

Assignemnt

by Andrew Hart

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Parallel RLC Resonance

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Electrical & Electronic Principles
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Abstract

The circuit in Figure 1 was to be created both physically and simulated to analysis the results and have the circuit behaved at resonant frequency. Background round research indicated that the circuit in question was a simple Bandpass filter and is commonly used in RF functions. Both circuits behaved similarly at resonance however with the variables of component and overall circuit impedance present in the physical circuit the results were not as substantial.

Introduction

The task set to student was to build a circuit (figure) using a simulation software, proteus in this case, and to record the voltage across the resistor and inductor in the circuit at a frequency range between 100Hz and 20KHz with the signal measuring 4v peak to peak. Upon completion of the record of results on the simulation software students were also asked to carry out the same process on a circuit they will build out of real components and instruments. Results were then to be compare and analysed, to aid comparison each set of results will be plotted on graphs (Voltage against frequency), these graphs will provide visual representation of the bandwidth, Q factor and the resonance frequency.

Awk.

Missing " , "

The circuit provided is a parallel resistor, inductor and capacitor (RLC) network, with the use of inductors and capacitors the circuit becomes an active filter. this circuit is also commonly known as a tank circuit, the tank circuit attains its name from the circuits ability to store energy between the magnetic and electric field of the inductor and capacitor respectively [1]. The capability to store the energy is stated by Floyd [1] 'stored energy is transferred back and forth between capacitor and coil on alternate half cycles'. With the resistance to current on each half cycle because of the direct opposite phase shifts between the inductor and capacitor it allows a response from desired signal [2]. This type of circuit is frequently used to amplify certain frequencies within Radio frequency (RF) circuit adaption can be made to the circuit to tune directly into the resonant frequency using a variable inductor or capacitor [3].

2

1

When Inductive reactance and capacitance reactance become equal in the circuit parallel resonance occurs the frequency which this happens is known as resonant frequency. Due to the opposite current phase shift in the capacitor and inductor (180 degrees out of phase), the current flowing is then cancelled out. The total resistance of the circuit (impedance) is at infinity creating a perfect environment for resonance [2].

Quality factor or 'Q' Factor is simplified as 'The ratio of reactive power to true power' stated by Floyd [2]. When a circulating current becomes larger than the supply current, inside the parallel branches it charges and discharges the capacitor. When the discharging current leaves the capacitor it then creates a magnetic field around the parallel inductor which creates that circulating current between the two components. Within a parallel resonant circuit, the Q Factor is the circulating current between the parallel capacitor and inductor compared to the supply current [4]. Q Factor is

also responsible for the size of the Bandwidth of the circuit. Bandwidth is the specified range of usable frequencies which the circuit can pass from input to output without affecting the amplitude. When the Q factor value is large the bandwidth becomes smaller and vice versa [2].

As mentioned earlier the provided circuit is basic tank which is used as a Bandpass Filter. This filter is commonly used within communication systems, AM/FM receivers are an example of an application of a bandpass filter when a certain range of frequencies are allowed through and non-required frequencies are subsequently blocked [5]. The characteristics of the circuit allows it to pass specific frequencies. When low frequencies are passing the overall impedance of the circuit is at its lowest which results in there being little to no voltage across the capacitor and inductor. In turn as the frequency increases so does the circuit impedance, increasing the voltage across the two components. When at resonant frequency circuit impedance is at its highest and the voltage across is therefore also at its highest. However, when the frequency rises above resonance the impedance and voltage begin to decrease [2]. The bandwidth of this filter can be calculated by finding the difference between the upper and lower 3-dB cut-offs. As a result, Q factor can be found by dividing the centre frequency by the bandwidth. Depending on the value of the Q factor the filter can be classed as either a Wideband filter or a Narrowband filter. When the Q factor is less than 1, then the filter is known as a wideband filter because of the range of the bandwidth. Results greater than 1 are class as a narrowband filter, again because of the smaller range of the bandwidth [5].

