Principles of Physics II (PHY112)

Lab

Experiment no: 9

Name of the experiment: Determination of the line frequency of Alternating Voltage signal generated by the electric power plant with the help of an alternating voltage signal of known frequency by forming Lissajous curves in an oscilloscope and the determination of the time base of the oscilloscope

YOU HAVE TO BRING TWO GRAPH PAPERS (cm scale) TO DO THIS EXPERIMENT.

Theory

Alternating current periodically alternates its direction while flowing through a wire. If the alternating current is *sinusoidal* then its magnitude gradually increases from zero to a maximum value towards one direction. This maximum value is the *amplitude* of the alternating current. Then, it decreases down to zero while flowing in this direction. Next, it begins flowing to the opposite direction and its magnitude gradually increases to that direction to reach maximum, i.e. amplitude. After that, its magnitude gets reduced to zero while flowing in the latter mentioned way. Thus a full cycle is completed by the alternating current. Then, again it begins flowing to the first direction and keeps the whole process continuously repeating. The number of complete cycles made by this alternating current per unit time is called its frequency.

Our power plant generates Alternating Current which we use for running our everyday's major electronic devices. In the first part of this experiment we are going to determine the frequency of this Alternating Current, called *power line frequency*. To transmit electrical power efficiently the power plant transmits the power at an alternating voltage of high amplitude and by means of an alternating current of low amplitude[1]. For safer use of this electric power we have to use a step down transformer to transform this alternating voltage of higher amplitude (and current of lower amplitude) to alternating voltage of lower amplitude (and current of higher amplitude). From the electric socket we get the alternating voltage output which is produced by the power plant. A step down transformer receives it as an input and gives an alternating voltage of lower amplitude as an output. However, the frequency of the output alternating voltage remains equal to that of the input alternating voltage. This is the power line frequency which we will determine by using the output alternating voltage.

[1] To know why power is transmitted at alternating voltage of higher amplitude and by means of an alternating current of lower amplitude, you can read this page: https://en.wikipedia.org/wiki/Alternating_current

Cathode Ray Oscilloscope

By using an oscilloscope we can visualize how an alternating voltage signal varies with time. Now, I will briefly discuss the working principle of a Cathode Ray Oscilloscope. In such an oscilloscope there is an electron gun as shown in the Figure 1. A coil is connected between two terminals A and B. A potential difference is created between A and B. The terminal A is positive and the terminal B is negative. The current passing through the coil heats up it to emit electrons. Potential difference between A and B heats up the coil. That is why it is called heater voltage.

There is a circular metallic disc, a short distance away from the coil, having a co-centric circular hole in it. This metallic disc is connected with a terminal C. Another voltage difference is created between B and C. B is negative and C is positive. Electrons emitted from the coil get attracted to the positive metallic disc and get accelerated to rush towards the disc. Since, the positive metallic disc attracts negative electrons; the metallic disc is the anode. On the other hand Coil which emits electrons is the cathode. The accelerated beam of electrons passes through the circular hole of the anode. This flow of electrons is called *Cathode Ray*. The system to produce cathode ray is called *cathode ray gun* or *electron gun*.

The cathode ray passes through a way between two horizontal plane metal plates as shown in the Figure 1. The plates are connected with two electrodes D and E which receive the input voltage signal- subject to our inspection. Voltage signal between D and E oppositely charges the metal plates. Figure 1 shows that at this moment the upper plate is positively charged and the lower one is negatively charged. Electrons, which are by nature negatively charged, will be attracted to the positive plate and will get deflected upward. Suppose, sinusoidal alternating voltage difference is provided between D and E and now the voltage difference is maximum. Next, as time moves on, the positive charge of the upper plate will gradually decrease and negative charge of the lower plate will also gradually decrease. As a result the amount of upward deflection of the cathode ray will gradually decrease. When the electrodes change their polarity the cathode ray gets deflected downward. The downward deflection increases with time, as positive voltage of E and negative voltage of D increase. After the voltage difference reaches maximum, the process reverses. Electrons begin getting deflected upward again. Hence, the alternating voltage input between the terminals D and E forces the cathode ray to oscillate vertically.

Next, the cathode ray passes through a way between two vertical plane metal plates. They are connected with another couple of terminals F and G which can receive alternating voltage signal. Convince yourself that the alternating electric field created between these two plates by the alternating voltage difference between F & G will force the cathode ray to oscillate horizontally.

Finally, the cathode ray strikes a screen of the display box of the oscilloscope. The screen is covered with fluorescent zinc sulfide layer. The point glows where the ray strikes. The screen is marked with horizontal and vertical gridlines.

