

JM Electronics Assignment

FINAL

by Joseph McNicholas

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Laboratory Experiment 1

**Comparison between a simulated
series RLC circuit and an experimental
circuit**

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Presenting the comparisons of a series RLC circuit created as a simulation in Proteus and using real components under lab conditions

1. Abstract

The purpose of this experiment was to compare Q factor and resonant frequency for a series RLC circuit (a circuit containing a resistor, inductor and capacitor). This circuit would be simulated on a software package and then recreated in a lab environment. Theoretical calculations for experimental and simulated component values gave similar values for Q factor and resonant frequency. When the results of the two circuits were compared, there was little difference between resonant frequency and a significant difference in Q factor. The curve produced from the experimental graph was much shallower and led to the bandwidth of the experimental circuit being much larger than the simulated bandwidth; this proved to be the major difference between the two circuits. This difference could have been down to human error or more likely the real-world component properties affecting the circuit.  1

2. Aim

The purpose of this investigation was to compare the Q factor and resonant frequency (rF)  2 calculated from a simulated series RLC circuit to that of an experimental circuit, and to investigate any differences in the values produced from these two circuits.

3. Introduction

Series RLC circuits are used in oscillator circuits in televisions and radios [1] to filter frequencies and magnify voltage, allowing certain frequencies to be selected and unwanted frequencies to be blocked. Both Q factor and resonant frequency play a role in this. Olsen posits that Q factor is a measure of how sharp the resonant curve is and that “the practical consequence of this is that a resonant circuit can select a signal operating at the resonant frequency, and discriminate against signals at all other frequencies” [2]. Floyd and Buchla give the definition of Q factor as “the ratio of reactive power in the inductor to the true power in the winding resistance of the coil” [3]. Q factor is dependent on the frequency of the circuit and can be calculated from the bandwidth of an rF curve. Inductive reactance X_L and capacitive reactance X_C are both proportional to frequency and both cancel each other out at resonant frequency, at this point the circuit becomes purely resistive. Below resonance the circuit becomes capacitive, above resonance it is inductive [4]. It is at resonant frequency that impedance becomes negligible due to capacitance and inductance cancelling each other out, Olsen defines impedance as the “total opposition to the flow of alternating current by a circuit containing a reactive component (C and/or L) as well as resistance” when the circuit is not at resonance impedance will add to the resistivity of the circuit [5]. From the resonant frequency bandwidth can be calculated and then Q factor.

To investigate methods of measuring these values, two RLC circuits have been evaluated; a simulation has been run on the Proteus design software and one done under lab conditions using real components. Bogatin says with regards to real versus ideal circuit elements “only real devices can be measured, and only ideal elements can be calculated or simulated” [6]. Once both circuits have been simulated ($V_L + V_C$) will be plotted to create a graph, V_L is the voltage across the inductor and V_C the voltage across the capacitor. At a certain frequency V_L will equal V_C and completely cancel each other out [7], as the frequency is changed it is expected the value between V_L and V_C will

fluctuate. The equations used to calculate the following are shown in Equation 1 to Equation 4 below:

$$rF = \frac{1}{2 \times \pi \sqrt{L} \times C}$$

Equation 1. Equation used to calculate resonant frequency (rF) [8]

$$XL = 2\pi FL$$

Equation 2. Equation used to calculate inductive reactance (X_L) [8]

$$XC = \frac{1}{2 \times \pi \times FC}$$

Equation 3. Equation used to calculate capacitive reactance (X_C) [8]

$$Q = \frac{2\pi FL}{R}$$

$$Q = \frac{1}{2\pi FCR}$$

$$Q = \frac{1}{R} \times \sqrt{\frac{L}{C}}$$

Equation 4. Equations used to calculate Q factor [9]

L = Inductor value

C = Capacitor value

F = Frequency

R = Resistance

4. Method

4.1. Simulated Circuit

The simulated circuit was created within the Proteus design suite software. First the components (resistor, inductor and capacitor) were created using the component creation tool (Figure 1) and given the stated values of the real components used in the experimental circuit. The resistor had a value of 3.3 Ohms (Ω), the inductor 1 milli Henry (mH) and the capacitor 1 microfarad (μF).