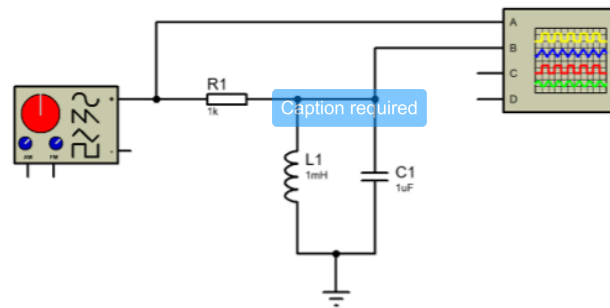
Equipment

- Proteus Simulation Software
- Signal generator
- Digital Oscilloscope
- Bread board
- Capacitor
- Resistor
- Inductor
- Single core wires
- Oscilloscope probe
- Microsoft excel

Method

Firstly, in the experiment the circuit shown in Figure 1 will be constructed and tested in the simulation software Proteus. Following the circuit closely the circuit was constructed in the same manner, using the software allows for identical component values can be used. Two inputs were monitored on the virtual oscilloscope, the first to measure the input of the signal from the signal generator and to allow for visual comparison to the output signal measuring the voltage across the

parallel inductor and capacitor. A range of frequencies were used as inputs to the circuit and the corresponding voltages were recorded into a table which can be found in the appendix. These



results will then be used to produce a graph for easy comparison, which can be found in the result section.

Once voltage results are recorded the Q factor and Bandwidth need to be calculated, to find these values first the attenuation results need to be found using the formula $20\log(V_{out}/V_{in})$ is used. These results will then be populated into another table allowing another graph to be produced using Microsoft Excel. Once the attenuation values have been found the Bandwidth can first be found by find the upper and lower -3dB cut-offs. To find these values a -3dB line is added to a magnified view of the peak of the graph of attenuation. The line is moved around to find where on the waveform to where it intersects, vertical lines are added to aid in this process and to record the frequency at which this occurs. Once found Bandwidth can be calculated by $F_{high} - F_{low}$, then allowing the Q

Sep. Eqn.

Figure 1 Circuit Given

Sep. Eqn.

factor to be calculated by using F_{res}/B_{width} (Resonant frequency/ Bandwidth). Resonant frequency

is calculated by using $\frac{1}{2\pi\sqrt{LC}}$ Sep. Eqn.

This process will then be repeated with the use of physical components using physical connections, cables and measuring and test equipment. Again, the results and graphs can be found within the results section and relating tables in the appendix.

