Cathode Ray Oscilloscope

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- An oscilloscope is an electronic measuring instrument used to display and analyze the waveform of electronic signals.
- It shows how a signal varies with time, presenting it as a graph where the horizontal axis represents time and the vertical axis represents voltage.
- Oscilloscopes are commonly used in electronics and engineering to observe signal behavior sine waves, square waves, etc,diagnose problems in circuits,Test and debug electronic devices and measure parameters like frequency, amplitude, and phase.

The key components of oscilloscope are:

- Cathode Ray Tube (CRT)
- Vertical Deflection System
- Horizontal Deflection System
- Time Base Generator
- Trigger Circuit
- Power Supply
- Amplifiers (Vertical and Horizontal)
- Input Section
- Graticule (Screen)
- Control Panel

Generating Lissajous Figures

Components required for this experiment

- Cathode Ray Oscilloscope
- Function Generator
- BNC cables or BNC connectors

Lissajous figures are complex patterns resulting from the interaction of two harmonic motions, typically visualized on an oscilloscope or generated using mathematical modeling.

1 Figure 1

The inputs taken for the two signals are given in Figure 1:

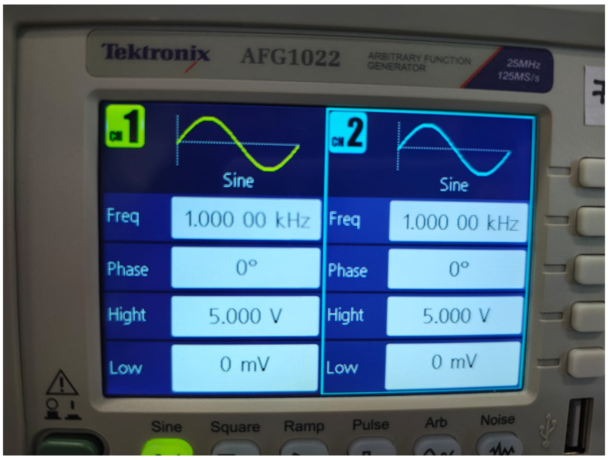

Figure 1

$$x(t) = A \sin \omega t \tag{1.1}$$
$$y(t) = A \sin \omega t \tag{1.2}$$

In our case,

$$A = 5\,\text{V (peak)}, \tag{1.3}$$
$$f = 1 \times 10^3\,\text{Hz}, \tag{1.4}$$
$$\omega = 2\pi f = 2\pi(10^3)\,\text{rad/s} = 2 \times 10^3\,\text{rad/s}. \tag{1.5}$$

On subtracting equations (1) and (2), we get:

$$x(t) - y(t) = 0, \tag{1.6}$$
$$y(t) = x(t). \tag{1.7}$$

On plotting $y(t)$ vs $x(t)$, we get a $y = x$ straight line.

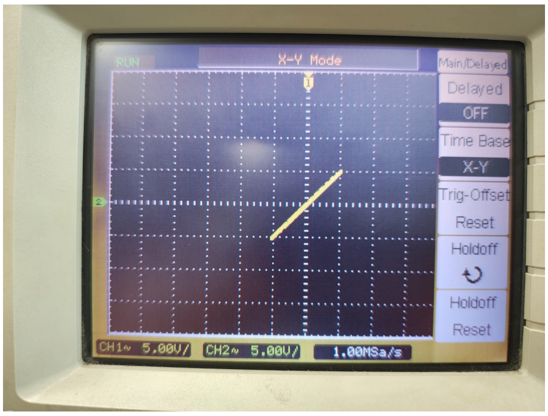

Figure 2: Obtained

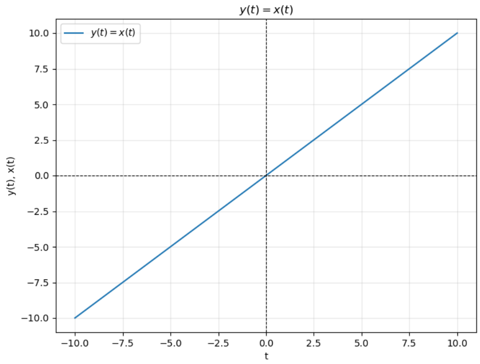

Figure 3: Generated

2 Figure 2

The inputs taken for the two signals are given in Figure 4:

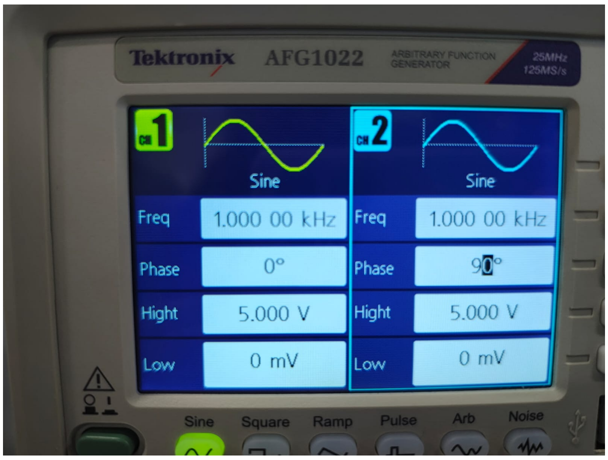

Figure 4

Given:

$$x(t) = A\sin(\omega t + \frac{\pi}{2}), \tag{2.1}$$

$$y(t) = A\sin\omega t. \tag{2.2}$$

Squaring and adding, we get:

$$x^2(t) + y^2(t) = A^2\sin^2(\omega t + \frac{\pi}{2}) + A^2\sin^2\omega t, \tag{2.3}$$

$$x^2 + y^2 = A^2. \tag{2.4}$$

This represents a circle centered at the origin with radius $A = 5$.

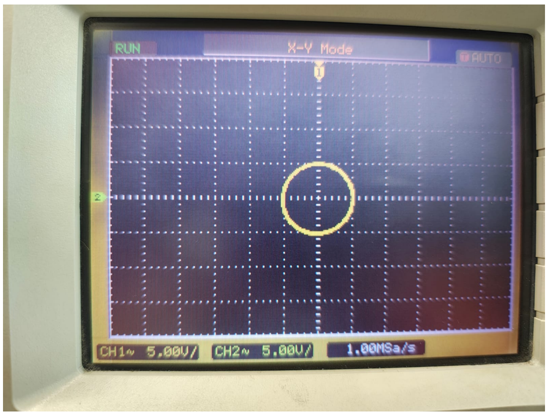

Figure 5: Obtained

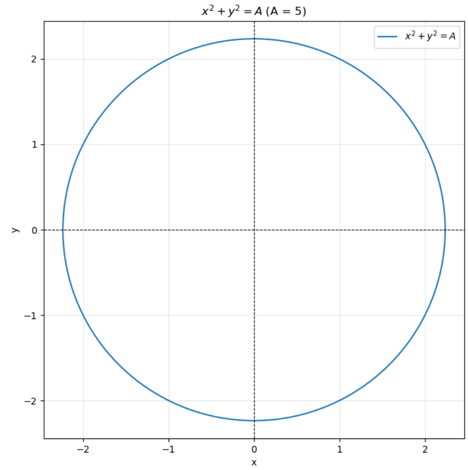

Figure 6: Generated

3 Figure 3

The inputs taken for the two signals are given in Figure 7:

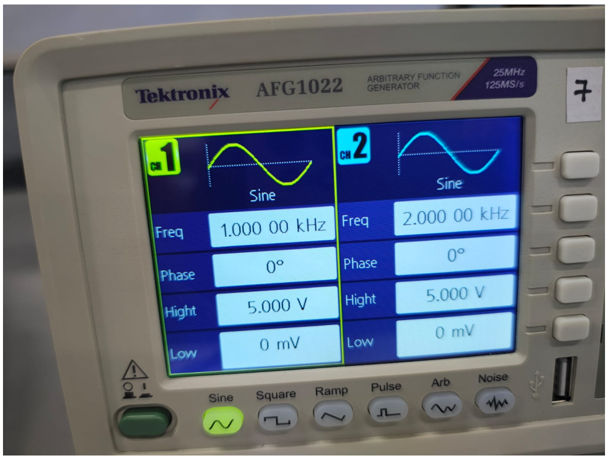

Figure 7

Given:

