

Electrical resonance

by Scott Ling

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ELECTRICAL RESONANCE

The comparison of Resonance within a series circuit.

ABSTRACT

Resonance in an electrical circuit exists where there is an equal magnitude between the inductive reactance and the capacitive reactance. In this report there will be comparative data on resonance within a series circuit. In order to gather the comparative data of resonance within the circuit, analysis was carried out on an assigned electrical circuit via two different types of experiment. Experiment one was carried out in a practical implementation within a laboratory using a breadboard, relevant components and oscilloscopes. Experiment two was conducted using a simulated approach through a software called Proteus 8 Professional. The analysis of this investigation was carried out using an RLC circuit in a series configuration. Resonance in an electrical circuit exists where there is an equal magnitude between the inductive reactance and the capacitive reactance. In this report there will be comparative data on resonance within a series circuit. In order to gather the comparative data of resonance within the circuit, analysis was carried out on an assigned electrical circuit via two different types of experiment. Experiment one was carried out in a practical implementation within a laboratory using a breadboard, relevant components and oscilloscopes. Experiment two was conducted using a simulated approach through a software called Proteus 8 Professional. The analysis of this investigation was carried out using an RLC circuit in a series configuration. In summary comparative data has been obtained from the two experiments. However, in both experiments there are variations between the results. These variations will be discussed in this report.

Scott Ling
Electrical and Electronic Principles

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1. Introduction.

For this assignment, analysis was supported by using two different types variations of —experiments. The first variant of the experiment consisted of a laboratory based practical implementation. Whilst the second experiment was simulator-based, using a software called Proteus 8 Professional.

For a circuit to be called an RLC circuit, it will contain three main components a Resistor (R), an inductor (L), and a capacitor (C), and these can be connected either in a series configuration or parallel configuration. The analysis for the data obtained during this investigation in this report was obtained whilst using an RLC Circuit in a series configuration.

1.1 What is Resonance?

Resonance within an electrical circuit, can occur when there is an equal magnitude between the inductive reactance and the capacitive reactance. This in-turn causes electrical energy to fluctuate between the magnetic field of the inductor and the

2. electronic field of a capacitor.

Resonance occurs with the collapse of the magnetic field of the inductor. This in turn generates a current-flow through its core which will then pass the current it has charged on to the capacitor.

Resonance can cause issues during the operation of communications circuit, as it can cause unwanted fluctuations. This has the potential to cause noise, signal distortion and also damage to the circuit itself. Resonance can be useful within an

electrical circuit as it means when the circuit is at "Resonance", the resistance and impedance are equal within the circuit.

This is useful in some industries when circuits are needed to be tuned such as in televisions and radios. Series resonance circuits have many uses to which they are can be found in various forms such as AC mains filters and noise filters. [(2)[3][4][5][6]]

1.2 Quality Factor (Q Factor).

Within an electrical circuit, the "Q Factor" is defined as the ratio of energy stored within the resonator, to the energy that is supplied-provided to it, per cycle. This is to keep signal amplitude constant, at a frequency where the stored energy is constant with time.

This can also be defined as an inductor when the ratio of its inductive reactance and its resistance is at a distinctive frequency, to measure its efficiency. [(2)(2)]

Below you will find the mathematical equations you would need to work out the "Q" factor. [4]

$$Q = X_L / R = (2 \cdot \pi \cdot f \cdot L) / R$$

$$\text{or } Q = X_C / R = 1 / (2 \cdot \pi \cdot f \cdot C \cdot R) =$$

$$\text{or } Q = f_r / \text{BW where BW is the bandwidth of the response. [(2)[3][4][5][6]] [5]$$

1.3 AC theory.

Below are some equations that define a series RLC circuit.

$$\text{Inductive Reactance: } X_L = 2\pi fL$$

$$\text{Capacitive Reactance: } X_C = \frac{1}{2\pi fC}$$

When $X_L > X_C$ the circuit is Inductive

When $X_C > X_L$ the circuit is Capacitive

[6] Total Circuit reactance = $X_t = X_L - X_C$ or $X_C - X_L$

$$\text{Total circuit impedance} = Z = \sqrt{R^2 + X_t^2} = R + jX$$

[7] In a circuit, if the frequency or the inductance is increased-enlarged the overall the overall inductance reactance value of the inductor would then increase-rise too. This can be seen in the above equation.

