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LABORATORY MANUAL

Electrical Circuit 2

ENT 132

Prepared by:

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Laboratory Report

Experiment 1

Introduction to Oscilloscope

Student Name:

Partner Name:

EXP. (1)

INTRODUCTION TO THE OSCILLOSCOPE

Objective:

To familiar with the operation of an oscilloscope and its use measuring, and displaying AC signals.

Discussion:

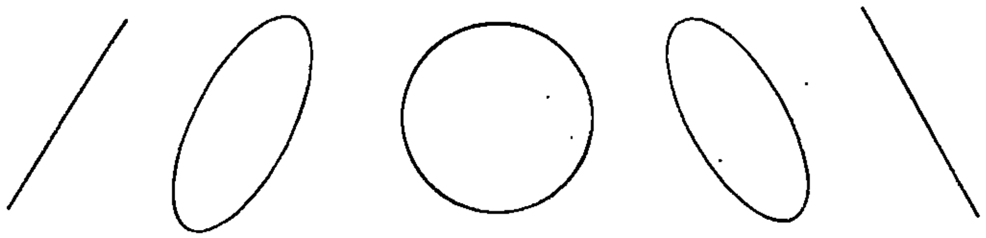
The cathode-ray oscilloscope generally referred, as "**SCOPE**" is the most versatile electrical measuring instrument available. It can measure i.e. **AC, DC, TIME, PHASE, FREQUENCY**, and a wide range of waveform elevations.

In digital Oscilloscopes, the XY display mode converts the oscilloscope from volts versus time display to a volt versus volt display. We can use various transducers so the display could show volts versus current, or volts versus frequency.

In this experiment we will use the XY display mode by measuring the phase shift between two signals of the same frequency with Lissajous method. Figure 1.1 shows several shapes witch indicates the difference in phase, to measure the phase difference use the following equation

$$\sin\theta = \frac{A}{B} or \frac{C}{D}$$

Where A,B,C, and D are measured as shown in Figure 1.2.



0° **45° or 316°** **90°** **135° or 225°** **180°**

Fig 1.1

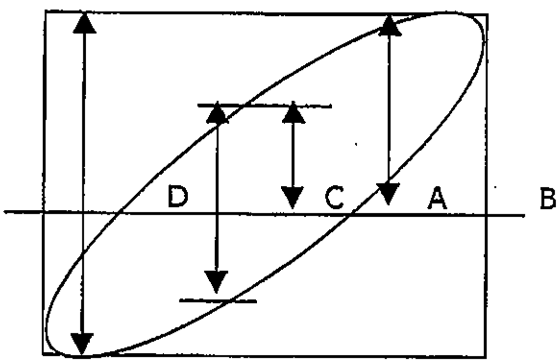


Fig 1.2

Equipment's:

Oscilloscope.
Function Generator.

Procedure:

1- Connect the generator's output to one of the inputs of your scope.

2- Press Auto-Scale key on your scope.

3- Familiarize your self with the knobs of the function generator, try to display all types of waveforms, change the level of the amplitude, and vary the frequency.

4- Set the generator to 1KHz sinusoidal waveform (select a reasonable amplitude).

5- Press Auto-scale key the scope will display a waveform similar to the one shown in figure 1.3.

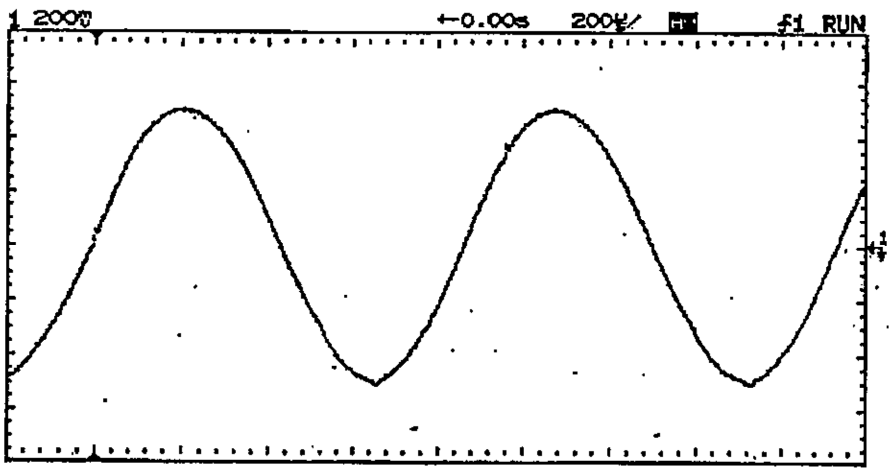
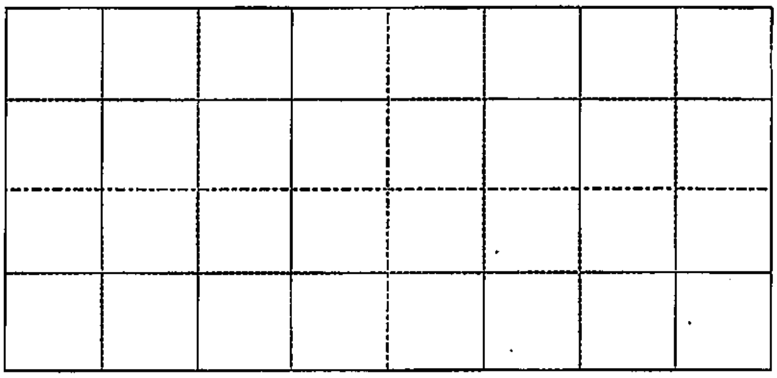


Figure 1.3

6- Familiarize your self with the data displayed on the screen of the scope, change the position of **Voltage/Division** knob see the changes, and do the same with **Time/Division** knob.

7- Set the generator to 8 K Hz square-wave with any amplitude.

8- Draw the waveform and measure the amplitude, and the frequency as shown in step (9).



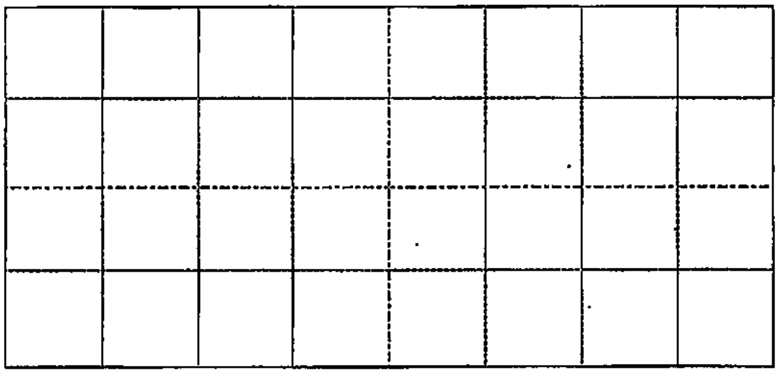
V/DIV ----------------- T/DIV --------------------

9- P-P voltage = number of squares (vertically) × voltage/division

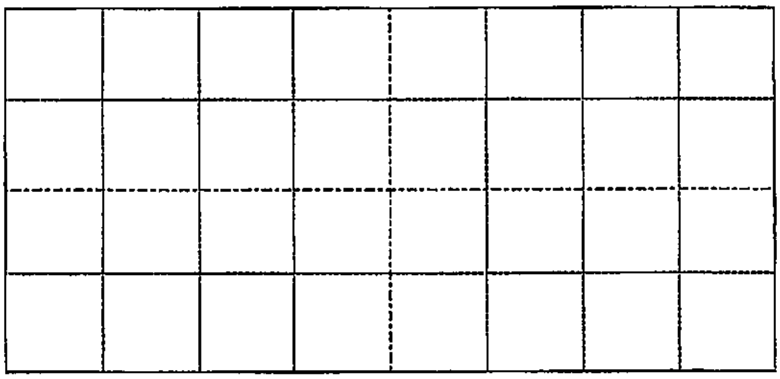
Time = number of squares (which covers complete cycle) × Time/division

Frequency = 1/time.

10- Repeat steps 8 and 9 for several waveforms.



V/DIV ----------------- T/DIV --------------------



V/DIV ----------------- T/DIV --------------------

11- Construct the circuit of Figure 1.4 to establish a phase shift.

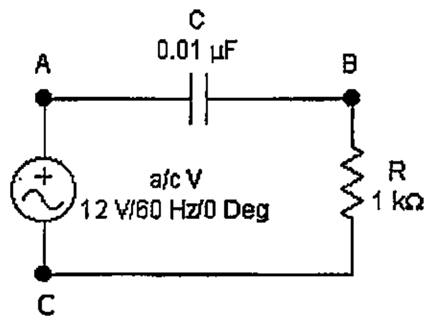


Fig 1.4

12- Connect channel (1) of the scope to point **A** of the circuit, and channel (2) to point **B** of the same circuit notice that point **C** is the reference point to both channels.

13- Press **Autoscale**, press **Main/Delayed**, then press **XY** softly.

14- Center the signal the signal on the display with the position knobs, and use the Volts/Div knobs and the vertical vernier softkeys to expand the signal for convenient viewing.

15- Press **cursors.**

16- Select the **Y2** cursor to the top of the signal, and set **Y1** to the bottom of the signal.
(Note the ΔY value at the bottom of the display).

17- Move the **Y1** and **Y2** cursors to the center of the signal.
(Again, note the ΔY value).

18- Calculate the phase difference using formula below.

$$\sin\theta = \frac{\sec ond\Delta Y}{first\Delta Y} = \deg rees$$

$\text{Sin}^{-1}\theta$ = --

Electrical Circuit (2) Laboratory

Laboratory Report

Experiment 2

Capacitors and Capacitance

Student Name:

Partner Name:

EXP. (2)

CAPACITORS AND CAPACITANCE

Objective:

To learn the meaning of the term "capacitance" and the characteristics of capacitors.

Discussion:

A capacitor is made up of two strips, or plates, of conducting material separated by insulating material (**called dielectric**). If you apply a voltage to it, electric charge will build up on one side and deplete the other side, until the resulting potential equal the applied voltage. If the applied voltage id DC, nothing farther will happen. We say the capacitor is charged. It has stored a quantity of electrical energy. A capacitor's storage capacity is known as capacitance, and is measured in farads. However, a farad is quit a large capacity and the capacitors we will be using have their capacities designated in microfarads (**μF**) or (**MFD**). If we provide a direct path, that is a short circuit, between the terminals of a capacitor, it will discharge fast, usually with a characteristic "crack" sound.

The fact that charges build up on one plate and leave the other plate at the same rate gives the capacitance of current flowing through the capacitor during the charging period. For DC, this time period id very short, so that it is fair to say that capacitors block the flow of DC. For AC, there is a continuous process of charging and discharging the capacitor, first with one polarity; then with the opposite polarity. Consequently, the current flow is continuously reversing its direction, at the same frequency as the potential. Although current doesn't actually flow through capacitors, alternating current does appear to flow through them, 90 degree out of phase with the potential. That is current flow reaches maximum as the potential crosses zero. Therefore, capacitors are spoken of as "**voltage-opposing device**" that causes **voltage to lag current by 90 degrees.**

Material and Equipment:

DC Source
AC Source
Analog AVO
Digital Multimeter

Capacitor 0.1 MFD
Capacitor 10 MFD (2)
Capacitor 100 MFD
Lamp with Holder
Switch DPDT

Procedure:

(Measure Resistance of Capacitors)

1- Set the solid state VOM to a range so that you can measure the resistance of the capacitor easily.

