ECE ECE145A (undergrad) and ECE218A (graduate)

Final Exam. Tuesday, December 10, 12-3 p.m.

Do not open exam until instructed to.
Open notes, open books, etc
You have 3 hrs.
Use all reasonable approximations (5% accuracy is fine.) , ***AFTER STATING THEM.***
Hint: Stop and think before doing complicated calculations. ***For some problems, there is an easier way.***

Problem	Points Received	Points Possible
1a		15
1b		10
1c		5
1d		10
2a		10
2b		5
2c		10
2d		5
2e		10
3a		5
3b		5
3c		5
3d		10
4a		10
4b		10
total		120

Name: ____________________________

$$G_T = \frac{|S_{21}|^2 (1-|\Gamma_s|^2)(1-|\Gamma_L|^2)}{|(1-\Gamma_s S_{11})(1-\Gamma_L S_{22}) - S_{21}S_{12}\Gamma_s\Gamma_L|^2} \qquad G_P = \frac{1}{1-\Gamma_{in}^{\ 2}} \cdot |S_{21}|^2 \cdot \frac{1-|\Gamma_L|^2}{|1-\Gamma_L S_{22}|^2}$$

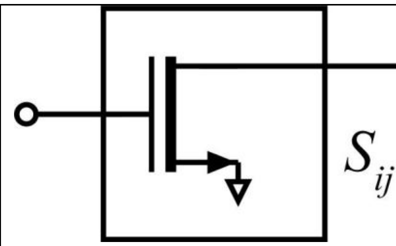
$$G_a = \frac{1-|\Gamma_S|^2}{|1-\Gamma_S S_{11}|^2} \cdot |S_{21}|^2 \cdot \frac{1}{1-\Gamma_{out}^{\ 2}} \qquad G_{\max} = \frac{|S_{21}|}{|S_{12}|} \cdot \left[K - \sqrt{K^2 - 1}\right] \text{if } K > 1$$

$$G_{MS} = \frac{|S_{21}|}{|S_{12}|} \cdot \text{if } K < 1$$

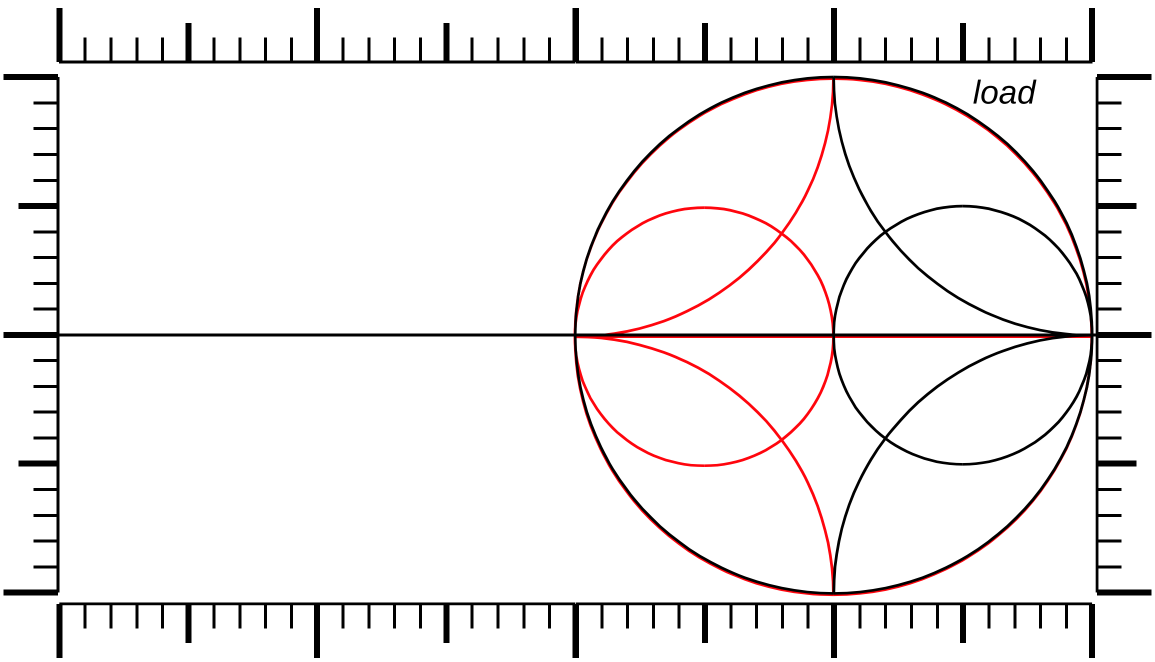
$$K = \frac{1-|S_{11}|^2 - |S_{22}|^2 + |\Delta|^2}{2|S_{21}S_{12}|} \quad \text{where } \Delta = \det[S]$$