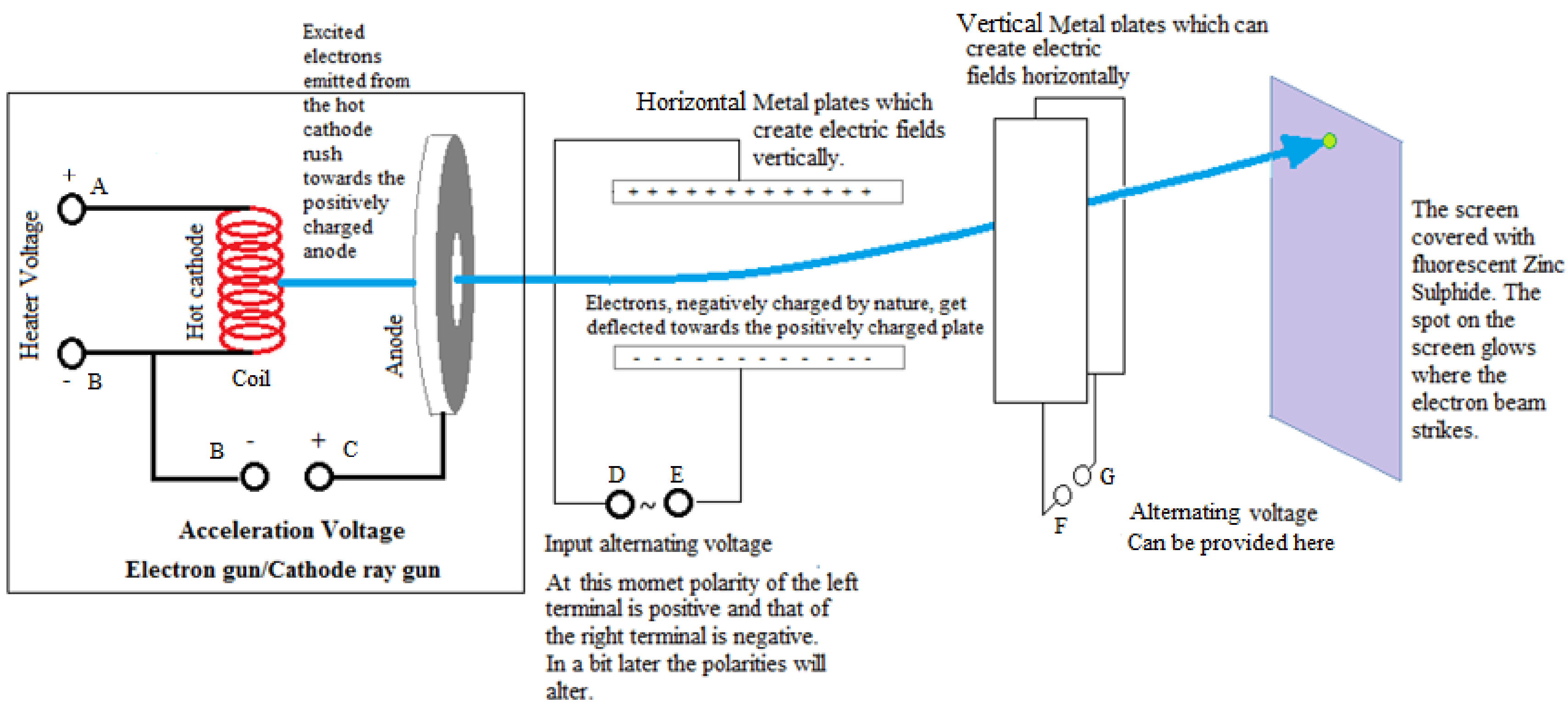


Figure 1: Internal view of a cathode ray oscilloscope

The amount of maximum deflection of the cathode ray depends on the speed of the electrons and the amplitude of the alternating electric field's magnitude between the plates. If the amplitude of the alternating voltage difference between D and E increases, then amplitude of the electric field's magnitude between the plates increases and the maximum deflection of the electron beam also increases. If voltage difference between B and C, i.e. acceleration voltage increases then speed of the electrons increases and the maximum deflection decreases. In the oscilloscope there is a knob called 'Volts/Div control'. The pointer of this knob indicates how much voltage difference a single vertical division represents along Y axis. The oscilloscope is engineered in such a way that by rotating this knob acceleration voltage can be modulated and/or the voltage signal between D and E can be amplified or diminished to see bigger or smaller deflection. However, **by rotating Volts/Div knob the input voltage given between the plates (here, horizontal plates) cannot be changed.** By rotating this knob the amplitude of oscillation of the bright spot (where the cathode ray strikes on the screen) may be varied but the voltage represented by every vertical division changes accordingly to display the actual amplitude of input voltage.

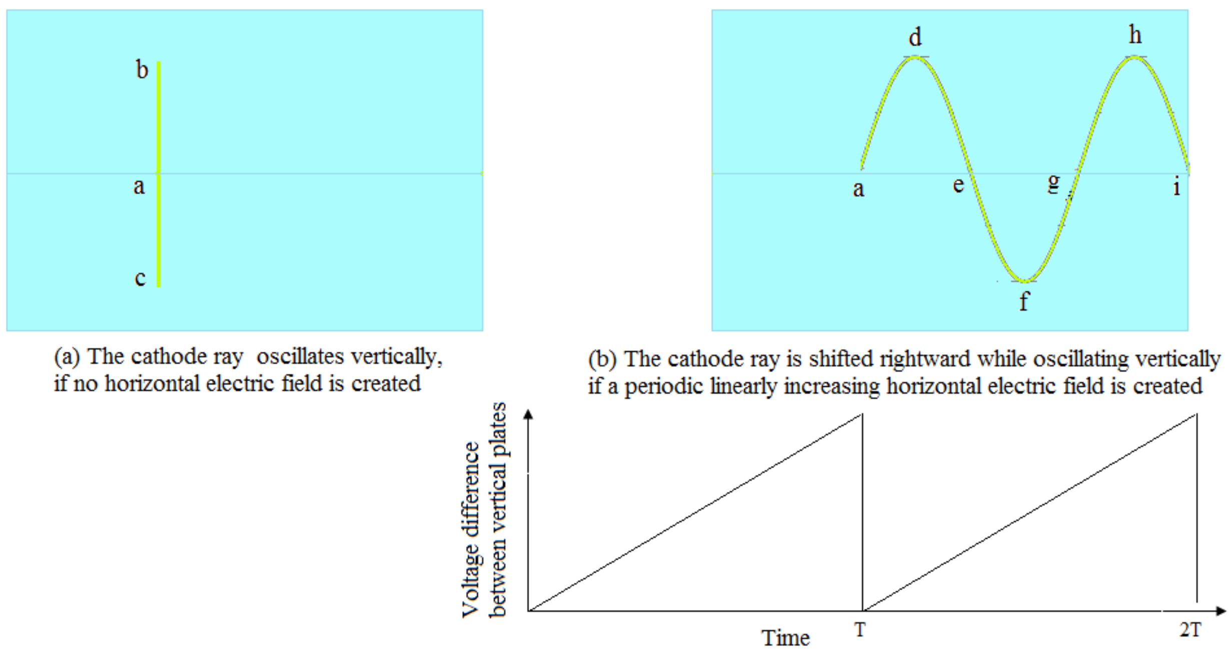
Visualization of Voltage versus Time Curve

If only D and E terminals take an input voltage difference between them, and no voltage difference is given between F and G, then the bright spot oscillates vertically. If the period of oscillation is less than 1 ms then oscillation occurs too fast to detect a single bright spot moving with time. Instead of that we see a bright vertical line.

