Your Name
Passive and Active Filters
Date Completed

PRELAB

MATLAB

1. Create a magnitude and phase Bode plot for the transfer function $H(s) = \dfrac{1000}{s + 1000}$, using 30 points from 5 rad/s to 5 krad/s. Paste your plot below. Remember to label your plot.

2. What happens if you use the **BODE** command without return arguments (i.e.: **bode(den,num))**?

USING LABVIEW TO CREATE BODE PLOTS

3. Below is a sample data file created by the Bode plot VI. Write the MATLAB code to open this file and read in values for the frequency and the magnitude (Hint: Use the **DLMREAD** command). Remember that the frequency needs to be converted from Hertz to radians per second.

   File name: lowpass.txt

   5.000,0.630
   6.777,-0.129
   9.184,-0.004
   12.448,-0.062
   16.871,-0.121
   22.865,-0.188
   30.990,-0.304

RC LOW PASS FILTERS

4. What is the transfer function of the RC low pass filter in Figure 3 of the lab experiment?

5. If the value of the capacitor is $C = 100$ nF, what value of resistor R will result in a cutoff frequency $\omega_c = 1.47$ k rad/s?

RC HIGH PASS FILTERS

6. What is the transfer function of the RC high pass filter in Figure 4 of the lab experiment?

7. If $C = 0.47$ μF, what value of resistor R will result in a cutoff frequency $\omega_c = 645$ rad/s?

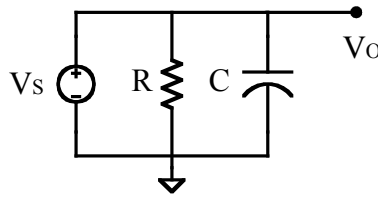8. Is the circuit in Figure A a filter? If so, what type of filter? If not, explain why.

Figure A. An RC Circuit.

RC DIFFERENTIATORS

9. What is the transfer function of the RC differentiator in Figure 5 of the lab experiment?

10. If the value of the resistor $R = 8.2$ kΩ, what value of capacitor C will result in a unity-gain frequency $\omega_o = 1.2$ krad/s?

RC INTEGRATORS

11. What is the transfer function of the RC integrator in Figure 6 of the lab experiment?

12. Choose components for the RC integrator that result in a unity-gain frequency $\omega_o = 1.2$ k rad/s. Choose circuit elements with values that can be realized using your set of resistors and capacitors.

ACTIVE LOW PASS FILTERS

13. Determine the transfer function of the active low pass filter shown in Figure 7 of the lab experiment.

14. Design an active low pass filter with a cutoff frequency $\omega_c = 1.47$ k rad/s and a DC gain of 2. Choose circuit elements with values that can be realized using your set of resistors and capacitors.

ACTIVE HIGH PASS FILTERS

15. Determine the transfer function of the active high pass filter shown in Figure 8 of the lab experiment.

16. Design an active high pass filter with a cutoff frequency $\omega_c = 645$ rad/s and a DC gain of 2. Choose circuit elements with values that can be realized using your set of resistors and capacitors.

ACTIVE BAND PASS FILTERS

17. Determine the transfer function of the active band pass filter in Figure 9 of the lab experiment.

18. Determine a pair of values for R_1 and C_1 that result in a lower cutoff frequency $\omega_{cl} = 645$ rad/s. Choose values that can be realized using your set of resistors and capacitors.

19. Determine a pair of values for R_2 and C_2 that result in an upper cutoff frequency $\omega_{ch} = 1.47$ k rad/s. Choose values that can be realized using your set of resistors and capacitors.

