References

CATHODE RAY OSCILLIOSCOPE(C.R.O)

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Unique Paper Code: 32221202

Paper Title: Waves and Optics Lab

Submitted on: June 16, 2021

Due On: June 17, 2021

File Name: 1140_CRO/1164_CRO

B.Sc(H) Physics Sem II

Submitted to: Dr. SHAAN AMEER

1 AIM

1. To trace each of the voltage waveforms generated by the given circuit, and to measure frequency and amplitude on a virtual cathode-ray oscilloscope (vCRO)
2. To measure the phase difference (ϕ) of the voltage waveforms generated by the given circuit
3. To trace the Lissajous figure that is obtained corresponding to superposition of the voltage waveforms generated by the given circuit using a vCRO.
4. To plot the variation of (ϕ) as a function of frequency for fixed value of R= 100Ω

2 Apparatus required to perform experiment in lab

- AC Power source
- Oscillioscope
- Resistance
- Inductance/Capacitance
- Voltmeter etc.

3 THEORY

3.1 CATHODE RAY OSCILLIOSCOPE

The cathode ray oscilloscope (C.R.O.) is one of the essential instrument in the physics laboratory to study d.c. as well as a.c. electric voltage variations in its magnitude and direction. We can visualize the exact nature of waveform of an a.c. voltage, particularly in amplifiers and oscillators.

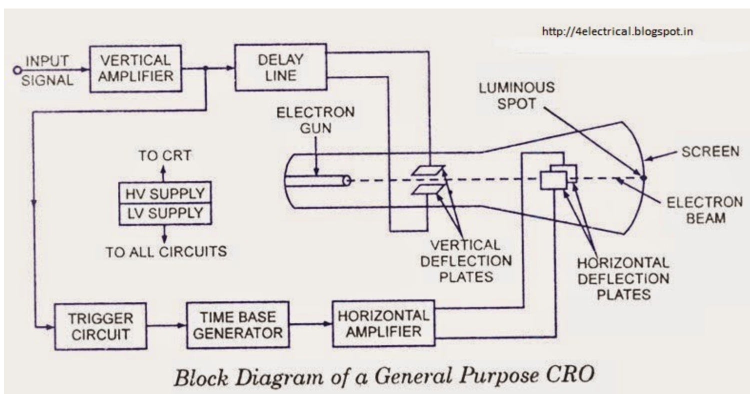
3.1.1 Cathode Ray Tube (C.R.T.)

It consists of an evacuated glass envelop in which are an electron gun, two sets of deflection plates, focussing arrangement and a fluorescent screen.The screen is coated with a desired fluorescent material that will emit light when an electron beam strikes on the screen. The colour of spot at which the cathode rays impinge on the screen depends upon the phosphor coated inside the screen. For example:

green : Zn silicate doped with Mn.

blue : ZnS doped with Ag.

red : Zn phosphate doped with Mn.



Block Diagram of a General Purpose CRO [?]

3.1.2 Time-base generator

It is a saw-tooth voltage generator which provides a uniform time scale along X -axis against which another voltage can be plotted by applying it to the vertical deflection plates.

3.1.3 Synchronization

When the frequency of sweep generator is made equal to the frequency of applied signal or some integral multiple ($nf, n = 1, 2, 3 \ldots$), then the sweep generator is called a synchronized sweep.

3.2 LISSAJOUS FIGURES

When a particle is acted upon simultaneously by two simple harmonic motions at right angles to each other, the resultant path traced out by the particle is called the Lissajous' figure. Let the vibrations are of equal frequencies and are along X and Y axes, such that

$$x = a \sin \omega t$$

and

$$y = b \sin(\omega t + \theta)$$

The resultant will be given by

$$\frac{y}{b} = \sin \omega t \cos \theta + \cos \omega t \sin \theta$$

$$= \tfrac{x}{a} \cos \theta + \sqrt{1 - \tfrac{x^2}{a^2}} \sin \theta$$

or

$$\tfrac{x^2}{a^2} + \tfrac{y^2}{b^2} - \tfrac{2xy}{ab} \cos \theta - \sin^2 \theta = 0$$

For,

$\theta = 0$, The resultant will be double straight line in the I and III quadrants.

$\theta = \pi/4$, The resultant will be oblique ellipse with major axis in I and III quadrants. $\theta = \pi/2$, The resultant will be symmetrical ellipse (or circle for $a = b$)

$\theta = 3\pi/4$, The resultant will be oblique ellipse with major axis in II and IV quadrants.

