Lab Report: Oscilloscope and Function Generator

Including Lissajous Figures

Krishna Patil-EE24BTECH11036
Deepak Ahirwar-EE24BTECH11014

Electrical Department, IIT-Hyderabad

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Experiment conducted as part of EE Laboratory Coursework.

Objective

1. To understand the working principles of an oscilloscope and function generator.
2. To study and observe Lissajous figures on a Cathode Ray Oscilloscope (CRO).
3. To justify the observed Lissajous patterns with theoretical principles.
4. To demonstrate how to capture a one-time event on a CRO.

Apparatus Required

- Cathode Ray Oscilloscope (CRO)
- Function Generator
- Connecting wires
- Patch cords and probes

Theory

Oscilloscope

An oscilloscope is an electronic test instrument used to display and analyze the waveform of electronic signals. It allows visualization of:

- Voltage versus time (in the Time Domain mode)
- Voltage versus another voltage (in X-Y mode, useful for Lissajous figures)

Function Generator

A function generator produces electrical waveforms, such as sine, square, and triangular waves, over a wide range of frequencies.

Lissajous Figures

Lissajous figures are graphical representations of parametric equations:

$$x = A\sin(\omega_x t + \phi_x), \quad y = B\sin(\omega_y t + \phi_y)$$

- A and B: Amplitudes of the signals
- ω_x and ω_y: Angular frequencies
- ϕ_x and ϕ_y: Phase angles

When these signals are fed into the X and Y inputs of a CRO in X-Y mode, the resulting patterns are Lissajous figures. The shape depends on:

1. The frequency ratio $\left(\frac{\omega_x}{\omega_y}\right)$.
2. The phase difference $\Delta\phi = \phi_x - \phi_y$.

Frequency Ratio ($f_x : f_y$)

- $f_x : f_y = 1 : 1$: Circular or elliptical figures.
- $f_x : f_y = 1 : 2$: Two loops in the vertical direction.
- $f_x : f_y = 2 : 1$: Two loops in the horizontal direction.
- $f_x : f_y = m : n$: Complex figures with m vertical and n horizontal intersections.

Phase Difference ($\Delta\phi$)

- $0°$: Line at $45°$.
- $90°$: Circle (if amplitudes are equal).
- $180°$: Line at $135°$.

Procedure

Setup

1. Connect the output terminals of the function generator to the CRO.
2. Configure the CRO:
    - Select the X-Y mode for Lissajous figures.
    - Adjust the intensity, focus, and time/div knobs for clear visibility.
3. Use the function generator to provide two sinusoidal signals of adjustable frequency and phase.

Observing Lissajous Figures

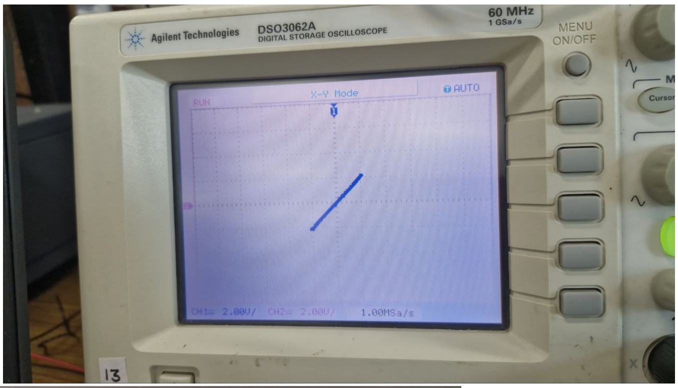
1. Set the horizontal (X-axis) frequency to f_x and the vertical (Y-axis) frequency to f_y.
2. Observe and sketch Lissajous patterns for different ratios ($1 : 1$, $1 : 2$, $2 : 1$, $m : n$).
3. Fix $f_x = f_y$ and gradually change the phase difference ($0°$, $90°$, $180°$). Note how the shape evolves.

