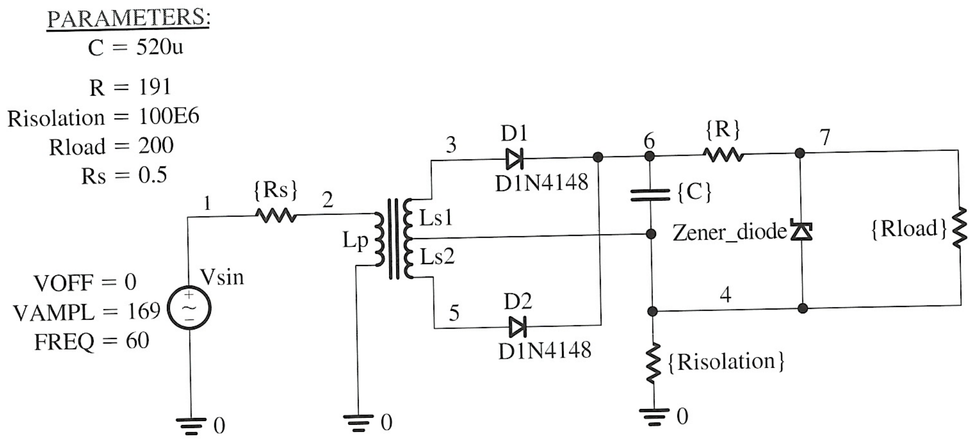

FIGURE 3.53 Capture schematic of the 5-V dc power supply in Example 3.10.

capacitor, and a zener voltage regulator. The only perhaps-puzzling component is $R_{isolation}$, the 100-MΩ resistor between the secondary winding of the transformer and ground. This resistor is included to provide dc continuity and thus "keep SPICE happy"; it has little effect on circuit operation.

Let it be required that the power supply (in Fig. 3.53) provide a nominal dc voltage of 5 V and be able to supply a load current I_{load} as large as 25 mA; that is, R_{load} can be as low as 200 Ω. The power supply is fed from a 120-V (rms) 60-Hz ac line. Note that in the PSpice schematic (Fig. 3.53), we use a sinusoidal voltage source with a 169-V peak amplitude to represent the 120-V rms supply (as 120-V rms = 169-V peak). Assume the availability of a 5.1-V zener diode having r_z = 10 Ω at I_Z = 20 mA (and thus V_{Z0} = 4.9 V), and that the required minimum current through the zener diode is I_{Zmin} = 5 mA.

An approximate first-cut design can be obtained as follows: The 120-V (rms) supply is stepped down to provide 12-V (peak) sinusoids across each of the secondary windings using a 14:1 turns ratio for the center-tapped transformer. The choice of 12 V is a reasonable compromise between the need to allow for sufficient voltage (above the 5-V output) to operate the rectifier and the regulator, while keeping the PIV ratings of the diodes reasonably low. To determine a value for R, we can use the following expression:

$$R = \frac{V_{Cmin} - V_{Z0} - r_z I_{Zmin}}{I_{Zmin} + I_{Lmax}}$$

where an estimate for V_{Cmin}, the minimum voltage across the capacitor, can be obtained by subtracting a diode drop (say, 0.8 V) from 12 V and allowing for a ripple voltage across the capacitor of, say, V_r = 0.5 V. Thus, V_{Smin} = 10.7 V. Furthermore, we note that I_{Lmax} = 25 mA and I_{Zmin} = 5 mA, and that V_{Z0} = 4.9 V and r_z = 10 Ω. The result is that R = 191 Ω.

Next, we determine C using a restatement of Eq. (3.33) with V_p/R replaced by the current through the 191-Ω resistor. This current can be estimated by noting that the voltage across C varies from 10.7 to 11.2 V, and thus has an average value of 10.95 V. Furthermore, the desired voltage across the zener is 5 V. The result is C = 520 μF.

Now, with an approximate design in hand, we can proceed with the SPICE simulation. For the zener diode, we use the model of Fig. 3.52, and assume (arbitrarily) that D_1 has I_S = 100 pA