ECE ECE145A (undergrad) and ECE218A (graduate)

Mid-Term Exam. November 2, 2017

Do not open exam until instructed to.

Open notes, open books, etc.

You have 1 hr and 15 minutes.

Use any and all reasonable approximations (5% accuracy is fine.) , ***AFTER STATING THEM.***

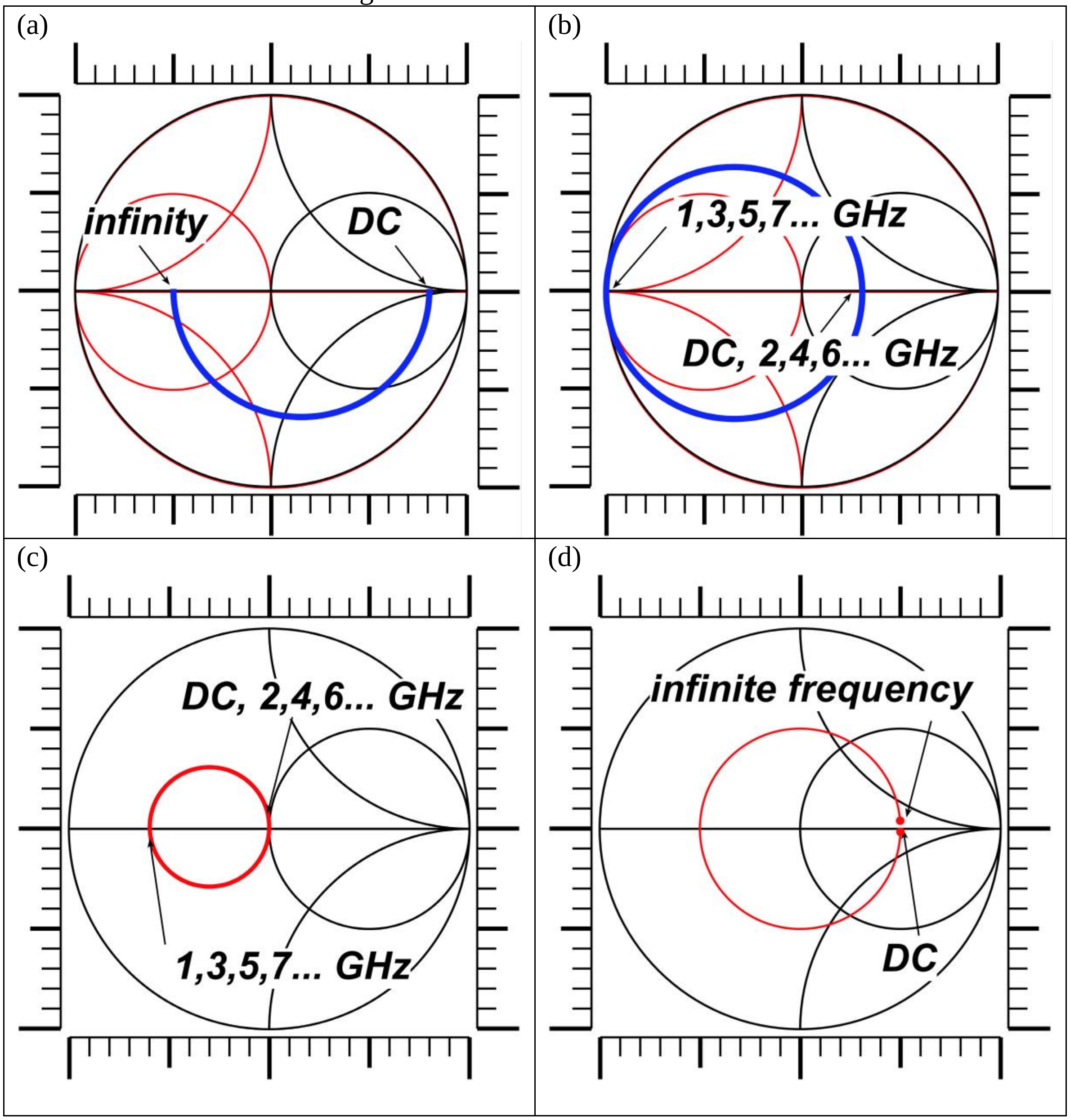
Problem	Points Received	Points Possible
1		15
2a		10
2b		15
2c (218 only)		15 (218)
3a		10
3b		10
3c		10
4		15
5a		7.5 (145) or 12.5 (218)
5b		7.5 (145) or 10(218)
total		85 (145) or 107.5 (218)