2- Measure the resistance of the 0.1 MFD capacitor, note the pointer movement, and explain what happens?

3- Replace the capacitor by the 10 MFD capacitor and repeat step (2).

(Capacitors will Charge to the Value of An Applied Voltage)

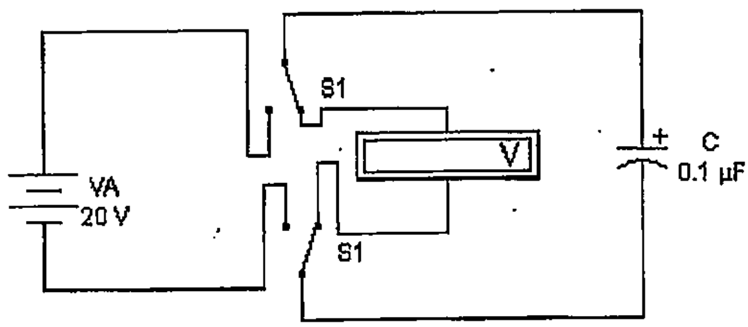


Fig 2.1

4- Set up the circuit of Figure 2.1.

5- With the switch thrown so as to connect the capacitor to the power source, bring the applied voltage up to 20 volts. Then throw the switch so as to connect the capacitor to the voltmeter. Read and record the initial voltmeter reading.

6- Substitute the 10 MFD capacitor for the one shown in Figure 2.1, and repeat Step 5.

7- Substitute two of 10 MFD capacitors in series and in parallel, and repeat Step 5.

(Capacitors Pass Alternating Current but Block Direct Current)

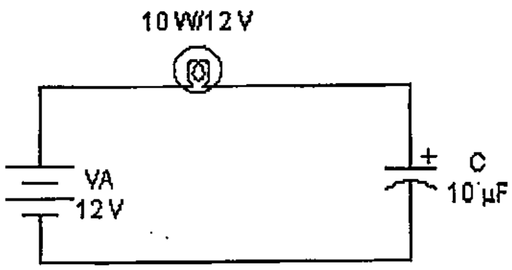


Fig 2.2

8- Set up the circuit of Figure 2.2. Be sure to observe polarities.

9- Apply 12 V DC and note the behavior of the lamp. Explain?

10- Gradually reduce the applied voltage to zero and substitute 20 V AC. Note the behavior of the lamp as the voltage is applied. Explain?

(Charged Capacitors, when disconnected from Circuit, will Hold a charge)

11- Remove the lamp from the circuit of Figure 2.2, and connect the positive terminal of the voltage source to the positive terminal of the capacitor.

12- Apply power to the circuit, increase the voltage up to 20 volts.

13- Disconnect the capacitor terminal **(make sure that you don't touch any metal parts of the capacitor)**, slowly short the terminals of the capacitor. Observe the rapid discharge. Explain what happens?

Quiz:

Select from the list the word that correctly completes each of the following sentences.

Alternating, Lags, Charge, Maximum, Voltage, Opposing, Zero, Shorting.

1- A capacitor will charge to the level of the value of ------------------- applied to it.

2- If the voltage across a capacitor is reduced, the capacitor will give up some of its ---- ----------- until it reaches the value of the new voltage.

3- A capacitor can be discharged rapidly by ------------------- its terminals.

4- When ----------------- current is supplied to a capacitor, it continually charge and discharge, with alternate polarities.

5- A capacitor is a voltage ----------------- device.

6- Alternating current flow "through" a capacitor is ------------------ when the voltage across it is ----------------------.

7- In capacitor, voltage --------------- current by 90 electrical degrees.

Electrical Circuit (2) Laboratory

Laboratory Report

Experiment 3

Capacitive Reactive

Student Name:

Partner Name:

EXP. (3)

CAPACITIVE REACTIVE

Objective:

To gain an understanding of opposition that capacitors provide to the flow of alternating current.

Discussion:

Capacitors permit the flow of alternating current by continuously charging and discharging in opposite direction. However, there is some energy lost in the process. We call this opposition to AC current flow **capacitance reactance.** It depends on both the capacitor's storage capacity (capacitance) and frequency of alternating current. The large the capacitance, the less opposition. Also, the higher the frequency, the less opposition. An easy way to prove this is to remember that DC current has a zero frequency and the opposition to its flow by a capacitor is infinitely large.

We learned previously that current flow is zero when the voltage across the capacitor is maximum. Capacitance causes current **lead voltage by 90** electrical degrees. Resistance, on the other hand, has no such effect. So we say that resistance has zero reactance angle.

Impedance is the term we use when speaking of the total opposition to current flow presented by any combination of capacitors, inductors, and resistors. Although both reactance and resistance are expressed in ohms, they cannot be simply added to compute impedance. As we shall see, the phase angle θ, between the voltage and current, as well as impedance Z, is computed using the principles of trigonometry. Capacitive reactance is considered negative with respect to the zero angle of resistance. Diagrammatically, these relationships are shown by vectors and solved by right triangles. Z, then, replaces R in an AC ohm's law equations.

$$Impedance(Z) = \sqrt{Xc^2 + R^2}$$

$$Capacitive reactance(Xc) = \frac{1}{2\pi fc}$$

Where f is frequency in hertz
C is capacitance in farads
R is resistance in ohms.

$$\sin\theta = \frac{C}{Z}$$

$$\cos\theta = \frac{R}{Z}$$

$$\tan\theta = \frac{Xc}{R}$$

Equipment's:

DC power supply.
AF Signal Generator.
Digital Multimeter

Capacitor, 10 MFD.
Capacitor, 0.001 MFD.
Resistor, 1 Megohm.
Resistor, 150 K ohm.
Switch, SPST.

Procedure:

(Effect of Applying DC and AC to A Resistance-Capacitance (RC) Circuit)

1- Set up the circuit of Figure 3.1.

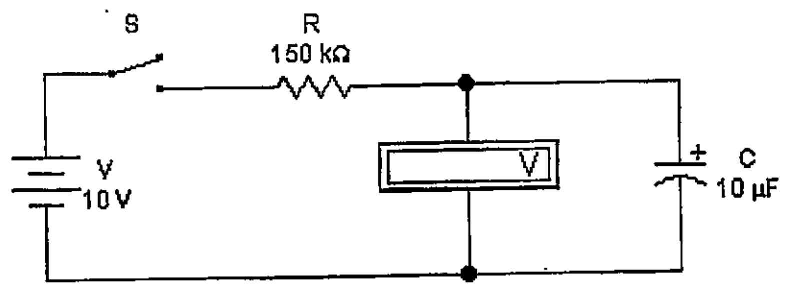


Fig 3.1

2- Set the power supply to 10 volts DC.

3- Close the switch and note the movement of the voltmeter pointer.

4- Open the witch and discharge the capacitor.

5- Connect the voltmeter across the resistor and repeat Steps 3 and 4.

Compare and explain the difference in pointer movement that you noted.

6- Set up the circuit of Figure 3.2

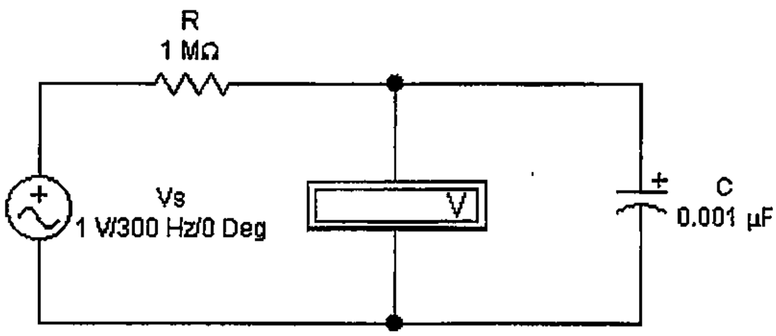


Fig 3.2

7- Set the AF signal generator to 300 Hz, 1 volt read and record in Table 3.1 the voltage across the capacitor Vc.
8- Interchange the capacitor and resistor, and repeat Step 7 for the voltage across the resistor, V_R.
9- Change the frequency of the AF signal generator to the frequencies indicated in Table 3.1, and repeat Steps 7 and 8.
10 Make the following computations and record in Table 3.1.

a) Compute circuit current, **I** from **R** and $\mathbf{V_R}$.

$I = V_R/R$ --

b) Compute circuit impedance, **Z**, from **Vs** and **I**.

$Z = V_S/I$ --

c) Compute capacitive reactance, $\mathbf{X_C}$, from **C** and $\mathbf{f_S}$.

$X_C = 1/2\pi f_S C$ --

d) Compute θ, from the value of **R**, $\mathbf{X_C}$, and **Z**.

$\theta = \tan^{-1} X_C/R$ --

10- Draw a vector diagram of R and X_C to determine Z and the phase angle, θ, for the measurements of 300 Hz only.

(Observe the Effect of Frequency on Capacitance Reactance)

11- Compute the frequency required to make the capacitive reactance of the 0.001MFD capacitor equal to 150 K ohms. Record in Table 3.2.

12- Using the circuit of Figure 3.2, replace the 1 Megohm resistor with 150K ohm resistor, set the AF generator for the frequency computed in Step 11 at an output of 1 volts. Read and record Vc in Table 3.2.

13- Connect the voltmeter across the resistor. Read and record V_R in Table 3.2.

14- Fine tune the frequency output until V_C equals V_R. Does their algebraic sum equal Vs. Explain?

Record actual frequency in Table 3.2.
How does the actual frequency compare with the computed one?

15- Replace the capacitor with the 1 Megohm resistor **(R_2)**. Read and record in Table3.2 the voltage across each. Does their algebraic sum equal Vs? Explain.

Fs	V_C	V_R	I	Z	X_C	θ
100 Hz						
200 Hz						
300 Hz						

Table 3.1

COMP. FREQ	V_C	V_R	ACTUAL FREQ	V_{R1}	V_{R2}

Table 3.2

(Measure the Phase Angle of A Capacitive Circuit)

16- Set up the circuit of Figure 3.3.

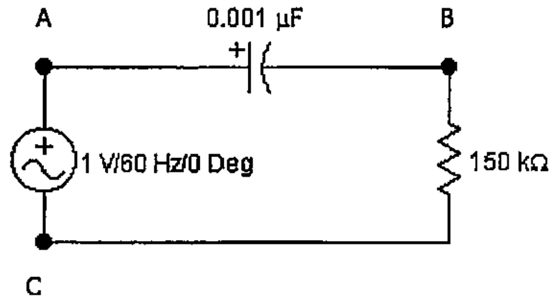


Fig 3.3

17- Connect channel (1) of the scope to point A of the circuit, and channel (2) to point B of the same circuit notice that point C is the reference point to both channels.

18- Press **Auto scale,** press **Main/Delayed**, then press **XY** softly.