To visualize how the input voltage signal varies with time, the cathode ray should be shifted towards horizontal direction. To do so the oscilloscope itself provides a periodic voltage difference between F and G terminals (which are connected with vertical plates in Figure 1). We call it *Sweeping Voltage.* If the voltage vs. time graph is plotted for this alternating voltage signal, then the shape of this graph seems to be a series of right triangles (Figure 2(c)).

Figure 2(a) implies that the bright spot oscillates vertically when voltage difference between vertical plates, and as well as the horizontal electric field created by it, is not there. Say, at time T the spot is at point 'a'. Then it moves upward to reach the topmost point 'b'. Next, it moves downward and reaches 'a'. After that it keeps moving continuously downward and reaches the bottommost point 'c'. Then again it moves upward. Now, suppose a linearly increasing periodic voltage difference (*sweeping voltage*) is applied between the vertical plates, as shown in the Figure 2(c). At time T the spot is at 'a' (Figure 2(b)) but from now on, it will get deflected rightward as it moves upward. Its rightward deflection increases with the linearly increasing sweeping voltage (Figure 2(c)). The bright spot moves along the sinusoidal curve through the points: a-d-e-f-g-h-i. Then at time 2T, the sweeping voltage suddenly drops down to zero and the bright spot almost instantaneously returns to the point 'a'. Then again another cycle starts. During time 2T to 3T the bright spot will again moves along the curve shown in the Figure 2(b). The time period of sweeping voltage is T.

We see that, in this example the bright spot completes $1\frac{1}{2}$ cycles during the period of T. Hence, we can find out the period of oscillation of the input voltage given between the horizontal plates, that is $\frac{2}{3}$T. If this input voltage signal makes *n* cycles during the time period of the sweeping voltage then the time period of the input voltage is T/*n*.



(a) The cathode ray oscillates vertically, if no horizontal electric field is created

(b) The cathode ray is shifted rightward while oscillating vertically if a periodic linearly increasing horizontal electric field is created

(c) Triangular shaped voltage difference between vertical plates vs. time graph

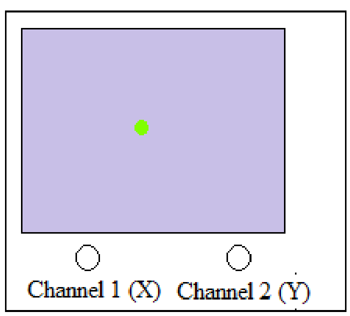
Figure 2: When a periodic linear *sweeping voltage* is applied between the vertical plates, trajectory of the bright spot (where the cathode ray strikes) represents the input voltage vs. time curve.

There is a knob called “Time/DIV control” in the oscilloscope. The pointer of this knob indicates the amount of time a single horizontal division (printed on the screen of the oscilloscope) represents. This is the *time base* of the oscilloscope. The time period of the sweeping voltage can be regulated by rotating this knob and the time represented per horizontal division will be varied accordingly. **By rotating Time/DIV control knob, the time period of the input voltage difference between the horizontal plates cannot be changed.**

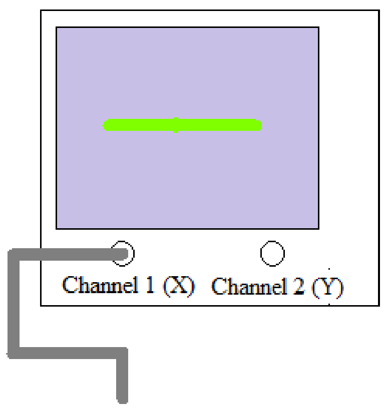
To generate a voltage vs. time curve on the screen, the ‘x-y’ button of the oscilloscope should be turned off. Usually, an oscilloscope has two channels (Channel 1 and Channel 2) to receive input voltage signal(s). By using a special switch, we can select the input voltage signal (s) from either of these two or both channels, to convey to the horizontal metal plates. Then the oscilloscope itself generates the sweeping voltage to produce the voltage vs. time curve for the chosen input voltage signal.

Generating Lissajous curves

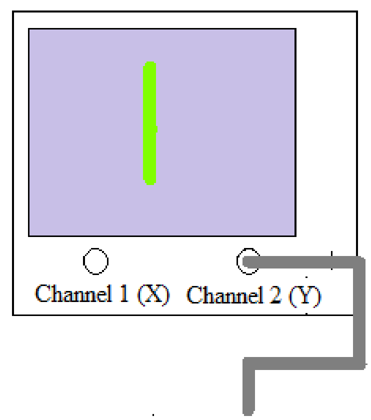
If the ‘x-y’ button of the oscilloscope is turned on then the oscilloscope does not generate any sweeping voltage between the vertical metal plates. Between the input voltage differences received by two outer channels, one is provided between horizontal metal plates and the other one is provided between the vertical metal plates. Suppose, the input voltage signal received by Channel 1 (X) is provided between the vertical metal plates which will force the cathode ray to oscillate horizontally along X axis and the voltage signal received by Channel 2 (Y) is provided between the horizontal metal plates which will force the cathode ray to oscillate vertically along Y axis.