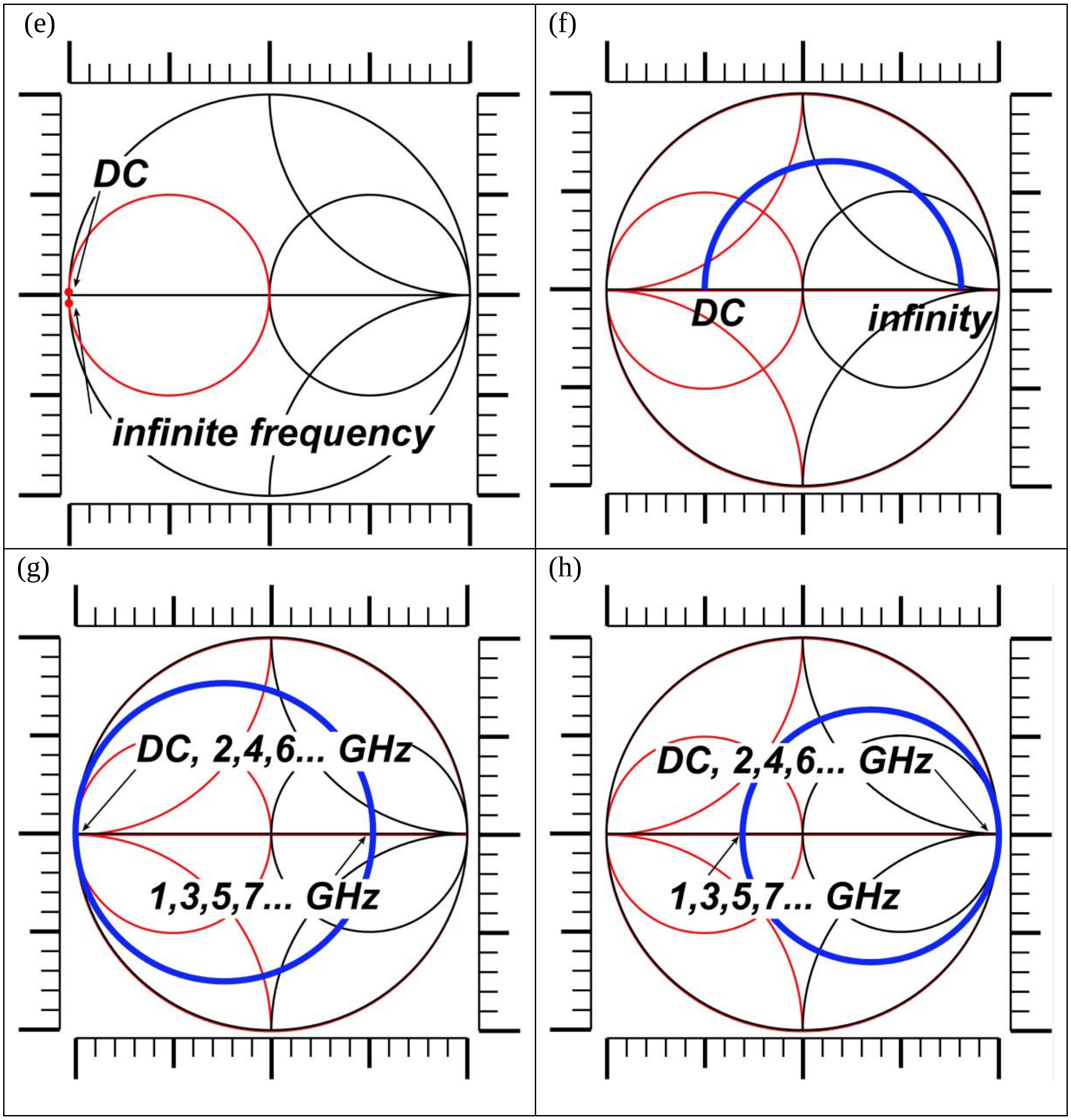
Name: _________________________

Problem 1, 15 points

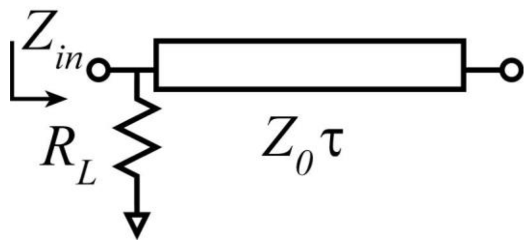
The Smith Chart and Frequency-Dependent Impedances.

HINT: use the scales on the figures to measure distances as needed.

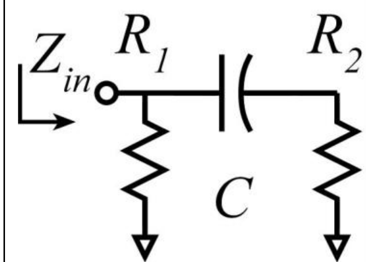



(e)
DC
infinite frequency
(f)
DC
infinity
(g)
DC, 2,4,6... GHz