When a frequency drops towards zero, the inductance will also decrease-reduce to zero. This has the opposite-reverse effect on-within the a-circuit, and this would cause it to short circuit-circuit. When this happens in a circuit it means that inductive reactance is proportional to frequency. [(2)[3][4][5][6].]

1.4 Bandwidth.

When an RLC is controlled by a frequency that is variable but at a constant power supply the magnitude is the proportional to the impedance.

For this experiment, the workings out of the frequency will be calculated by drawing a horizontal line on the graph across $V_L + V_C$ with a value equal to 70.7% of the max voltage. Next step is to draw two lines from the new horizontal line where it intersects the curve down to the bottom off the graph. This will provide two frequency values, taking the lowest value (f_l) and subtracting from the highest value (f_h) will give the $B_{\text{bandwidth}}$.

$$BW = f_h - f_l$$

Within a low resistance high Quality circuit there will be a narrow $B_{\text{bandwidth}}$ value. In a high resistance low Quality circuit there will be a greater $B_{\text{bandwidth}}$ value.

In a more selective-indiscriminate circuit, there is will be a tighter narrower $B_{\text{bandwidth}}$ which will provide give a higher "Q" factor, meaning there is low resistance within the circuit. In a circuit with a wider band with there is a lower "Q" factor which means there is more resistance. The selectivity of a series circuit can be controlled-measured by adjusting the resistance only and all the other components will remain the same.

[(2)[3][4][5][6].-)

1.5 Component properties.

Resistor

Stated value-3.3 Ω

Measured resistance-2.89 Ω

Measured Inductance-13.7uH

Inductor

Stated value-1mH

Measured inductance-0.977mH

Series Resistance-2.89 Ω

Capacitor

Stated value 1uF

Measured capacitance-1.013uF

ESR @ 1kHz-5.09189 x 10E5

2.0

~~The~~ The Oscilloscope probe was connected between the ~~R~~resistor and the inductor to measure the voltage between the inductor and the ~~C~~capacitor. Visual guides are from a step by step set-up of the circuit configuration through the various stages prior to the experiment commencing.

- Breadboard,
- Resistor (R) (3.3Ω)
- Inductor (L) (1mH),
- Capacitor (C)(1uF),
- Oscilloscope,
- Signal generator,
- Probe,
- Relevant wires need to complete the circuit.



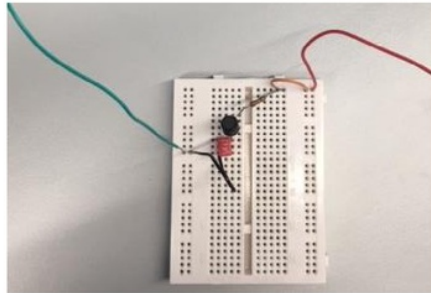


Figure 2 RLC circuit configured pre-analysis.

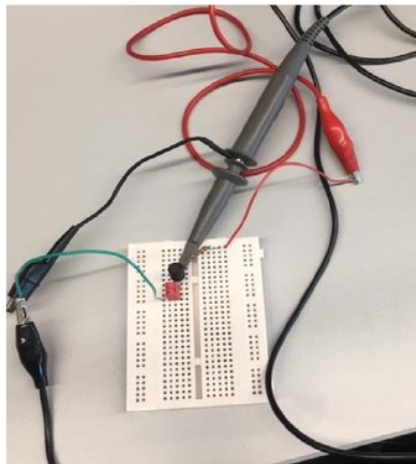


Figure 3 Oscilloscope probe connected to the RLC circuit between the Resistor and the Inductor.

