**A green tree on a black background

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BIRZEIT UNIVERSITY

Physics Department

## Physics 112

**Experiment No. 8**

**Impedance & Reactance**

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Date: 1-1-2024

**Abstract:**

* **The aim of the experiment is** :to find out the frequency at which the phase difference equals zero, and compare it with the theoretical one. And also to find out the phase differences between![A black background with a black square

  Description automatically generated with medium confidence](data:image/png;base64,iVBORw0KGgoAAAANSUhEUgAAADUAAAA5CAMAAACh+pM5AAAAAXNSR0IArs4c6QAAAARnQU1BAACxjwv8YQUAAAAkUExURQAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAKZYAkcAAAALdFJOUwBCTlyJlqC2yvf+HMEgJgAAAAlwSFlzAAAh1QAAIdUBBJy0nQAAAKVJREFUSEvt0NsOgyAQRVGsvVn+/38LMk4Enck5JtqHsl9AcYWJodf732JJnsJYP5q1HyFmoz4QahWGGgWiWj1BVCsUZSU7fL5K4WilCLRWsgK9VMVbWZESKoqZTxWFFjVQaFEcyurNzjcrHs2KRkXJHi+pOMkeLqP9q8yDlH3mIOfMQc7ZCUrWTR6yu1B5/93uwgEfqhit6C4r1MGrNHnT+10hfAFmJAferOXYJQAAAABJRU5ErkJggg==), ![A black background with a black square

  Description automatically generated with medium confidence](data:image/png;base64,iVBORw0KGgoAAAANSUhEUgAAADAAAAA3CAMAAAB92TkNAAAAAXNSR0IArs4c6QAAAARnQU1BAACxjwv8YQUAAAAkUExURQAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAKZYAkcAAAALdFJOUwAfT46anbjP2+HkhSCI0wAAAAlwSFlzAAAh1QAAIdUBBJy0nQAAALZJREFUSEvtkFkOwzAIBd194f73LWZJsZSYh9SfSh4p2IneGJy2WPwYcuKb7A8ZInmcGTJAfhCQ/CjYOiOOjeRjA2igIJygfBCw/Fegq64ZLmAXYDZBKoAJcN4EeCAT7nj+TPSoDKQNCnkRChcwwfYQLJTyu8J7dsReg2nP4kAs2ApzLNz4wY7TKbmif9CEfjw95UuCN/BtigkXtzLs7F5LwlZSNIoLL/09PYtOJFnd9rr4Y1r7AGtJB1q+TKDVAAAAAElFTkSuQmCC) and  in an AC-powered RLC circuit.
* **The method used is:** by using the CRO to find the phase shift between the driving voltage and the current, ![A black background with a black square

  Description automatically generated with medium confidence](data:image/png;base64,iVBORw0KGgoAAAANSUhEUgAAAC4AAAA3CAMAAABEvohWAAAAAXNSR0IArs4c6QAAAARnQU1BAACxjwv8YQUAAAAqUExURQAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAoTzogAAAANdFJOUwABQlxemaaq3ePo7feXFS0VAAAACXBIWXMAACHVAAAh1QEEnLSdAAAAs0lEQVRIS+2SSQ4DIQwEyZ6ZhP9/NxhssBWWZi5RJOpCGwrjA26xOIgXrrqKR3Xs+UAOGMH7N6cWVt85NLGzcGijdMA2Oq8dgi0WYJP+kJTWLrn5GbGLDtlZx2zRocEDosdiTNJRO+n+xtWIE+no4LF50LkYE+wLbsfuL84GetW5ZyoypHPUpM3vo6qd9yo6B0XZQ/R7T+dVUXuwzTanz9l/rRcfuyf/An6F/t3sTItf49wH6gkIfFQ9+bcAAAAASUVORK5CYII=) and ![A black background with a black square

  Description automatically generated with medium confidence](data:image/png;base64,iVBORw0KGgoAAAANSUhEUgAAADAAAAA5CAMAAABH01h9AAAAAXNSR0IArs4c6QAAAARnQU1BAACxjwv8YQUAAAAhUExURQAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAG3RSMEAAAAKdFJOUwAsLTg7c4Kq4v6bp3BvAAAACXBIWXMAACHVAAAh1QEEnLSdAAAAq0lEQVRIS+2SwQ4CIQwFUVxX+f8PNtAHoYTK62EPmzAHKWZmtyaGzeaGxFSIuAa54jJnEFb6JMBg4vV1cK59HRC+CoiFVMD6VXsyfh9QfhdQC3UB6bfgRfo5kLN8EiBgF6oB70tw8L4EDv+bA8dC+QXlHTRevwQYFeZj7ADDiPWkPwGGATvAOWD6/sDAG6T0xkRy+UYP/0/AwNICNqxB+si5Iv8hBXyxuYQQfnSOBsumZFQPAAAAAElFTkSuQmCC).
* **The main Result :**

= sin-1 = sin-1  = 24.04 diq

*f0  =*  = = 4800 HZ

between (VR & VL) = ( 1.74 Rad)

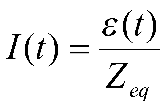
between (VR & VC) = - ( 1.507 Rad)

**Theory:**

A diagram of a circuit

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Description automatically generated with medium confidenceThe current in the AC-powered RLC circuit shown in fig.1 is given by:  
 where , and ,*

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Description automatically generated with medium confidence***Z R , Z C and Z L** *b*eing the resistive impedance, the capacitive impedance, and the inductive impedance respectively. While the quantities are the

capacitive reactance and inductive reactance

respectively.

