ECE 5320 / 6322 Midterm II

November 6, 2006

Name Key

Are you taking ECE 5320 or ECE 6322 (circle only one :))

Random Student Number ______________

You may use your portfolio and a calculator but no textbook. Read each problem carefully. Good luck, and do well!

NOTE that the point distribution is:

	ECE 5320	ECE6322
Problem 1	10 points	10 points
Problem 2	30 points	30 points
Problem 3	30 points	30 points
Problem 4	30 points	30 points
Problem 5	xxxxxxx	20 points
Total	100 points	120 points

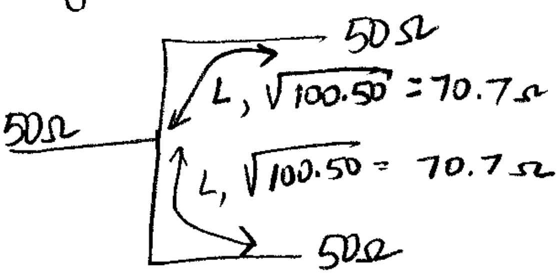
1. (10 points) Design a 3dB T-junction, Wilkinson, and Quadrature power dividers for 1 GHz. The input and output of the couplers should be 50 ohms. The microstrip substrate has $\epsilon_r = 4$ and d/w = 1.0. Sketch all three designs, and specify all impedances in ohms and all lengths in cm.

$$\varepsilon_{reff} = \left(\frac{\varepsilon_r+1}{2}\right) + \left(\frac{\varepsilon_r-1}{2}\right)\frac{1}{\sqrt{1+12\,d/w}} = 2.916$$

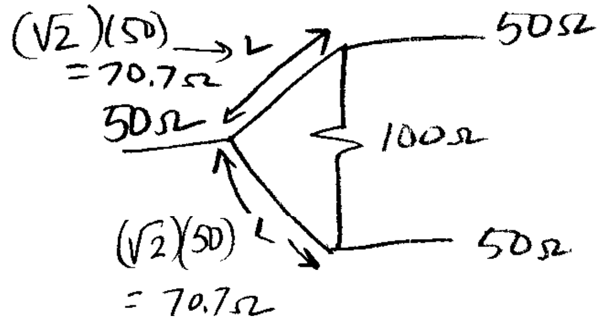
$$\lambda_{eff} = \frac{C_0}{F\sqrt{\varepsilon_{reff}}} = \frac{3\times10^{8}\ \text{m/s}}{(1\times10^{9}\ 1/\text{s})\sqrt{2.916}} = 0.1756\ \text{m}$$