19- Center the signal the signal on the display with the position knobs, and use the Volts/Div knobs and the vertical vernier soft keys to expand the signal for convenient viewing.

20- Press **cursors.**

21- Select the **Y2** cursor to the top of the signal, and set **Y1** to the bottom of the signal.
(Note the ΔY value at the bottom of the display).

22- Move the **Y1** and **Y2** cursors to the center of the signal.
(Again, note the ΔY value).

23- Calculate the phase difference using formula below.

$$\sin\theta = \frac{\sec ond\Delta Y}{first\Delta Y} = \deg rees$$

Quiz: True (T) or False (F)

a. ----------- Capacitors do not offer any opposition to the flow of alternating current.

b. ----------- The capacitive reactance of a capacitor depends on both its capacitance and the frequency of AC voltage applied.

c. ------------ The capacitance of a capacitor is determined by the way it is designed and manufactured.

d. ------------ Capacitors are often used to block alternating current.

e. ------------ At the instant voltage across a capacitor is maximum, current flow is zero.

f. ----------- Capacitive reactance causes voltage to lag 90 electrical degrees behind current.

g. ----------- The impedance of a capacitor-resistor series combination is determined by adding resistance and capacitance reactance algebraically.

h. ---------- You would never use a capacitor in a circuit that contains direct current.

Electrical Circuit (2) Laboratory

Laboratory Report

Experiment 4

Impedance Relationship in A Series RC Circuit

Student Name:

Partner Name:

EXP. (4)

IMPEDANCE RELATIONSHIP IN A SERIES RC CIRCUIT

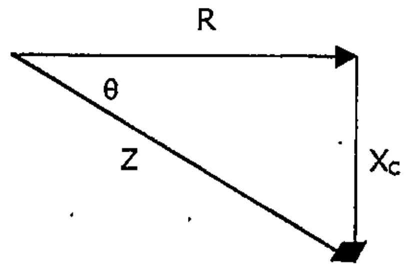
Objective:

To learn the relationship between resistance, capacitive reactance, and impedance in circuits having a resistor and capacitor in series.

Discussion:

The opposition to current flow by capacitors is called **capacitive reactance, X_C.** Although measured in ohms, capacitive reactance is not like resistance. Except for a tiny amount of leakage current, a capacitor uses no power. All the energy given it is given back. That's why you just add resistance and capacitive reactance algebraically.

The total impedance offered by an RC circuit is the "vector" sum of **R** and **X_C**. Once again we may use aright triangle to represent the two quantities that are 90° out of phase. RC diagrams look like this.



$Z^2=R^2+X_C^2$ and from that $Z=\sqrt{R^2+X_C^2}$

$$\theta = \tan^{-1}\left(\frac{Xc}{R}\right)$$

Equipment's:

Micrometer.
Digital Multimeter

Resistor, 18K ohm.
Resistor, 33K ohm.
Capacitor, 0.1 MFD.
Capacitor, 0.05 MFD.
Potentiometer, 500K ohm.

Procedure:

1- Connect the circuit of Figure 4.1, using the 18K-ohm resistor for R and the 0.1 MFD capacitor C.

2- Apply approximately 12 volts and adjust the potentiometer until the ammeter reads 100 microamperes (0.0001 amps).

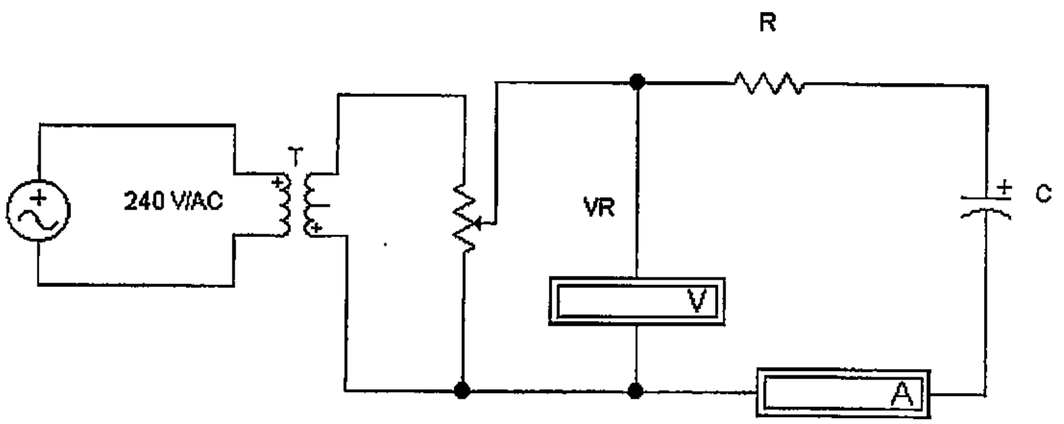


Fig 4.1

3- Measure the voltage applied to the series RC combination, V the voltage drop across the resistor V_R, and the voltage drop across the capacitor V_C. Record the readings in Table 4.1.

4- Calculate impedance **Z** from the equation **Z=V/I** and record in Table 4.1.

Z= V/I --

5- Calculate the resistance of **R** from the equation $\mathbf{V_R/I}$, and the capacitive reactance of **C** from the equation $\mathbf{X_C= V_C/I}$. Record in Table 4.2.

$R = V_R/I$ --

$C = V_C/I$ --

6- Calculate the impedance from the following equation $Z=\sqrt{R^2+Xc^2}$ Record in Table 4.2.

$Z=\sqrt{R^2+Xc^2}$ --

7- Construct an impedance phasor diagram, measure length of hypotenuse Z. Record in Table 4.2.

8- Calculate the angle θ from the equation $\theta = \tan^{-1} X_C/R$. record in Table 4.3.

$\theta = \tan^{-1} X_C/R$ --.

9- Calculate the impedance using the equation $Z = R/\cos\theta$. Record in Table 4.3.

$Z = R/\cos\theta$ --.

10- Replace the 18K-ohm resistor with the 33K-ohm resistor and replace the 0.1 MFD capacitor with the 0.05 MFD capacitor.

11- Repeat Steps 2 through.

	Rated		MEASURED			Z OHMS
I AMPS	R OHMS	C MFD	V VOLTS	V_R VOLTS	V_C VOLTS	V/I
0.0001	18K	0.1				
0.0001	33K	0.05				

Table 4.1

		CALCULATED		Z	VECTOR
R	C	R (OHMD)	X_C(OHMS)	($\sqrt{R^2 + Xc^2}$)	
18K	0.1 MFD				
33K	0.05 MFD				

Table 4.2

R	C	$Tan^{-1}\theta$ X_C/R	Cos θ	Z (R/ Cos θ)
18K	0.1 MFD			
33K	0.05 MFD			

Table 4.3

Electrical Circuit (2) Laboratory

Laboratory Report

Experiment 5

Frequency Response of A Reactive Circuit (RC Series Circuit)

Student Name:

Partner Name:

EXP. (5)

FREQUENCY RESPONSE OF A REACTIVE CIRCUIT (RC Series Circuit)

Objective:

To investigate the change in impedance caused by changing frequency in a RC series circuit.

Discussion:

The capacitive reactance of a capacitor varies in inversely with frequency according to the equation $X_C = 1/2\pi fC$. Therefor, as frequency increases, the impedance $Z = \sqrt{R^2 + Xc^2}$ goes down. This makes the current increases, where the voltage is constant.

In the following experiment, we will take data and plot a curve to show current impedance change as frequency changes.

Equipment's:

AF Signal Generator.
Digital Multimeter.

Capacitor, 0.1 MFD.
Resistor, 10K ohm.

Procedure:

1- Connect the circuit of Figure 5.1.

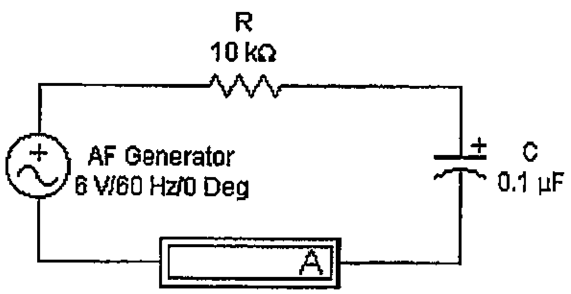


Fig 5.1

2- Set the Signal Generator to 50 Hz, 6 volts, and connect to the input of the circuit.

3- Read the current meter, record in Table 5.1.

4- Adjust the Signal Generator output frequency for 150 Hz, holding the output voltage constant at 6 volts.

5- Read the current and record in Table 5.1.

6- Repeat Steps 4 and 5 for the frequencies shown in Table 5.1.

7- Disconnect the Signal Generator, and calculate the impedance (**Z=V/I**), in ohms for each frequency reading, record in Table 5.1.

Z=V/I --

8- Plot the current versus frequency. Label the curve Current.

9- On the same graph plot the impedance values versus frequency. Label this curve Impedance.

10- Calculate the value of X_C, **Z**, and **I** for each value of frequency. Record in Table 5.1.

$X_C = 1/2\pi fc$ --

$Z = \sqrt{R^2 + X_C^2}$ --

I= V/Z --

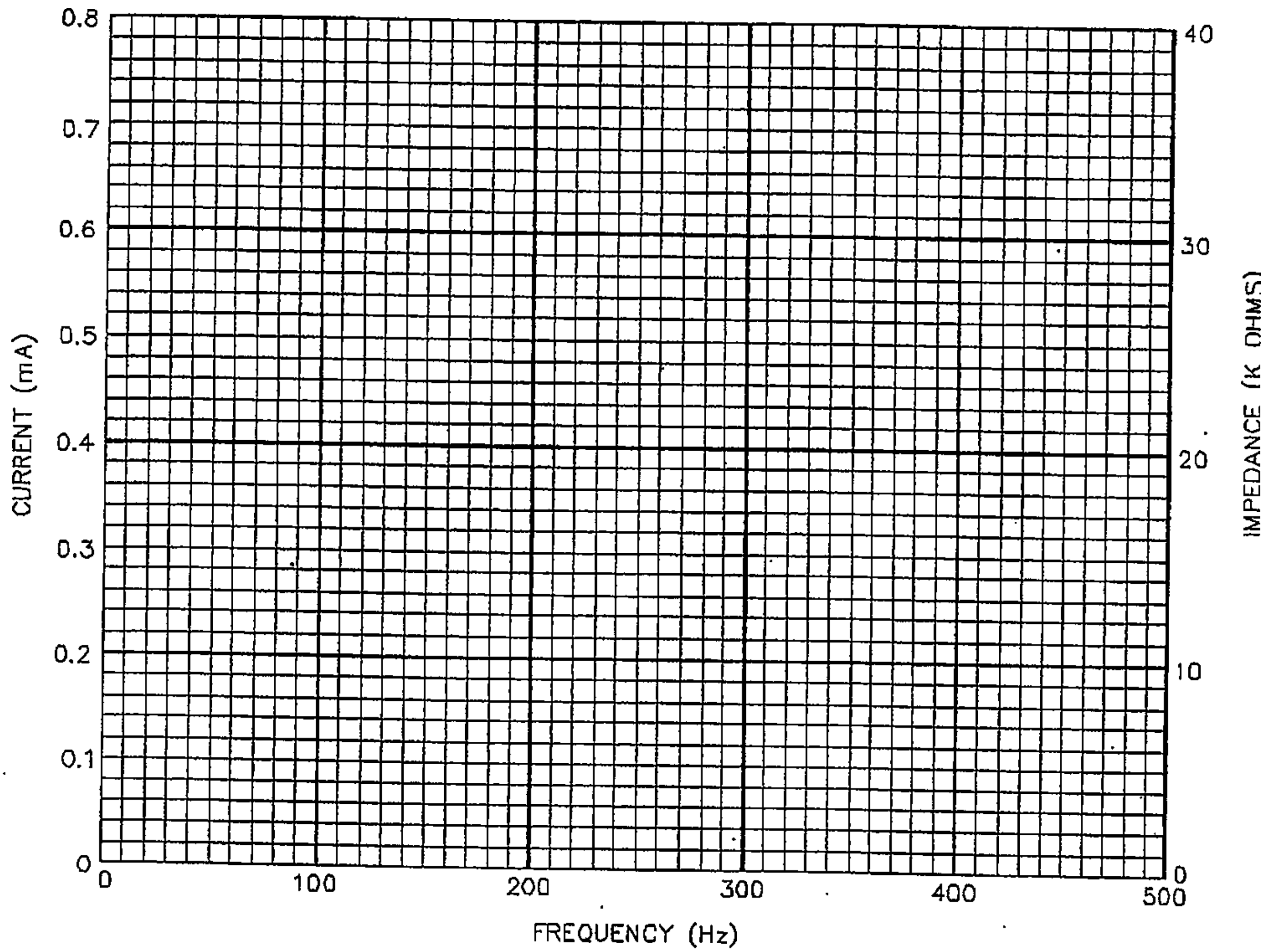
11- On the same graph plot the calculated values of X_C, and I versus frequency.