ACTIVE TONE CONTROL

Bass Control

20. If $R_1 = 12$ kΩ and $R_2 = 100$ kΩ, what would be the range of $|A_B|$?

21. Using the values obtained Question 20, what is the maximum cut? The maximum boost?

22. What value of capacitor C_1 would result in a value of $\omega_B = 210$ rad/s?

Treble Control

23. If $R_1 = R_5 = 12$ kΩ, $R_3 = 3.9$ kΩ, and $R_4 = 500$ kΩ, what would be the range of A_T?

24. Using the values obtained from Question 23, what is the maximum cut? The maximum boost?

25. What value of capacitor C_2 would result in a value of $\omega_T = 54.5$ k rad/s?

LAB

RC LOW PASS FILTERS

26. Measure and record the values for the resistor and capacitor in Table A, along with the computed value of ω_c.

	Nominal Value	Measured Value
R		
C		
ω_c		

Table A. Nominal and Measured Values for Low Pass Filter.

27. Use MATLAB to create three magnitude Bode plots for the low pass filter. For the first and second plots, use the transfer function of the circuit with the nominal and measured values from Table A, respectively, and a frequency range of 10π rad/s $\le \omega \le 20{,}000\pi$ rad/s. For the third plot, use the empirical data generated by the Bode plot VI. Create all three Bode plots on the same graph. Make sure to label your plot and include a legend indicating what each curve is. Your plot should look similar to the plot in Figure 13 of the lab exercise. Paste a copy of your plot below.

28. Using the Bode plot of the empirical data, determine the cutoff frequency of the circuit in rad/s.

29. Calculate the percent error in the cutoff frequency between the nominal value and the empirical value.

RC HIGH PASS FILTERS

30. Measure and record the values for the resistor and capacitor in Table B, along with the computed value of ω_c.

	Nominal Value	Measured Value
R		
C		
ω_c		

Table B. Nominal and Measured Values for High Pass Filter.

31. Use MATLAB to create three magnitude Bode plots for the high pass filter. For the first and second plots, use the transfer function of the circuit with the nominal and measured values from Table B, respectively, and a frequency range of 10π rad/s $\leq \omega \leq 20,000\pi$ rad/s. For the third plot, use the empirical data generated by the Bode plot VI. Create all three Bode plots on the same graph. Make sure to label your plot and include a legend indicating what each curve is. Paste a copy of your plot below.

32. Using the Bode plot of the empirical data, determine the cutoff frequency of the circuit in rad/s.

33. Calculate the percent error in the cutoff frequency between the nominal value and the empirical value.

RC DIFFERENTIATORS

34. Measure and record the values for the resistor and capacitor in Table C, along with the computed value of ω_o.

	Nominal Value	Measured Value
R		
C		
ω_o		

Table C. Nominal and Measured Values for Differentiator.

35. Use MATLAB to create three magnitude Bode plots for the differentiator. For the first and second plots, use the transfer function of the circuit with the nominal and measured values from Table C, respectively, and a frequency range of 10π rad/s $\leq \omega \leq 6,000\pi$ rad/s. For the third plot, use the empirical data generated by the Bode plot VI. Create all three Bode plots on the same graph. Make sure to label your plot and include a legend indicating what each curve is. Paste a copy of your plot below.

36. At what frequency does the circuit start to fail (saturate)?

RC INTEGRATORS

37. Measure and record the values for the resistor and capacitor in Table D, along with the computed value of ω_o.

	Nominal Value	Measured Value
R		
C		
ω_o		

Table D. Nominal and Measured Values for Integrator.

38. Use MATLAB to create three magnitude Bode plots for the integrator. For the first and second plots, use the transfer function of the circuit with the nominal and measured values from Table D, respectively, and a frequency range of 200π rad/s $\leq \omega \leq 20{,}000\pi$ rad/s. For the third plot, use the empirical data generated by the Bode plot VI. Create all three Bode plots on the same graph. Make sure to label your plot and include a legend indicating what each curve is. Paste a copy of your plot below.

39. At what frequency values ω does this circuit provide magnification? Attenuation?

40. At what frequency does the circuit start to fail (saturate)?

ACTIVE LOW PASS FILTERS

41. Measure and record the values for the resistors and the capacitor in Table E, along with the computed values for ω_c, and the gain A.

