, where C is in microfarads, E is the maximum dc supply voltage, I is the maximum current of the supply in amperes, and e is the rms voltage of the transformer secondary. Here again, the resistor should be equivalent to the load impedance on the supply. (If there is any doubt about this, use 100 ohms.) For transient suppression, it is also possible to use a commercial suppressor such as those in the GE MOV line.

Current-limiting Resistors. It is wise to use series current limiting resistors with silicon rectifiers. Knowing the voltage on the transformer secondary and the maximum allowable diode current (from its specifications), you can calculate the value of resistance that will safely limit the current if a direct short were to occur across the rectifier (which happens when the supply is first turned on and the filter capacitors are not charged). Calculate the power and use a resistor of sufficient size to prevent rapid burnout.

If the secondary voltage of the transformer is too high for the PIV of the diodes you have on hand, put two or more diodes in series. To equalize the PIV, connect a resistor of about 470,000 ohms across each diode. To reduce possible transient damage, connect a 0.01-μF, 1-kV capacitor across each diode as shown at C. There is another good reason for using these shunt capacitors, which can be explained as follows.

Silicon diodes, such as those used as rectifiers, do not conduct until the applied forward voltage reaches about 0.6 volt. As the input reaches this value, the diode junction suddenly snaps into conduction, producing a small, but steep, waveform. The waveform can have harmonics that go far up into the r-f spectrum, producing signals that can interfere with a radio receiver. Using capacitors across the rectifier diodes suppresses this r-f generation.

If you have a receiver that uses solid-state diodes in the rectifier and you are troubled by strange signals that don't seem to make sense, try connecting a capacitor across each rectifier diode. ◈