EET 1150

1. LAB NUMBER: 8

2. TITLE: Filter Circuits

3. OBJECTIVES:

After completing this lab, the student will be able to:

1) determine experimentally the response of a Low Pass Filter,
2) determine experimentally the response of a High Pass Filter,
3) compare computer simulations with real responses.

4. EQUIPMENT:

METEX MS-9150 Generator
Oscilloscope
Experimenter board
Multisim software

5. COMPONENTS:

1 - 510 Ω ½ watt 5% Resistor
1 – 33 nF Capacitor
1 - 15 mH Inductor

6. TEXT REFERENCE:

Circuit Analysis: Theory and Practice (5^{th} Edition):
A.H. Robbins and W.C. Miller

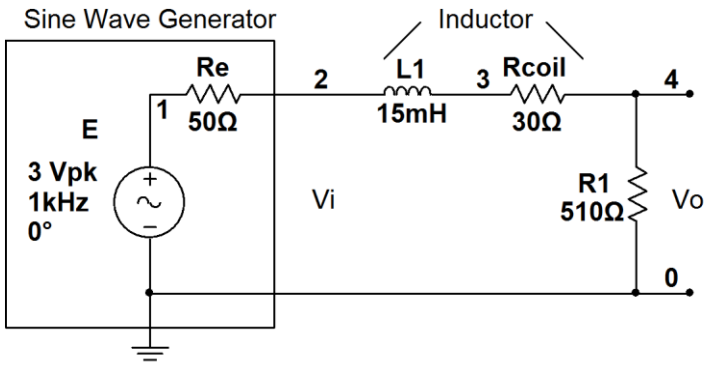
Chapter 22: Filters and the Bode Plot

7. PRE-LAB ASSIGNMENT:

A – Low Pass Filter:

Study the circuit of Fig.1 and do the following calculations:

Figure 1:



~~a) Write the Transfer Function of this Low Pass Filter in terms of the component labels (L1, R1, Rcoil). Record your result in Table 1.~~

Skip transfer function

~~Table 1:~~

~~$TF_L = \frac{V_O}{V_I}$~~	

b) Determine the cutoff frequency and record in Table 2.

Table 2:

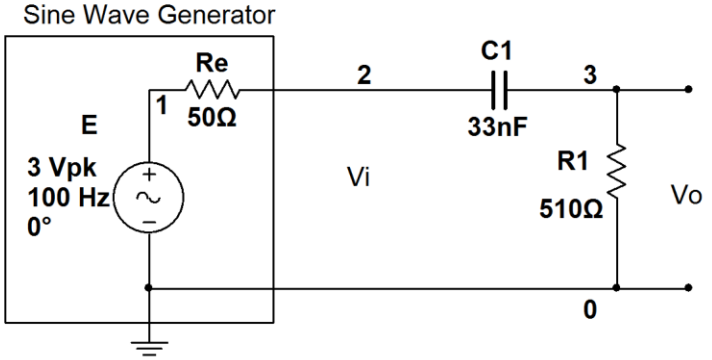
ω_{CL} (rad/s)	
f_{CL} (Hz)	

c) Sketch the Bode Plots of the gain (Av = magnitude of Vo/Vi) and phase over the frequency range from 100 Hz to 50 kHz. (Use Appendix B).

B – High Pass Filter:

Study the circuit of Fig.2 and do the following calculations:

Figure 2:



d) Write the Transfer Function of this High Pass Filter in terms of the component labels (C1, R1). Record your result in Table 3.

Skip transfer function

Table 3:

$TF_H = \frac{V_O}{V_I}$	

e) Determine the cutoff frequency and record in Table 4.

Table 4:

ω_{CH} (rad/s)	
f_{CH} (Hz)	

f) Sketch the Bode Plots of the gain (Av = magnitude of Vo/Vi) and phase over the frequency range from 1 kHz to 100 kHz. (Use Appendix B).

8. MEASUREMENTS:

A – Low Pass Filter:

a) Build the circuit of Fig.1. Connect CH1 (AC) of the oscilloscope to point "2" to measure Vi and CH2 (AC) to point "4" to measure Vo. Trigger is set to CH1. Set the output of the Sine Wave Generator (METEX) to 3 V peak at the starting frequency of 100Hz. With the aid of the sketches in Pre-Lab 7 (c) fill Table 5 with the frequency points you need to create experimental plots of the gain (Av = Vo/Vi) and phase responses. Note the sign of the phase shift.

