ECE202A Mid-Term Exam.

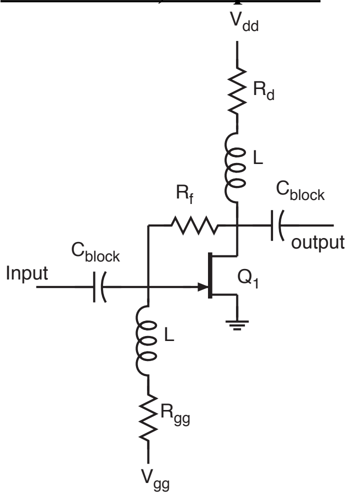
Nov. 9, 1993

This is a 1--2 hour exam (you have two hours). There are xx questions. Please don't turn the cover page until the exam is distributed to everyone.

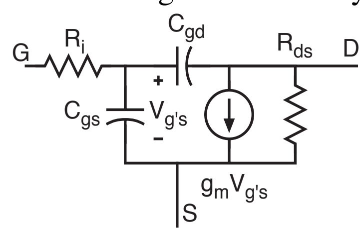
Use any and all reasonable approximations in circuit analysis, after stating them.

Name: ______________________________

Problem 1, 30 points



At left is shown a FET feedback amplifier and below the FET equivalent circuit. The FET obeys the idealized square--law model and has Vp=–1 Volt and Idss=100 mA.The transistor Rds is large and Ri is small; these can be neglected.f_t=50 GHz and Cgs/Cgd=20. The power supplies are ±10 Volts. The feedback amplifier is to have 12 dB gain in a 50Ω system.



Part A, 5 points

Elementary feedback amplifier properties

What are the required values of the feedback resistor R_f and the transistor transconductance g_m?

Part B, 5 points

DC bias conditions

At what drain current must the transistor be biased? If the transistor is to be biased at V_{drain}=+5 Volts, what are the required values of R_{gg} and R_d?

Part C, 10 points

Bandwidth analysis

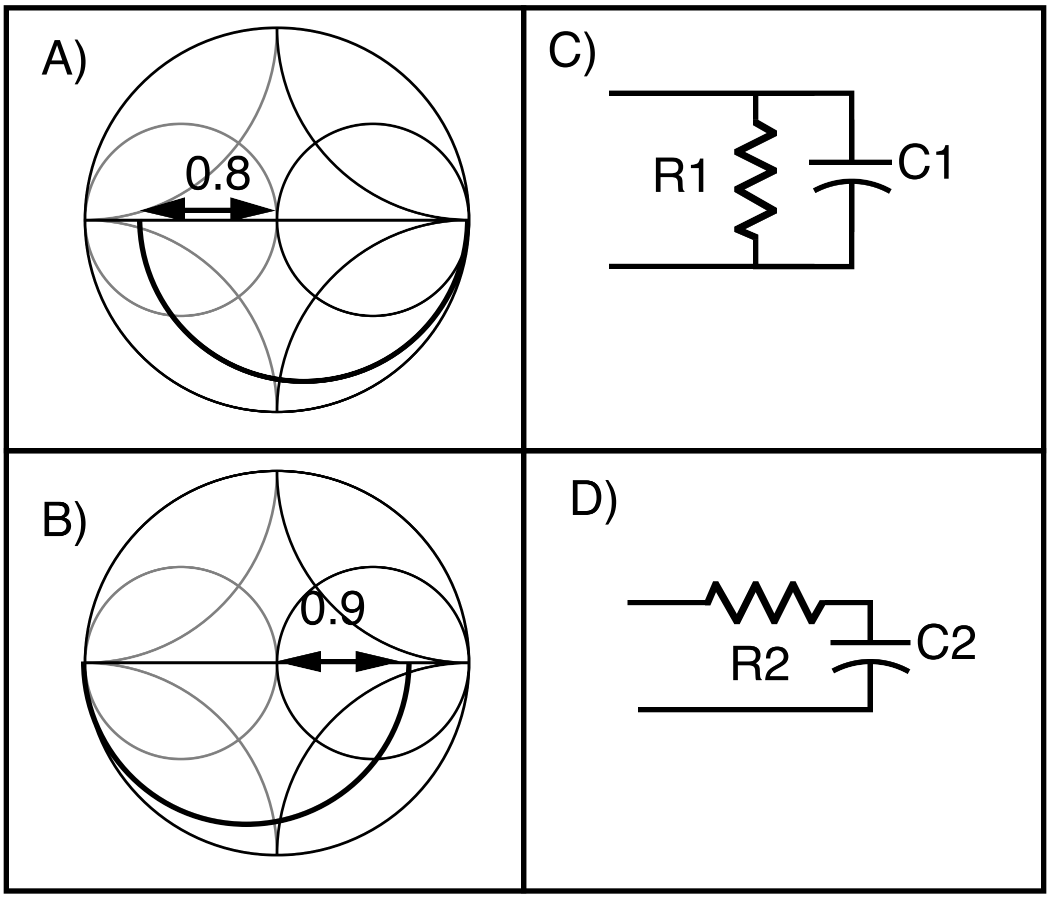
What is the amplifier -3 dB bandwidth, in Hz? Give an algebraic expression of S_{21} as a function of frequency.