$$x(t) = A \sin \omega t, \tag{3.1}$$
$$y(t) = A \sin(2\omega t). \tag{3.2}$$

$$y = 2Asin(\omega t)\sqrt{1 - sin^2\omega t} \tag{3.3}$$

$$y = 2x\sqrt{1 - \frac{x^2}{A^2}} \tag{3.4}$$

$$\frac{y^2}{4x^2} = 1 - \frac{x^2}{A^2} \tag{3.5}$$

$$\frac{x^2}{A^2} + \frac{y^2}{4x^2} = 1 \tag{3.6}$$

$$y^2 = 4x^2 - \frac{4x^4}{A^2} \tag{3.7}$$

The graph of the obtained equation is shown below.

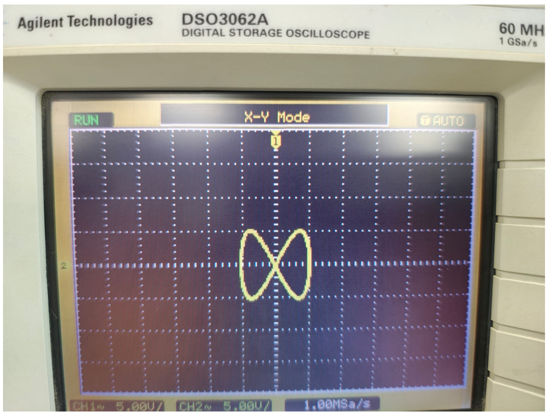

Figure 8: Obtained

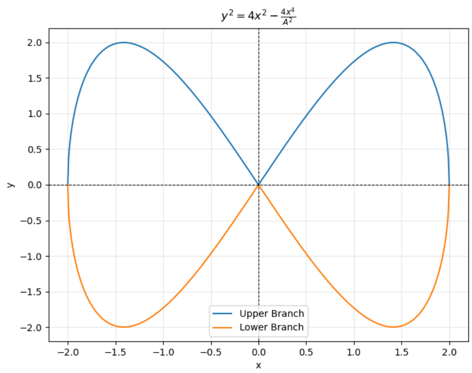

Figure 9: Generated

4 Figure 4

The inputs taken for the two signals are given in Figure 10:

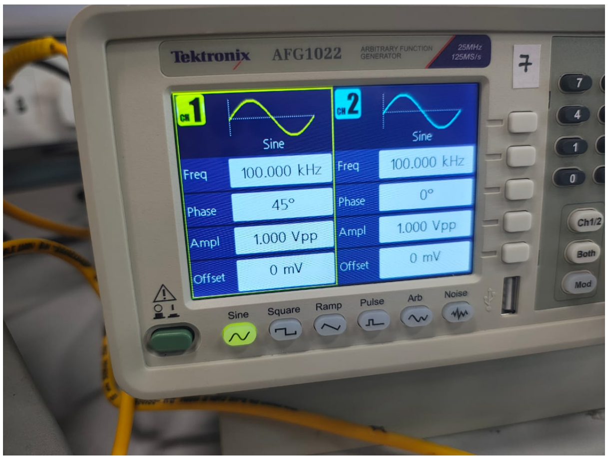

Figure 10

Given:

$$x(t) = A\sin(\omega t), \tag{4.1}$$

$$y(t) = A\sin(\omega t + \frac{\pi}{4}). \tag{4.2}$$

$$y = A\left(\frac{sin\omega t}{\sqrt{2}} + \frac{cos\omega t}{\sqrt{2}}\right) \tag{4.3}$$

$$y = \frac{x}{\sqrt{2}} + \frac{A\sqrt{1-\frac{x^2}{A^2}}}{\sqrt{2}} \tag{4.4}$$

$$\sqrt{2}y - x = \sqrt{A^2 - x^2} \tag{4.5}$$

Squaring on both sides;

$$2x^2 + 2y^2 - 2\sqrt{2}xy = A^2 - x^2 \tag{4.6}$$

$$A = 1Vpp \tag{4.7}$$

$$x^2 + y^2 - \sqrt{2}xy = \frac{A^2}{2} \tag{4.8}$$

It is the equation of ellipse.

