Introduction

Most wireless systems are comprised of several subsystems (subcircuits) that are connected together to accomplish a specific task. For example, a wireless receiver typically consists of amplifiers, filters, mixers, and other circuits (often called stages) all operating together as a unit. An important consideration in RF system design is the proper interfacing between system stages. The input port of a given stage might need to present a specific load impedance to the preceding stage. This might be necessary to ensure maximum power transfer. Also, most filters require carefully controlled source and load impedances (sometimes very different from the standard 50 Ω) in order to operate properly. The effective source or load impedance of a stage can be made to “look” like a different value through a design technique called impedance transformation, or impedance matching. One way to match impedances is to insert an L network consisting of one series reactive element (an inductor or a capacitor) and one shunt reactive element between the stages. (The “L” in “L network” refers to the circuit’s L shape, not to the inductor in it.) In this lab exercise, you will design and test an L network to transform a load impedance of 300 Ω to 50 Ω. Randomly generated lab groups are listed at the end of this handout.

Experimental Procedure

Your deliverables for this lab session will be a completed L network and documentation from your group that contains the items specified below. The documentation is due before the next lab session. Grades will be quantized as indicated next to each item.

- Design an L network to match a load resistance of 300 Ω to a system impedance of 50 Ω at an operating frequency of 7 MHz. The load impedance simulates the radiation resistance of a folded dipole antenna fed with standard 300-Ω “twin lead” (a parallel-wire transmission line commonly used with consumer FM radio receivers).

Item #1 [0, 10, 20, 30%]: List the formulas and assumptions used in your design process and the results. Include the final inductor and capacitor values and the network’s topology (i.e., sketch a circuit diagram or carefully describe it). Also include the $Q$ (quality factor) of the matching network.

- Calculate the input impedance of the matching network/load impedance combination over the frequency range 1-30 MHz using a Matlab script, and use the results to plot the VSWR (with respect to 50 Ω) over that range. You do not have to plot VSWR values over 10:1. You will be required to plot some measured data on the same axes, so do not print out the plot yet. On separate axes, plot the real and imaginary parts of the input impedance over the same frequency range. For both plots, include axis labels with units (if any), a legend, and a descriptive title. You should use different line styles (e.g., solid and dashed) for different traces in case a black & white copy or print-out needs to be made. Also consider using axis,
figure, and text property commands in Matlab to increase the line weight and make the title and axis labels more readable. The formulas for VSWR and reflection coefficient $\Gamma$ are:

$$VSWR = \frac{1 + |\Gamma|}{1 - |\Gamma|} \quad \Gamma = \frac{Z_L - Z_o}{Z_L + Z_o},$$

where $Z_L$ is the load impedance as seen at the input to the L network, and $Z_o$ is the system impedance (50 $\Omega$ in this case). You are calculating the VSWR that would be present at different frequencies along a 50-Ω transmission line connected to the load/L-network combination.

- Build the L network using the components available to you using “open air” construction by soldering the components together. A PC board is not available, and you should not use a protoboard. The inductor should be wound on a toroidal iron powder core. Information on fabricating inductors of this type is available via a link on the Laboratory web page. The required capacitance can be approximated using series and/or parallel combinations of standard capacitor values, although you should try to minimize the number of capacitors to save space and keep lead lengths short. Use a 300-Ω resistor to simulate a folded-dipole load. Leave wire leads of one to two inches each to allow connection to the impedance analyzer.

**Item #2 [0, 10, 20, 30%]:** Assembled L network.

- Use one of the handheld impedance analyzers to plot the VSWR vs. frequency over the same range for which you calculated the VSWR using circuit analysis. You will have to copy the displayed data manually into your Matlab script. Eight to ten data points, including the point of best match, should be sufficient. You do not need to record VSWR values above 10:1. Plot the measured VSWR data along with the predicted VSWR data on the same graph using your Mathcad script.

**Item #3 [0, 10, 20, 30%]:** Print the plot of predicted and measured VSWR, the plot of the predicted real and imaginary parts of the input impedance, and the Matlab script you used.

**Item #4 [0, 5, 10%]:** Answer the following thought question: Besides measurement error, what other factors might account for any differences you see between the measured and predicted VSWR data?

**Group Assignments**

The randomly generated groups for this lab exercise are listed below:

Selevan-Hoolachan
Swaim-Walls
Opalinski-Collins
Goesseringer-Kwiatkowski

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