RF Design FINAL EXAM Spring 2001

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 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

5 Points Each

1. S-parameters of devices such as amplifiers do not depend on frequency.

   a) True b) False

2. Input return loss of a 2-port terminated in Zo is $-10 \log_{10}(| s_{11} |^2)$.

   a) True b) False

3. The angle of the reflection coefficient, Γ, of a short circuit is

   a) 0° b) 90° c) 120° d) none above

4. The return loss of a 100 ohm resistor in a Z_0=50 ohm system is

   a) 0 dB b) 6 dB c) 9.5 dB d) none above

5 Points each

5. An isolator is equivalent to a circulator with its third port terminated.

   a) True b) False

6. An impedance of 50 + j 50 is equivalent to an admittance of

   a) 50 – j50 b) 0.01 - j 0.01 c) 0.02 + j 0.02 d) none above

7. An amplifier with source and load impedances of Z_0 and with $s_{21} = 10$ has a transducer gain of

   a) 10 dB b) –10 dB c) 20 dB d) none above

8. The impedance of a 50 ohm, $\lambda/8$ length, transmission line terminated by a short circuit is

   a) –j 25 Ω b) j 50 Ω c) ∞ Ω d) none above

5 Points each

9. Q “circles” on a Smith Chart help indicate the bandwidth of a circuit.

   a) True b) False

10. Multiple (>2) reflections occur on a transmission line only if both the source and load impedances do not equal Z_0.

    a) True b) False

11. 90-degree hybrids cannot be used as a power splitter.

    a) True b) False

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

    a) 0.3 dB b) 3 dB c) 6 dB d) none above

5 Points each

13. The impedance of a 1 micron wide microstrip line on a SiO_2 dielectric of thickness 1 micron and dielectric constant 4 is

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

14. A 33 dBm signal in 50 ohms is

    a) 1 Vrms b) 3.3 Vrms c) 10 Vrms d) none above

15. A –20 dBv signal in 50 ohms is

    a) 3 dBm b) -7 dBm c) -13 dBm d) none above

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

    a) -174 dBm b) -100 dBm c) -74 dBm d) none above

5 Points each

17. The percentage of incident power delivered to a load with Γ=0.5 is

a) 25% b) 50% c) 75% d) none above

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

a) 11% b) 22% c) 89% d) none above

19. The percentage of incident power reflected from a load with 10 dB return loss is

a) 10% b) 20% c) 50% d) none above

20. A wavelength at 1500 MHz in 50 ohm coaxial cable with dielectric constant 4 is

a) 0.1 m b) 0.2 m c) 0.3 m 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.

21. For Z= 25 + j25, $|\Gamma|$ =

a) .25 b) .35 c) .45 d) .55

22. For Z= 25 + j25, $\angle\Gamma$ =

a) -116° b) -58° c) 58° d) 116°

23. For Z= 25 + j25, $|s_{11}|$ =

a) .14 b) .38 c) .45 d) .57

24. For Z= 25 + j25, Yn =

a) 1 – j1 b) 0.5 – j2 c) 0.5 + j2 d) 0.5 - j 0.5

25. For Z= 25 + j25, return loss =

a) 3 dB b) 7 dB c) 10 dB d) 14 dB

25 Points

26. 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	-3.0		10.0		20.0		G
nf,dB	3.0		10.0		20.0		NF
OIP3, dBm	50.0		10.0		30.0		OIP3
Output P1dB, dBm	50.0		0.0		20.0		P1dB
TOTAL							
gain,dB	-3.0		7.0				G
nf,dB	3.0						NF
OIP3,dBm	50.0		10				IP3
P1dB out, dBm	50.0		0				1dB

