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 \( V_p = 1 \) Volt and \( I_{dss} = 100 \) mA. The transistor \( R_{ds} \) is large and \( R_i \) is small; these can be neglected. \( f_t = 50 \) GHz and \( C_{gs}/C_{gd} = 20 \). The power supplies are \( \pm 10 \) 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 \( V_{drain} = \pm 5 \) 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 $C_{gs}=0.32 \text{ pF}$, $R_{i}=25\Omega$, $L=0.40 \text{ nH}$, and $R_{ds}=500\Omega$. $g_{m}=100 \text{ mS}$

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 $50\Omega$. 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 $g_m=40 \text{ mS}$, $R_{ds}=1000\Omega$, $f_t=100 \text{ GHz}$, $f_{\text{max}}=200 \text{ GHz}$.

The series line sections are $100 \Omega$ impedance, the shunt line sections are $10\Omega$.

Part A, 10 points
The amplifier is to have $50\Omega$ 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.