Results

Proteus Results

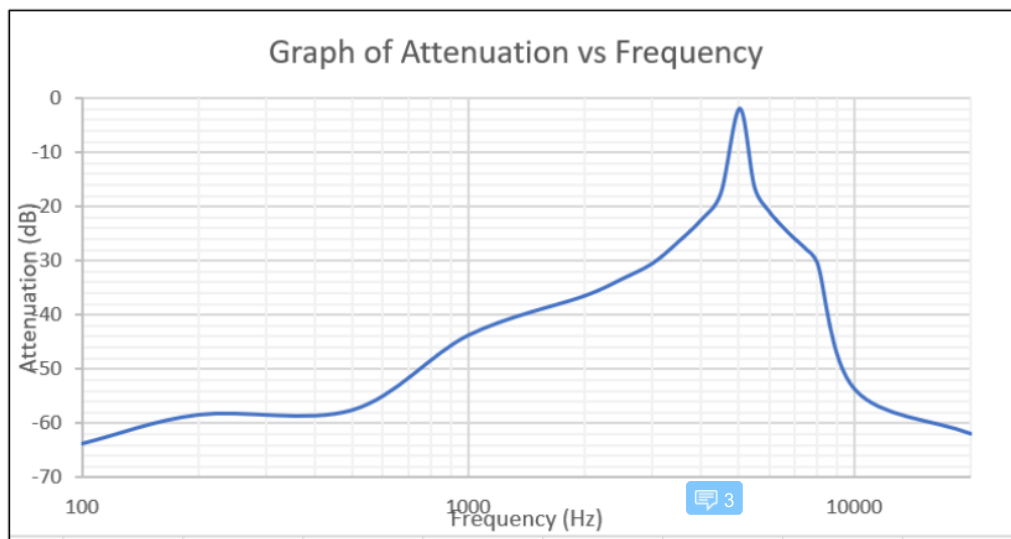


Figure 2 Graph of Simulation Results

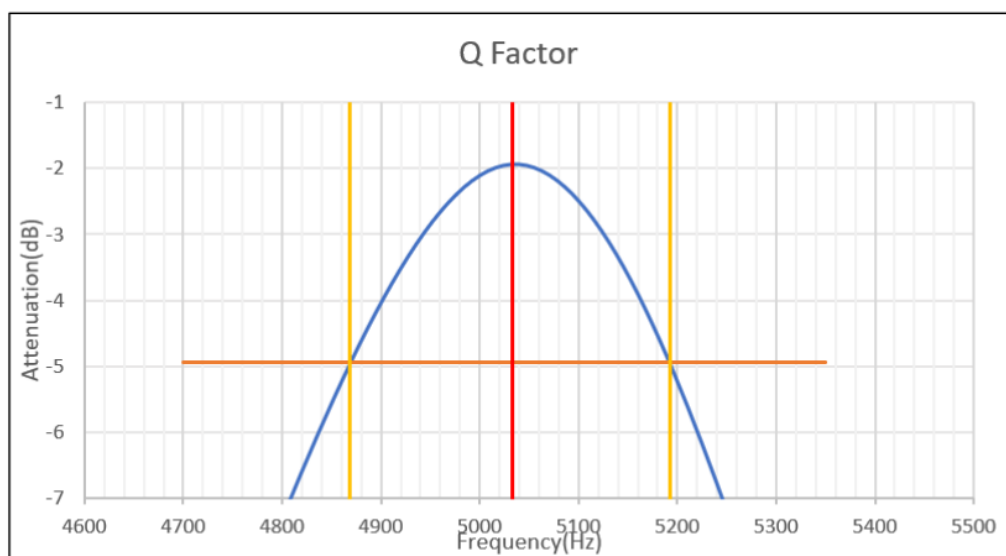


Figure 3 Simulation Q Factor and Bandwidth

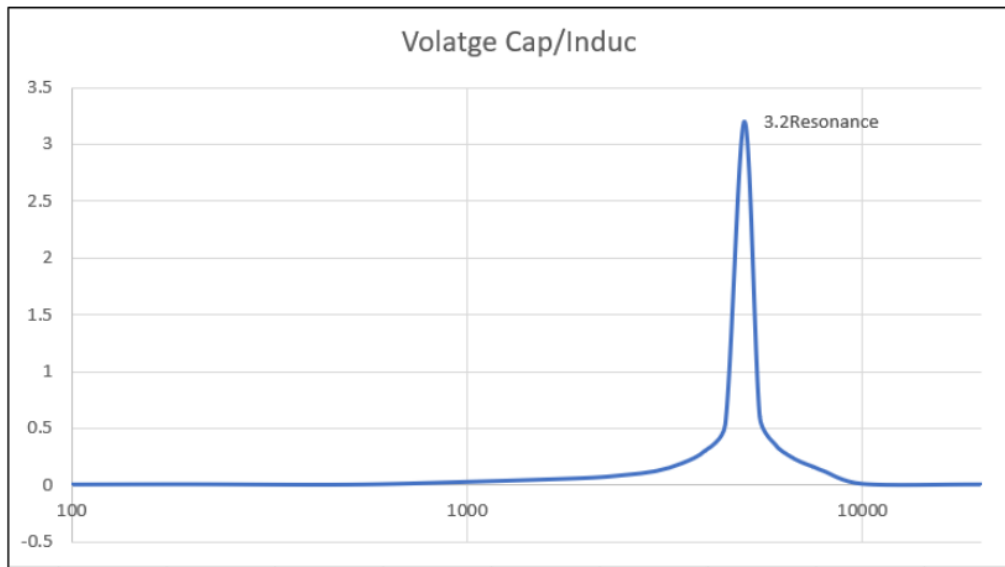


Figure 4 Simulation Voltage Results

Resonant Frequency: 5032 Hz

Voltage at Resonance: 3.2V

Bandwidth: 324

Q Factor: 15.5

Physical Results

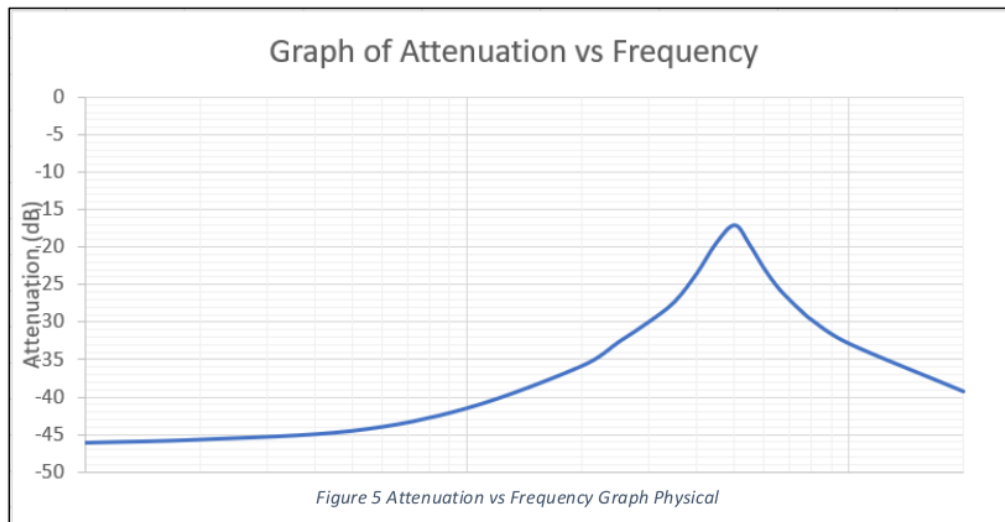


Figure 5 Attenuation vs Frequency Graph Physical

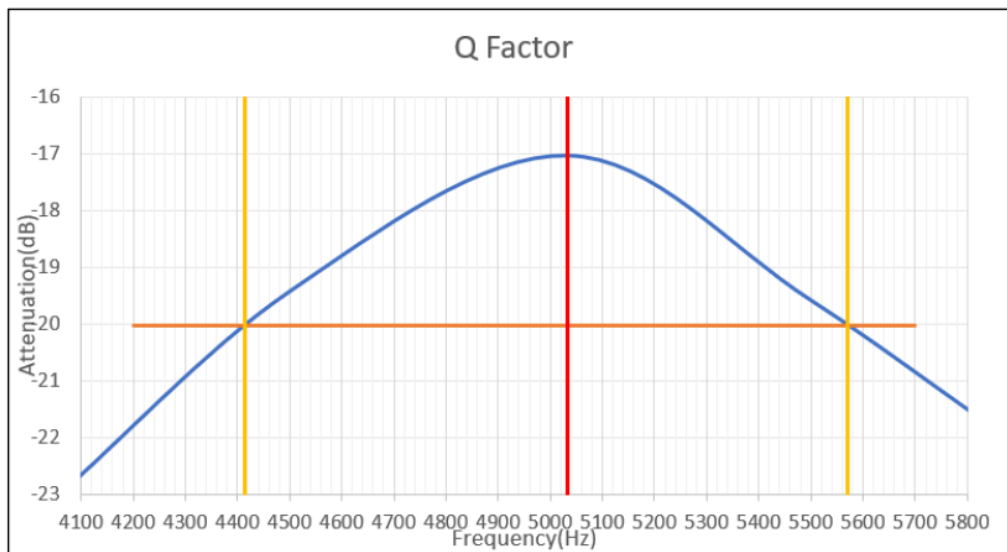


Figure 6 Q Factor of Physical

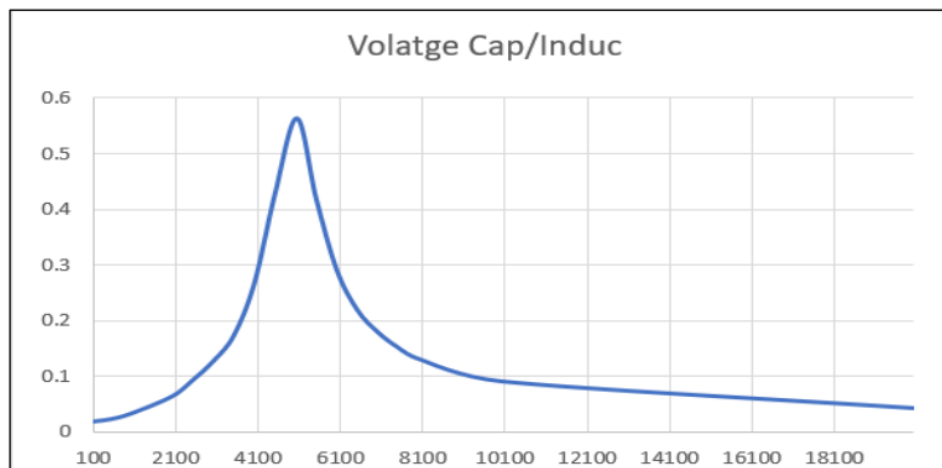


Figure 6 Breadboard Voltage

Resonant Frequency: 5032 Hz

Voltage at Resonance: 0.54V

Bandwidth:1155

Q Factor:4.35

Discussion

Upon the first part of the experiment the construction of the circuit was very simple to follow and finding the correct component values were not an issue as the user any values they desire. When recording results, the virtual oscilloscope in the software was difficult to read and was not easy to obtain accurate results, this is visible in the graph of attenuation when the waveform which is expected to be a smooth gradual rise has a slight dip. This inaccurate result is likely caused by user error in reading the output voltage off the virtual oscilloscope. Another issue whilst recording results on the software was the difficulty in selecting the resonant frequency on the virtual signal generator, the generator would only adjustments in the 100s. The calculated resonant frequency for the circuit is 5032Hz, the nearest available frequencies for this value was 5000Hz or either 5100Hz, 500Hz was selected in the end as it is obviously the closest to the resonant frequency.

