ELG3331: Design of a DC Power Supply

(Microelectronic Circuits: Sedra/Smith)

Design a DC power supply that provides 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. Assume the availability of a 5.1-V zener diode having r_z = 10 Ω at I_z = 20 mA (and use V_{zo} = 4.9 V), and that the required minimum current through the zener diode is I_{zmin} = 5 mA.

Design Process:

- The 120-V supply is stepped down to provide 12-V (peak) sinusoid 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.
- To determine a value for R, we may use the following expression

$$R = \frac{V_{C\,\min} - V_{Z0} - r_Z I_{Z\,\min}}{I_{Z\,\min} + I_{L\,\max}}$$

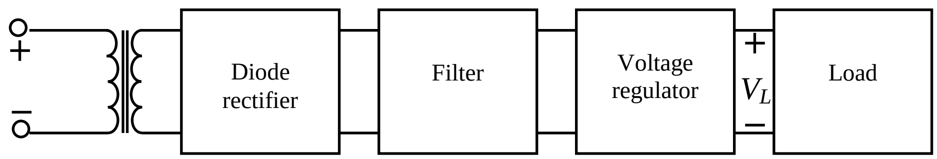
- An estimate for $V_{C\min}$, the minimum voltage across the capacitor, can be obtained by subtracting a diode drop (say, 0.8 V) from 12 V and allowing for a ripple voltage across the capacitor of, say, V_r = 0.5 V. Therefore, V_{Cmin} = 12 - 0.8 - 0.5= 10.7 V. Substituting the values in the above equation, we get R = 119 Ω.

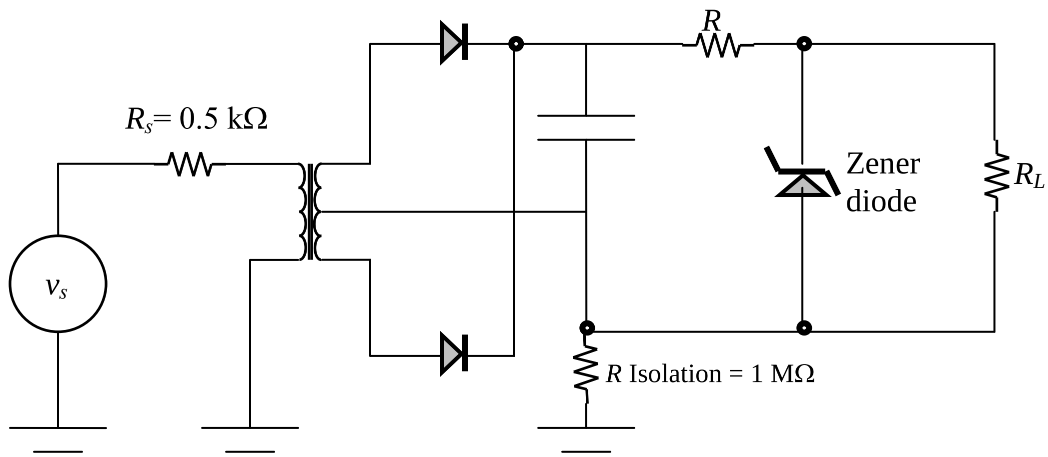
$$R = \frac{10.7 - 4.9 - 10 \times 5 \times 10^{-3}}{5 \times 10^{-3} + 25 \times 10^{-3}} = 191\Omega$$

- Next, we determine C

$$V_r = \frac{V_p}{2fCR}$$

Replace V_p/R by current through 191-Ω resistor. This current can be estimated by noting that the voltage across C varies from 10.7 V to 11.2 V, and therefore has an average value of 10.95 V. Further, the desired voltage across the zener is 5 V. The value of C = 520 μF.




R
R_s= 0.5 kΩ
v_s
Zener
diode
R_L
R Isolation = 1 MΩ