

Resonance - 2205436

by Jade Williams

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Resonance

SamanthaJade Williams - 2205436

Electrical and Electronic Principles

Electrical and Electronic Engineering



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3 Abstract

In this assignment, the task was to build an appropriate circuit on a suitable circuit simulator to demonstrate and measure resonance in a circuit. The chosen simulation software was Proteus. Testing was to be done to determine the measurements, the resonant frequency, and the Q factor of the digital circuit using the digital signal generator and oscilloscope available on Proteus. The circuit was then to be built on a breadboard and tested again. This was done with the physical signal generator and oscilloscope, which can then be used to determine the measurements, resonant frequency, and the Q factor of the physical circuit. These two sets of results were then to be compared to each other. This was done to later discuss the similarities, the differences, and the discrepancies. The circuit was built by connecting a series resistor to a capacitor and inductor which were in parallel. The testing equipment was then to be connected appropriately – the signal generator in series with the other components and the oscilloscope in parallel to the circuit. The testing consisted of using a signal generator to give a voltage of 2V and using an oscilloscope to measure the output voltage using the sine wave. This was done by measuring the peak-to-peak voltage of the output sine wave which in this case was through channel B. The resonant frequency of both circuits was found to be 5033Hz, and the Q factor was calculated to be 31.6.

Introduction

A resonant circuit can also be referred to as a tuned circuit. Resonance is considered to be a frequency which is determined by the values of resistance, capacitance, and inductance in an RLC circuit [1]. Resonance in a circuit happens when the voltage across both the inductor and capacitor in an RLC circuit is equal, meaning that the voltage can be consumed by the resistor, producing a peak or maximum current value. Another way to explain this is that the resonant circuit is used to focus on a single frequency or filter through various frequencies. This single frequency is the peak frequency also known as the resonant frequency. There are two types of resonant circuits, series and parallel. The circuit used in this task is a parallel circuit also known as a tank circuit. A tank circuit is a resonant circuit which has the capacitor and inductor in parallel with each other [2]. This means that the circuit provided to use in this task is referred to as a tank circuit. There are also various other calculations and figures that can be found from these

resonant circuits, such as the Q factor, which is also known as the quality factor of a resonant circuit, and the attenuation of the circuit, which can be referred to as the loss in a resonant circuit. The main uses of resonant circuits according to [3] are for radio or television broadcasting signals, communication systems, voltage magnification, induction heating, and oscillator circuits. This type of circuit is used in radio and television broadcasting due to its ability to focus on a single frequency. In the example of radio broadcasting, when the resonant frequency is matched, the circuit current reaches its maximum and the signal is accepted [4]. This means that a frequency can be selected from a series of frequencies. This is the same for the communication systems as they use radio waves. Voltage magnification can be done using series resonant circuits and current magnification is done using parallel resonant circuits. They are used in induction heating because of the low power factor [5]. Resonant circuits are added to the circuits to compensate for this with reactive power. Parallel resonant circuits are used for oscillator circuits. For the remainder of this report, a detailed summary of how the circuit was built and tested will be presented. The report will also show how the results were obtained and what equations were used for the calculations. There will also be a further discussion of the similarities and differences between the two sets of results and the two graphs associated with the sets of results. Finally, the conclusion will include a statement of findings from the circuit testing, as well as the discussion about the task.

Simulation Setup

The circuit shown in figure 2 and also shown in figure 3 is a resonant or tuned circuit and consists of six components. These are a $1\text{k}\Omega$ resistor, a 1mH inductor, a $1\mu\text{F}$ capacitor, a signal generator set to 2V , an oscilloscope, and on the virtual circuit, a ground. The inductor and capacitor are connected in parallel, in other words this particular type of circuit can also be known as a tank circuit. This circuit was first built on a breadboard, which is shown in figure 3, and was tested with physical equipment as well as the virtual circuit being tested with virtual equipment. In both tests, the signal generator used was set to 2V peak to peak and was kept at that setting throughout all of the testing which was done as part of this assignment. The frequencies used for this testing were from 100Hz - 10KHz , using a logarithmic scale. The circuit was then methodically tested at the various

frequencies in order to find the output voltage and to calculate the attenuation. The attenuation is calculated from the following equation which is shown in figure 1.

$$A = 20 \times \log_{10} \frac{V_L}{V_i}$$

Figure 1: equation for attenuation.

