The University of Texas Rio Grande Valley
College of Engineering and Computer Science
Department of Electrical & Computer Engineering

EECE 3225 Electrical Engineering Laboratory 1
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Lab Report 1

By

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Contents

I. INTRODUCTION

In this laboratory we will be working on Measure of Impedance and Complex Power. We will calculate the theorical impedance and the measure impedance and compare them to each other to see if they are like one another.

OBJECTIVES

- Learn/reinforce techniques for measurement of phase, impedance, complex power.
- Apply phasor analysis techniques to circuits, with comparison to measurements.

EQUIPMENT REQUIRED

- Dual Trace Oscilloscope
- Function Generator
- LCR Meter
- Miscellaneous Cables, Breadboard

PARTS REQUIRED

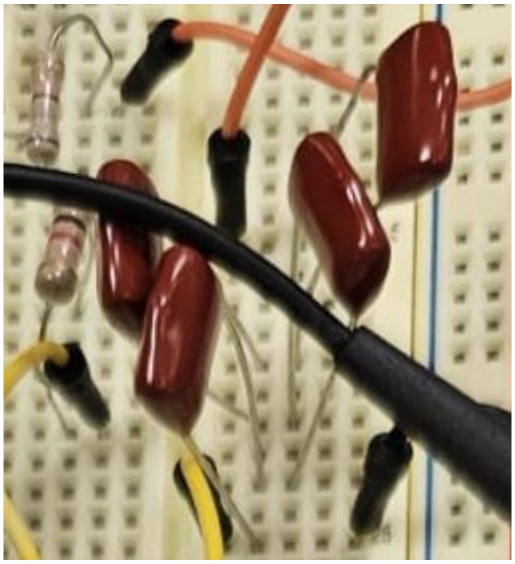
- 2.7 KΩ Resistor
- 0.40 Capacitor Microfarad
- 1.1689 kΩ Resistor
- 3.250 kΩ Resistor
- 2.37 kΩ Resistor
- Mystery Component #5

II. DESCRIPTION OF MAIN CONCEPTS

The following concepts provide an initial explanation and description of the topics addressed in this report.

A capacitor is a device that stores electrical energy by accumulating electrical charges on two closely spaced surfaces that are insulated from each other.

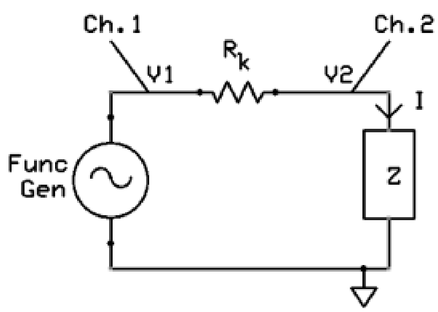
Impedance, represented by the symbol Z, is a measure of the opposition to electrical flow. It is measured in ohms. For DC systems, impedance and resistance are the same, defined as the voltage across an element divided by the current (R=V/I). An example of impedance is displayed in figure 2 by connecting 4 capacitors in series of 0.1 uf to get a total of 0.4 uF and a resistor of 2.7 kΩ.

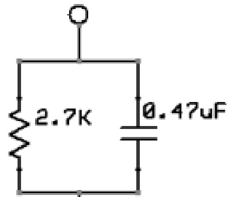


Mystery Component #5. This component replaces the capacitor and the resistor creating an impedance.

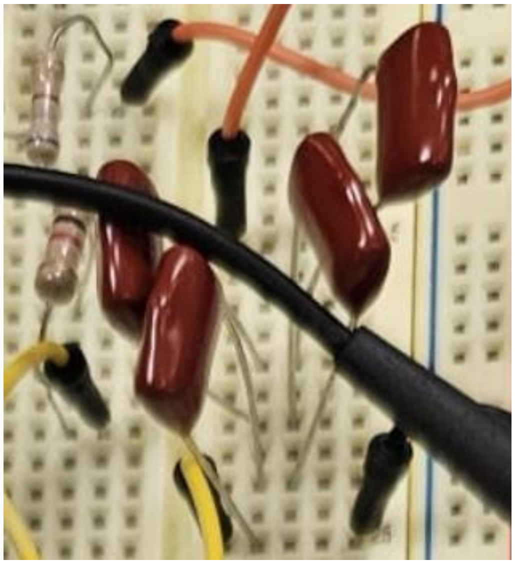
III. DEVELOPMENT

PART 1: Circuit Assignments, Construction, and Preparatory Calculations





(C)



