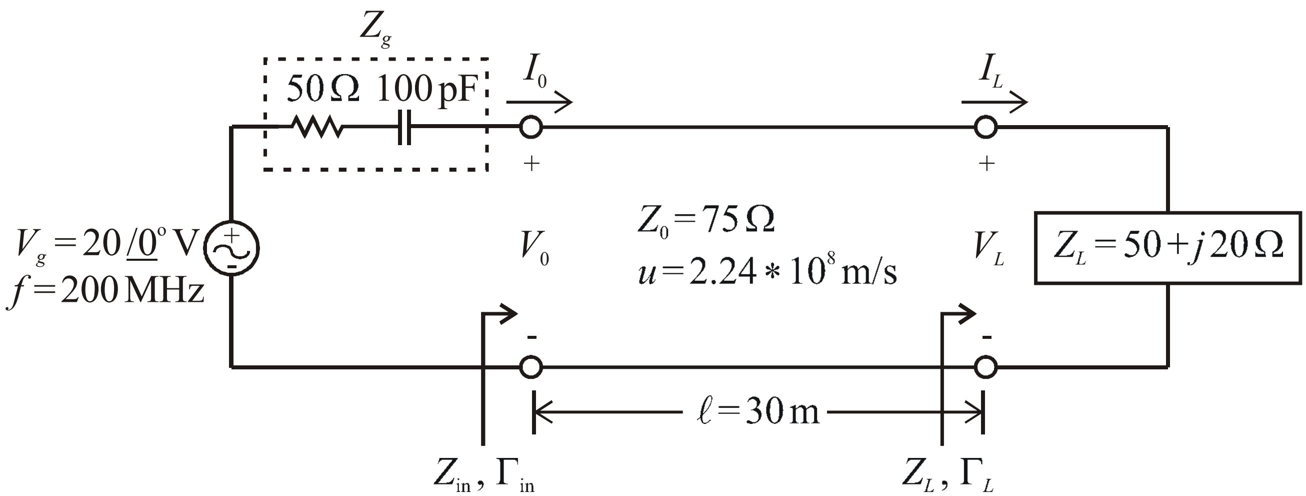
EE 381 Lossless Transmission Line example with power

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

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

$L := 30$ m $\quad u := 2.24 \cdot 10^8$ m/s $\quad Z0 := 75$ Ω $\quad ZL := 50 + j \cdot 20$ Ω

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

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

Calculate reflection coefficients and SWR

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

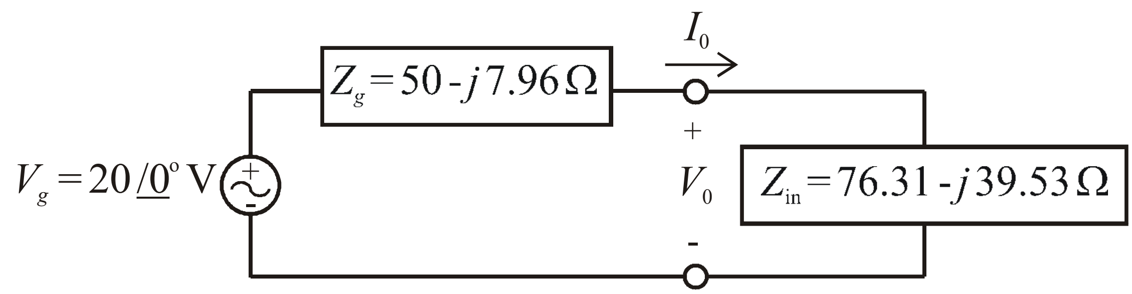
$\Gamma in := \Gamma L \cdot e^{-j \cdot 2 \cdot \beta \cdot L} \qquad \boxed{|\Gamma in| = 0.2529} \qquad \boxed{arg(\Gamma in) \cdot \frac{180}{\pi} = -73.464}$ deg

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

Calculate input impedance

$Zin := Z0 \cdot \frac{1 + \Gamma in}{1 - \Gamma in}$ $\boxed{Zin = 76.3073 - 39.5296i}$ Ω

Calculate input current, voltage, and power using equivalent circuit



$I0 := \frac{Vg}{Zg + Zin}$ $\boxed{|I0| = 0.1482}$ A $\boxed{\arg(I0) \cdot \frac{180}{\pi} = 20.605}$ deg

