RF Design Midterm Spring 2003

Name: _____

Student Number: _____

Do NOT begin until told to do so
Make sure that you have all pages before starting
Open notes
DO ALL WORK ON THE SPACE GIVEN
Do NOT use the back of the pages, do NOT turn in extra sheets of work/paper
Multiple-choice and true/false answers should be within 5% of correct value
Show all work, even for multiple choice

ACADEMIC INTEGRITY:
Students have the responsibility to know and observe the requirements of The UNCC Code of Student Academic Integrity (1999-2001 Catalog page 375). This code forbids cheating, fabrication or falsification of information, multiple submission of academic work, plagiarism, abuse of academic materials, and complicity in academic dishonesty.

Unless otherwise noted:

$F\{\}$ denotes Fourier transform
$F^{-1}\{\}$ denotes inverse Fourier transform
ω denotes frequency in rad/s
$*$ denotes linear convolution
$x^*(t)$ denotes the conjugate of $x(t)$

Useful constants, etc:

$e \approx 2.72$
$1/e \approx 0.37$
$\sqrt{3} \approx 1.73$
$\sqrt{7} \approx 2.64$
$\ln(2) \approx 0.69$
$\log_{10}(2) \approx 0.30$
$\log_{10}(10) \approx 1.0$
$\log_{10}(e) \approx 0.43$

$\pi \approx 3.14$
$\sqrt{2} \approx 1.41$
$\sqrt{5} \approx 2.22$
$\sqrt{10} \approx 3.16$
$\ln(4) \approx 1.38$ &
$\log_{10}(3) \approx 0.48$ &
$\log_{10}(0.1) \approx -1$
$\cos(\pi / 4) \approx 0.71$

$\cos(A)\cos(B) = 0.5\cos(A - B) + 0.5\cos(A + B)$
$e^{j\theta} = \cos(\theta) + j\sin(\theta)$

5 Points each

1. The wavelength in free space at 150 MHz is

   a) 2 m b) 6 m c) 12 cm d) none above

2. An amplifier with source and load impedances of Z_0 and with $s_{21} = 4 \angle 45^\circ$ has a transducer gain of

   a) 4 dB b) 6 dB c) 12 dB d) none above

3. The impedance of a 50 ohm, 1/8 λ length, transmission line terminated by a short circuit is

   a) $-j\ 25\ \Omega$ b) $j\ 50\ \Omega$ c) $\infty\ \Omega$ d) none above

4. The angle of the reflection coefficient, Γ, of a 25 Ω resistor in a Z_0=50 Ω system is

   a) 0° b) 90° c) 180° d) none above

5 Points each

5. A 16 dB difference in signal level is equivalent to a factor of 40 in power.

   a) True b) False

6. The percentage of incident power delivered to a load with VSWR=2 is

   a) 25% b) 33% c) 89% d) none above

7. The return loss of a 10 ohm resistor in a Z_0=50 ohm system is

   a) 1.7 dB b) 3.5 dB c) 9.5 dB d) none above

8. An impedance of 0.3 + j 0.1 ohms is equivalent to an admittance of

   a) 3 - j10 b) 3 + j1 c) 3 – j1 d) none above

5 Points each

9. The cascade noise figure of a 3 dB attenuator followed by an amplifier with 3 dB noise figure and 40 dB gain is:

   a) 4dB b) 6 dB c) 46 dB d) none above

10. The maximum transducer gain possible for a 2-port in dB is $10\log_{10}(| s_{21} |^2)$

    a) True b) False

11. A transmission line is measured to have a capacitance of 40 pF/m and inductance of 400 nH/m, the impedance of the line is.

    a) 10 Ω b) 50 Ω c) 100 Ω d) none above

12. A transmission line is measured to have a capacitance of 40 pF/m and inductance of 400 nH/m, the velocity of the line is.

    a) 10^8 m/s b) $2.5x10^8$ m/s c) $3x10^8$ m/s d) none above

5 Points each

13. A 30 dBm signal in 50 ohms is

    a) 1 Vrms b) 3.3 Vrms c) 7 Vrms d) none above

14. The impedance of a 1 micron wide microstrip line on an integrated circuit with SiO_2 dielectric of thickness 1 micron and dielectric constant 4 is

    a) 36 Ω b) 50 Ω c) 74 Ω d) none above

15. A 0 dBV signal in 100 ohms is

    a) 10 dBm b) -10 dBm c) -23 dBm d) none above

16. The effective output noise in a 1 MHz bandwidth at the input of an amplifier with 20 dB gain, 14 dB noise figure is

    a) -140 dBm b) -90 dBm c) -80 dBm d) none above

5 Points each

For the following questions, assume Z_0=50 ohms, and use the Smith chart and select the closest answer.