Problem 1, 30 points
stability

part a, 15 points

At 10GHz, a transistor has S11=4/5, S12=1/10, S21=8, S22=0. These S-parameters are normalized to a 50 Ohm reference impedance	

Draw the *load* stability circle on the graph below:
(to do this perfectly, you would need a compass: you can sketch most of the curve, but be sure to plot *exactly* the points where the stability circle crosses the real axis, i.e. the x-axis.)



part b, 10 points

Continuing with part A above, you must add either a parallel or a series resistance on the *output* to make the device unconditionally stable. ***Only one of the two choices will work***. Should you use a parallel or a series element ? What value should you use ?

Parallel or series ? ___________________________

R=_____________________

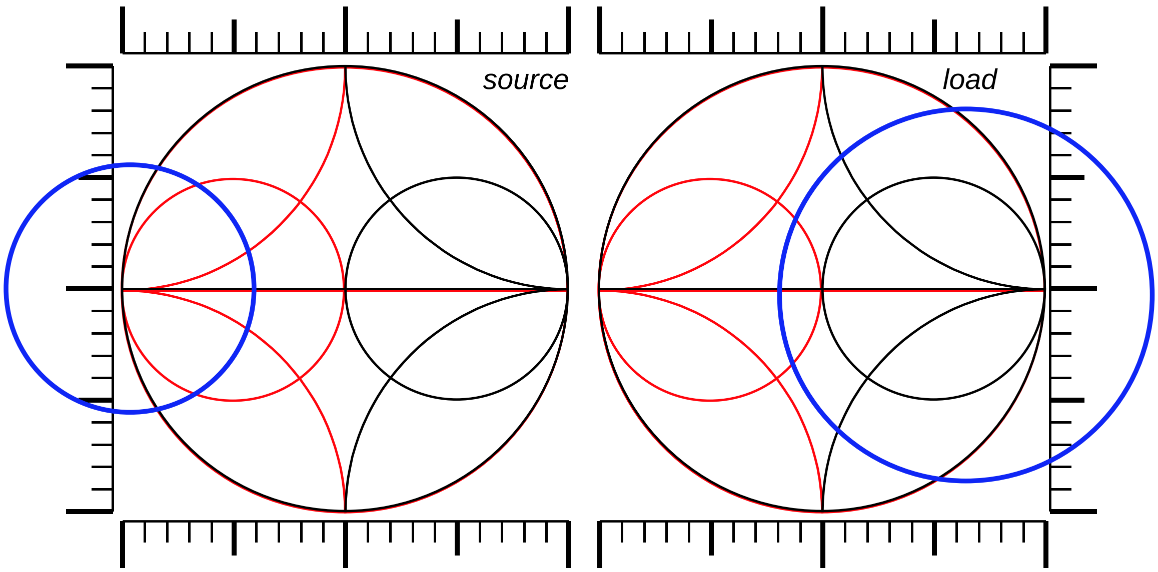
part c, 5 points

Continuing with part A above, after stabilization, if we then impedance-match on input and output, what will be the resulting power gain ?

Power gain = ______________________

part d, 10 points

A bipolar transistor in common-emitter mode has the source and load stability circles below at 10GHz. The magnitude of S11 and of S22 are both less than 1 at this frequency. Draw circuit diagrams of *three* different stabilization circuits, giving element values, where the stabilization is set at the value minimum necessary to obtain unconditional stability.



Problem 2, 35 points

2-port parameters and signal flow graphs

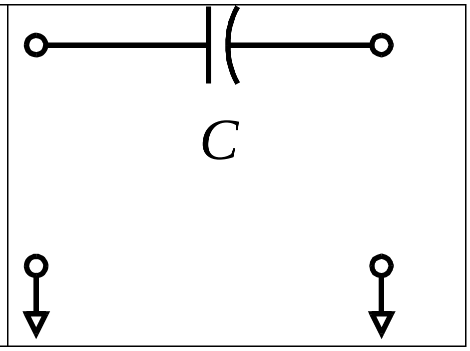
part a, 10 points

The network at the right is for DC blocking.

If we want $\|S21\| > -3$ dB at 1GHz, what is the minimum value of the capacitor ?

If we want $\|S11\| < -40$ dB at 1GHz, what is the minimum value of the capacitor ?

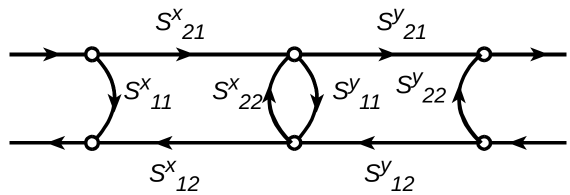
Assume a 50 Ohm impedance standard.



