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FACULTY OF ENGINEERING

EEE 222 ELECTRICAL CIRCUIT LABORATORY II

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EXPERIMENT I

INTRODUCTION TO

RMS and AVARAGE VALUE MEASUREMENT
IMPEDANCE MEASUREMENT

Part I

AVERAGE AND RMS VALUES

1. OBJECTIVE

In this experiment, it is aimed that how to use digital multimeter for different purposes and measure RMS value of sinusoidal, triangular and square waveforms using DMM.

2. PRELIMINARY

P1. Calculate the RMS values of the following waveforms using below formula:

$$V_{RMS} = \sqrt{\frac{1}{T}\int_0^T v(t)^2\, dt}$$

a) Apply the sinusoidal waveform given below in order to calculate V_{rms}

$$v(t) = V_M \sin\left(\frac{2\pi}{T}t\right) \quad for \quad 0 \le t \le T$$

b) Apply the square waveform which is given below in order to calculate V_{rms}

$$v(t) = V_M \quad for \quad 0 \le t \le \frac{T}{2}$$

$$v(t) = -V_M \quad for \quad \frac{T}{2} \le t \le T$$

c) Apply the triangular waveform which is given below in order to calculate V_{rms}

$$v(t) = \frac{4V_M t}{T} \quad for \quad 0 \le t \le \frac{T}{4}$$

$$v(t) = 2V_M - \frac{4V_M t}{T} \quad for \quad \frac{T}{4} \le t \le \frac{3T}{4}$$

$$v(t) = -4V_M + \frac{4V_M t}{T} \quad for \quad \frac{3T}{4} \le t \le T$$

P2. Calculate the average values of the each rectified waveform obtained in P1 via the formula given below:

$$V_{average} = \frac{1}{T}\int_0^T |v(t)|\,dt$$

P3. Calculate the correction factor of sinusoidal, square and triangular waveforms via below formula and fulfill the blanks of the Table I:

$$\text{Correction Factor} = \frac{V_{RMS}}{V_{Average}}$$

Table I- Theoretical Calculation Results

Parameters	Sinusoidal Waveform	Square Waveform	Triangular Waveform
V_{rms}			
$V_{avarage}$			
Correction Factor			

P4. Concerning the explanations given in introduction, how can you correct the measurement error of square and triangular waveform if their RMS values are measured by an ordinary DMM? Explain your method in details.

EQUIPMENT LIST

- Digital Multimeter (DMM)
- Oscilloscope
- Frequency Generator
- 1k ohm resistor Actual value of resistor measured by DMM:

EXPERIMENTAL PROCEDURE

E1 Setup the circuit given in Figure 1 . Set frequency of function generator 100 Hz V_m=10V

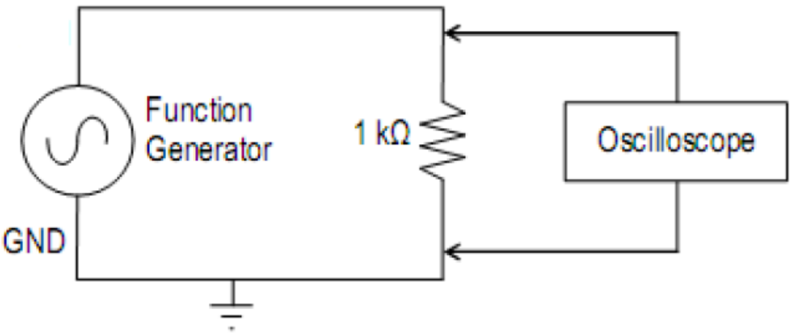

Figure1: The electrical circuit representation fed by signal generator including sinusoidal, triangular and square waveforms

a) Measure the voltage across 1kΩ resistor through oscilloscope.

b) Measure the voltage across 1kΩ resistor through DMM.

E2 Apply the procedure in E1 in order for triangular wave with V_m=10V.

E3 Apply the procedure in E1 in order for square wave with V_m=10V.

CONCLUSION

C1. Calculate the RMS values using the formulas that you obtained in preliminary work by taking V_m=10V. Compare the results that you obtained in the experiments E1, E2, and E3. If there are any differences, explain why.

Part II

IMPEDANCE MEASUREMENT

1. OBJECTIVE

The aim of this part is that how to measure the impedance of the capacitor and inductor through Digital Multimeter.

