ECE 233
## Laboratory Experiment 8
Capacitors and Inductors I

Capacitors are two terminal circuit elements that can store electrical energy. When a capacitor is excited by an AC voltage source, if the frequency of the source is high enough it behaves as short circuit. When the capacitor is excited by a DC voltage source in that case the capacitor will charge immediately (assuming there is no resistance or the resistance is negligible) and finally it will behave as open circuit.

1- Construct the circuit in Figure 1 (**C=100 nF**, this experimental set up is prepared to measure the capacitance value of the given capacitor). Adjust $V_{in} = 5\sqrt{2}Sin(2\pi ft)$ Volt where f=5000 Hz (The RMS value of $V_{in}(t)$ will be 5 Volt). Use digital multimeters for current and voltage measurements in **AC mode.** We know that the magnitude characteristics of impedance of a capacitor can be calculated using the formula $\left|X_C(jw)\right| = \left|\dfrac{V(jw)}{I(jw)}\right| = \left|\dfrac{1}{jwC}\right| = \dfrac{1}{wC} = \dfrac{1}{2\pi fC}$ where $X_C(jw)$ is the impedance of the capacitor, f is the frequency of the applied input to the capacitor, C is the capacitance value and V(jw) and I(jw) are the phasors of voltage and current waveforms observed over the capacitor. Instead of the phasor values we can use the RMS current and voltage readings over the multimeter. Hence, the capacitance value can be derived using the formula $C = \dfrac{I_{RMS}}{2\pi fV_{RMS}}$ where V_{RMS} and I_{RMS} stand for the measured voltage and current values by the multimeters in **AC mode.**
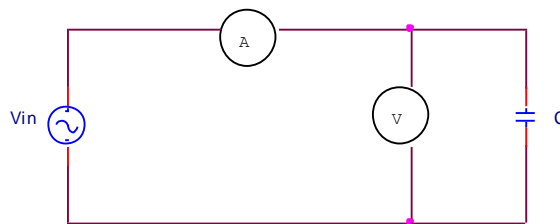
Figure 1: The circuit diagram for capacitance measurement

$V_{RMS}=$ $I_{RMS}=$ $C = \dfrac{I_{RMS}}{2\pi fV_{RMS}} =$

Inductors are two terminal circuit elements that can store magnetic energy. When an inductor is excited by an AC current source, if the frequency of the source is high enough it behaves as open circuit. When the capacitor is excited by a DC current source in that case the capacitor will let all the current to flow over and hence for this reason it behaves as short circuit. Indeed a better practical realistic model for the inductor can be seen in Figure 2. In this Figure due to the copper wires over the inductor a small resistance value should exist in the model which is represented by 'r' and the inductance will be symbolized by the letter 'L'
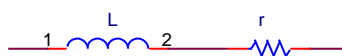
Figure 2: A practical model for an inductor with a series small resistance value r and the actual inductance value L

2- Construct the circuit in Figure 3 (**L=100 mH**, this experimental set up is prepared to measure the impedance value of the given capacitor). Adjust $V_{in} = 5\sqrt{2}Sin(2\pi ft)$ Volt where f=500 Hz (The RMS value of $V_{in}(t)$ will be 5 Volt). Use digital multimeters for current and voltage measurements in **AC mode.** We know that the magnitude characteristics of impedance of an inductor whose model is shown in Figure 2 can be calculated using the

formula $\left|X_L(jw)\right| = \left|\dfrac{V(jw)}{I(jw)}\right| = \left|jwL + r\right| = \sqrt{r^2 + (wL)^2} = \sqrt{r^2 + (2\pi fL)^2}$ where $X_L(jw)$ is the

impedance of the inductor modeled in Figure 2, f is the frequency of the applied input to the inductor, L is the impedance value, r is the small resistance due to the copper wires over the inductor and V(jw) and I(jw) are the phasors of voltage and current waveforms observed over the inductor. Instead of the phasor values we can use the RMS current and voltage readings over the multimeter. After measuring I_{RMS} and V_{RMS} note these values and disconnect the inductor from the circuit. In order to find the resistance value r of the inductor, just measure the resistance value of the inductor using the multimeter in r**esistance measurement mode**

and node the value of 'r'. Now using the formula $L = \dfrac{\sqrt{\left|\dfrac{V_{RMS}}{I_{RMS}}\right|^2 - r^2}}{2\pi f}$ the inductance value can

be derived where V_{RMS} and I_{RMS} stand for the voltage and current values measured by the multimeters in **AC mode.**