EET 1150

1. LAB NUMBER: **7**

2. TITLE: **Resonance Circuits**

3. OBJECTIVES:

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

1. obtain experimentally the response of a series resonant circuit,
2. obtain experimentally the response of a parallel resonant circuit,
3. verify the theory of resonant circuits.

4. EQUIPMENT:

METEX MS-9150 Generator
Oscilloscope
Experimenter board

5. COMPONENTS:

1 - 33 Ω ½ watt 5% Resistor
1 - 1 kΩ ½ watt 5% Resistor
1 - 33 nF Capacitor
1 - 0.220 μF Capacitor
1 - 15 mH Inductor

6. TEXT REFERENCE:

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

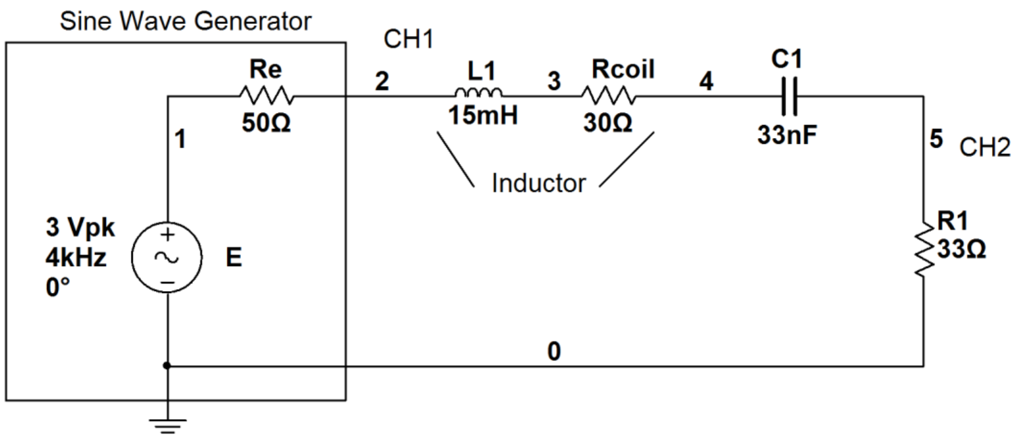
Chapter 21: Resonance

7. PRE-LAB ASSIGNMENT:

A – Series Resonant Circuit:

Study Figure 1 and do the following calculations:

Figure 1:



a) The coil has an estimated resistance Rcoil. Calculate the resonant frequency in rad/s and Hz. Record your results in Table 1.

Table 1:

$\omega_s = \dfrac{1}{\sqrt{L_1 C_1}}$ (rad/s)	
$f_s = \dfrac{\omega_s}{2\pi}$ (Hz)	

b) Calculate the Quality factor (Q_s), Bandwidth (BW_s), and half-power frequencies (f_1, f_2). Record your results in Table 2:

Table 2:

$Q_s = \dfrac{\omega_s L_1}{R_1 + R_{coil}}$	
$BW_s = \dfrac{f_s}{Q_s}$ (Hz)	
$f_1 = f_s - \dfrac{BW_s}{2}$ (Hz)	
$f_2 = f_s + \dfrac{BW_s}{2}$ (Hz)	

c) Calculate the voltage drop across R1 at resonance, this is a maximum value. (Assume 3V peak at CH1) Record your result in Table 3.

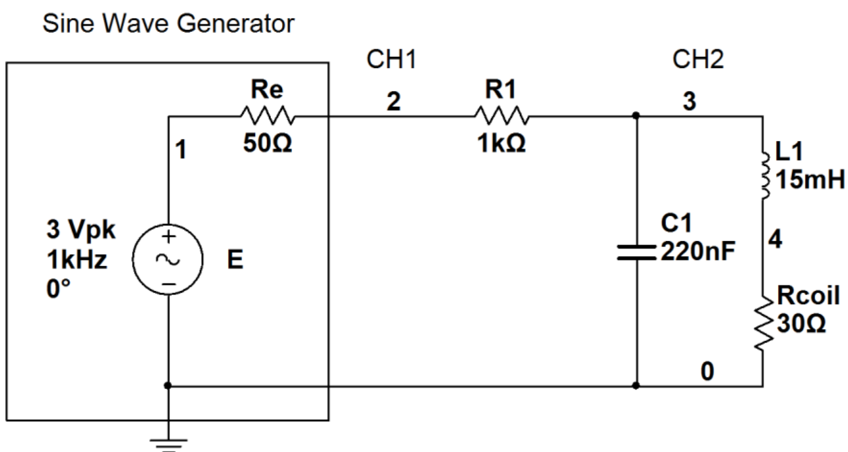
Table 3:

V_{R1}(max) (Vp)	

B – Parallel Resonant Circuit:

Study Fig.2 and do the following calculations:

Figure 2:



d) R1 is used in series with the source E to simulate a Current Source condition. Calculate the resonant frequency (in both rad/s and Hz) and record your results in Table 4. (We can use these formulas because $(R_{coil})^2 << L_1 / C_1$).

