ECEG 497 **Wireless System Design** **Spring 2023**

Homework Assignment #2 – due via Moodle at 11:59 pm on Wednesday, Feb. 8, 2023

Instructions, notes, and hints:

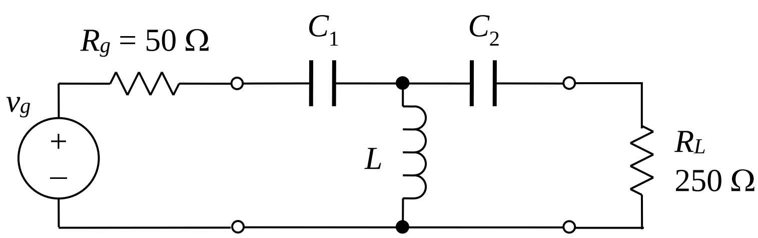
Provide the details of all solutions, including important intermediate steps. You will not receive credit if you do not show your work.

It is your responsibility to review the solutions when they are posted and to understand and rectify any conceptual errors that you might have. You may contact me at any time for assistance.

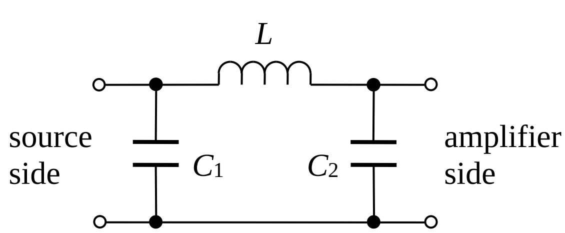
The first set of problems will be graded and the rest will not be graded. Only the graded problems must be submitted by the deadline above. Do not submit the ungraded problems. One graded problem will be randomly selected for detailed evaluation; the others will be evaluated using a coarse rubric.

***Graded Problems*:**

1. Recall that in HW #1 you were asked to match a load impedance of 250 Ω to 50 Ω at a frequency of 1.9 MHz, which is the center of the "160-meter" amateur radio band. Design a T network using an inductor as the shunt element, if possible, to accomplish the same transformation but this time with a target matching bandwidth of 200 kHz. (The 160-meter band extends from 1.8 to 2.0 MHz.) A diagram of the matching network is shown below. Specify the capacitor and inductor values using appropriate units.



2. Specify the components (L and C values) required in a pi network to match a source impedance of 50 Ω to the input port of a common-gate MOSFET amplifier that has an input impedance of 100 Ω. The frequency of operation is 144 MHz (the lower end of the "2-meter" amateur radio band), and the desired impedance matching bandwidth is 18 MHz. Strive for the topology shown below.



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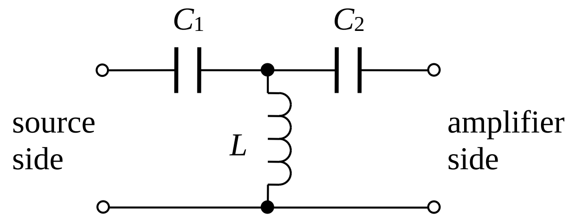
3. Repeat the previous impedance matching task, but this time use a T network topology like the one shown below.



4. A certain inductor made with copper wire has a design value of 1.0 μH, a measured self-resonant frequency of 120 MHz, and a Q of 45 measured at a frequency of 10 MHz. Find the equivalent series resistance of the inductor at 10 MHz. Because a real inductor can be modeled as an inductor in series with a resistor, the quality factor is given by $Q = X_L/R_w$, where X_L is the inductive reactance and R_w is the winding (or wire) resistance. Use your research skills and/or reasonable approximations to make up for missing information and/or to simplify your work. The resistance per unit length of a wire with a circular cross-section of radius a is shown below (where f = frequency, μ = the permeability of the wire, and σ = the conductivity of the wire). Also find the approximate equivalent series resistance of the inductor at 3.5 MHz (the bottom end of the amateur radio "80-meter" band).

$$R' = \frac{1}{2\pi a}\sqrt{\frac{\pi f \mu}{\sigma}}$$

***Ungraded Problem*:**

The following problem will not be graded. However, you should attempt to solve it on your own and then check the solution. Try not to give up too quickly if you struggle to solve it. Move on to a different problem and then come back to the difficult one after a few hours.

1. Refer to Graded Problems 1 and 2 above. Suppose that a 50 Ω coaxial cable will connect the signal source to the matching network and load. Write a *Matlab* m-file (script) that plots the VSWR vs. frequency for both networks over the 1–3 MHz range on the same set of 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 (the upper limit corresponds a return loss of roughly −3 dB). Add grid lines. Comment on the results.