12- What you conclude form the two columns of impedance and current.

Frequency Hz	Measured			Calculated		
	V Volts	I mA	Z Ohms	X_C Ohms	Z Ohms	I mA
50	6					
150	6					
200	6					
250	6					
300	6					
350	6					
400	6					
450	6					
500	6					

Table 5.1

FREQUENCY RESPONSE OF SERIES R C CIRCUIT



Electrical Circuit (2) Laboratory

Laboratory Report

Experiment 6

Inductance and Inductive Reactance

Student Name:

Partner Name:

EXP. (6)

INDUCTANCE AND INDUCTIVE REACTANCE

Objective:

To learn the meaning of the terms "**inductance**" and "**inductive reactance**" and to verify experimentally that inductive reactance is directly proportional to inductance and frequency.

Discussion:

Whenever a conductor is in the presence of a magnetic field (linked magnetically) and the field is varying in straight (a change in flux linkages), there is a voltage induced into the conductor. The induced voltage becomes significantly large when the inductor is wound into a coil. With variation of alternating current from minimum to maximum, the electromagnetic field that surrounds the wire carrying this current is constantly expanding and collapsing. The magnetic flux links all of the conductors of the coil, a "**back voltage**" is induced which opposes the applied voltage, and 180 degrees out of phase to it. This ability of a coil to induce voltage into it self is called **inductance (L)**. The inductance of a coil depends on the number of turns, the length, and diameter, and the material of core. The unit of inductance is the **henry (H)**. One henry is the amount of inductance that allows one volt to be induced when the current changes at a rate of one ampere per second.

The current that flows through a coil depends on the net voltage. The net voltage is the applied voltage minus the un measurable back voltage. The only way we have of knowing that the back voltage exists is the reduction in current flow to the power source, the back voltage looks like a resistance. We call this type of **inductance reactance (X_L)**. With the knowledge of voltage across a coil and the current through it $X_L = E/I$, and it can be calculated as $X_L = 2\pi f L$, where f is the frequency, and L is the inductance in Henry.

Equipment's:

AVO meter.
Digital Multimeter.
AF Signal Generator.
Oscilloscope.

Resistor, 1K ohm.
Coil, 8 H.
Coil, 33 mH.

Procedure:

Investigate the Effect of Inductance on Current

1- Connect the circuit of Figure 6.1.

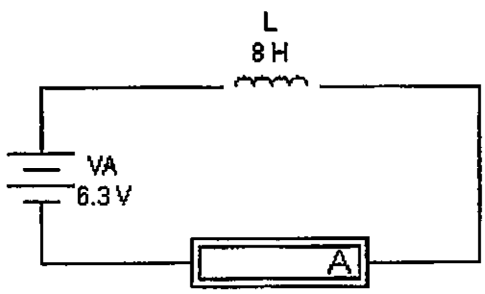


Fig 6.1

2- Turn on the power, measure the DC current through the coil. Record in Table 6.1.

3- Compute the DC resistance of the coil. Record in table 6.1.

R = E/I --

4- Replace the DC source with a 6.3 AC source.

5- Measure the AC current. Record in Table 6.1.

6- Compute the inductive reactance of the coil X_L = **E/I**.

X_L= E/I --

Observe the Change in Inductive reactance with frequency

7- Connect the circuit of Figure 6.2.

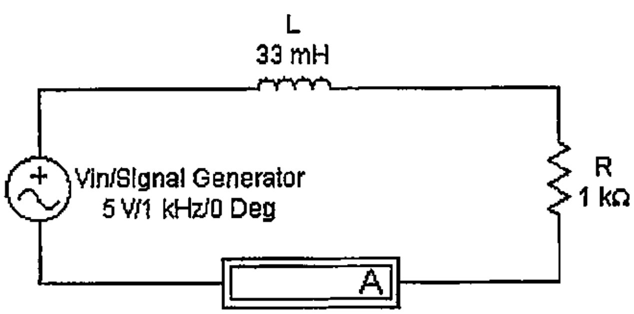


Fig 6.2

8- Setup the signal generator to 5 volts peak-to-peak at 1 kHz, and apply to the circuit.

9- Measure the voltage across the resistor and the coil using the oscilloscope. Record in Table 6.2. (Peak-to-peak voltage).

10 Change the frequency of the signal generator to 2 kHz. Readjust its output, if necessary, to maintain 5 V_{P-P}.

11- Repeat Step 9, for frequency of 2 kHz.

12- Repeat Step 9, for frequency of 3 kHz.

13- Compute the value of inductive reactance. Record in Table 6.2.

$\mathbf{I = V_R/R = V_L/X_L}$ and from that

$\mathbf{X_L = (V_L/V_R) \times R}$ ------------------------------------

14- Compute the value of inductive reactance. Record in Table 6.2.

$\mathbf{X_L = 2\pi fL}$ ------------------------------------

V_A	I	R	X_L
6.3 V (DC)			
6.3 V (AC)			

Table 6.1

f Hz	V_{in}	V_R	V_L	X_L $(V_L/V_R)\times R$	X_L $2\pi fL$
1 k Hz	**5 V_{P-P}**				
2 K Hz	**5 V_{P-P}**				
3 k Hz	**5 V_{P-P}**				

Table 6.2

(Measure the Phase Angle of A Inductive Circuit)

15- Disconnect the current meter from the circuit of Figure 6.2.

16- Connect channel (1) of the scope across the source of the circuit, and channel (2) between the inductor and the resistor of the same circuit, notice that the two channels have the same reference point.

17- Press **Auto scale**, press **Main/Delayed**, then press **XY** softly.

18- Center the signal the signal on the display with the position knobs, and use the Volts/Div knobs and the vertical vernier soft keys to expand the signal for convenient viewing.

19- Press **cursors.**

20- Select the **Y2** cursor to the top of the signal, and set **Y1** to the bottom of the signal.
(Note the ΔY value at the bottom of the display).

21- Move the **Y1** and **Y2** cursors to the center of the signal.
(Again, note the ΔY value).

22- Calculate the phase difference using formula below.

$$\sin^{-1}\theta = \frac{second\Delta Y}{first\Delta Y} = degrees$$

Electrical Circuit (2) Laboratory

Laboratory Report

Experiment 7

Impedance of A Series RL Circuit

Student Name:

Partner Name:

EXP. (7)

IMPEDANCE OF A SERIES RL CIRCUIT

Objective:

To learn a method for determining the impedance of an inductance and a resistance in series.

Discussion:

The opposition offered by inductors to any change in current is called "Inductive reactance". The amount of reactance that an inductor presents to ac depends upon two factors:

1- Inductance of the inductor.
2- Frequency of the varying current or voltage applied to the inductor.

The value of X_L is measured in ohms. This is done because reactance affects ac the same way that resistance affects dc. In fact, if we have the value of X_L, we can compute the amount of current that is flowing in the circuit by using Ohm's low $\mathbf{I = V_L/X_L}$.

The impedance of a combination of a resistance and reactance is the total of opposition that electrical circuit offers to the flow of varying current at a given frequency.

If you find the impedance of an RL circuit by adding X_L and R like vectors:
$\mathbf{(Impedance)^2 = R^2 + X_L^2}$
The impedance usually is given the symbol **Z** in formulas and in various forms of circuit analysis, then

$$Z = \sqrt{R^2 + X_L^2}$$

The reactance and resistance can be represented as vectors shown in Figure 7.1

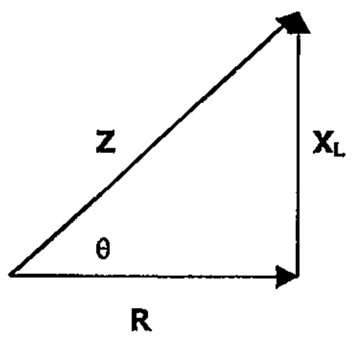


Fig 7.1

The length of the arrow represents the magnitude or the size of the vector, while the arrowhead shows the direction of the vector. The resultant between the two is the value of impedance (Z). From Figure 7.1 we see that the inductive reactance and the resistance are 90 deg. Apart. The angle "θ" between the impedance and resistance is known as phase angle. Angle "θ" describes the angle (how much out of phase) between the applied voltage and the resulting current.

$$\theta = \sin^{-1} X_L/Z = \cos^{-1} R/Z = \tan^{-1} X_L/R$$

Equipment's:

AC power supply.
Multimeter.

Choke, 8 H.
Resistor, 4.7k ohm.
Resistor, 8.2k ohm.

Procedure:

1- Connect the circuit of Figure 7.1. Using the 4.8k ohm resistor and 8 H choke.

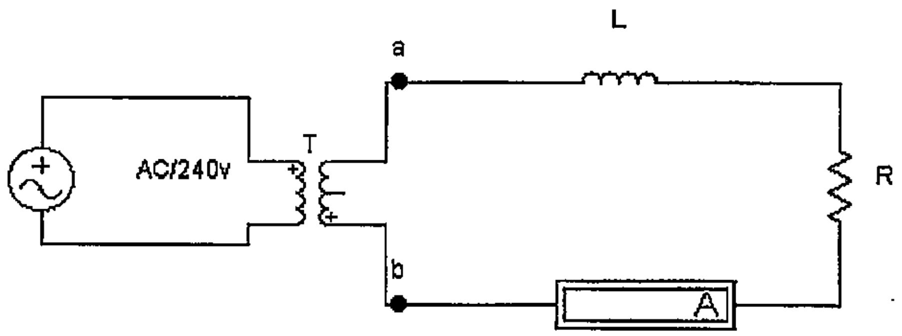


Fig 7.1

2- Read the current through the circuit, record in Table 7.1.