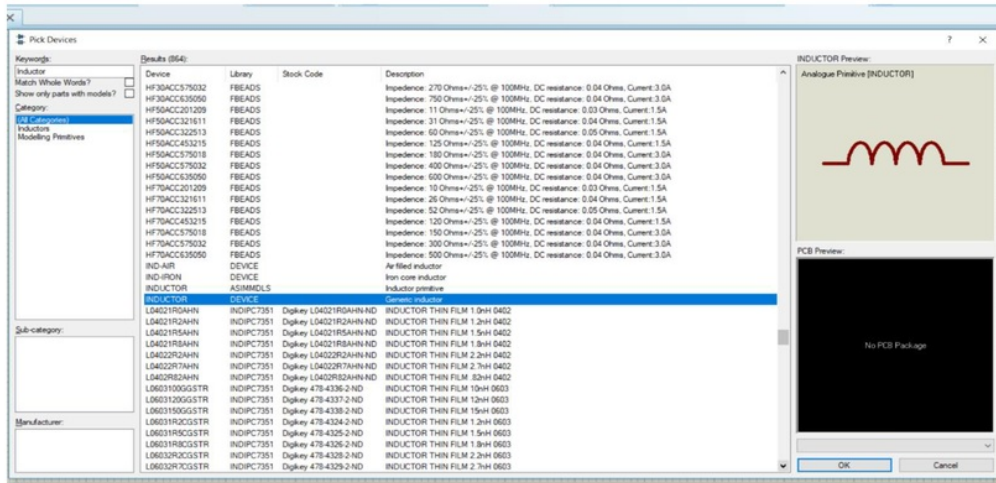


Figure 1. Proteus component creation tool

Within the software, the selected components were used to create a series RLC circuit connected to a virtual oscilloscope and a signal generator (Figure 2). Within Figure 2 the resistor is represented by R1, the inductor by L1 and the capacitor by C1. The oscilloscope is represented by the box in the top right of Figure 2 and the wave form generator the box in the bottom left.

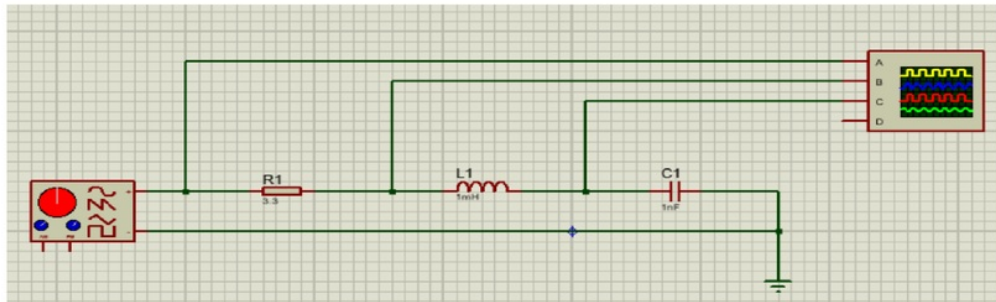


Figure 2. Complete series RLC circuit with resistor (R1), inductor (L1) and capacitor (C1)

The signal generator used within the program was set to a voltage which would be replicated in the experimental circuit. In this case, the output voltage was set to 2Vpk – pk at 100 Hz. As seen in Figure 3, the voltage is dictated by the 2 pink coloured controls on the right, with the amplitude set at 1 volt (V) and the level being set at 2 to represent 2 volts. The two dials on the left dictate the frequency of the circuit, the dial on the left controlling the number of the frequency and the other controlling the units of the frequency i.e Hz or KHz.

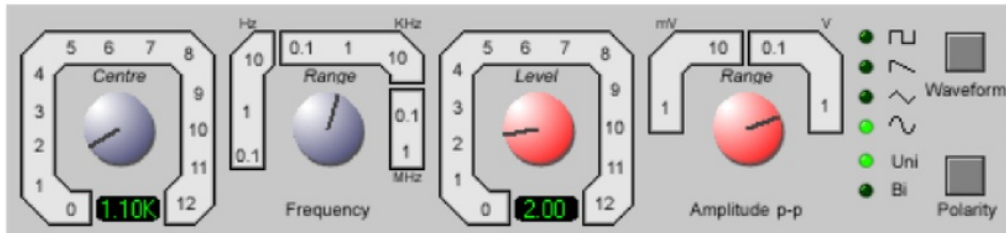


Figure 3. Signal generator control panel

$V_L + V_C$ is worked out by counting the number of squares the wave takes on the digital oscilloscope. In the example given in Figure 4, each square on the oscilloscope represents 0.2 V (set in channel B), a tenth of the supply voltage. The cursor function in the oscilloscope can also be used to take accurate $V_L + V_C$ measurements. The position of the wave on the oscilloscope can be adjusted using the controls on the channel panels. As the resonant frequency is achieved, the size of the wave will decrease and reach zero.