Group	Frequency
A	150 Hz
B	180 Hz
C	200 Hz
D	260 Hz
E	120 Hz
F	300 Hz

Table 1: Frequency Assignments

(1) We were given to do circuit C. The circuit shown in Figure 4 will be the impedance that we will use. The sampling resistor R_k is not shown and is not considered part of Z (impedance).

(2) We used an RCL meter to measure and record the resistor and capacitor values. We use the measured values to be able to do our calculations. We measured 2.6651 kΩ and 0.40 uF for the capacitor. We used a total of 4 capacitors of 0.1 uF and put them on series to be able to get the total of 0.4 uF.

(3) We used the assigned Frequency given in table 1, which in our case was 200 Hz.

(a) The impedance

$$Z = R + \frac{1}{jwc}$$

$$Z = 2700 + \frac{1}{j \cdot 2 \cdot pi \cdot 200 \cdot 0.40x10^{-6}} = 3225.67 < -36.7415$$

(b) Complex Power if a voltage 5<0 V_{pk} is applied to the circuit

$$I = \frac{V}{Z}$$

$$I = \frac{5 < 0}{3.225 < -36.7415} = 1.55039 < 36.7415$$

$$S = VI^{\cdot}$$

$$S = P + JQ$$

$$Vrms = \frac{Vpk}{\sqrt{2}} = \frac{5 < 0}{\sqrt{2}} = 3.54Vrms$$

$$Irms = \frac{Vrms}{Z} = \frac{3.54}{3225.67 < -36.7415} = 1.097 < 36.7415$$

$$S = Vrms \cdot Irms = 3.54 \cdot 1.097 < -36.7415 = 3.883 < -36.7415$$

$$P = 3.883\cos(-36.7415) = 3.11161 -\!\!\rightarrow RealPower$$

$$Q = 3.883\sin(-36.7415) = -2.32283 -\!\!\rightarrow ReactivePower$$

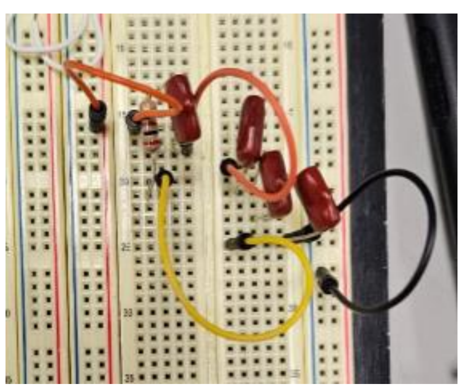
$$|S| = \sqrt{P^2} + Q^2 = \sqrt{(3.11161)^2 + (-2.32283)^2} = 3.883VAR -\!\!\rightarrow Apperant\ Power$$

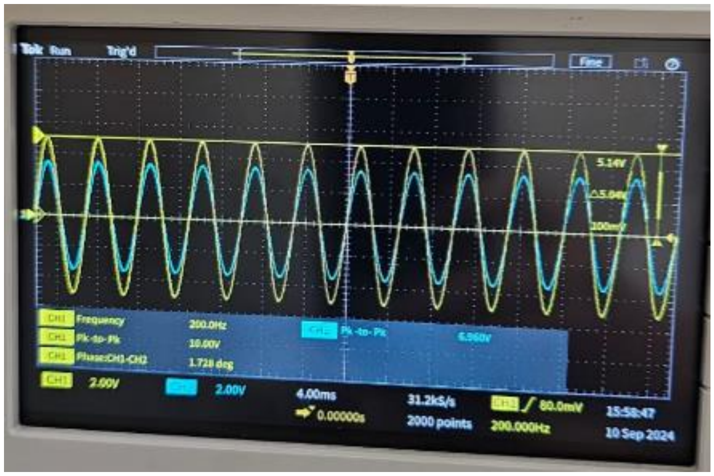
$$Power\ Factor = \frac{P}{|S|} = \frac{3.11161}{3.883} = 0.801342$$