Table 5:

Frequency (kHz)	Vi (V)	Vo (V)	Av (dB)	Phase (deg)
1- 0.1				
2- 0.5				
3- 1				
4- 2				
5-				
6-(f_{CL})				- 45
7-				
8- 10				
9- 20				
10- 50				

b) Since we are interested in the ratio of Vo/Vi to calculate Av (dB), the output of the Generator at CH1 needs not be kept at the constant amplitude of 3V peak. However, in order to determine the break frequency f_{CL} accurately we need to find the frequency at which Vo = 0.707 Vi (-3dB point), so a known value of 3 V will make things easier. In addition to that, we need to check the phase shift of Vo (CH2) with respect to Vi (CH1) to see if the shift is equal to -45°.

c) From the results of Table 5, plot graphs of Av (dB) and Phase shift as functions of frequency using semi-log scales (copy in Appendix B of this Manual).

B – High Pass Filter:

d) Build the circuit of Fig.2. Connect CH1 (AC) of the oscilloscope to point "2" to measure Vi and CH2 (AC) to point "3" to measure Vo. Trigger is set to CH1. Set the output of the Sine Wave Generator (METEX) to 3 V peak at the starting frequency of 1kHz. With the aid of the sketches in Pre-Lab 7 (f) fill Table 6 with the frequency points you need to create experimental plots of the gain (Av = Vo/Vi) and phase responses. Note the sign of the phase shift.

Table 6:

Frequency (kHz)	Vi (V)	Vo (V)	Av (dB)	Phase (deg)
1- 1				
2- 2				
3- 4				
4- 7				
5-				
6-(f_{CH})				+ 45
7-				
8- 20				
9- 40				
10- 100				

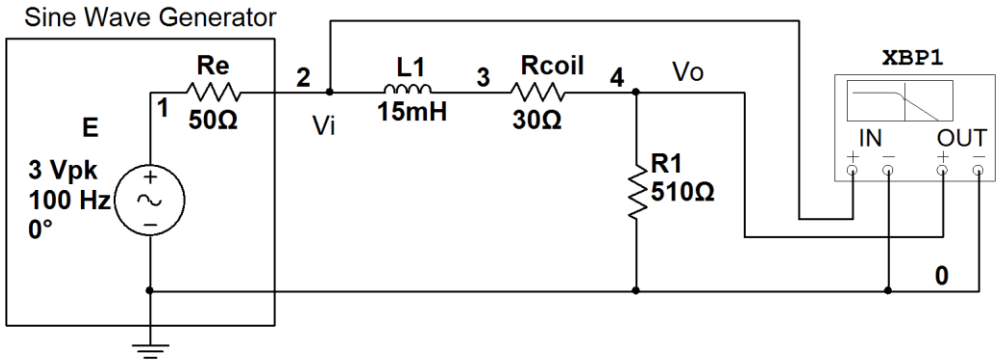
e) f_{CH} is found when Vo = 0.707 Vi (-3db point) and the phase shift of CH2 relative to CH1 is +45°.

f) From the results of Table 6, plot graphs of Av (dB) and Phase shift as functions of frequency using semi-log scales (copy in Appendix B of this Manual).

C – Multisim Simulations:

g) Create Multisim circuit for the Low Pass filter as in Fig.3.

Figure 3:



h) Use a Bode Plotter (XBP1) with Input connected to point "2" and output to point "4". Double click on the icon for the setup table. Set the Bode Plotter with the following parameters:

Magnitude

	Horizontal (Log)		*Vertical (Log)*
Final	100 kHz	Final	0 dB
Initial	100 Hz	Initial	-20 dB

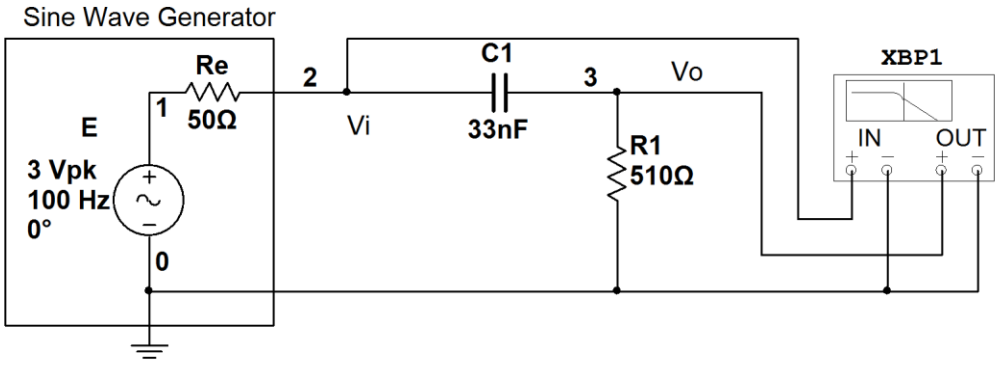
Phase

	Horizontal (Log)		*Vertical (Linear)*
Final	100 kHz	Final	0 deg
Initial	100 Hz	Initial	-90 deg

i) Run the simulation and print the results. Compare these to 8 (c).

j) Create Multisim circuit for the High Pass filter as in Fig.4.