Analysis of the circuit shows that the circuit behaved as expected with a significant rise in voltage at resonance across the parallel inductor and capacitor. There is also a steady rise leading up to resonance and a decline after which again is expected behaviour of this circuit. The circuit produced within proteus is an ideal circuit, so there is no internal resistance within the capacitor or the inductor, these components also have no tolerance are the exact values. The virtual signal generator used also has no internal impedance as well as the oscilloscope, measuring cables and connections between components have no resistance at all. This allows for results to show how resonance and a parallel circuit can react within an ideal circuit, providing excellent visualisation of the characteristics with the aid of the graphs produced in Microsoft Excel.

The first issue upon construction of the physical circuit arose when selecting the components. As  4 mention above the values in the circuit given were not standard values and not readily available, as a result the nearest values were selected for this part of the experiment. As well as slight differences in values of components the physical components all have a tolerance, meaning that they may or may not be the value represented on the component. Both these factors will result in the comparison not being completely accurate or fair. Although resonant frequency was easier to select on a physical signal generator compared to a virtual one, the resonant frequency would not be the same for the physical circuit. The physical circuit should have had its own resonant frequency calculated before the recording of results took place.

After calculating the results for the physical circuit, it is evident that it does not produce the as high as results as the simulation software, this is visible in the voltage graphs of both circuits. Although the rise in voltage was not as significant the effect of resonance is still visible with a rise and fall of voltage before and after the resonant frequency. As results show the simulation circuit has got a much higher Q factor of **15.5** compared to the **4** of the real circuit meaning that a more specific frequency can be selected for receiving and amplifying as an example mentioned in the introduction. The resulting Q Factors mean a bandwidth of **324** and **1155** for the simulation and physical circuits respectively, showing that the simulation circuit has a much narrower range of passable frequencies compared to the physical.  5

Conclusion

The reason for such variation in the two sets of results can be clarified by using physical components, which all have a slight resistance within them and the tolerance of each component. These impedances in the components and within the breadboard connections, signal generator and oscilloscope probes will add up to affect the overall circuit impedance, whereas the circuit in the simulation software is using ideal components in an ideal setting. The circuit is a good representation of how the use of two components characterises and how they both react within a circuit can be used as a simplified bandpass filter, and how it can achieve this.

References

- [1] T. L. Floyd, "Electric Circuits Fundamentals," 6th ed., Pearson, pp. 625-626.
- [2] T. L. Floyd, Electric Circuits Fundamentals.  6
- [3] P. H. a. W. Hill, "Resonant Circuits," in *The Art of Electronics*, Third ed., 2015, pp. 52-53.
- [4] J. Bird, Electrical and Electronic Principles and Technology.
- [5] A. Malvino and D. Bates, Electronic Principles, 8th ed.

