ECE 5320 / 6322 Midterm I

October 11, 2006

Name Key

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

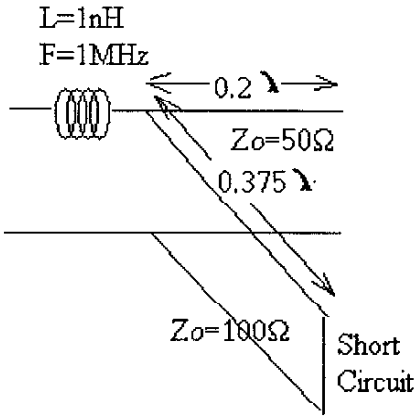
Random Student Number _____

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:

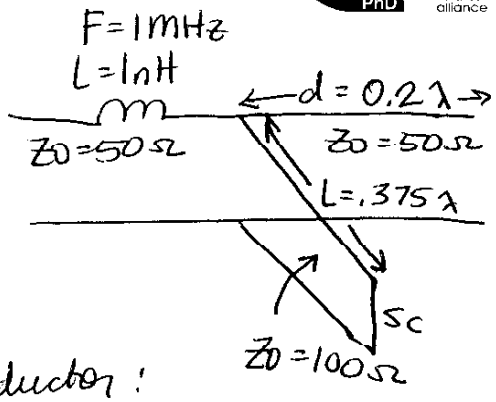
	ECE 5320	ECE6322
Problem 1	30 points	+10points (extra part of the problem)
Problem 2	30 points	+10 points (extra part of the problem)
Problem 3	20 points	
Problem 4	20 points	
Total	100 points	120 points

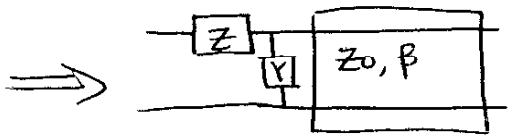
1. (30 points) Write an expression for S_{12} of the following network. Your equation can be as complicated as you want to leave it (ie. no need to compute or simplify). Write it in such a way that you could later use Matlab to find a numerical value. SPECIFY THE VALUE OF ALL VARIABLES. Hint: There are many ways to do this problem, so give some thought as to which might be the easiest.



Additional question for ECE6322 Students (10 points): BRIEFLY describe at least one other method of finding the S parameters that is significantly different than what you did above.

Problem1 Find ABCD



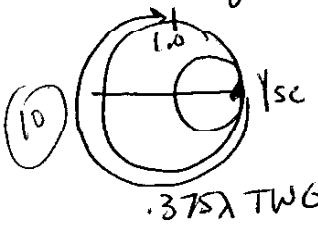


Find Z of inductor:

(5) $Z = j\omega L = j\,2\pi(1\times10^{6}\,Hz)(1\times10^{-9}\,H)$

$Z = j2\pi\times10^{-3}\,\Omega$

Find Y of Stub:



(10) $Y = (j1.0)\left(\frac{1}{100\Omega}\right)$

$Y = 0.01j\ \mho$

Find ABCD of Z: (tab6.4-1)

$$\begin{bmatrix} A & B \\ C & D \end{bmatrix}_Z = \begin{bmatrix} 1 & j2\pi\times10^{-3} \\ 0 & 1 \end{bmatrix}$$

Find ABCD of Y:

$$\begin{bmatrix} A & B \\ C & D \end{bmatrix}_Y = \begin{bmatrix} 1 & 0 \\ 0.01j & 1 \end{bmatrix}$$

Find ABCD of line

(10) $$\begin{bmatrix} A & B \\ C & D \end{bmatrix}_{line} = \begin{bmatrix} \cos\left(\frac{2\pi}{\lambda}0.2\lambda\right) & j50\sin\left(\frac{2\pi}{\lambda}0.2\lambda\right) \\ j\frac{1}{50\Omega}\sin\left(\frac{2\pi}{\lambda}0.2\lambda\right) & \cos\left(\frac{2\pi}{\lambda}0.2\lambda\right) \end{bmatrix}$$

$\begin{bmatrix} AB \\ CD \end{bmatrix}$ total =

(5) $\begin{bmatrix} AB \\ CD \end{bmatrix}_Z \begin{bmatrix} AB \\ CD \end{bmatrix}_Y \begin{bmatrix} AB \\ CD \end{bmatrix}_{line}$

2.(30 points) Design a double stub matching network to match a load of $Z_L = 5\text{-}j17\ \Omega$ to a 50 Ω line. Use parallel short circuited stubs. Use a distance of 0.1 wavelengths between the load and the first stub, and a distance of 0.375 wavelengths between the two stubs. Although there are two possible configurations, you only need to calculate one. Sketch and clearly label your system and your Smith Chart.