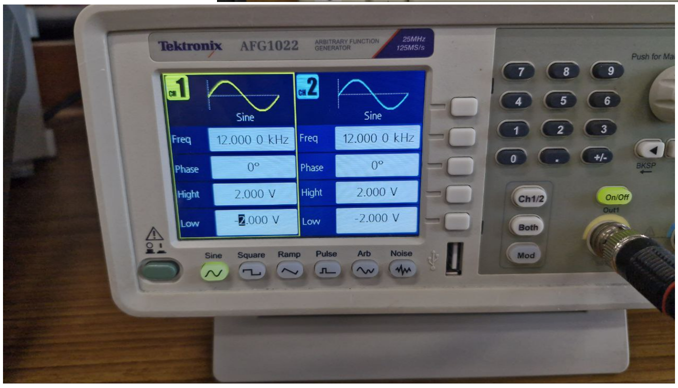
Observations

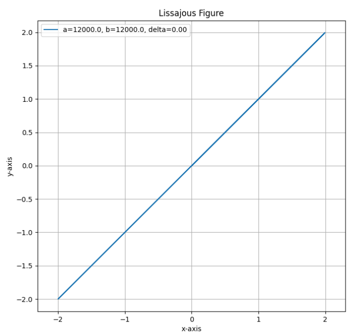
$f_x : f_y$	$\Delta\phi$	Observed Pattern	Justification
1:1	0°	Line at 45°	Equal frequencies, no phase lag.
1:1	90°	Circle	Orthogonal signals with equal amplitude.
1:2	0°	Two vertical loops	Double frequency on Y-axis.
2:1	0°	Two horizontal loops	Double frequency on X-axis.
9:7	0°	Complex figure	nine vertical and seven horizontal intersections.
9:7	30°	Complex figure	nine vertical and seven horizontal intersections.

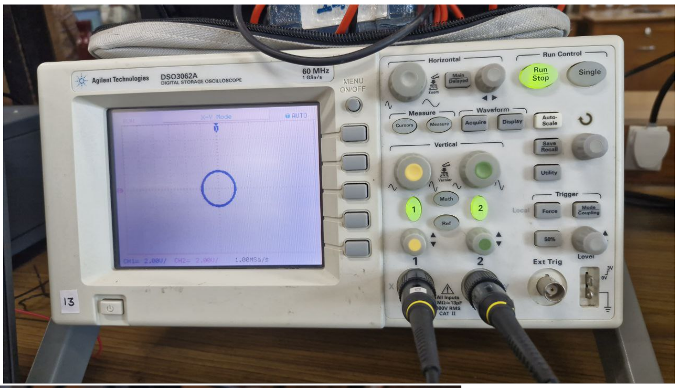
Table 1: Observation Table for Lissajous Figures