After some mathematical treatment we get the value of the current as

follows :

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*A black background with a black square

Description automatically generated with medium confidence*where and

As we can see from fig.2 the current heads or lags the voltage by

A graph of a function

Description automatically generatedtime interval that is dependant on the frequency of the cosine function. In other words there exists a phase shift A black background with a black square

Description automatically generated with medium confidencebetween them.

The voltage across the inductor can be obtained as follows:

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Description automatically generated with medium confidenceNote that ![A black background with a black square

Description automatically generated with medium confidence](data:image/png;base64,iVBORw0KGgoAAAANSUhEUgAAACcAAAA1CAMAAAD1YwKXAAAAAXNSR0IArs4c6QAAAARnQU1BAACxjwv8YQUAAAAeUExURQAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAALcob2oAAAAJdFJOUwAxVmpxecjy85xu+fsAAAAJcEhZcwAAIdUAACHVAQSctJ0AAACVSURBVEhL7ZJLDoAgDETxb+9/YQVHHEOhXehK38JO6qPFxPDzw0hEyQX8SmREKrl5K4ICefWlO+yhqojMZ0LVyeOaW9lD1cnXa2vZM7ZeXnrWgWdp8BanZ2qHZ2vJG5yeQ9u9TibkFiK9b1z6Xia2iqN6D4FQtIqHQLh7qIzzqMbjHqrBS9czbQiW5xsXf4sDNL5FCBsyyQT/nSaxogAAAABJRU5ErkJggg==) is just the current multiplied by the inductive reactance

with a phase shift of introduced. (Generalized Ohm’s law)

The voltage across the resistor is:

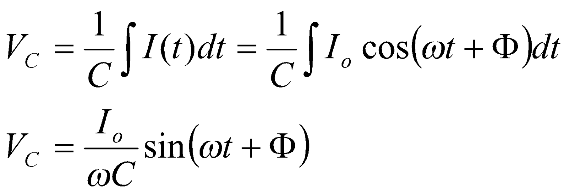
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![A black background with a black square

Description automatically generated with medium confidence](data:image/png;base64,iVBORw0KGgoAAAANSUhEUgAAAC4AAAA1CAMAAAAJdildAAAAAXNSR0IArs4c6QAAAARnQU1BAACxjwv8YQUAAAAqUExURQAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAoTzogAAAANdFJOUwABJ1ZrbYSpuczY5vJDk+ShAAAACXBIWXMAACHVAAAh1QEEnLSdAAAAt0lEQVRIS+2TSQrEMAwEPfuq/393bKknkfHWvuTkgkRbIUQgYbE4ClFqRZ1sPpILHUkTr4/tXEfs4HRiudMZ++p0xB7RviCz0Gdbzpyy6y/K3nTO/uty1mqI6dzhEehWjFGdtlWnTwmnqPN2Wj5hq450R3fIF5Un9ZE6tNkcFFizMqraHf2GJKOtI+bArg8L1HuzdtorckcxRj7xeaAY8kxX0KeYOalP/AL2Jn14nK4fUU2ERZsQfpbGCSWnlMOoAAAAAElFTkSuQmCC)Note that is just the current multiplied by the resistance. (Ohm’s law)

And finally the voltage across the capacitor is:



Note that Vc is just the current multiplied by the capacitive reactance with a phase shift of introduced.

The phase shifts between the current and the voltages across the different circuit elements in fig.1 are also related to Φ which is a function of ω*.*

**Data:**

**C = 0.1 MF L = 10 mH R = 1k**Ω

|  |  |  |  |
| --- | --- | --- | --- |
| *f* (KHz) |  |  |  |
| 0.2 KHz | 1200 | 1.256 | 1.5072 |
| 0.5 KHz | 420 | 3.14 | 1.3188 |
| 1 KHz | 160 | 6.28 | 1.0048 |
| 4 KHz | 6 | 25.12 | 0.1507 |
| 4.8 KHz | 0 | 30.144 | 0 |
| 5.5 KHz | - 4 | 34.54 | - 0.1381 |
| 10 KHz | - 8 | 62.8 | - 0.5024 |
| 20 KHz | - 7.2 | 125.6 | - 0.9043 |
| 50 KHz | - 4 | 314 | - 1.2560 |
|  |  |  |  |

A graph of a function

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**Calculations:**

= sin-1 = sin-1  = 24.04 diq

*f0  =*  = = 4800 HZ

between (VR & VL) =

between (VR & VC) = -

**Analysis & Conclusion :**

By analysing the graphs, data and the numerical results we can see that:

1. At the resonant frequency, the phase shift is zero.
2. The resonant frequency that we experimentally found matched the theoretically calculated one.
3. As the frequency changes the phase shift changes in the shape of a sinusoidal function. (This might be a little vague when we look at the data because there we only measured the absolute values of –a- and –b-.)
4. As we expected for the second part of the experiment, the phase shift of the voltage across the inductor and the capacitor is 
5. Despite the phase shift mentioned above, VR, VL and VC all have the same frequency and shape.

This experiment discussed the phase difference between the graphs of resistor voltage  and voltage input. It was found that all values of ∆t were at a higher value when frequency was at  a lower value, but slowly started to decrease as frequency increased. However, after the  frequency, 4.8kHz, the time half and phase shift were equal to 0, the frequency and time-half  began to increase. Therefore, determining that frequency and time-half have an alternating  relationship where their graph would be a cosine graph.

The theoretical and exponential values for the phase shift and omega had been proven to  be similar with a small percentage error. As for the phase shift vs. Omega graph, it was shown to  be an exponential decay due to the negative values received after ∆t is equal to 0.