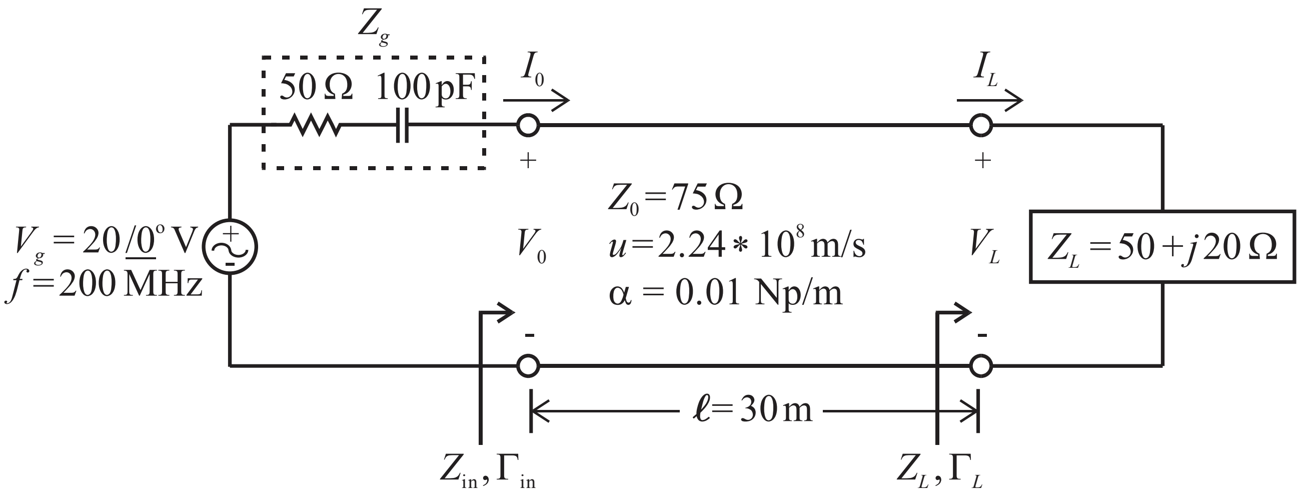
EE 381 Lossy Transmission Line example with power

For the circuit shown below, calculate the standing wave ratio as well as input & load currents, voltages, powers, reflection coefficients, and impedances. Also, plot the magnitude of the current and voltage as a function of position near generator.



Enter given information

$ZL := 50 + j \cdot 20 \quad \Omega$

$Vg := 20 \cdot e^{j \cdot 0 \cdot \frac{\pi}{180}}$ V $\qquad f := 200 \cdot 10^{6}$ Hz $\qquad Rg := 50 \quad \Omega \qquad Cg := 100 \cdot 10^{-12}$ F

$L := 30$ m $\qquad u := 2.24 \cdot 10^{8}$ m/s $\qquad Z0 := 75 \quad \Omega \qquad \alpha := 0.01$ Np/m

Calculate variables related to generator and transmission line

$\omega := 2 \cdot \pi \cdot f \qquad \omega = 1.257 \times 10^{9}$ rad/s $\qquad \beta := \frac{\omega}{u} \qquad \beta = 5.61$ rad/m $\qquad \gamma := \alpha + j \cdot \beta$

$Zg := Rg - \frac{j}{2 \cdot \pi \cdot f \cdot Cg} \qquad Zg = 50 - 7.9577i \quad \Omega \qquad \lambda := \frac{u}{f} \qquad \lambda = 1.12$ m

Calculate reflection coefficients and SWR

$\Gamma L := \frac{ZL - Z0}{ZL + Z0} \qquad |\Gamma L| = 0.2529 \qquad \arg(\Gamma L) \cdot \frac{180}{\pi} = 132.25$ deg

