

Resonance

by Aaron Stewart Hillam

FILE	1400_AARON_STEWART_HILLAM_RESONANCE_226192_1336961639.DOCX (1.61M)		
TIME SUBMITTED	06-FEB-2020 05:26PM (UTC+0000)	WORD COUNT	1994
SUBMISSION ID	119701160	CHARACTER COUNT	10368



Resonance

BEng Electronics Engineering
ACDB4002 – Electrical & Electronic Principles

Prepared by:

Mr Aaron Hillam

P141233

Submitted to:

Dr Steve Mosey

School of Computing

06/02/2020

Abstract

The purpose of this assignment is to develop the skills and experience in the electronic discipline by conducting exercises including practical measurements and data analysis. This has been completed by setting up two experiments, the first a simulation of an RLC circuit, which uses a signal generator and a virtual oscilloscope to generate ideal readings. The second experiment consists of a physical RLC circuit built on a breadboard; this is then tested using a physical oscilloscope.

The data is then correlated and translated onto logarithmic graphs which show the VLC values, the rate of attenuation and the power output. The data has been used to determine the bandwidth and the quality factor of a signal / frequency.

The results of the experiments have shown that there are many variables in the real world which reduce functioning properties, these can include the resistance within all the materials and the medium transfer / attenuation.

It is determined that the physical circuit needs to be adjusted to compensate for the external factors, by using the simulation as a guide.

The work required to complete this report has resulted in a more general understanding of RLC circuits and its properties.

Contents

1.0 Introduction	5
1.1 Aims and Objectives	5
1.2 Background Research	6
2.0 Equipment	7
2.1 Simulation Setup	7
2.2 Physical Setup	7
3.0 Methodology	8
4.0 Results	11
5.0 Evaluation	20
6.0 Conclusion	21
7.0 References	22
8.0 Appendix 1	23
8.1 Appendix 2	24

Figures and Tables

Figure 1: Simulation Setup	8
Figure 2: Physical Setup	9
Figure 3: Simulation VLC	11
Figure 4: Physical VLC	12
Figure 5: Simulated Attenuation / Frequency	13
Figure 6: Physical Attenuation / Frequency	14
Figure 7: Simulated Q Factor	15
Figure 8: Physical Q Factor	16
Figure 9: Simulated V-Out	18
Figure 10: Physical V-Out	19
Table 1: Q Factor Results Simulated	17
Table 2: Q Factor Results Physical	17
Table 3: Proteus Data	23
Table 4: Breadboard Data	24

1.0 Introduction

This report has been developed for the purpose of improving the experience and skillset within the electronic discipline. It focuses on the deployment of practical measurements and data analysis of an RLC circuit (includes resistors, inductors and capacitors).

An exercise has been completed, which consists of constructing a virtual and a physical RLC circuit, both are tested using virtual and physical testing equipment.

The data is then collected, interpreted and presented by means of suitable graphs and tables.

1.1 Aim and Objectives

The aim is to develop and improve practical electronic / electrical measurement skills and record and analyse data by conducting a laboratory exercise. To guide the development of the skills, the following objectives have been determined:

- Develop and assess a computer simulation of a suitable circuit.
- Develop and assess a physical copy of the simulated circuit.
- Determine and appraise the resonant frequency of the circuit.
- Determine and appraise the Q factor.

1.2 Background Research

The exercise focus on an RLC circuit, this consists of the connection of a resistor, inductor, capacitor and a power source such as a battery. These are typically used within tuning circuits for analogue radios. The RLC circuit can be used either as high pass filter, low pass filter, band pass filter or band stop filter. This can be accomplished by narrowing in on specific radio wave frequencies. [1] [2] [3]

The purpose of the low pass filter is to take in signals and filter the high frequency range. Thus, outputting of low frequencies. [4] [5]

The purpose of the high pass filter is to take in signals and filter the low frequency range. This, outputting of high frequencies. [2] [6]

The purpose of the band pass filter is to take in signals and filter every frequency outside the bandwidth. This function makes it possible to isolate and focus on a specific frequency, by removing the surrounding noise. [2] [6]

The purpose of the band stop is to take in signals and filter every frequency within the bandwidth. This is particularly useful for blocking unwanted signals. [1] [2]

The bandwidth is the frequency range between the low cut-off frequency (FL) and the high cut-off frequency (FH). The wider the bandwidth is, the more surrounding frequencies are included, this could be interpreted as unwanted noise or wanted noise, dependent on its application. The shorter the bandwidth is, the less surrounding noise there is, again this can be interpreted as wanted or unwanted noise. [4] [5]

The Q factor or quality factor defines the sharpness of tuning. [7] This is expressed as:

$$Q = \frac{\text{Voltage across } L \text{ or } V}{\text{Voltage across } R}$$

Caption required

The sharpness tuning can be accomplished by changing the values within the circuit. Such as, the increase of impedance (Z), which increases the current and narrows the bandwidth, this provides better quality of signal. In principle, to get a sharp signal, the circuit should be used at a high frequency. If the signal is that of music, where a vast range of frequencies is required, then a low frequency is required. [4] [4] The sharpness of tuning can also be

expressed as: $\text{Sharpness of tuning} = \frac{\text{Operating Frequency}}{\text{Bandwidth}}$

Sep. Eqn.

2.0 Equipment

Throughout the experiment, the following equipment was used for the setup and testing of the simulated and physical RLC circuits:

2.1 Simulation Setup

- Proteus electronic design suite
- Excel (Recording data)

2.2 Physical Setup

- Breadboard
- 1k Resistor
- 1mH Inductor
- 1uF Capacitor
- 4 x Connection wires
- 2 x Passive oscilloscope probes
- Excel (Recording data)
- Tektronix TDS 2002 oscilloscope
- SJ Electronics LTD MKII universal T&M system

3.0 Methodology

Throughout the exercises, both a simulation and a physical setup had been completed.

The simulation setup was conducted to provide a fast and easy method of conducting the exercise. The setup used the proteus electronic design suite, which consisted of the $1k\Omega$ resistor connected to a $1mH$ inductor and a $1\mu F$ capacitor. This circuit was then connected to a virtual signal generator and an oscilloscope, as shown in Figure 1.

