

ECE ECE145A (undergrad) and ECE218A (graduate)

Mid-Term Exam. October 26, 2016

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.***

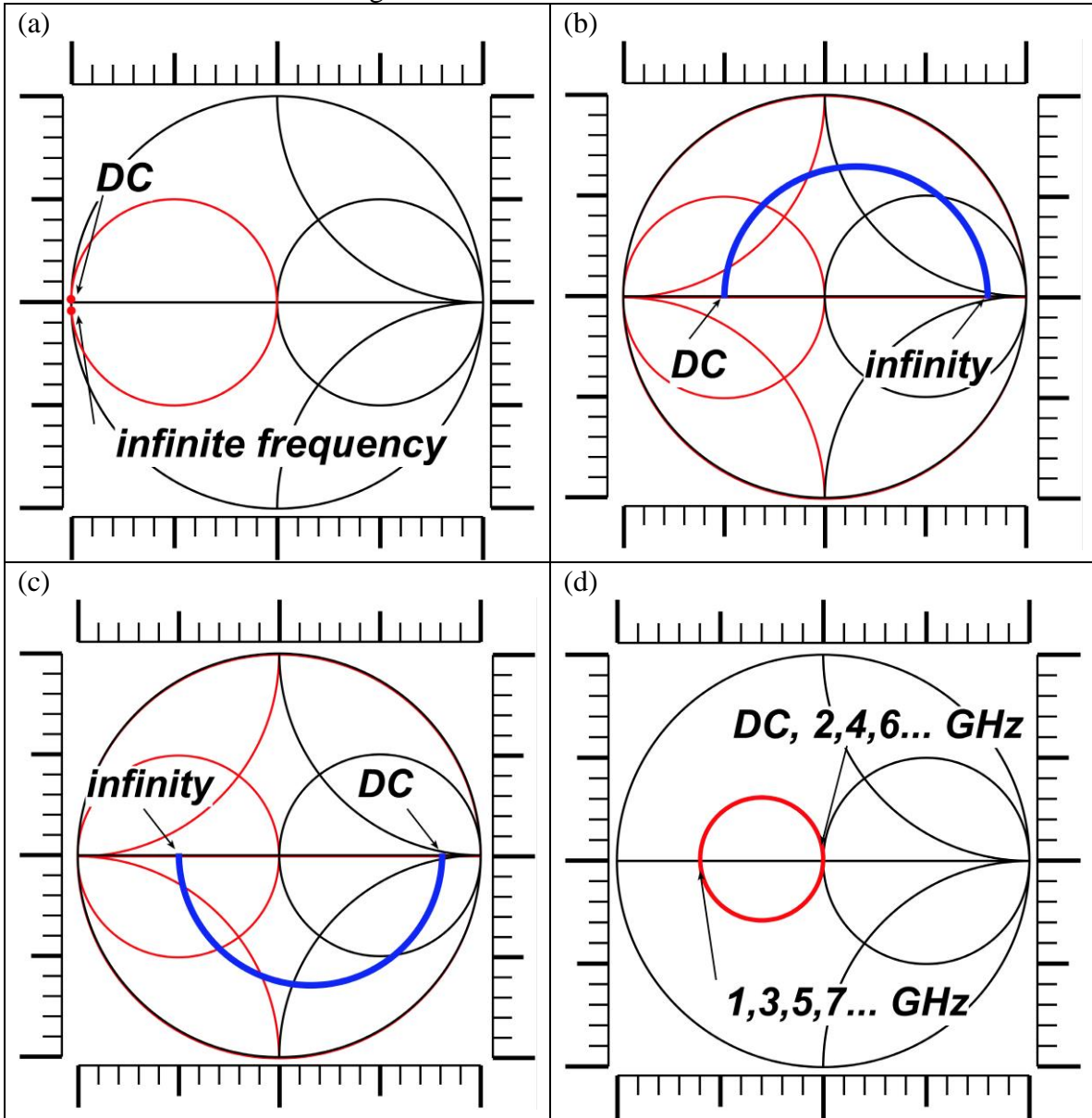
Problem	Points Received	Points Possible
1		15
2a		10
2b		15
2c (218 only)		15 (218)
3a		10
3b		10
3c		10
4		15
5a		7.5 (145) or 12.5 (218)
5b		7.5
total		85 (145) or 105 (218)