Part D, 10 points

Properties of S-parameters

Given the Miller approximation, calculate S_{11} as a function of frequency.

Problem 2, 15 points



Part xx, 5 points

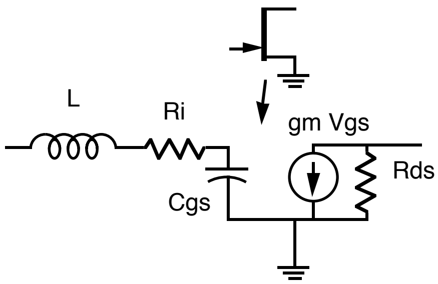
Two Smith Charts (A and B) are measurements of the S_{11} for two RC circuits. Which Smith chart corresponds to which circuit?

Part xx, 10 points

For each circuit, the angle of S_{11} is 90° at 10 GHz. Find R1,R2, C1, C2

Problem 3, 30 points

Mostly an Impedance--matching exercise



The transistor has Cgs=0.32 pF, Ri=25Ω, L=0.40 nH, and Rds=500Ω. gm=100 mS

The transistor is to operate at 10 GHz

Part a, 10 points

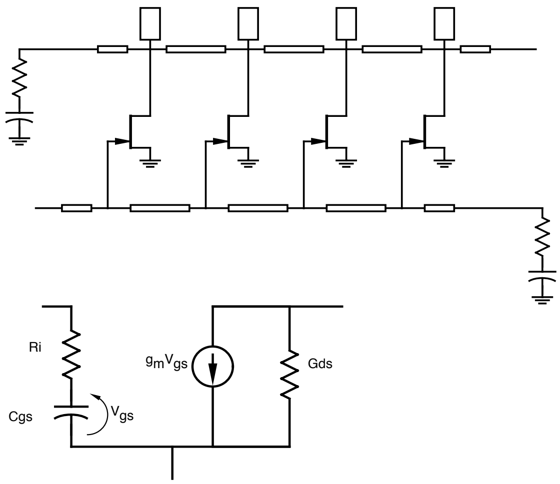
Using the attached Smith Chart, design lumped-element (LC) impedance-matching networks to match the amplifier input and output to 50Ω. There are several possible solutions; make sure that the solutions chosen use shunt capacitors and series inductors.

Part b, 10 points
Warning: a tricky question involving careful thinking and not much math.
Given an amplifier consisting of the transistor and the 2 matching networks you have designed, give the **magnitudes** of the 4 S-parameters at 10 GHz.

Part c, 10 points
lumped-element equivalents
Lumped elements are not available to you. Instead, the matching network must be implemented using lines of between 20Ω and 90Ω characteristic impedance. All lines have an effective dielectric constant of 2. Draw the circuit diagrams of the resulting approximate distributed realizations of the lumped--element prototypes, giving physical lengths and characteristic impedances.

Problem 4, 25 points

Traveling--wave amplifiers



A traveling-wave amplifier and the FET model are shown at left. Each of the 4 FETs has gm=40 mS, Rds=1000Ω, f_t=100 GHz, f_{max}=200 GHz.

The series line sections are 100 Ω impedance, the shunt line sections are 10Ω.

Part A, 10 points

The amplifier is to have 50Ω synthetic gate and drain lines. Find the length of the series and shunt drain lines, and find the Bragg frequency.

Part B, 5 points
Find the low--frequency gain

Part C, 10 points
Find the per-section attenuation (nepers/section) on the gate line and drain line at 75% of the Bragg frequency.