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 $\Omega$. 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 $r_z = 10 \Omega$ 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:

\[
R = \frac{V_{Cmin} - V_{Zo} - r_z I_{zmin}}{I_{zmin} + I_{Lmax}}
\]

- 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. Therefore, $V_{Cmin} = 12 - 0.8 - 0.5 = 10.7$ V. Substituting the values in the above equation, we get $R = 119 \Omega$.

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

- Next, we determine $C$

\[
V_r = \frac{V_p}{2 fCR}
\]

Replace $V_p/R$ by current through 191-$\Omega$ 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 $C = 520 \mu F$. 

![Diagram of the power supply system](image-url)
Isolation = 1 MΩ

$R_s = 0.5 \, \text{kΩ}$

$Zener$  

diode

$R_L$