ECE ECE145A (undergrad) and ECE218A (graduate)
TAKE HOME Final Exam. Return before Friday December 15, 2017

HONOR SYSTEM: Open book. You have 3 hrs. WORK WITHOUT HELP.
Use all reasonable approximations (5% accuracy is fine.) ,
AFTER STATING and justifying THEM.
Think before doing complex calculations. ***Sometimes there is an easier way.***

Problem	Points Received	Points Possible
1A		5
1B		5
1C		5
1D		10
1E		10
1F		10 (218A only)
2A		10
2B		5
2C		5
2D		5
3A		10
3B		10
4A		5
4B		10
4C		10 (218A only)
total		95 (145A), 115 (218A)

I certify that

1) I have taken no more that 3 hours to work the exam. (or DSP) limits.

2) I have help from no one

3) I did not read the exam until the time I took the exam.

Signed: __________________________

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

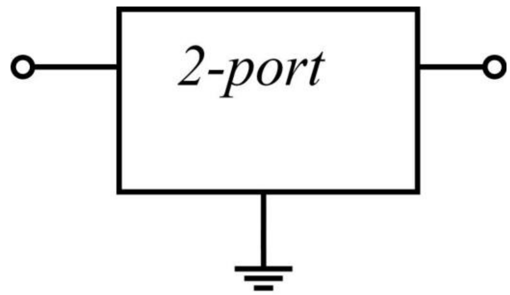
$$G_a = \frac{1-|\Gamma_S|^2}{|1-\Gamma_S S_{11}|^2}\cdot|S_{21}|^2\cdot\frac{1}{1-\|\Gamma_{out}\|^2} \qquad G_{\max} = \frac{|S_{21}|}{|S_{12}|}\cdot\left[K-\sqrt{K^2-1}\right]\text{if } K>1$$

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

Unconditionally stable if : (1) K>1 **and** (2) $\|\det[S]\|<1$

Problem 1, 35 points (145A), 45 points (218A)

Two-port properties, Power gain definitions

At a signal frequency of 10 GHz, a transistor has $S_{11} = 0$, $S_{12} = 0.2$, $S_{21} = 2$ and $S_{22} = 0.8$, as defined with a 50 Ohm impedance reference.	

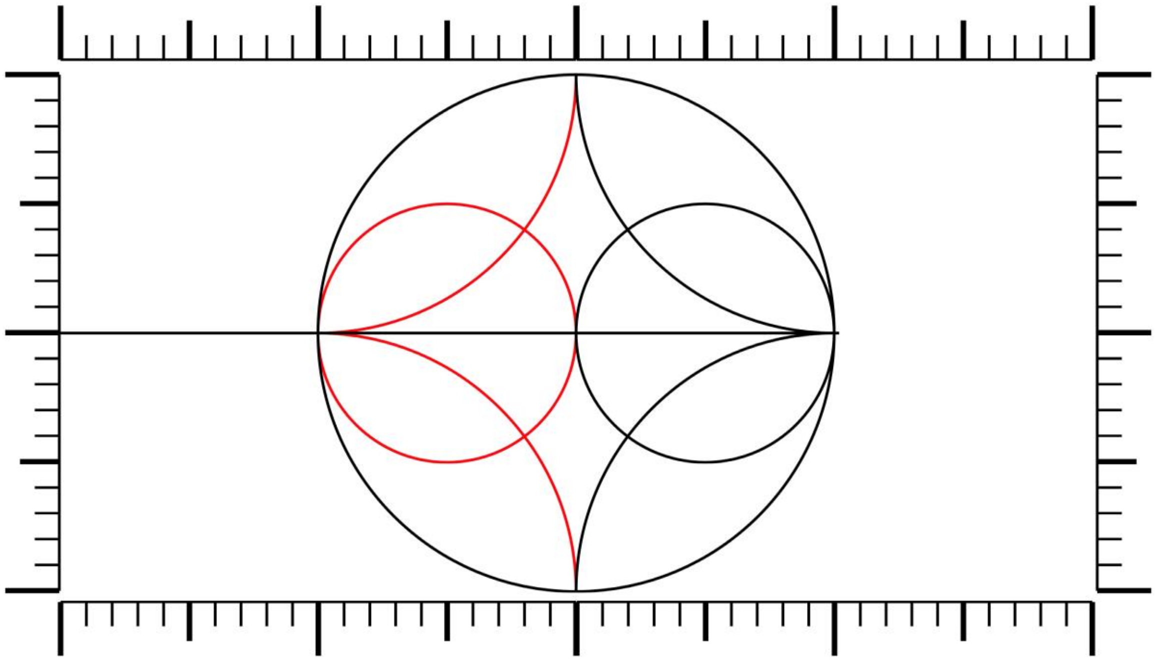
<u>part a, 5 points</u>

Is the circuit unconditionally stable ? Hint: examine the expressions for Γ_{in} and Γ_{out}

Yes/No: ? ____________________________

part b, 5 points

Please draw a SOURCE stability circle



part c, 5 points

The transistor is connected to a 100 Ohm generator with 1mW available power. The output of the transistor is impedance matched to the load. How much power will be delivered to the load ?

load power = ________________________

part d, 10 points

IF necessary, the transistor is stabilized, and is then impedance-matched to a 50 Ohm generator and a 50 Ohm load ? If the generator has 1mW available power, how much power will be delivered to the load ?

load power = ________________________

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

In the case of part D, above, if we consider the transistor, the possible stabilization network, and the matching networks to be, in combination, an amplifier, what are $\|S21\|$, $\|S11\|$, $\|S22\|$, $\|S12\|$ of the *amplifier* ?