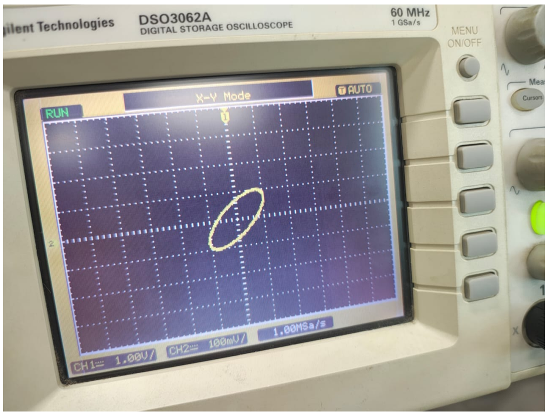

Figure 11: Obtained

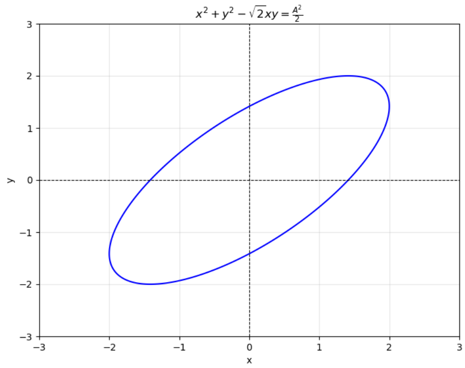

Figure 12: Generated

5 Figure 5

The inputs taken for the two signals are given in Figure 13:

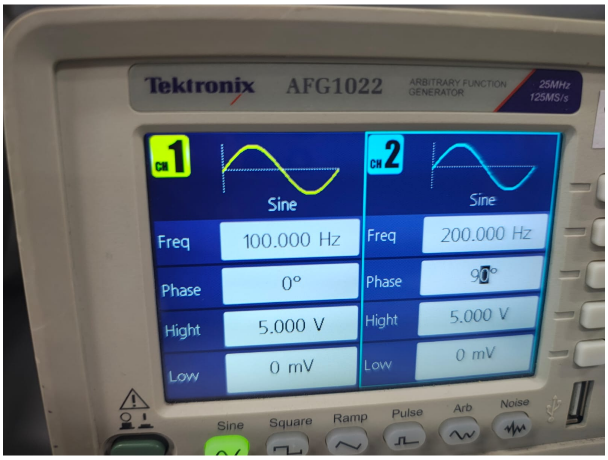

Figure 13

$$x(t) = A\sin(\omega t), \tag{5.1}$$

$$y(t) = A\sin(2\omega t + \frac{\pi}{2}). \tag{5.2}$$

$$y = Acos2\omega t \tag{5.3}$$

$$y = A\left(\frac{1 - sin^2\omega t}{2}\right) \tag{5.4}$$

$$y = \frac{A}{2} - \frac{A}{2}\left(\frac{x}{A}\right)^2 \tag{5.5}$$

$$y = \frac{A}{2}\left(1 - \frac{x^2}{A^2}\right) \tag{5.6}$$

The graph obtained is a parabola as shown;