2.FOREKNOWLEDGE

The steady-state behavior of circuits that are energized by sinusoidal sources is an important area of study. A sinusoidal voltage source produces a voltage that varies sinusoidally with respect to the time. Using the cosine function, a sinusoidally varying voltage can be written as follows :

$$v(t) = V_m \cos(\omega t + \phi) \qquad (1)$$

and correspondingly sinusoidally varying current can be written as below :

$$i(t) = \mathrm{I_m} \cos(\omega t + \theta) \text{ where } \omega = 2\pi \mathrm{f} = 2\pi/\mathrm{T} \text{ radians/second} \quad (2)$$

The purpose of using sinusoidal signals is to determine the frequency, phase angle and maximum amplitude including peak and peak to peak values. Given the sinusoidal function given in Equation (1), phasor representation is defined as $\mathrm{V} = \mathrm{V_m} e^{j\phi}$ (3) where the $\mathrm{V_m}$ is the maximum amplitude of the voltage signal and ϕ is the phase angle of the sinusoidal function. Additionally, the phasor representation can also be expressed in terms of rectangular form and Equation (3) has led to a shorthand notation called the angle notation as follows $\mathrm{V_m}\angle\phi$ (4) .Figure 2 represents phasor domain representation of passive circuit elements in order to understand the usage of phasor representation.

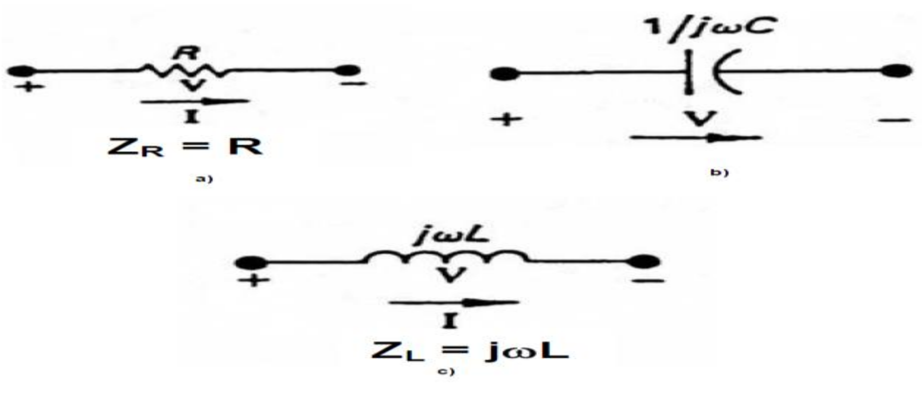

Figure 2: Phasor Domain Representation of passive circuit elements a)resistor b)capacitor and c)inductor

3.PRELIMINARY

P1. Find a method and describe your method in details to determine the inductance (L) of a coil by using the readings of the meters shown in Figure 3. Be careful with the RMS and peak values of the instruments. R_{in} is the internal resistance of the inductor. The internal resistance of inductor R_{in} can be measured by a DMM where R=1kΩ.

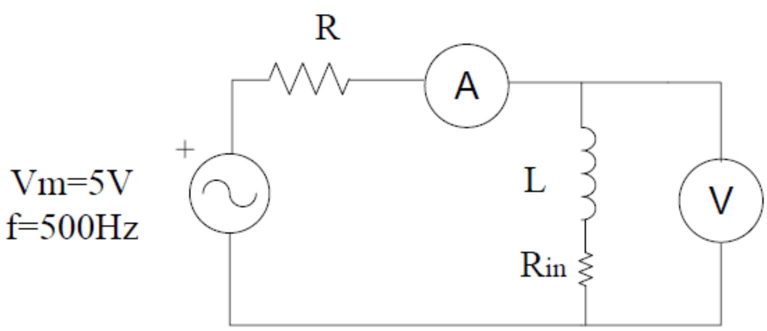

Figure 3: Series RL circuit diagram representation with signal generator when Vm=5V and f=500 Hz(Measurement of the inductance)

P2. Find a method to determine the capacitance value of the capacitor using the readings of the meters where R=1kΩ.