$$\frac{\lambda_{eff}}{4} = L = 4.39\ \text{cm}$$

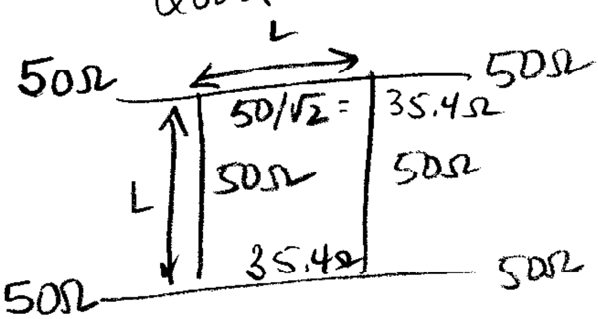
T junction



Wilkinson

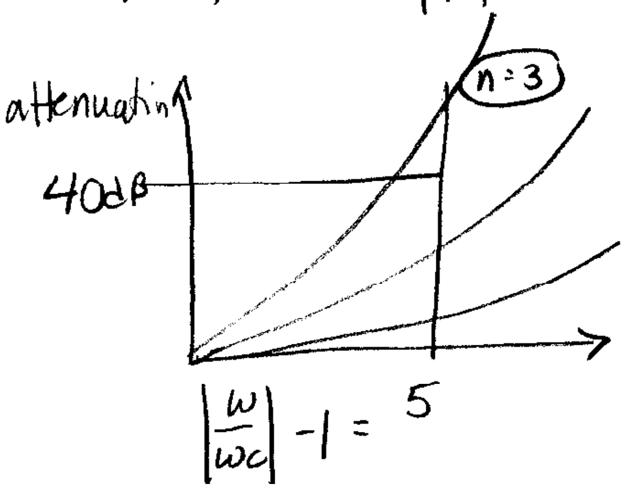


Quad



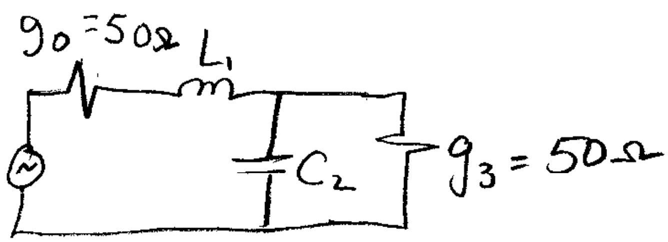
2.(30 points) Design and sketch a 50 ohm maximally flat low pass **lumped element filter** with a cutoff frequency of 1 GHz that is 40 dB down at 6 GHz.

$$\left|\frac{\omega}{\omega_c}\right| - 1 = \left|\frac{6}{1}\right| - 1 = 5 \quad \text{Plot Fig 8.26}$$



$N = n-1 = 2$

$g_0 = g_3 = 1, \; g_1 = g_2 = 1.4142$



$$L_1 = \frac{(50)(1.4142)}{2\pi(1\times10^9\ Hz)} = 11.23\ nH$$

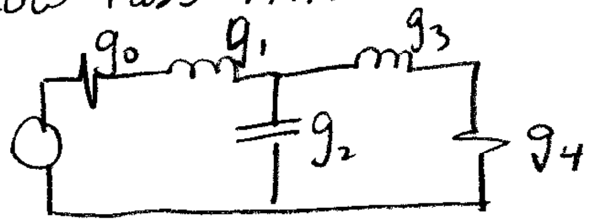
$$C_2 = \frac{1.4142}{(50)(2\pi)(1\times10^9 Hz)} = 4.49\ pF$$

3. (30 points) Describe in detail how to design a low pass **STUB microstrip filter** with a cutoff frequency of 1 GHz and an equal ripple of 0.5 dB. Use go = 1, g1 = 1.5963, g2= 1.0967, g3=1.5963, and g4=1. The filter should be input and output matched to 50 ohms. The wavelength is λ

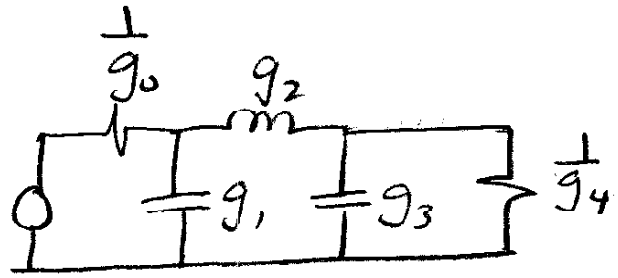
Items that must be included in your description:

1) How to apply the Kuroda identities to this problem, including computation (numbers) for ONE transformation.
2) Include a sketch of each step of the Kuroda transformations. (OK to leave out the computations, and equations)
3) After all Kuroda transformations have been completed, give variable names to each of the sections.
4) Describe (using these variable names) how to convert to the stub design. Include details on the length of each stub and the distances between the stubs and the impedances of all lines and stubs in the model.

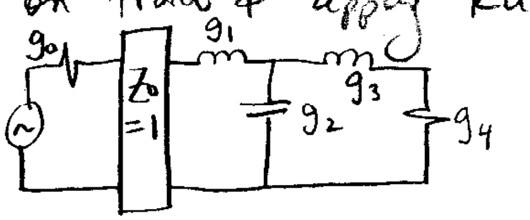
Low Pass Filter



OR



Add λ/8 length of $Z_0 = 1$ (because system is normalized) line on front & apply Kuroda transformation

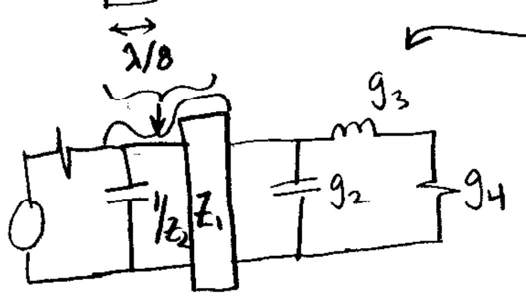


$Z_1/n^2 = g_1 \qquad n^2 = 1 + Z_2/Z_1$

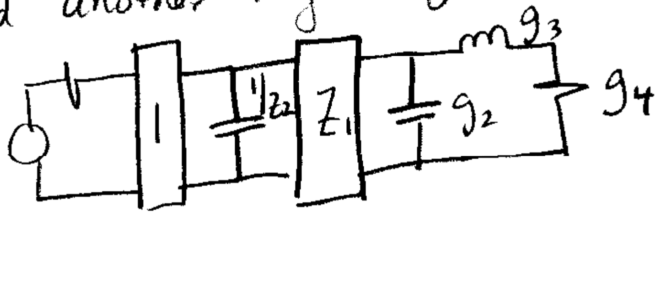
$Z_2/n^2 = 1 \qquad\qquad = 1 + 1/g_1 = 1.627$