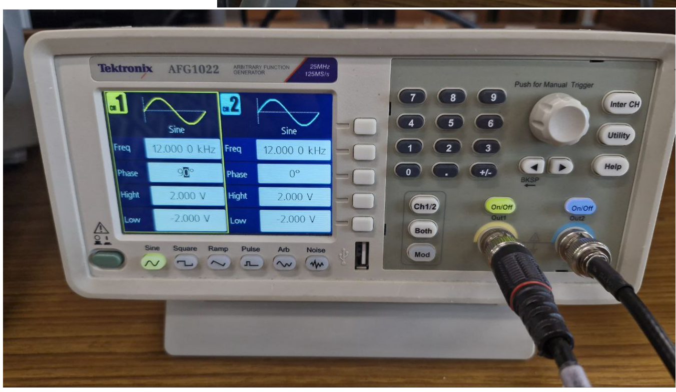
Lissajous Figures

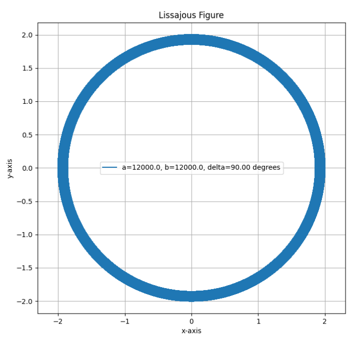


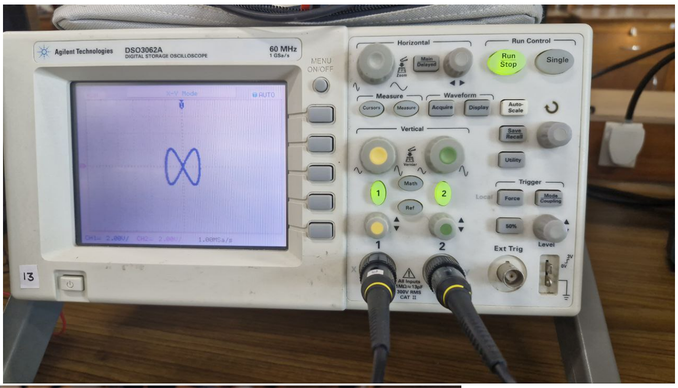








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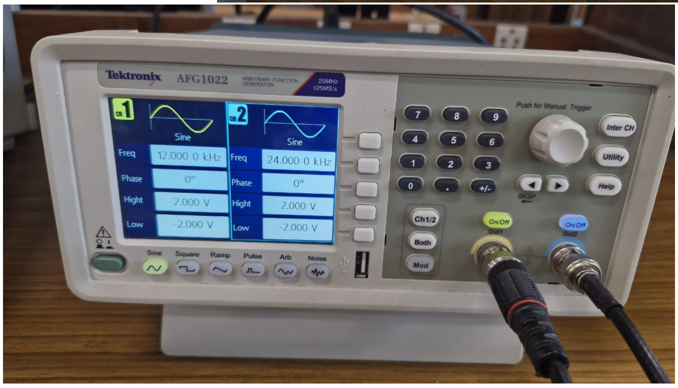
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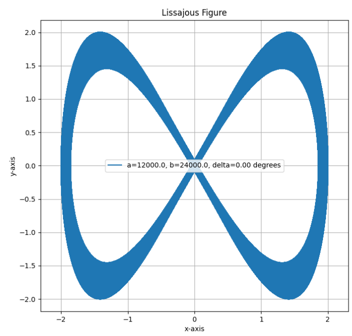
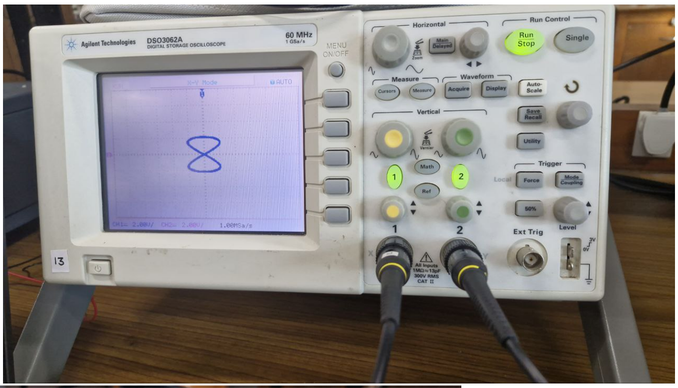