3.3 LR SERIES AC CIRCUIT

In an A.C. circuit containing L and R in series, the voltage across the inductor (V_L) leads the voltage across the resistor (V_R) by a phase angle $\pi/2$ i.e. $90°$ so that the resultant voltage across L_R combination i.e. V_{LR} leads the voltage (or the current I across R by a phase angle ϕ given by $\tan\phi = \frac{Lw}{R}$ where $Lw = X_L$ = reactance due to inductance and $w = 2\pi f$ where f is the frequency of A.C.

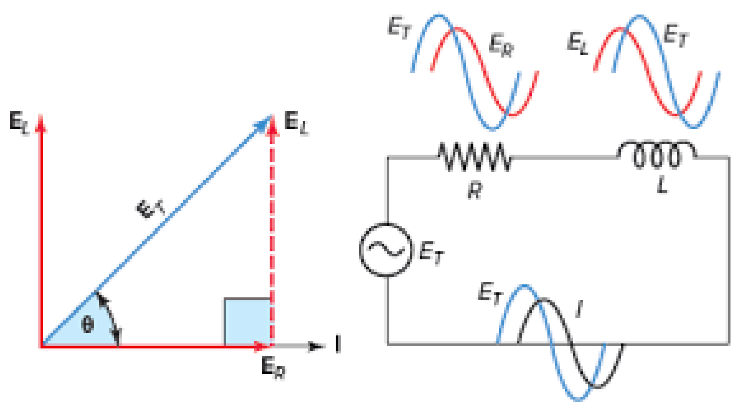


Figure 1: R-L Circuit rl$_circuit$

4 PROCEDURE

4.1 Procedure for vCRO

1. Place the components
   - Tap the Source subpalette and tap AC Voltage and tap on the workspace.
   - Place a resistor and inductor by dragging from the Passive subpalette.
   - Place a ground connector by dragging from the Schematic Connectors subpalette.

- Place Voltmeter and its reference probes.

2. Streaming data to Oscillioscope
    - Click either through  the access command or the button on the top right.
    - Select voltage probes and click OK
3. To measure phase shift
    - Use cursors to read specific datapoints on a graph. Drag cursors from their handles (C1, C2), or anywhere along the cursor.
    - Measure T_d by adjusting C1 and C2.
    - Note down T_p
    - $\theta = T_d/T_p \times 360 = 10ns/100ns \times 360^\circ \times \pi/180 = \theta_{rad}$

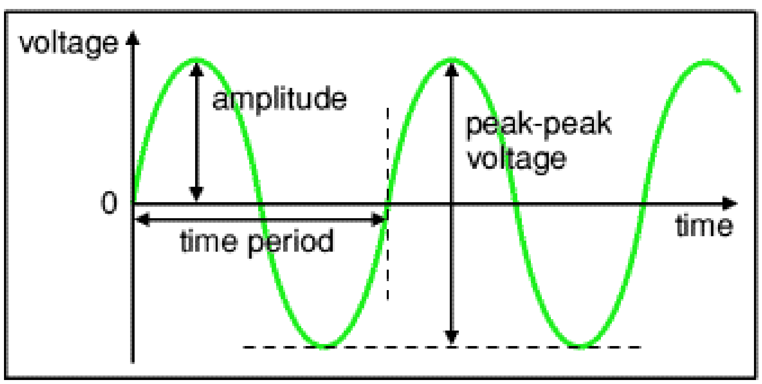


Figure 2: CRO Display with Labels [?]

4.2 Procedure for physical Oscillioscope

- Switch 'ON' the Time/Base CRO.
- Connect the unknown A.C. source to Y - INPUT (VER-INPUT) of the CRO.
- By using focus and INT knobs, obtain a sharp waveform on the screen. Now adjust TimeBase selector switch to get distinct number of waves which will be countable on the screen.
- The waveforms (sinusoidal, rectangular or any shape) are centered by HOR-SHIFT and VER-SHIFT knob and of proper amplitude using VER-GAIN.
- Set the cross wire at k^{th} ring then move towards 20^{th} and note down the reading.
- the scale count the maximum number of complete waves and the note down the distance (in cm) occupying these waves. Note down the Time-Base you have selected.
- Change the Time-Base and again repeat above procedure.