$Z_1 = g_1 n^2 = 3.223$

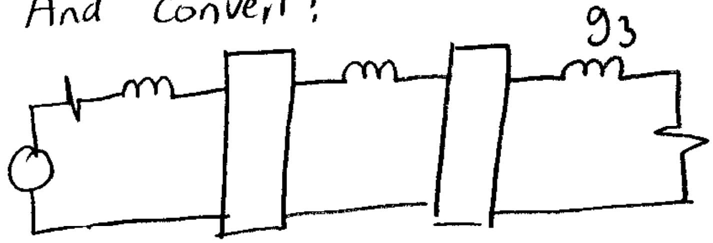
$Z_2 = n^2 = 1.627$



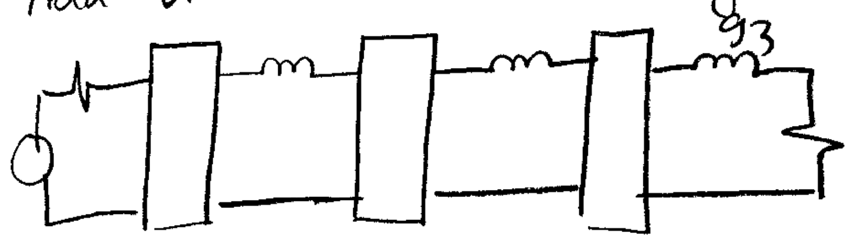
Add another length of λ/8 Z=1 line



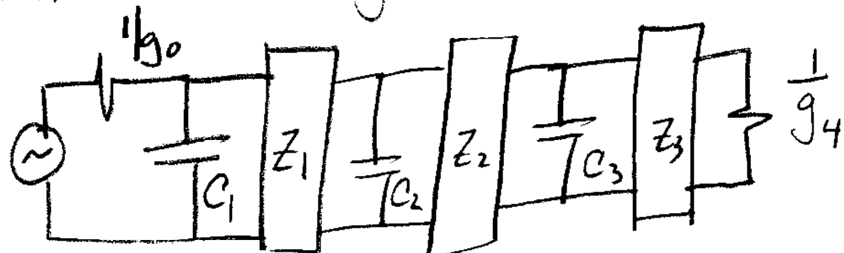
And convert:



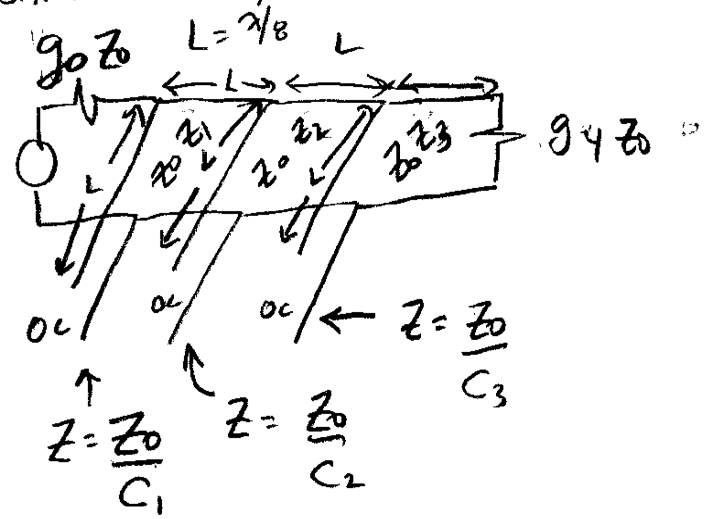
Add one more $\lambda/8$ $Z=1$ length



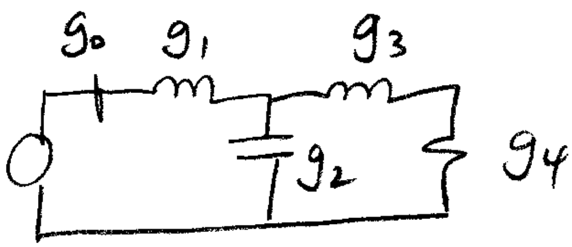
And convert again



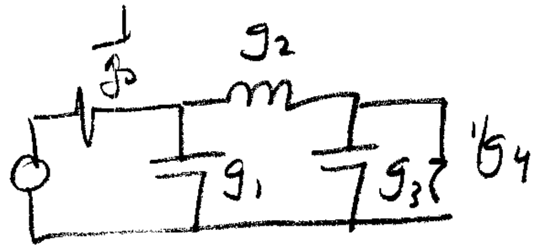
Convert to parallel stubs. Each stub is $\lambda/8$ long



4. (30 points) Design a low pass **stepped impedance filter** with an equal ripple of 0.5 dB. Use go = 1, g1 = 1.5963, g2= 1.0967, g3=1.5963, and g4=1. The filter should be input and output matched to 50 ohms. The wavelength is 2 cm. The highest impedance that can be manufactured is 150 ohms, and the lowest impedance allowed due to size restrictions is 25 ohms. Specify the lengths and impedances of all sections of the filter, and SKETCH to the final design.



or

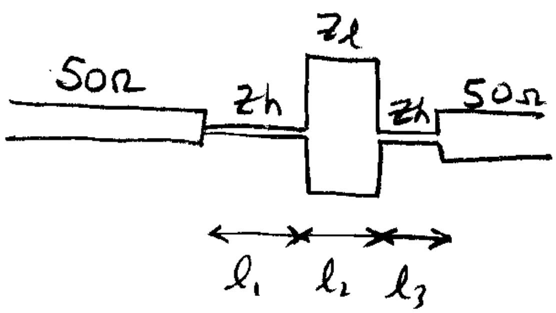


$\lambda_{eff} = 2\,cm = 2\pi$ radians

1 radian $= \frac{.02}{2\pi}$ m $= 0.003183$ m

$\beta = \frac{2\pi}{\lambda_{eff}} = 314 \frac{radians}{meter}$

$Z_h = 150\Omega \quad Z_\ell = 25\Omega$



$\beta \ell_1 = \frac{g_1 Z_0}{Z_h}$ radians

$\ell_1 = \ell_3 = \frac{g_1 Z_0}{Z_h (2\pi/2cm)}$

$= \frac{(1.5963)(50\Omega)}{(150\Omega)(2\pi/2cm)}$

$\ell_1 = \ell_3 = 0.169\,cm$

$\ell_2 = \frac{g_2}{(\beta/\lambda)} \frac{Z_\ell}{Z_0} = \frac{(1.0967)(25\Omega)}{(2\pi/2cm)\,50\Omega}$

$\ell_2 = 0.1745\,cm$

5. (20 points) ECE6322 students ONLY.

a) Problems 2,3,4 asked you to design various filters using specifications for the cutoff frequency, and how far down the filter should be at other nearby frequencies. Describe the OUT OF BAND response of each of these filters. The out of band response is what happens far from the pass band of the filter.

Lumped Element Filter (Problem 2)

No additional pass bands beyond those designed.

Stub Filter (Problem 3)

Stepped Impedance Filter (Problem 4)

} Both of these include additional periodic pass bands.

b) Even and Odd modes were used to derive the design equations for the Wilkinson and Quadrature power dividers, and for coupled line sections. It was stated that any mode could be divided into even and odd modes. Suppose that a Wilkinson device is used as a power COUPLER. The input to port 2 is 3V, and the input to port 3 is 5V. Port 1 is the output port. Calculate the even and odd mode INPUT voltages.

$V_e + V_o = 3V$

$V_e - V_o = 5V$

$2V_e = 8V$

$V_e = 4V$

$V_o = -1V$ or → $+1V$

Note; V_o could also = $+1V$ using

$V_e - V_o = 3V$

$V_e + V_o = 5V$

Both answers are correct

Name ________________________________

ECE 6320

Problem 1 __________ / 10 points

Problem 2 __________ / 30 points

Problem 3 __________ / 30 points

Problem 4 _________ / 30 points

Problem 5 + __________ / 20 points

Total Score (ECE5320) ___________ / 100 points

(ECE 6322) ___________ / 120 points

Never fear, the final exam can replace all midterm scores. ☺