2.35 For the lossless transmission line circuit shown in Fig. P2.35, determine the equivalent series lumped-element circuit at 400 MHz at the input to the line. The line has a characteristic impedance of 50 Ω and the insulating layer has $\varepsilon_r = 2.25$.

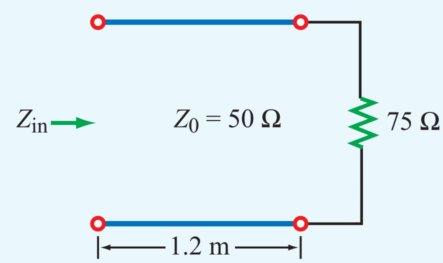


Figure P2.35 Circuit for Problem 2.35.

Solution: At 400 MHz,

$$\lambda = \frac{u_p}{f} = \frac{c}{f\sqrt{\varepsilon_r}} = \frac{3 \times 10^8}{4 \times 10^8 \sqrt{2.25}} = 0.5 \text{ m.}$$

$$\beta l = \frac{2\pi}{\lambda} l = \frac{2\pi}{0.5} \times 1.2 = 4.8\pi.$$

Subtracting multiples of 2π, the remainder is:

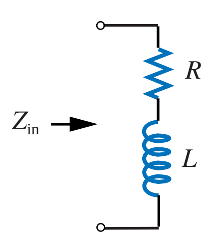
$$\beta l = 0.8\pi \text{ rad.}$$

Using (2.79),

$$Z_{in} = Z_0 \left(\frac{Z_L + jZ_0 \tan \beta l}{Z_0 + jZ_L \tan \beta l} \right)$$

$$= 50 \left(\frac{75 + j50 \tan 0.8\pi}{50 + j75 \tan 0.8\pi} \right) = (52.38 + j20.75) \ \Omega.$$

Z_{in} is equivalent to a series RL circuit with



$$R = 52.38\ \Omega$$

$$\omega L = 2\pi f L = 20.75\ \Omega$$

or

$$L = \frac{20.75}{2\pi \times 4 \times 10^8} = 8.3 \times 10^{-9}\ \text{H},$$

which is a very small inductor.