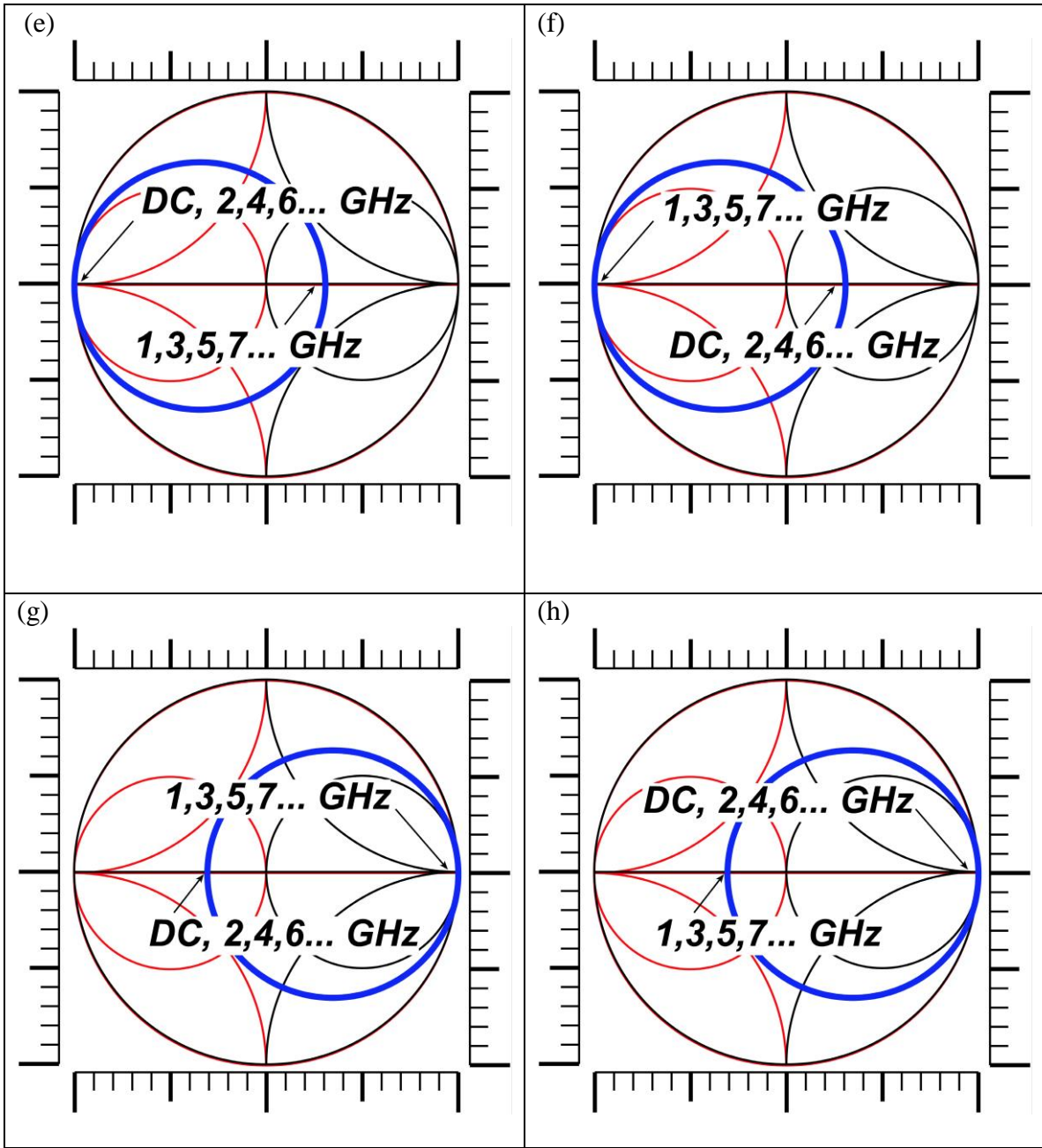
Name: _____

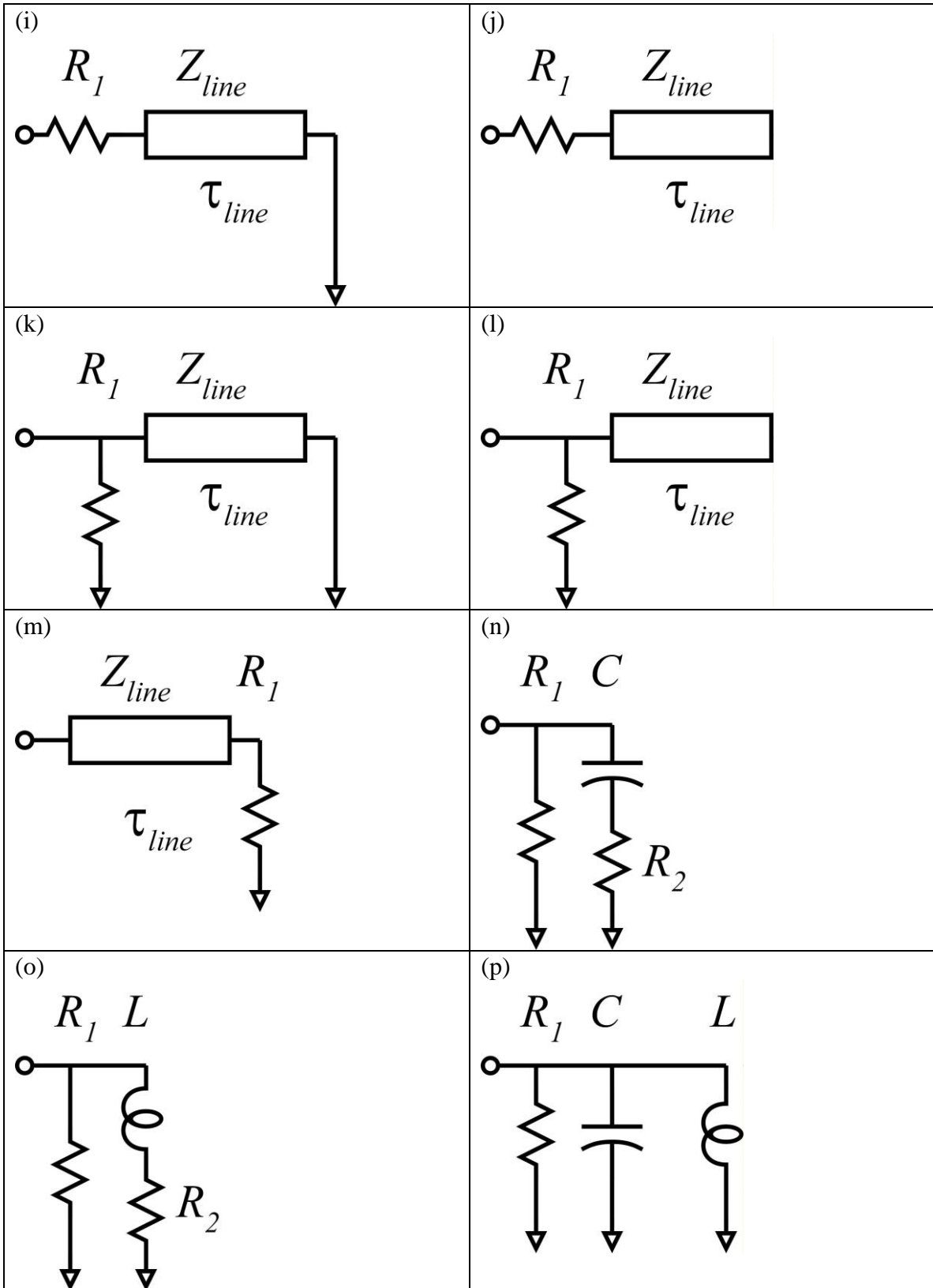
Problem 1, 15 points

The Smith Chart and Frequency-Dependent Impedances.

