Problem 9.1

What are the Thevenin equivalent circuits for the following lossless air-filled 100-ohm TEM lines at 1 MHz?

a) An open-circuited line \(7\lambda/8\) long.
b) A 50-ohm resistor at the end of a line \(\lambda/8\) long
c) A voltage source \(V_0\) in series with a 100-ohm resistor at the end of a \(\lambda/4\) line.

Problem 9.2

The line of Problem 9.1 is terminated with a load \(R\). What fraction of the incident power is reflected if:

a) \(R = 50\) ohms
b) \(R = -50\) ohms

Problem 9.3

A 100-ohm source is to be matched to a 200-ohm load at wavelength \(\lambda\).

a) Design a quarter-wave TEM transformer for a TEM line with \(\epsilon = 4\epsilon_0\). What are the line impedance \(Z_0\) and length \(D\)?
b) Using a Smith chart, design a matching circuit that uses an inductor \(L\) in series with a 100-ohm TEM line to match a load at \(\lambda\) that has impedance \(100 + 100j\) ohms. What are \(L\) and the line length \(D\)?
c) Repeat (b) for the case where the inductor is connected in parallel with the 100-ohm line. Again, what are \(L\) and the line length \(D\)?
Problem 9.4

We want to design a 10-MHz RLC resonator that utilizes a resistor $R = 1$ ohm and has a $Q$ of 100.

a) What are $L$ and $C$ for a series resonator?
b) What are $L$ and $C$ for a parallel resonator?

Problem 9.5

We wish to connect a 100-ohm TEM line with a matched source to an RLC resonator so as to achieve a matched load at 10 MHz with a loaded $Q$ of 100 ("loaded $Q$" means $Q = \omega / \Delta \omega$ is measured with the line and source connected).

a) Design this RLC resonator (choose $R$, $L$, $C$, and either a series or parallel configuration) so as to achieve an open-circuit line termination as $f \rightarrow 0$ or $\infty$ Hz.
b) What are the external and internal $Q$'s ($Q_E$ and $Q_I$) for your circuit?
c) If this resonator is energized and then is allowed to decay by transmitting power down the TEM line to a matched load, what is the decay rate $\alpha$ for the resonator voltage $V$; e.g., $V = V_0 e^{-\alpha t}$? Note that parts (b) and (c) do not require knowledge of the specific values you chose for $L$ and $C$. 