Instructions, notes, and hints:

You may make reasonable assumptions and approximations in order to compensate for missing information, if any. Provide the details of all solutions, including important intermediate steps. You will not receive credit if you do not show your work.

Assignment:

1. A certain inductor has a design value of 1 μH, a measured self-resonant frequency of 210 MHz, and a measured wire resistance at that frequency of 0.5 Ω. Assuming that the realistic inductor model given in Sec. 2.11 of the textbook can be applied to this inductor, what is its stray capacitance?

2. Attenuators constructed from resistors are an important and widely used tool for RF measurements. They are often used to improve the impedance match between devices when the minimization of reflections or the establishment of a controlled input impedance is more important than the loss of power in the attenuator. Consider the case of an amplifier that is supposed to have an input impedance of 50 Ω but, because of a design flaw, actually has an input impedance of 26 + j34 Ω. The 3-dB T network attenuator “pad” shown below is added to the input of the amplifier to improve the impedance match to the source. Calculate the reflection coefficient magnitude “seen” by the signal source assuming a system impedance of $Z_0 = 50 \, \Omega$ with and without the attenuator in place. Also calculate the associated VSWR and return loss for both cases.

3. A load impedance of 250 Ω needs to be transformed to 50 Ω at a frequency of 1.8 MHz.
   a. Design an L network using an inductor as the shunt element, if possible, to accomplish the impedance transformation. A complete design includes specifications of the capacitor and inductor values. You do not have to specify standard values.
   b. Design a T network using an inductor as the shunt element, if possible, to accomplish the same transformation. The target overall $Q$ is 10.
   c. Using a Matlab m-file (script), plot the VSWR vs. frequency for both networks over the 1-3 MHz range on the same axes. Use different line styles (and a legend to identify them) so that the curves can be distinguished in black & white print. The VSWR axis should range from 1 to 6 (a return loss of roughly 3 dB). Add horizontal and vertical grid lines.
   d. Comment on the results obtained in part c.

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4. Design an L network to match a 75-Ω source impedance to a load of 200 – j150 Ω at an operating frequency of 50 MHz. Use a capacitor as the shunt (parallel) element, if possible.

5. Specify the components required in a pi network to match a source impedance of 50 Ω to the input port of a common-gate MOSFET amplifier whose input impedance is modeled as 100 Ω in parallel with 20 pF. The frequency of operation is 144 MHz, and the T network should have an overall Q of 8. Strive for the topology shown below; however, it is possible that one or more of the reactive elements might have to be of the opposite type shown (e.g., a capacitor might actually have to be an inductor).

6. The input impedance of a certain small loop antenna can be modeled at its operating frequency as a 0.4-Ω resistance in series with 400 Ω of inductive reactance. Use the quality factor (Q) to find the parallel equivalent circuit representation of the input impedance.

7. Use the results of Prob. 6 to show that the small loop antenna can be matched to a system impedance of 50 Ω using a matching network consisting of two capacitors added to the loop antenna, one in a shunt configuration and one in a series configuration. Find the required capacitor values, and draw a sketch of the matching network and the load represented by its parallel equivalent circuit. Capacitors and inductors should be labeled by their respective reactances. Hint: The Q of the matching network is a very large two-digit value.