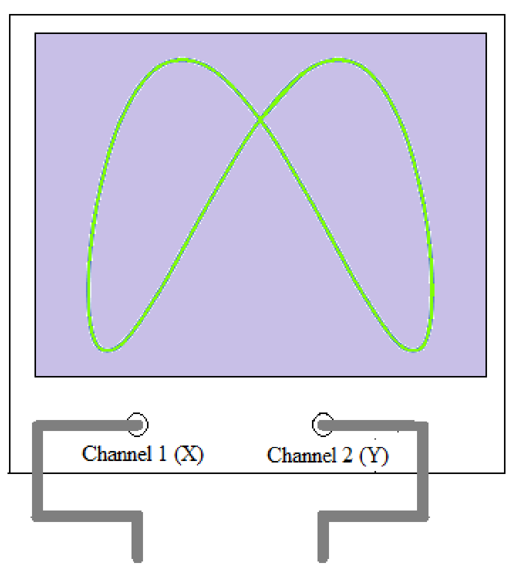
(a) A bright spot will be seen if no voltage signal is received by the channels



(b) Horizontal line will be displayed if only channel 1 (x) receives an input voltage.



(c) Vertical line will be displayed if only channel 2 (y) receives an input voltage.



(d) Curves of different shapes will be formed when both channels receive alternating voltage signals.

Figure 3: Graphs generated on the display screen when ‘x-y’ button is turned on. Horizontal plates receive voltage difference between them from the Channel 2 (Y). Vertical plates receive voltage difference between them from the Channel 1 (X).

Figure 3 shows the graphs generated on the display screen in different situations when the ‘x-y’ button is turned on. If no voltage signal is given through Channel 1 and 2, then no electric field will be created between the two couples of metal plates and the cathode ray will not get deflected. We see a bright spot on the screen where the beam strikes (Figure 3(a)). If we apply a voltage signal in Channel 1 only (Figure 3(b)), then this signal will be conveyed to the vertical plates and horizontal alternating electric field will be created which will force the cathode ray to oscillate horizontally. Since no voltage signal is given in Channel 2, there is no potential difference between the horizontal plates, hence no vertical alternating electric field will be created to force the cathode ray oscillate vertically. We see a bright horizontal line which is the trajectory of the bright spot on the screen. Similarly, a vertical trajectory of the bright spot is created on the screen when only Channel 2 receives an input alternating voltage signal.

When input alternating voltage signals are applied through both channels (Figure 3 (d)), then periodic electric field generated by the input voltage signal of Channel 1 (X) tries to force the cathode ray oscillate horizontally and the periodic electric field generated by the input voltage signal of Channel 2 (Y) tries to force the cathode ray oscillate vertically. The combined result of the two alternating voltage inputs will be the curves of different forms, depending on the frequencies and amplitudes of the input voltages.

If the lines of action of two sinusoidal forces are perpendicular to each other and they are both applied on a single particle, then the trajectory of the particle, projected on the plane of the lines of action of two forces, forms a Lissajous (/ˈlɪsəʒuː/) curve. “Lissajous figure is the graph of a system of parametric equations: $x = A\sin(at+\delta), y = B\sin(bt)$ where t is the parameter; a, b, A, B and δ are constants” (Wikipedia).

Determining the Ratio of the Time Periods of two Alternating Voltage Signals by Observing Lissajous Curves

We can figure out the ratio of the time periods of the alternating voltages which create the Lissajous curves on the display screen of the oscilloscope. Let, T_x is the time period of the voltage signal which creates horizontal electric fields and T_y is the time period of the voltage signal which creates vertical electric fields. In other words T_x and T_y are the periods of oscillation along X and Y axes respectively. See Figures 4, 5 and 6. In every case, let A is the starting point of the bright spot. The projection of point A on the X and Y axes are x_o and y_o respectively. As the bright spot moves around the Lissajous curve, think about the projection of the position of this moving bright spot on the both axes. Count how many number of times the bright spot’s projection on x axis completes full cycle along X axis (by returning to x_o) and how many number of times the spot's projection on Y axis completes full cycle along Y axis (by returning to y_o), for making a complete cycle around the curve.

In Figure 4, we see a one loop pattern of Lissajous curve. The bright spot moves along the curve in the following order:
A-B-C-D-A
It makes a complete cycle along Y axis when it completes the whole A-B-C-D-A loop.
On the other hand, the spot makes a single cycle along X axis too, when it completes the whole A-C-D-B-A closed path.

Hence, the time during which the spot completed one cycle along X axis, it makes one cycle along Y axis. Therefore,

$$T_x/T_y = 1$$

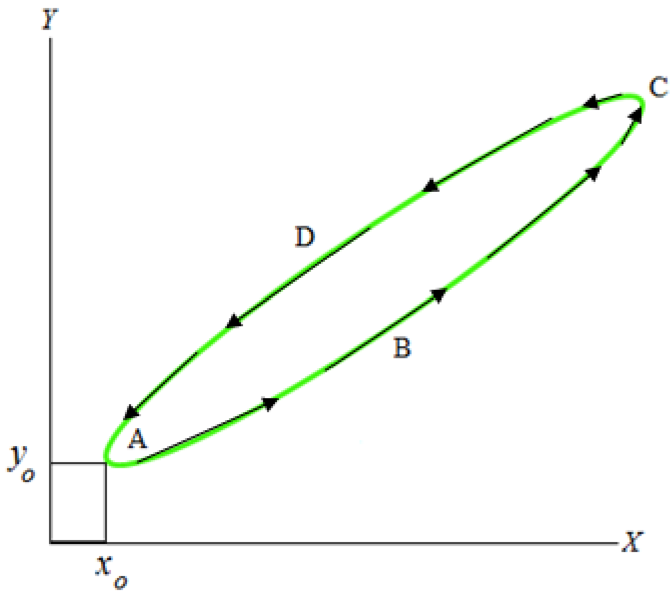


Figure 4: 1 loop pattern

In Figure 5 we see a Lissajous curve of two loops (horizontal) pattern. The bright spot moves along the curve in the following order:
A-B-C-D-A

The bright spot makes a ful cycle along Y axis when it completes the portion A-B-C of the trajectory. The bright spot makes another full cycle along Y axis when it completes the portion C-D-A.
On the other hand, along X axis the spot makes a single full cycle when it completes the whole A-B-C-D-A loop.