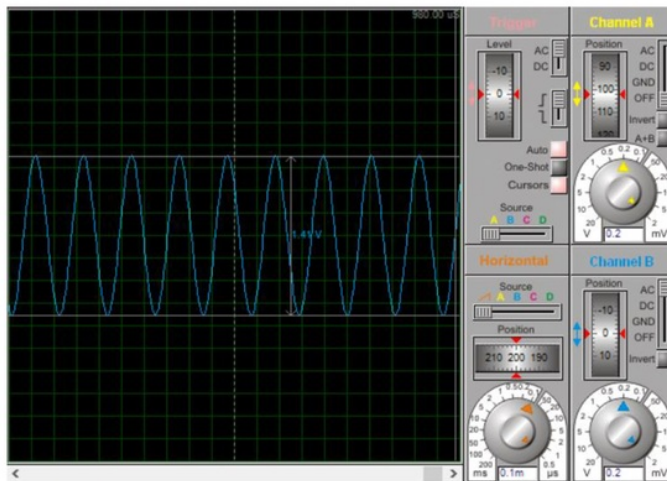


Figure 4. Oscilloscope read out

To determine the resonant frequency of the circuit, the oscilloscope was configured as per Figure 4 and $V_L + V_C$ readings were taken at a range of frequencies. 18 readings were taken in total, starting at 100 Hz and rising until the $V_L + V_C$ value began to decrease. From this point, 100 Hz increases were made to the frequency until the $V_L + V_C$ value began to increase, after which two further readings were taken at 10 KHz and 20 KHz. The frequencies and $V_L + V_C$ values were plotted on a graph to form a curve.

4.2. Experimental circuit

The experimental circuit was created using a breadboard (Figure 5) as a base for adding the components. A signal generator (Figure 6) and an oscilloscope (Figure 7) were added, along with the components, to create an RLC series circuit identical to the circuit created in Proteus.

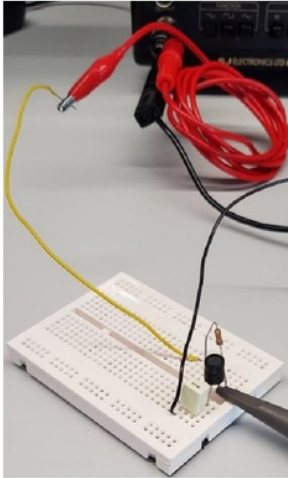


Figure 5. Breadboard with real world components



Figure 6. Signal generator with frequency readout and inputs

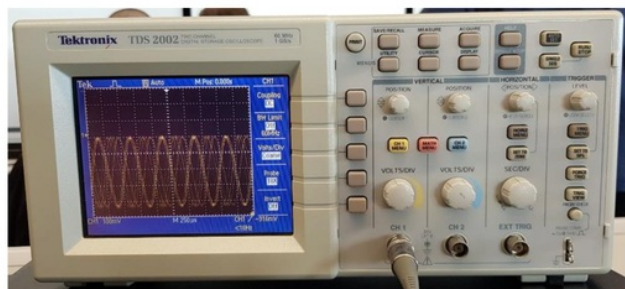


Figure 7. Oscilloscope with time and position dials

The components used had the same resistance, inductance and capacitance values as those used in the simulated circuit. However, there was some difference between the stated values of these components and their actual measured values, as detailed in Table 1.

Component	Stated Value	Measured Value
Resistor	3.3 Ω	2.89 Ω
Inductor	1 mH	0.977 mH
Capacitor	1 μ F	1.013 μ F

Table 1. Stated and measured values for the components used in the experimental circuit

Once the circuit was created, the supply voltage was set to 2 Vpk-pk at 100 Hz to match the simulated circuit and $V_L + V_C$ readings were then taken at the same frequencies tested for the simulated circuit. These values were recorded and plotted against the frequencies and a graph plotted of frequency against V_L+V_C .

5. **Results**

5.1. **Simulated circuit**



As seen in **Error! Reference source not found.** and Table 2 the V_L+V_C values recorded for the simulated circuit begin to decrease after 2000 Hz and keep falling as frequency is increased in 100 Hz increments, until the lowest V_L+V_C value was recorded at a frequency of 5000 Hz. The graph generated from the simulation shows the resonant frequency to be between 5000 Hz and 5100 Hz; after this point the V_L+V_C value begins to increase until reaching supply voltage at 10 KHz.