17. For Z= 100 + j100, $|\Gamma|$ =

a) .25 b) .35 c) .45 d) .62

18. For Z= 100 + j100, $\angle\Gamma$ =

a) -116° b) -58° c) 30° d) 116°

19. For Z= 100 + j100, $|s_{11}|$ =

a) .14 b) .38 c) .49 d) .62

20. For Z= 100 + j100, Yn =

a) 0.25 – j0.25 b) 0.35 – j2 c) 0.5 + j2 d) 0.5 - j 0.5

21. For Z= 100 + j100, return loss =

a) 4 dB b) 7.1 dB c) 9 dB d) 14 dB

25 Points

22. Three devices are cascaded in a system. Fill in the cascade analysis table as shown in class.

NOTE: the analysis for IP3 and P1dB are OUTPUT IP3 and OUTPUT P1dB of the stages and cascades!!!

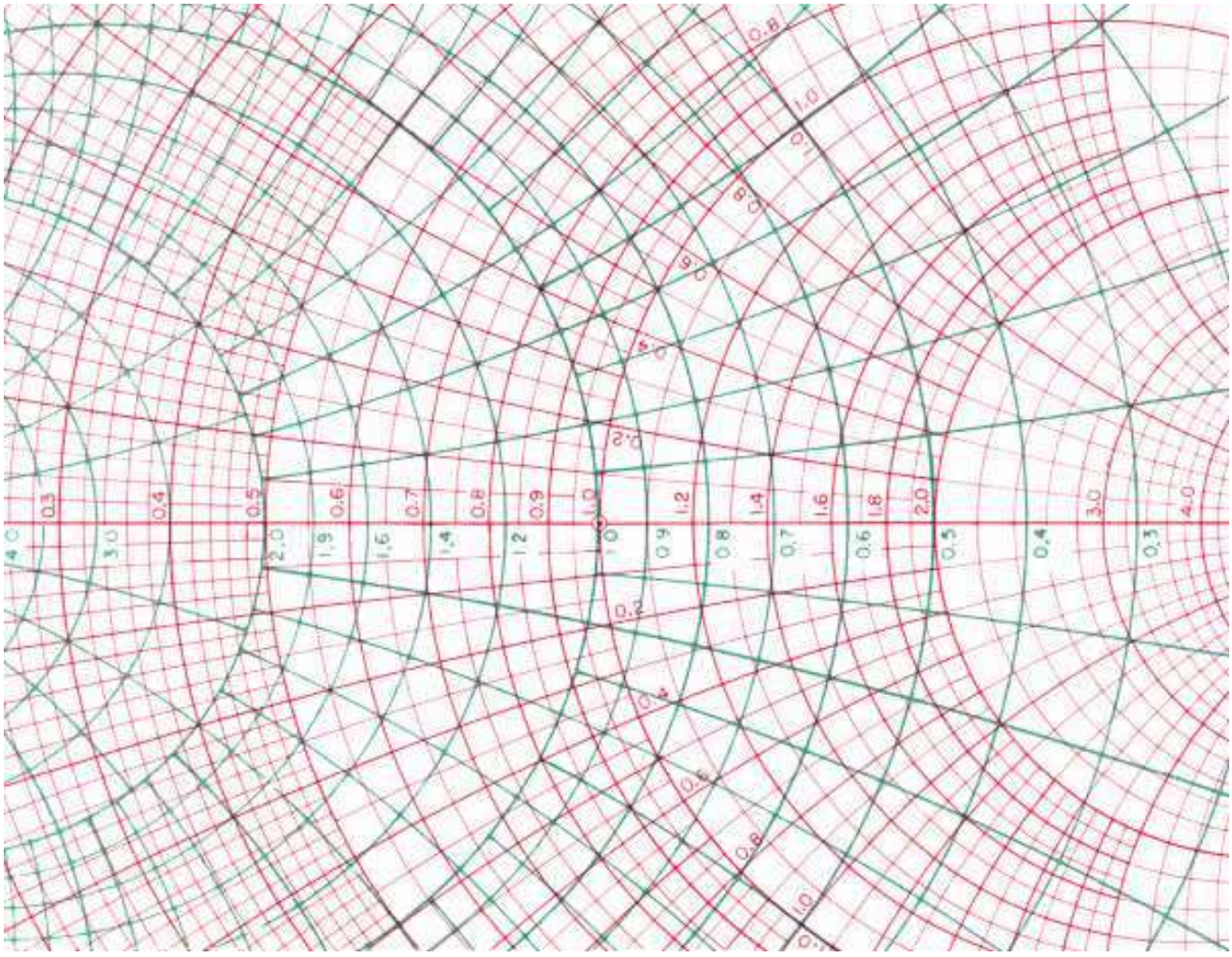
STAGE	Filter		Amp1		Amp2		
gain,dB	-6.0		7.0		20.0		G
nf,dB	6.0		7.0		20.0		NF
OIP3, dBm	50.0		5.0		30.0		OIP3
Output P1dB, dBm	50.0		-10.0		20.0		P1dB
TOTAL							
gain,dB	-6.0						G
nf,dB	6.0						NF
OIP3,dBm	50.0						IP3
P1dB out, dBm	50.0						1dB

