(AC2-11) Lissajou's Patterns Exercise

Aim of experiment

To use Lissajous' patterns for frequency and phase difference measurements.

Apparatus

Function Generators – Oscilloscope- Random Generator.

Theory of experiment

The oscilloscope, or scope as it is commonly called, is one of the most important test instruments for use in measuring ac quantities, but this device may also be used to measure dc quantities as well. The basic operation of the oscilloscope will now be examined and then consider some of the ways it is used to measure and analyze ac waveforms. Although this discussion will be very brief, it contains background informations which should prove highly beneficial.

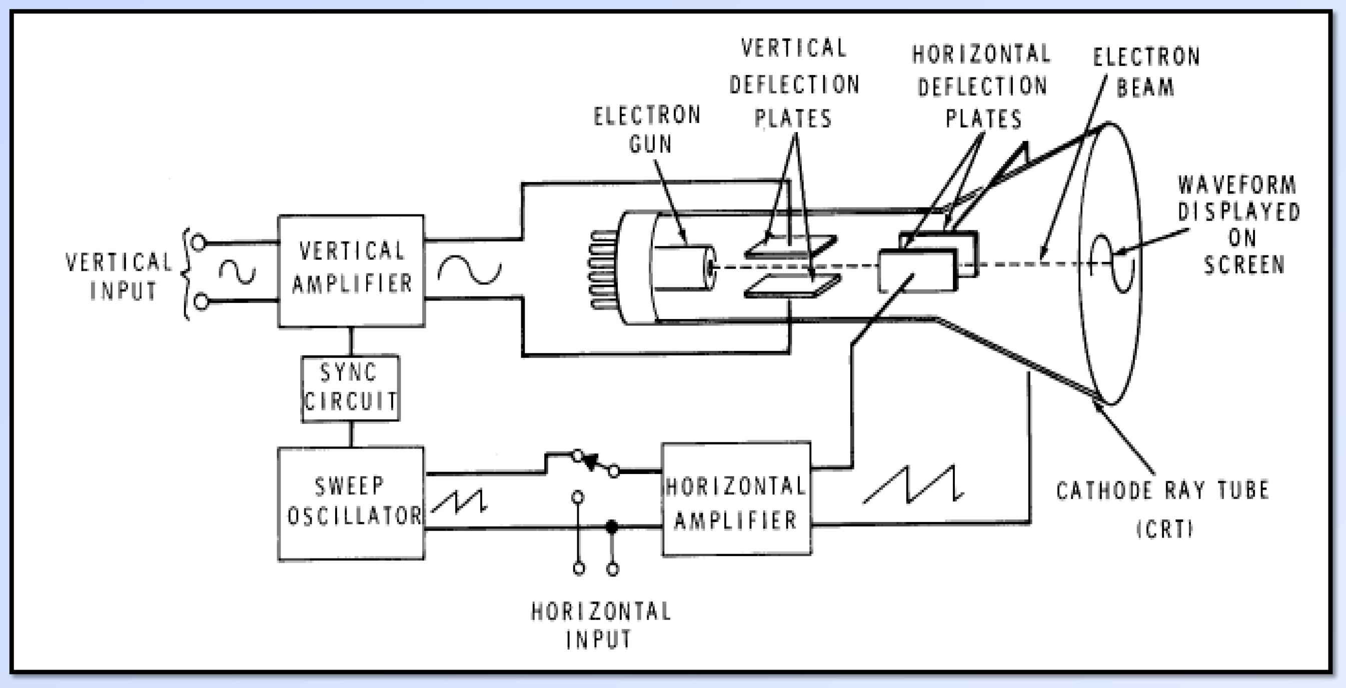

Figure 1. A basic schematic diagram of an oscilloscope

As shown in figure 1, the CRO contains an electron gun and two sets of deflection plates. These components are mounted inside of a large glass tube which fans out at one end to form a screen which closely resembles the screen on a television picture tube. The air is pumped out of the tube and the end is sealed so that the components will operate within a vacuum. In this respect the device is similar to an ordinary vacuum tube. The electron gun produces a stream of electrons which are focused into a narrow beam and aimed at the CRO screen. When the beam strikes the screen, it illuminates a phosphorus coating on the screen so that a spot of light is produced

Lissajous' patterns are formed when one combines periodic waves moving back and forth with periodic waves moving up and down. This allows the user to control the frequency of the X and Y motions independently. The resulting pattern can be observed on an oscilloscope.

In electronic applications we can generate Lissajous patterns by applying different signals to the horizontal and vertical inputs of an oscilloscope. In facts, this technique was often too used to measure frequencies in the days before frequency meters. A signal of a known frequency was applied to the vertical input. The resulting pattern was a function of the ratio of the two frequencies.

Lissajous' Figures

A Lissajous' figure is produced by taking two sine waves and displaying them at right angles to each other. This easily done on an oscilloscope in XY mode. If the oscilloscope has the x-versus-y capability, one can apply one signal to the vertical deflection plate while applying a second signal to the horizontal deflection plate. The horizontal sweep section is automatically disengaged at this time. The resulting waveform is called Lissajous figure. This mode can be used to measure phase or frequency relationships between two signals.