5 EXPERIMENT DATA AND CALCULATIONS

Input voltage is sinusoidal with peak-to-peak value(V_p = 20 V)

Frequency(ω) = 100Hz

Team Number = 29

Value of Inductance, L = Team no. $\times$100mH = $2.9H$

Resistance of inductor = 100 Ω

Phase Difference(θ) = $T_d/T_p \times 360$

=10 n s / 100 n s $\times 360° \times \pi/180 = \theta_{rad}$

Here, T_d and T_p are time delay and time period respectively

x = $A_x\sin(2\times\omega \times t)$

y = $A_y\sin(2\times\omega \times t + \theta)$

Here, A_x and A_y are peak amplitude of x and y waveform

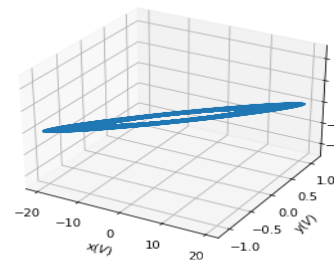
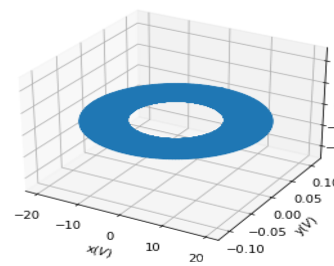
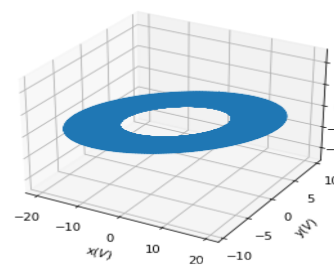
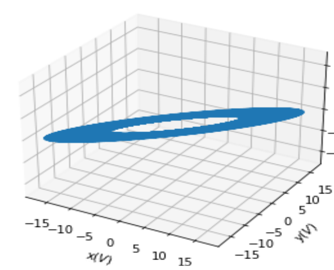
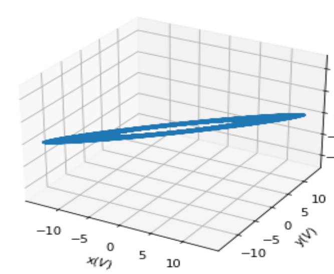
R(Ω)	A_{x} (V)	A_{y} (V)	T_{d}(ms)	T_{p}(ms)	θ(rad)	Lissajous Figures
0.1	19.97	1.093	2.8125	10	6.08375	
10	19.97	0.1093	2.5	10	1.57	
1K	19.97	9.56	1.875	10	1.1775	
100K	17.005	16.865	0.625	10	0.3925	
1M	13.54	13.555	0.3125	10	0.19625	

Table 1: Table for Lissajous Figures with variable resistance

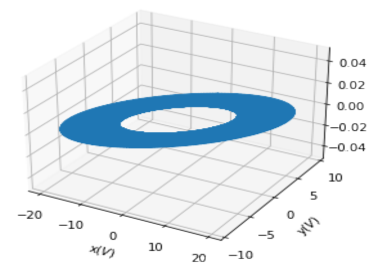
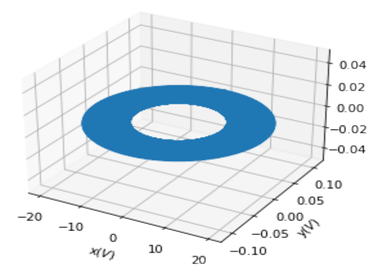
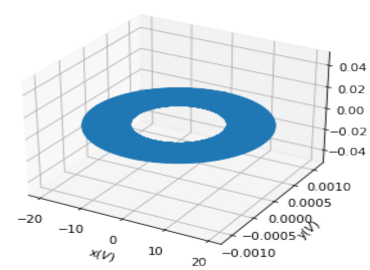
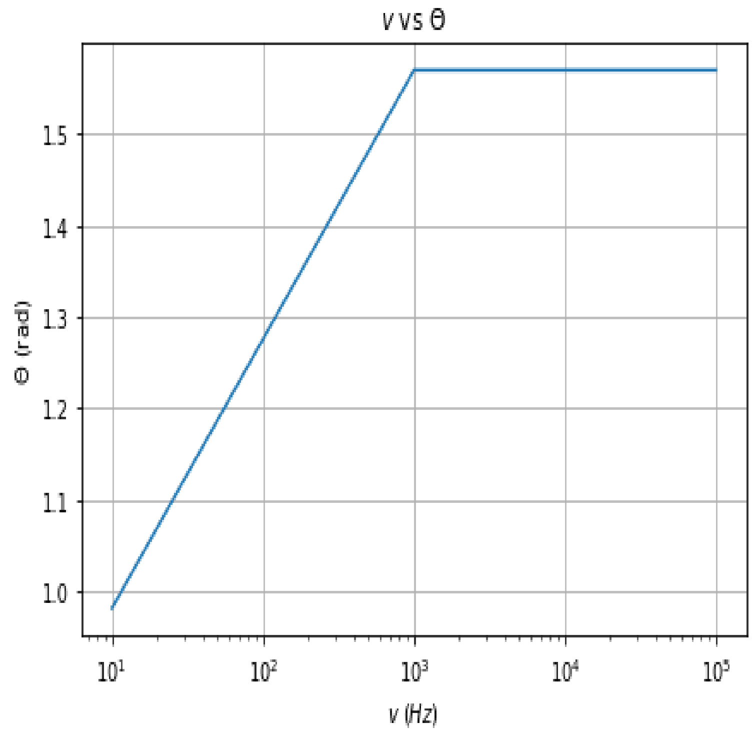
v (Hz)	A_{x} (V)	A_{y} (V)	T_{d}(ms)	T_{p}(ms)	θ(rad)	Lissajous Figures
10	19.97	9.33	15.625	100	0.98125	
1K	19.97	0.1093	0.25	1	1.57	
100K	19.97	0.0010925	0.0025	0.01	1.57	