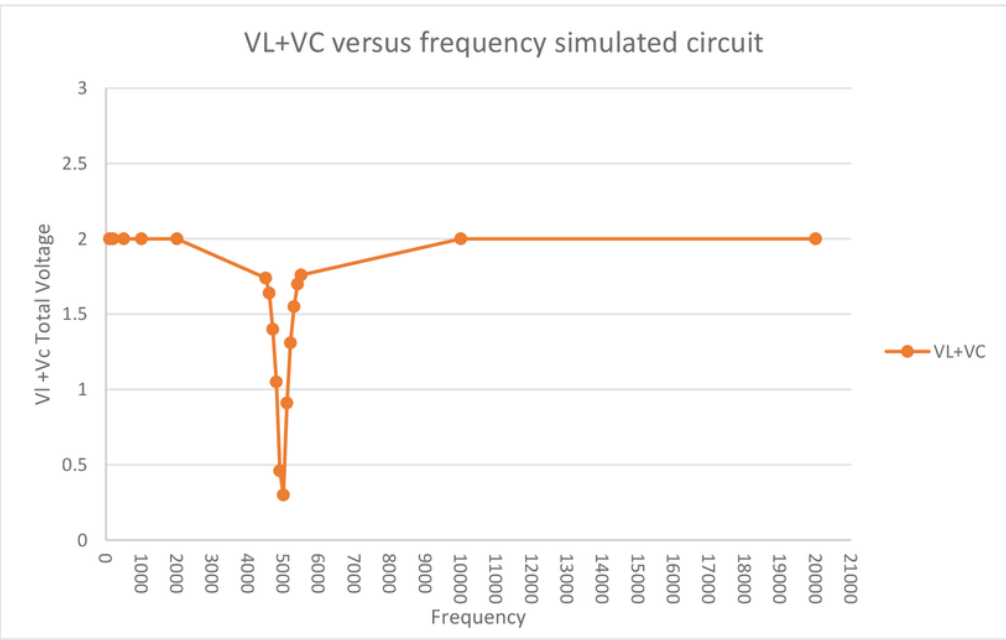


Figure 8. Graph showing V_L+V_C values plotted against frequency in the simulated circuit

Frequency (Hz)	100	200	500	1000	2000	4500	4600	4700	4800
V _L +V _C	2	2	2	2	2	1.74	1.64	1.41	1.05
Frequency (Hz)	4900	5000	5100	5200	5300	5400	5500	10000	20000
V _L +V _C	0.46	0.3	0.91	1.31	1.55	1.7	1.76	2	2

Table 2. Table showing the V_L+V_C values measured at each frequency and used to plot the graph in **Error! Reference source not found.**

5.1.1. Resonant Frequency Calculations

The resonant frequency was accurately recorded using the formula in Equation 5. The values for L and C were 1×10^{-3} and 1×10^{-6} respectively. Using this formula, the resonant frequency was determined to be 5032.921 Hz.

$$Rf = \frac{1}{2 \times \pi \sqrt{0.0001 \times 0.0000001}} = 5032.921 \text{ Hz}$$

Equation 5. Resonant frequency calculation

To confirm this resonant frequency value, the equations for X_L and X_C (Equation 6 and Equation 7) were used to input the calculated resonant frequency into these equations. The value for both X_L and X_C is 31.622, showing that X_L and X_C cancelled each other out and therefore validating the calculated value for resonant frequency.

$$X_L = 2\pi \times 5032.921 \text{ Hz} \times 0.001 = 31.622$$

Equation 6. Inductive reactance calculation

$$X_C = \frac{1}{2 \times \pi \times 5032.921 \times 0.000001} = 31.622$$

Equation 7. Capacitive reactance calculation

5.1.2. Q Factor and Bandwidth Calculations

The Q factor for the simulated circuit has been calculated, using the formulae detailed in Equation 8 - Equation 10 , at 9.582. Using this value for Q factor, the bandwidth (Bw) of the simulated circuit can be calculated using Equation 11, giving a bandwidth value 525.247 Hz.

$$Q = \frac{2 \times \pi \times 5032.921 \times 0.001}{3.3} = 9.582$$

Equation 8. Inductive reactance over resistance

$$Q = \frac{1}{2 \times \pi \times 5032.921 \times 0.000001 \times 3.3} = 9.582$$

Equation 9. 1 / capacitive reactance x resistance

$$Q = \frac{1}{3.3} \times \sqrt{\frac{0.001}{0.000001}} = 9.582$$

Equation 10. Q factor in terms of passive components

$$Bw = \frac{Fr}{Q} \quad Bw = \frac{5032.921}{9.582} = 525.247 \text{ Hz}$$

Equation 11. Bandwidth calculation

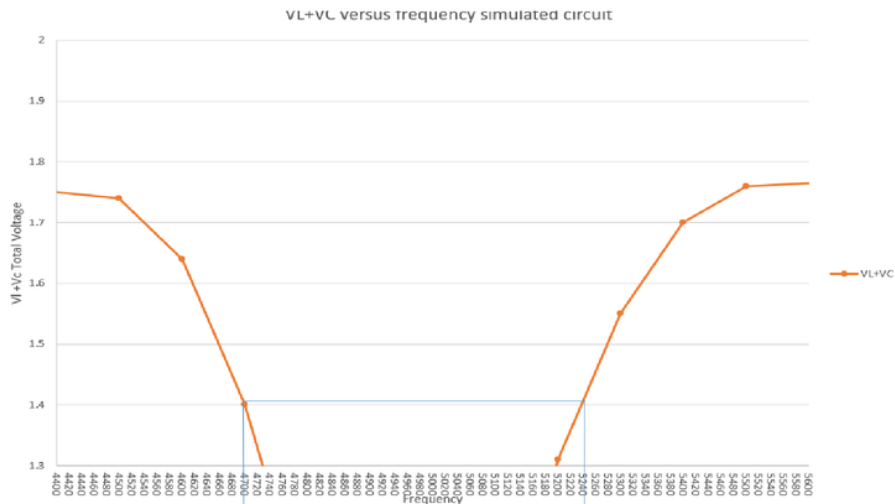


Figure 9. Graph showing $V_L + V_C$ plotted against frequency with high band edge and low band edge plots