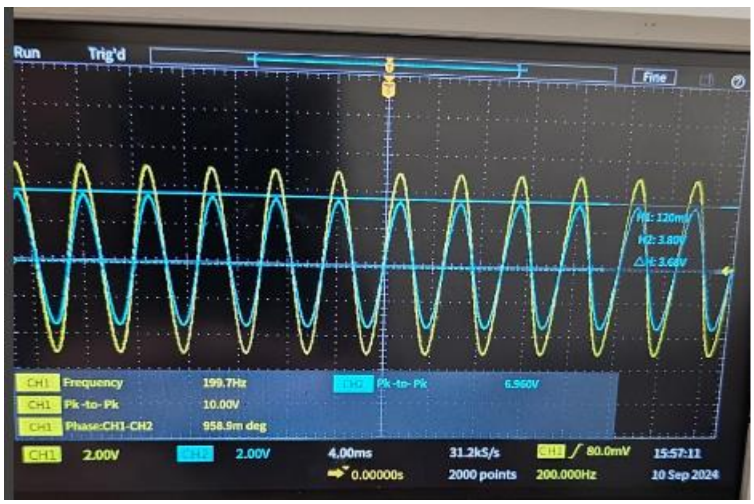
PART II: Impedance Measurement

For part II of the lab, we added an additional sampling resistor in series between the function generator and the input to our circuit. The sampling resistor would be used to help measure the input impedance.

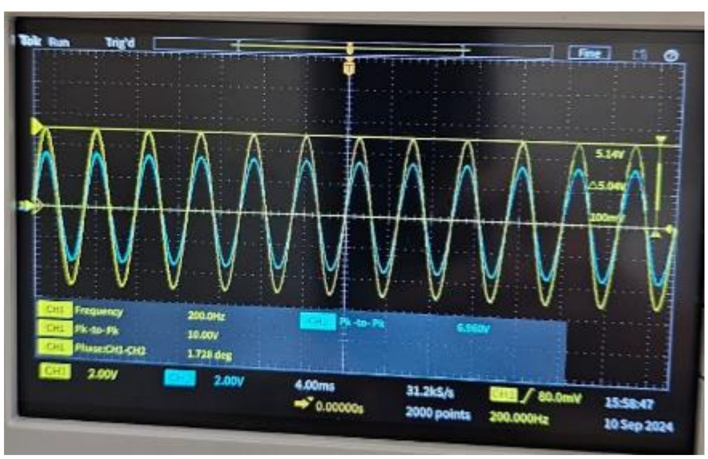
(1) We set up the function generator with the correct frequency and waveform. We determined the appropriate amplitude.
(2) We made our measurement and then found the impedance using the method described in section D (2). We included scope shot(s)

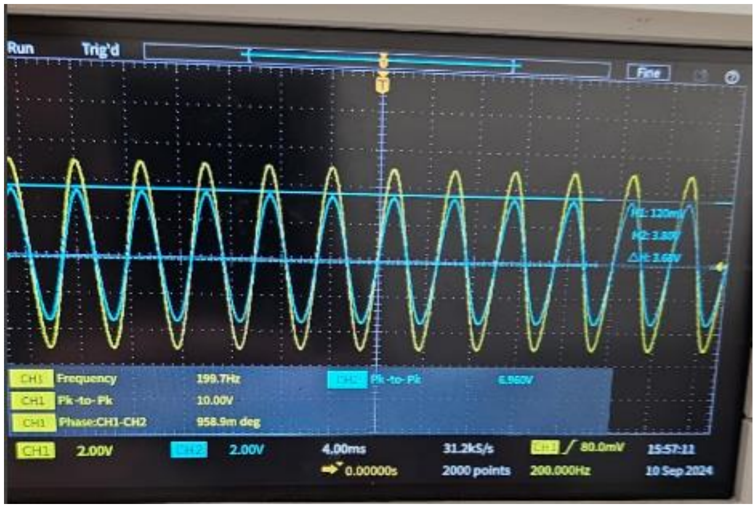






(3) We checked the consistency and repeated step (2) using a different function generator amplitude and sampling resistor.