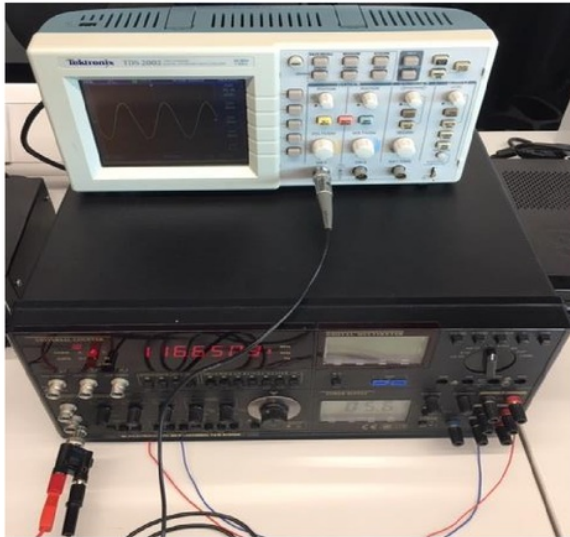


Figure 4 Oscilloscope and Signal generator used in the laboratory.

Once the components were setup and connected, the experiment could be started by inputting the frequency values that were being used into an excel document.

The frequencies between 4500kHz and 5500kHz went up in increments with a value of "100kHz", as this is where a change in the circuit is expected.

The relevant figures have been inputted into excel document, Obtaining the results can begin. This was carried out by setting the Signal generator to 4Volts and manually turning the dial on the Oscilloscope to the relevant value needed for the data required.

2.1 Step by step for practical setup.

The first step of the practical experiment, was to complete the Breadboard configuration. The first step is to connect So firstly, the Resistor (R), Inductor (L) and the Capacitor (C). These were were joined plugged into the Breadboard in a series configuration.

Next step for the setup, is to connect the remaining wires to Breadboard configuration. For the Breadboard configuration, the Resistor (R), Inductor (L) and the Capacitor (C) were connected joined in a series configuration.

The Oscilloscope probe was connected between the Resistor and the Inductor to measure the voltage between the Inductor and the capacitor Capacitor. Whilst, also making sure the circuit was connected to Ground.

Once the Breadboard configuration was complete it was time to connect the probe from the Breadboard to the Oscilloscope and Signal generator.

The final stages of setup are setting the signal generator to the first frequency that is required and also making sure the Oscilloscope is set to the required 4volts.

In this experiment the voltage being analysed was set to a value of 4Volts. The frequencies measured ranged from 0.1kHz-20kHz. The Voltage was set on the Signal generator to the required 4Volts and was manually tuned to the required frequency, allowing the Oscilloscope to see the frequency change within the circuit.

This allowed the relevant data to be collected for the data comparison. The process was then repeated by changing the required frequencies on the Signal generator, capturing all remaining data required for analysis.

3.0 [Method for Simulated experiment.](#)

For the Simulated experiment, a software called Proteus 8 Professional was used-operated for the data retrieval.

For the Simulated experiment the components that were used are listed below, these are found in the device list within the Proteus device list. A visual guide has been added below to be able to for understanding how the circuit is configured of what the circuit configuration. This was taken from the Proteus 8 Professional software before the voltage and frequencies were inputted.

The components that were used in the Simulated experiment are predefined and generic and consisted of:

- Signal Generator,
- Resistor,
- Inductor,
- Capacitor,
- Oscilloscope,
- Ground.

3.1 [Step by step for simulated experiment.](#)

The first step of the simulated experiment was to select the required components from the components list. These components can be found when you select the "Pick device window", which is found by selecting the device menu in Proteus 8 Professional.

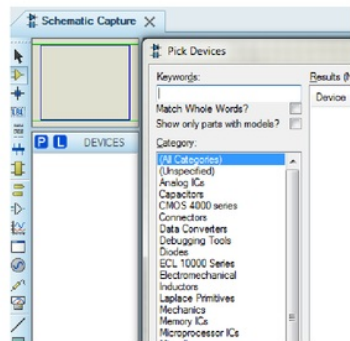


Figure7 Proteus "Pick device window".