3- Measure the voltage applied to the series RL combination V_{ab}, the voltage drop across the resistor V_R, and the voltage drop across the inductor V_L. Record the readings in Table 7.1.

4- Calculate impedance **Z** from the equation **Z=V/I** and record in Table 7.1.

Z=V/I --

5- Calculate the resistance of **R** from the equation $\mathbf{V_R/I}$, and the inductance reactance of **L** from the equation $\mathbf{X_L = V_L/I}$. Record in Table 7.2.

$X_L = V_L/I$ --

6- Calculate the impedance from the following equation $\mathbf{Z}=\sqrt{R^2+X_L^2}$. Record in Table 7.2.

$Z=\sqrt{R^2+X_L^2}$ --

7- Construct a phasor diagram for the impedances calculated.

8- Measure the total impedance **Z** (resultant), record in Table 7.2.

9- Calculate the angle θ from the equation **$\theta = \tan^{-1} X_L/R$**. record in Table 7.3.

$\theta = \tan^{-1} X_L/R$ --

10- Calculate the impedance using the equation **$Z = R/\cos\theta$**. Record in Table 7.3.

$Z = R/\cos\theta$ --

11- Replace the 4.7k ohm resistor with the 8.2K ohm resistor.

12- Repeat Steps 2 through 10.

	Rated		MEASURED			Z OHMS
I AMPS	R OHMS	L H	V_{ab} VOLTS	V_R VOLTS	V_L VOLTS	V_{ab}/I
	4.7K	8				
	8.2K	8				

Table 7.1

		CALCULATED		Z	VECTOR
R	L	R (OHMD)	X_L(OHMS)	($\sqrt{R^2+X_L^2}$)	
4.7K	8H				
8.2K	8H				

Table 7.2

R	L	$Tan^{-1}\,\theta$ X_L/R	Cos θ	Z (R/ Cos θ)
4.7K	8H			
8.2K	8H			

Table 7.3

Electrical Circuit (2) Laboratory

Laboratory Report

Experiment 8

Frequency Response of A Reactive Circuit
(RL Series Circuit)

Student Name:

Partner Name:

EXP. (8)

Frequency Response of A Reactive circuit (RL Series Circuit)

Objective:

To investigate the change in impedance caused by changing frequency in a RL series circuit.

Discussion:

We have seen that the inductive reactance of a coil varies with frequency according to the equation $X_L = 2\pi fL$, where f is the frequency in Hertz and L inductance of the coil in Henry.

Further, the impedance of an RL circuit varies with inductive reactance according to the equation $Z = \sqrt{R^2 + X_L^2}$. From this we can see that as frequency increases the impedance of a series RL circuit goes up. This makes the current go down according to the equation **I = V/Z,** where the applied voltage V held constant.

In the following experiment, we will take data and plot a curve to show current and impedance change as frequency changes.

Equipment's:

AF Signal Generator.
Solid-State VOM.
Multimeter.

Inductor(choke), 8H.
Resistor, 10K ohm.

Procedure:

1-Connect the circuit of Figure 8.1.

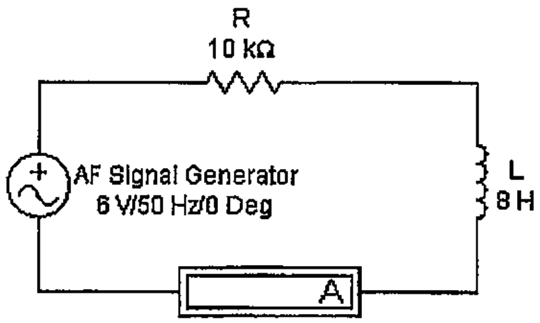


Figure 8.1

2- Set the Signal Generator to 50 Hz, 6 volts, and connect to the input of the circuit.

3- Read the current meter, record in Table 8.1.

4- Adjust the Signal Generator output frequency for 150 Hz, holding the output voltage constant at 6 volts.

5- Read the current and record in Table 8.1.

6- Repeat Steps 4 and 5 for the frequencies shown in Table 8.1.

7- Disconnect the Signal Generator, and calculate the impedance (**Z=V/I**), in ohms for each frequency reading, record in Table 8.1.

8- Plot the current versus frequency. Label the curve Current.

9- On the same graph plot the impedance values versus frequency. Label this curve Impedance.

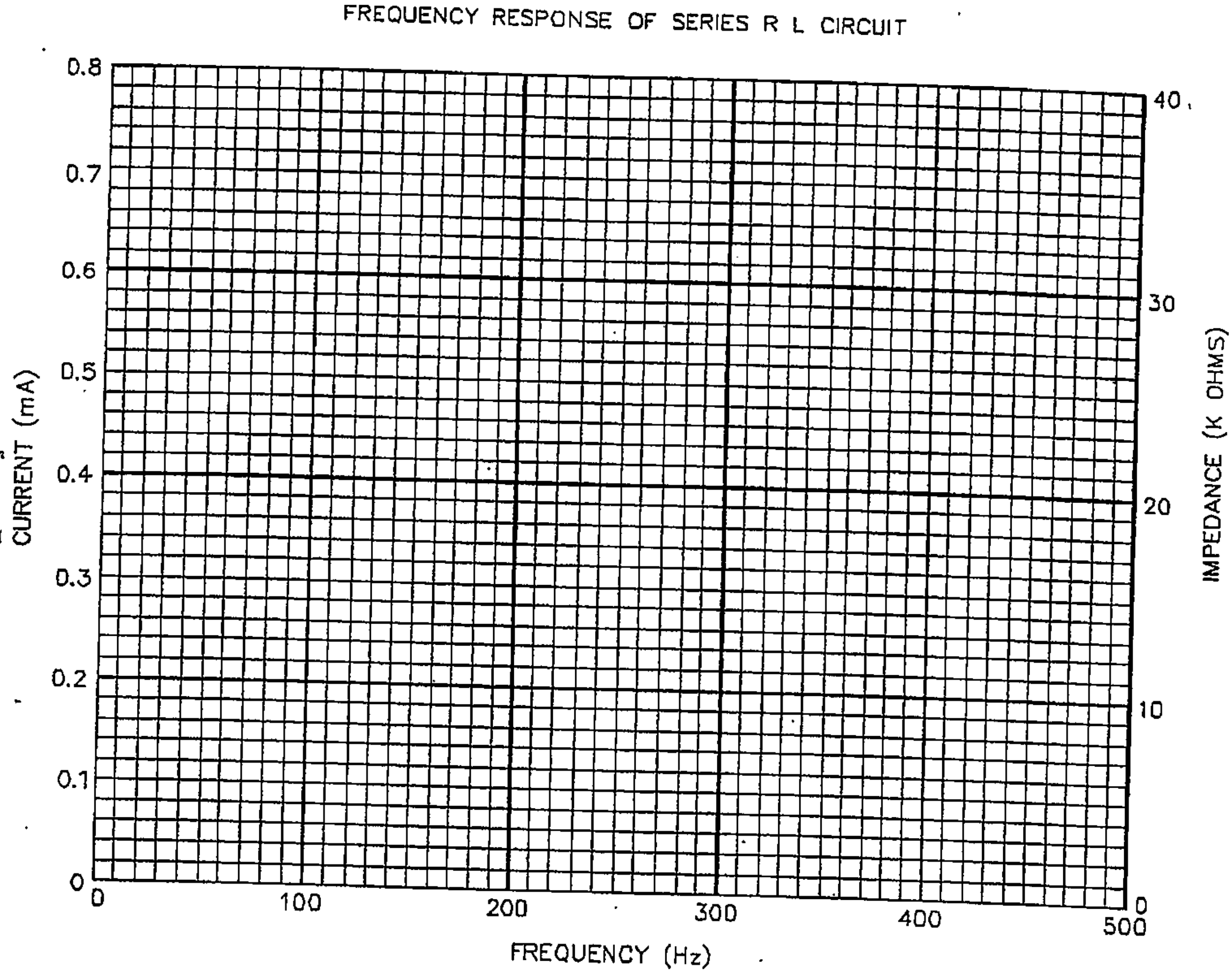
10- Calculate the value of $\mathbf{X_L}$, **Z,** and **I** for each value of frequency. Record in Table 8.1.

11- On the same graph plot the calculated values of X_L, and I versus frequency.

12- What you conclude form the two columns of impedance and current.

Frequency Hz	Measured			Calculated		
	V Volts	I mA	Z Ohms	X_L Ohms	Z Ohms	I mA
50	6					
150	6					
200	6					
250	6					
300	6					
350	6					
400	6					
450	6					
500	6					

Table 8.1



FREQUENCY RESPONSE OF SERIES R L CIRCUIT
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
CURRENT (mA)
40
30
20
10
0
IMPEDANCE (K OHMS)
0
100
200
300
400
500
FREQUENCY (Hz)

Electrical Circuit (2) Laboratory

Laboratory Report

Experiment 9

Impedance of A Series RLC Circuit

Student Name:

Partner Name:

EXP. (9)

IMPEDANCE OF A SERIES RLC CIRCUIT

Objective:

To investigate the resulting current and impedance when inductive and capacitance reactances are connected in series with a resistance.

Discussion:

An inductor in a circuit causes current to lag voltage by 90 degrees. A capacitor in a circuit causes current to lead voltage by 90 degrees. That's why we can't add resistance and reactance algebraically.

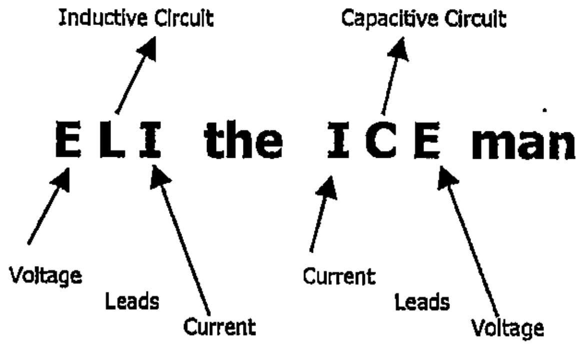


Figure 9.1 serves as memory aid to memorize

When there is both inductive reactance and capacitive reactance in a circuit, however you can combine these two algebraically. You always subtract the smaller from the larger. The reason is this: The voltage across the inductor is 180 degrees out of phase with the voltage across the capacitor. The result, then, is the difference between the two.

When we drew voltage vector diagram, we drew the line representing the resistance voltage drop horizontally, left to right. This is the position of 0 degrees on a vector diagram.

The voltage drop across the inductor is drawn upward at 90 degrees. That is because this voltage at every instant of time is 90 degrees ahead of the current (which is our starting point).