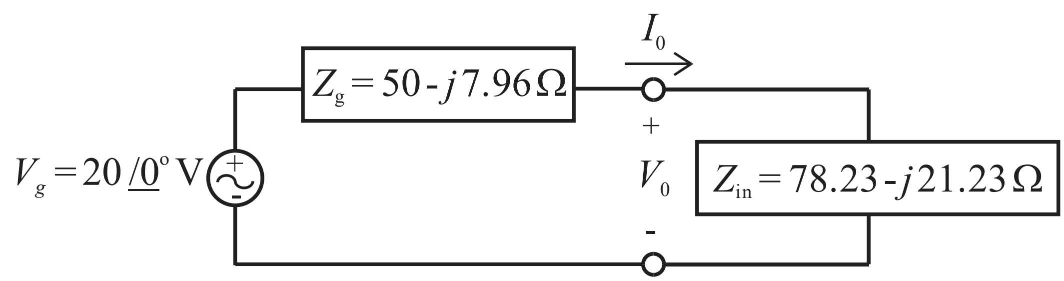
$\Gamma in := \Gamma L \cdot e^{-2 \cdot \gamma \cdot L} \qquad |\Gamma in| = 0.1388 \qquad \arg(\Gamma in) \cdot \frac{180}{\pi} = -73.464$ deg

$SWR := \frac{1 + |\Gamma L|}{1 - |\Gamma L|} \qquad SWR = 1.677$

Calculate input impedance

$Zin := Z0 \cdot \dfrac{1 + \Gamma in}{1 - \Gamma in}$ $\quad$ $Zin = 78.2287 - 21.2269i$ Ω

Calculate input current, voltage, and power using equivalent circuit



$I0 := \dfrac{Vg}{Zg + Zin}$ $\quad$ $|I0| = 0.1521$ A $\quad$ $\arg(I0) \cdot \dfrac{180}{\pi} = 12.822$ deg

$V0 := Vg \cdot \dfrac{Zin}{Zg + Zin}$ $\quad$ $|V0| = 12.3274$ V $\quad$ $\arg(V0) \cdot \dfrac{180}{\pi} = -2.359$ deg

$Pave\_in := 0.5 \cdot \mathrm{Re}\left(V0 \cdot \overline{I0}\right)$ $\quad$ $Pave\_in = 0.9047$ W

Calculate phasor forward traveling voltage wave amplitude V_0^+

$Vfwd := \dfrac{V0}{1 + \Gamma in}$ $\quad$ $|Vfwd| = 11.7629$ V $\quad$ $\arg(Vfwd) \cdot \dfrac{180}{\pi} = 4.935$ deg

Define reflection coefficient, phasor current & voltage in terms of position

$\Gamma(z) := \Gamma L \cdot e^{-2 \cdot \gamma \cdot (L - z)}$

$Is(z) := \dfrac{Vfwd}{Z0} \cdot e^{-\gamma \cdot z} \cdot (1 - \Gamma(z))$ $\quad$ $Vs(z) := Vfwd \cdot e^{-\gamma \cdot z} \cdot (1 + \Gamma(z))$