(4) Before we moved to the next part, we compared both our measurements to our calculated results from part I Step(3a). Which we should be in a reasonable agreement of 10% max error in both the real and imaginary parts.

$$V1 = 5.12 < 0$$

$$V2 = 3.68 < 4.032$$

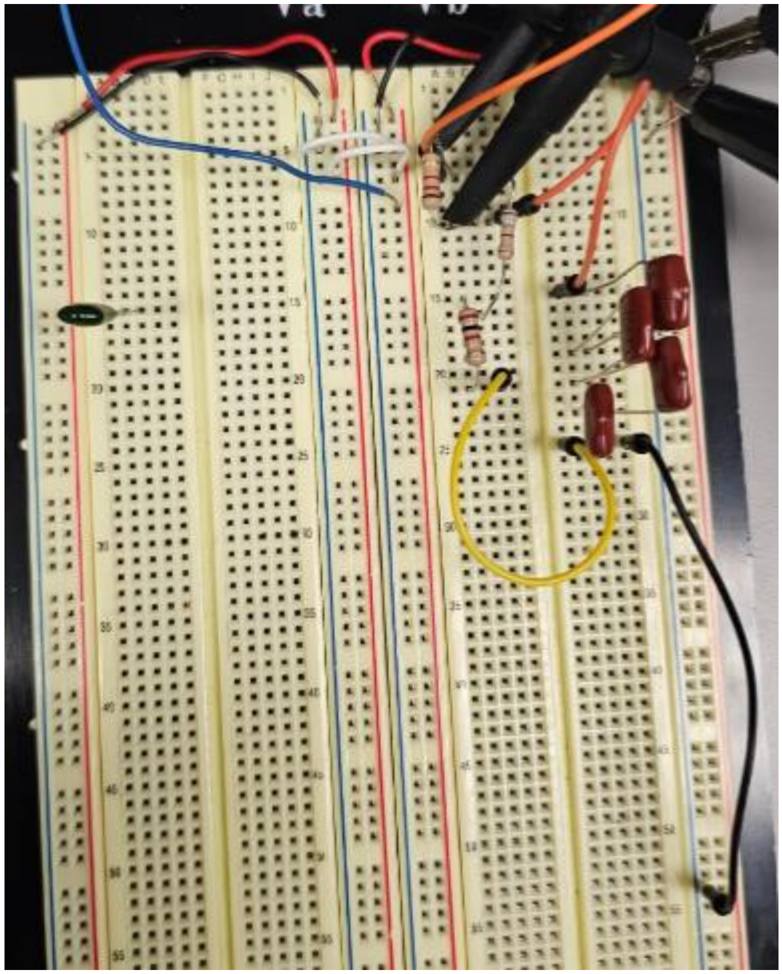
$$I = \frac{V1 - V2}{Rx} = \frac{5.12 < 0 - 3.68 < 4.032}{1.1689} = 1.25933 < -10.1241$$

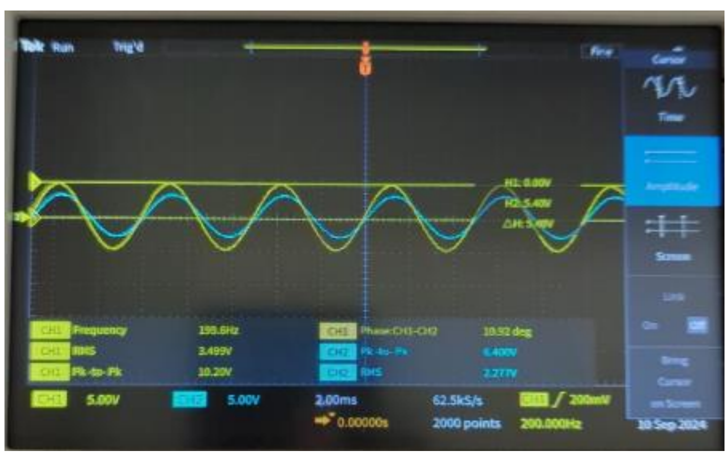
$$Z = \frac{V2}{I} = \frac{3.68 < 4.032}{1.25933 < -10.1241} = 2.92 < 14.1561$$