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







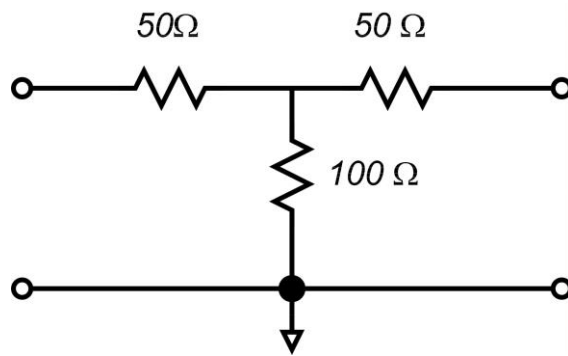
First match each Smith Chart with each circuit. ***Then determine as many component values as is possible*** (RLC values, transmission line delays and characteristic impedances)...note that some values cannot be determined with the information given. The charts all use 50 Ohm normalization:

- 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

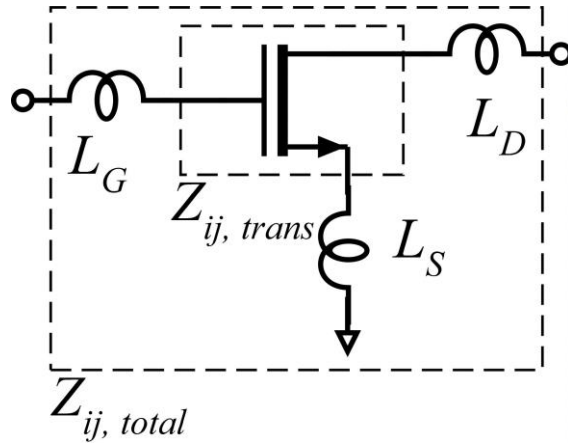
Part a, 10 points

For the network at the right, give numerical values for the four S-parameters. Assume that the reference Z_0 is 50 Ohms.



Part b, 15 points

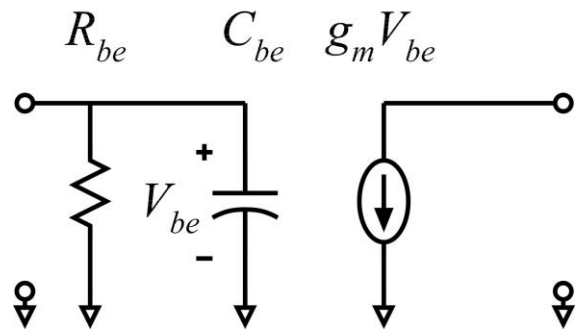
A transistor has four Z-parameters $Z_{ij,trans}$.
Derive algebraic expressions for the four Z-parameters of the overall network $Z_{ij,total}$



Part c. ECE218A students only 15 points

For the network at the right, give algebraic expressions for the four S-parameters.

Assume a normalization to impedance Z_0 for the S parameters.



Problem 3, 15 points

Transmission lines in the time domain.