When the two sine waves are of equal frequency and in-phase, diagonal line to the right will be produced. When the two sine waves are of equal frequency and 180^{o} degrees out-of-phase a diagonal line to the left will be produced. When the two sine waves are of equal frequency and 90^{o} degrees out-of-phase a circle will be produced. When the horizontal and vertical sine wave frequencies differ by a fixed amount, this is equivalent to constantly rotating the phase between them.

Phase Measurements Using Lissajous' Figures

If the ratio of the first frequency to the second is a rational number, then a closed curve will be observed on the CRO. If the two frequencies are unrelated, then there will be only a patch of light observed because of the persistence of the oscilloscope screen.

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If the two signals have the same frequency, then the Lissajou's patterns will assume the shape of an ellipse. The ellipse's shape will vary according to the phase difference between the two signals, and according to the ratio of the amplitude of the two signals. The formula used for determining the phase is:

$$\sin\theta = \pm\frac{Y_o}{Y_{max}}$$

Where Y_{max} is half the maximum vertical height of the ellipse and Y_o is the intercept on the y-axis. Two signals that are identical in frequency and have a phase difference of 45^0, but with different amplitude ratios. Note that is necessary to know the direction that the Lissajous trace is moving in order to determine the sign of the phase difference. In practice, if this is not known a priori, then it can be determined by testing with a variable frequency signal generator. In the case, one of the signals under consideration is replaced with the variable frequency signal; the signal generator is adjusted until its frequency and phase equal that of the other signal input. When this happens, a straight line will exist. The signal generator frequency is then increased a little with the relative phase thus being effectively changed in a known direction. This can be used to determine the correct sign in the equation above.

Lissajous' patterns methods are a little more robust to noise than direct oscilloscope methods. This is because there are no triggering problems due to random noise fluctuations. Direct methods are, however, much easier to interpret when harmonics are present. The accuracy of oscilloscope methods is comparatively poor. The uncertainly of the measurement is typically in excess of 1^o.

Frequency Measurements Using Lissajous Figures

Lissajous pattern also helps to measure frequency. The signal whose frequency is to be measured is given to y- plates or vertical plates and the signal whose frequency is given to X-plates or horizontal plates. Now the know frequency or standard frequency is adjusted until Lissajous patterns can be obtained on the screen which depends on the ratio of two frequencies. In figure 2, let, f_y – Unknown frequency signal applied to vertical plates, f_h – Known frequency signal applied to horizontal plates

Two lines are drawn, one vertical and one horizontal so that they do not pass through any intersection on Lissajous pattern. Then the number of intersections of the horizontal and vertical lines with the Lissajous patterns and counted separately. So after finding the tangencies if we know we can easily calculate the unknown frequency applied to vertical plate.