$V0 := Vg \cdot \frac{Zin}{Zg + Zin}$ $\boxed{|V0| = 12.7373}$ V $\boxed{\arg(V0) \cdot \frac{180}{\pi} = -6.781}$ deg

$Pave\_in := 0.5 \cdot Re\left(V0 \cdot \overline{I0}\right)$ $\boxed{Pave\_in = 0.8381}$ W

Calculate phasor forward traveling voltage wave amplitude V_0^+

$Vfwd := \frac{V0}{1 + \Gamma in}$ $|Vfwd| = 11.5893$ V $\arg(Vfwd) \cdot \frac{180}{\pi} = 5.963$ deg

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

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

$Is(z) := \frac{Vfwd}{Z0} \cdot e^{-j \cdot \beta \cdot z} \cdot (1 - \Gamma(z))$ $Vs(z) := Vfwd \cdot e^{-j \cdot \beta \cdot z} \cdot (1 + \Gamma(z))$

Calculate the load current, voltage, and power

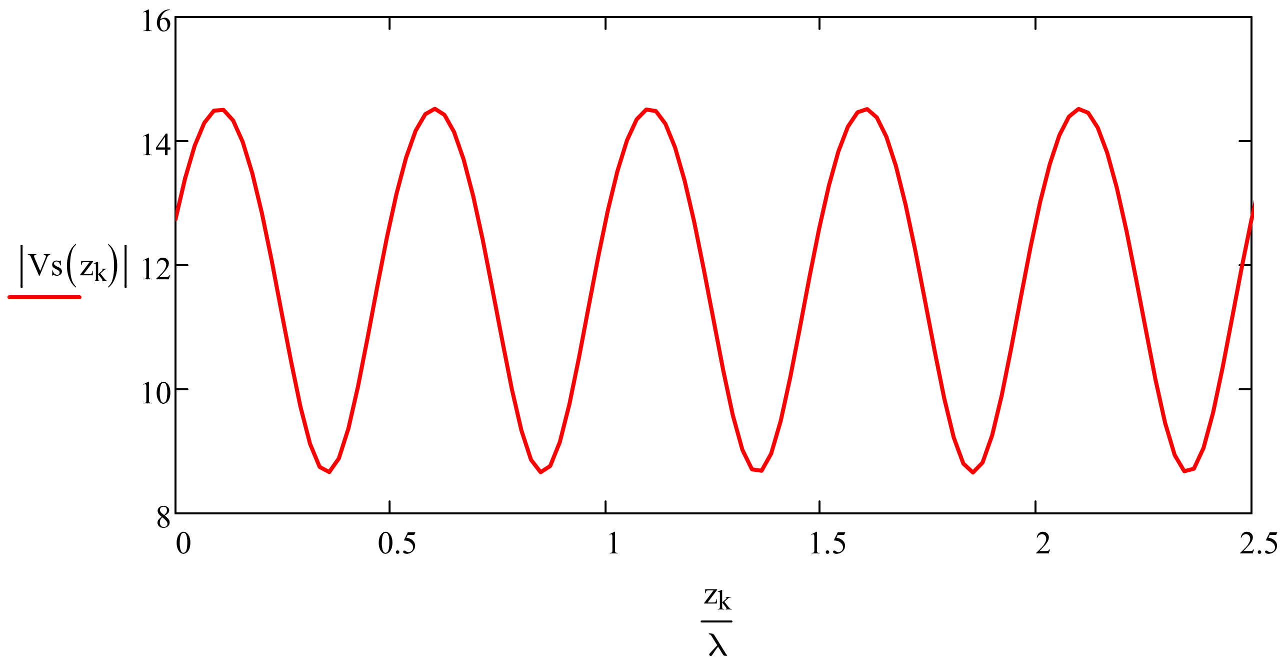
$IL := Is(L)$ $\boxed{|IL| = 0.1831}$ A $\boxed{\arg(IL) \cdot \frac{180}{\pi} = 74.016}$ deg