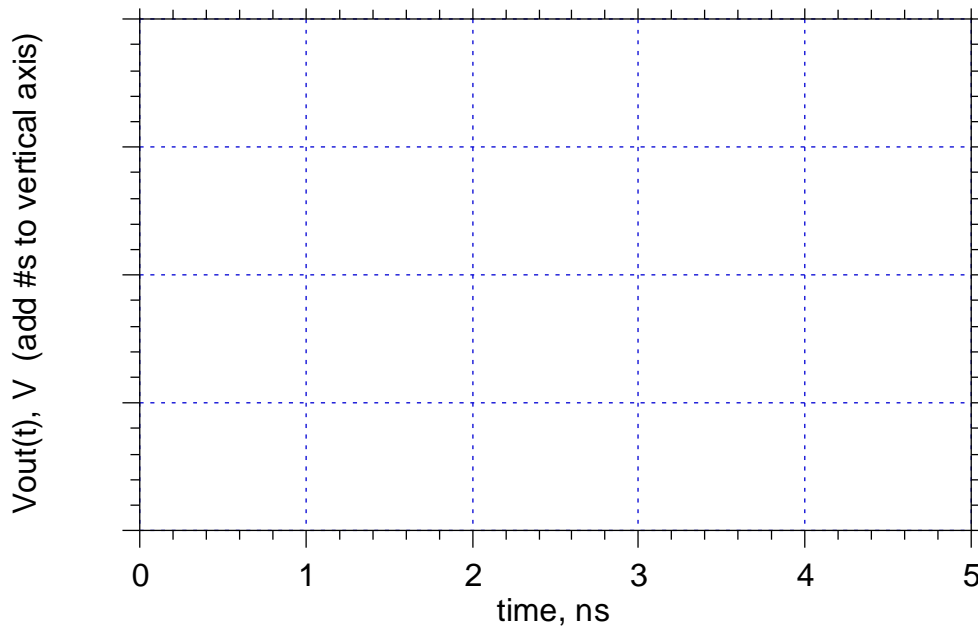
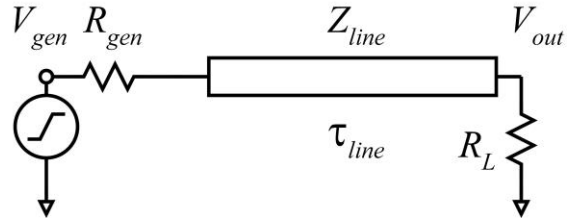
Part a, 7.5 points

V_{gen} is a 1V step-function occurring at $t=0$ seconds. Z_{line} is 50 Ohms. τ_{line} is 1/2 ns.

R_L is infinite. R_{gen} is 150 Ohms.

Plot $V_{out}(t)$ on the graph below.

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

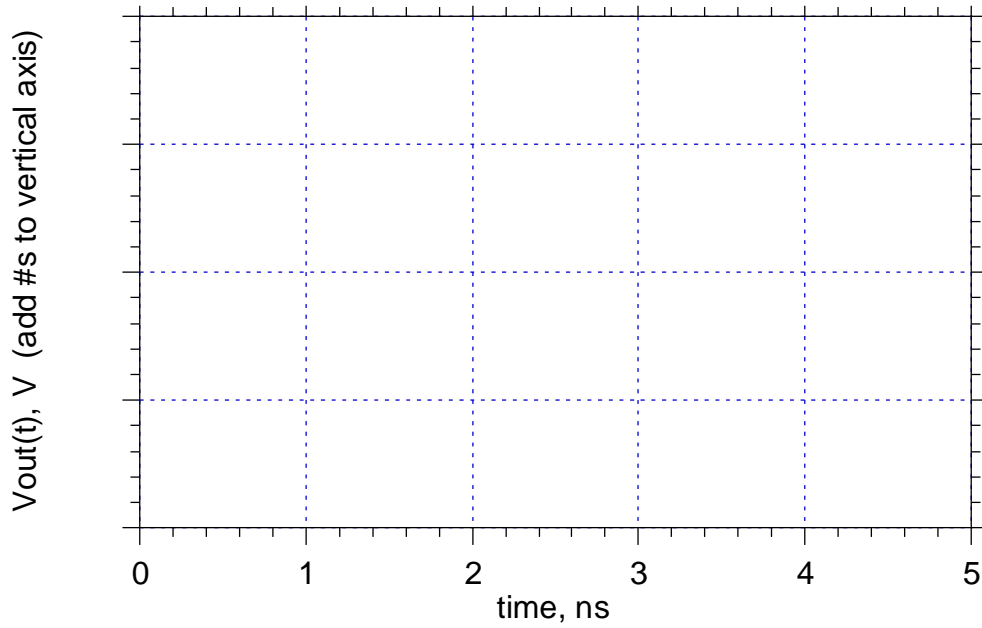
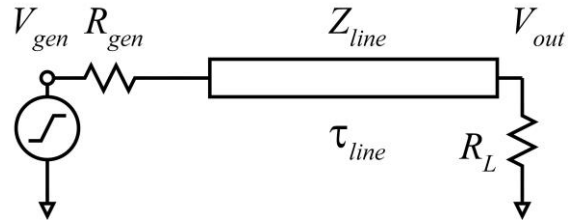


