

Name \_\_\_\_\_

**ELC 4384 – RF/Microwave Circuits II**  
**Spring 2017**  
**Midterm Exam – March 2, 2017**  
**Open Book/Open Notes/Mathcad Allowed**  
**1 hour and 15 minutes**

1. The exam is open-book/open-notes.
2. A calculator and the assigned computer using Mathcad software may be used to assist with the test.  
No laptops or tablets are allowed. No cellular phones may be used in any way during the test.  
Unauthorized electronic device use will result in disqualification.
3. You must circle or box your answers to get full credit.
4. All work and steps toward a solution must be clearly shown to obtain credit.
5. Partial credit may be given provided that the grader can clearly follow your work to the extent that an understanding of the problem is demonstrated.
6. No collaboration is allowed on this examination. Only Dr. Baylis may be consulted for clarification.
7. Please attach all hand calculations, Mathcad sheets and additional Smith Charts (if necessary) to the exam. Mathcad sheets should contain appropriate comments to allow the grader to follow your work. Each page should contain your name, the problem number, and the page number for that problem.

Please sign the statement below. YOU MUST SIGN THE STATEMENT OR YOU WILL GET A ZERO FOR THIS EXAMINATION!!!

I hereby testify that I have neither provided or received information from unauthorized sources during the test and that this test is the sole product of my effort.

Signed \_\_\_\_\_

Date \_\_\_\_\_

**PROBLEM 1 (25 points):** Use a ZY Smith chart to design a Pi matching network to transform  $Z_{\text{LOAD}} = 50 \Omega$  to the input impedance  $Z_{\text{IN}} = (100 - j80) \Omega$  with a  $Q_n$  of 4. Draw the matching network with the load and input sides clearly indicated. Give the impedance of each component in Ohms.

**PROBLEM 2 (20 points):** Design a microwave transistor amplifier for  $G_{T, \text{max}}$  using a GaAs field-effect transistor (FET) whose S-parameters in a 50- $\Omega$  system under certain bias conditions at 2.4 GHz are the following:

$$S_{11} = 0.02 \angle -28^\circ$$

$$S_{12} = 0.02 \angle 59^\circ$$

$$S_{21} = 6.3 \angle 176^\circ$$

$$S_{22} = 0.07 \angle -11^\circ$$

Answer the following questions. Turn in any applicable Mathcad sheets and Smith charts.

- (a) (5 points) Is the device unconditionally stable at 2.4 GHz? Justify your answer.
- (b) (5 points) What is the maximum value of transducer gain,  $G_{T, \text{max}}$ , in dB?
- (c) (10 points) What values of  $\Gamma_s$  and  $\Gamma_L$  will provide  $G_{T, \text{max}}$ ?

**PROBLEM 3 (40 points):** A Si bipolar junction transistor (BJT) has the following S-parameters at 1.9 GHz:

$$S_{11} = 0.73 \angle -25^\circ$$

$$S_{12} = 0.04 \angle -51^\circ$$

$$S_{21} = 4.8 \angle -25^\circ$$

$$S_{22} = 0.48 \angle -109^\circ$$

- (a) (5 points) Is the device unconditionally stable at 1.9 GHz? Why or why not?
- (b) (10 points) If the device is potentially unstable, plot the input and output stability circles on two separate Smith charts. Indicate clearly the stable and unstable regions. Identify the Smith charts clearly as the  $\Gamma_s$  and  $\Gamma_L$  Smith charts, appropriately.
- (c) (20 points) Design a stable amplifier with  $G_T = 18$  dB. Use the approach of designing for  $G_p = 18$  dB and then setting  $\Gamma_s = \Gamma_{IN}^*$ . Your solution must include drawing the  $G_p = 18$  dB circle on the  $\Gamma_L$  Smith chart. Clearly give your design values of  $\Gamma_s$  and  $\Gamma_L$ . For sake of time in this exam, you are not required to evaluate that your choice of  $\Gamma_s$  is in the stable region on the  $\Gamma_s$  chart. Simply choose  $\Gamma_L$  in the stable region of the  $\Gamma_L$  chart, set  $\Gamma_s = \Gamma_{IN}^*$  and move on.
- (d) (5 points) Determine  $(VSWR)_{in}$  and  $(VSWR)_{out}$ . You may get a negative value for VSWR, depending on your choice of  $\Gamma_s$  and  $\Gamma_L$ .

**PROBLEM 4 (15 points):** Three cascade amplifiers have noise figures of  $F_1 = 1.1$  dB,  $F_2 = 4.8$  dB, and  $F_3 = 9.3$  dB, with gains  $G_{A1} = 3$  dB,  $G_{A2} = 10$  dB, and  $G_{A3} = 15$  dB. Calculate the overall noise figure in dB.