ECE ECE145A (undergrad) and ECE218A (graduate)

Mid-Term Exam. November 14, 2019

Do not open exam until instructed to.

Open notes, open books, etc.

You have 1 hour and 15 minutes.

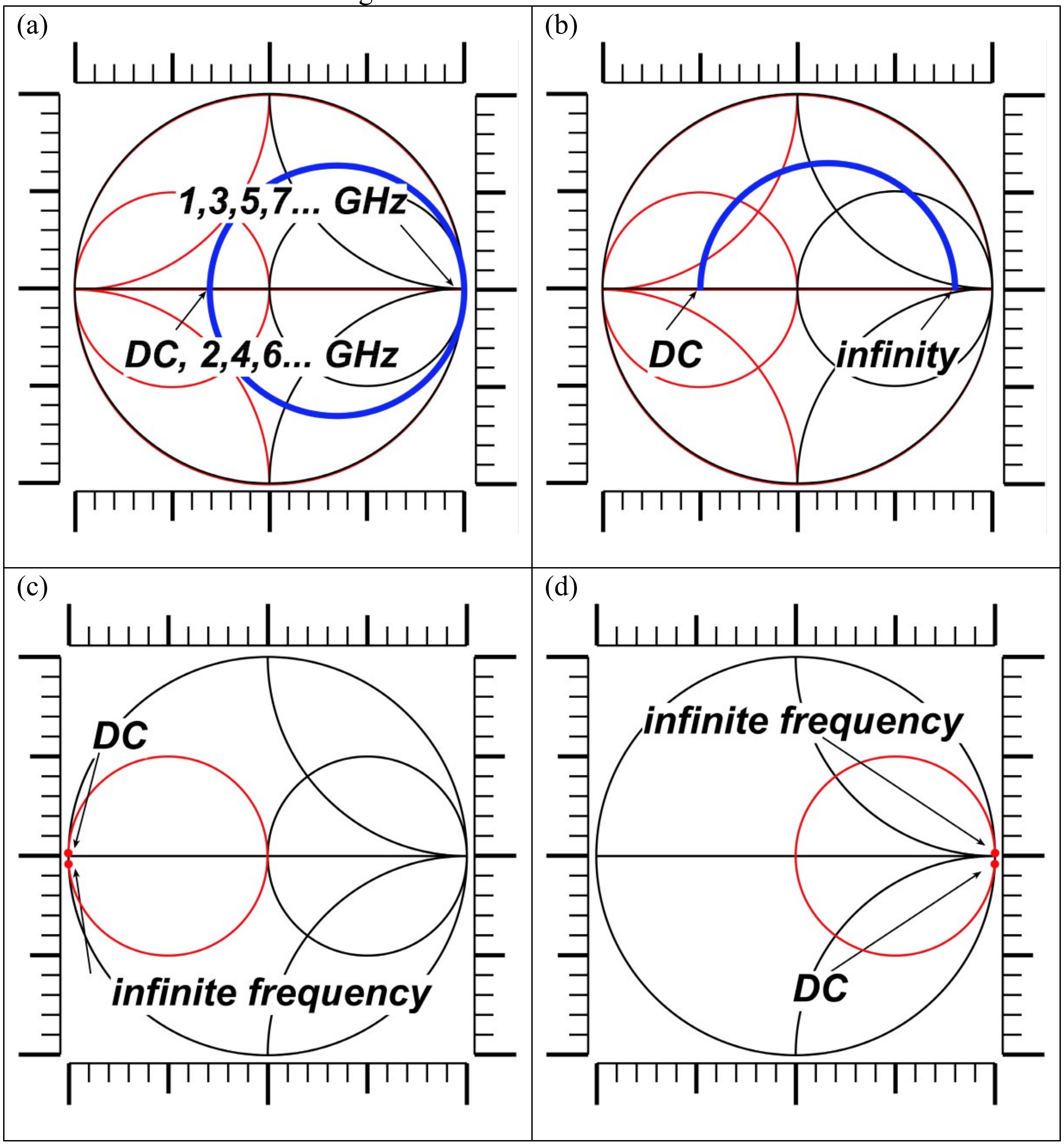
Use any and all reasonable approximations (5% accuracy is fine.) , ***AFTER STATING THEM.***