1,3,5,7... GHz
(h)
DC, 2,4,6... GHz
1,3,5,7... GHz

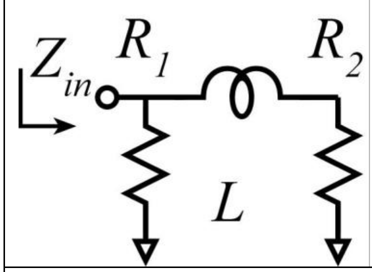
(i)


Z_{in}
R_L
$Z_0 \tau$

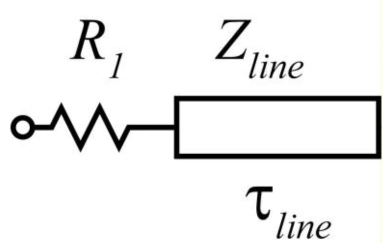
(j)


Z_{in}
R_1
R_2
C

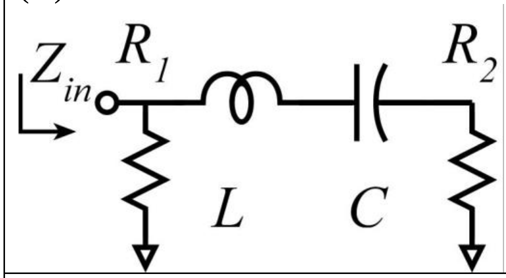
(k)


Z_{in}
R_1
R_2
L

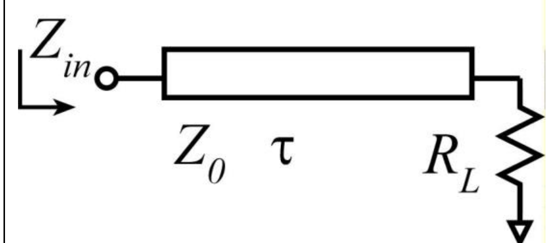
(l)


R_1
Z_{line}
τ_{line}

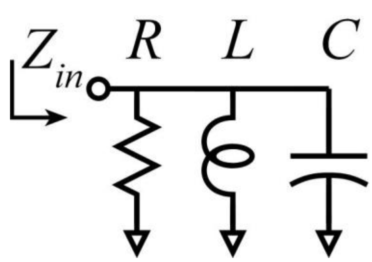
(m)