Appendix

1. Simulation Voltages

Frequency	Voltage Resistor	Volatge Cap/Induc
100	4	0.0026
200	4	0.0048
500	4	0.0013
1000	4	0.026
2000	4	0.06
2500	4	0.086
3000	4	0.12
3500	4	0.19
4000	4	0.3
4500	4	0.53
5032	4	3.2
5500	4	0.6
6000	4	0.36
6500	4	0.26
7000	4	0.2
7500	4	0.16
8000	4	0.12
10000	4	0.0082
20000	4	0.0032

2. Physical Voltages

Frequency	Voltage Resistor	Volatge Cap/Induc
100	4	0.02
200	4	0.021
500	4	0.024
1000	4	0.034
2000	4	0.065
2500	4	0.094
3000	4	0.128
3500	4	0.174
4000	4	0.268
4500	4	0.428
5032	4	0.564
5500	4	0.42
6000	4	0.292
6500	4	0.22
7000	4	0.18
7500	4	0.152
8000	4	0.132
10000	4	0.092
20000	4	0.044

3. Simulation Attenuation

Frequency	Voltage In	Volatge Cap/Induc	dB
100	4	0.0026	-63.742
200	4	0.0048	-58.416
500	4	0.0053	-57.556
1000	4	0.026	-43.742
2000	4	0.06	-36.478
2500	4	0.086	-33.351
3000	4	0.12	-30.458
3500	4	0.19	-26.466
4000	4	0.3	-22.499
4500	4	0.53	-17.556
5032	4	3.2	-1.9382
5500	4	0.6	-16.478
6000	4	0.36	-20.915
6500	4	0.26	-23.742
7000	4	0.2	-26.021
7500	4	0.16	-27.959
8000	4	0.12	-30.458
10000	4	0.0082	-53.765
20000	4	0.0032	-61.938