Calculate the load current, voltage, and power

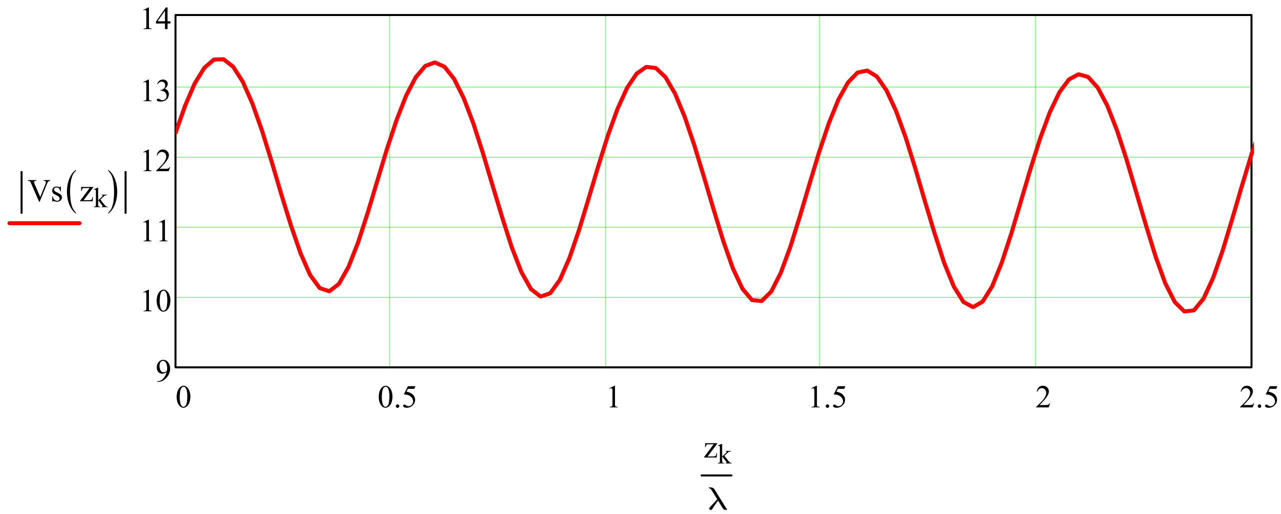
$IL := Is(L)$ $\quad$ $|IL| = 0.13768$ A $\quad$ $\arg(IL) \cdot \dfrac{180}{\pi} = 72.988$ deg

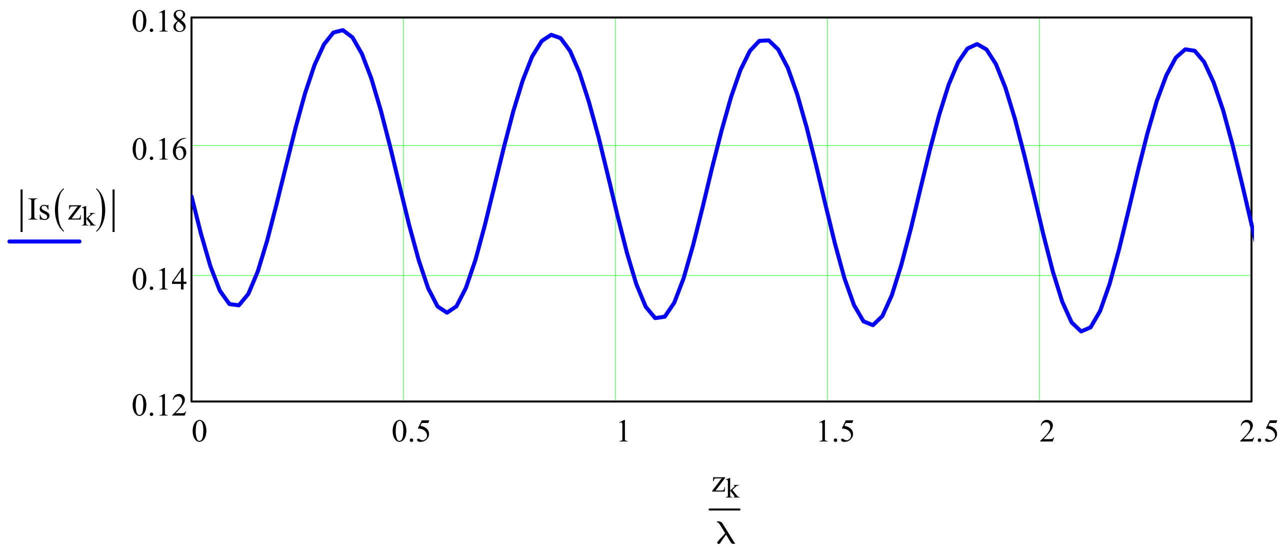
$VL := Vs(L)$ $\quad$ $|VL| = 7.4141$ V $\quad$ $\arg(VL) \cdot \dfrac{180}{\pi} = 94.789$ deg