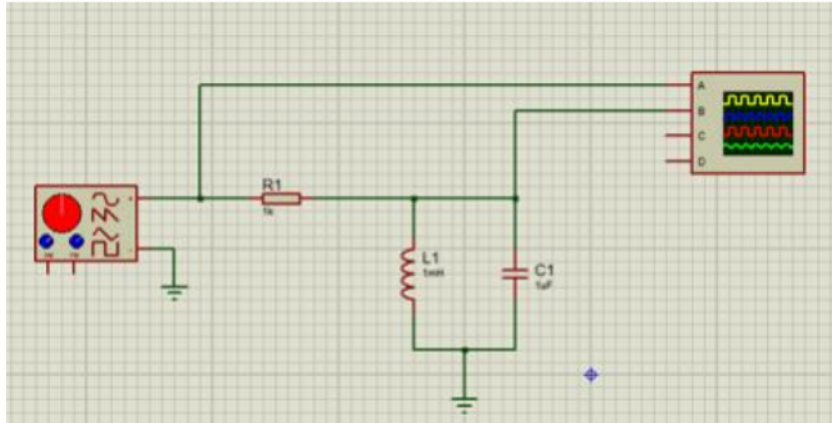


Figure 2: Simulation RLC circuit on Proteus.

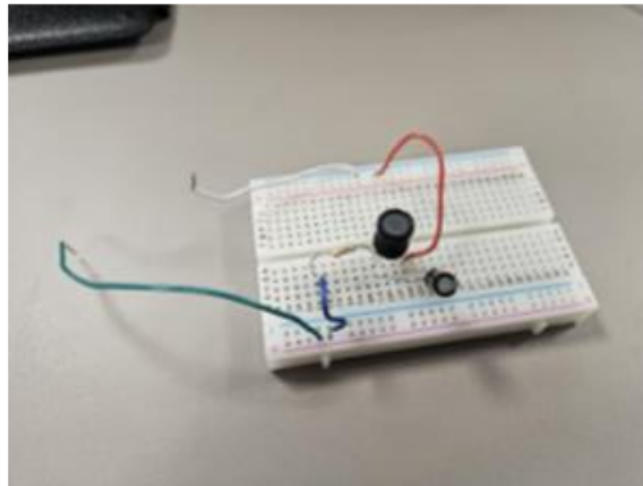


Figure 3: Breadboard circuit

Shown clearly in figure 3 is the physical rendition of the circuit constructed on a breadboard. The breadboard has been used as a suitable solderless alternative to a PCB. It has been done this way because it is much easier to modify a circuit without the possibility of needing to add or remove solder to move components if incorrectly placed or if or when another mistake is made. The circuit constructed on

the breadboard consists of the same components as the virtual circuit - a 1kΩ resistor, a 1mH inductor, a 1uF capacitor, and four wires. The wires in question are used to make the connections needed between the three components and the testing equipment. The wires depicted in figure 3 which are connected only on one end are to be later connected to the signal generator and the oscilloscope. These wires were connected to the testing equipment to measure the output voltages at each frequency for the attenuation to be calculated. These results are clearly depicted in table 2 for the physical circuit and table 1 for the virtual circuit. These tables of results were then converted into graph form as shown in figure 6 and figure 7. It was using these graphs and tables of results that the resonant frequency, Q factor and the bandwidth were all found or calculated.

Results

The information conveyed through the table of results for the Proteus circuit as shown in table 1 are the measured results for testing the digital circuit on Proteus, which is shown in figure 2. The tables of results depicted in table 1 and table 2 list the measurements of each output voltage at each value of frequency and also the calculated attenuation using each set of results. Also listed in these two sets of results is the input voltage of 2V. The data from these two tables of results is clearly conveyed by the graphs which are shown in figure 6 as well as figure 7. As clearly shown in table 1, the peak voltage is seen to be 0.1925V. As previously stated, the attenuation can be calculated through the use of the equation, which is shown in figure 1, and also using the two tables of results. The value of the attenuation at the peak voltage of 0.1925V can then be calculated to be -20.33dB. Here there is a noticeable difference between the two sets of results. The difference is that even though the peak voltages are both at the same frequency, the peak voltage from table 2 is found to be 0.232V. From this data, the attenuation is then calculated to be -18.71dB. Then the equation, which is clearly shown below in figure 4, for the resonant frequency is used which presents the calculated resonant frequency of 5033Hz. Following this, the Q factor is calculated by using the equation also shown below in figure 5. This was then found to be 31.6.

$$f_r = \frac{1}{2\pi\sqrt{LC}}$$

Figure 4: Resonant frequency equation.