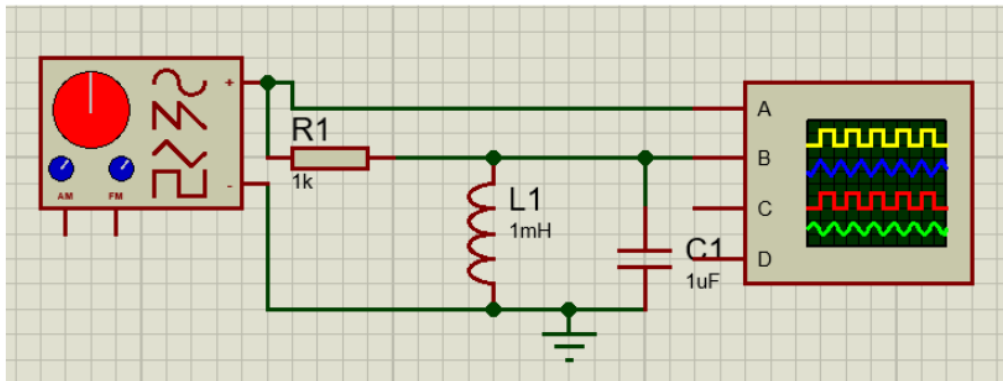


Figure 1: Simulation Setup

The physical setup included a breadboard, with the $1\text{K}\Omega$ resistor, a 1mH inductor and a $1\mu\text{F}$ capacitor connected using connection wires. This setup used an SJ Electronics LTD MK2 universal T&M system, which provided a power supply to the circuit and enabled control over the frequency change. A Tektronix TDS 2002 oscilloscope along with two passive oscilloscope probes were used to monitor and determine the capacitor inductor voltage (VLC). As shown in figure 2.

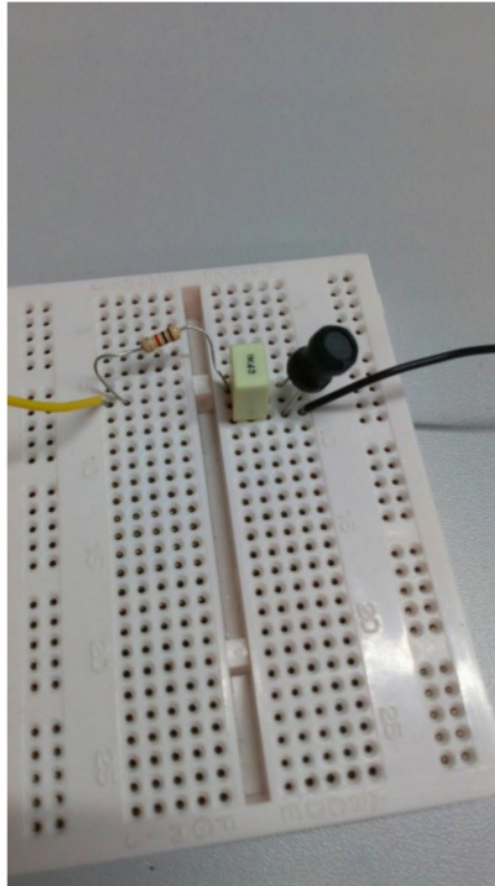


Figure 2: Physical Setup

The virtual and physical oscilloscopes were used to monitor the change in capacitor inductor voltage (VLC), as a range of frequencies from 100Hz up to 20KHz were tested and recorded on to logarithmic scale graph in an excel spreadsheet (see appendix 1 and 2). The corresponding data was added into the following formula, to gain the decibel value (dB).

$$dB = 20 * LOG10 \left(\frac{VLC}{V_{in}} \right) \quad \text{Caption required}$$

The decibel values were then plotted against the corresponding range of frequencies, to show how the attenuation changes in respect to the frequency.

The graph of attenuation vs frequency was then used to determine the frequency resonance and the Q factor. To determine these values the -3dB line, FL line and FH line are added to the graph and the frequency is then determined using the formula.

$$F_{res} = \frac{1}{2\pi\sqrt{LC}} \quad \text{Caption required}$$

The Q factor is then determined using the following formula:

$$Q = \frac{F_{res}}{F_H - F_L} \quad \text{Caption required}$$

To conclude that all aspects of the circuit have been correctly accounted for, the voltage output was then determined. This was conducted by calculating and adding the impedance and the capacitive reactance, using the following formulae respectively:

$$Z_I = 2\pi LrLF \quad \text{Caption required}$$

$$X_C = \frac{1}{2\pi FC} \quad \text{Caption required}$$

The sum of these two formulae is then written as:

$$Z_{LC} = Z_I + X_C \quad \text{Caption required}$$

The value of Vout is then calculated using the formula:

$$V_{out} = V_{in} * \frac{Z_{LC}}{R + Z_{LC}} \quad \text{Caption required}$$

The values of Vout were then plotted to highlight how the voltage changes, as the frequency is altered.