Lissajous Figure
a=12000.0, b=24000.0, delta=0.00 degrees
y-axis
x-axis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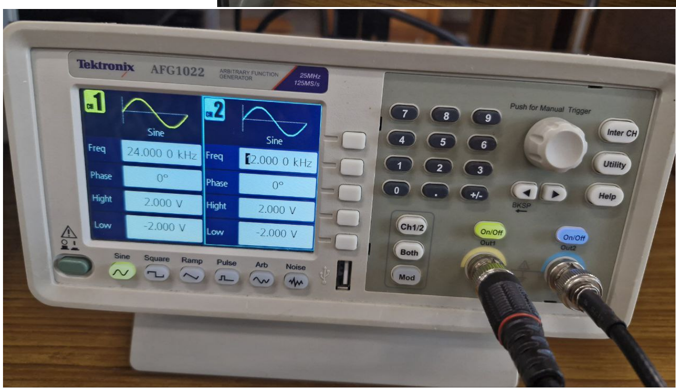
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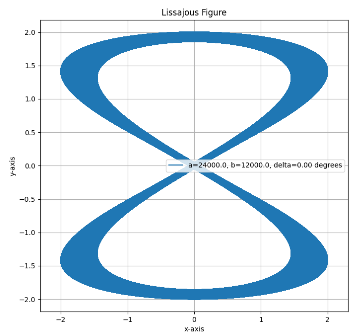
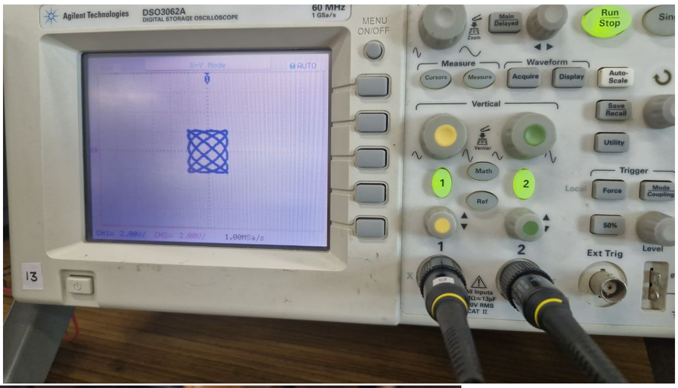
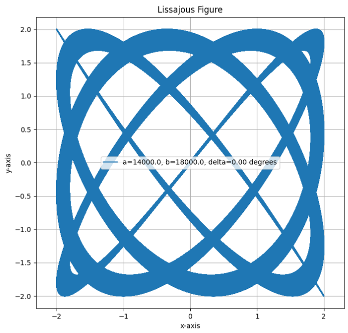
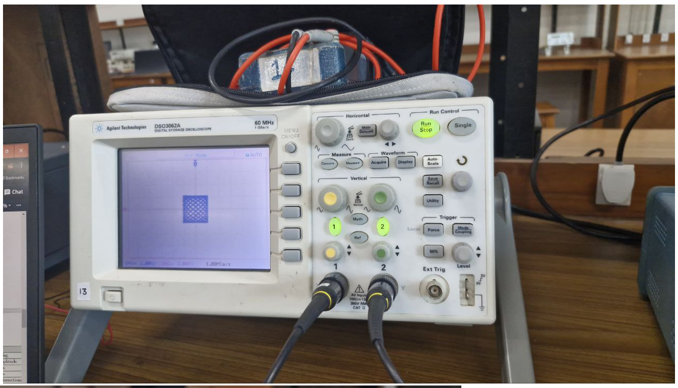
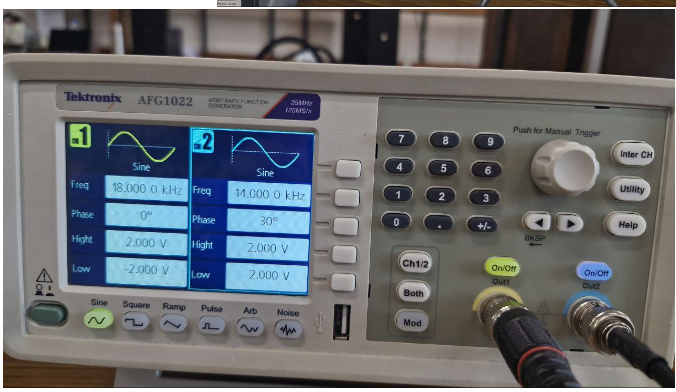
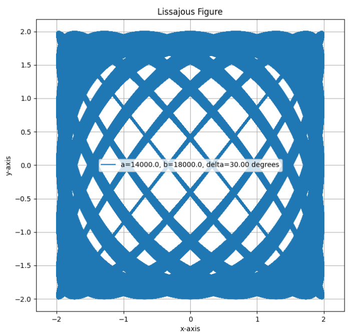