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

Figure 5: Q factor equation.

Finally, the bandwidth will then need to be calculated. The bandwidth is then found by measuring the two points on both of the graphs where the amplitude of the graph is at 70.7%. The frequency, f_1 , which was found to be 3558Hz, is then subtracted from the frequency f_2 , which was found to be 6508Hz, to find the bandwidth, which is then calculated to be 2950Hz.

frequency (Hz)	Vin (V)	VL (V)	A (dB)
100	2	0.0013	-63.74173287
200	2	0.0025	-58.06179974
300	2	0.0038	-54.42492798
400	2	0.0051	-51.86919639
500	2	0.0064	-49.89700043
600	2	0.0076	-48.40432807
700	2	0.009	-46.93574972
800	2	0.0103	-45.76385542
900	2	0.0117	-44.65688268
1000	2	0.0132	-43.60912129
2000	2	0.03	-36.47817482
3000	2	0.059	-30.60355968
4000	2	0.1375	-23.25454595
5000	2	0.1925	-20.33198524
6000	2	0.175	-21.15983894
7000	2	0.0925	-26.69776526
8000	2	0.065	-29.76233278
9000	2	0.05	-32.04119983
10000	2	0.0425	-33.45282131

Table 1: Table of results for simulated circuit.

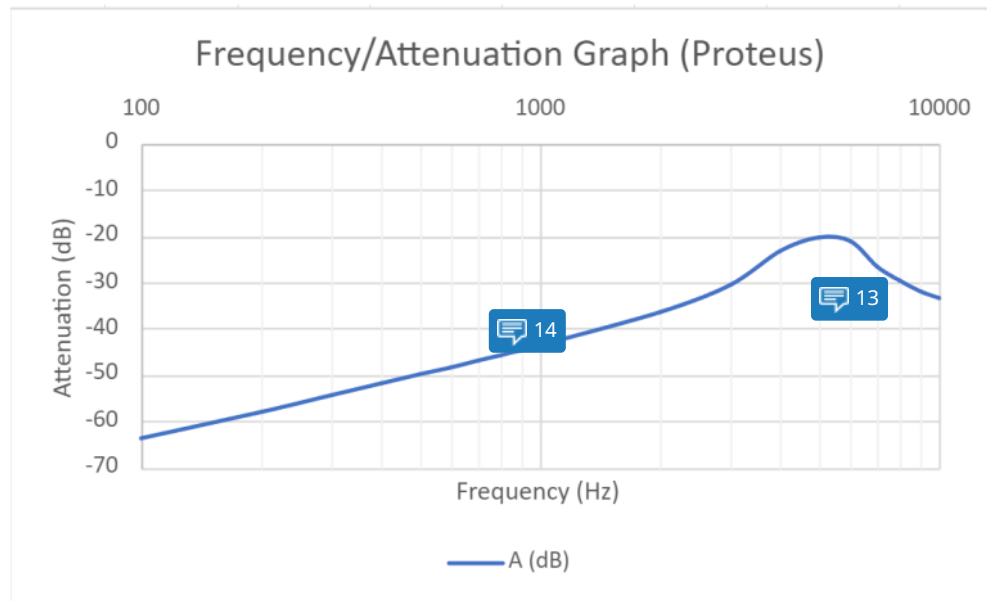


Figure 6: Graph of frequency against attenuation for table 1.

frequency (Hz)	Vin (V)	VL (V)	A (dB)
100	2	0.0096	-46.37517525
200	2	0.0096	-46.37517525
300	2	0.0096	-46.37517525
400	2	0.0096	-46.37517525
500	2	0.0112	-45.03623946
600	2	0.012	-44.43697499
700	2	0.0128	-43.87640052
800	2	0.0136	-43.34982175
900	2	0.0152	-42.38372815
1000	2	0.0164	-41.72372295
2000	2	0.0328	-35.70312304
3000	2	0.0552	-31.18181836
4000	2	0.116	-24.73144013
5000	2	0.232	-18.71084022
6000	2	0.184	-20.72424345
7000	2	0.106	-25.51448261
8000	2	0.078	-28.17870786
9000	2	0.062	-30.17276612
10000	2	0.05	-32.04119983

Table 2: Table of results for breadboard testing.

