ECE ECE145A (undergrad) and ECE218A (graduate)

Mid-Term Exam. November 8, 2011

Do not open exam until instructed to.

Open notes, open books, etc

You have 1 hr and 15 minutes.

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

<table>
<thead>
<tr>
<th>Problem</th>
<th>Points Received</th>
<th>Points Possible</th>
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<tr>
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<td>2a</td>
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Name: ______________________
Problem 1, 20 points
The Smith Chart and Frequency-Dependent Impedances.

HINT: use the scales on the figures to measure distances as needed.
Match each Smith Chart with each circuit, and give all resistor values, and all transmission line delays and characteristic impedances. 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=_____________________
Problem 2, 40 points

Elementary impedance matching network design.

To the left is the equivalent circuit of a FET. The Transconductance is 100 mS, $R_i=10$ Ohms, $C_{gs}=100$ fF, $R_{ds}=100$ Ohms

Part (a), 15 points.

Using the impedance-admittance charts that have been passed out, design a lumped-element matching network to match the input impedance to 50 Ohms at 10 GHz. Use a series inductor and a shunt capacitor. Give the circuit diagram and the element values.
Part (b), 15 points.

Using the impedance-admittance charts that have been passed out, design a lumped-element matching network to match the output impedance to 50 Ohms at 10 GHz. Use a shunt inductor and a series capacitor. Give the circuit diagram and the element values.
Part (c), 10 points

Now instead design a quarter-wave line to match the load to 50 Ohms. Find the required line impedance and the physical length.
Problem 3, 25 points
Transmission-lines and lumped elements

Part a: 5 points

A transmission line has plates of 300 \( \mu \text{m} \) width and 100 \( \mu \text{m} \) separation. The line is 1 cm long. The region between the plates has a dielectric constant of 2.0. Neglect the fringing fields at the edges of the plates.

Find the following:
- characteristic impedance: ____________
- propagation velocity: ______________
- propagation delay: ______________
- total inductance: ______________
- total capacitance: ______________
part b, 10 points

Above is an accurate scale drawing of a microstrip circuit. The dots represent the connection points. The circuit board is 0.25 mm thick and has a dielectric constant of 2.0. To approximately model fringing fields, the effective conductor width is taken as the physical conductor width plus the board thickness.

First, draw a transmission-line equivalent circuit for the circuit, giving all characteristic impedances and line propagation delays. Second, assuming a signal frequency of 5 GHz, draw a second circuit diagram in which you replace line sections shorter than an eighth-wavelength with T or Pi-section models, giving the computed values of all LC elements of these sections.
part c, 10 points

We now repeat the problem for the structure above.

**First** draw an equivalent circuit using transmission-line sections for all elements, giving all line impedances and delays.

**Second** draw a transmission line circuit where all elements are replaced by LC *PI-sections*, giving the values of all L's and C's.

**Third**, neglecting the *inductances* of the *shunt line elements*, please comment on the approximate behavior of the structure.
Problem 4, 15 points
resistive feedback amplifiers

A FET has a transconductance of 0.3 mS per micron of gate width.

\[ f_t = \frac{g_m}{2\pi(C_{gs} + C_{gd})} \]

is 100 GHz, and \( C_{gd} \) is 20% of \( C_{gs} \).

Design a resistive feedback amplifier with 12 dB gain S21 for a 50 Ohm system using this FET. Draw the circuit diagram with all element values and determine the following:

FET width=_____________
transconductance=______________
\( C_{gs} \) =______________
\( C_{gd} \) =______________

amplifier 3-dB bandwidth (from nodal analysis or the time constant method).