Minimum value of C to meet S21 specification= ___________________

Minimum value of C to meet S11 specification= ___________________

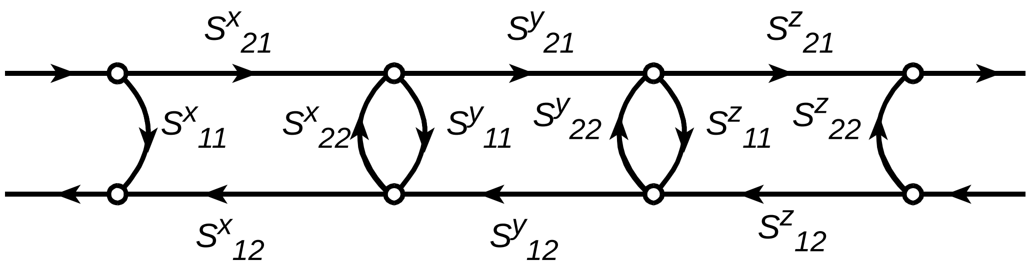
<u>part b, 5 points</u>

The signal flow graph to the right represents the cascade of two-ports "x" and "y". If we call the combined network "z", find S_{21}^{Z} and S_{12}^{Z}	

$S_{21}^{Z}=$________________________

$S_{12}^{Z}=$________________________

part c, 10 points

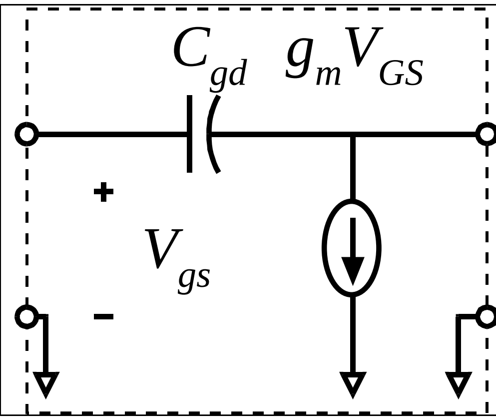


The signal flow graph above represents the cascade of two-ports "x", "y", and "z" If we call the combined network "a", find S^a_{21}

S^a_{21}=____________________________________

part d, 5 points

It can be proved that $S_{21}/S_{12} = Y_{21}/Y_{12}$ for any two-port. For the circuit to the right, find Y_{21}/Y_{12}. After finding an exact answer, assume that $g_m >> \omega C_{gd}$ to find a simpler answer.

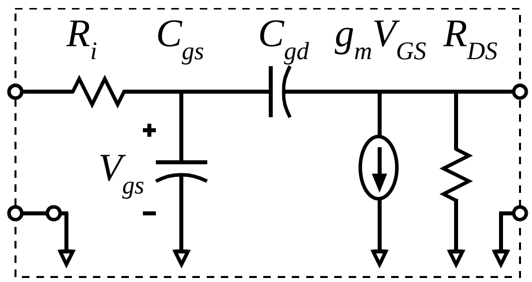


$Y_{21}/Y_{12} =$ ______________________________

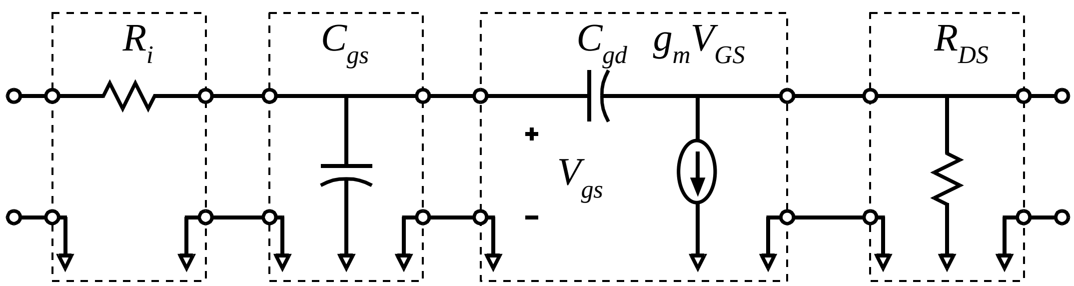
$Y_{21}/Y_{12} \cong$ ______________________________

part e, 10 points

(A)



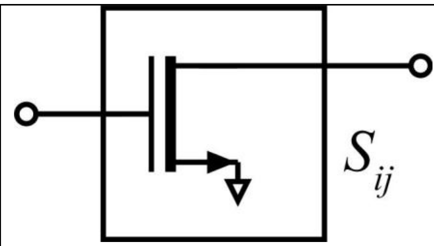
(B)



The network (A) above can be represented as the cascaded network (B) below.
If we assume that the network is potentially unstable (it will be at lower frequencies), find an expression for the maximum stable gain.