Additional question for ECE6322 Students (10 points): Tell how the length of the first stub would change if the impedance of that stub (only) is 100 ohms instead of 50 ohms.

Problem 2

$Z_0 = 50\Omega$

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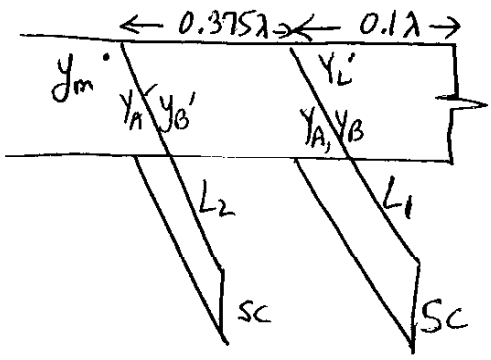
-5 for any concept mistake

-1 for math



$Z_L = (5 - j17)/50\Omega$

$= (0.1 - j0.34)$ Plot

(1) Normalize & Plot Z_L

Convert to Y_L

(2) Rotate 0.1λ TWG to $Y_L' = 1 - j3$

(3) Rotate circle 0.375λ TWL

(4) Choose point A or B on circle

Following real part (1.0)

(5) $Y_A = 1 + j0$ $\quad Y_B = 1 - j2.05$

$Y_{SA} = Y_A - Y_L' = (1 + j0) - (1 - j3) = j3$

or $Y_{SB} = Y_B - Y_L' = (1 - j2.05) - (1 - j3) = j0.95$

Plot them. Rotate TWG from Y_{SC} to Y_A or Y_B

$L_{1A} = 0.5 - (0.25 - 0.199)$ $\quad L_{1B} = 0.5 - (0.25 - 0.12)$

$\boxed{L_{1A} = 0.448\lambda}$ $\quad \boxed{L_{1B} = 0.37\lambda}$

(6) Rotate circle back to original location to Y_A' & Y_B'

$Y_A' = 1 + j0$ $\quad Y_B' = 1 + j2.75$

(7) $y_m = 1 + j0$ (matched)