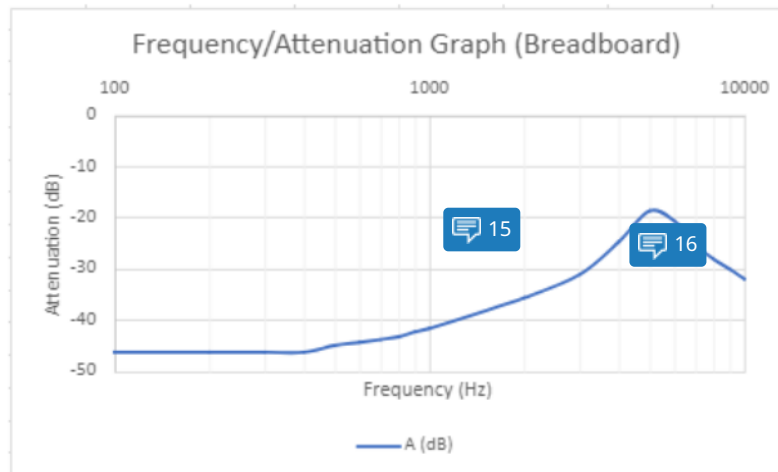


Figure 7: Graph of frequency against attenuation for table 2.

Discussion

From the results gathered in this task, it can be said that since the resonant frequency is found to be the same for both the physical breadboard circuit and the simulated proteus circuit, as a result of this finding, values for both the bandwidth and the Q factor will also be the same. This is because the Q factor and the resonant frequency are both calculated using the same values in their respective equations, and the bandwidth is found using the resonant frequency. This is further shown in the graphs of frequency and attenuation shown in both figure 6 as well as figure 7. A slight difference between the two graphs, however, is a noticeable linear shape to the graph which is associated with the virtual Proteus circuit in comparison to the clear curve shown in the graph which is associated with the physical breadboard circuit. A difference in shape such as this can be attributed to differences in overall circuit resistance despite the resistors being of the same value of resistance. A common discrepancy that happens when comparing the virtual circuits to their physical alternatives, is a difference in the value of overall resistance. This tends to be due to physical components having internal resistances which can affect the measured resistance values in physical circuits, but not a virtual circuit as virtual circuits do not account for internal resistances of component in a circuit. This is conveyed through the graphs as how linear the results are. For example, for the graph depicted in figure 6, the graph was linear until the graph reached the amplitude, before curving down steadily decreasing in value, as virtual circuits have no internal resistance, and for the graph depicted in

figure 7, the results seem to fluctuate slightly before reaching the amplitude, and then steadily decreasing in amplitude in a curved fashion. This could suggest that there will be external factors, such as additional resistance, which could be due to the internal resistances of the components and wires. Another point to make note of regarding the two sets of results shown in table 1 and table 2, are the differences in the ranges of values of attenuation. From table 1, the values range from -20.33dB to -63.74dB . This is quite different to the values shown in table 2, which are shown to be from -18.71dB to -46.38dB . Despite the values of the component remaining the same, as well as the test frequencies and input voltage also both remaining the same, these values are noticeable as the difference between the maximum two values of attenuation was found to be only 1.62dB , whereas the difference between the lowest measured values was as high as 17.36dB .

Conclusion

This section will serve as the final conclusion of this report. As has been previously stated in the abstract, the main aim of this specific task was to then build the designated resonant circuit. This was done on the digital simulation software. The software that was chosen to be used was Proteus. Afterwards the circuit was then built physically on a breadboard. After this stage, the two completed circuits were then to be properly tested and the results were to be put into a table and then afterwards converted into a graph to be later compared. It was then determined that for this specific circuit the resonant frequency, Q factor and also the bandwidth were then to be calculated. From the results of these calculations, it was accurately determined that the resonant frequency was 5033Hz . Upon careful calculation the Q factor was found to be 31.6 and following this the bandwidth was then found to be 2950Hz . This was done by using the equations mentioned throughout the body of this report. From the testing that was undertaken on the two circuits discussed, it was then determined that despite the fact that the values of the components in the circuits were set to be perfectly identical, it was then verified through the difference in results that a simulated circuit cannot be used as an accurate alternative to the physical circuit. This is primarily because while simulated or digital circuits will work accordingly with the purpose, testing will be inaccurate due to the fact that digital

circuits do not take into account any external factors. These include things such as internal resistances within the components when testing exclusively on the digital circuit. This was proven in the report through the results themselves to be true, such as the difference between the two maximum attenuation values, which was accurately calculated to be 17.36dB. If the external factors were to be taken into account when working on the calculations for the digital circuit, this value would as a result be found to be much smaller. This means that the previous calculations for this circuit can be considered quite consistent with the final findings from the results provided.