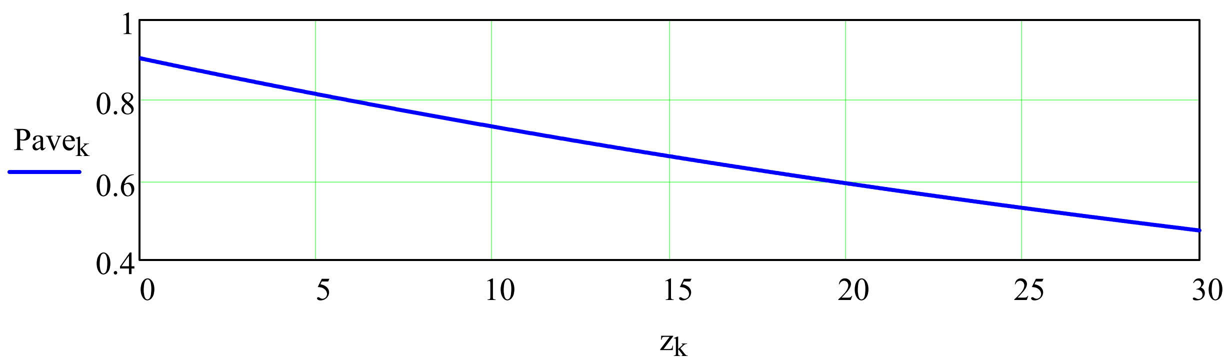
$Pave\_L := 0.5 \cdot \mathrm{Re}\left(VL \cdot \overline{IL}\right)$ $\quad$ $Pave\_L = 0.4739$ W $\quad$ Smaller than input power!

Plot magnitude of current & voltage and power as functions of position

$k := 0 .. 1200 \qquad z_k := \frac{k}{1200} \cdot L \qquad Pave_k := 0.5 \cdot \mathrm{Re}\left(Vs(z_k) \cdot \overline{Is(z_k)}\right)$



