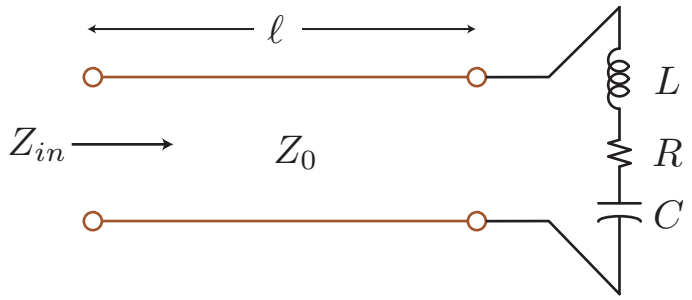
University of California, Berkeley *Spring 2007*
EECS 117 *Prof. A. Niknejad*

Problem Set 3
Due Thursday February 22, 2007

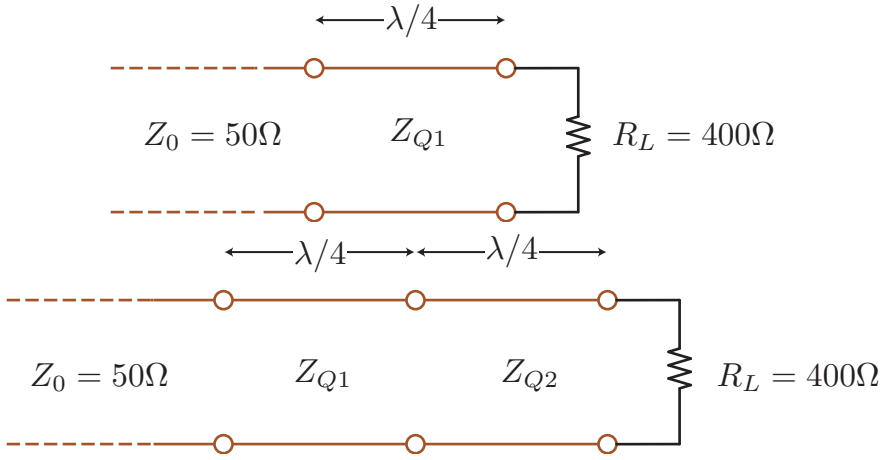
1. Find the input impedance Z_{in} for the circuit below. Show the input impedance is that of a second order circuit. Draw an equivalent lumped circuit diagram for Z_{in} and find the quality factor and resonant frequency.

   The series resonant circuit is fed from a lossless transmission line with $Z_0 = 50\Omega$ and of length $\ell = 2$cm and $v = 1 \times 10^8$m/s. The lumped elements have the following parameter values: $L = 2$nH, $C = .901$pF, and $R = 2\Omega$.



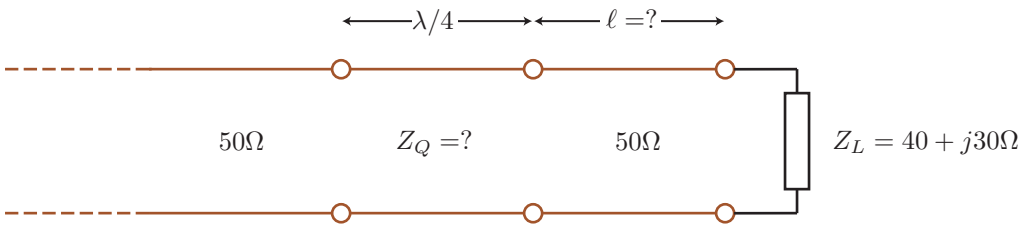
2. Redo the first problem with $R = 0$ but now consider the transmission line as lossy. Assume that the transmission line $Q = 30$.

3. (Problem 3-31) **Quarter-wave matching.** Many microwave applications require very low values of S over a broad band of frequencies. The two circuits shown in the figure below are designed to match a load of $Z_L = R_L = 400\Omega$ to a line with $Z_0 = 50\Omega$, at 900MHz. The first circuit is an air-filled coaxial quarter-wave transformer, and the second circuit consists of two air-filled coaxial quarter-wave transformers cascaded together. (a) Design both circuits. Assume $Z_{Q1}Z_{Q2} = Z_0 Z_L$ for the second circuit. (b) Compare the bandwidth of the two circuits designed by calculating S on each line at frequencies 15% above and below the design frequency.



4. Design a shunt stub matching network to match a load of $Z_L = 10 + j30$ to a feed line of characteristic impedance of $Z_0 = 50\Omega$. Using SPICE or your favorite mathematical analysis tool, compare the design using a short, open, and lumped element stub. Which design results in the largest bandwidth? Assume that we can tolerate an SWR of 1.2.

5. (Problem 3-38) **Quarter-wave matching.** (a) For the transmission line system shown below, determine the value of the characteristic impedance of a quarter-wave transformer (i.e. Z_Q) and its location ℓ with respect to the load needed to achieve matching between Z_L and Z_0. (b) Repeat part (a) for $Z_L = 80 - j60\Omega$.



6. Derive the insertion loss (P_L/P_{in}) for a lossy quarter wave transformer assuming a real load/source resistance $R_L > R_S$. The final expression can be expressed as a function of the quality factor of the line $Q = \beta/2\alpha$ and the transformation ratio $m = R_L/R_S$.