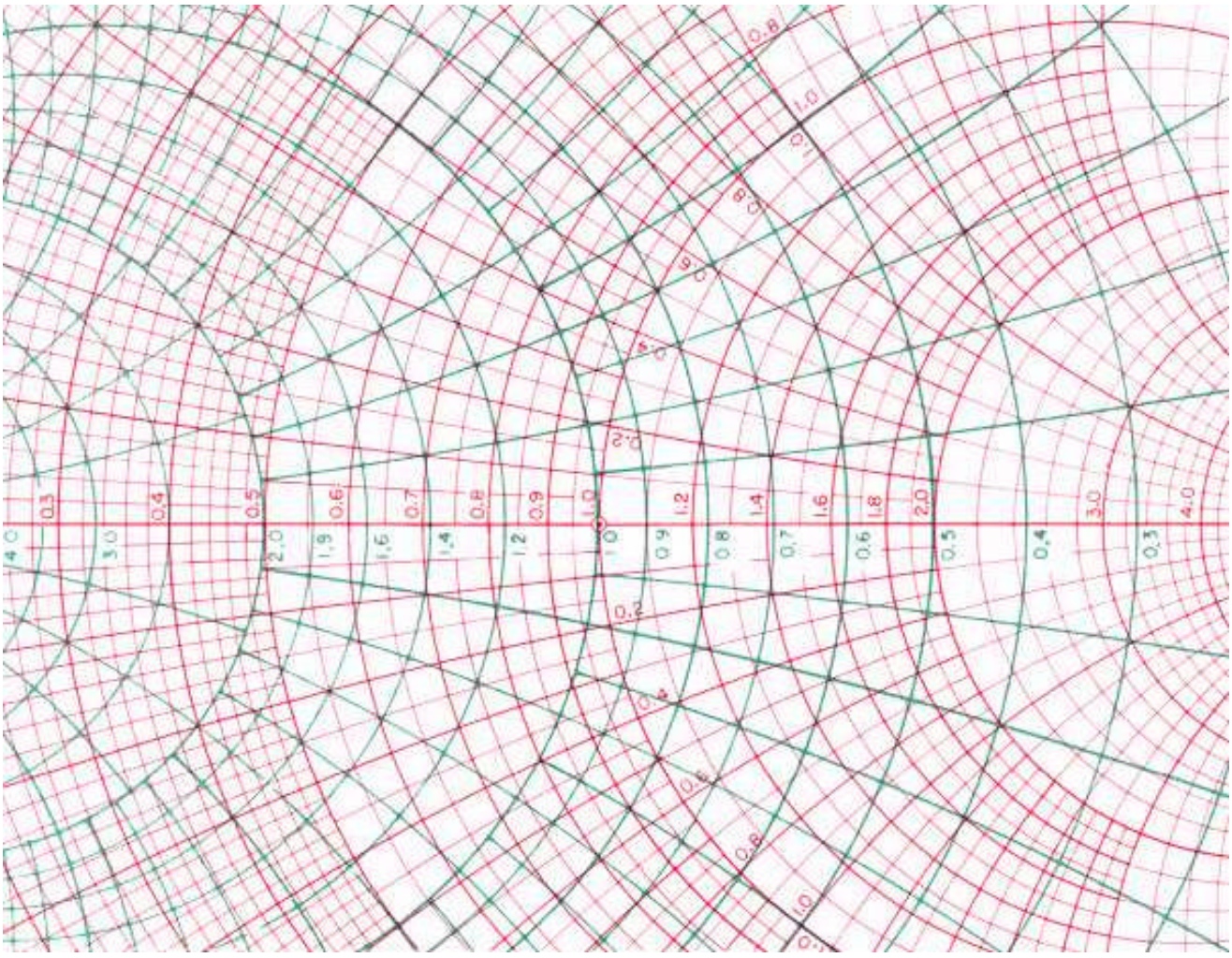
Use this page for any additional work from previous page

10 Points Each

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

27. Show the location of Z=25 + j 10 ohms as an “X” on the Smith chart below.

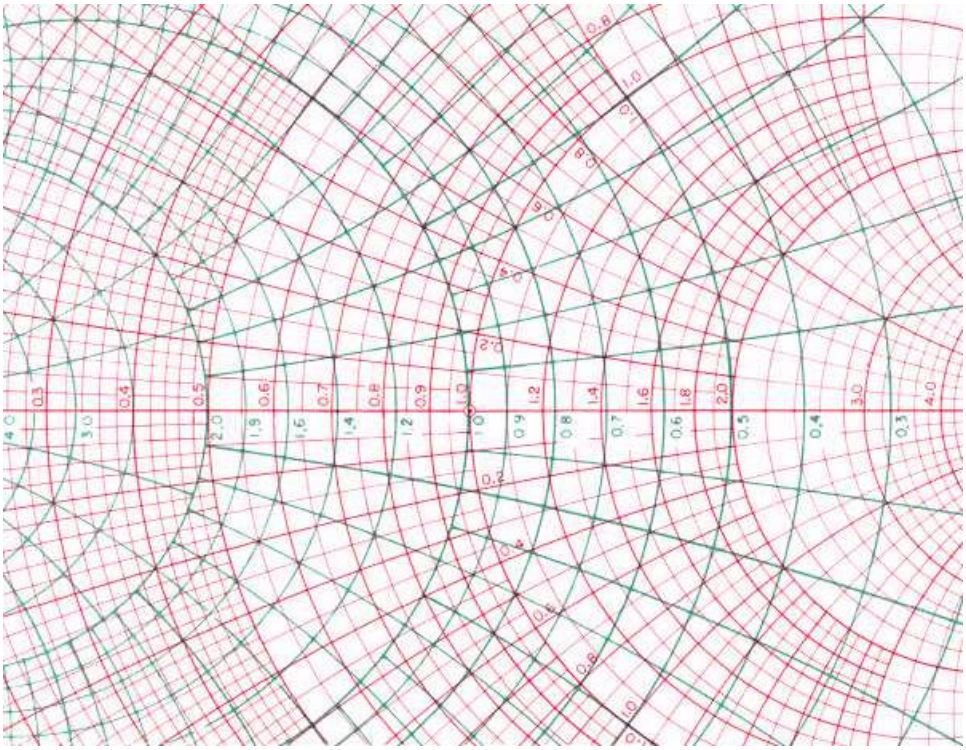
28. Show the location of Z=100 - j 30 ohms as an “O” on the Smith chart below.