Part b, 7.5 points

R_L is infinite. R_{gen} is $(50/3)$ Ohms.

Plot $V_{out}(t)$ on the graph below.

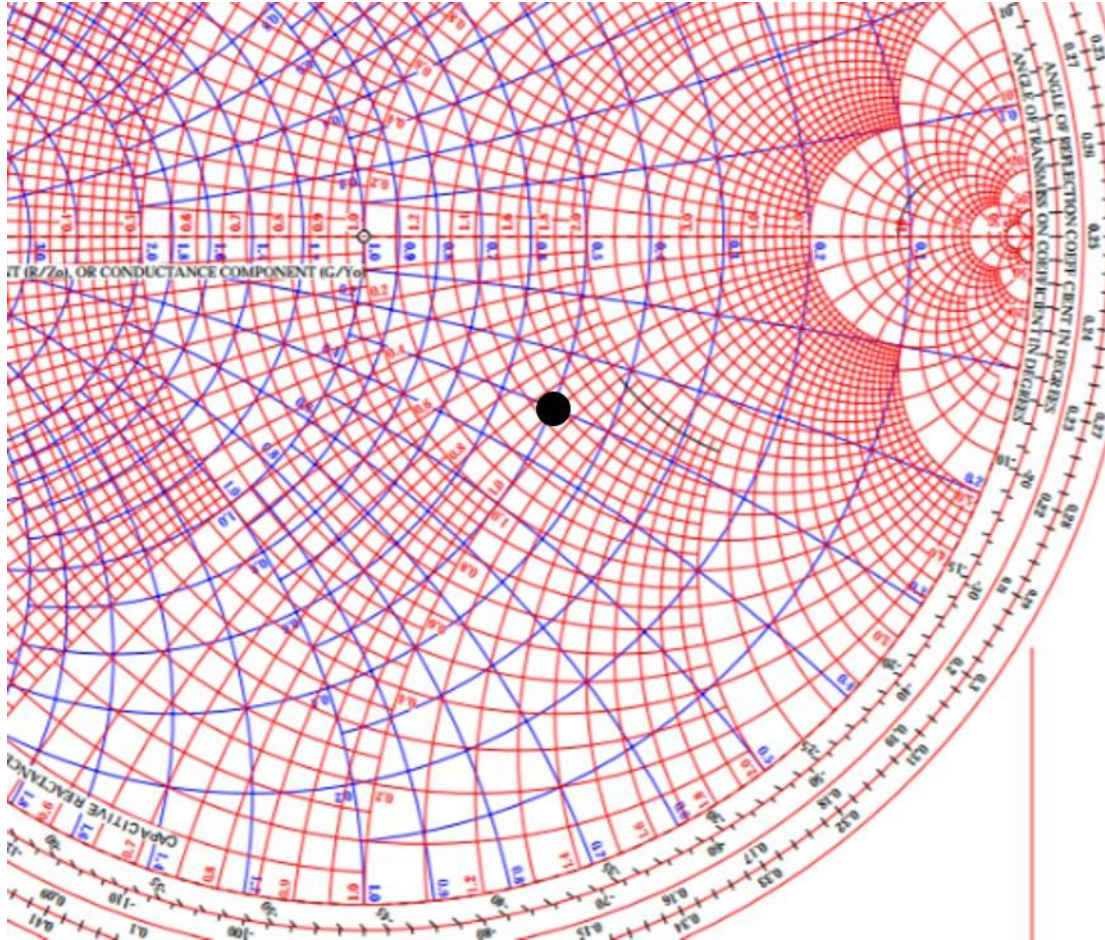
Does the step response of the line appear inductive, capacitive, both, or neither ?