Hence, the time during which the spot completed one cycle along X axis, it makes two cycles along Y axis. Therefore,

$$T_x/T_y = 2$$

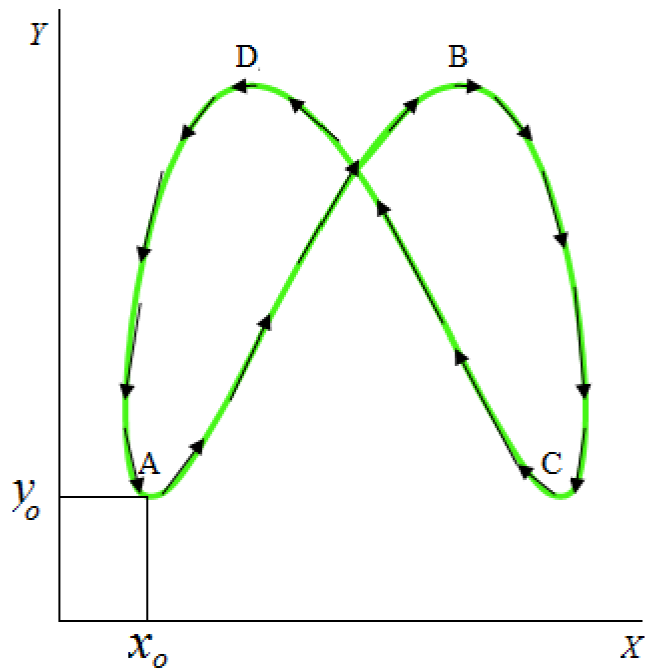


Figure 5: 2-loops (horizontal) pattern

In Figure 6 we see a Lissajous curve of three loops (horizontal) pattern. The bright spot moves along the curve in the following order:
A-B-C-D-E-F-A

The bright spot makes a full cycle along Y axis when it completes the portion A-B-C of the trajectory. Then the bright spot makes another full cycle along Y axis when it completes the portion C-D-E. Next, it makes the third full cycle along the same axis when it completes the portion E-F-A.

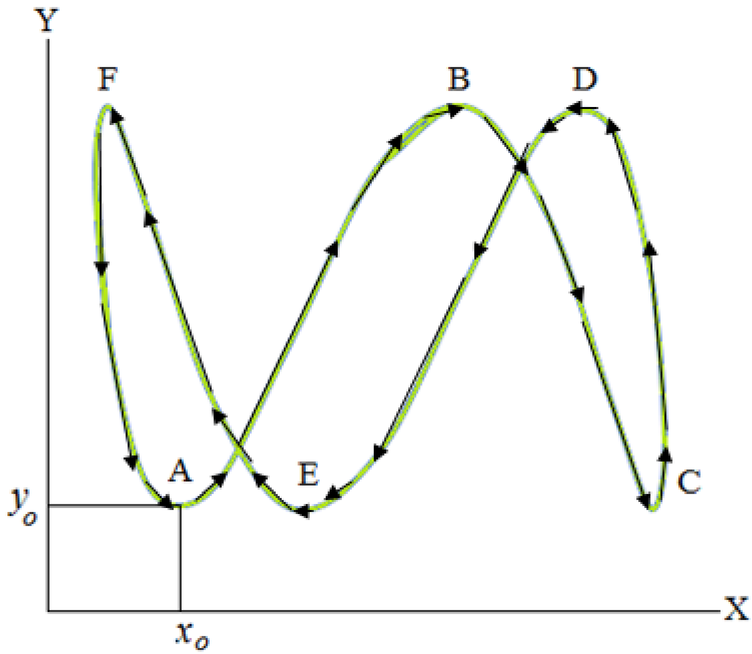


Figure 6: 3 loops (horizontal) pattern

On the other hand along X axis the spot makes a single full cycle when it completes the whole A-B-C-D-E-F-A closed path.
Hence, the time during which the spot completed one full cycle along X axis, it makes three full cycles along Y axis. Therefore,

$$T_x/T_y = 3$$

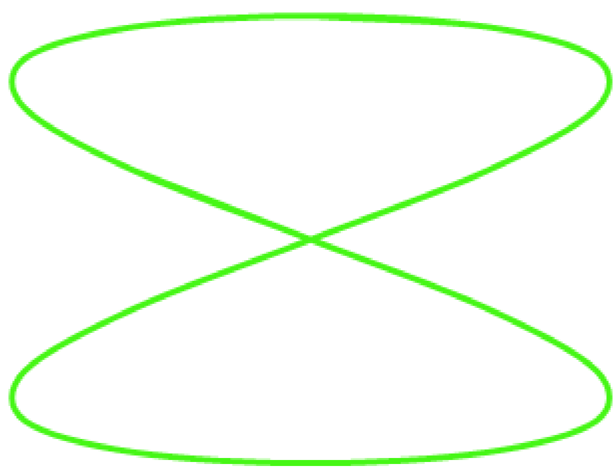


Figure 7: 2 loops (vertical) pattern

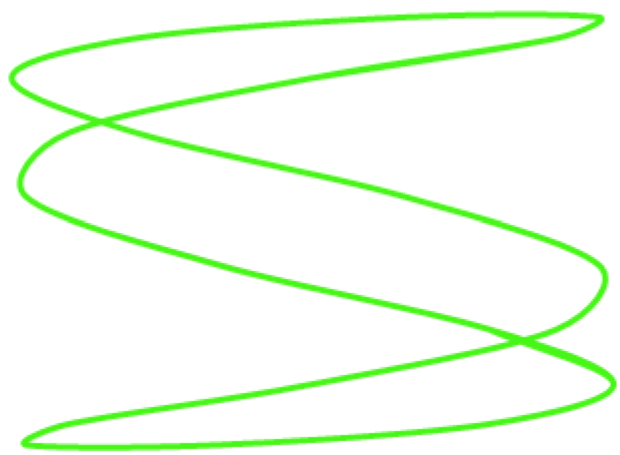


Figure 8: 3 loops (vertical) pattern

In the same way we can argue that in the case of a Lissajous curve of 2 loops (vertical) pattern as shown in Figure 7,

$$T_x/T_y = 1/2$$

In the case of a Lissajous curve of 3 loops (vertical) pattern as shown in Figure 8,

$$T_x/T_y = 1/3$$

By analyzing all the exemplar curves we can formulate the following rule:

$$\frac{T_x}{T_y} = \frac{n_y}{n_x} \tag{1}$$

Here, n_x = number of full cycles completed along x axis for a complete cycle around the Lissajous curve

n_y = number of full cycles completed along y axis for a complete cycle around the Lissajous curve

