NAME ______________________________ ID# ____________________

EXAM #1

EE523 September 30, 1999

2:00 - 3:30 p.m.

Instructions: Write your name and ID# where indicated. You are allowed to have a calculator, writing instruments, compass and ruler. All other materials are prohibited. The examination consists of 5 problems worth a total of 100 points. Read each question *carefully* and follow its instructions. Do all work within the space provided on this exam, beginning your work on the page of the problem and continuing on the following page if needed. *Show all work* and indicate the units of your answers as needed. **Place a box around your final answer to each question.**

P1. (*25 pts*)	P2. (*25 pts*)	P3. (*20 pts*)	P4. (*15 pts*)	P5. (*15 pts*)	Total (*100 pts*)

Useful Formulas

General Transmission Lines:

$$\hat{Z}(\ell) = Z_o \frac{Z_L + jZ_o \tan\beta\ell}{Z_o + jZ_L \tan\beta\ell} = Z_o \frac{1+\overline{\Gamma}(\ell)}{1+\overline{\Gamma}(\ell)}, \quad \Gamma_L = \frac{Z_L - Z_o}{Z_L + Z_o},\ \Gamma(\ell) = \Gamma_L e^{-j\beta\ell} \ \ \rho = \frac{1+|\Gamma|}{1-|\Gamma|}$$

Rectangular Waveguide:

$$f_c = \frac{c}{2\pi}\sqrt{\left(\frac{m\pi}{a}\right)^2 + \left(\frac{n\pi}{b}\right)^2},\ \beta_z = \beta\sqrt{1-\left(f_c/f\right)^2},\ v_p = c\,/\sqrt{1-\left(f_c/f\right)^2}\ \ v_g = c\sqrt{1-\left(f_c/f\right)^2}$$

$$Z_{TM} = \eta\sqrt{1-\left(f_c/f\right)^2}, \quad Z_{TE} = \eta\,/\sqrt{1-\left(f_c/f\right)^2}$$

Microstrip Line:

$$\varepsilon_e = \frac{\varepsilon_r+1}{2} + \frac{\varepsilon_r-1}{2}\frac{1}{\sqrt{1+12h/W}}, \quad Z_o = \begin{cases} \dfrac{60}{\sqrt{\varepsilon_e}}\ln\left(\dfrac{8h}{W}+\dfrac{W}{4h}\right) & \dfrac{W}{h}\le 1 \\ \dfrac{120\pi}{\sqrt{\varepsilon_e\left[\dfrac{W}{h}+1.393+0.667\ln\left(\dfrac{W}{h}+1.444\right)\right]}} & \dfrac{W}{h}\ge 1 \end{cases},$$

$$\frac{W}{h} = \begin{cases} \dfrac{8e^A}{e^{2A}-2} & \dfrac{W}{h}<2 \\ \dfrac{2}{\pi}\left[B-1-\ln(2B-1)+\dfrac{\varepsilon_r-1}{2\varepsilon_r}\left(\ln\left(B-1\right)+0.39-\dfrac{0.61}{\varepsilon_r}\right)\right] & \dfrac{W}{h}>2 \end{cases} \quad v_g = c\sqrt{1-\left(f_c/f\right)^2}$$

$$A = \frac{Z_o}{60}\sqrt{\frac{\varepsilon_r+1}{2}} + \frac{\varepsilon_r-1}{\varepsilon_r+1}\left(0.23+0.11/\varepsilon_r\right),\ \ B = 377\pi\,/\,(2Z_o\sqrt{\varepsilon_r})$$

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P1. A 75 Ω coaxial transmission line of length 3.75 cm is terminated by a 100 Ω load, and is driven by a 1 volt source at 1 GHz with a matched source impedance (Z_s = 75 Ω). The coaxial transmission line has a relative permittivity $\varepsilon_r = 4.0$.

a) Determine the length of the line in wavelengths
b) Determine the reflection coefficient at the load.
c) Determine the SWR of the line.
d) Determine the input impedance of the transmission line.