Figure 4:



k) Use a Bode Plotter (XBP1) with Input connected to point "2" and output to point "3". Double click on the icon for the setup table. Set the Bode Plotter with the following parameters:

Magnitude

	Horizontal (Log)		*Vertical (Log)*
Final	100 kHz	Final	0 dB
Initial	1 kHz	Initial	-20 dB

Phase

	Horizontal (Log)		*Vertical (Linear)*
Final	100 kHz	Final	90 deg
Initial	1 kHz	Initial	0 deg

l) Run the simulation and print the results. Compare these to 8 (f).

9. LAB REPORT REQUIREMENT:

Your team's Lab Report should contain the followings:

A Cover Page with Lab Number, Lab Title, Team members' Names and Date.
An Introductory Page with list of Equipment and Components used.

Result Pages with:

A – Low Pass Filter:

Procedure:

(Summarize the main activities that your team did (past tense) in this section).

Results:

Show a copy of Table 5.
Attach the Bode plots of 8 (c).

Discussions:

1) Compare the experimental results, the calculated results and the Multisim ones.
2) Measure the actual coil resistance and discuss factors that cause the differences.
3) Do the experimental plots show Low Pass characteristics? Explain.

B – High Pass Filter:

Procedure:

(Summarize the main activities that your team did (past tense) in this section).

Results:

Show a copy of Table 6.
Attach the Bode plots of 8 (f).

Discussions:

1) Compare the experimental results, the calculated results and the Multisim ones.
2) Discuss factors that cause the differences.
3) Do the experimental plots show High Pass characteristics? Explain.

C- Conclusions:

1) Can the theory of Low Pass Filter predict the behavior of real circuit? Explain your answer.

2) Can the theory of High Pass Filter predict the behavior of real circuit? Explain your answer.

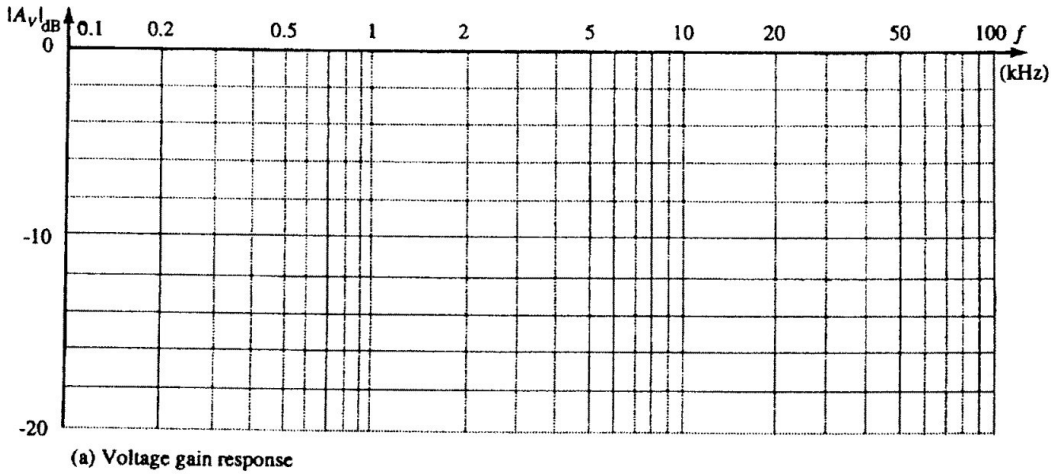
3) Are all the Lab objectives met? Explain if some are not.

Appendix:

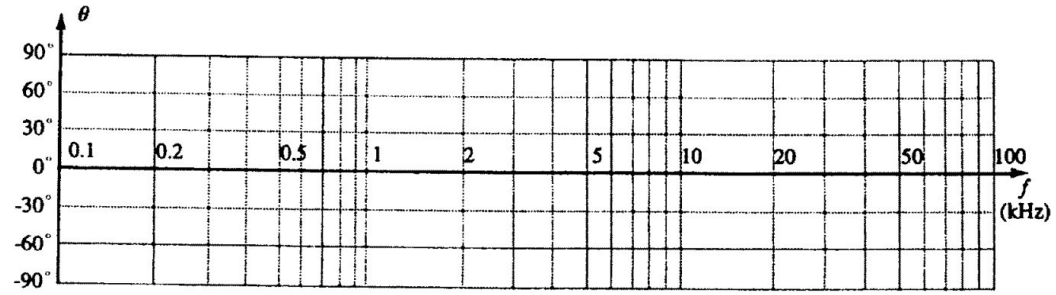
Attach all Multisim simulations and Pre-Lab calculations.

APPENDIX B: Semi-log scales for Bode plot

(Copy from Lab Manual to Accompany Circuit Analysis: Theory and Practice 4th Edition, Allan H. Robbins and Wilhelm C. Miller page 181)



(a) Voltage gain response



(b) Phase shift response