10 Points Each

On the Smith chart below, assume Z0=50 ohm.

23. Show the location of Z=90 - j 15 ohms as an “X” on the Smith chart below.

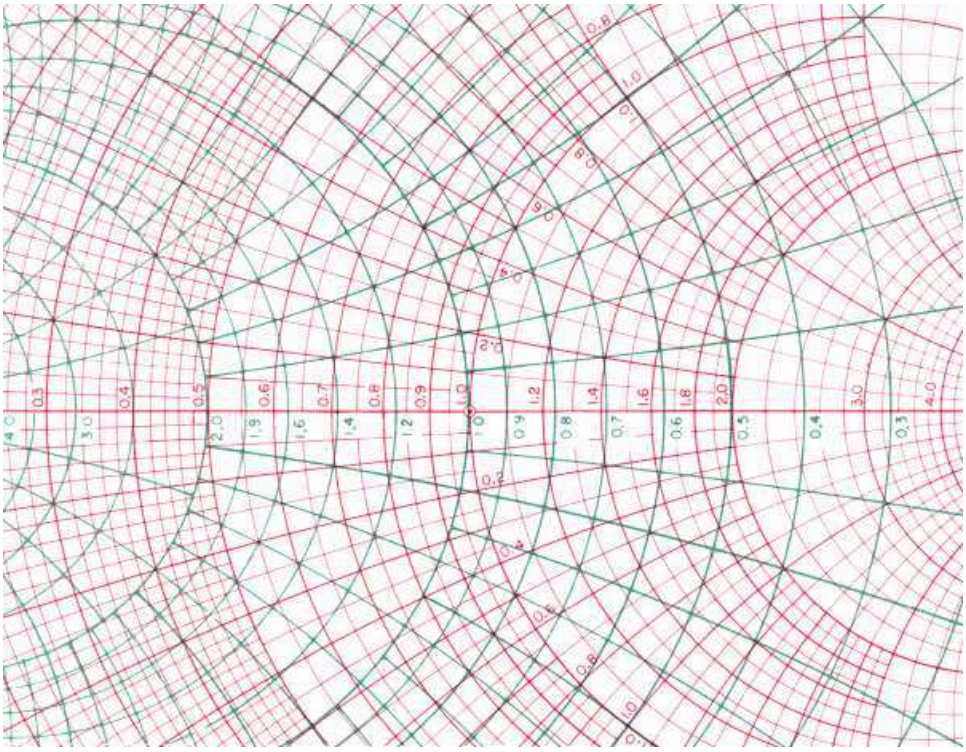
24. Show the location of Y = 0.04 + j 0.004 Siemens as an “O” on the Smith chart below.

