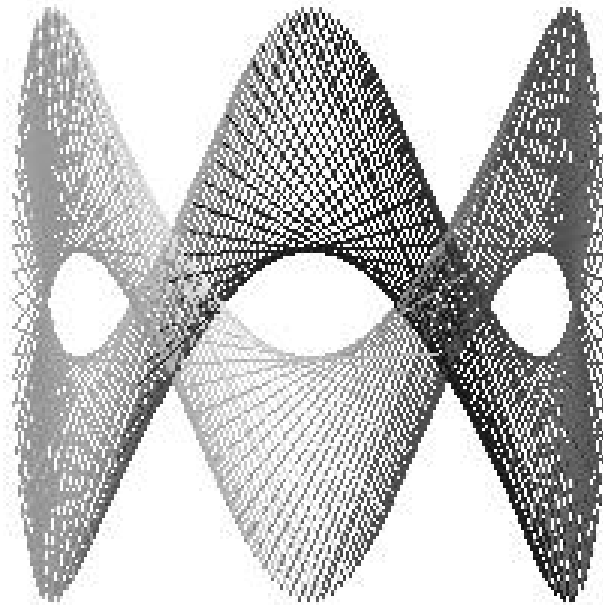


# Physics 4e

## Assessable Prac #1

*“Determining Inductance  
using Lissajous patterns”*



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**Aim:** To use Lissajous figures analysis to determine the inductance of a given coil.

**Conclusion:** The coil had a determined inductance of 4.36 Henrys when it was tested with a 10k resistor and an inductance of 0.902 Henrys when it was tested with a 1k resistor. The reason for the large difference in inductance is because the resistance was changed the Phasor diagram changed, therefore the  $X_L$  and obviously the inductance.

**Background:**

The Lissajous pattern was discovered by the French physicist Jules Antoine Lissajous. A Lissajous pattern is a graph of one frequency plotted on the y-axis combined with a second frequency plotted on the x-axis. Y and X are both periodic functions of time t given by equations such as  $x = \sin(\omega t + c)$  and  $y = \sin(\omega t)$ . Different patterns may be generated for different values of n (period shift) and c (phase shift). The simplest patterns are formed when n is a ratio of small whole numbers such as  $\frac{1}{2}$ ,  $\frac{2}{3}$  or  $\frac{1}{3}$ . The value of c is usually taken as 0 or  $1.57$  (which is  $\frac{\pi}{2}$ )

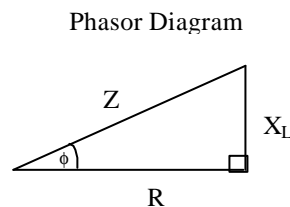
Lissajous figures are used to measure either phase shift between two sinusoidal signals or the frequency of an unknown sinusoidal signal. A pattern or Lissajous figure is developed on the CRO and is used to determine the phase shift or frequency of the unknown signal. Lissajous figures are particularly useful for measurements on low quality CROs and for signal trace scopes where two inputs cannot be compared at one time. The inductance (L) can be calculated from the phase angle, which in turn, can be calculated from the pattern itself. The phase angle is calculated by using the formula :

$$f = \sin^{-1}\left(\frac{A}{B}\right)$$

Where A is the distance between the y-intercepts, when the pattern is centered horizontally, and B is the total height of the pattern. The inductance (L) of the circuit can be determined by using a Phasor diagram with (R) resistance and the phase angle to calculate  $X_L$  (inductive reactance), and hence, with the formula:

$$L = \frac{X_L}{2\pi f}$$

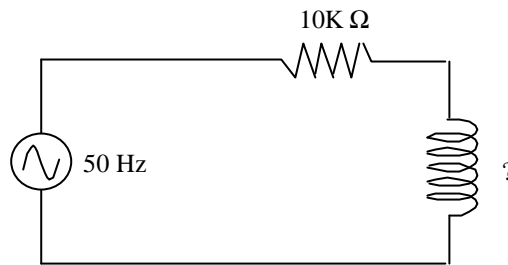
L can be determined.