Now the components have been selected in the "pick device window", this these means they can now be added to the circuit schematic circuit blueprint.

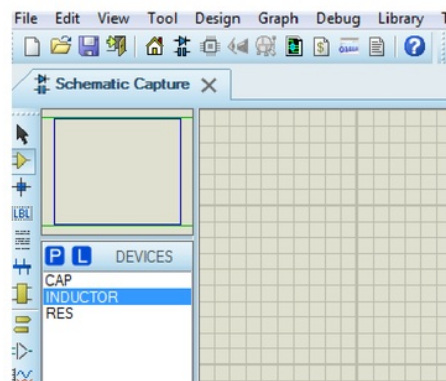


Figure 8 Proteus 8 professional Components list.

So firstlyThe first step is to layout, the Signal generator, Resister (R), Inductor (I) and the Capacitor (C). Oscilloscope and Ground. The components are mapped out in the schematic in a series set-up. Next step is to connect-join all the components with wiring.

Channel A on the Oscilloscope is taking a supply voltage reading, channel B is taking a reading from the connection between the Resistor and the inductor, to measure the voltage which is supplied to between the inductor and the Capacitor.

-There is a connection to between-channel C on and the Oscilloscope, however this connection was obsolete and no data was taken from this channel.

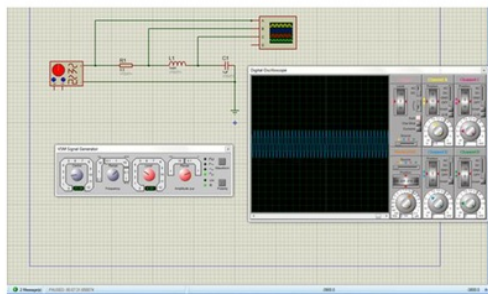


Figure 10 Simulation circuit mapped out on the Proteus 8 professional Schematic.

The final stages of setup, are setting the Signal generator to the Oscilloscope to the relevant Voltage and Frequency. In this experiment the Voltage being analysed had a value of 4Volts, the Frequencies ranged from 0.1kHz-20kHz.

-Now the Voltage has been set on the Signal generator, manually tuning the Oscilloscope to the required frequency allows the relevant data to be collected for the data comparison, whilst and the remaining list of required Frequencies can be tuned into the Oscilloscope, to be able to obtain all remaining data for the experiment.

4.0 Results for Laboratory experiment.

Freq	VL+VC Lab.	
kHz	Volts.	
100	4	

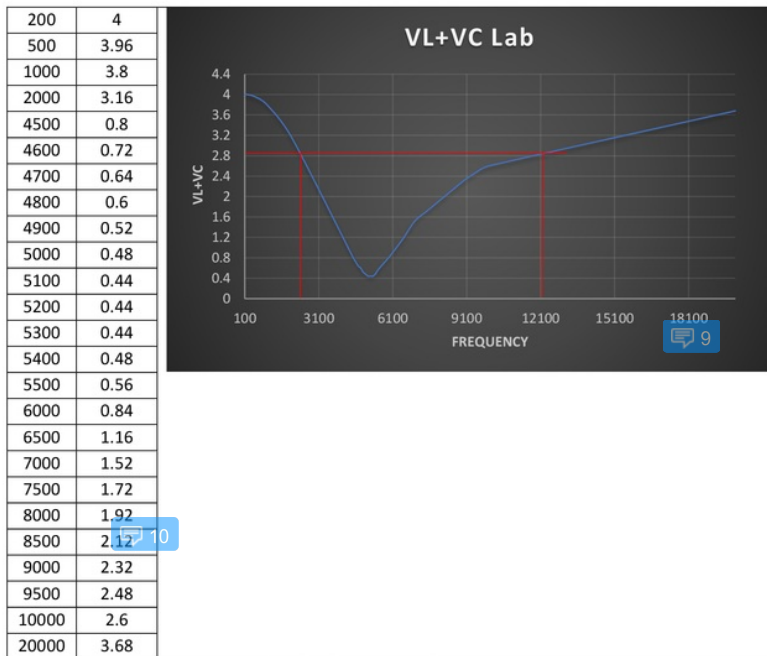


Figure 11 Results and graph from Practical implementation.

