Measuring Inductance

What is needed?

For these measurements we need:

- a known reduction transformer (120/240V to 6/12V or whatever you have at hand).
- a potentiometer (I recommend something in the 10K to 100K Ohm linear range)
- a multimeter
- the coil to be tested

All the calculations will be done at 50Hz, which is the standard household AC frequency in NL.

Setup

Steps

1. Ordered List ItemWith the multi-meter set to Ohms, measure the resistance between the terminals of the inductor. You will be measuring the real value of the parasitic resistance of the inductor winding. Write it down somewhere.
2. The diagram of the circuit that we are going to use for the test is shown above.
3. Connect the circuit without plugging it to the power outlet.
4. Set the potentiometer to its maximum value (this is good practice, you start by presenting the maximum impedance to the power supply thereby minimizing the current, and move down the impedance from there)
5. Connect the circuit to the power outlet
6. With the multi-meter set to AC voltage measure the Voltage between terminals of both the Resistor (VR) and the inductor (VL).
7. Move the potentiometer until the read of VR equals VL.
8. Turn off the power
9. Disconnect the potentiometer gently so you don't change its value.
10. With the multi-meter set to Ohms measure the value of the potentiometer.
11. If the value read in 10 is more than 10 times bigger than the value read in 1 then discard the inductor resistance in the calculation. Note: If it is not, you will need much more theory, mathematics and calculus to determine L.
12. Using the formula L = R / (6.28 x 60 Hz) you will get an approximate value for L.

The Theory

The equivalent circuit of a physical (real) inductor is represented by an inductor in series with a resistor and a capacitor in parallel. Fig 1. At audio frequencies we can assume that the parasitic capacitance will be insignificant and discard it for practical purposes. The new equivalent circuit is an inductor with a resistor in series. Fig 2.

Kirchhoff's voltage law (KVL) says that “the algebraic sum of all voltages in a loop must equal zero”.

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Eq.1) V+VR+VL=0
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Where V is the power supply voltage, VR is the voltage between the resistor (potentiometer) terminals, and VL is the voltage beween the inductor terminals. Note: I will use CAPITAL letters V for Voltage and I for Current even though they are both alternate signals. For practical purposes I will not differentiate between Peak Values vs RMS. The multi-meter measures RMS, and this is the value that is required for the calculations.

Ohms law says that:

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Eq.2) V = I * Z
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Where V is the voltage between terminals of the measured component, I is the current through the component, and Z is the impedance.

Replacing Eq. 2 in Eq. 1 we get:

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Eq.3) V + IR * ZR + IL * ZL = 0
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ZL is the impedance of the Inductor determined by the equation

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Eq.4) ZL= j w L
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For a resistor (assumed ideal) Z = R. In a series circuit, by definition, the current is the same throughout. Then: IL = IR replacing in Eq. 3 we get:

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Eq.5) V + I * ZL + I * R = 0
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Method

The method consists in changing the value of R (the potentiometer) until the measured VR is equal to the measured VL. VR and VL will have the same “Value” but their “Phase” will be different. The voltage applied by the power transformer is not important and will not be part of the calculations from now on. Also, the phase is not important to the calculation of L. If the phase is not considered, j does not have any meaning, then:

```
|VR| = |VL| => I * R = I * w L =>
```

I am using brackets for the voltages to represent that I am not considering the phase change between Voltage and Current due to the inductor. I recommend reading about circuit theory, for a deeper understanding on that matter.

In Summary, when |VR| = |VL|:

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Eq.6) R = w L
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By definition w = 2 x Pi x Freq ⇒

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Eq.7) R = 2*Pi*F*L
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2 Pi aprox 6.28, then the equation that we are looking for is:

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Eq.8) L = R / (6.28 x 60Hz)
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Which is the equation that we used in Step 1 when calculating the inductor “L” value.

Links

With thanks to: https://www.instructables.com/Measuring-Inductance-With-a-Multimeter-and-a-Resis/

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