MSG=________________________________

Problem 3, 25   points
gain definitions

At a signal frequency of 10 GHz, a two-port has $S_{11} = 0.5$, $S_{12} = 0$, $S_{21} = 10$ and $S_{22} = 0.316$, as defined with a 50 Ohm impedance reference.	

part a, 5 points

The device is directly connected to a 50 Ohm generator with 1 microwatt available power, and is directly connected to a 50 Ohm load. Find the RF power in the load.

$P_{Load} =$ ____________________

part b, 5 points

The device is connected to a 50 Ohm generator with 1 microwatt available power, and is connected via a conjugate impedance-matching network to a 50 Ohm load. Find the power in the load.

$P_{Load} =$ ____________________

part c, 5 points

The device is connected via a conjugate impedance-matching network to a 50 Ohm generator with 1 microwatt available power, and is connected via a conjugate impedance-matching network to a 50 Ohm load. Find the power in the load. Find the source and load impedances presented to the transistor.

$P_{Load} =$ ____________________ Z_{source} ____________________ $Z_{Load} =$ ______________

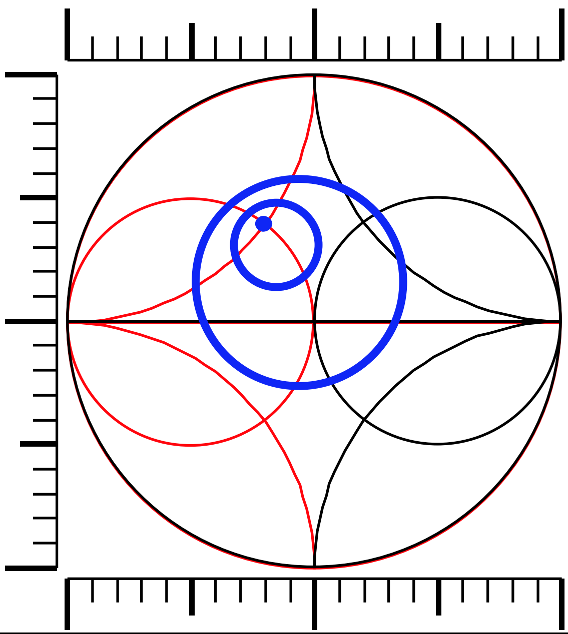
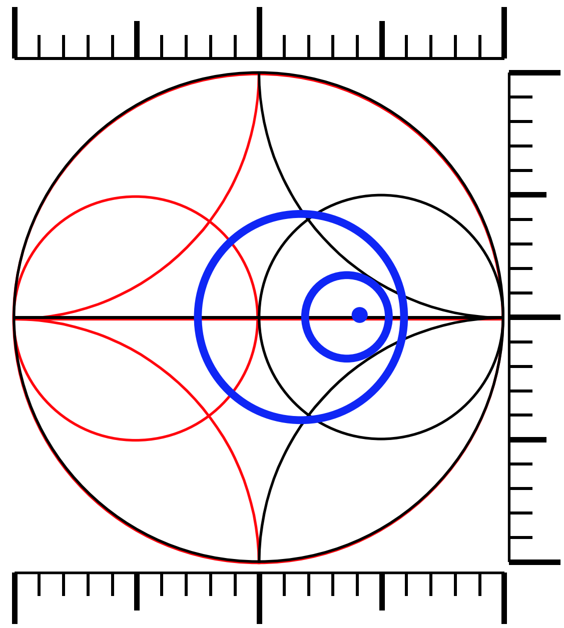
part d, 10 points

Using the impedance-matching networks of part C (they are NOT CHANGED for part d), the device is now connected to a 25 Ohm generator with 1 microwatt available power, and is directly connected to a 100 Ohm load. Find the RF power in the load.

$P_{Load} =$ ____________________

Problem 4, 20 points
more gain relationships

<u>part a, 10 points</u>

Available gain circles	Operating gain circles
	

At 1 GHz, a MOSFET in common-source mode operating and available gain circles as shown. Find the optimum generator and load impedances (in complex Ohms). Assume 50Ohm normalization.

Z_{source}____________________ $Z_{Load}=$ ________________

part b, 10 points

Working with the gain circles of part (a), if the transistor has S_{12}=0 and S_{21}=10, find the transistor's S_{11} and S_{22} and find the transistor's maximum available gain.

S_{11}=________________________________

S_{22}=________________________________

MAG=________________________________