The voltage drop across the capacitor is drawn downward at 270 degrees. That is because this voltage is 90 degrees behind the current. Because the total reactance of a coil and a capacitor, in series, is less than either one separately, the RLC, circuit impedance must also be less. This is shown by the impedance equation for RLC circuit.

$$Z = \sqrt{R^2 + (X_L - X_C)^2}$$

Even if the capacitive reactance is larger (producing a minus reactance), the equation still holds true. The square of negative number is still plus.

Equipment's:

AVO meter
Resistor, 4.7k ohm
Choke, 8 H
Capacitor, 1 MFD
Switch, SPST

Procedure:

1- Connect the circuit of Figure 9.1.

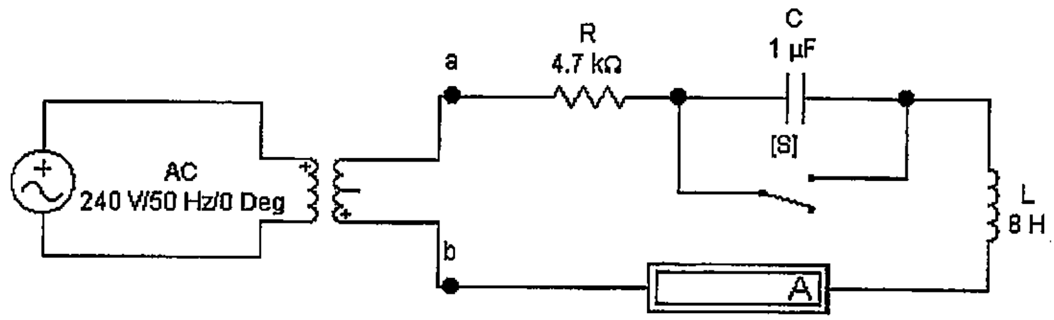


Fig 9.2

2- With the switch S closed, eliminating the capacitor from the circuit, apply approximately 7 volts to the circuit.

3- Measure the current, I, and the applied voltage, V. Record these values in Table 9.1.

4- Measure the voltage across the resistor, V_R, and the voltage across the choke V_L. Record these values in Table 9.2.

5- Open switch S, putting the capacitor in series with the resistor and choke. Repeat Step 3.

6- Measure the voltage across the resistor, V_R, the voltage across the capacitor, V_C, and the voltage across the choke, V_L. Record these values in Table 9.2.

7- Calculate the impedance **Z=V/I** of both RL circuit and the RLC circuit. Record these values in Table 9.1.

Z= V/I ------------------------------------

8- Calculate the total reactive voltage $V_X=V_L-V_C$ of both the RL and RLC circuits. Record these values in Table 9.2.

$V_X=V_L-V_C$ --

9- Calculate the phase angle for the RL and RLC circuits $\theta = \tan^{-1} V_X/V_R$. Record in Table 9.3.

$\theta = \tan^{-1} V_X/V_R$ --

10- Construct a voltage phasor diagram for each of the circuits.

11- Measure the applied voltage **V** (the resultant), and the phase angle θ, and record these values in Table 9.3.

	V Volts	I mA Current	Z ohms
RL Circuit			
RLC Circuit			

Table 9.1

	V_R	V_L	V_C	V_X
RL Circuit			**0 V**	
RLC Circuit				

Table 9.2

	Calculated θ	Measured θ	Measured V
RL Circuit			
RLC Circuit			

Table 9.3

Electrical Circuit (2) Laboratory

Laboratory Report

Experiment 10

Series Resonance

Student Name:

Partner Name:

EXP. (10)

SERIES RESONANCE

Objective:

To understand the nature of resonance and how capacitors and inductors are combined in series to produce resonant circuit.

Discussion:

We learned that the capacitive reactance, X_C, depends, in part, upon the frequency of the voltage across it, and that X_C lags by 90 degrees compared with the zero reference angle of pure resistance. Also, we learned that inductive reactance, X_L, is related to frequency and that X_L leads by 90 degrees. It follows that for any given combination of a capacitor and a coil, there must be a frequency at which X_C and X_L will be equal. Further, at that frequency, they will be 180 degrees out of phase, canceling each other. This is the **resonant** frequency, $\mathbf{f_r}$.

There are two computed values that help us visualize the nature of any given resonant circuit. One is the **figure of merit,** or **quality,** usually just called **Q**. It is ratio between the inductive reactance at resonant frequency and the resistance in series with the coil (including the resistance of the coil itself): $\mathbf{Q = X_L/R}$. Q can also be computed more directly from the ratio between the voltage across the coil (or capacitor, since these two values are identical) and the source voltage, $\mathbf{Q = V_L/V_S}$. The other item is **bandwidth.** The bandwidth of a resonant circuit reveals how quickly current drops off on each side of the resonant frequency.

The boundaries (called edge frequencies) of this span of frequencies (including the resonant frequency in the center) are those at the current equals **70.7** percent of the maximum. These are the half –power points and are used for convenience in making computations. Bandwidth is computed by subtracting the lower edge frequency from the upper one, $\mathbf{BW = f_2 \quad f_1}$. It is also equal to the resonant frequency divided by Q. $\mathbf{BW = f_r/Q}$.

Since the maximum current flow occurs only at the resonant frequency and drops off sharply as the frequency changes, the series resonant circuit may be used for frequency-sensitive device such as tuning circuits.

Equipment's:

AF Signal Generator
Oscilloscope
Coil, 33 mH
Capacitor, 0.001 MFD
Resistor, 4.7k ohm

Procedure:

1- Set up the circuit of Figure 10.1.

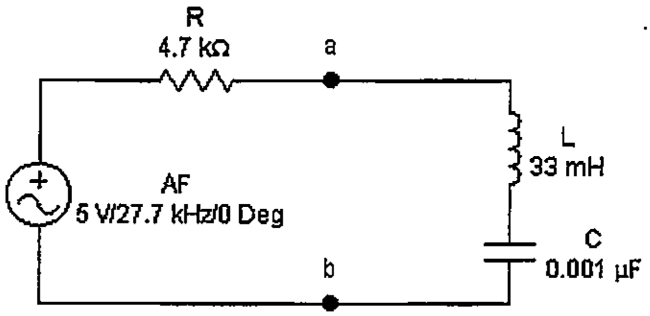


Fig 10.1

2- Compute the resonant frequency $\mathbf{f_r}$, of this circuit using the equation :

$$f_r = \frac{1}{2\pi\sqrt{LC}}$$ ---

3- With the AF generator set for maximum output, adjust its frequency to value of $\mathbf{f_r}$ computed in Step 2.

4- Slowly adjust the AF generator frequency up and down until the lowest voltage is indicated on the oscilloscope by measuring the voltage at points a and b. This is the setting used for subsequent experiment.

5- Connect the circuit of Figure 10.2. Leave the AF generator set on the resonant frequency established in Step 4 and adjust its output, V_A to 1 volt. Read and record the voltage drop across the resistor, V_R. Also record f_r in Table 10.1. Complete the column one of Table 10.1.

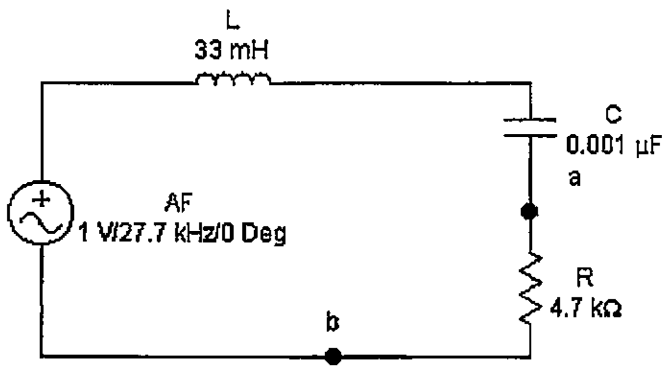


Fig 10.2

6- Vary the AF generator frequency above and below resonance, 5k Hz at a time.

7- At each stop, read and record V_R in Table 10.1. Maintain the AF generator's 1-volt output at each step.

8- Compute the circuit current for each frequency and record in Table 10.1.

$I = V_R/R$ ____

9- Interchange the circuit position of L and R, so that the coil will be between the points a-b.

10- With the oscilloscope connected across points a-b shown in Figure 10.2 read and record the voltage across the coil, V_L, for each frequency given in Table 10.1. Maintain the AF generator's 1-volt output at each step.

11- Interchange the positions of C and L.

12- With the oscilloscope connected across points a-b shown in Figure 10.2 read and record the voltage across the capacitor, V_C, for each frequency given in Table 10.1. Maintain the AF generator's 1-volt output at each step.

13- Compute **Q**, at resonance frequency, using the equation:

$Q = V_L/V_A$ ____

14- From the data you have recorded in Table 10.1, plot a curve of current I, versus frequency, f.

15- Make the half-power points on your curve. Drop straight lines down to the abscissa.

$(0.7071)*I$ ____

16- Compute the bandwidth from the edge frequencies on your curve.

$f_2 - f_1$ ____

17- Compute the bandwidth using the equation:

f_r/Q ____

FREQUENCY	V_R	I	V_L	V_C
$f_r - 25$ kHz=				
$f_r - 20$ kHz=				
$f_r - 15$ kHz=				
$f_r - 10$ kHz=				
$f_r - 5$ kHz=				
f_r =				
$f_r + 5$ kHz=				
$f_r + 10$ kHz=				
$f_r + 15$ kHz=				
$f_r + 20$ kHz=				
$f_r + 25$ kHz=				

Table 10.1

QUIZ

Check the statement that correctly complete each sentence.

1- At resonance, a series LC circuit appears to the source as

a. capacitive. b. inductive. c. resistive.

2- At frequencies higher than resonant, a series LC circuit appears to the source as

a. capacitive. b. inductive. c. resistive.

3- At frequencies lower than resonant, a series LC circuit appears to the source as

a. capacitive. b. inductive. c. resistive.

4- We can recognize the resonant frequency of a series LC circuit from the current. It

a. reaches maximum. b. becomes nearly zero. c. remains unchanged.

5-The impedance of a series LC circuit at resonance

a. reaches maximum. b. becomes minimum. c. remains the same.

Electrical Circuit (2) Laboratory

Laboratory Report

Experiment 11

Impedance of Parallel RL, RC, and RLC Circuit

Student Name:

Partner Name:

EXP. (11)
IMPEDANCE OF PARALLEL RL, RC, AND RLC CIRCUITS

Objective:

To learn the technique of solving AC parallel circuits containing inductance and resistance, capacitance and resistance, and inductance, capacitance, and resistance.

Discussion:

When studying resistance in parallel, we learned that any circuit could be represented by a single resistance in series with the power source. The equivalent resistance can be calculated from the current and voltage **R = E/I**. There is, after all one voltage and one current from a power source.

There are similarities and differences in AC parallel reactance circuits. Any AC circuit can be represented by a resistance in series with a reactance. An AC power source has only one voltage and one current, which is either leading or lagging the voltage by some phase angle. The current is the vector sum of the current in each leg.

