Name_____

ELC 4384 – RF/Microwave Circuits II

Spring 2019

Midterm Exam – March 7, 2019

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 Tee matching network to transform Z_{LOAD} = 50 Ω to the input impedance Z_{IN} = (25 – j6) Ω with a Q_n of 4. Draw the matching network with the load and input sides clearly indicated. Give the <u>impedance</u> of each component in Ohms.

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

$$S_{11} = 0.05\underline{/24°}$$
$$S_{12} = 0.01\underline{/-38°}$$
$$S_{21} = 6.3\underline{/54°}$$
$$S_{22} = 0.11\underline{/-36°}$$

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, $G_{T, max}$, <u>in dB</u>?

(c) (10 points) What values of Γ_s and Γ_L will provide $G_{T, max}$?

PROBLEM 3 (40 points): A Si bipolar junction transistor (BJT) has the following S-parameters at 4.1 GHz:

$$S_{11} = 0.51\underline{/25°}$$
$$S_{12} = 0.05\underline{/-60°}$$
$$S_{21} = 4.8\underline{/106°}$$
$$S_{22} = 0.82\underline{/-48°}$$

(a) (5 points) Is the device unconditionally stable at 4.1 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 Γ_s and Γ_L Smith charts, appropriately.

(c) (20 points) Design a stable amplifier with $G_T = 17$ dB. Use the approach of designing for $G_A = 17$ dB and then setting $\Gamma_L = \Gamma_{OUT}*$. Your solution must include drawing the $G_A = 17$ dB circle on the Γ_s Smith chart. Clearly give your design values of Γ_s and Γ_L. For sake of time in this exam, you are not required to evaluate that your choice of Γ_L is in the stable region on the Γ_L chart. Simply choose Γ_s in the stable region of the Γ_s chart, set $\Gamma_L = \Gamma_{OUT}*$ 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 Γ_s and Γ_L.

PROBLEM 4 (15 points): Three cascade amplifiers have noise figures of $F_1 = 1.4$ dB, $F_2 = 4.5$ dB, and $F_3 = 7.5$ dB, with gains $G_{A1} = 7$ dB, $G_{A2} = 10$ dB, and $G_{A3} = 20$ dB. Calculate the overall noise figure in dB.