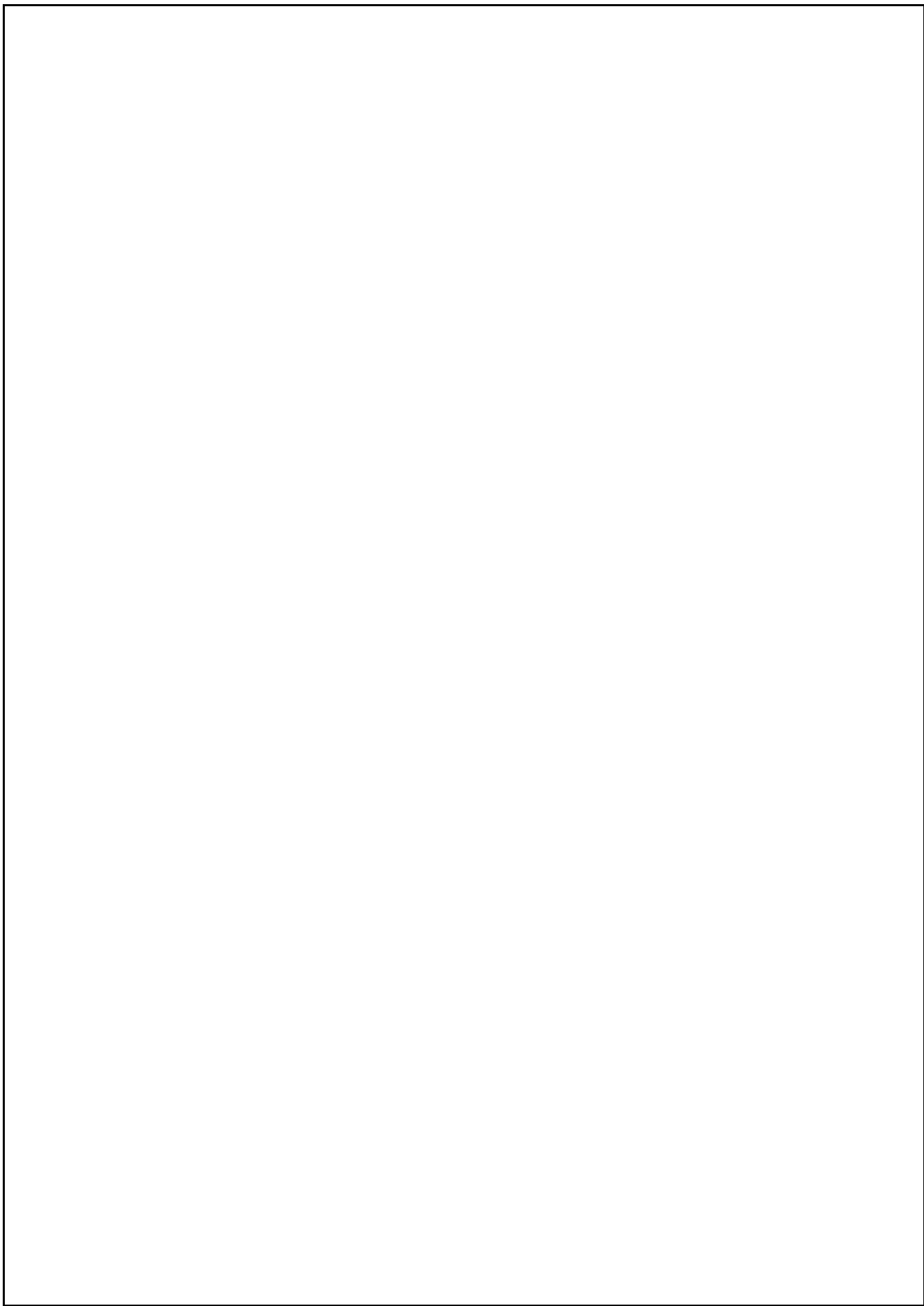
4. Physical Attenuation

Frequency	Voltage Resist	Volatge Cap/Induc	dB
100	4	0.02	-46.021
200	4	0.021	-45.597
500	4	0.024	-44.437
1000	4	0.034	-41.412
2000	4	0.065	-35.783
2500	4	0.094	-32.579
3000	4	0.128	-29.897
3500	4	0.174	-27.23
4000	4	0.268	-23.479
4500	4	0.428	-19.412
5032	4	0.564	-17.016
5500	4	0.42	-19.576
6000	4	0.292	-22.734
6500	4	0.22	-25.193
7000	4	0.18	-26.936
7500	4	0.152	-28.404
8000	4	0.132	-29.63
10000	4	0.092	-32.765
20000	4	0.044	-39.172

5. Further Reading Websites

<https://www.elprocus.com/guide-on-resonant-rlc-circuits-working-and-application/>

<https://www.testandmeasurementtips.com/basics-lc-oscillators-and-measuring-them/>



Assignemnt

GRADEMARK REPORT

FINAL GRADE

GENERAL COMMENTS

Instructor

63/100

PAGE 1

PAGE 2

QM

Missing ","

Missing comma:

Though it may not always be grammatically necessary, a comma can often help to prevent a misreading. When a sentence opens with an introductory element (a phrase, clause or word that is logically related to another phrase or clause in the same sentence), it is a great help to your reader to place a comma after that introductory element. Such phrases will often begin with words like "because," "while" or "although," as in the following example: "While everyone was fighting, the bear wandered away." As you can see, without the comma, the sentence would be confusing.

QM

Awk.

Awkward:

The expression or construction is cumbersome or difficult to read. Consider rewriting.



Comment 1

Active filters also contain op-amps. This is a passive filter.



Comment 2

Typo?

PAGE 3

PAGE 4

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

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

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.

PAGE 5



Comment 3

I suspect these are your experimental results, not your simulated results. Either that or you have several data handling errors causing the lumps in the graph.

PAGE 6

PAGE 7

PAGE 8



Comment 4

They were standard values and easily available. What was different was:

1. The real components had a tolerance applied to the value.
2. The real components had small amounts of parasitic resistance / inductance / capacitance.

The main difference being the inductor, which has a DC resistance of about 4 ohms due to the wire in its windings.



Comment 5

Why is there a difference?

Where does this difference come from? What, specifically, caused it?

PAGE 9



Comment 6

Are references 1 and 2 the same source? That should not happen. If you need to cite the same source more than once, use the same number for it in your text.

PAGE 10

PAGE 11

PAGE 12

GRADING FORM: SMU GENERIC_SMOSEY

ANDREW HART

62.70

ENGAGEMENT WITH LITERATURE

including reading, referencing, academic conventions and academic honesty



Inclusion of a range of research-informed literature, including sources retrieved independently.
Referencing conventions mostly consistently applied.

2.9

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.

18.6

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

19.5

PRACTICAL APPLICATION SKILLS

Different approaches to solving problems in particular contexts.



A very good application of a range of methods, materials, tools and/or techniques. Very good consideration of the context of the application, with perceptive use of examples, where relevant. Evidence of some innovation and creativity.

18.9

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 effectively in a suitable format, but may have minor errors. Mostly coherent work and is in a suitable structure.

2.8