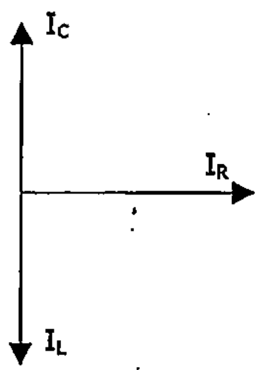


Fig 11.1

To draw current vector diagram, the 0 degrees vector represents the current through the resistor because current through a resistor is in phase with the voltage. The vector representing current through the capacitive leg is vertically up word because current leads voltage by 90 degrees. The line representing current through the inductive leg is vertically downward because the current lags the voltage by 90 degrees as shown in Figure 11.1. Therefore the total current can be represented by the following equation:

$$I_T = \sqrt{I_R^2 + (I_C - I_L)^2}$$

Once we have determined the total current, we can find the impedance and the phase angle from the equations:

$$Z = \frac{V}{I} \quad \text{And} \quad \theta = \tan^{-1}\frac{(I_C - I_L)}{I_R}$$

Equipment's:

AC power supply
Digital voltmeter
Resistor, 4.7k ohm
Choke, 8 H
Capacitor, 0.5 MFD
3 Switches, SPST

Procedure:

Determine the equivalent circuit of a resistor and coil in parallel

1- Connect the circuit of Figure 11.2

2- Adjust the ac power source until the applied voltage is exactly 10 volts, with switches SR, SL, and SC all open.

3- Close switch SR and read current. This is the current through the resistance leg, I_R. Record in Table 11.1.

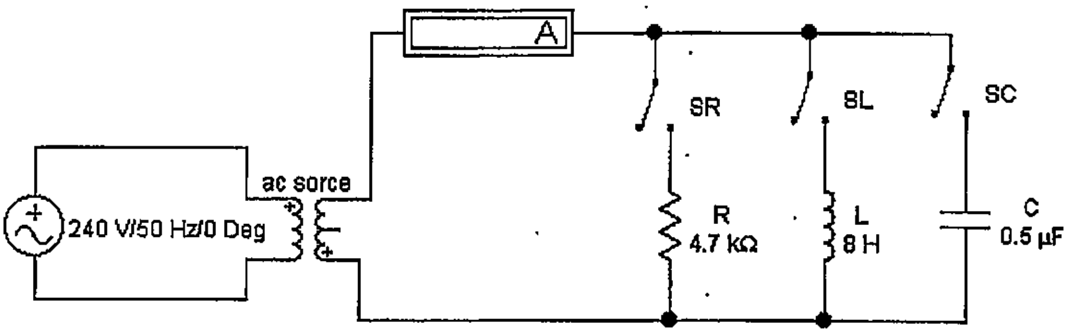


Fig 11.2

4- Open Switch SR and close Switch SL. Read the current through the inductance leg I_L. Record in Table 11.1.

5- Close Switch SR. The ammeter is now reading the total current I_T flowing to the RL parallel circuit. Record in Table 11.1.

Determine the equivalent circuit of a resistor and capacitor in parallel

6- Open Switch SR and SL.

7- Repeat Step 3 to 5 for the parallel RC leg. Record in Table 11.1.

8- Open Switch SR and SC.

Determine the equivalent circuit of a resistor, a coil, and a capacitor connected in parallel

9- Adjust the output voltage from the ac source to 10 volts if necessary.

10- Close Switch SR, read and record current through the resistive leg in Table 11.1.

11- Open Switch SR and close Switch SL. Read Current, I_L and record in Table 11.1.

12- Open Switch SL and close Switch SC. Read current I_C, and record in Table 11.1.

13- Close Switches SR and SL. Read the current I_T, and record in Table 11.1.

14- Turn off the power supply.

15- Calculate the out-of-phase current I_X, for each case RL, RC, and RLC. Record in Table 11.1.

$I_X = I_C \quad I_L$ --

16- Calculate the phase angle θ, for RL, RC, and RLC. Record in Table 11.1

$\theta = \tan^{-1} I_X/I_R$ --

17- Calculate the impedance, **Z** for RL, RC, and RLC. Record in Table 11.1.

$Z = V_{in}/I_T$ --

17- Construct a current vector diagram, for RL, RC, and RLC. Measure I_T, and θ. Record in Table 11.1.

	Measured					**Calculated**		**Diagram**	
	I_R	I_L	I_C	I_X $I_C - I_L$	I_T	θ	**Z**	I_T	θ
RL									
RC									
RLC									

Table 11.1

Electrical Circuit (2) Laboratory

Laboratory Report

Experiment 12

Parallel Resonance

Student Name:

Partner Name:

EXP. (12)

PARALLEL RESONANCE

Objective:

To learn the meaning of parallel resonance and the characteristics of tank circuit.

Discussion:

In experiment 10 it was established that in series AC circuit containing both inductance and capacitance, there is **resonant** frequency at which the inductive reactance will be equal to, and 180 degrees out of phase with, the capacitive reactance. When the inductor, or coil, and the capacitor are connected in parallel in what is known as a **tank circuit**, the voltage across the combination remains relatively constant. However, the impedance of the tank circuit becomes enormously high at resonant frequency because current in the external circuit drops to nearly zero (Z=V/I).

As with the series resonant circuit, the **figure of merit,** or **quality, Q,** of a parallel resonant circuit is the ratio of inductive reactance at resonant frequency to the series resistance, $X_{L(at\ fr)}/R_S$. It is also the ratio of the total impedance to the inductive reactance at resonance, $Z_T/X_{L(at\ resonance)}$.

Bandwidth, however, is computed somewhat differently. Since it is the impedance that reaches maximum at resonance, the bandwidth is measured between the two frequencies (edge frequencies) which corresponds to 70.7 percent of the maximum Z. For parallel resonant circuit with Q higher than 10, the equation:

Bandwidth = F_r/Q may be used.

Equipment's:

AF Signal Generator
Digital Multimeter
Oscilloscope

Coil, 33 mH
Capacitor, 0.001 MFD
Resistor, 4.7k ohm

Procedure:

1- Set up the circuit of Figure 12.1.

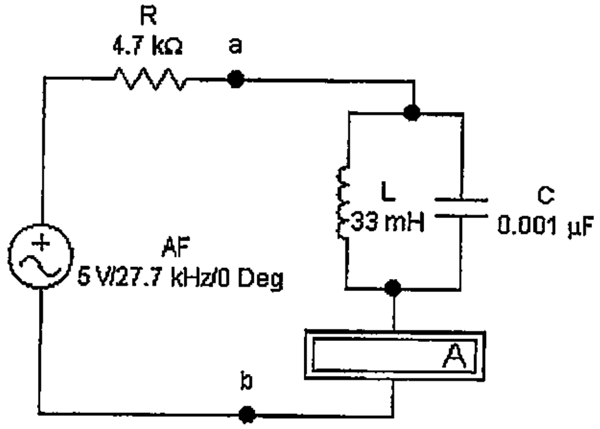


Fig 12.1

2- Compute the resonant frequency f_r, of this circuit using the equation :

$$f_r = \frac{1}{2\pi\sqrt{LC}}$$ --

3- With the AF generator set for maximum output, adjust its frequency to value of f_r computed in Step 2.

4- Slowly adjust the AF generator frequency up and down until the oscilloscope across the **tank** circuit (points a-b) shows a maximum indication of V_T (max reading). This is the actual resonant frequency, f_r.

5- With the AF generator set at resonant frequency established in Step 2, adjust the AF generator's output to 1 volt.

6- Measure the voltage, V_T across the tank circuit (points a-b) and the line current **I**. Record these values in the f_r row of Table 12.1. Also record f_r in Table 12.1. Complete column one of Table 12.1.

7- Compute the impedance of the tank circuit **Z = V_T/I**. Record in Table 12.1.

Z= V_T/I --

8- Vary the AF generator frequency above and below resonance, 5k Hz at a time. Measure and record **V_T** and **I** for each of the values given in Table 12.1. At each stop, be sure to adjust the out of the AF generator, if necessary, to maintain a 1-volt output. Compute **Z** for each step. Record all of your readings and computation in Table 12.1.

9- Compute the figure of merit from the equation:

$$Q = \frac{Z(at\text{`}resonance)}{2\sqrt{fL}}$$ ------------------------------------

10- From the data you have recorded in Table 12.1, plot a curve of impedance, **Z**, versus frequency using graph paper.

11- Make the half-power points on your curve. Drop straight lines down to the abscissa to show bandwidth.

(0.7071)*Z ------------------------------------

12- Compute the bandwidth from the edge frequencies on your curve.

$f_2 - f_1$ ------------------------------------

13- Compute the bandwidth using the equation:

f_r/Q ------------------------------------

14- At frequencies other than resonance, the line current **I**, will be either inductive or capacitive. Explain which it is at frequencies higher than resonance and explain why.

FREQUENCY	V_T	I	Z
f_r – 25 kHz=			
f_r – 20 kHz=			
f_r – 15 kHz=			
f_r – 10 kHz=			
f_r – 5 kHz=			
f_r =			
f_r + 5 kHz=			
f_r + 10 kHz=			
f_r + 15 kHz=			
f_r + 20 kHz=			
f_r + 25 kHz=			

Table 12.1

Quiz:

Check the statement that correctly completes each sentence.

1- At resonance, a parallel LC circuit appears to the source as

a. capacitive. b. inductive. c. resistive.

2- At frequencies higher than resonant, a parallel LC circuit appears to the source as

a. capacitive. b. inductive. c. resistive.

3- At frequencies lower than resonant, a parallel LC circuit appears to the source as

a. capacitive. b. inductive. c. resistive.

4- We can recognize the resonant frequency of a parallel LC circuit from the main line current.

a. reaches maximum. b. becomes nearly zero. c. remains unchanged.

5-The impedance of a parallel LC circuit at resonance

a. reaches maximum. b. becomes minimum. c. remains the same.

Electrical Circuit (2) Laboratory

Laboratory Report

Experiment 13

Transformers

Student Name:

Partner Name:

EXP. (13)

TRANSFORMERS

Objective:

To become familiar with the construction, characteristics, and applications of transformers and autotransformers.

Discussion:

Transformers have the unique ability to transfer electrical power without electrical contact. They do this through the medium of magnetism.

A transformer usually consists of two or more coils wound on the same core. The transformer we will be studying in this experiment has an iron core. Other transformers used in electronics have air cores or ferrite cores. One coil, called the **primary,** is connected to the power source. The other, called the **secondary** is connected to the load. Alternating current through the primary coil produces an expanding and collapsing magnetic field in the core. Now, both the primary coil and the secondary coil are in the presence of this changing field because they are both wound on the same core.

As we know, a changing field induces a voltage into any wire links. A voltage is introduced into the primary, which is equal and opposite to the applied voltage. This works out to a certain number of volts per turn. If the number of turns of the secondary coil is higher than the primary coil, then the voltage would be stepped-up and it would be called a **step-up** transformer. But if the number of turns of the primary coil is higher than the secondary coil, then the voltage would be stepped-down and it would be called a **step-down** transformer.