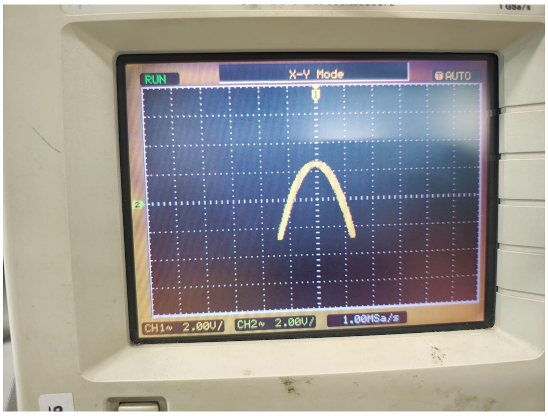

Figure 14: Obtained

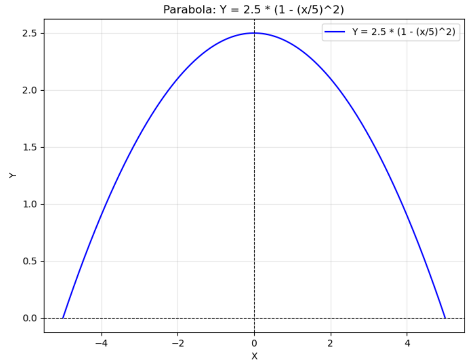

Figure 15: Generated

6 Figure 6

The inputs taken for the two signals are given in Figure 16:

Figure 16

$$x = Asin\omega t \tag{6.1}$$
$$y = Asin(\omega t + \pi) \tag{6.2}$$

$$\therefore y = -Asin\omega t \tag{6.3}$$
$$y = -x \tag{6.4}$$

It is the equation of a straight line with slope -1.

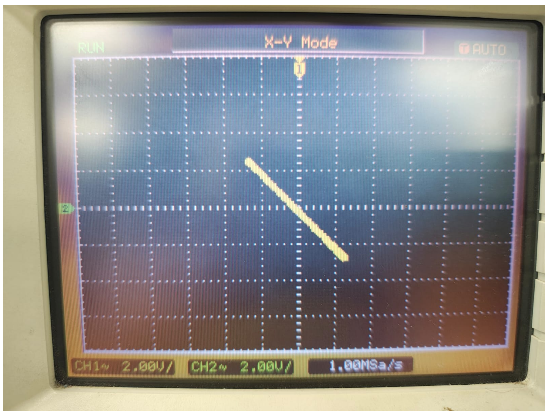

Figure 17: Obtained

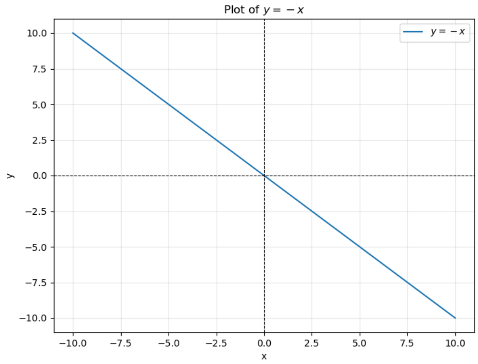

Figure 18: Generated

7 Impulse

- In addition to generating Lissajous figures, the setup can effectively capture rapidly changing signals, such as impulses, commonly referred to as ”on-off” phenomena.
- This capability allows for precise analysis of transient events within a system.
- Notably, only a single-channel connection is required to record these signals, making the setup both efficient and simple.
- An example of such a recorded signal is presented below.
- This approach is particularly useful in scenarios where high-speed signal detection is critical, such as in communication systems, control circuits, or transient analysis in electronic devices.

Figure 19

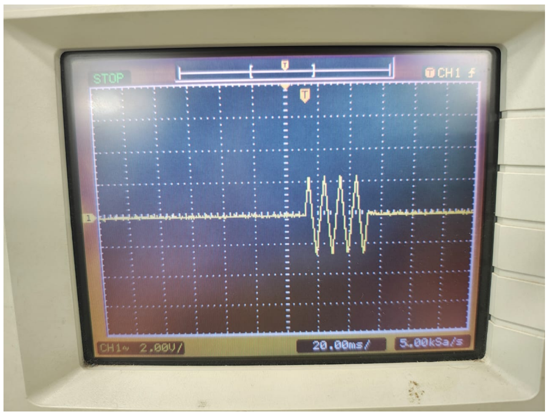

Figure 20

Precautions
When working with the oscilloscope and inputting signals, certain precautions must be followed to ensure accurate results and safety:

- Ensure the phases of the input signals are correct, and verify that the oscilloscope is not imposing its own phase difference on the signals, as this could lead to incorrect measurements.

- Check that all connections are secure and not loose, as loose connections can introduce unwanted noise into the signals, potentially distorting the Lissajous figures.
- Always turn off the oscilloscope and related equipment before making or modifying connections to avoid the risk of electrical shocks or damage to the device.