Lissajous Figure
a=24000.0, b=12000.0, delta=0.00 degrees
y-axis
x-axis











Python Code for verifying the lissajous figures

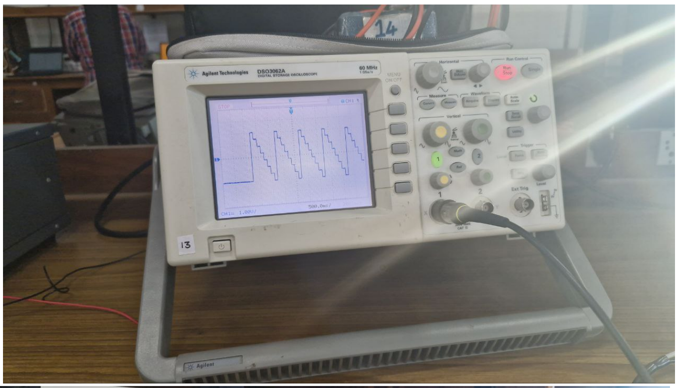
Below code can be used to verify the lissajou's figure

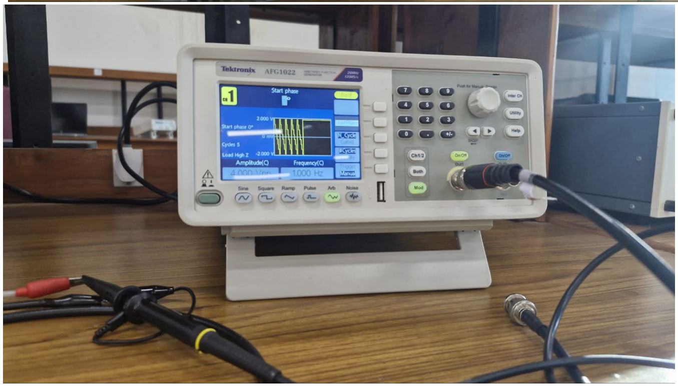
```
import numpy as np
import matplotlib.pyplot as plt

def lissajous_figure(A, B, a, b, delta, t_max=2*np.pi, num_points=100000):
    """
    Generate and plot a Lissajous figure.
```

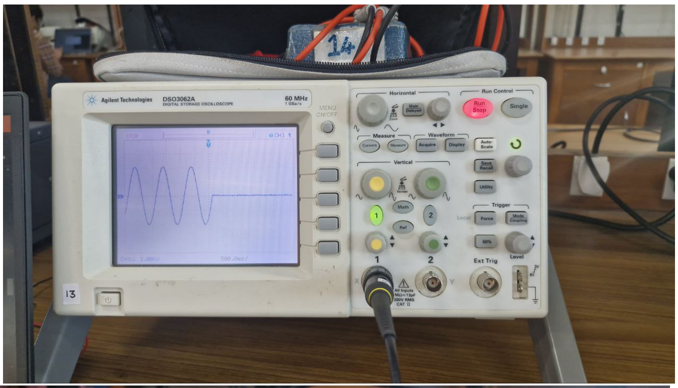
```

    Parameters:
        A (float): Amplitude of the sine wave along the x-axis.
        B (float): Amplitude of the sine wave along the y-axis.
        a (float): Ratio of frequencies along the x-axis.
        b (float): Ratio of frequencies along the y-axis.
        delta (float): Phase difference between the two waves (in radians).
        t_max (float): The maximum value of t to plot (default is 2*pi).
        num_points (int): Number of points to plot (default is 1000).
    """
    # Generate time points
    t = np.linspace(0, t_max, num_points)

    # Compute x and y
    x = A * np.sin(a * t + delta)
    y = B * np.sin(b * t)

    # Plot the figure
    plt.figure(figsize=(8, 8))
    plt.plot(x, y, label=f"a={a}, b={b}, delta={np.degrees(delta):.2f} degrees")
    plt.title("Lissajous Figure")
    plt.xlabel("x-axis")
    plt.ylabel("y-axis")
    plt.axis("equal")
    plt.legend()
    plt.grid(True)
    plt.show()

# Example usage
if __name__ == "__main__":
    # Ask user for parameters
    print("Phase difference (delta) should be entered in degrees.")
    A = float(input("Enter amplitude along x-axis (A): "))
    B = float(input("Enter amplitude along y-axis (B): "))
    a = float(input("Enter frequency ratio along x-axis (a): "))
    b = float(input("Enter frequency ratio along y-axis (b): "))
    delta_degrees = float(input("Enter phase difference in degrees (delta): "))
    delta = np.radians(delta_degrees)  # Convert degrees to radians

    lissajous_figure(A, B, a, b, delta)
```