**Method:**

1. The circuit was constructed as shown.
2. The Y input of the CRO was connected to the circuit at the resistor,

3. The X input of the CRO was connected at the inductor.
4. On the ellipse that was displayed on the CRO the distance between the two y intercepts was measured.
5. The total height of the ellipse was then measured and recorded.
6. The phase angle was calculated using the formula and through that the inductance was calculated.
7. Steps 1 – 6 were repeated using a 1K  $\Omega$  resistor.

**Data:**

	50 Hz, 10 KW	50 Hz, 1 KW
<b>A</b>	1.725 Volts	3.6 Volts
<b>B</b>	12.7 Volts	13.2 Volts

**Analysis:**

For the 10 K resistor.

A = 1.725 Volts

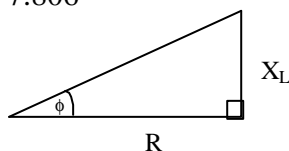
B = 12.7 Volts

$$f = \sin^{-1}\left(\frac{A}{B}\right)$$

$$f = \sin^{-1}\left(\frac{1.725}{12.7}\right)$$

$$f = \sin^{-1}(0.1358)$$

$$f = 7.806^\circ$$



$$\phi = 7.806$$

For the 1 K resistor.

A = 3.6 Volts

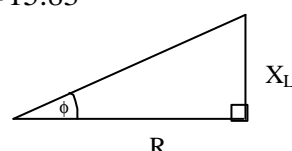
B = 13.2 Volts

$$f = \sin^{-1}\left(\frac{A}{B}\right)$$

$$f = \sin^{-1}\left(\frac{3.6}{13.2}\right)$$

$$f = \sin^{-1}(0.273)$$

$$f = 15.83^\circ$$



$$\phi = 15.83$$

$$R = 10 \text{ K}\Omega$$

$$\tan(7.806) = \frac{X_L}{10000}$$

$$10000 \times \tan(7.806) = X_L$$

$$X_L = 1370.89$$

$$L = \frac{X_L}{2\pi f}$$

$$L = \frac{1370.89}{2\pi \times 50}$$

$$L = \frac{1370.89}{314.159}$$

$$L = 4.36 \text{ Henrys}$$

$$R = 1 \text{ K}\Omega$$

$$\tan(15.83) = \frac{X_L}{1000}$$

$$1000 \times \tan(15.83) = X_L$$

$$X_L = 283.54$$

$$L = \frac{X_L}{2\pi f}$$

$$L = \frac{283.54}{2\pi \times 50}$$

$$L = \frac{283.54}{314.159}$$

$$L = 0.902 \text{ Henrys}$$

The difference in the inductions between the 10K and the 1K resistors are caused by errors such as core saturation and also because when you change the resistor in the circuit the Phasor diagram changes and with it the inductive reactance of the inductor. When the  $X_L$  is changed, obviously there is going to be a change in the inductance of the coil. A better method to crosscheck the induction would have been to change the frequency instead of the resistor therefore leaving the  $X_L$  untouched by a change in resistance.

### Errors:

1. The CRO was partially damaged and therefore caused "CRO drift", where the static pattern drifts and stretches vertically, pseudo-randomly, therefore, alters results. For example, if the CRO drifts vertically by a factor of .2 divisions, in our experiment would have meant an uncertainty of .1 volts, the end results will have been degraded significantly because when you multiply the number the error also multiplies.
2. Core Saturation in the transformer is where the coil starts to magnetize the iron core in the transformer because of the electricity running through it. This causes problems because as the magnetic field builds up it resists the induction of the coil and could cause significant changes in inductance, therefore affect the results dramatically.
3. 5% tolerance/error within resistor. The resistor may not be exactly the value it claims to be.
4. Non-uniform coiling of inductor wire will cause concentrated and dilute sections of inductance causing erratic readings.
5. Inaccuracy of signal generator, frequency is not constant and the graduations on the dial make it almost impossible to get the exact frequency desired.