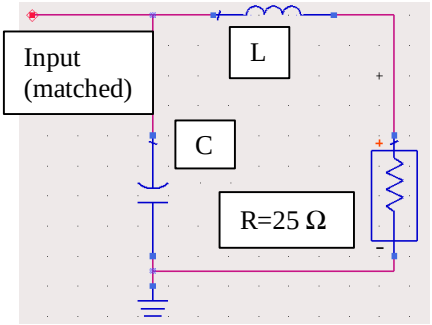


On the Smith chart below, assume Z0=50 ohm.

29. (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 25 ohm termination R into 50 ohms.





5 Points each

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

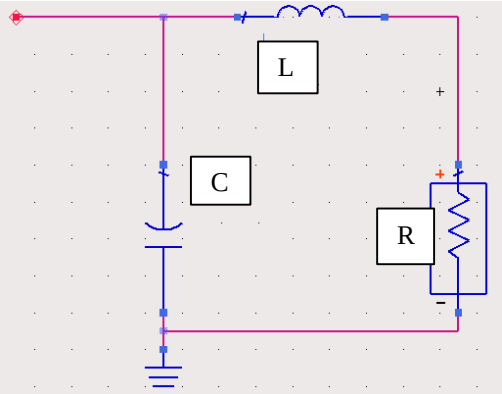
a) 1 – j1 b) –j 0.5 c) j 0.5 d) 0.5 + j 0.5

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

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

5 Points Each

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



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

a) 160 pF b) 16 pF c) 3.2 pF d) none above

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

a) 0.16 nH b) 8 nH c) 18 nH d) none above

5 Points Each

34. The average output frequency (with phase noise/frequency fluctuations averaged out to zero) of a properly operating phase-locked-loop (PLL) frequency synthesizer is (circle the correct answer):

a) approximately $f_{reference} \cdot N_{divider}$, having a fixed frequency error depending on the loop natural frequency (f_n) and damping coefficient (ζ);
b) exactly $f_{reference} \cdot N_{divider}$, having a fixed phase error; or
c) the open-loop VCO output frequency.

35. Increasing PLL natural frequency (f_n), assuming the damping coefficient (ζ) remains fixed at 0.7, results in (circle all that are true):

a) faster lock time when the loop divider ($N_{divider}$) is changed to select a new output frequency;
b) more potential of VCO frequency modulation due to phase detector output ripple;
c) more overshoot in the output frequency when the loop divider ($N_{divider}$) is changed to select a new output frequency; and
d) more cancellation of VCO phase noise/frequency fluctuations through the PLL negative feedback.

5 Points

36. Problem deleted.

(15 points)

37. A PLL frequency synthesizer is needed for the local oscillator of a superheterodyne FM broadcast receiver where the receive channel spacing is 200 kHz (88.1, 88.3, 88.5 – 107.9 MHz channels).

a) The maximum PLL reference frequency for tuning all channels is _____ kHz.

b) For reception at 88.9 MHz using a 10.7-MHz intermediate frequency with high-side injection, the PLL output frequency is _____ MHz.

c) To obtain the needed PLL output frequency of b using the reference frequency of a, the loop frequency divider ($N_{divider}$) must be _____.

20 Points

38. A 900-MHz PLL synthesizer has the following characteristics:

f_{ref} = 5 MHz
K_ϕ = 1.65 V/cycle (phase detector gain)
K_V = 100 MHz/V (VCO gain)
Active lag-lead compensator values (for circuit shown in your PLL notes)
R1 = 9.29 kΩ
R2 = 1.27 kΩ
C = 1,000 pF

a) The PLL loop divider is _____.

b) The PLL gain ($G = K_\phi \bullet K_V / N_{divider}$) is _____ rads/sec (no unit conversions are necessary)

c) The PLL natural frequency (f_n) is _____ Hz.

d) The PLL damping coefficient (ζ) is _____.

e) This PLL synthesizer exhibits severe frequency overshoot and ringing as the loop divider is changed to select a new output frequency. Why?
_____.

f) Without changing the PLL natural frequency (f_n), find new active lag-lead compensator values for a damping coefficient (ζ) of 1.0. Keep C = 1,000 pF.
R1 = _____Ω. R2 = _____Ω.

g) Will the above component value change(s) likely correct the frequency overshoot and ringing problem (yes or no)? _____.

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