$\|S11\|$ = ________________________

$\|S12\|$ = ________________________

$\|S21\|$ = ________________________

$\|S22\|$ = ________________________

part f, 10 points (somewhat tricky, ece218c students only)

I now connect the *amplifier* of parts D and E to a 100 Ohm generator of 1 mW available power. The load is 25 Ohms. What is the power delivered to the load ?

Pload=______________

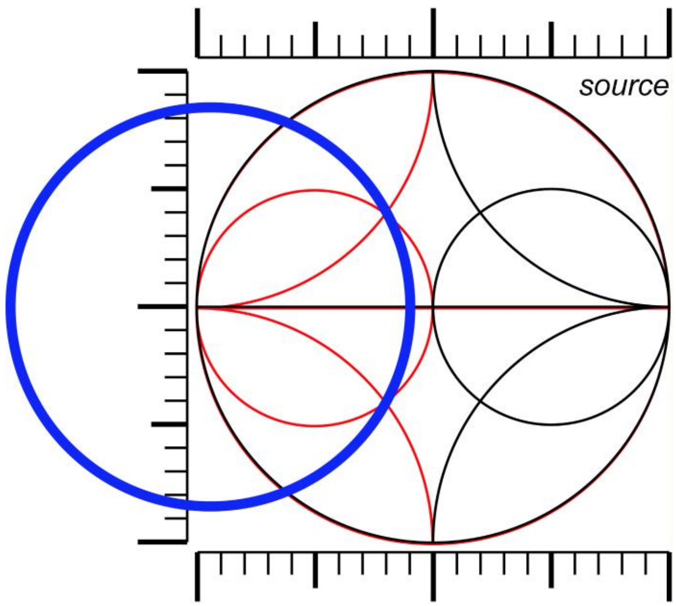
Problem 2, 25 points

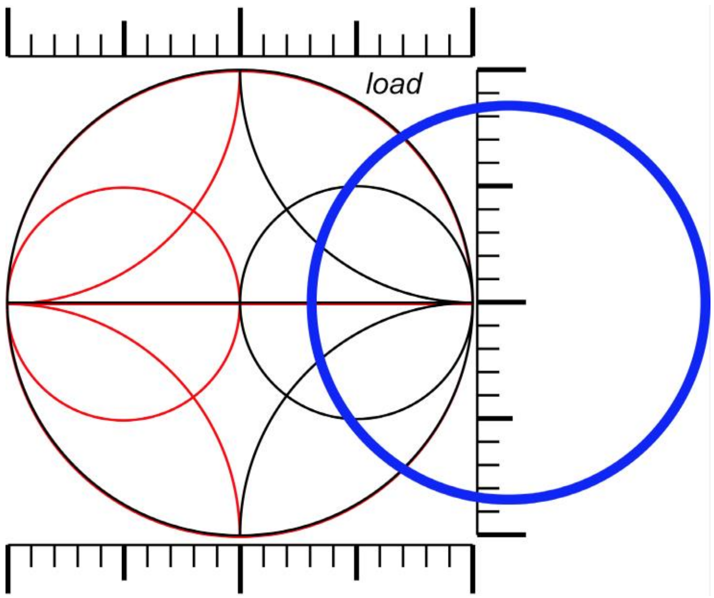
Unconditionally stable and Potentially unstable amplifier design, gain circles

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

A MOSFET in common-source mode has ||S11|| < 1 and |S22|| >1, and has stability circles (50Ohm reference impedance) as below.