We know that the frequency of a body in simple harmonic motion is inversely proportional to the time period. Suppose, f_x and f_y are the frequencies of the voltage signals given in Channel 1 (X) and Channel 2 (Y) respectively. Therefore,

$$\boxed{\frac{f_x}{f_y} = \frac{n_x}{n_y}} \tag{2}$$

Determination of the Time Base

Now, the ‘x-y’ button of the oscilloscope is turned off. An input alternating voltage signal is given through either Channel 1 or Channel 2. This voltage signal produced alternating potential difference between the horizontal plates. The oscilloscope itself will generate the sweeping voltage difference between the vertical plates. A voltage vs. time curve (Figure 9) is generated on the display screen. We want to determine ‘Time Base’ of the oscilloscope that is the amount of time represented by a single division of horizontal side of a square drawn on the display box of the oscilloscope. We know the frequency, f of the applied alternating voltage signal. By using it we can find out the time period, T (= $1/f$).

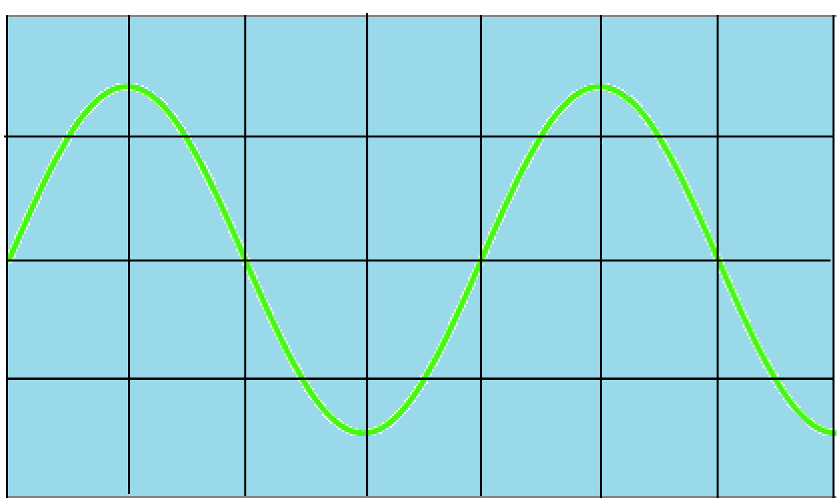


Figure 9: Voltage vs. time curve on the display screen

If there are D number of divisions between two consecutive peaks, D divisions represent an amount of time which is equal to the time period, T ($=1/f$) of the alternating input voltage signal. Therefore, a single division represents $T/D=1/(D\,f)$ amount of time.

Time base of the oscilloscope,

$$\boxed{T_B = \frac{1}{Df}} \tag{3}$$

Apparatus

An oscilloscope, a step down transformer (a transformer which converts an alternating voltage signal of higher amplitude (with an associated alternating current of lower amplitude) to an alternating voltage signal of lower amplitude (with an associated alternating current of higher amplitude)), a function generator and two coaxial cables

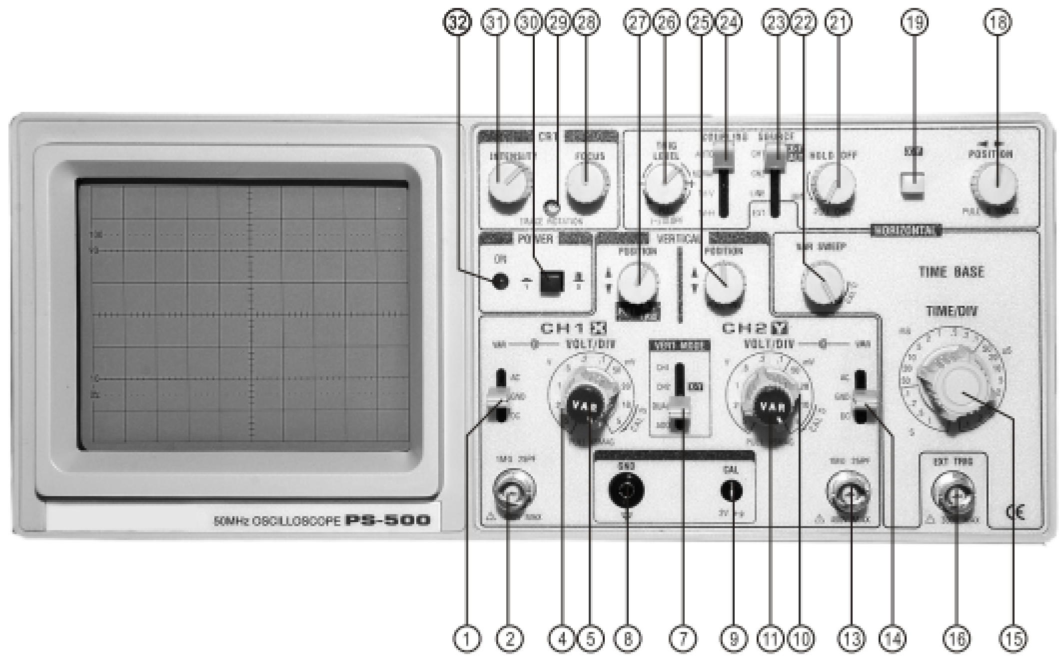


Figure 10: An oscilloscope (courtesy: pintek.com)

Procedure

Determination of the Line Frequency (frequency of the Alternating Current supplied by the power plant)

1) There is a plug which is connected with the input channel of the step down transformer. Insert this plug into the electric socket which provides the alternating current generated in the local

power plant. From the output channel (having two terminals) of the transformer we get an alternating voltage as output. The amplitude of this alternating voltage signal is lower than the amplitude of the alternating voltage signal supplied by the power plant.