Z_{in}
R_1
R_2
L
C

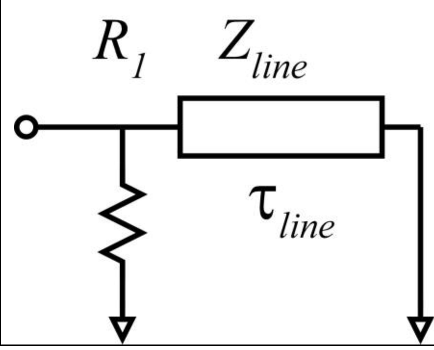
(n)


Z_{in}
Z_0
τ
R_L

(o)


Z_{in}
R
L
C

(p)


R_1
Z_{line}
τ_{line}

.

First match each Smith Chart with each circuit. ***Then determine as many component values as is possible*** (RLC values, transmission line delays and characteristic impedances)...note that some values cannot be determined with the information given. The charts all use 50 Ohm normalization:

Smith chart (a). Circuit=___________.
Component values: _______________ , _______________ , _______________ ,

Smith chart (b). Circuit=___________.
Component values: _______________ , _______________ , _______________ ,

Smith chart (c). Circuit=___________.
Component values: _______________ , _______________ , _______________ ,

Smith chart (d). Circuit=___________.
Component values: _______________ , _______________ , _______________ ,

Smith chart (e). Circuit=___________.
Component values: _______________ , _______________ , _______________ ,

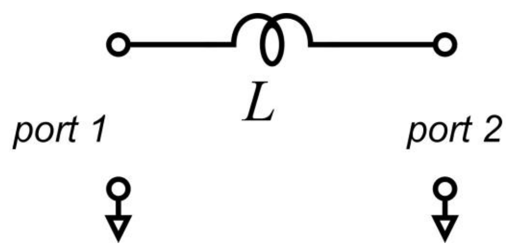
Smith chart (f). Circuit=___________.
Component values: _______________ , _______________ , _______________ ,

Smith chart (g). Circuit=___________.
Component values: _______________ , _______________ , _______________ ,

Smith chart (h). Circuit=___________.
Component values: _______________ , _______________ , _______________ ,

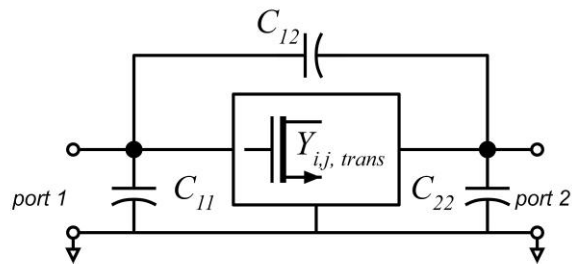
Problem 2, 25 points (ece145A), 40 points (ece218A)
2-port parameters and Transistor models

Part a, 10 points
For the network at the right, give numerical values for the four S-parameters. Assume that the reference Zo is 50 Ohms.



<u>Part b, 15 points</u>

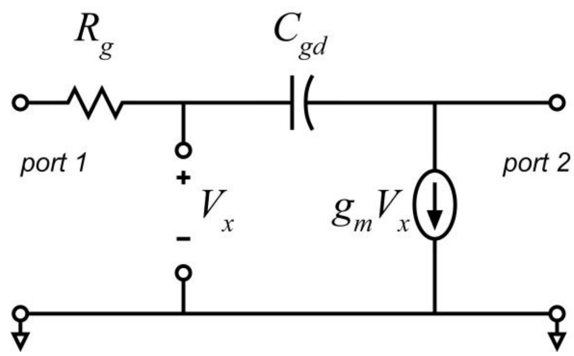
A transistor has four Y-parameters $Y_{ij,trans}$.
Derive algebraic expressions for the four Y-parameters of the overall network $Y_{ij,total}$



Part c, ***ECE218A students only*** 15 points

For the network at the right, give an algebraic expressions for Y_{12} and Y_{22}. Please write as a Taylor series in $j\omega$, omitting terms of power $(j\omega)^3$ and higher.