4.0 Results

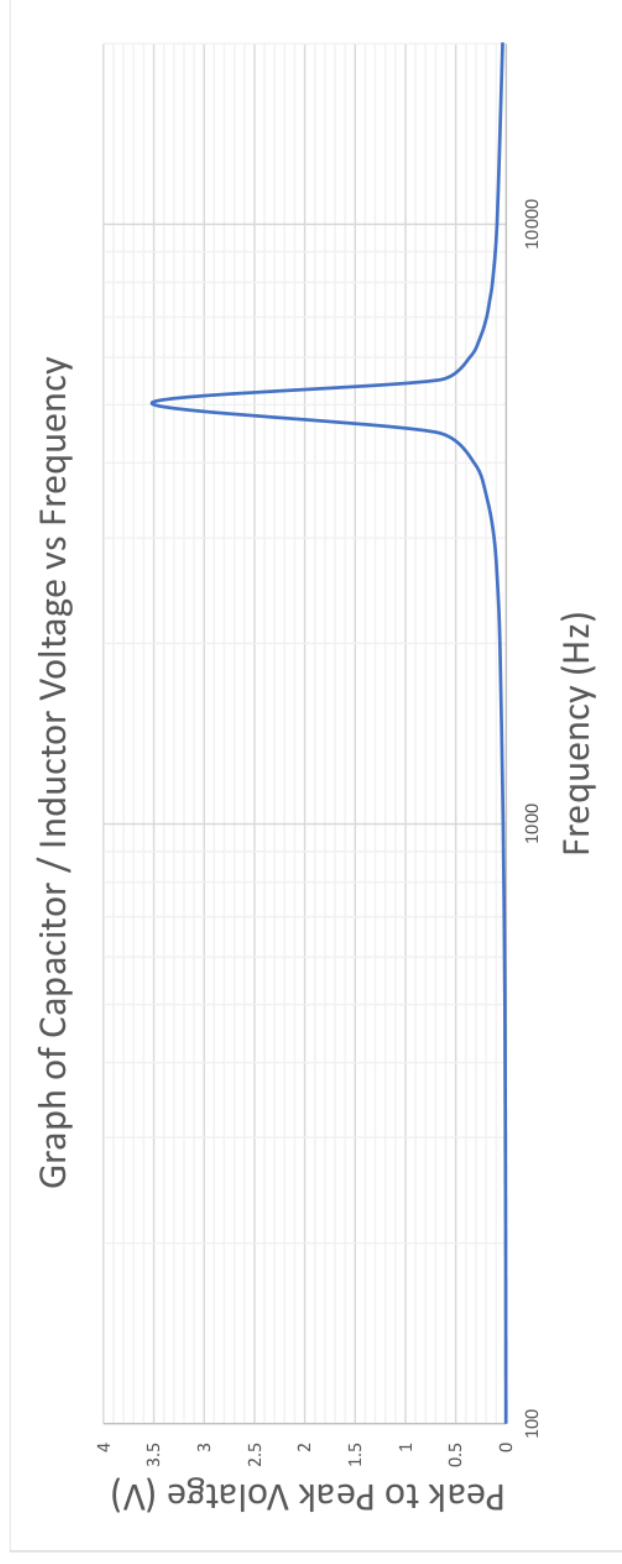


Figure 3: Simulated VLC

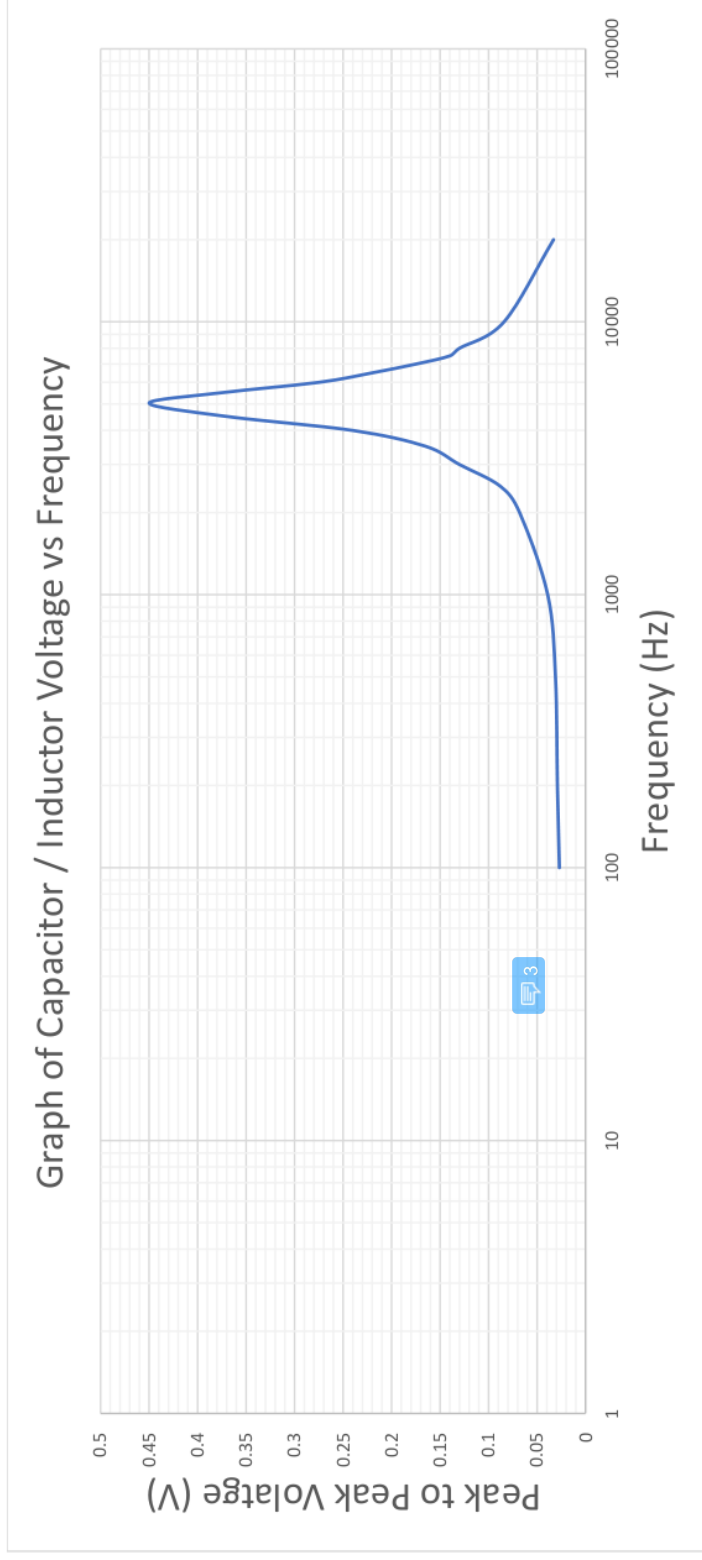


Figure 4: Physical VLC

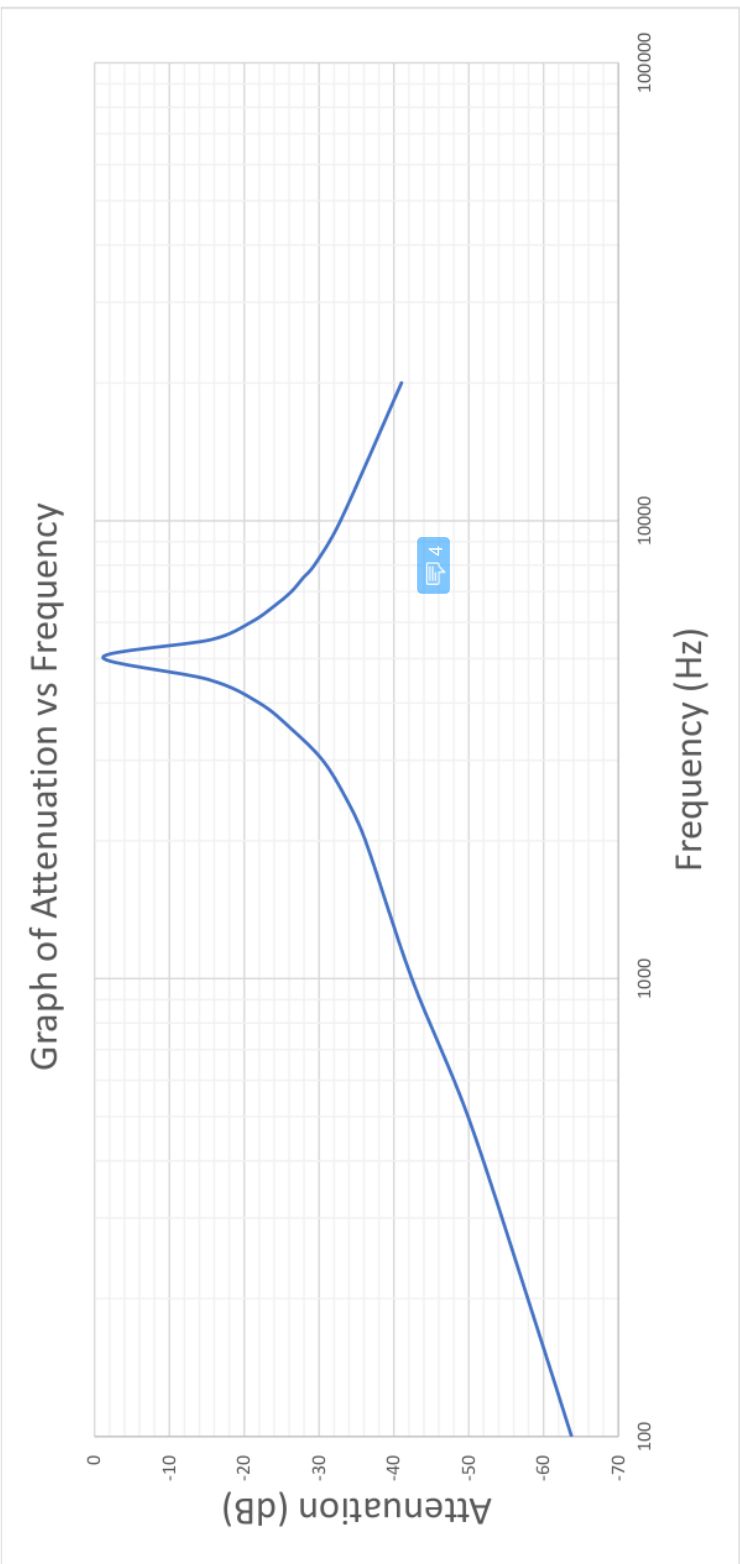


Figure 5: Simulated Attenuation / Frequency

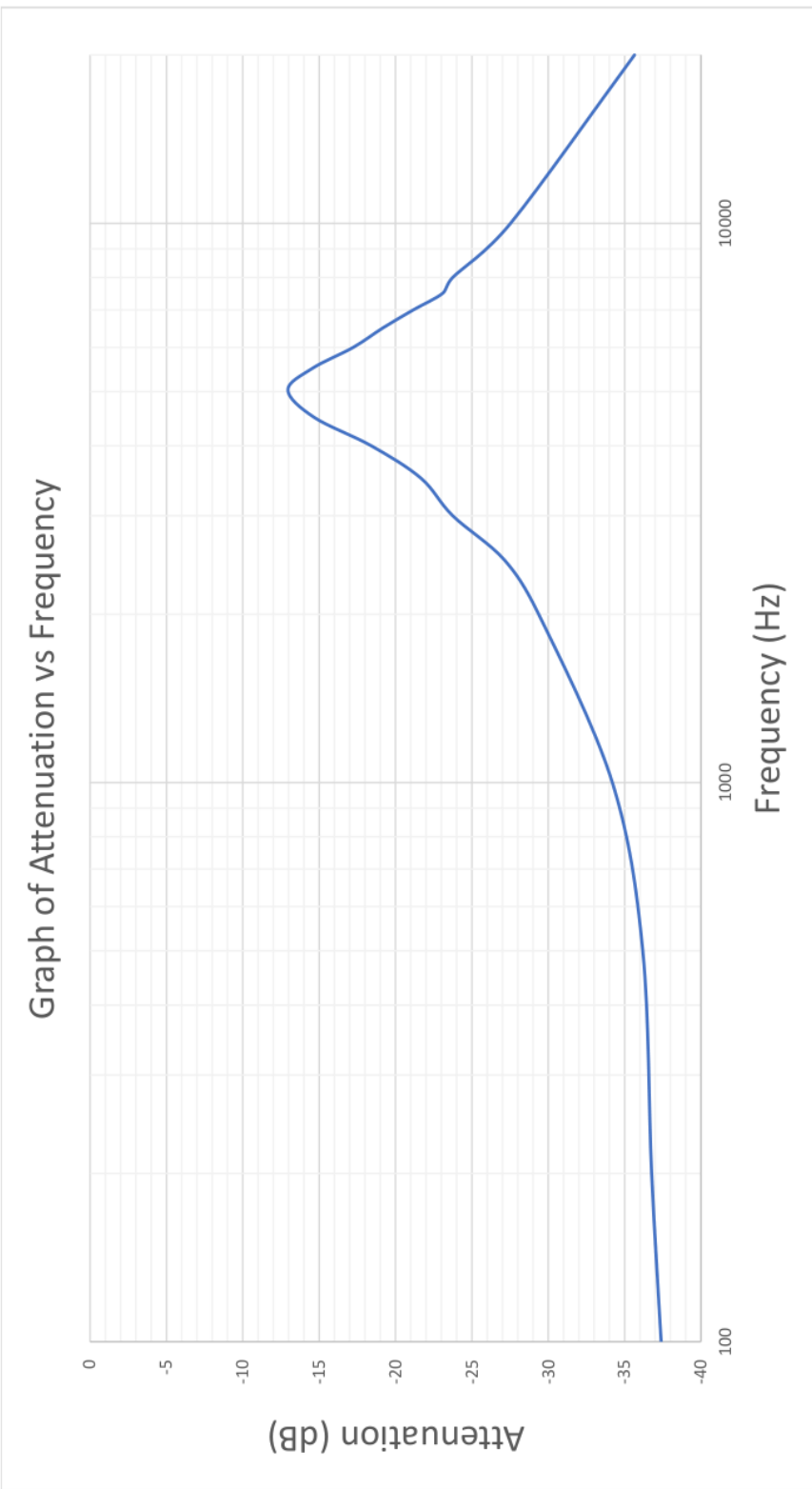


Figure 6: Physical Attenuation / Frequency