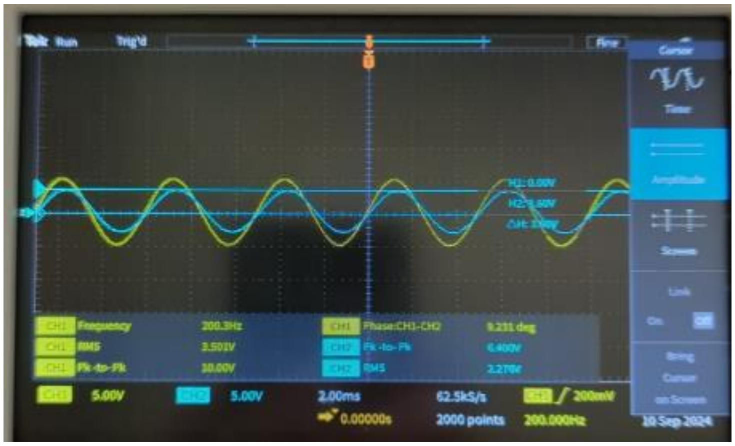
$$\%error = \frac{3.225 - 2.92}{2.92}(100) = 10.4$$

PARTIII: Complex Power

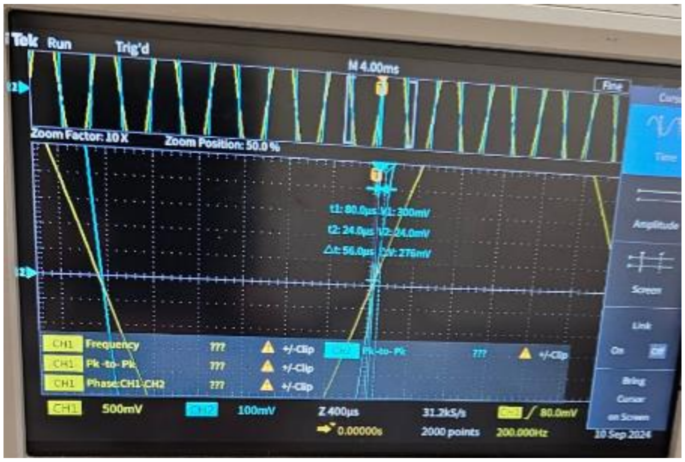
(1) Still using our assigned frequency (200Hz) and using 1.1689 kΩ for our Rk which gave us the best result, we adjusted the function generator amplitude to bet 5 Volts peak and amplitude at V2. The function generator will not be 5 volts because 5Volts is at V1. We included a scope shot showing that we had the correct amplitude.




Tek Run
Trig'd
Cursor
Time
Amplitude
Screen
H1: 0.00V
H2: 5.40V
CH1 Frequency 199.6Hz
CH1 RMS 3.499V
CH1 Pk-to-Pk 10.20V
CH1 Phase:CH1-CH2 10.92 deg
CH2 Pk-to-Pk 6.400V
CH2 RMS 2.277V
CH1 5.00V
5.00V
2.00ms
0.00000s
62.5kS/s
2000 points
200mV
200.000Hz
10 Sep 2024



(2) We made our phasor measurements and used them to calculate the complex power. We also found real power, reactive power, apparent power, and power factor.



$$V1 = 5.04$$

$$V2 = 7.36$$

$$Rx = 1.1689$$

$$V1rms = 5.04\sqrt{2} = 7.12 -\!\!\rightarrow \frac{8.28}{\sqrt{2}} -\!\!\rightarrow 5.85484$$

$$V2rms = 7.36\sqrt{2} = 10.40 -\!\!\rightarrow \frac{5}{\sqrt{2}} -\!\!\rightarrow 3.53$$