This is an exercise in device model extraction from measured S/Y/Z parameters.



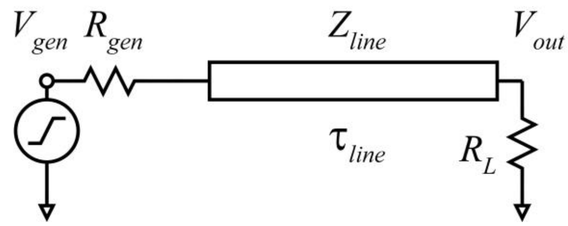
Problem 3, 15 points
Transmission lines in the time domain.

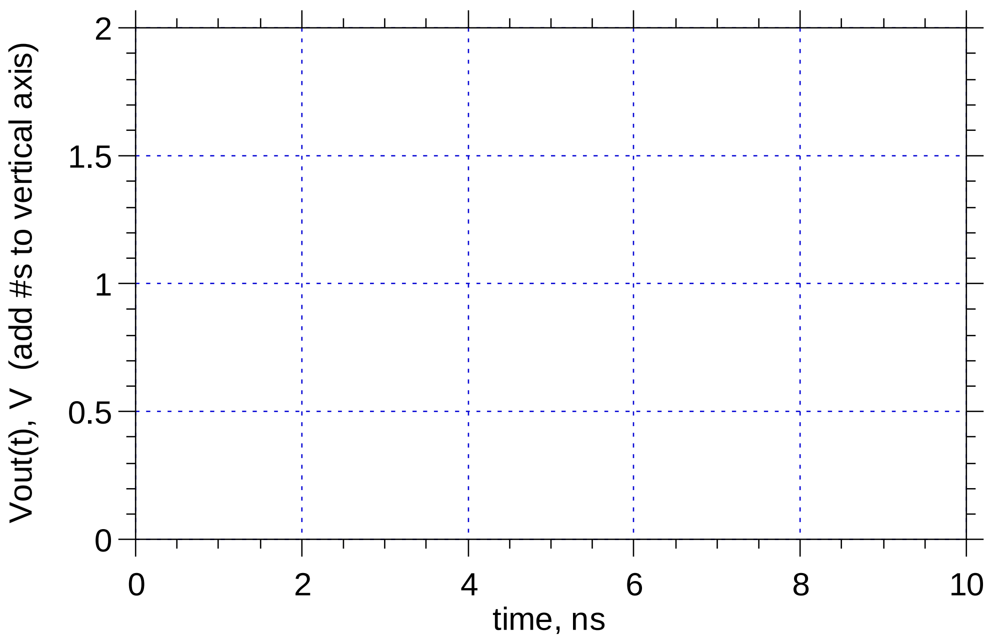
<u>Part a, 7.5 points</u>
Vgen is a 1V step-function occurring at t=0 seconds. Zline is 50 Ohms. τ_{line} is 1 ns.

RL is 5 Ohms. Rgen is 5 Ohms.

Plot Vout (t) on the graph below.

Does the step response of the line appear inductive, capacitive, both, or neither ?