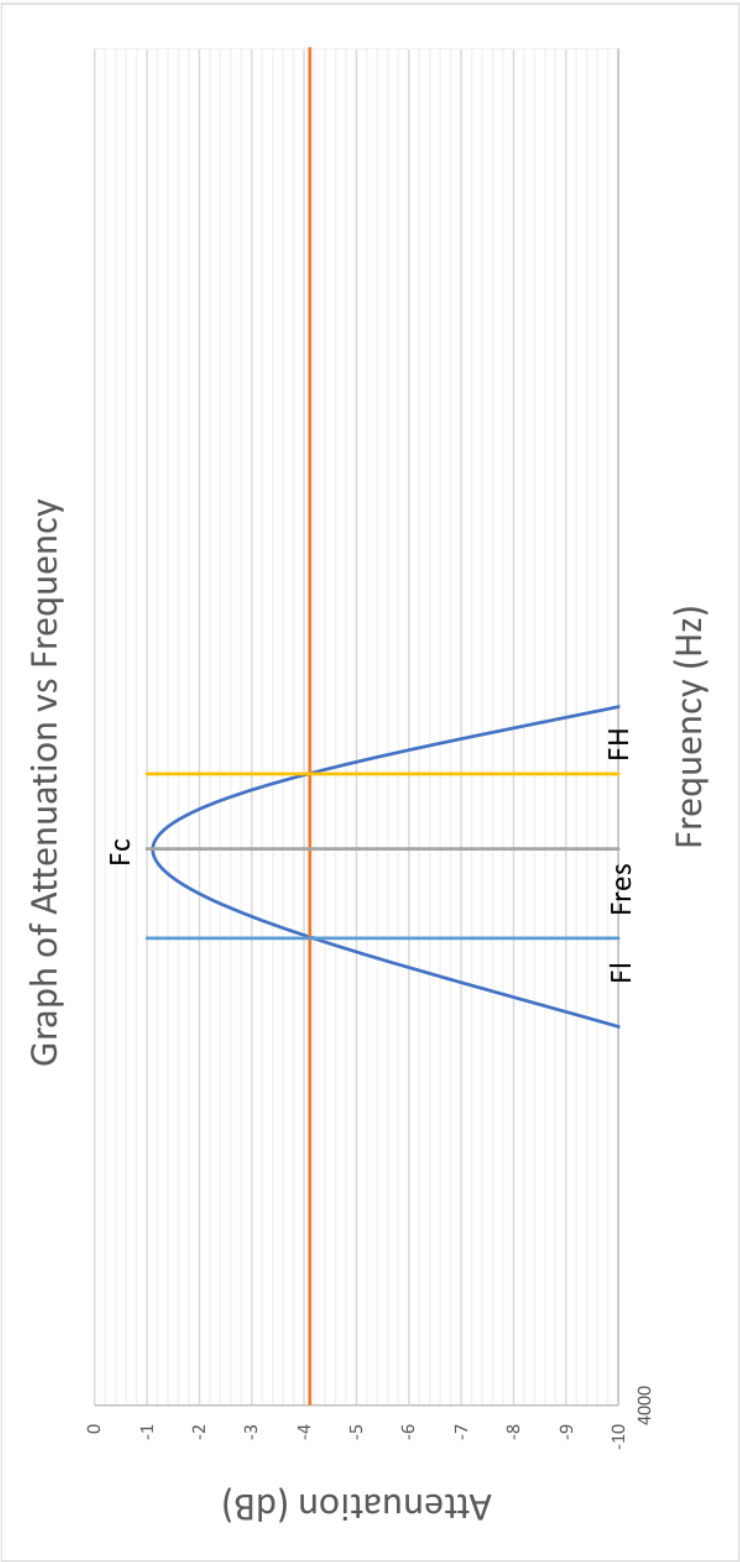


Figure 7: Simulated Q Factor

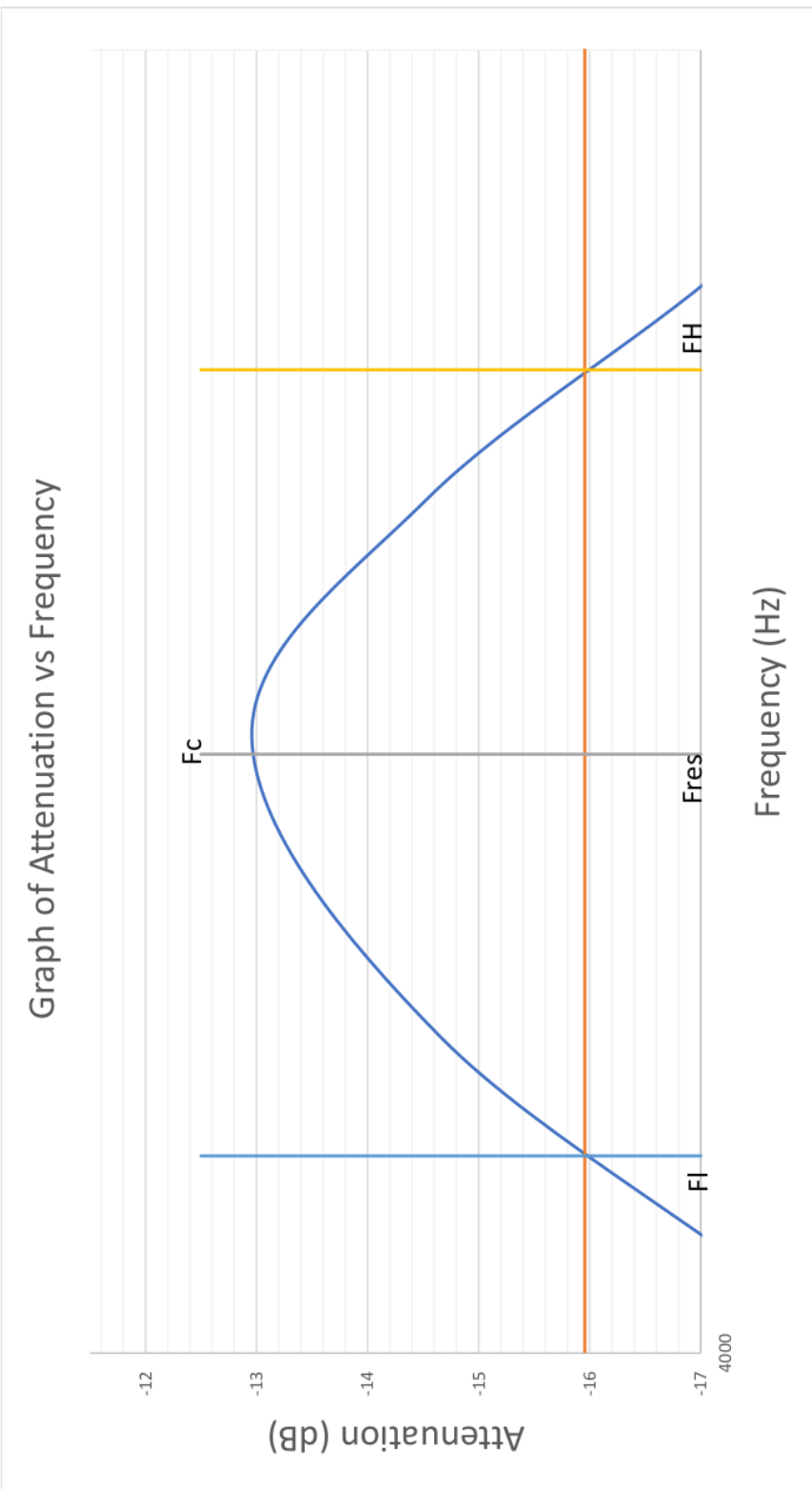


Figure 8: Physical Q Factor

-3dB line Simulation	
x	y
4000	-4.110346557
7000	-4.110346557
FI line Simulation	
x	y
5032	-1
5032	-10
FH Line Simulation	
x	y
5190	-1
5190	-10
Fres Simulation	
x	y
4850	-1
4850	-10
BW	340
Q Factor	30.69620253

Table 1: Q Factor Results Simulated

-3dB line Physical	
x	y
3000	-15.95634964
7500	-15.95634964
FI line Physical	
x	y
5000	-12.5
5000	-17
FH Line Physical	
x	y
5770	-12.5
5770	-17
Fres Physical	
x	y
4305	-12.5
4305	-17
BW	1465
Q factor	5.590909091