Q factor can also be calculated from the bandwidth which can be taken from Figure 9. Taking the values of the frequencies at 70.7% of the voltage gives the bandwidth of the circuit, where 70.7% of 2 V is 1.414 V [10]. Reading across the graph at this value to the curve produced by our measured frequencies gives the high band edge and the low band edge of the bandwidth, 5240 Hz and 4700 Hz respectively and a bandwidth of 540 Hz. The bandwidth equation can be rearranged to calculate a Q factor of 9.32, as shown in Equation 12. Rearranging the formula for bandwidth. This is the Q factor value derived from the graph.

$$Q = \frac{5032.921}{540} = 9.32$$

Equation 12. Rearranged bandwidth equation to show the Q factor value from the graph

5.2. Experimental circuit

As seen in Figure 10 and Table 3, V_L+V_C values recorded for the experimental circuit begin to decrease after 500 Hz and steadily fall until 4800 - 4900 Hz, where the lowest V_L+V_C value was recorded. After this point V_L+V_C begins to rise steadily to 10 KHz and then 20 KHz. The graph generated from the experimental circuit shows the resonant frequency to be between 4800 Hz and 5000 Hz.

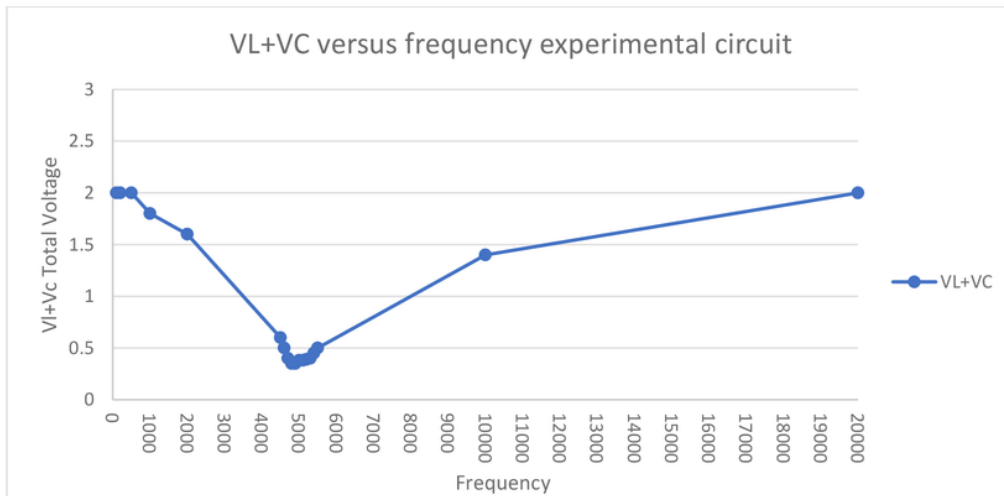


Figure 10. Graph showing V_L+V_C values plotted against Frequencies in the experimental circuit

Frequency (Hz)	100	200	500	1000	2000	4500	4600	4700	4800
V_L+V_C	2	2	2	1.8	1.6	0.6	0.5	0.4	0.35
Frequency (Hz)	4900	5000	5100	5200	5300	5400	5500	10000	20000

Table 3. Table showing the V_L+V_C values measured at each frequency and used to plot the graph in Figure 10

VI+Vc	0.35	0.38	0.38	0.39	0.4	0.45	0.5	1.4	2
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5.2.1. Resonant Frequency calculations

Resonant frequency for this circuit was recorded using the formula in Equation 13. The values for L and C were 0.977×10^{-3} and 1.013×10^{-6} respectively. Using this formula, the resonant frequency was determined to be 5059.04 Hz.

$$Rf = \frac{1}{2 \times \pi \sqrt{0.000977 \times 0.000001013}} = 5059.04 \text{ Hz}$$

Equation 13. Resonant frequency calculation

To confirm the value above Equation 14 and Equation 15 were used to input the calculated resonant frequency into these equations. The value for both X_L and X_C was 31.055, showing that X_L and X_C cancelled each other out and validated the value for calculated resonance frequency.

$$X_L = 2\pi \times 5059.04 \text{ Hz} \times 0.000977 = 31.055$$

Equation 14 - Inductive reactance calculation

$$X_C = \frac{1}{2 \times \pi \times 5059.04 \text{ Hz} \times 0.000001013} = 31.055$$

Equation 15 - Capacitive reactance calculation

5.2.2. Q Factor Calculations

The Q factor for the experimental circuit has been calculated using the formulae detailed in Equation 16 – Equation 18, at 10.745. Using this value for Q factor, the bandwidth (Bw) of the simulated circuit is calculated using Equation 19, giving a bandwidth value 525.247 Hz.