Now the Practical experiment has been completed and the raw data collated. The Bandwidth can be calculated from the raw data in the graph. So, following Using the method in the next paragraph the Band-width for this graph will be calculated.

By drawing a horizontal line on the graph across VL+VC with a value equal to 70.7% of the max voltage. The next step is Next is to draw two lines from the new horizontal line, where it intersects the curve down to the bottom of the graph. This will provide two Frequency values, taking the lowest value (F_l) and subtracting from the highest value (F_h) will give the Bandwidth.

From the results taken from the Practical implementation you can see in Figure 11, the graph that at 5.1 kHz the circuit is at its lowest voltage. So, Using the method and equation provided stated earlier you can see the approximate (F_h) value is 12200 and the approximate value for (F_l) is 2600. Following the formula written above this will give an approximate value of 9500 kHz for the Bandwidth in the Practical experiment.

4.1 Results for Simulated experiment.

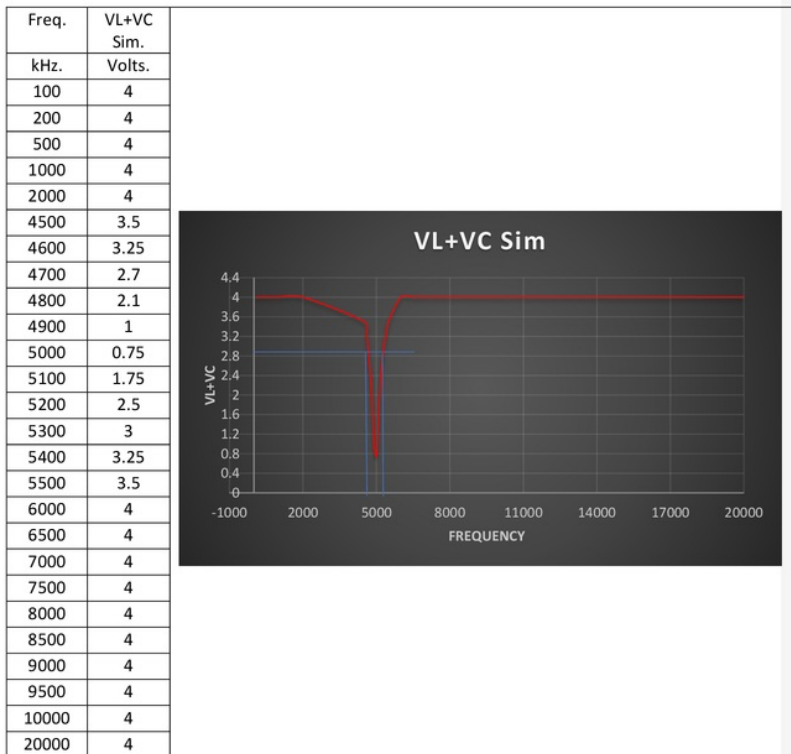


Figure 12 Results and graph for simulated experiment.

Now the simulated experiment has been completed and the raw data collated. The Bbandwidth can be calculated from the raw data in the graph. FSo, following the method in the next paragraph the Bband-width for from this graph canwill be calculated.

By drawing a horizontal line on the graph across VL+VC with a value equal to 70.7% of the max voltage. Next step, is to draw two lines from the new horizontal line where it intersects the curve down to the bottom off the graph. This will provide two frequency values, taking the lowest value (Fl) and subtracting from the highest value (Fh) will give the Bbandwidth.

From the results taken from the Ssimulated experiment, it is evident in the you can see in the graph that at 5kHz the circuit is at its lowest voltage. So, Uusing the method and equation stated earlier, you can see the approximate (Fh) value is approximately 5300kHz and the approximate value for (Fl) is 4700khz. This will give an approximate value of 600kHz for the Bbandwidth in the Ssimulated experiment.

