

Measuring Inductance

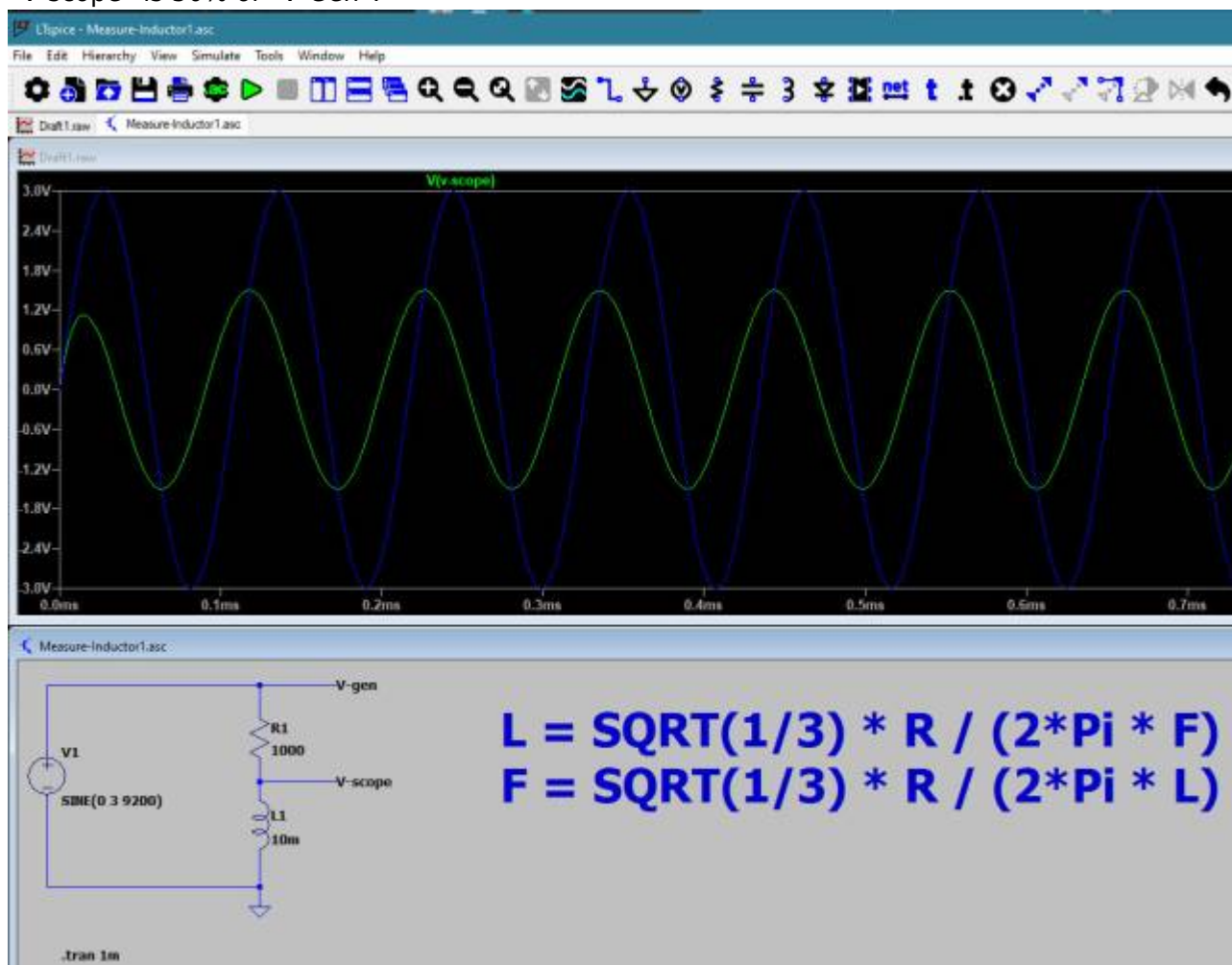
What is needed?

For these measurements we need:

- Function Generator.
- Oscilloscope
- Coil to be tested
- Resistor (value depends on the coil value and frequency range)

Setup

Connect the coil with a series resistor to the function generator. Adjust the frequency until the peak-to-peak voltage over the coil is the same as the peak-to-peak voltage over the resistor. In that case “V-scope” is 50% of “V-Gen”.



Formulas

The exact ratio between the generator voltage and the voltage measured by the scope over the inductor can be calculated with the following network theory:

$$\begin{aligned}\left| \frac{V_{scope}}{V_{gen}} \right| &= \left| \frac{j\omega L}{R + j\omega L} \right| = \left| \frac{j\omega L}{R + j\omega L} \cdot \frac{R - j\omega L}{R - j\omega L} \right| = \left| \frac{j\omega RL + \omega^2 L^2}{R^2 + \omega^2 L^2} \right| = \\ &= \left| \frac{\omega^2 L^2}{R^2 + \omega^2 L^2} + j \frac{\omega LR}{R^2 + \omega^2 L^2} \right| = \sqrt{\frac{\omega^4 L^4}{(R^2 + \omega^2 L^2)^2} + \frac{\omega^2 L^2 R^2}{(R^2 + \omega^2 L^2)^2}} = \\ &= \frac{\sqrt{\omega^4 L^4 + \omega^2 L^2 R^2}}{(R^2 + \omega^2 L^2)} = \frac{\sqrt{\omega^2 L^2 (R^2 + \omega^2 L^2)}}{(R^2 + \omega^2 L^2)} = \frac{\omega L}{\sqrt{R^2 + \omega^2 L^2}}\end{aligned}$$

In this formula L represent the inductance, R the resistance, and omega the radial frequency (= 2 π f with f in Hz). The question now is for what frequency (Vscope/Vgen) = 0.5:

$$\begin{aligned}\left| \frac{V_{scope}}{V_{gen}} \right| &= \frac{1}{2} \Rightarrow \frac{\omega L}{\sqrt{R^2 + \omega^2 L^2}} = \frac{1}{2} \\ \frac{\omega^2 L^2}{R^2 + \omega^2 L^2} &= \frac{1}{4} \\ 4\omega^2 L^2 &= R^2 + \omega^2 L^2 \\ L^2 &= \frac{R^2}{3\omega^2} \\ L &= \sqrt{\frac{1}{3} \frac{R}{\omega}} = \sqrt{\frac{1}{3} \frac{R}{2\pi f}} \rightarrow L = \sqrt{\frac{1}{3} \frac{R}{2\pi f}} = \sqrt{\frac{1}{3} \frac{50}{2\pi f}} = \frac{4.57}{f}\end{aligned}$$

Links

<https://www.dos4ever.com/inductor/inductor.html>

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