$$Q = \frac{2 \times \pi \times 5059.04 \times 0.000977}{2.89} = 10.745$$

Equation 16 - Inductive reactance over resistance

$$Q = \frac{1}{2 \times \pi \times 5059.04 \times 0.000001013 \times 2.89} = 10.745$$

Equation 17 - 1 / capacitive reactance x resistance

$$Q = \frac{1}{2.89} \times \sqrt{\frac{0.000977}{0.000001013}} = 10.745$$

Equation 18 - Q factor in terms of passive components

$$Bw = \frac{Fr}{Q} \quad Bw = \frac{5059.04}{10.745} = 470.827 \text{ Hz}$$

Equation 19 - Bandwidth calculation

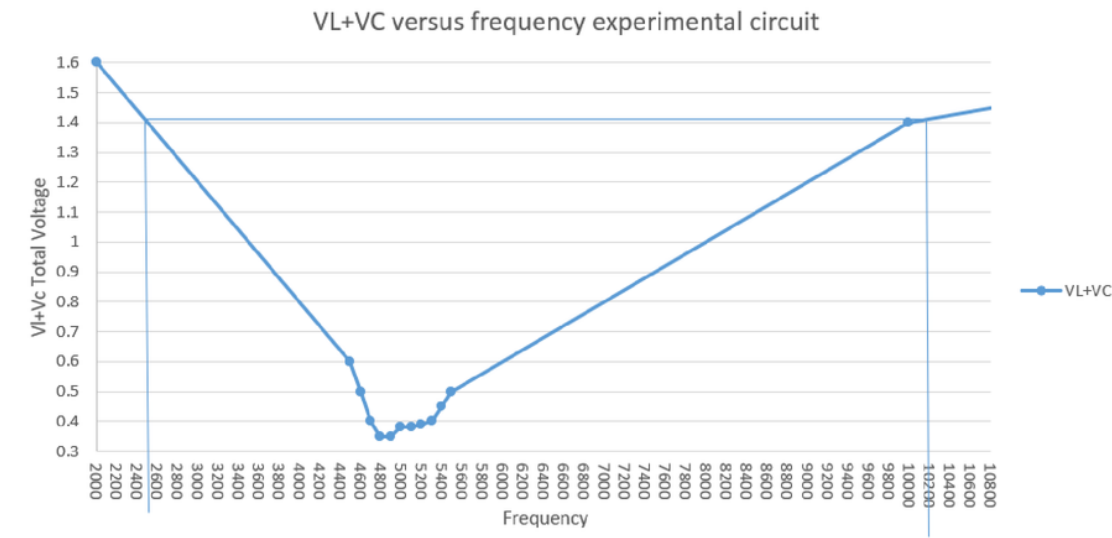


Figure 10. Graph showing V_L+V_C values plotted against Frequencies in the experimental

Once again, a value of 1.41 VL+VC was used to give the 70.7% needed to give a high band edge and low band of 2500Hz and 10200Hz respectively as well as a bandwidth of 7500Hz. Rearranging the formula for bandwidth gives the Q factor derived from the graph as.

$$Q = \frac{5059.04}{7700} = 0.657$$

Equation 20 - Rearranged bandwidth equation to show the Q factor value from the graph

6. Discussion

As seen from the graph in **Error! Reference source not found.**, V_L+V_C begins to decline at 4500 Hz, the lowest reading of V_L+V_C taken from the simulated readings was 0.3 at 5000 Hz before increasing again to 0.91 at 5100 Hz. The calculated value of resonant frequency was 5032.921 Hz, this was validated by calculating X_L and X_C at this frequency with both giving the same figure of 31.622. It is therefore likely that if more readings had been taken between 5000Hz and 5100Hz then the recorded V_L+V_C values would have been closer to zero and resonant frequency could have been plotted on the graph. The two results combined seem to confirm the simulated circuit has run

correctly, as the basic theory calculations validate the results taken from the graph and the simulation. This is due to simulated components working perfectly according to their stated value with no tolerance or additional impedance.

Q factor was calculated using the same graph in **Error! Reference source not found..** The value derived from the graph was 9.32 calculated using a bandwidth of 540 Hz. Whereas the basic theory calculations give a Q factor value of 9.582 and a bandwidth of 525.247Hz. The values derived from basic theory calculations do somewhat support the values gained from the graph, however they are slightly off, this may have been due to human error in determining the low band edge and high band edge frequencies off an excel graph using the line tool.

