EE 458/
EE 558

Microwave Circuit Design and Measurements Laboratory

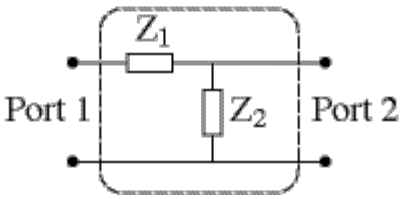
Instructor: Patrick Fay
261 Fitzpatrick Hall
631-5693
pfay@nd.edu

Exam #1
10/30/03

This is a closed book, closed notes test; you may, however, use your laboratory notebook for reference. You may use calculators for numerical calculations, but you must show your work and sufficient intermediate results to justify your answers. For full credit, you must show a clear path through the problem solution so that I can follow your work. Be sure to *write down the equations that you use symbolically prior to plugging in any numbers*. Please label and circle or box your answers so that I can find them.

Problem 1 (35 pts):

For problem 1, please refer to the following figure.

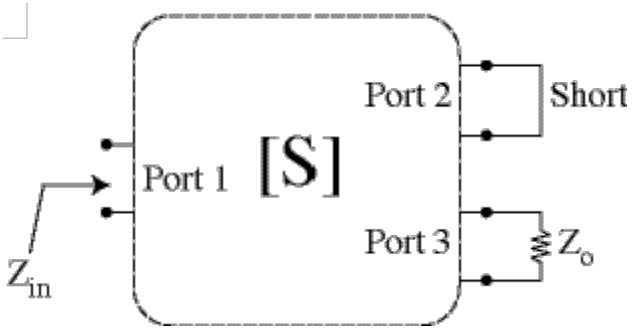


Based on this circuit, please find the following:

a.) Find symbolic expressions for the 2-port s-parameters of this circuit in terms of Z_1 and Z_2.
b.) If Z_1 is 30 Ω and Z_2 is 75 Ω, find the numerical values of the s matrix elements for Z_o=50 Ω.
c.) If port 2 is terminated in a 50 Ω load, what is the VSWR that would result if a Z_o=50 Ω transmission line were connected to port 1?

Problem 2 (30 pts):

For problem 2, please refer to the following figure.



where $S = \begin{bmatrix} 0.05\angle 45^\circ & 0.3\angle 30^\circ & 0.5\angle 60^\circ \\ 0.3\angle 30^\circ & 0.5\angle 0^\circ & 0 \\ 0.5\angle 60^\circ & 0 & 0.5\angle 0^\circ \end{bmatrix}$ and $Z_o = 50\ \Omega$.

Based on this circuit, please:

a.) Is the network represented by [S] reciprocal?
b.) Compute the input return loss (at port 1) if ports 2 and 3 are terminated as shown in the figure. Please express your final result in dB.
c.) What is the input impedance at port 1 (see figure)?

Problem 3 (35 pts):

Design a single-stub, shunt-configuration matching network with a short-circuited stub to match a load $Z_L = 100+j50\ \Omega$ to a 50 Ω transmission line. Use $Z_o=50\ \Omega$ for all the transmission lines in your design. Express the lengths of the transmission lines in terms of the wavelength, λ. If multiple solutions exist, please find all possible solutions. Please provide brief documentation of your design procedure so that I can follow your work.

Bonus Problem: (max 25 pts):

In your rather lucrative job as a microwave designer, you've been asked to design a matching network to match a 150 Ω load (Z_L) to a 50 Ω transmission line at 10 GHz, using a single series line (see the figure below). An additional constraint is that for the lines available, the RLCG parameters (from the telegrapher's equations) are R=0, G=0 (i.e. the lines are lossless), and L=8 nH/cm. Find the C parameter (line capacitance/length) required and physical length (in cm) needed for this design. Please provide documentation of your design procedure so that I can follow your work. Hint: recall that the characteristic impedance of the line (Z_1) and propagation constant (β) can be expressed in terms of R, L, C, and G from the telegrapher's equations.