	Nominal Value	Measured Value
R_1		
R_2		
C		
ω_c		
A		

Table E. Nominal and Measured Values for Active Low Pass Filter.

42. Use MATLAB to create three magnitude Bode plots for the high pass filter. For the first and second plots, use the transfer function of the circuit with the nominal and measured values from Table E, respectively, and a frequency range of 10π rad/s $\leq \omega \leq 20{,}000\pi$ rad/s. For the third plot, use the empirical data generated by the Bode plot VI. Create all three Bode plots on the same graph. Make sure to label your plot and include a legend indicating what each curve is. Paste a copy of your plot below.

43. Using the Bode plot of the empirical data, determine the cutoff frequency of the circuit in rad/s.

44. Calculate the percent error in the cutoff frequency between the nominal value and the empirical value.

ACTIVE HIGH PASS FILTERS

45. Measure and record the values for the resistors and capacitor in Table F, along with the computed values for ω_c and the gain, A.

	Nominal Value	Measured Value
R_1		
R_2		
C		
ω_c		
A		

Table F. Nominal and Measured Values for Active High Pass Filter.

46. **Use MATLAB to create three magnitude Bode plots for the high pass filter. For the first and second plots, use the transfer function of the circuit with the nominal and measured values from Table F, respectively, and a frequency range of 10π rad/s $\leq \omega \leq 20,000\pi$ rad/s. For the third plot, use the empirical data generated by the Bode plot VI. Create all three Bode plots on the same graph. Make sure to label your plot and include a legend indicating what each curve is. Paste a copy of your plot below.**

47. **Using the Bode plot of the empirical data, determine the cutoff frequency of the circuit in rad/s.**

48. **Calculate the percent error in the cutoff frequency between the nominal value and the empirical value.**

ACTIVE BAND PASS FILTERS

49. **Measure and record the values for the resistors and capacitors in Table G, along with the computed values for $\omega_o, \omega_{cl}, \omega_{ch}, \beta$, Q, and the gain, A.**

	Nominal Value	Measured Value
R_1		
R_2		
C_1		
C_2		
ω_o		
ω_{cl}		
ω_{ch}		
β		
Q		
A		

Table G. Nominal and Measured Values for Active Band Pass Filter.

50. **Use MATLAB to create three magnitude Bode plots for the high pass filter. For the first and second plots, use the transfer function of the circuit with the nominal and measured values from Table G, respectively, and a frequency range of 10π rad/s $\leq \omega \leq 20,000\pi$ rad/s. For the third plot, use the empirical data generated by the Bode plot VI. Create all three Bode plots on the same graph. Make sure to label your plot and include a legend indicating what each curve is. Paste a copy of your plot below.**

51. **Using the Bode plot of the empirical data, determine the lower cutoff frequency of the circuit in rad/s.**

52. **Calculate the percent error in the lower cutoff frequency between the nominal value and the empirical value.**

53. **Using the Bode plot of the empirical data, determine the upper cutoff frequency of the circuit in rad/s.**

54. **Calculate the percent error in the upper cutoff frequency between the nominal value and the empirical value.**

ACTIVE TONE CONTROL

55. **Use MATLAB to create magnitude Bode plots for the bass and treble controllers using the empirical data generated by the Bode plot VI. You should have a total of 10 curves on your plot. When plotting the data, plot the bass control responses in blue and plot the treble control responses in red. Make sure to label your plot and include a legend indicating which curves are from the bass controller and which are from the treble controller. Your plot should look similar to the plot in Figure 14 of the lab exercise. Paste a copy of your plot below.**

56. **Adjust both potentiometers so you can see an obvious difference between V_S and V_O on the oscilloscope. Capture the oscilloscope screen and paste it below.**

57. **Leaving the circuit connected, disable the power to the op amp. You should barely be able to hear the radio signal. Does adjusting the potentiometers affect the signal you hear?**