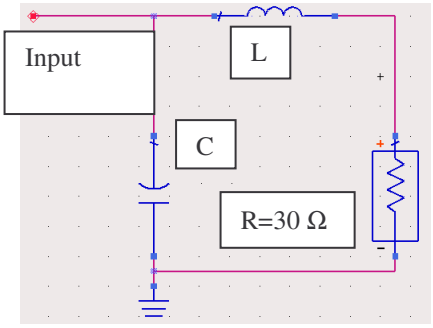


On the Smith chart below, assume Z0=50 ohm.

25. (20 Points)

Draw the paths (for L and C) on the Smith chart corresponding to the matching network of the circuit shown below. The circuit matches the 30 ohm termination R into **50** ohms.





5 Points each

26. In the above circuit, the Normalized impedance of the inductor in the matching circuit Zn =

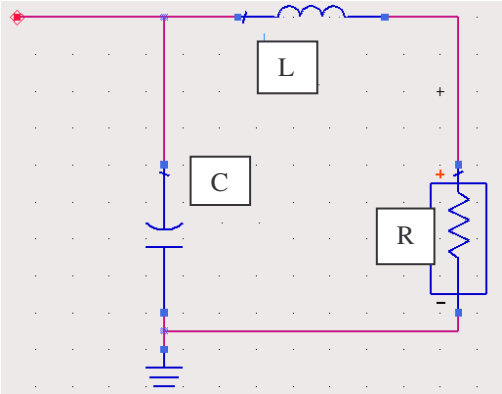
a) j1 b) j 0.2 c) j 0.5 d) 0.5 + j 0.5

27. In the above circuit, the Normalized Admittance of the capacitor in the matching circuit Yn =

a)- j1 b) +j 0.8 c) + j 1 d) + j 0.5

5 Points Each

In the circuit below, the normalized impedances of the inductor L is Zn = j 2, and the normalized impedance of the capacitor C is Zn = –j 1 , where Zo=50 ohms. The frequency is 1000 MHz.

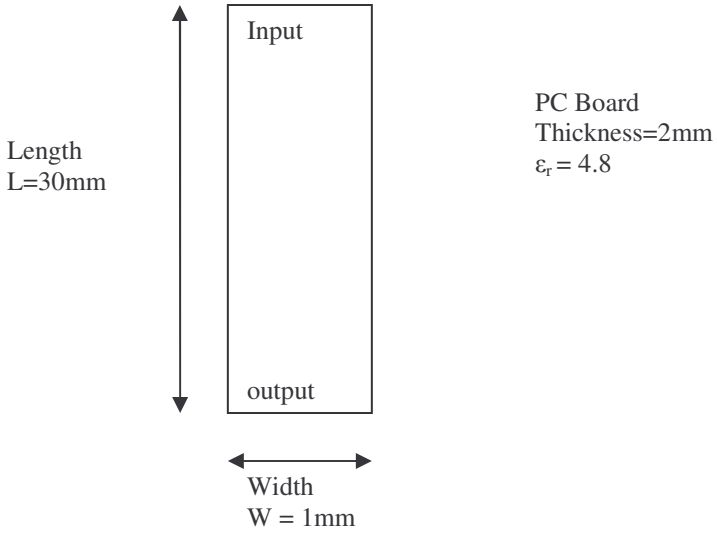


28. In the above circuit, the value the capacitor (within 5%) in the matching circuit is

a) 320 pF b) 1.6 pF c) 3.2 pF d) none above

29. In the above circuit, the value the inductor (within 5%) in the matching circuit is

a) 0.39 nH b) 3.8 nH c) 16 nH d) none above



30. In the above microstrip line, the Z_0 (within 5%) of the transmission line is

a) 47 Ω b) 58 Ω c) 90 Ω d) none above

31. In the above microstrip line, the effective dielectric constant ε_e is

a) 2.3 b) 3.3 c) 4.8 d) none above

32. In the above microstrip line, the velocity is

a) 0.55 c b) 0.69 c c) 1.1 c d) none above

33. The above microstrip line is one wavelength long at

a) 5.5 GHz b) 7.8 GHz c) 11 GHz d) none above

20 points

34. An amplifier has a gain of 10 dB and OIP3 of 20 dBm. If the input of the amplifier is two equal-amplitude sinusoids of 0 dBm at 120 and 130 MHz, plot the output frequency spectrum including third order products,, from 100 to 150 MHz.