Table 4:

$\omega_p = \dfrac{1}{\sqrt{L_1 C_1}}$ (rad/s)	
$f_p = \dfrac{\omega_p}{2\pi}$ (Hz)	

e) Determine the following quantities for the circuit. Review Section 21.6 for their meanings. Record your results in Table 5.

Table 5:

$Q_{coil} = \frac{\omega_p L_1}{R_{coil}}$	
$R_p = (Q_{coil}^2 + 1)R_{coil}$ (Ω)	
$R_{eq} = R1 // R_p$ (Ω)	
$Q_p = \frac{R_{eq}}{X_{C1}}$	
$BW_p = \frac{f_p}{Q_p}$ (Hz)	
$f_1 = f_p - \frac{BW_p}{2}$ (Hz)	
$f_2 = f_p + \frac{BW_p}{2}$ (Hz)	

8. MEASUREMENTS:

A – Series Resonant Circuit:

a) Build the circuit of Fig.1 and connect CH1 (AC) of the oscilloscope to point “2” to measure the output from the Sine Wave Generator and CH2 (AC) to point “5” to measure the voltage drop across R3 (which reflects the behavior of the current through the circuit). Set the output of the Generator to 3V peak at 4 kHz. CH1 is the trigger source.

b) Change the frequency through a series of values as in Table 6. *For each frequency make sure that CH1 still shows 3V peak*, adjust the output of the generator if necessary. This is because the total impedance of the circuit changes and this affects the source current and thus the drop across the source resistance Re. By keeping the output constant, we try to keep the Generator like an ideal voltage source.

Record the value of VR3 (peak value is acceptable) at each frequency as well as noting the direction of its phase shift (leading/lagging). Your actual frequency may be slightly different from those of the table. Record your actual values. The resonance frequency (fs) is found when the phase shift is zero.

Table 6:

Frequency (kHz)	VR3 (V)	Phase (lead/lag)
4.0		
5.0		
6.0		
6.5		
7.0		
(fs)		0°
7.5		
8.0		
8.5		
9.0		
10.0		

c) Note the value of VR3 at fs then calculate the voltage of the half-power points (f1, f2) which is (VR3 max x 0.707). Adjust your frequency up and down around the value of fs to find f1 and f2, record your results in Table 7.

Table 7:

Half-Power Voltage (V)	f1 (khz)	f2 (kHz)

d) Use all data in Tables 6 and 7 to plot a smooth curve showing VR3 as a function of frequency. Note specially the points f1, fs and f2.

e) From the above data calculate Q_s and BW_s.

f) Compare all experimental results with those of Tables 1, 2 and 3. Measure the coil resistance and use it in your discussion.

B – Parallel Resonant Circuit:

g) Build the circuit of Fig.2.and connect CH1 (AC) of the oscilloscope to point "2" to measure the output from the Sine Wave Generator and CH2 (AC) to point "3" to measure the voltage drop across the resonant circuit. Set the output of the Generator to 3V peak at 1 kHz. CH1 is the trigger source.

h) Change the frequency through a series of values as in Table 8. *For each frequency make sure that CH1 still shows 3V peak*, adjust the output of the generator if necessary.

Record the value of VC1 (peak value is acceptable) at each frequency as well as noting the direction of its phase shift (leading/lagging). Your actual frequency may be slightly different from those of the table. Record your actual values. The resonance frequency (fp) is found when the phase shift is zero.

Table 8:

Frequency (kHz)	VC1 (V)	Phase (lead/lag)
1.0		
1.5		
2.0		
f1 (half-power)		
2.5		
fp		0°
3.0		
f2 (half-power)		
4.0		
4.5		
5.0		

i) Note the value of VC1 at fp, then calculate the magnitude at the half-power frequencies (x 0.707) and determine these points.

j) Use data in Table 8 to plot a smooth curve showing VC1 as a function of frequency. Mark the points f1, fp, f2 on the curve.

k) From these data calculate BW_p and Q_p.

l) Compare the experimental results with those in Tables 4 and 5.

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 – Series Resonant Circuit:

Procedure:

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

Results:

Show a copy of Tables 6 and 7.
Show the series resonant curve.

Discussions:

1) Answer 8 (f)
2) What are the factors that cause the differences between calculated and measured results?
3) Explain the change in the sign of the phase shift of VR3.
4) Does the curve show a resonant behavior?

B – Parallel Resonant Circuit:

Procedure:

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

Results:

Show a copy of Table 8.
Show the parallel resonant curve.

Discussions:

1) Answer 8 (l).
2) What are the factors that cause the differences between calculated and measured results?
3) Explain the change in the sign of the phase shift of VC1?
4) Does the curve show a resonant behavior?

C – Conclusion:

1) Is the theory of series resonance reliable? Explain your answer.

2) Is the theory of parallel resonance reliable? Explain your answer.

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

Appendix:

Attach all Pre-Lab calculations.