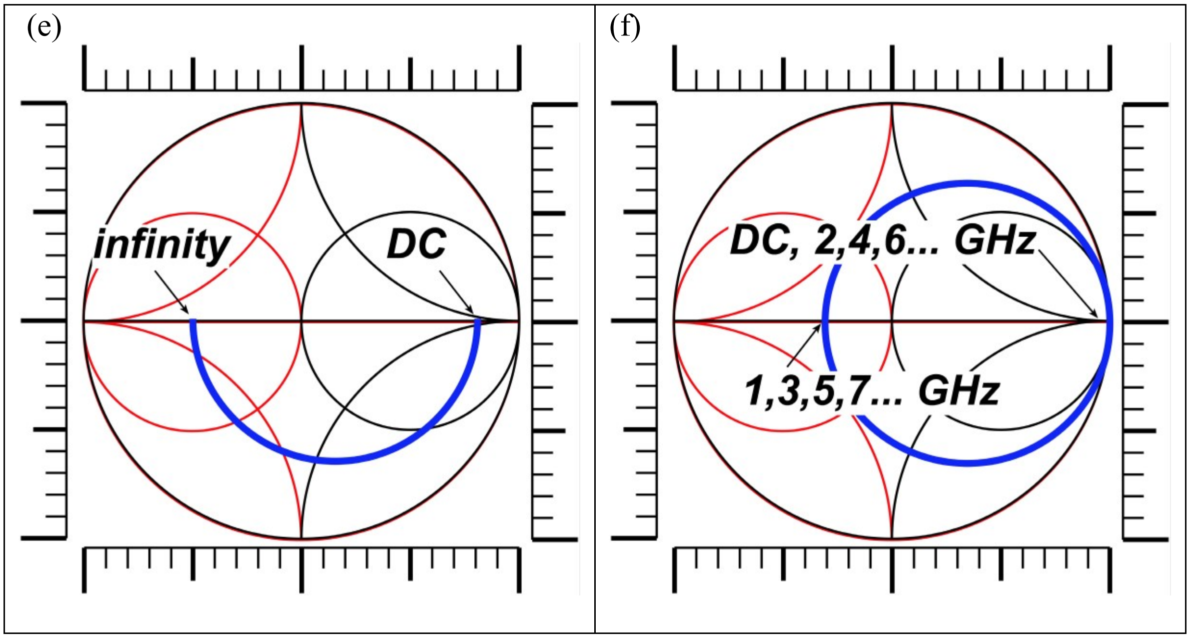
Problem	Points Received	Points Possible
1		15
2a		10
2b		7
2c		8
2d (218 only)		15 (218A only)
3a		7.5
3b		7.5
4		15
5a		5
5b		5
5c		5
5d (218 only)		15 (218A only)
total		85 (145), 115 (218A)

Name: __________________________

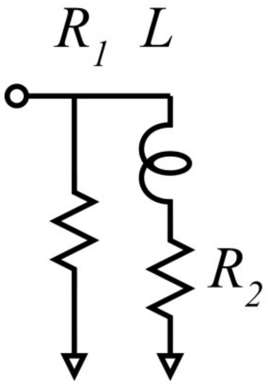
Problem 1, 15   points
The Smith Chart and Frequency-Dependent Impedances.

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

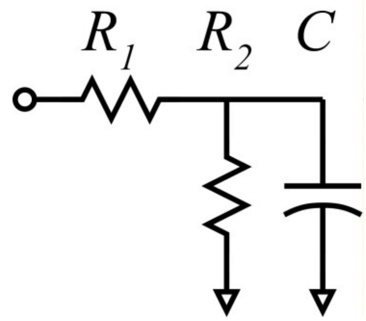



(e)
infinity
DC
(f)
DC, 2,4,6... GHz
1,3,5,7... GHz

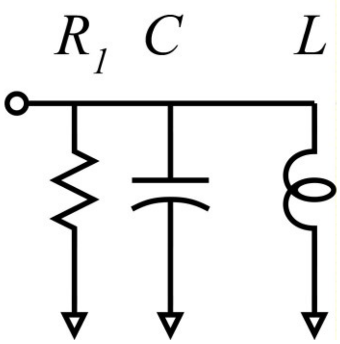
(i)



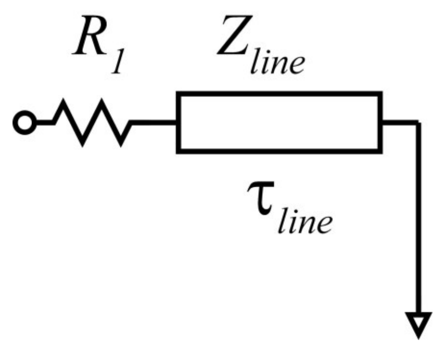
(j)



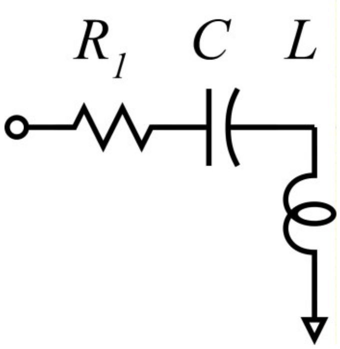
(k)



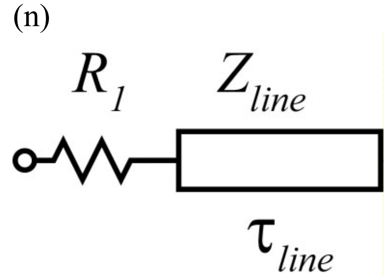
(l)