Table 2: Q Factor Results Physical

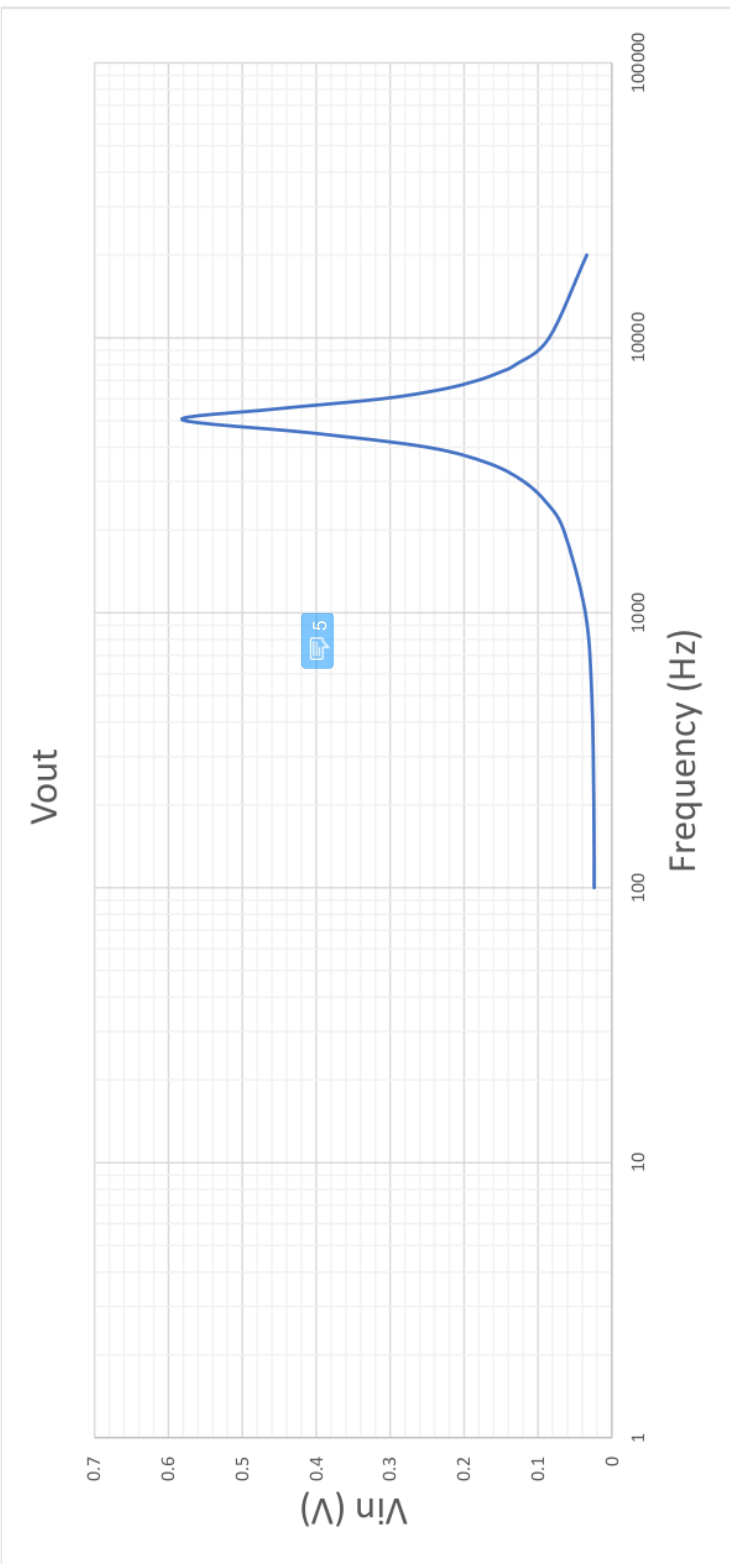


Figure 9: Simulated V-Out

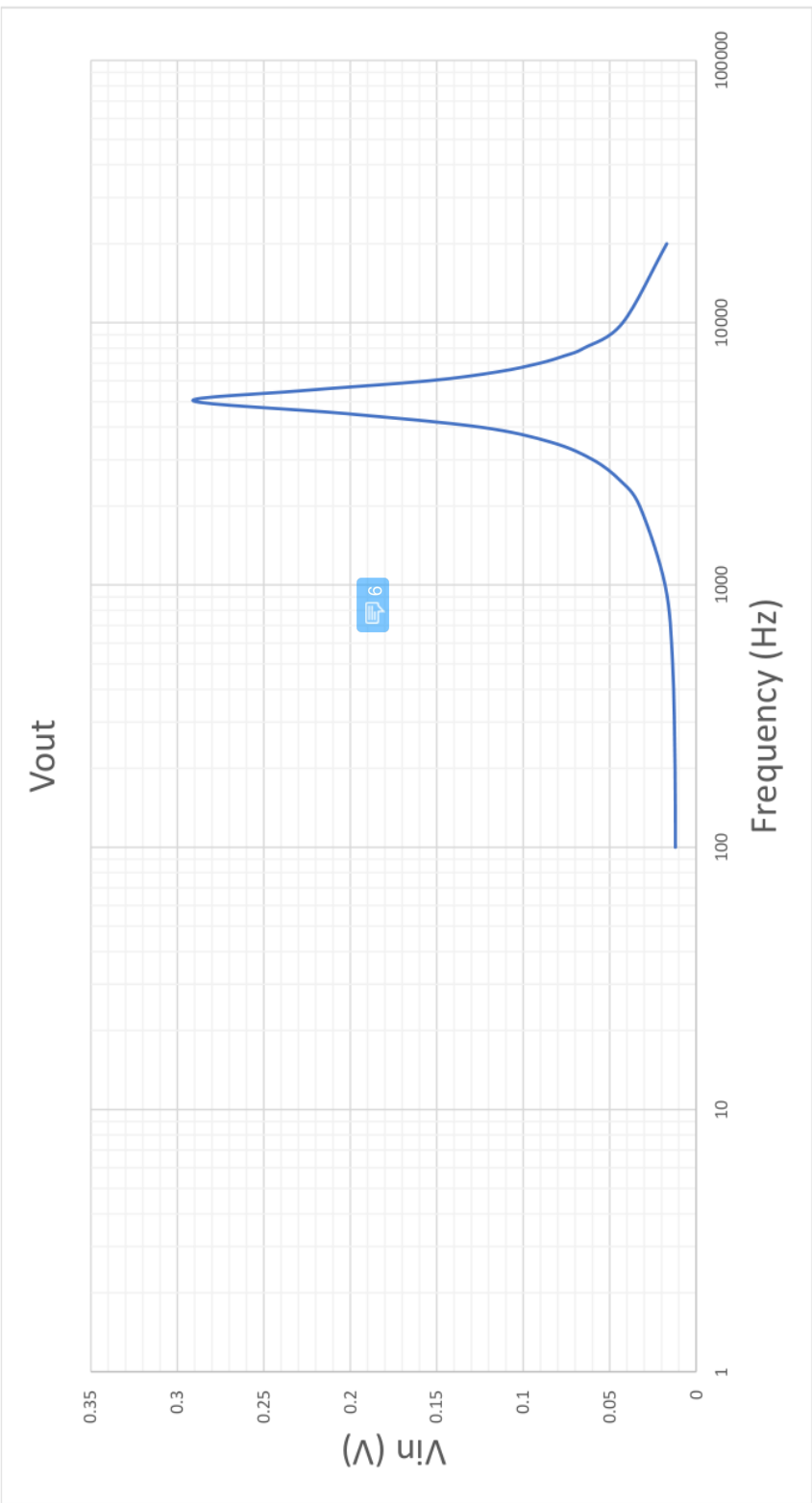


Figure 10: Physical V-Out

5.0 Evaluation

Figure 3 and figure 4 represents how the sum of the capacitor / voltage changes against the frequency. The figures show that the VLC value increases exponentially until it reaches resonance. After resonance has been determined, any higher frequencies will lower the VLC value.

