EET 1150

1. **LAB NUMBER:** **3**

2. **TITLE:** **Series AC Circuit Analysis**

3. **OBJECTIVES:**

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

a) measure the amplitude and phase of the voltage drop across a component,
b) verify Kirchhoff's Voltage Law,
c) verify Voltage Divider Rule.

4. **EQUIPMENT:**

METEX MS-9150 Generator
Oscilloscope
Experimenter board
Multisim software

5. **COMPONENTS:**

1 - 620 Ω ½ watt 5% Resistor
1 - 33 nF Capacitor
1 - 15 mH Inductor

6. **TEXT REFERENCE:**

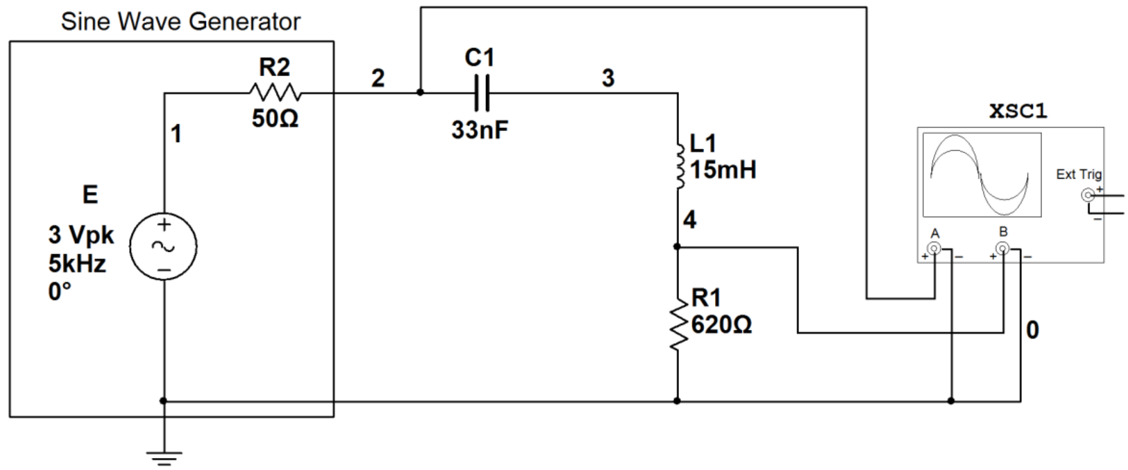
Circuit Analysis: Theory and Practice (5th Edition):
A.H. Robbins and W.C. Miller

Section 18.2 AC Series Circuits
Section 18.3: Kirchhoff's Voltage Law and the Voltage Divider Rule

7. PRE-LAB ASSIGMENT:

Study Fig.1 and do all the following calculations:

Figure 1:



a) Use the following Reactance formulas to calculate the reactance for C1 (X_{C1}), for L1 (X_{L1}) and the total Impedance (Z_T):

$$X_{C1} = \frac{1}{2\pi f C_1} \ (\Omega) \qquad X_{L1} = 2\pi f L_1 \ (\Omega) \qquad Z_T = R_1 + jX_{L1} - jX_{C1}$$

Record your results in Table 1:

Table 1:

X_{C1}	X_{L1}	Z_T
Ω < °	Ω< °	Ω< °

b) Use the following Voltage Divider Rule formula to determine the voltage drop across each component (magnitude and phase):

$$V_x = \frac{Z_x}{Z_T} E \ (\text{V}) \qquad \text{where} \quad Z_x = R_1, X_{C1}, X_{L1}$$

E = 2.12V <0° (RMS)

Record your result in Table 2 (all Voltage Amplitudes are in RMS):

Table 2:

V_{R1}	V_{C1}	V_{L1}
V< °	V< °	V< °

c) From the above formulas, can you conclude that in a series circuit the voltage drop V_x is independent of the location of the component?