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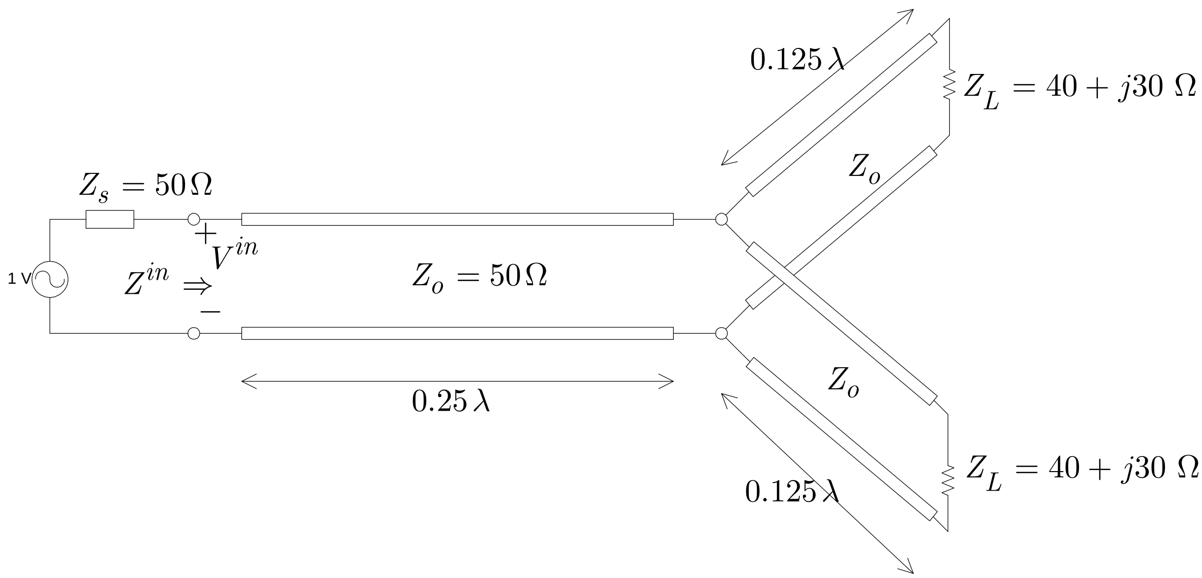
P2. The transmission line network in the figure below illustrates two 0.125 λ long 50 Ω transmission lines terminated by loads $Z_L = 40 + j30\ \Omega$ loads. The two lines are connected in shunt across the end terminals of a 0.25 λ long 50 Ω transmission line.

a) Determine the input impedance Z^{in}.

b) Determine the input voltage V^{in} across the input terminals of the transmission network.

c) Determine the time-average power delivered to each load.



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P3. You are to match a 50 Ω transmission line is terminated by a load impedance $Z_L = 50 + j50\,\Omega$ using a single stub tuner. Using the Smith Chart, determine the shortest distance ℓ_1 that the stub can be placed to the load and the corresponding stub length ℓ_s for a matched condition if the stub tuner is an open circuit stub.

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P5. An air-filled rectangular waveguide of cross section $a \times b$ is to be designed for single mode operation. Assuming that $a = 3 \cdot b$.

a. What is the dominant TE mode?
b. Find the dimensions of the waveguide that will support single mode operation for a signal operating in the band of 10 - 12 GHz that minimize dispersion.

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P5. A 50 Ω microstrip line is composed of a 15 mil wide strip printed on a 15 mil Alumina substrate (ε_r = 9.8) and is to be matched to a patch antenna with an input impedance of 100 Ω at 18 GHz. You are to design a quarter wave transformer (QWT) made from a microstrip line to match the uniform transmission line to the patch antenna.

a. Find the physical width of the QWT microstrip line (W_q) which is also assumed to be printed on the 15 mil Alumina substrate.

c. Find the physical length of the QWT.