The data represented in figure 5 and 6 measures the rate of attenuation as the frequency increases. This is due to a damping effect as a result of the resistance within the circuit as well as an energy loss through the medium.

The data shown on table 1 and 2 represent the half power point (-3dB). The low cut-off frequency (FL), the high cut off frequency (FH), the frequency resonant frequency (Fres), the bandwidth (BW) and the Q factor.

As previously discussed, the size of the bandwidth controls the quality factor / sharpness of tuning, the narrower the bandwidth is, the less noise surrounds it, the wider the bandwidth increases the amount of noise. With respect to figure 7 and 8 it is clear that the simulation setup has a significantly reduced bandwidth, this is a very high-quality bandwidth. However, the physical setup presents a bandwidth of more than 4 times the size of the simulation. Thus, producing a noisy signal. This is further represented with the Q factor, as shown the quality of the simulation setup is almost 6 times that of the physical setup.

Figures 9 and 10 depicts the remaining voltage output by comparing the voltage-in against the frequency. The data presented in both graphs show a strong correlation in regarding the voltage in and the voltage out, as such, the voltage in for the Proteus setup is double that of the breadboard run, thus the voltage out on the simulation is also double that of the breadboard setup.

By considering the information gathered, it is evident that there are many factors in the real world which affect the overall quality of the circuit. The simulation version provides an ideal example of the circuit. This can then be used to guide modifications within the physical circuit.

6.0 Conclusion

The aim of the assignment was to develop and improve analytical experience and skillset within the electronics discipline.

By conducting the experiments, it does indeed improve experience, first within the software used for simulation (Proteus), secondly using instruments to measure properties within the circuit and thirdly, analysing, interpreting and presenting of data using a suitable spreadsheet such as excel.

The background research into the circuit, has led to the discovery and understanding of oscillator circuits, resonance, bandwidths, damping, quality factors and the variety of filters which can be created using the circuit type.

Further studies have led to the understanding of how the frequencies can be adjusted within the circuit, in order to block or transmit signals, such as those within a radio.

The exercise was successfully conducted and the comparison between the simulated setup and the physical setup has shown there to be many variables which affect the physical setup, these should be taken into account, when developing the circuit to reach close to the simulated / ideal results.

7.0 References

- [1] D. B. Albert Malvino, Electronic Principles, New York: McGraw-Hill Education, 2016.
- [2] W. H. Paul Horowitz, The Art of Electronics, New York: Cambridge University Press, 2015.
- [3] J. C. Rawlins, Basic AC Circuits, Woburn: Butterworth-Heinmann, 2000.
- [4] K. S. Kumar, Electric Circuits and Networks, New Delhi: Dorling Kindersley Pvt.Ltd, 2009.
- [5] A. G. A. B. U.A.Bakshi, Electric circuits and electron devices, Pune: Technical Publications Pune, 2009.
- [6] W. A. Gerard kiernan, Electric Circuits Problem Solver, New Jersey: Research & Education Association, 2012.
- [7] I. D. Clive Poole, Microwave Active Circuit Analysis and Design, London: Elsevier Ltd, 2016.

8.0 Appendix 1

R		1000
C	1.00E-06	
L	1.00E-03	
Lr	6	
Fres	4850	

Frequency	Vin	VLC	dB	Zi	Xc	ZLC	Vout
100	4	0.0026	-63.74173287	6+0.628318530717959j	-1591.54943091895j	6.0046548100132+0.605920723305281j	0.023996565
200	4	0.0051	-57.8897963	6+1.25663706143592j	-795.77471545947j	6.01865138423494+1.21317326553229j	0.02441868
500	4	0.0128	-49.89700043	6+3.14159265358979j	-318.309886183791j	6.1179946671507+3.05643699500117j	0.027189454
1000	4	0.03038	-42.38944444	6+6.28318530717959j	-159.154943091895j	6.49334533147521+6.28657602906975j	0.035917875
2000	4	0.062	-36.19336604	6+12.5663706143592j	-79.57471545947j	8.39402353878759+14.1713215506899j	0.065328175
2500	4	0.085	-33.45282131	6+15.707963267949j	-63.6619772367581j	10.4115493575714+19.5506199848958j	0.087671043
3000	4	0.12	-30.45757491	6+18.8495559215388j	-53.0516476972984j	14.0048937447819+26.7811291641669j	0.119176582
3500	4	0.192	-26.37517525	6+21.9911485751286j	-45.4728408833987j	21.1217048580191+37.1893882002842j	0.16742585
4000	4	0.318	-21.99265743	6+25.1327412287183j	-39.7887357729738j	37.8745217165852+52.7260615011194j	0.249878761
4500	4	0.695	-15.20150373	6+28.2743338823081j	-35.3677651315323j	86.9503473430589+67.428286697493j	0.404141442
5032	4	3.52	-1.110346557	6+31.6169884657277j	-31.6285657972765j	166.727074976614-31.3068566930822j	0.581386582
5500	4	0.665	-15.58476692	6+34.5575191894877j	-28.9372623803446j	74.3363312407331-98.5688076840859j	0.457737172
6000	4	0.362	-20.86702842	6+37.6991118430775j	-26.5258238486492j	26.24757374285096-75.4043729875281j	0.31036331
6500	4	0.254	-23.94452549	6+40.8407044966673j	-24.4853758602916j	11.8525206353292-56.7940208869972j	0.228991611
7000	4	0.194	-26.28516523	6+43.9822971502571j	-22.7364204416993j	6.36386921170484-45.2707505519107j	0.1815235
7500	4	0.162	-27.85089954	6+47.1238898038469j	-21.2206590789194j	3.82176060469818-37.7199835320752j	0.150968475
8000	4	0.136	-29.37042166	6+50.2654824574367j	-19.8943678864869j	2.47777946904591-32.4365219091436j	0.129734669
10000	4	0.091	-32.86037198	6+62.8318530717959j	-15.9154943091895j	0.679356029746023-21.2276461790402j	0.08487287
20000	4	0.0356	-41.01219987	6+125.663706143592j	-7.9577471545947j	0.0273531669467391-8.49435227907011j	0.03397543