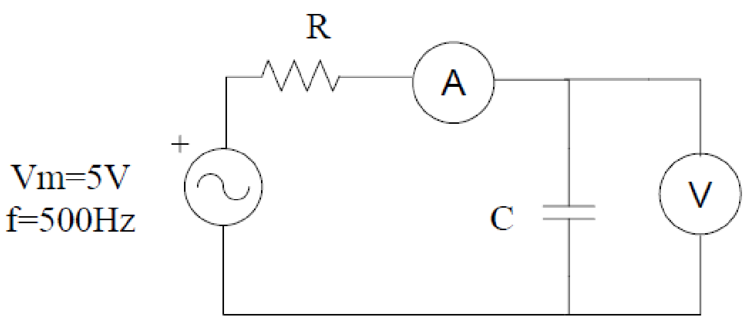

Figure 4: Series RC circuit diagram representation with signal generator when Vm=5V and f=500 Hz(Measurement of the conductance)

P3. Fill in the following table for the circuit given in Figure 5-a. Take R1=1k, R2=100 ohm and L=5mH. All values must be in phasor domain. For example phasor domain equivalence of 3+4j is $5\angle 53{,}13$. Plot |ZAB| versus frequencies given in Table II

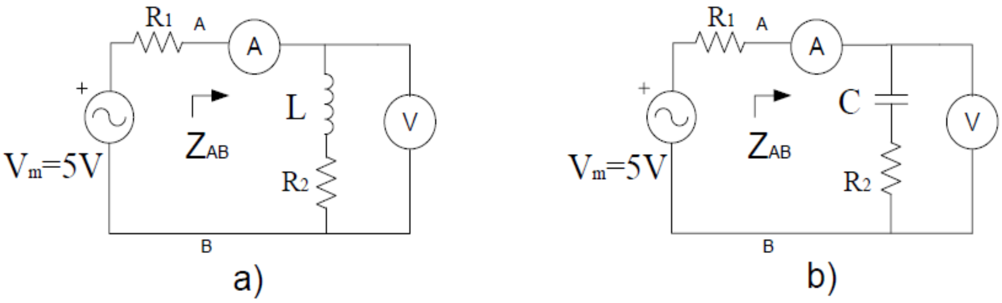

Figure 5: Series circuit representation a) RL circuit diagram and b) RC circuit diagram

Table II-Calculation of voltage and current with respect to the different frequencies

Frequency (Hz)	V_s (Volt)	V_{AB} (Volt)	V_R (Volt)	I (Amper)	Z_{AB} (Ω)
500					
1000					
1500					
2000					
3000					
4000					
6000					
8000					
10000					

P4. Repeat P3 for the circuit given in Figure 5- b. All values must be in phasor domain. **Plot $|Z_{AB}|$ versus frequencies in table III** where C=1µF.

Table III-Calculation of voltage and current with respect to the different frequencies

Frequency (Hz)	V_s (Volt)	V_{AB} (Volt)	V_R (Volt)	I (Amper)	Z_{AB} (Ω)
500					
1000					
1500					
2000					
3000					
4000					
6000					
8000					
10000					

EQUIPMENT LIST

- Oscilloscope
- DMM
- Function Generator
- 1 kΩ and 470 Ω resistors Actual value of resistors measured by DMM:
- 4.7 mH inductor Actual value of inductor measured by DMM:
- 0.1 µF capacitor Actual value of capacitor measured by DMM:

- DATA TABLES

Voltage (V) - Current (I)	**Scale (V/Div)**	**Number of Divisions**	**Voltage - Current Scope**	**Voltage - Current DMM**
Osciloscope				
Theory	X	X		

EXPERIMENTAL PROCEDURE

E1. Measure the winding resistances of 4.7mH coils by DMM. Setup the circuit shown in Figure 3 and determine the inductance values of the coils using the method you propose in P1.

E2. Setup the circuit shown in Figure 4, and determine the capacitance values of the 1µF capacitor using the method you propose in P2. Secondly,energize the circuit and record the capacitor voltage every 10 seconds in Table IV. After that, remove the power supply from the circuit and record the capacitor voltage every 10 seconds in Table IV. Using the data from Tables IV, create two plots of capacitor voltage versus time and compare them to the theoretical plots found in conclusion part.

Table IV-Charge and Discharge voltage of capacitor in every 10 seconds

Time (sec)	V_C(charge)	V_C(discharge)
0		
10		
20		
30		
40		
50		
60		
70		
80		
90		
100		

E3. Setup the circuit given in figure 5a. Fill in the Table II just using the magnitude values. **Plot $|Z_{AB}|$ versus frequency.**

E4. Setup the circuit given in Figure 5b. Fill in the Table III just using the magnitude values. **Plot $|Z_{AB}|$ versus frequency.**

CONCLUSION

C1. Consider P1 and P2. Is there any difference between actual values and experimental values for calculating inductance and capacitance values? State possible reasons.

C2. What happens to $|Z_{AB}|$ when frequency is increased for E3? Why?

C3. What happens to $|Z_{AB}|$ when frequency is increased for E4? Why?

C4. Compute and record the percent deviation between experimental and theory for all steps.