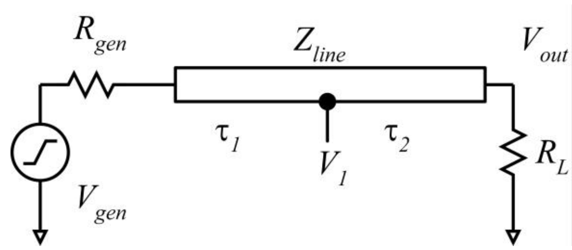


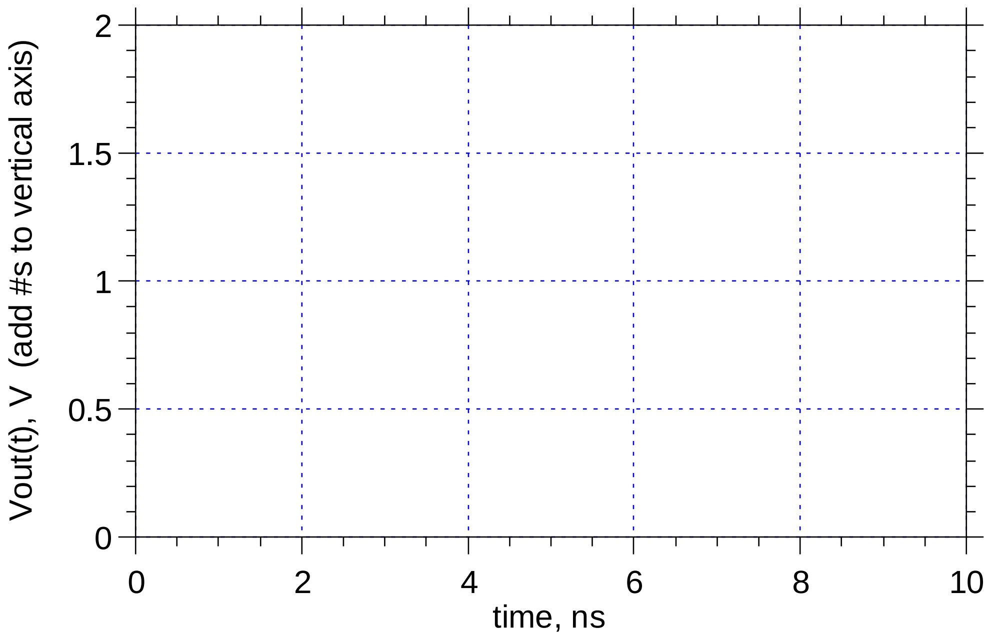


Part b, 7.5 points

Vgen is, again, a 1 V step-function.
Rgen is 50 Ohms and RL is 100 Ohms.
tau_1 and tau_2 are both 1/2 ns

