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| **A-11.**  **Inductors** |  |

**OBJECTIVES:**

After performing this experiment, you will be able to:

1. Describe the effect of Lenz’s law in a circuit.

2. Measure the time constant of an LR circuit and test the effect of series and parallel inductances on the time constant.

**READING:**

Nilsson, Electric Circuits, Section 6.1, The Inductor, and Section 7.1, *RL* Circuit

**MATERIALS NEEDED:**

Two 7 H inductors (approximate value) (Triad C-8X or equivalent) (second inductor may be shared with another student)

One neon bulb (NE-2 or equivalent)

One 33 k Ω resistor

For Further Investigation: One unknown inductor Application Problem: One 100 |F capacitor, one 1N4001 diode

**SUMMARY OF THEORY:**

When current is in a coil of wire, a magnetic field is created in the region surrounding the wire. This electromagnetic field accompanies any moving electric charge and is proportional to the magnitude of the current. If the current in the coil changes, the electromagnetic field causes a voltage to be induced across the coil which opposes the change. This property, which causes a voltage to oppose a change in current, is called inductance.

Inductance is the electrical equivalent of inertia in a mechanical system. It opposes a change in current in a manner similar to how capacitance opposed a change in voltage. This property of inductance is described by Lenz’s law. According to Lenz’s law, an inductor develops a voltage across it which counters the effect of a change in current in the circuit. Inductance is measured in henries. One henry is defined as the quantity of inductance present when one volt is generated as a result of a current changing at the rate of one ampere per second. Coils made to provide a specific amount of inductance are called inductors.

When inductors are connected in series, the total inductance is the sum of the individual inductors. This is similar to resistors connected in series. Likewise, the formula for parallel inductors is similar to the formula for parallel resistors. Unlike resistors, an additional effect can appear in inductive circuits. This effect is called mutual inductance and is caused by interaction of the magnetic fields. The total inductance can be either increased or decreased due to mutual inductance.

Inductive circuits have a time constant associated with them, just as capacitive circuits do, except the rising exponential curve is a picture of the current in the circuit rather than the voltage, as in the case of the capacitive circuit. Unlike the capacitive circuit, if the resistance is greater, the time constant is shorter.

The time constant is found from the equation:

where= time constant in seconds,

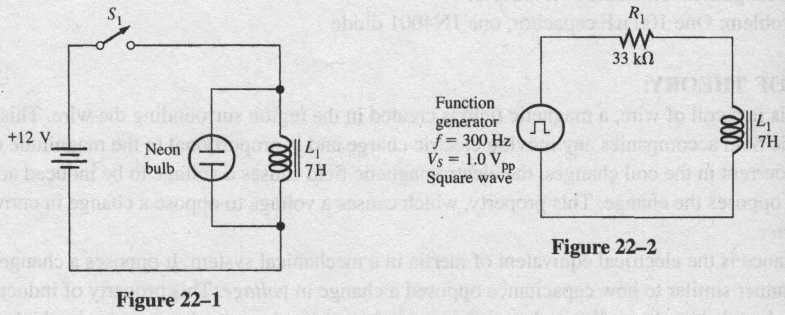
L = inductance in henries and

R = resistance in ohms.

PROCEDURE:

1. In this step, you can observe the effect of Lenz’s law. Connect the circuit shown in Figure 22-1 with a neon bulb in parallel with a large inductor. Neon bulbs contain two insulated electrodes in a glass envelope containing neon gas. The gas will not conduct unless the voltage reaches approximately 70 V. When the gas conducts, the bulb will glow. When the switch is closed, dc current in the inductor is determined by the inductor’s winding resistance. Close and open several times and describe your observations in the report.

2. Find out if the neon bulb will fire if the voltage is lowered. How low can you reduce the voltage source and still observe the bulb? Record your observations in the report.



3. Connect the circuit shown in Figure 22-2. This circuit will be used to view the waveforms from a square-wave generator. Set the generator, for a 1.0 square wave at a frequency of 300 Hz This frequency is chosen to allow sufficient time to see the effects of the time constant. View the generator voltage on CH1 of a two-channel oscilloscope and the inductor waveform on ch2. If both channels are calibrated and have the volts/div controls set to the same setting, you will be able to see the voltage across the resistor using the difference channel. Set the oscilloscope sec/div control to 0.5 ms/div. Sketch the waveforms you see on Plot 22-1.

4. Compute the time constant for the circuit. Enter the computed value in Table 22-1. Now measure the time constant by viewing the waveform across the resistor. The resistor voltage has the same shape as the current in the circuit, so you can measure the time constant by finding the time required for the resistor voltage to change from 0 to 63% of its final value.[[1]](#footnote-1) Stretch the waveform across the oscilloscope screen to make an accurate time measurement. Enter the measured time constant in Table 22-1.

5. When inductors are connected in series, the total inductance increases. When they are connected in parallel, the total inductance decreases. To see the effect of parallel inductors, connect one end of a second 7 H inductor to the first inductor. Then, while observing the waveform across the first inductor, complete the parallel connection of the inductors. You should observe the waveform change as you alternately add or remove the parallel inductor.

You can see the effect of series inductors by placing the two inductors in series. While observing the waveform across both inductors, short out one of the inductors with a jumper wire. Note what happens to the voltage waveforms across the resistor and the inductors. Describe your observations in the space provided in the report.

FOR FURTHER INVESTIGATION:

Suggest a method in which you could use a square-wave from a function generator and a known resistor to determine the inductance of an unknown inductor. Then obtain an unknown inductor from your instructor and measure its inductance. Report on your method, your result, and how your result compares to the accepted value for the inductor.

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| **Report for**  **Experiment A-11** | **Name**  **Date**  **Class** |

**ABSTRACT:**

**DATA:**

*Observations from Step 1:*

*Observations from Step 2:*

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*Observations from Step 5:*

**RESULT AND CONCLUSION**:

**FURTHER INVESTIGATION RESULTS**:

**EVALUATION AND REVIEW QUESTIONS**:

1. The ionizing voltage for a neon bulb is approximately 70 V. Explain how a 12 V source was able to cause the neon bulb to conduct.

2. When a circuit containing an inductor is opened suddenly, an arc may occur across the switch. How does Lenz’s law explain this?

3. (a) What is the total inductance when two 100 mH inductors are connected in series?

(b) In parallel?

4. What would happen to the time constant in Figure 22-2 if a 3.3 k resistor were used instead of the 33 k resistor?

5. What effect does an increase in the frequency of the square wave generator have on the waveforms observed in Figure 22-2?

6. State a rule for determining the polarity of the voltage induced across the inductor.

1. Alternatively, you can measure the rise time and convert the reading to time constant.

   The relation between rise time and time constant is [↑](#footnote-ref-1)