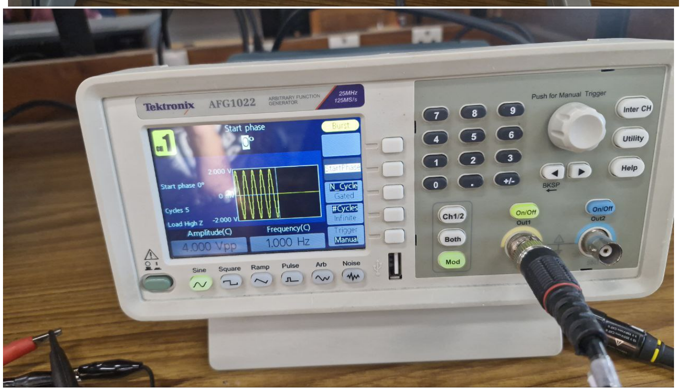
Capturing a One-Time Event

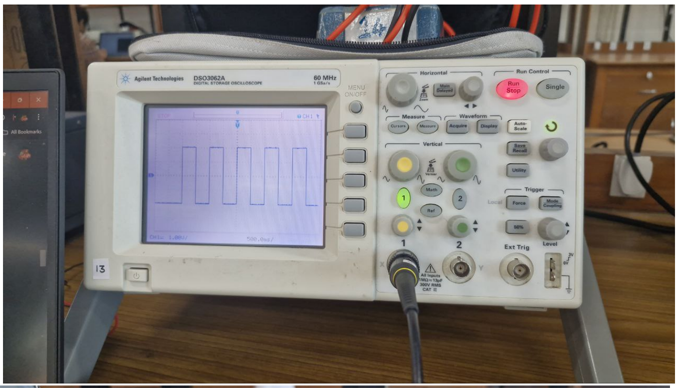
1. Set the CRO to "Single Trigger" mode.
2. Adjust the trigger level and slope (positive or negative).
3. Connect the one-time signal source to the CRO's input.
4. Once the event occurs, the CRO freezes the display for analysis.

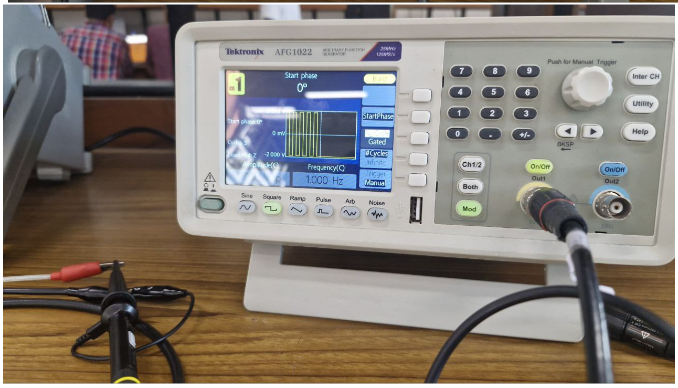












Discussion

Lissajous Figures

- The figures provide a visual representation of frequency and phase relationships.
- They are especially useful for comparing unknown signal frequencies by matching them against a known reference signal.

Phase Interpretation

- Variations in the phase difference ($\Delta\phi$) directly affect the symmetry and orientation of the figures.

Capturing One-Time Events

CROs with a single-trigger mode are vital for observing transient phenomena like surges or spikes.

Conclusion

1. The oscilloscope and function generator together allow precise visualization and analysis of signal waveforms.
2. Lissajous figures are highly effective for frequency and phase comparison.
3. CROs can be configured to capture and analyze one-time events using triggering mechanisms.