$$7.12 - 10.40 = -3.28 \; or \; 3.28 + 5 = 8.28$$

$$Phasor\ Angle = \Delta T \cdot f \cdot 360$$

$$Phasor\ Angle = 56x10^{-6} \cdot 200 \cdot 360 = 4.032$$

$$V1rms = 5.85484 < 0$$

$$V2rms = 3.53 < -4.032$$

$$I = \frac{5.85484 < 0 - 3.53 < -4.032}{1.1689} = 2.00761 < 6.07145$$

$$5.85484(\cos(0) + j\sin(0)) - 3.53[\cos(-4.032) + j\sin(-4.032)]$$

$$I = \frac{(5.85484 + j0) - (3.52126 - j0.2482071)}{1.1689} = 2.00 < 6.08$$

$$Z = \frac{V2}{I} = \frac{3.53 < -4.032}{2.00 < 6.08} = 1.765 < -10.112$$

$$Z = 1.73758 - j0.3098$$

$$S = I^2rms - jI^2rmsX$$

$$S = 4.56756 - j1.2392 = 4.73268 < -15.1792$$

$$P = 4.7326\cos(-15.1792) = 4.56749 -\rightarrow \ Real\ Power$$

$$Q = 4.73268\sin(-15.1792) = -1.23918 -\rightarrow Reactive\ Power$$

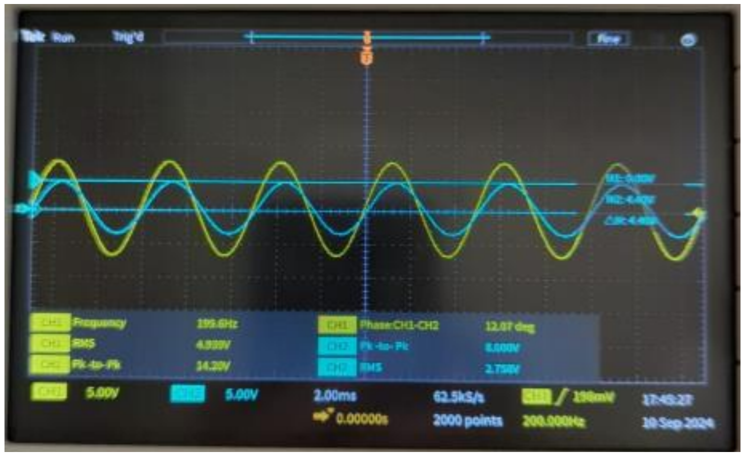
$$|S| = \sqrt{P^2} + Q^2 = \sqrt{(4.56749)^2 + (-1.23918)^2} = 4.7326 -\rightarrow Apperant\ Power$$

$$Power\ Factor = \frac{P}{|S|} = \frac{4.56749}{4.73268} = 0.965096$$

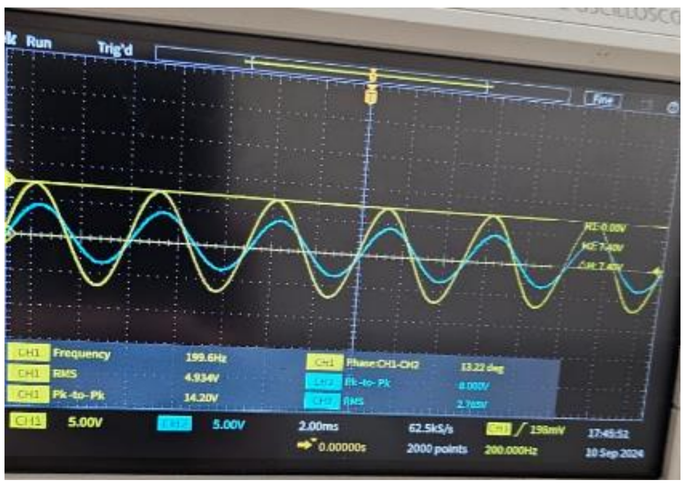
(3) Before moving on, we compared the result to the calculations from part I Step (3b). There should be a reasonable agreement (10% max error) on all quantities.