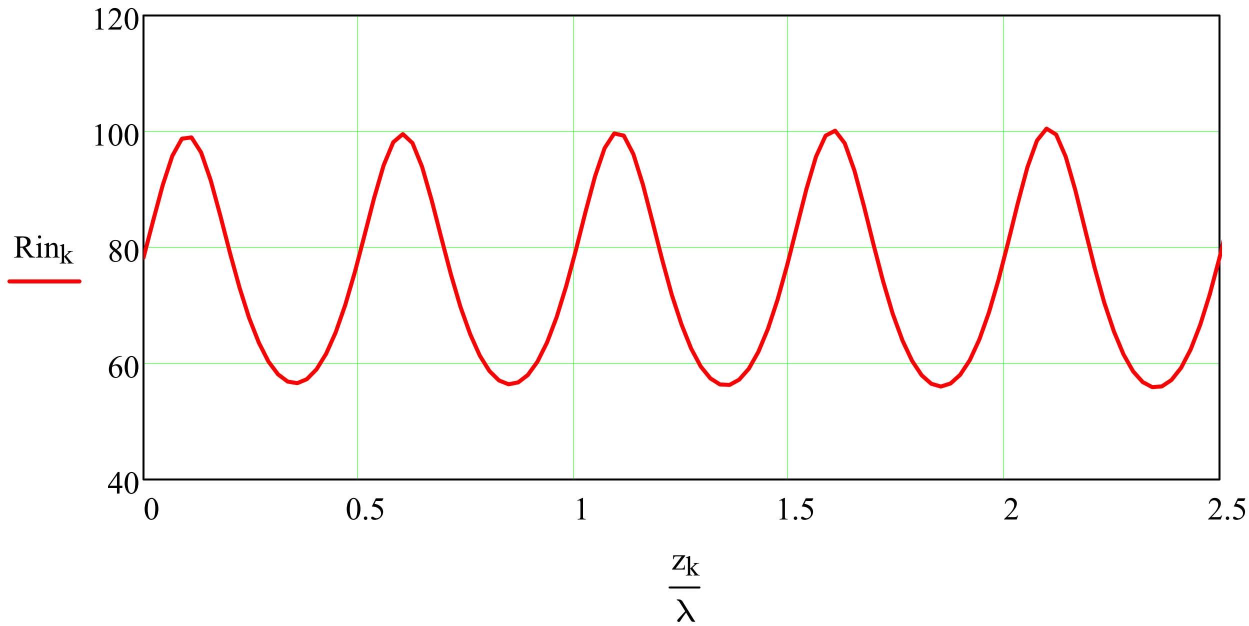


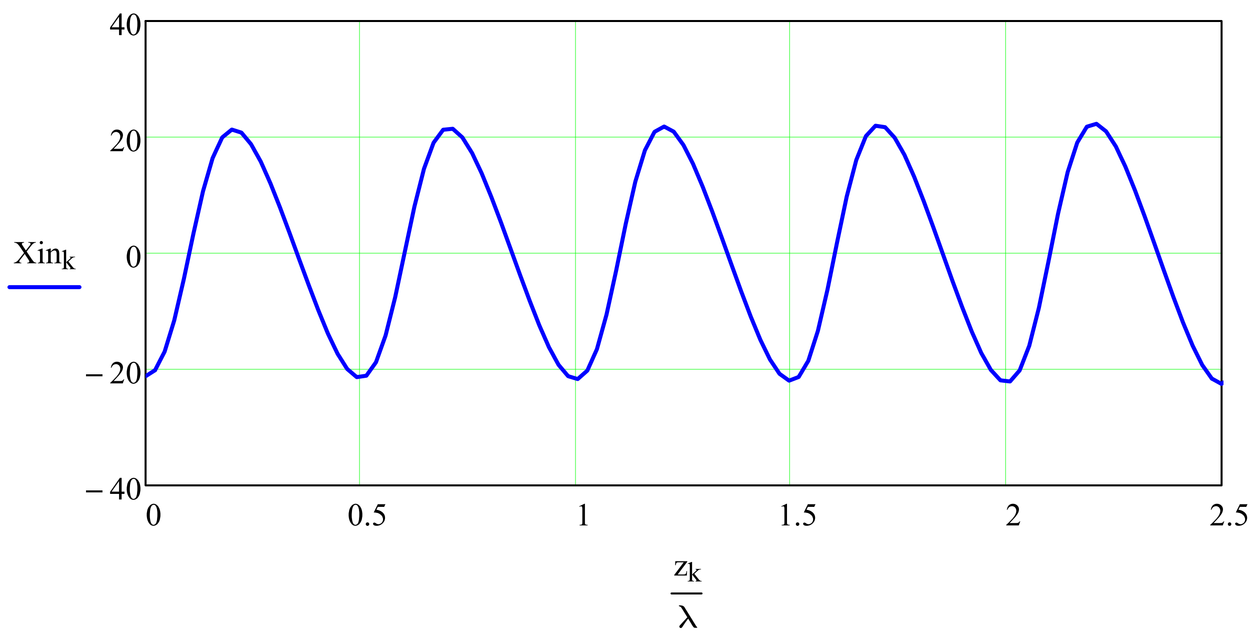


Plot the input impedance as a function of position near the generator

$$Zin_k := Z0 \cdot \left(\frac{1 + \Gamma(z_k)}{1 - \Gamma(z_k)} \right) \qquad Rin_k := \mathrm{Re}(Zin_k) \qquad Xin_k := \mathrm{Im}(Zin_k)$$

Remember Z_{in} is complex, separate the real & imaginary parts for plotting.





Everything nearly repeats at λ/2 intervals on this low loss TL!