Table 3: Proteus Data

8.0 Appendix 2

R	C	L	Ir	Fres	1000	Breadboard Run									
		1.00E-06				Frequency	Vin	VLC	dB	Zi	Xc	ZLC	Vout		
						100	2	0.027	-37.39332463	6+0.628318530717959j	-1591.54943091895j	6.0046548100132+0.605920723305281j	0.011998252		
						200	2	0.029	-36.77263996	6+1.25663706143592j	-795.77471545947j	6.01865138423494+1.213173265553229j	0.012205934		
						500	2	0.031	-36.19336604	6+3.14159265358979j	-318.309886183791j	6.1179946671507+3.05643699500117j	0.013594727		
						1000	2	0.039	-34.19930777	6+6.28318530717959j	-159.154943091895j	6.49334533147521+6.28657602906975j	0.017958937		
						2000	2	0.068	-29.37042166	6+12.5663706143592j	-79.577471545947j	8.39402353878759+14.1713215506899j	0.032664088		
						2500	2	0.088	-27.13094647	6+15.707963267949j	-63.6619772367581j	10.4115493575714+19.5506199848958j	0.043835522		
						3000	2	0.13	-23.74173287	6+18.8495559215388j	-53.0516476972984j	14.0048937447819+26.7811291641669j	0.059588291		
						3500	2	0.165	-21.67092103	6+21.9911485751286j	-45.4728408833987j	21.1217048580191+37.1893882002842j	0.083712925		
						4000	2	0.24	-18.41637508	6+25.1327412287183j	-39.7887357729738j	37.8745217165852+52.7260615011194j	0.12493938		
						4500	2	0.37	-14.65656543	6+28.2743338823081j	-35.3677651315323j	86.9503473430589+67.428286697493j	0.202070721		
						5032	2	0.45	-12.95634964	6+31.6169884657277j	-31.6285657972765j	166.727074976614-31.306856693082j	0.290693291		
						5500	2	0.375	-14.53997456	6+34.5575191894877j	-28.9372623803446j	74.3363312407331-98.5688076840859j	0.228868586		
						6000	2	0.275	-17.23394604	6+37.6991118430775j	-26.5258238486492j	26.24757374285096-75.4043729875281j	0.155181655		
						6500	2	0.22	-19.1721463	6+40.8407044966673j	-24.4853758602916j	11.8525206353292-56.7940208869972j	0.114495806		
						7000	2	0.175	-21.15983894	6+43.9822971502571j	-22.7364204416993j	6.36386921170484-45.2707505519107j	0.09076175		
						7500	2	0.14	-23.0980392	6+47.1238898038469j	-21.2206590789194j	3.82176060469818-37.7199835320752j	0.075484238		
						8000	2	0.13	-23.74173287	6+50.2654824574367j	-19.8943678864869j	2.47777946904591-32.4365219091436j	0.064867285		
						10000	2	0.084	-27.53501419	6+62.8318530717959j	-15.9154943091895j	0.679356029746023-21.2276461790402j	0.042438643		
						20000	2	0.033	-35.65032112	6+125.663706143592j	-7.95774715459477j	0.0273531669467391-8.49435227907011j	0.016987715		

Table 4: Breadboard Data

Resonance

GRADEMARK REPORT

FINAL GRADE

GENERAL COMMENTS

61 / 100

Instructor

PAGE 1

PAGE 2

PAGE 3

PAGE 4

PAGE 5

PAGE 6



Comment 1

Usually they would use an AC source



Comment 2

...and digital

QM

Caption required

You should always include a caption on figures, equations and tables to allow you to refer to them in your text.

e.g. An illustration of this can be seen in figure 2. The relationship of the variables is shown in equation 2. Table 1 shows the results of the first experiment where the control variable, temperature in degrees celsius is shown in the first column....

QM

Sep. Eqn.

Separate Equations:

Equations should be given their own line and caption to allow you to discuss them in your text. You should also identify and describe each of the variables in the equation.

QM

Caption required

You should always include a caption on figures, equations and tables to allow you to refer to them in your text.

e.g. An illustration of this can be seen in figure 2. The relationship of the variables is shown in equation 2. Table 1 shows the results of the first experiment where the control variable, temperature in degrees celsius is shown in the first column....

QM

Caption required

You should always include a caption on figures, equations and tables to allow you to refer to them in your text.

e.g. An illustration of this can be seen in figure 2. The relationship of the variables is shown in equation 2. Table 1 shows the results of the first experiment where the control variable, temperature in degrees celsius is shown in the first column....

QM

Caption required

You should always include a caption on figures, equations and tables to allow you to refer to them in your text.

e.g. An illustration of this can be seen in figure 2. The relationship of the variables is shown in equation 2. Table 1 shows the results of the first experiment where the control variable, temperature in degrees celsius is shown in the first column....

QM

Caption required

You should always include a caption on figures, equations and tables to allow you to refer to them in your text.

e.g. An illustration of this can be seen in figure 2. The relationship of the variables is shown in equation 2. Table 1 shows the results of the first experiment where the control variable, temperature in degrees celsius is shown in the first column....

QM

Caption required

You should always include a caption on figures, equations and tables to allow you to refer to them in your text.

e.g. An illustration of this can be seen in figure 2. The relationship of the variables is shown in equation 2. Table 1 shows the results of the first experiment where the control variable, temperature

in degrees celsius is shown in the first column....

QM

Caption required

You should always include a caption on figures, equations and tables to allow you to refer to them in your text.

e.g. An illustration of this can be seen in figure 2. The relationship of the variables is shown in equation 2. Table 1 shows the results of the first experiment where the control variable, temperature in degrees celsius is shown in the first column....

QM

Caption required

You should always include a caption on figures, equations and tables to allow you to refer to them in your text.

e.g. An illustration of this can be seen in figure 2. The relationship of the variables is shown in equation 2. Table 1 shows the results of the first experiment where the control variable, temperature in degrees celsius is shown in the first column....

PAGE 11

PAGE 12



Comment 3

There seems to be a lot of wasted space on this graph. Your X-axis should have started at 100, not 1, and ended at 20k.

PAGE 13



Comment 4

See comment for fig 4

PAGE 14

PAGE 15

PAGE 16

PAGE 17

PAGE 18



Comment 5

See comment for fig 4



Comment 6

See comment for fig 4

GRADING FORM: SMU GENERIC_SMOSEY

AARON STEWART
HILLAM

60.90

ENGAGEMENT WITH LITERATURE

including reading, referencing, academic conventions and academic honesty



"Inclusion of a wide range of research-informed literature, including sources retrieved independently. Selection of relevant and credible sources. Very good use of referencing conventions, consistently applied.

3.4

KNOWLEDGE & UNDERSTANDING

Knowledge of the basic underlying concepts and principles of a subject.



Knowledge is extensive. Exhibits understanding of the breadth and depth of established views.

18.9

COGNITIVE & INTELLECTUAL

Evaluate underlying concepts and principles of a subject and interpret qualitative and quantitative data in order to develop lines of argument and make sound judgements.



Sound, logical, analytical thinking; synthesis and evaluation. Ability to devise and sustain persuasive arguments, and to review the reliability, validity & significance of evidence. Ability to communicate ideas and evidence accurately and convincingly. Sound, convincing conclusions / recommendations

18

PRACTICAL APPLICATION SKILLS

Different approaches to solving problems in particular contexts.



A good and appropriate application of standard methods, materials, tools and/or techniques. Good appreciation of the context of the application, with some use of examples, where relevant.

17.1

TRANSFERABLE SKILLS

Communicate the results of their study/work accurately and reliably, and with structured and coherent arguments; the qualities needed for employment requiring the exercise of some personal responsibility within a structured and managed environment.



Can communicate professionally and, confidently in a suitable format. Work is coherent, very fluent and is presented professionally.

3.5