8. MEASUREMENTS:

a) Build the circuit of Fig. 1. Connect the probe of CH1 at point “2” to measure the output of the Sine Wave Generator (METEX). This is the reference probe; the signal at this point is assumed to have zero phase shift. All other voltages have their phases measured relative to the voltage at CH1. CH2 probe can be moved between point “3” and “4”.

b) Set the Vertical mode to 2 channels (Alt.). Set both Vertical gain to 1V/div and Horizontal rate to 20 μsec/div. Set trigger source to CH1 with positive slope and auto mode. Center both traces to the center of the screen. Increase output from the Sine Wave Generator until **CH1** amplitude is 3V peak. Make necessary adjustment so that one full cycle of CH1 is on the screen.

Technical Note:

In this Lab you learn two techniques of measuring the amplitude and phase of the voltage drop across each component. The amplitude is the peak value, so it must be converted to RMS for it to be compatible with the calculated one. The phase is always measured relative to that at the output of the signal generator which is assumed to be zero. There are two methods for measuring phase:
- *Differential Mode method*
- *Grounded component method*

Each method will be described below:

A – Differential Mode Method:

c) For this method to work, two conditions must be met: Both channel Vertical gains must be equal (1V/div) and signal on CH1 (reference) location must be well noted, especially the zero-crossing points (0° and 180°), this channel must be selected for triggering.

d) Apply this method to measuring the voltage drop across capacitor C1: Move CH2 to point “3” on the other side of C1. Set CH2 to “Invert” and Vertical mode to “Add”. This forces the oscilloscope to display CH1-CH2 which is the voltage across C1. Since the signal is still triggered by CH1, it is shifted due to the angle of C1 (relative to point “2”), this shift can be measured by comparing its zero-crossing point to the zero-crossing point of CH1 (noted before as this signal is not shown in Differential mode). Measure the shift and convert to degrees, noting if it is leading (+) or lagging (-). Record your result in Table 3:

Table 3:

V_{C1}
V< °

e) If your oscilloscope does not have capability for this mode, skip it.

B – Grounded Component Method:

f) In this method, the component to be measured must have one end connected to Ground (like R1 in Fig. 1), CH2 is connected to the other end. Two traces are shown on the screen (CH1 and CH2) which show clearly the amplitudes (V_{R1}) and phase shift (of CH2 relative to CH1).

g) Take turn moving the component to R1 position, then measure its amplitude and phase (with respect to signal at CH1). Make sure that the circuit must always have all three components connected! Record your results in Table 4 (in RMS):

Table 4:

V_{R1}	V_{C1}	V_{L1}
V< °	V< °	V< °

h) Compare Table 2 to Table 4 (and to Table 3 if available).

C – Multisim Simulations:

i) Create Multisim circuit as in Fig. 1. Double click on the oscilloscope and set the parameters similar to those on your real oscilloscope.

j) Simulate voltages of CH1 and CH2 (for R1), measure amplitude and shift. Print your oscilloscope display.

k) Exchange locations of L1 and R1, repeat step j.

l) Exchange locations of C1 and L1, repeat step j.

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 – Voltage Drop Measurements:

Procedure:

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

Results:

Show a copy of Table 4.

Discussions:

1) Answer 8(h) together with Multisim results.
2) Discuss any factors that may create the differences between answers.

B – Verify Kirchhoff's Voltage Law:

Results:

Calculate the sum of all voltage drops (Table 4) in the circuit (magnitudes and phases) and compare it to E.

Discussions

1) Discuss any differences.
2) What conclusion can you make?

C – Verify Voltage Divider Rule:

Discussions:

1) Answer 8 (h).
2) Do the differences affect the accuracy of the Voltage Divider Rule?

D – Conclusions:

1) What can you conclude about the validity of Kirchhoff's Voltage Law? Explain your answer.
2) What can you conclude about the accuracy of the Voltage Divider Rule? Explain your answer.
3) Are all the Lab objectives met? Explain if some are not.

Appendix:

Attach all Pre-Lab calculations and Multisim simulations.