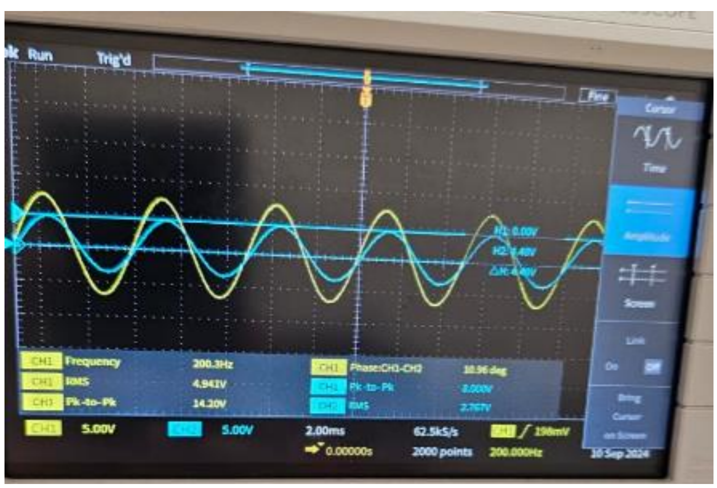
PART IV. Unkown impedance: a transformer

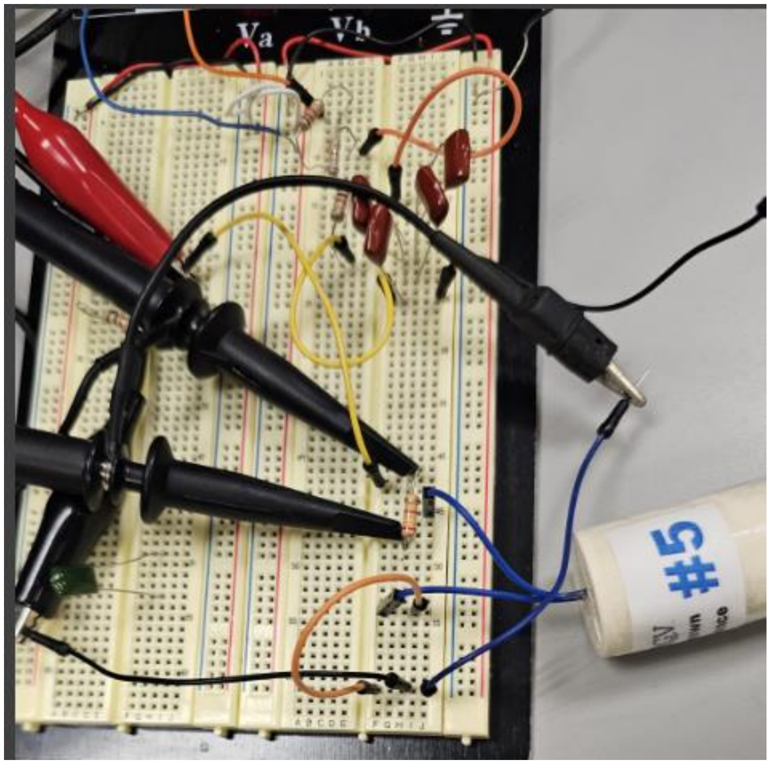
(1) For this part of the lab, we used a sealed “mystery” device with two terminals.
(2) We used the assigned frequency from Table 1, in our case it was 200 Hz. We measured the impedance, making our own judgement on the amplitude and sampling resistor. We include scope shot(s) as appropriate.



(3) To check the result of (2), we measure again using a different amplitude and sampling resistor. Include scope shot(s) as appropriate.







$$Frequency = 200Hz$$

$$Amplitude = 7V$$

$$Resistor = 3.250\ k\Omega$$

$$V1 = 7.40$$

$$V2 = 4.40$$

We Need to Convert V1 and V2 to V1rms and V2rms

$$V1 = 7.40\sqrt{2} \longrightarrow 10.4652 \longrightarrow 9.2427 \longrightarrow 6.53558 = V1rms$$

V2= $4.40\sqrt{2} = 6.2225 \longrightarrow \frac{5}{\sqrt{2}} \longrightarrow 3.53 = V2rms$