2) See Figure 10. Turn on the oscilloscope by pressing **POWER Pushbutton (30)**. Turn on the **X-Y button (19)**. Keep the **AC-GND-DC Switch** of both channels **(1, 14)** to AC position. Keep the **VERTICAL Mode Switch (7)** at **CH-2/X-Y** position. Keep the **Trigger COUPLING Switch (24)** at **Auto** position. Keep the **Source switch (23)** at position **Channel-1/X-Y.**

3) One of the coaxial cables has two crocodile clips at its one end. Connect them with the two terminals of the output channel of the transformer. Connect the other end of the transformer with the **Input Jack** of Channel-2/Y **(13)** of the oscilloscope.

4) Take another coaxial cable. Connect its one end with the output channel of the function generator and the other end with the **Input Jack** of channel-1/X **(2)** of the oscilloscope.

5) Turn on the function generator. Turn on the switch of the function generator which has a symbol of sinusoidal wave. Now, the output voltage signal provided by the function generator is sinusoidal. The frequency of this alternating voltage is shown on its display box. Rotating a Frequency Control Knob the frequency of the alternating voltage can be varied.

6) Lissajous curves should be displayed on the screen. Tuning the Frequency Control Knob of the function generator form curves of vertical 1-loop (Figure 1), 2-loops (Figure 7), 3-loops (Figure 8), 4-loops patterns. For each case note down the 'known frequency', i.e., the frequency of the function generator's output alternating voltage, f_x and the number of cycles along X & Y axes for one complete cycle around the Lissajous curve, n_x and n_y respectively. If you generate the curves of the mentioned patterns, then in every case $n_y = 1$.

7) Calculate the line frequency, f_y for every case by using equation (2). Finally, find out their average.

8) Plot an n_x vs. f_x graph. If n_y is always 1, then it should be a straight line passing through the origin. Work out the slope of the line.

$$\frac{f_x}{f_y} = \frac{n_x}{n_y} \Rightarrow n_x = \frac{n_y}{f_y} f_x = \left(\frac{1}{f_y}\right) f_x \quad \text{(Since, } n_y = 1\text{)}$$

We can see that the slope of the graph is equal to $\frac{1}{f_y}$.

Find out f_y from the slope.

Determination of the Time Base of the oscilloscope

1) Turn off the **X-Y button (19)**.

2) Unplug the coaxial cable from Channel-2 (Y). Hence, the transformer is disconnected with the oscilloscope. Keep the cable, coming from the output channel of the function generator, connected with the **Input Jack** of Channel-1(X).

3) Keep the **VERTICAL Mode Switch (7)** at **CH-1.**

4) You should see a sinusoidal voltage vs. time curve. By rotating the Frequency Control Knob of the function generator you can change the time period, i.e., distance between two consecutive peaks of the curve. By spinning **POSITION/PULL X 10 MAG Control (18)** you can shift the curve horizontally. Tune the frequency of the output alternating voltage of the function generator and the horizontal position of the curve in such a way that two consecutive peaks of the curve cut two vertical lines of the display screen. It is to make sure that the number of divisions, D, between two consecutive peaks is an integer. Note down the frequencies of the function generator's voltage correspond to D = 2, 3, 4, 5. Find out time base of the oscilloscope for each case by using the equation (3). Next, find their average.

5) Plot a 1/D vs. f_x graph. According to (3) it should be a straight line passing through the origin whose slope is equal to the time base of the oscilloscope. Work out the slope, i.e., the time base of the oscilloscope.

Read carefully and follow the following instructions:

- **Please READ the theory carefully, TAKE printout of the 'Questions on Theory' and ANSWER the questions in the specified space BEFORE you go to the lab class.**

- **To get full marks for the 'Questions on Theory' portion, you must answer ALL of these questions CORRECTLY and with PROPER UNDERSTANDING, BEFORE you go to the lab class. However, to ATTEND the lab class you are REQUIRED to answer AT LEAST the questions with asterisk mark.**

- **Write down your NAME, ID, THEORY SECTION, GROUP, DATE, EXPERIMENT NO AND NAME OF THE EXPERIMENT on the top of the first paper.**

- **If you face difficulties to understand the theory, please meet us BEFORE the lab class. However, you must read the theory first.**

- **DO NOT PLAGIARIZE. Plagiarism will bring ZERO marks in this WHOLE EXPERIMENT. Be sure that you have understood the questions and the answers what you have written, and all of these are your own works. You WILL BE asked questions on these tasks in the class. If you plagiarize for more than once, WHOLE lab marks will be ZERO.**

- **After entering the class, please submit this portion before you start the experiment.**

Name: ______________________ ID: ______________ Sec: ___ Group: __ Date: __________

Experiment no: ___

Name of the Experiment: ____

____

Questions on theory (all diagrams should be drawn by using a pencil and a scale)

*1) What is 'power line frequency'? [0.25]

Ans:

2) Briefly explain how a cathode ray oscilloscope works. [1]

Ans:

*3) What is Lissajous curve? [0.25]

Ans:

4) See the Figure 11

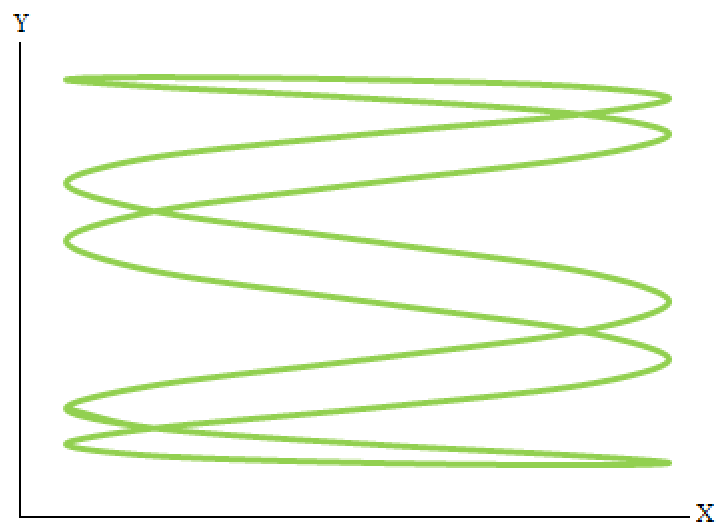


Figure 11: Figure for question 4

For this Lissajous curve what is T_x/ T_y ? [1]

Ans:

*5) Write down the working formula to find out the unknown frequency of a voltage signal, by using another voltage signal of known frequency and forming Lissajous curve. Mention what every variable represents. [0.5]

Ans:

*6) What is *time base* of an oscilloscope? [0.5]

Ans:

*7) Write down the working formula to find out the time base of an oscilloscope by observing the voltage vs. time curve and knowing the frequency of the alternating voltage. Mention what every variable represents. [0.5]

Ans:

8) See Figure 9. If the frequency of the input alternating voltage is 50 Hz then what is the time base of the oscilloscope? [1]

Ans:

- **Draw the data table(s) and write down the variables to be measured shown below (in the 'Data' section), using pencil and ruler BEFORE you go to the lab class.**

- **Write down your NAME and ID on the top of the page.**
- **This part should be separated from your Answers of "Questions on Theory" part.**
- **Keep it with yourself after coming to the lab.**
- **Do not forget to bring a graph paper.**

Data

Table 1: Data for working out the unknown frequency of an alternating voltage signal

Known frequency (frequency of the alternating voltage signal generated by function generator) f_x (Hz)	Number of complete cycles along the x axis for one complete cycle around the Lissajous curve n_x	Number of complete cycles along the y axis for one complete cycle around the Lissajous curve n_y	Frequency to be determined (line frequency) f_y (Hz)	Average value of the frequency to be determined $\bar{f}_y$ (Hz)

Slope of n_x vs. f_x graph:

Frequency to be determined (line frequency), f_y =

Table 2: Data for determining *time base* of the oscilloscope

Frequency of the alternating voltage signal generated by function generator f (Hz)	Number of horizontal divisions between two consecutive peaks D	Time base (time/division) T_B (s/Div)	Average value of the Time base (time/division) $\bar{T}_B$ (s/Div)

Slope of $1/D$ vs. f graph:

Time base of the oscilloscope, T_B =

Time base of the oscilloscope as shown by the **TIME/DIV Knob (15)** (Figure 15)

Percentage of deviation of the experimental value of the *time base* from the value shown by the “TIME/DIV” Knob’s pointer:

- **READ the PROCEDURE carefully and perform the experiment by YOURSELVES. If you need help to understand any specific point draw attention of the instructors.**
- **DO NOT PLAGIARIZE data from other group and/or DO NOT hand in your data to other group. It will bring ZERO mark in this experiment. Repetition of such activities will bring zero mark for the whole lab.**
- **Perform calculations by following the PROCEDURE . Show every step in the Calculations section.**
- **Write down the final result(s)**

Calculations

Results:

- **TAKE printout of the ‘Questions for Discussions’ BEFORE you go to the lab class. Keep this printout with you during the experiment. ANSWER the questions in the specified space AFTER you have performed the experiment.**
- **Attach Data, Calculations, Results and the Answers of ‘Questions for Discussions’ parts to your previously submitted Answers of ‘Questions on Theory’ part to make the whole lab report.**
- **Finally, submit the lab report before you leave the lab.**

Name: ___________________________ ID: __________________

Questions for Discussions

1) In this experiment why did you use a transformer? [0.5]

Ans:

2) You know the time base of the oscilloscope. How can you find out the line frequency, in a different way, by forming the transformer's output voltage vs. time graph without the help of any other alternating voltage of known frequency? [0.5]

Ans:

3) In this experiment the Lissajous curves which you formed contained only loops in their pattern. However, while tuning the Frequency Control Knob of the function generator you must have seen curves of complex patterns like the following one (Figure 12)

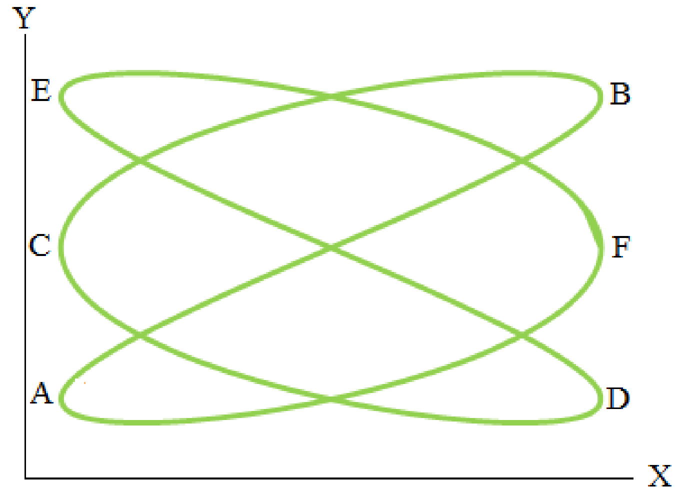


Figure 12: Figure for question 3

The bright spot is moving in the following order: A-B-C-D-E-F-A

What is T_x / T_y for this Lissajous curve? [1]

Ans:

NOTE: Figure 10 is collected from http://www.pintek.com.tw/pdf/Analog_Oscilloscope_0224.pdf which is a free manual available in internet for their customers.