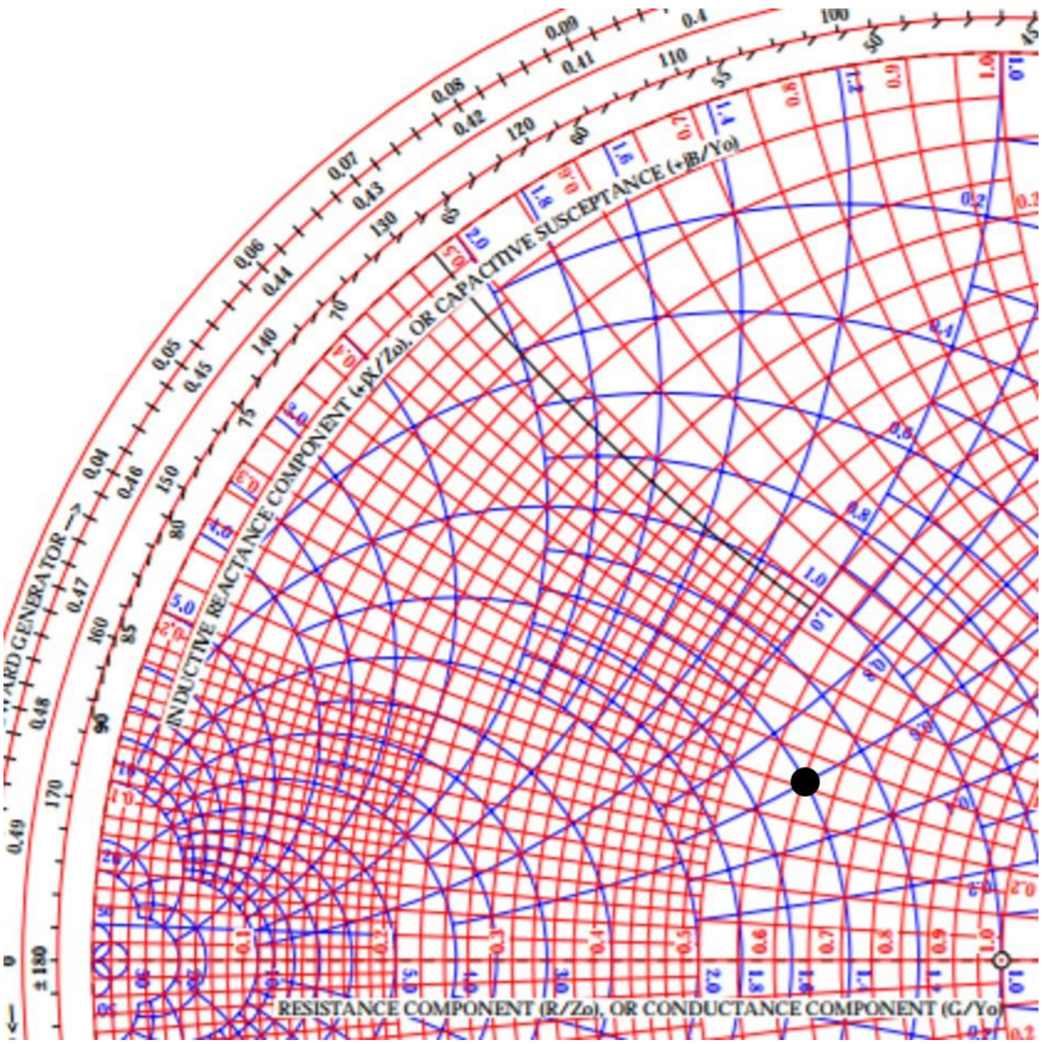
Plot below Vout(t) and V1(t)





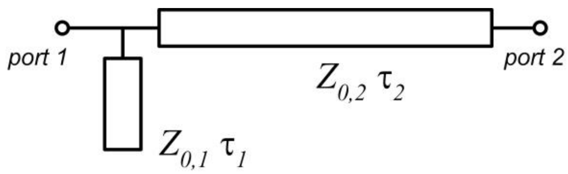
Problem 4, 15 points
Impedance-matching exercise.

The (50 Ohm normalization) Smith chart gives the input impedance of a circuit at 10 GHz signal frequency. Design a lumped-element matching network which converts this impedance to **50Ohms** at 3 GHz. Give all element values. Use the full impedance-admittance chart which has been provided to you.



Problem 5, 15 points (ece145A), 20 points (218A)
Transmission-line properties.

Part a, 7.5 points (145A), 12.5 points (218A)
We have designed a transmission-line impedance-matching network, as shown on the right.
Zo2=75 Ohms, tau2=100ps
Z01=25 Ohms, tau1=75ps



This is constructed on a circuit board whose dielectic constant is 3.8 and whose thickness is 1mm. Neglecting fringing fields, determine the length and width of both lines.

line 1 length=___________
line 1 width=____________

line 2 length=___________
line 2 width=____________

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ECE 218 students only (5 more points)
The conductivity of copper is $59.6*10^6$ Siemens/meter and $\mu_0 = 4\pi*10^{-7} H/m$. For line 2, Find the total line attenuation at 1.25GHz signal frequency.
Hint----the skin depth is $\delta = \sqrt{2/\omega\mu_0\sigma}$
line 2 attenuation, dB = ____________

Part b, 7.5 points

We are using these transmission-lines at 1.25GHz. Representing line 2 as a Pi network and line 1 as a T network, draw an approximate lumped-element equivalent circuit for the matching network, giving element values. **ECE 218 students only (2.5 more points)** please be sure to include the equivalent skin-effect resistance for both line sections.