10.4652-6.225=4.2401

4.2424+5=9.2427

V1rms=6.53558<0

$$Formula\ for\ Phasor = \Delta T \cdot F \cdot 360$$

$Phasor\ for\ V2rms\ =\ 168x10^{-6} \cdot 200 \cdot 360 = 12.096\ deg.$

Will be equal to –12.096 because channel 2 is lagging

V2rms=3.53<-12.096

$$I = \frac{V1 - V2}{Rx} = \frac{0.53558 < 0 - 3.53 < -12.096}{3250} = 0.976 < 13.4881$$

$$Z = \frac{V2}{I} = \frac{3.53 < -12.096}{0.976 < 13.4881} = 3.6168 < -25.5841$$

$$Ampolitude = 5V$$

$$Frequency = \ 200Hz$$

$$Resistor = 2.3752k\Omega$$

$$V1 = 5.40 -\!\!\rightarrow 5.40\sqrt{2} -\!\!\rightarrow \frac{7.63675}{\sqrt{2}} -\!\!\rightarrow 7.82842 -\!\!\rightarrow 5.53$$

$$V2 = 3.40 -\!\!\rightarrow 3.40\sqrt{2} -\!\!\rightarrow 4.80833 -\!\!\rightarrow 5 -\!\!\rightarrow 3.53$$

$$7.63675 - 4.80833 = 2.82842 + 5 = 7.82842$$

$$FormulaforPhasor = \Delta T \cdot F \cdot 360$$

$$Phasor\ for\ V2rms = \ 136x10^{-6} \cdot 200 \cdot 360 = 9.792 = -9.792\ because\ channel\ 2\ is\ lagging$$

$$V1rms = 5.53 < 0$$

$$V2rms = 3.53 < -9.792$$

$$I = \frac{V2}{I} = \frac{5.53 < 0 - 3.53 < -9.792}{2.3752k\Omega} = 0.899 < 16.31$$

$$Z = \frac{V2}{I} = \frac{3.53 < -9.792}{0.899 < 16.31} = 3.92261 < -26.1042$$

$$\frac{3.92 - 3.61}{3.61}(100) = 8.45499\%$$

IV. CONCLUSIONS

- In conclusion, when we found our V1 and V2 value and we noticed our channel 2 was lagging which is why our phasor was at a negative angle. We were able to calculate our current which was based on us getting our V1 and V2 and dividing them by our sampling resistor. After getting the current we were able to get our impedance which is z = v2/I. After calculating the impedance, we were able to calculate our complex power, real power, reactive power, and apparent power. For part 2 of the lab, we measured our impedance and current and compared them to another pair of impedance and current to determine our percent error and successfully had the error below 10 percent. In part 3, using our assigned frequency, 200Hz, and our sampling resistor, we adjusted the function generator to get 5 volts peak and got our phasor measurements. Using the phasor, we calculated our complex power, real power, reactive power, apparent power, and power factor. With our calculations, we compared them to part one and made sure there was a less than 10 percent error. In part 4 we used a random transformer, replacing our capacitors and resistors. Using the same frequency, we measured our impedance and decided the amplitude and sampling resistor on our own. We did the same thing again, but this time with a different amplitude and sampling resistor.

- The lab results demonstrated the importance of accurate phase alignment for reliable impedance measurement, as evidenced by the observed phase lag and negative phasor angle. Accurate impedance calculations were crucial for deriving complex, real, reactive, and apparent power values. Achieving a percent error below 10% validated the precision of our measurements. Adjusting the function generator and varying circuit components showed the impact of frequency and configuration on impedance and power, confirming that our results were consistent with theoretical predictions and highlighting the effectiveness of our experimental approach.
- Several factors may have influenced the accuracy of the experiment's results. Measurement errors in voltages (V1 and V2) or current can affect impedance and power calculations, with small inaccuracies in tools or reading techniques leading to deviations. Variability in the sampling resistor's resistance, potentially affected by temperature changes, could also impact current calculations. Additionally, the 200 Hz frequency used might introduce reactance that wasn't perfectly accounted for, especially with non-ideal component characteristics. Furthermore, phasor angle errors, such as the lag observed in Channel 2, can lead to inaccuracies in power factor calculations and overall power metrics.
- Future research could focus on improving measurement accuracy with advanced tools like high-resolution oscilloscopes and digital multimeters. Investigating how component tolerances and environmental factors affect results, exploring impedance and power changes across various frequencies, and studying complex phasor behavior and reactive components using simulations could provide deeper insights. Additionally, expanding research to include different transformer configurations and non-linear loads would help understand their impact on impedance and power metrics.