Table 2: Table to form Lissajous Figures with variable Frequency

6 Plotting variation of (ϕ) as a function of frequency for fixed value of R= 100Ω



7 Discussion of Result

- We measure time delay and thus the phase difference.
- We plotted Lissajaus's Figures accordingly.
- We went through the theory of experiment by sharing links with info of concerned points and definitions.
- We worked together on simulator by sharing screen via GMeet.

- At last we jotted down the final results in a single PDF.

8 Programming Code

```
import numpy as np
import matplotlib.pyplot as plt
import pandas as pd

def res_var():
    data = pd.read_csv('var_res.csv')
    A_x = data['Ax(in V )']
    A_y = data['Ay(in V )']
    delta = data['delta( in rad)']
    t = np.linspace(-np.pi,np.pi,300)

    for i in range(0,5):
        x = A_x[i]*np.sin(2*100* t)
        y = A_y[i]*np.sin(2*100* t + delta[i])
        fig = plt.figure()
        ax = plt.axes(projection='3d')
        ax.set_xlabel("x($V$)")
        ax.set_ylabel("y($V$)")
        plt.tight_layout()
        ax.grid(True)
        plt.plot(x,y)
        plt.show()

def freq_var():
    data = pd.read_csv('var_freq.csv')
    A_x = data['Ax(in V )']
    A_y = data['Ay(in V )']
    delta = data['delta( in rad)']
    t = np.linspace(-np.pi,np.pi,300)

    for i in range(0,3):
        x = A_x[i]*np.sin(2*100* t)
        y = A_y[i]*np.sin(2*100* t + delta[i])
        fig = plt.figure()
        ax = plt.axes(projection='3d')
        ax.set_xlabel("x($V$)")
        ax.set_ylabel("y($V$)")
        plt.tight_layout()
        ax.grid(True)
        plt.plot(x,y)
        plt.show()

def delta_vs_freq():
    data = pd.read_csv('var_freq.csv')
    delta = data['delta( in rad)']
    freq = data['v(Hz)']

    plt.xscale('log')
    plt.tight_layout()
```

```
    plt.grid(True)
    plt.xlabel("$v$ $(Hz)$")
    plt.ylabel("$\Theta$ (rad)")
    plt.title("$\Theta$ vs $v$")
    plt.plot(freq,delta)
    plt.show()

def freq_not():
    data = pd.read_csv('var_freq.csv')
    v = data['v(Hz)']
    Ax = data['Ax(in V )']
    Ay = data['Ay(in V )']
    fig, ax = plt.subplots()
    ax.plot(v,Ax)
    ax.plot(v,Ay)
    ax.set_xlabel("$A_x(V)$")
    ax.set_ylabel("$A_y(V)$")
    plt.xticks(np.arange(12, 21, 1.0))
    plt.yticks(np.arange(0, 18, 2.5))
    #ax.annotate("(17,17)", (17,17),xytext=(17,17))
    plt.title("$A_x$ vs $A_y$")
    plt.grid(True)
    plt.show()



if __name__ == "__main__":
    res_var()
    freq_var()
    delta_vs_freq()
```

9 Precautions

- The Time-Base must be selected properly.
- The pattern must be steady. Hence locking must be done by SYNC. control.
- The beginning of first wave should start from extreme left of the scale.
- Note down carefully the distance L on X -axis that occupies n waves.
- For more accuracy, take maximum number of waves on the screen (of course complete waves).

10 RESULT

Lissajous Figures formed successfully.

11 Contribution of each Partner

Partner A
Name: Anjali
Roll No. : 2020PHY1164
Contributions :

1. Theory
2. Procedure
3. Experiment Data and Calculations
4. Error Correction

Partner B
Name: Preetpal Singh
Roll No. : 2020PHY1140
Contributions :

1. Theory
2. Procedure
3. Experiment Data and Calculations
4. Programming Code

12 REFERENCES

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