(m)



(n)



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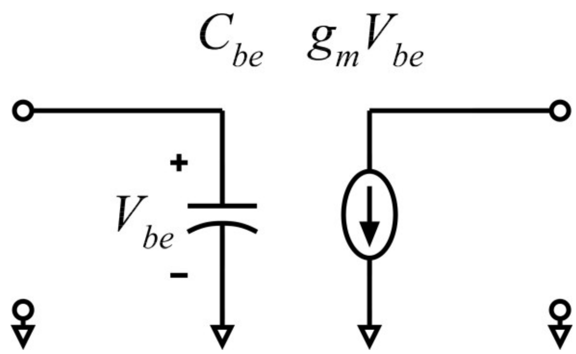
First match each Smith Chart with each circuit. ***Then determine as many component values as is possible*** (RLC values, transmission line delays and characteristic impedances)...note that some values cannot be determined with the information given. The charts all use 50 Ohm normalization:

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: ______________ , ______________ , ______________ ,

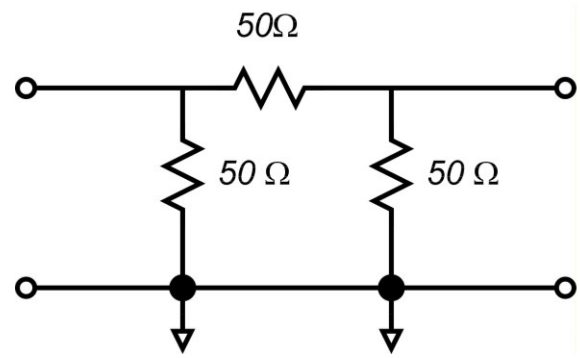
Problem 2, 25 points (ece145A), 40 points (ece218A)
2-port parameters and Transistor models

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. The signal frequency is 10GHz, gm=1 mS, and Cbe=1fF.



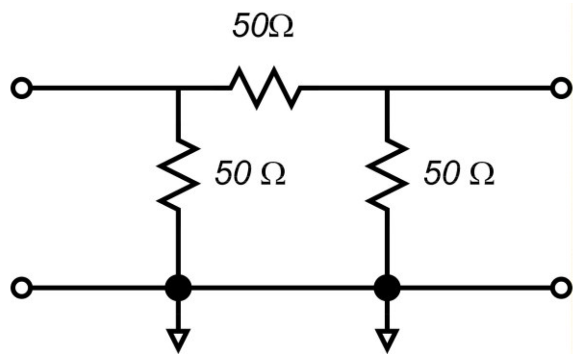
Part b, 7 points

Compute the Y parameters for this network



Part c, 7 points

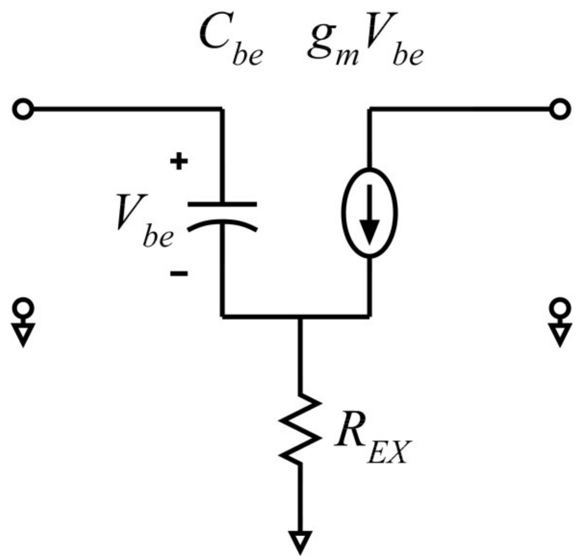
Compute the ***Z *** parameters for this network



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

For the network at the right, give an algebraic expressions for Y_{11} and Y_{21}. 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

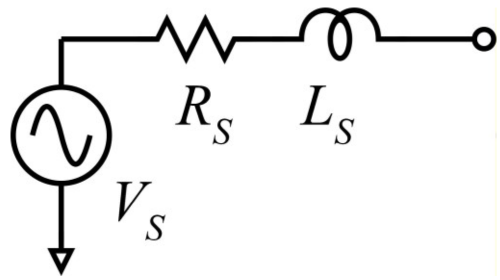
Available source power relationships, lumped/distributed relationships.

<u>Part a, 7.5 points</u>

Vs is 0.1V RMS at 2GHz

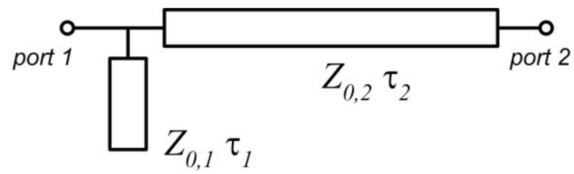
Rs is 10 Ohms, Ls is 1nH.