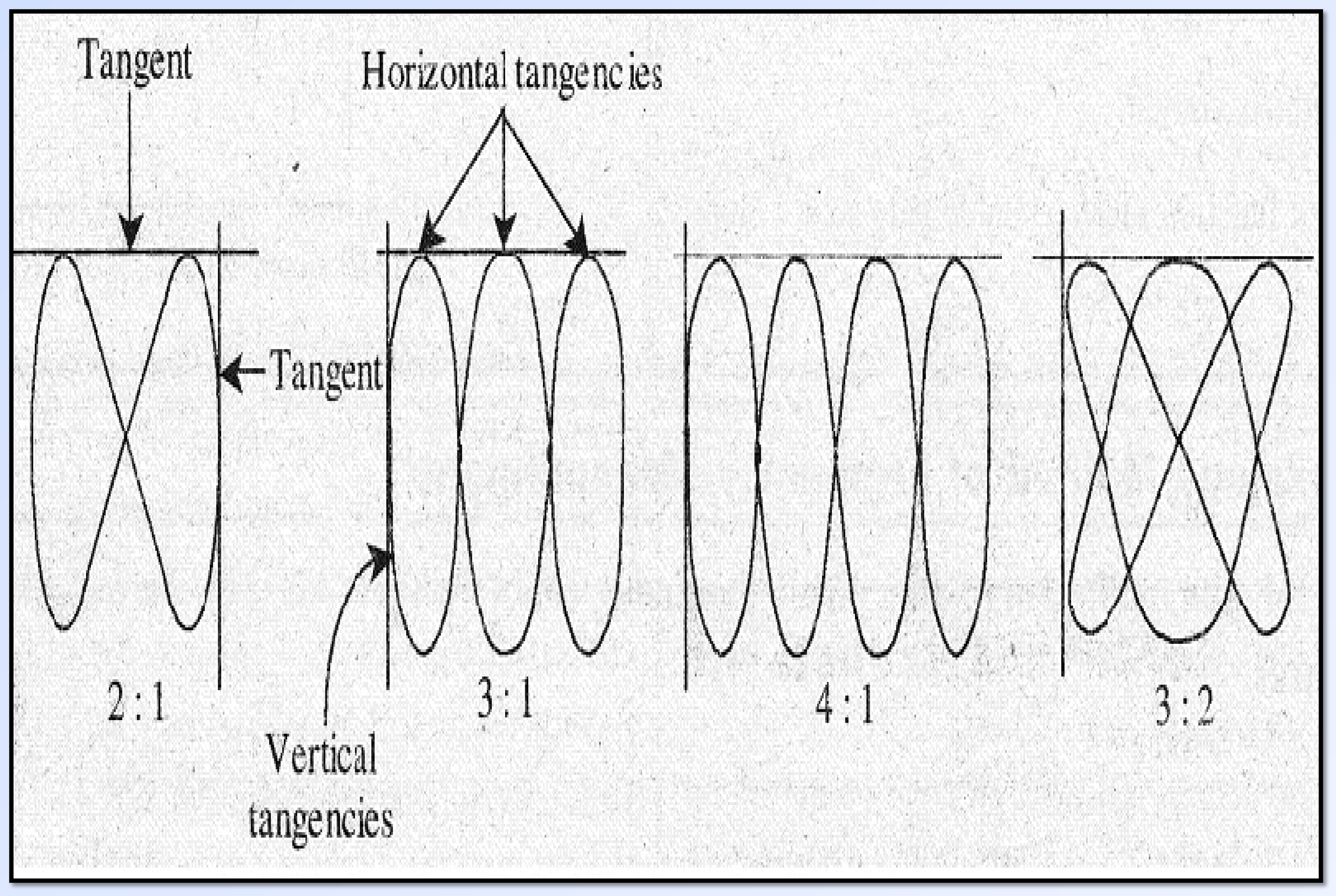

Figure 2 Lissajous patterns of waveforms of different frequencies

All electronic circuits in the oscilloscope like attenuators, time base generators, amplifiers cause some amount of time delay while transmitting signal voltage to deflection plates. We also know that horizontal signal is initiated or triggered by some portion of output signal applied to vertical plates of CRT. So the delay line is used to delay the signal for sometime in the vertical section of CRT.

In this experiment, simple wave forms of phase differences, 0, 45, 90, 135, 180, 225, 270, 315, and 360 measured in degree and of the same the frequency are used.

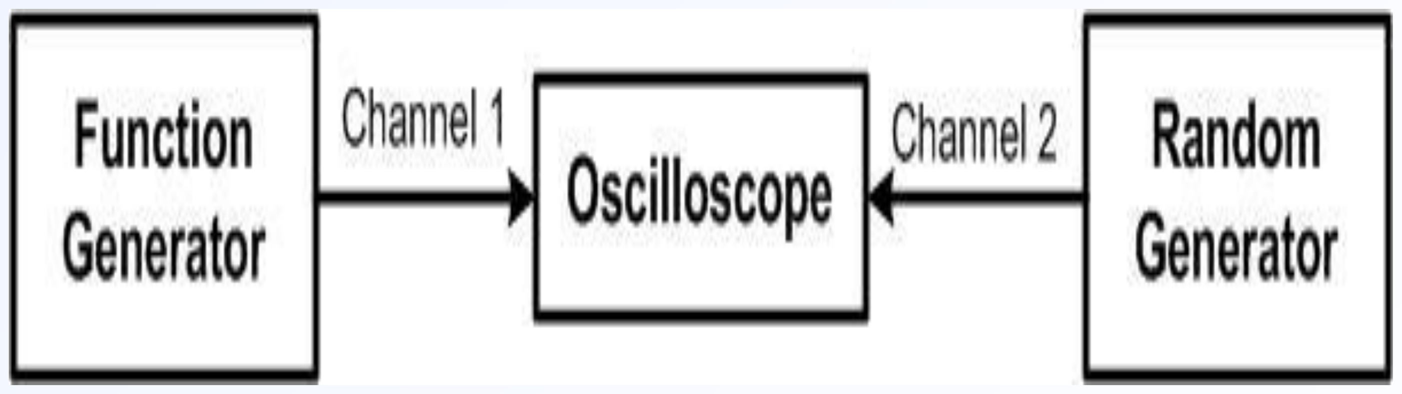

Figure 3 A sketch of the circuit diagram

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Procedures

1. Connect the circuit as shown in figure 3.
2. Turn on the oscilloscope and function generator and set amplitude and frequency of channel 1.
3. Connect the random generator of unknown frequency and phase to channel 2 in oscilloscope.
4. Set the wave form to the same amplitude as that of channel 1.
5. Turn the oscilloscope to XY mode, and change slowly the frequency of the function generator until you get one of known Lissajous figures.
6. Record this frequency which is the frequency of unknown signal.
7. Determine the phase shift from Lissajous patterns.
8. Repeat steps 4-8 with different unknown frequency at least 3 times and find the average frequency and phase shift.

Results

Unknown frequency	Measured frequency 1 And phase shift	Measured frequency 2 And phase shift	Measured frequency 3 And phase shift	Measured frequency av And phase shift
Trial 1				
Trial 2				
Trial 3				

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