The basic theory calculations using the measured values of the components when compared with the oscilloscope readings and graph from the experimental circuit do not give the same value for resonant frequency. The resonant frequency taken from the graph would give a value between 4800Hz and 5000 Hz, the lowest value taken was 0.35 at 4800 Hz, this is maintained at 4900Hz and increases to 0.38 at 5000 Hz. The resonant frequency value from the basic theory calculations is 5059.04 Hz and was validated by calculating X_L and X_C both of which had a value of 31.055. This shows that the value taken from the graph does not support the value derived from the basic calculations. The basic theory calculations took the measured values of the components used in the experiment. This indicates that the values taken from the graph during the experiment have been miscalculated, there was no cursor tool to accurately measure the exact value of $V_L + V_C$ and was done by counting the number of squares covered by the wave on the oscilloscope.

The Q factor calculated from the graph in the experimental circuit was 0.657 with a bandwidth of 7700 Hz. This is in stark contrast to the Q factor values derived from basic theory calculations, which gave a figure of 10.745 for a bandwidth of 470.827 Hz. The difference in Q factor from the graph and calculated values is large. This is most likely due to the degree of separation of the high band edge and low band edge frequencies in the graph. As with the simulated circuit there was some degree of human error in calculating the band edges in excel but the difference is still large.

There are differences between the resonant frequency values and Q factor between the simulated and experimental circuits. When comparing the basic theory calculations of the two, the difference appears to be minimal with a difference of 26.119 Hz, which could account for the difference in the values of the components. We see the same in the difference between the Q factor values of the two circuits with the Q factor of the simulated circuit being 9.582 and the experimental 10.745, a difference of 1.163. However, the graphs themselves and the values gathered from them are different. While the calculated resonant frequency is confirmed by the graph generated from the results taken in the simulation, the same cannot be said for the experimental circuit. As seen from the shape of the two graphs, there is a much sharper peak for the simulated graph than the experimental graph. This has led to a much larger bandwidth for the experimental circuit and a smaller Q factor. Bogatin says "Ideal devices are mathematical descriptions of specialized circuit elements that have precise, specific definitions" [11] and as such the simulated circuit is an ideal device in that all of its components have precise definitions and values, any simulated circuit would give highly accurate values comparable to basic theory calculations. He also notes that "The resistance of an ideal resistor, the capacitance of an ideal capacitor, and the inductance of an ideal inductor are all constant with frequency" and not subject to fluctuation due to the simulation rigidly using input values from the user.

The materials and the construction of the components used in the experimental circuit can affect the data we have collected for the circuit. There are many different kinds of resistors, a Texas

instruments report discusses some of them, including wire wound, carbon film and metal film resistors [12]. Each type of resistor has different properties at different temperatures and can have different tolerances, which would change their true resistive value from the stated value. A technical information sheet from Roederstein discusses film capacitors and the materials they are made from, these can either be film/foil capacitors or metalized film, both are different materials deposited onto an insulating plastic film called a dielectric. The report goes on to discuss capacitance drift “the capacitance of a capacitor is also subject to irreversible changes known as capacitance drift” [13]. This phenomenon can be caused by regular and extreme temperature change. As the history of the components is unknown, it may be feasible to say that the components may have undergone some capacitance drift. As mentioned before there are no ideal components outside a simulation and real-world components may have unwanted properties, also known as parasitics. Niknejad and Dunsmore discuss parasitics of components noting “parasitics add loss and limit the upper frequency range over which the components function properly” [14]. They note the internal parasitics of inductors, and explain how the windings of the coil are tightly wound and “at very high frequencies signals can skip the loop and travel from winding to winding through the intrinsic capacitance between the windings” [15]. The inductor used in the experiment also has its own resistance, which would not have been accounted for in the simulation [16]. While in the experimental circuit $V_L + V_C$ returned to a supply voltage at 20 KHz this may account for the shallower peak gathered around the 5000 Hz mark; it was the shallower peak in Figure 10 that had caused the lower Q factor value as this gave a much greater bandwidth.

7. Conclusions

The differing values of the real-world components and the simulated components gave slight differences in theoretical calculations for resonant frequency and Q factor. However, the $V_L + V_C$ values taken differed dramatically between the two, as seen in the curves produced for each set of results. Radwan notes from his data that “quality factor is proportional to resonance frequency” [17] we can see this in the results given the experimental calculations produced a larger Q factor and resonant frequency. However this was not apparent when looking at the data produced from Figure 10, the width of the curve produced from the experimental graph lead to a much larger bandwidth and thus a much-reduced Q factor for the experimental circuit. The difference between the two sets of results can be attributed to real world components having different properties given the way they are built. This was not replicated in the simulated circuit, giving a much different bandwidth and Q factor.