$= y_A' + y_{S2A \text{ or } B}$

$y_{S2A} = y_m - y_A'$

$= (1 + j0) - (1 + j0)$

$= 0$ No stub needed

$y_{S2B} = (1 + j0) - (1 + j2.75)$

$= -j2.75$

Plot

Rotate TWL to y_{SC}

$\boxed{L_{2A} = 0}$

$L_{2B} = 0.308 - 0.25$

$\boxed{L_{2B} = .058\lambda}$

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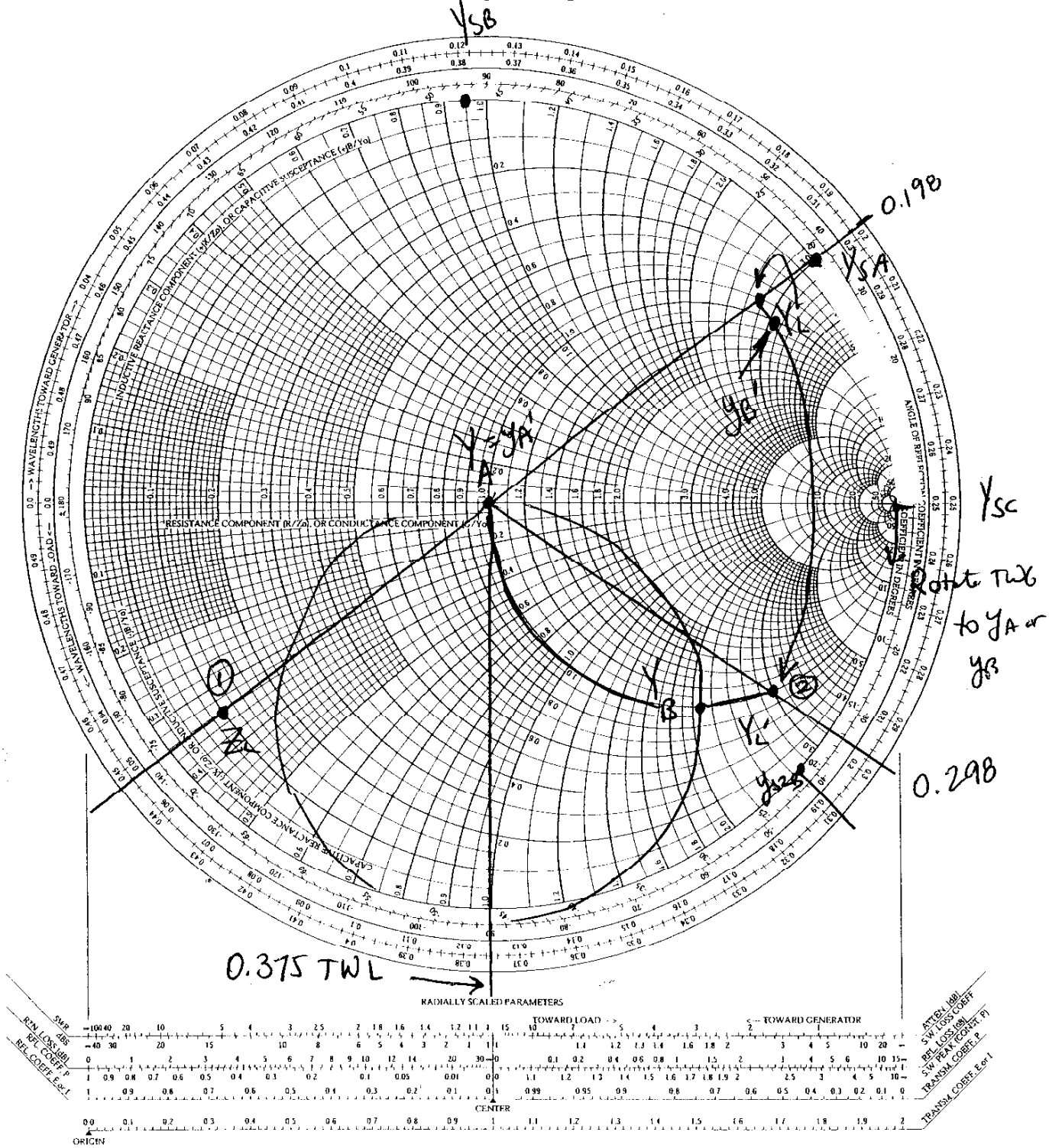
Problem 2

The Complete Smith Chart

Black Magic Design



3.(20 points) Design an L matching network to match a load of Z_L = 100 ohms to a 25 ohm line. Specify the value of all capacitors and inductors to make this a low pass configuration. (Assume f = 1MHz)

Soln

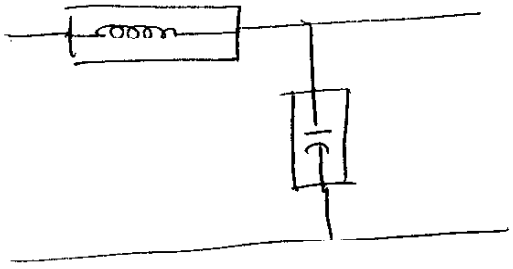
1) Compare Z_L & Z_g

$\therefore Z_L > Z_g$

$R_p = 100\Omega$

$R_s = 25\Omega$

2) Choose the ckt



[LPF configuration]

5

3] Calculate Q

$$Q_s = Q_p = Q = \sqrt{\frac{R_p}{R_s} - 1} = \sqrt{\frac{100}{25} - 1} = \sqrt{3}$$