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 **50 Ohms** at 10 GHz. Give all element values. Use the full impedance-admittance chart which has been provided to you.

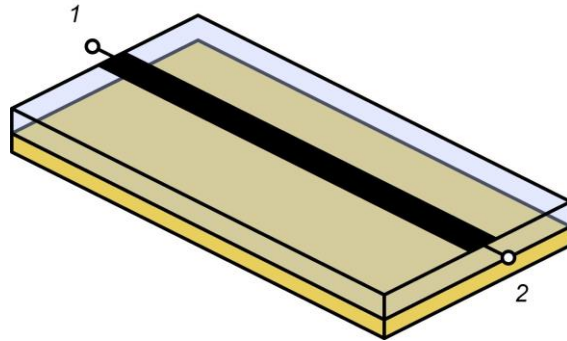


Problem 5, 15 points (ece145A), 20 points (218A)

Transmission-line parasitics.

Part a, 7.5 points (145A), 12.5 points (218A)

We are designing a microstrip line and calculating its properties. We will assume dimensions typical of a dielectric stack on an IC: the signal and ground planes are separated vertically by $5\ \mu\text{m}$, and the dielectric constant is 3.8.



If we approximate the effective conductor width as being the physical conductor width plus the dielectric thickness then (1) what width is required for a 50 Ohm characteristic impedance ?

If the line were 300 microns length, what is the total wiring inductance and total wiring capacitance in that length ?

ECE 218 students only (5 more points)

The conductivity of copper is 59.6×10^6 Siemens/meter and $\mu_0 = 4\pi \times 10^{-7} \text{ H/m}$. Find the skin depth, the attenuation constant α , and the total line attenuation at 60GHz signal frequency.

Hint---the skin depth is $\delta = \sqrt{2 / \omega \mu_0 \sigma}$

line width required for $Z_0=50$ Ohms; $W=$ _____

total inductance in 100 microns $L=$ _____

total capacitance in 100 microns $C=$ _____

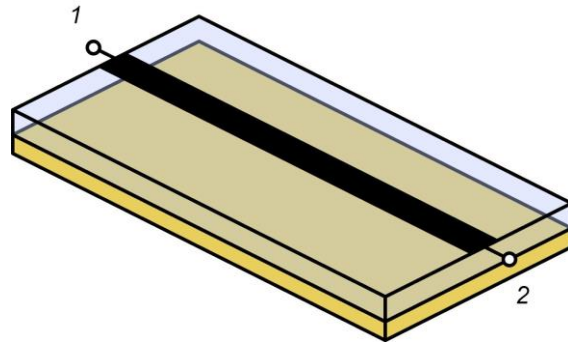
skin depth $\delta =$ _____

attenuation constant $\alpha =$ _____ (nepers/meter)

total attenuation, $S_{21} =$ _____ (dB)

Part b, 7.5 points

Using the very crude approximation that the effective conductor width is the physical conductor width plus the substrate thickness, what is the highest characteristic impedance which we can obtain ?



Assuming a signal frequency of 60 GHz, what is the maximum conductor width allowable to suppress propagation of parasitic *transverse* modes on the conductor ?

Setting a practical limit of width 2:1 smaller than that, what would be the resulting Z_0 .

Maximum feasible Z_0 = _____

Minimum feasible Z_0 = _____

Maximum width to prevent transverse modes at 60 GHz W = _____

Characteristic impedance with width set to 1/2 of the above, Z_0 = _____