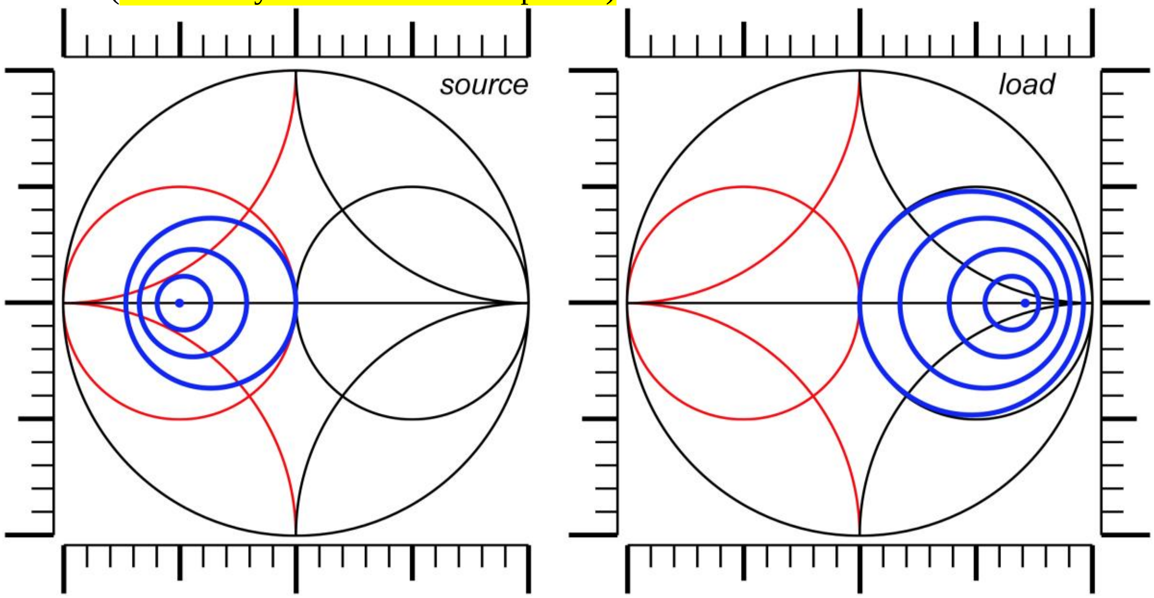
In the boxes below, draw circuit diagrams of *two* methods of stabilizing the transistor.




load

part b, 5 points

A transistor has available and operating gain circles as below. These are graphed in 1dB gain increments. The transistor MAG is 10dB, and the transistor is unconditionally stable. (the stability circles have been updated)



What source and load impedances are required for 10dB gain?

Zs=______________________ Zl=______________________________

part c, 5 points

We continue with the transistor of part B. If the generator impedance is 50Ohms, and the load impedance is matched to the transistor output impedance, then what power gain will the transistor have ?

Power gain =______________________

part d, 5 points

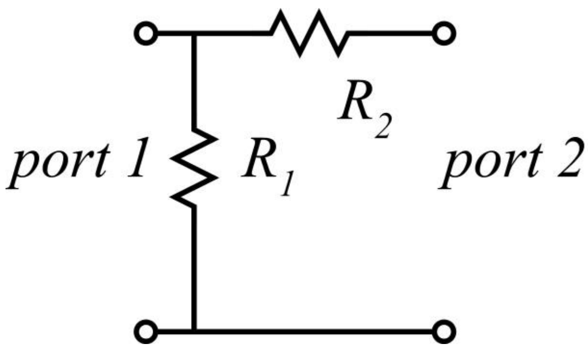
We continue with the transistor of part B. If the load impedance is 50Ohms, and the generator impedance is matched to the transistor input impedance, then what power gain will the transistor have ?

Power gain =______________________

Problem 3, 20 points
S parameters and Signal flow graphs

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

We have R1=100 Ohms and R2=50 Ohms
Given a 50 Ohm impedance reference,
Find the four S-parameters of this network



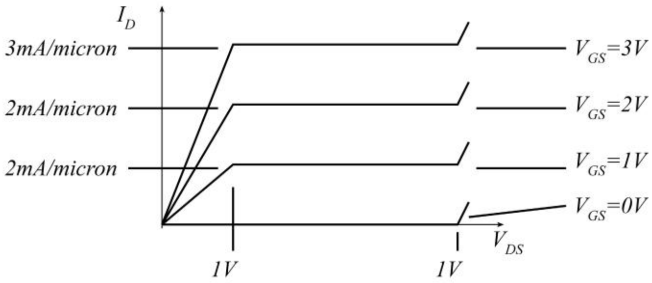
S11=______________, S12=______________ S21=______________, S22=______________

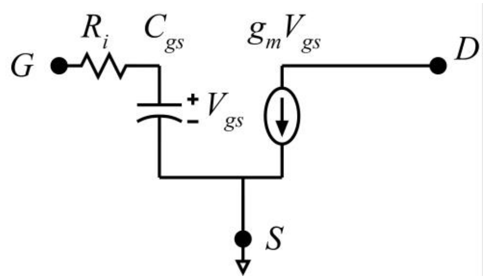
part b, 10 points

We have a transistor having S11=0.5, S12=0.1, S21=3, S22=0.5. We connect the network of part a to the transistor's INPUT. Please find S21 of the combined network

S21 of the combined network = ______________________________

Problem 4, 15 points (145A), 25 points (218A)
Power amplifier design (the graph is updated)





A FET has the common-source characteristics above, normalize to FET gate width. You can infer gm from the data above. We have Ri=1/gm, and f_τ is 200 GHz. The signal frequency is 50 GHz

part a, 5 points
Assuming TEMPORARILY a 1 micron FET width, give the following.

gm=___________________, Cgs = ____________________ Ri=____________________

part b, 10 points

When we attempt to design impedance-transformation networks, we have found that the minimum load impedance we can synthesize is 10 Ohms.
What FET width should we select ? Wg= __________________________
What maximum undistorted output power will we obtain ? Pout=________________
What input power does this require ? Pin= ________________________________

part c, 10 points

218A students ONLY

We want to combine the power of 4 such FETs. Draw circuit diagrams, with all element values given, of (1) the output matching network of an individual FET and (2) the output power-combining network.