5

4) Calculate X_s & X_p

$$X_s = Q_s R_s = \sqrt{3} \times 25 = 43.3\Omega$$

5

$$X_p = \frac{R_p}{Q_p} = \frac{100}{\sqrt{3}} = 57.736\Omega$$

5) $X_s = \omega L$

$$L = \frac{X_s}{\omega} = \frac{43.3}{2\pi \times 1 \times 10^6}$$

$$= 6.891 \mu H$$

$$X_p = \frac{1}{\omega C}$$

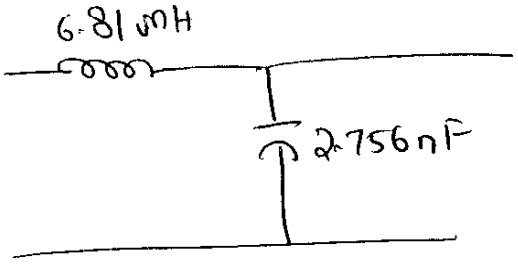
$$C = \frac{1}{\omega X_p}$$

$$= \frac{1}{2\pi \times 1 \times 10^6 \times 57.736}$$

$$= 2.756 nF$$

5

6) Draw final ckt

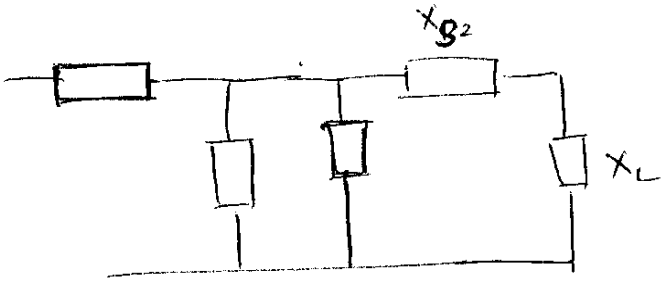


4. (20 points) Absorption and Resonance:

ECE 5320 Students: Suppose you design a T matching network. Your value for X_{p2} = 4, and the load has an $X_L = 6$. DESCRIBE THE STEPS in detail to absorb as much of the load as possible and resonate the rest. Demonstrate each step by calculating the appropriate values for this Pi system. Sketch the final system that should be built, and give values to your components. Put a box around the load to clearly show what is the load, and what parts are external components.

ECE 6322 Students: Suppose you design a Pi matching network. Your value for X_{p2} = 1/4 , and the load has an $X_L = 1/6$. DESCRIBE THE STEPS in detail to absorb as much of the load as possible and resonate the rest. Demonstrate each step by calculating the appropriate values for this Pi system. Sketch the final system that should be built, and give values to your components. Put a box around the load to clearly show what is the load, and what parts are external components.

Soln ECE 5320

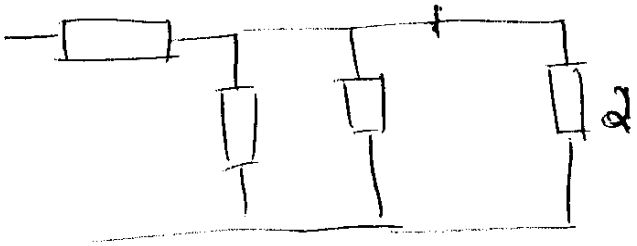


For absorption

$\therefore X_{S_2} = 4$ & $X_L = 6$ (10)

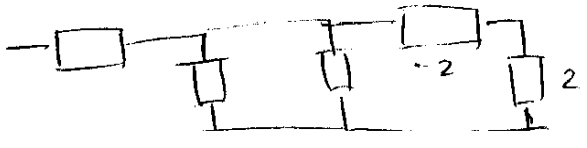
we can absorb 4

So modified ckt is

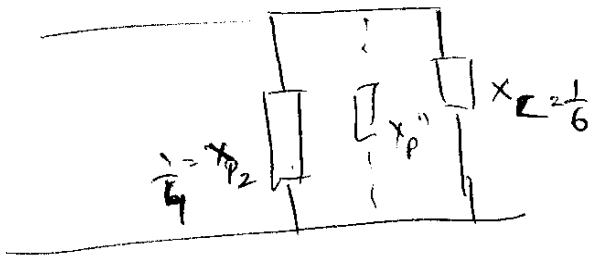


(10)

This 2Ω can be absorbed by using a series reactance of -2



Soln ECE 6322

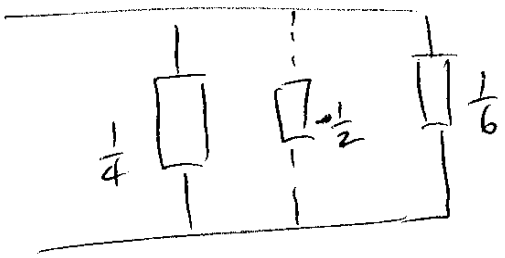


10

If we consider the Y matrix

$X_{p_2} = 4$ & $X_L = 6$

So we can absorb the load by using following ckt



10

$$X_p'' = \frac{X_p' X_L'}{X_L' - X_p'}$$

$$X_p'' = \frac{1}{2}$$

Since we have to absorb

$$X_p'' = -\frac{1}{2}$$

Name _____

ECE 6320

Problem 1 _____ / 30 points + _____ / 10 points

Problem 2 _____ / 30 points + _____ / 10 points

Problem 3 _____ / 20 points

Problem 4 _____ / 20 points

Total Score (ECE5320) _____ / 100 points

(ECE 6322) _____ / 120 points

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