At 2GHz, what power would be delivered into a 50 Ohm load ? What is the available signal power ?



<u>Part b, 7.5 points</u>

In the network to the right, Zo2=100 Ohm, Zo1=25 Ohms, tau_2=50ps, tau_1=50ps.



Representing line #2 as a pi-section and line #1 as a T-section, give an approximate lumped equivalent circuit model, with element values, for the network.

Approximately what would be the highest frequency at which the lumped network might reasonably approximate the distributed network (rough answer only) ?

Problem 4, 15 points
Impedance-matching exercise.

At 10GHz signal frequency, an antenna has an input impedance of 25-j20 Ohms. Design a matching network, using a series inductor and a shunt capacitor, which matches this impedance to 50 Ohms at 10GHz.

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, 5 points

Coaxial cable uses a signal conductor of round cross-section with an insulating dielectric and a ground conductor both wrapped around it. The characteristic impedance is

$Z_0 = (1/2\pi)(\mu_0/\varepsilon_r\varepsilon_0)^{1/2}\ln(D/d)$

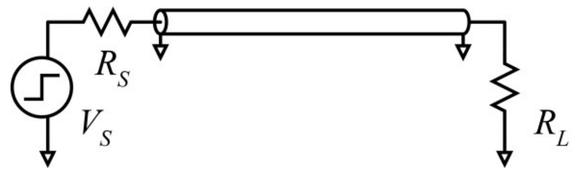
where $(\mu_0/\varepsilon_0) = 377\Omega$, ε_r is the insulator dielectric constant, and d and D are the diameters of the inner and outer conductors.

The velocity is $v = c/\varepsilon_r^{1/2}$, where c is the speed of light.

Suppose that the dielectric is Polyethylene, which has ε_r =2.25, and that the inner conductor is 1mm diameter.
For 50 Ohms characteristic impedance, what must be the outer conductor diameter ?
What is the wave velocity on the transmission line ?
If the cable is 1 meter long ,what is the total line capacitance and inductance ?

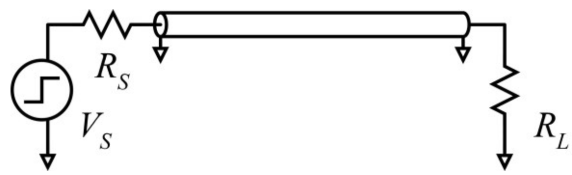
Part b, 5 points

Using the parameters from part a, if we drive the cable with a step-function and with Rs=RL=1 Ohm, what will be, approximately, the 10%-90% risetime of the voltage waveform at the load ?

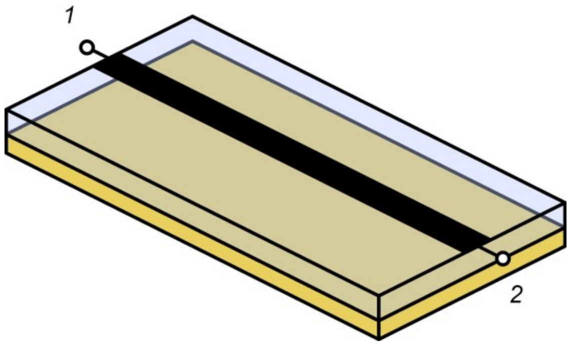


Part c, 5 points

Using the parameters from part a, if we drive the cable with a step-function and with Rs=RL=10 kOhm, what will be, approximately, the 10%-90% risetime of the voltage waveform at the load ?



Part d, 15 points ECE 218 students only



We will make a 50 Ohm microstrip line on commercial board material (like that used in the class) with a dielectric constant of 2.2.

The design frequency is 140GHz.

You are to design a 50 Ohm transmission-line. To approximately model the effect of fringing fields, assume that

$Z_0 \cong (\mu_0 / \varepsilon_r \varepsilon_0)^{1/2} (H / (H + W))$

where W is physical conductor width and H is the board thickness.

To adequately suppress coupling to dielectric slab modes, keep the board thickness less than or equal to the 1/4 of a wavelength *in the dielectric* at the design frequency.

To adequately suppress lateral transmission-line models, keep the conductor width less than or equal to 1/4 of a wavelength *in the dielectric* at the design frequency.

The conductivity of (very pure) copper is 5.96×10^7 (1/Ohm/meter) at 20C.

-Determine the board thickness and the conductor width.
-Determine the skin effect loss, in dB/mm, at 140GHz.

(hint: the skin depth is $\delta = (2/\omega\mu_0\sigma)^{1/2}$, where $\mu_0 = 4\pi \cdot 10^{-7}$ H/m)