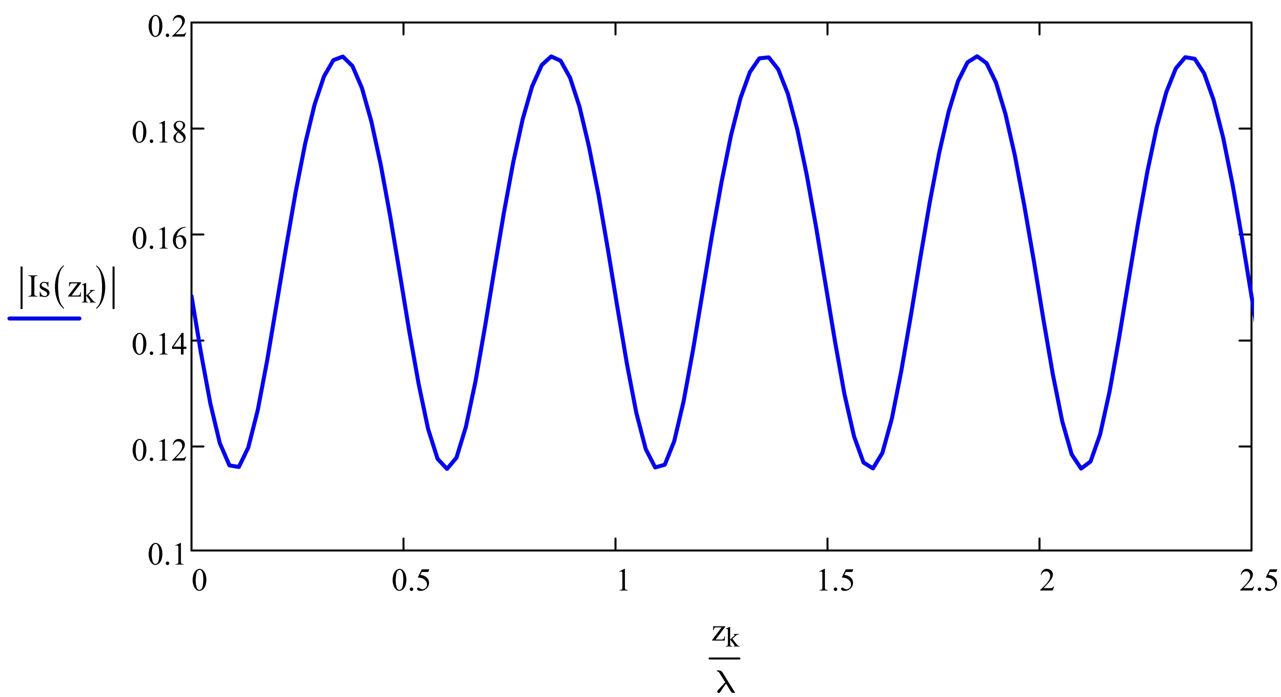
$VL := Vs(L)$ $\boxed{|VL| = 9.8603}$ V $\boxed{\arg(VL) \cdot \frac{180}{\pi} = 95.817}$ deg

$Pave\_L := 0.5 \cdot Re\left(VL \cdot \overline{IL}\right)$ $\boxed{Pave\_L = 0.83815}$ W Same as input power!