8. References

- [1] Electronics|Projects|Focus, "Guide on Resonant RLC circuits Working and Applications" ELPROCUS 2013. [Online]. Available <https://www.elprocus.com/guide-on-resonant-rlc-circuits-working-and-application/>. [Accessed 05/02/2019]
- [2] G.Olsen. Electronics, *A course book for students*. 2nd Edition. Trowbridge. Butterworths. 1982. Ch 3. Pp 105.
- [3] T.Floyd, D. Buchla. "Electronic Fundamentals, *"circuits, devices and applications"*. Eighth Edition. Harlow, Pearson. 2017. Ch 11. Pp 524
- [4] Learnabout Electronics, "– AC Theory", ERIC COATES 2018. [Online]. Available http://www.learnabout-electronics.org/ac_theory/lcr_series_92.php. [Accessed 01/02/2019]
- [5] G.Olsen. Electronics, *A course book for students*. 2nd Edition. Trowbridge. Butterworths. 1982. Ch 3. Pp 77.
- [6] Bogatin, E. Signal Integrity, Impedance and Electrical Models. *Informit*. 23/12/2003. [Online]. Available: <http://www.informit.com/articles/article.aspx?p=102225&seqNum=3>. [Accessed 28/12/2018]
- [7] Electronics Tutorials, "Series Resonance Circuit" ELECTRONIC TUTORIALS 2019. [Online]. Available <https://www.electronics-tutorials.ws/accircuits/series-resonance.html> . [Accessed 14/01/2019]
- [8] Mosey, S. "AC theory Lecture Slides" OME – Electrical and Electronic Principles 2019. [Online]. Available: <https://moodle.uwtsd.ac.uk/course/view.php?id=5757>. [Accessed 28/12/2018]
- [9] Mosey, S. "Q factor" OME – Electrical and Electronic Principles 2019. [Online]. Available: <https://moodle.uwtsd.ac.uk/course/view.php?id=5757>. [Accessed 28/12/2018]
- [10] ElectronicsTutorials. "Series Resonance Circuit". ELECTRONICS TUTORIALS 2019. [Online]. Available: <https://www.electronics-tutorials.ws/accircuits/series-resonance.html>. [Accessed 05/02/2019].
- [11] Bogatin, E. Signal Integrity, Impedance and Electrical Models. *Informit*. 23/12/2003. [Online]. Available: <http://www.informit.com/articles/article.aspx?p=102225&seqNum=3>. [Accessed 28/12/2018]
- [12] "Understanding Basic Analog – Passive Devices". Texas Instruments. SLOA027. 1999. [Online]. Available: <http://www.ti.com.cn/cn/lit/an/sloa027/sloa027.pdf> . [Accessed 03/02/2019].
- [13] V. Roederstein. *Film Capacitors*. Vishay 2017. Document number:26033. Last Revised: 17/05/2017. [Online]. Available: <https://www.vishay.com/docs/26033/gentechinfofilm.pdf>. [Accessed 28/12/2018].
- [14] A.M.Niknejad, J.Dunsmore. "High Frequency Passive Components". Laboratory 1. University of California. Berkeley. 2013. Ch 2. Pp1 [Online]. Available: <http://rfic.eecs.berkeley.edu/142/labs/componentlab.pdf> [Accessed 04/01/2019].
- [15] A.M.Niknejad, J.Dunsmore. "High Frequency Passive Components". Laboratory 1. University of California. Berkeley. 2013. Ch 4.2. Pp7 [Online]. Available: <http://rfic.eecs.berkeley.edu/142/labs/componentlab.pdf> [Accessed 04/01/2019]

[16] Mosey, S. "Components used in assignment". MOODLE 2018. [Online]. Available: <https://moodle.uwtsd.ac.uk/mod/page/view.php?id=152419>. [Accessed 06/02/2019].

[17] A.G.Radwan. "Resonance and Quality factor of the RLC Fractional Circuit". *IEEE Journal on Emerging and Selected Topics in Circuits and Systems*. Volume 3. Issue 3. Page Range 377-385. 19/07/2017. [Online]. DOI: [10.1109/JETCAS.2013.2272838](https://doi.org/10.1109/JETCAS.2013.2272838). [Accessed 05/02/2019].

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GRADEMARK REPORT

FINAL GRADE

GENERAL COMMENTS

Instructor

67/100

PAGE 1

PAGE 2



Comment 1

Good abstract. All the information needed is present.



Comment 2

Usually this would be written as Fr, not rF

PAGE 3

PAGE 4

PAGE 5

PAGE 6

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Comment 3

I think something has gone wrong with your figure reference. I assume you mean Figure 8

PAGE 8



Comment 4

As you have included a graph, you do not need to include the table of values also. A graph is preferred over a table as trends are more easily identified from a graph.

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JOSEPH MCNICHOLAS

67.10

ENGAGEMENT WITH LITERATURE

including reading, referencing, academic conventions and academic honesty



A comprehensive range of research informed literature embedded in the work. Excellent selection of relevant and credible sources. High-level referencing skills, consistently applied.

3.9

KNOWLEDGE & UNDERSTANDING

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

Excellent knowledge and understanding of the main



concepts and key theories. Clear awareness of challenges to established views and the limitations of the knowledge base.

21.9

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. Convincing conclusions

18.9

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.

19.5

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.

2.9