Mathematically, we can express this relationship as follows:

$$\frac{V_P}{N_P}=\frac{V_S}{N_S} or \frac{V_P}{V_S}=\frac{N_P}{N_S}$$

Where:

V_P is the voltage applied to the primary
V_S is the voltage across the secondary
N_P is the number of turns on the primary
N_S is the number of turns on the secondary

Autotransformers have only one coil, tapped at one or more points. Unlike conventional transformers, autotransformers do not isolate the power source from the load. Some of the turns are shared by the primary and the secondary. If voltage is applied across a portion of the winding and the load voltage is taken across the full winding, the voltage is stepped up. Voltage and current are related to the turns ratio of an autotransformer in the same way as a conventional transformer.

Equipment's:

AC Source
Digital Multimeter
Analog meter
Transformer, Type F26-X
Resistor, 100 ohm
Resistor, 500 ohm
Switch, SPST

Procedure:

Determine the Turns Ratio and Exciting Current of A Transformer

1- Connect the high side (primary) of the transformer to the power source as shown in Figure 13.1.

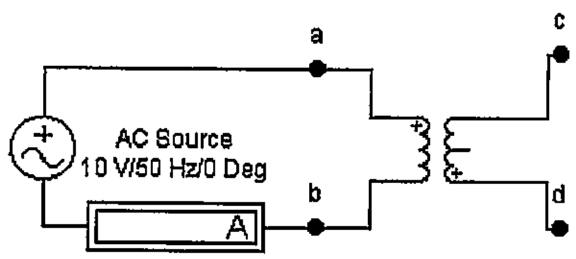


Fig 13.1

2- Measure the exciting current and record in Table 13.1.

3- Measure the primary voltage (points a-b), record in Table 13.1.

4- Measure the secondary voltage (points c-d), record in Table 13.1.

5- Compute the turns ratio of this transformer, record in Table 13.1.

$\frac{V_P}{V_S} =$ ____

Determine the Voltage and Current Ratios of A Load Transformer

6- Connect the circuit shown in Figure 13.2, with a load resistor of 500 ohm.

7- Read the primary voltage V_P (points a-b), and Secondary Voltage (across R_L). record in Table 13.2.

8- Read the primary current I_P, and the secondary current I_S. Record in Table 13.2.

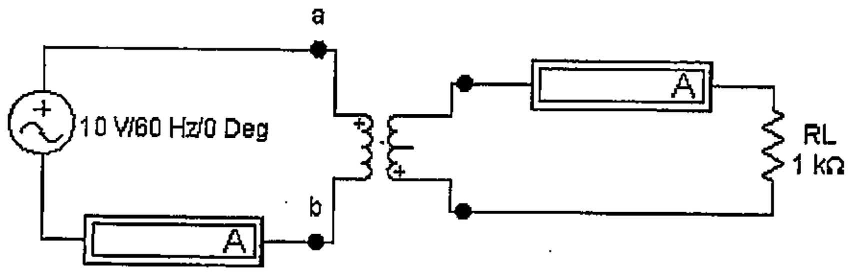


Fig 13.2

9- Subtract the exciting current, which you recorded in Table 13.1, from the primary current read in Step 8. This will give you the value of primary current that is due to the load. Record in Table 13.2.

$I_{P(W/NL)} - I_{P(WL)} =$ --

10- Divide the primary voltage, V_P, by the secondary voltage, V_S, and record in Table 13.2.

$\frac{V_P}{V_S}$ --

11- Divide the secondary current I_S, by the primary current I_P, record in Table 13.2.

$\frac{I_S}{I_P}$ --

12- Substitute the 100-ohm resistor as RL and repeat Steps 8 through 11.

Observe the Operation of an Autotansformer

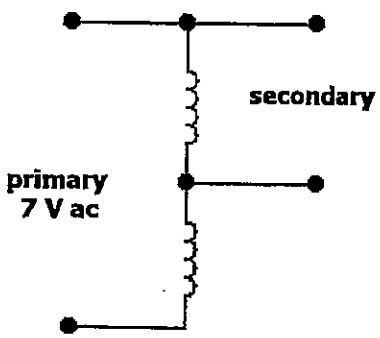


Fig 13.3

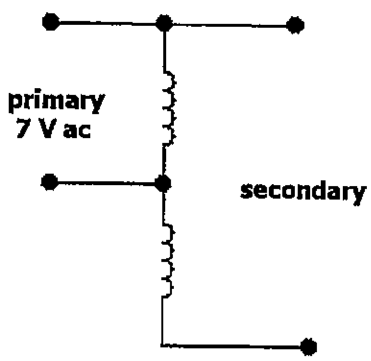


Fig 13.4

Note: You will not be using the high side of the transformer in tis part of the experiment. It would be a good idea to put a tape on the terminals so that you cannot touch them accidentally.

13- Let the full low side winding be the primary of a step-down autotansformer. Apply approximately 7 volts to the primary, as shown in Fig 13.3.

14- Measure the primary and secondary voltages and record these values in Table 13.3.

15- Turn off the power and reconnect the transformer so that half of the low side winding serves as the primary of a step-up autotransformer, as shown in Figure 13.4. Repeat Step 14.

Exciting Current	**Primary Voltage**	**Secondary Voltage**	**V_P/V_S**

Table 13.1

Load	**V_S**	**V_P**	**I_S**	**$I_{(P1-P2)}$**	**I_P**	**V_P/V_S**	**I_s/I_P**
500Ω							
100Ω							

Table 13.2

Autotransformer			
Step-down		**Step-up**	
V_P	**V_S**	**V_P**	**V_S**

Table 13.3

TRAY 51

PART NO.	DESCRIPTION	QTY
220	*Resistor, 220 ohms, 10%	2
223	*Resistor, 390 ohms, 10%	1
236	*Resistor, 4.7k ohms, 10%	1
241	*Resistor, 10k ohms, 10%	2
247	*Resistor, 33k ohms, 10%	1
255	*Resistor, 150k ohms, 10%	1
284	Resistor, 500 ohms, 10%, 5 watts	1
415	Potentiometer, 1k ohms, 5 watts	1
417	Potentiometer, 5k ohms, 2 watts	1
547	Diode, Silicon, 1N5625	4
568	Transistor, NPN, 2N2102	2
570	Transistor, PNP, 2N4036	1
728	Holder for "C" Cells	1
737	Relay, DC, DPDT	1
738	Lamp, Miniature with Socket	3
740	Solar Cell	1
748	Motor, DC Permanent Magnet	1

* May be either 1/4 watt or 1/2 watt.

LOOSE PARTS

729	Switch, SPST	3
731	Switch, DPDT	2
823	"C" Cell, 1.5 Volts	2
832	Bar Magnet	2
833	Compass	1
839	Thermocouple Wire, 1 ft.	1
840	Nichrome Wire, 2 ft.	1

220	223	241	247	415	547	547	568	570	728		738	740
220	236	241	255	417	547	547	568	284	737	748	738	738

TRAY 52

PART NO.	DESCRIPTION	QTY.
228	*Resistor, 1k ohms, 10%	3
240	*Resistor, 8.2k ohms, 10%	1
260	*Resistor, 470k ohms, 10%	1
262	*Resistor, 1 M ohms, 10%	1
422	Potentiometer, 500k ohm, 2 watts	1
531	Zener Diode, 1N3020	1
571	Transistor, NPN, 2N3904	2
611	Choke, 8H	1
617	Transformer, Filament, F26-X	1
736	Fused Line Cord	1
914	Capacitor, 0.001 MFD	2
919	Capacitor, 0.01 MFD	2
923	Capacitor, 0.1 MFD	1
929	Capacitor, 10 MFD	2
932	Capacitor, 25 MFD	1
937	Capacitor, 100 MFD	2

* May be either 1/4 watt or 1/2 watt.

228	240	260	571	531	617		914	919	929	923	937
228	228	262	571	736	422	611	914	919	929	932	937

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TRAY 53

PART NO.	DESCRIPTION	QTY.
225	*Resistor, 560 Ohms, 10%	1
244	*Resistor, 18 kohms, 10%	1
256	*Resistor, 220 kohms, 10%	1
278	Resistor, 100 ohms, 10%, 2 watts	2
300	*Resistor, 470 ohms, 10%	1
622	Coil, 30mH	1
911	Capacitor, 47 PFD	1
913	Capacitor, 250 PFD	1
922	Capacitor, 0.05 MFD	3
924	Capacitor, 0.5 MFD	1
932	Capacitor, 25 MFD	2
937	Capacitor, 100 MFD	2
945	Capacitor, 1 MFD	1

* May be either 1/4 watt or 1/2 watt

	225	278	256	911	922	922	932	937	622	
	244	278	300	913	922	924	932	937	945	

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TRAY 56

PART NO.	DESCRIPTION	QTY.
712	Tube Socket, 9-pin	1
727	Speaker	1
749	PC Board, RF Amplifier	1
750	PC Board, Converter	1
751	PC Board, IF Amplifier	1
752	PC Board, Detector	1
753	PC Board, Audio Amplifier	1
621	Antenna Coil	1
970	Capacitor, 1 PFD	1

LOOSE PART

873	Vacuum Tube, 6BN8	1

	712	749	751	752	970
	621	750	753	727	

TRAY 55

PART NO.	DESCRIPTION	QTY.
217	*Resistor, 150 ohms, 10%	1
229	*Resistor, 1.2 kohms, 10%	1
233	*Resistor, 2.2 kohms, 10%	1
251	*Resistor, 68 kohms, 10%	1
264	*Resistor, 2.2.Mohms, 10%	1
266	*Resistor, 4.7 Mohms, 10%	1
273	*Resistor, 5.1 kohms, 10%	1
282	Resistor, 5 ohms, 5 watts, 10%	1
418	Potentiometer, 10K ohms, 2 watts	1
537	JFET, 2N5459	1
567	MOSFET, 3N187 or SK3065	1
613	Transformer, Input, 155-08	1
614	Transformer, Output, 175-45	1
620	Hartley Oscillator Coil	1

* May be either 1/4 watt or 1/2 watt

	217	233	264	273	537	418	613	
	229	251	266	282	567	620	614	

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TRAY 54

PART NO.	DESCRIPTION	QTY.
216	*Resistor, 100 ohms, 10%	1
230	*Resistor, 1.5k ohms, 10%	1
235	*Resistor, 3.3k ohms, 10%	1
239	*Resistor, 6.8k ohms, 10%	2
249	*Resistor, 47k ohms, 10%	2
254	*Resistor, 120k ohms, 10%	2
286	Resistor, 50 ohms, 10% , 10 watts	1
287	Resistor, 300 ohms, 10%, 10 watts	1
289	Resistor, 5k ohms, 10%, 10 watts	1
419	Potentiometer, 25k ohms, 2 watts	1
548	SCR, 2N1597	1
549	UJT, 2N2160	1
572	Transistor, PNP, 2N2907	1
715	Pushbutton, N.O.	2
734	Varistor	1
735	Thermistor	1
739	Neon Bulb	1
741	Laminated "U" Core Section	1
746	Photocell, CL703	1
925	Capacitor, 1 MFD	1
936	Capacitor, 50 MFD	1

* May be either 1/4 watt or 1/2 watt.

LOOSE PARTS

628	100-Turn Coil	1
629	200-Turn Coil	1
835	Laminated "I" Core Section	1

	216	230	239	249	254	286	548	572	734	739	925	419	715
	289	235	239	249	254	287	549	572	735	746	936	741	