Plot the magnitude of the current & voltage as functions of position

$k := 0 .. 1200 \qquad z_k := \frac{k}{1200} \cdot L$



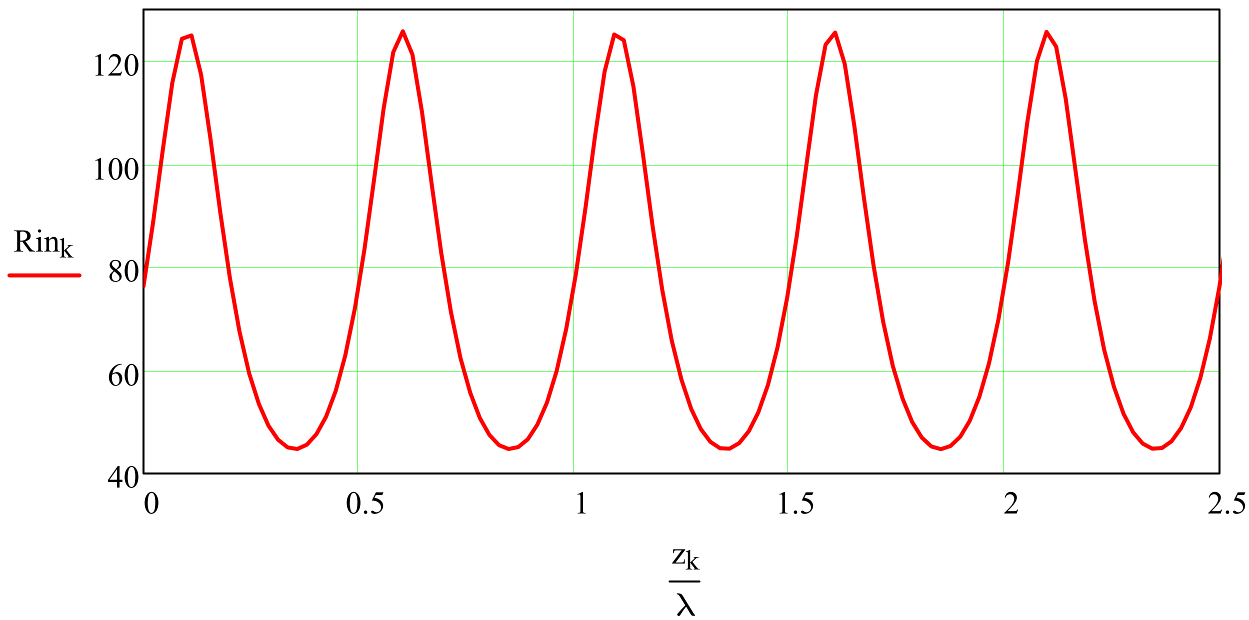


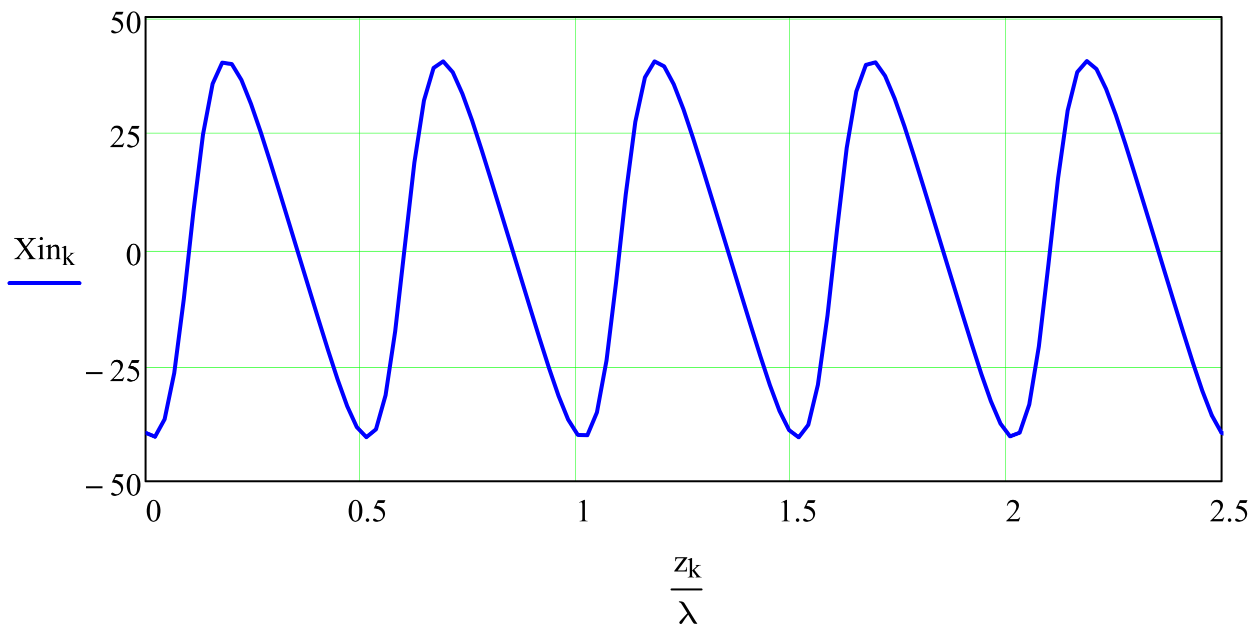
Everything repeats at $\lambda/2$ intervals!

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 Zin is complex, separate the real & imaginary parts for plotting.





Everything repeats at λ/2 intervals!