References

- [1] "Resonance," Resonant RLC Circuits, <http://hyperphysics.phy-astr.gsu.edu/hbase/electric/serres.html> (accessed Dec. 29, 2023).
- [2] W. Storr, "Parallel resonance and parallel RLC Resonant Circuit," Basic Electronics Tutorials, <https://www.electronics-tutorials.ws/accircuits/parallel-resonance.html> (accessed Dec. 29, 2023).
- [3] "5 applications of resonant circuits," GBC Electronics Technician, <https://www.etcourse.com/news-blog/5-applications-resonant-circuits> (accessed Dec. 29, 2023).
- [4] J. Thomas, D. K. A. B, and J. Khim, "Resonant circuits," Brilliant Math & Science Wiki, <https://brilliant.org/wiki/resonant-circuits/> (accessed Dec. 29, 2023).
- [5] A. S. Kharadi, A. S. Patel, and J. A. Dhantiya, "Design Analysis and Simulation of Resonant Inverter for Induction Heating Process," *Journal of Applied Engineering*, vol. 2, no. 5, May 2014. Accessed: Dec. 29, 2023. [Online]. Available: https://kaizerpowerelectronics.dk/files/application_notes/induction_heating/Design_Analysis_Simulation_Resonant_Inverter_Induction_Heating_Process.pdf



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PAGE 1



Comment 1

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PAGE 2



Comment 2

The
table of content should have the page number of each headings

PAGE 3



Comment 3

It is
better to number each heading



Comment 4

It is better to number each page



Comment 5

It would improve the readability if this paragraph were divided into several paragraphs



Comment 6

Equation is not a figure, It should not be considered as figure.



Comment 7

It would have been better if the screenshot of simulated outputs are included in the report



Comment 8

It would have been better if the picture of Oscilloscope output is included in the report



Comment 9

It would improve the readability if this paragraph were divided into several paragraphs



Comment 10

It would improve the readability if this paragraph were divided into several paragraphs



Comment 11

Equation is not a figure, It should not be considered as figure.



Comment 12

Equation is not a figure, It should not be considered as figure.



Comment 13

It is better to mention Fr , Fu and Fl



Comment 14

Good work



Comment 15

Good work



Comment 16

It is better to mention Fr , Fu and Fl



Comment 17

Q factor for Simulated output and Q factor for Breadboard connected circuit are missing



Comment 18

It would improve the readability if this paragraph were divided into several paragraphs



Comment 19

It would improve the readability if this paragraph were divided into several paragraphs

GRADING FORM: GRADING

JADE WILLIAMS

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ENGAGEMENT WITH LITERATURE

Marks for engagement with literature skills will be gained through the use of information collected from appropriate reference material embedded in mainly the introduction, but also in the discussion and conclusion sections of your report. This reference material should be used to explain concepts and to support arguments in the discussion of your results.



Engagement with an appropriate range of literature, including sources retrieved independently. Some over-reliance on texts rather than other sources. Referencing shows minor inaccuracies or inconsistencies. Citations and referencing require improvement.

3

KNOWLEDGE AND UNDERSTANDING

Marks for knowledge and understanding skills will be given for the accuracy of your description of the concepts and principles of resonance and how this relates to the experimental setup used.



Excellent knowledge and understanding of the basic underlying concepts and principles of

22

Electrical and Electronics Engineering, which is evident through the description on the experimental setups,

COGNITIVE AND INTELLECTUAL

Marks for cognitive and intellectual skills will be given for the quality and validity of your interpretation of the experimental results gathered. You should consider the differences between the simulated and experimental and explain possible causes for them.



Good evaluation of the underlying concepts and principles of the Electrical and Electronics Engineering. Can interpret data with minor errors. Ability to use evidence to support the argument. Mostly valid arguments and logical judgements is evident from the description.

16

PRACTICAL SKILLS

Marks for practical skills will be given for your use of the available tools, models and techniques to explain your results and their relationship to the theory of the concepts.



Good application of a range of basic methods, materials, tools and/or techniques in circuit design. Very good consideration of the context of the application. Very good evidence of different approaches to problem-solving in Electrical and Electronic circuits and proposes appropriate solutions.

19

TRANSFERABLE SKILLS FOR LIFE

Marks for transferable skills for life and professional practice will be given for the structure, coherence, presentation and overall quality of your report.



The report displays a reasonable level of structure and coherence. Presentation is generally clear, contributing.

3