5.0 Comparison between the Laboratory and simulated experiment. Results

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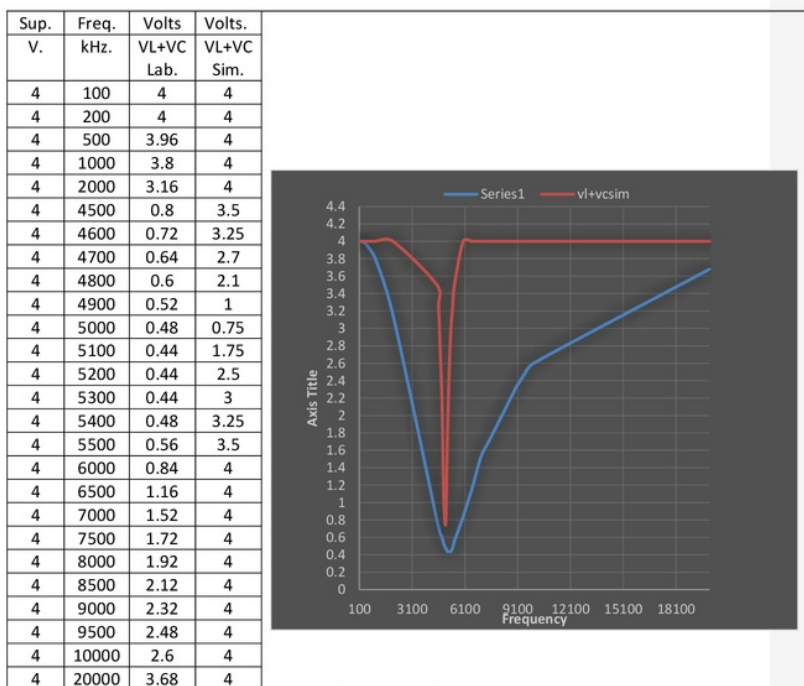


Figure 13 Comparative data and graph from Ppractical and Ssimulated experiment.

In comparison to both sets of data acquired, there is evidence it can be seen that there is a vast difference between the two sets of results. There are various different reasons to why this maybe, and they those possible reasonings for this behind this will be discussed later in the discussion part of the report.

So, from the results held in the table and the graph in figure 11, there is a difference with the voltage between the **P**practical and the **S**simulation experiment. There is a drop in the voltage ~~far earlier in a lot sooner from~~ the practical experiment, ~~than then~~ there is within the simulated experiment. The simulated experiment returns back to 4V volts with in the frequency range, whereas the practical experiment only returns back to 3.68volts.

There is also a clear difference in the **B**bandwidths between the **P**practical ~~simulated~~ experiment and the simulated experiment. The practical experiment has an approximate **B**bandwidth value of 9500kHz, whereas the **S**simulated experiment has an approximate value of 600kHz.

The **P**practical experiment has a much wider **B**bandwidth ~~bandwidth~~ which means the circuit has a lower "Q" factor and more resistance, whereas the **S**simulated experiment has a narrow **B**bandwidth which means it has a higher "Q" factor giving the circuit less resistance.

5.0

Discussion.

So, ~~A~~ after carrying out the **P**practical and **S**simulated experiment, the data has now been retrieved for a comparative study. However, from this comparison it can be seen that a **S**simulated experiment will give you a much narrower **B**bandwidth than that of a **P**practical experiment.

The **P**practical experiment has a wider **B**bandwidth this could be due to various reasons. The **B**breadboard that was used had been used previously, so over time the **B**breadboard could have a build up of impurities within the internal connections ~~ers~~.

The RLC components that were also used were not brand-new components, so they could have a +/- tolerance to values stated earlier in the report this could have affected the resistance, and played a part in why the **B**bandwidth was much greater.

The wires that were used within the circuit configuration, were not of equal length so this could mean the longer the wire the more resistance was produced within the circuit.

6.0

Conclusion

In conclusion to this experiment, data has been obtained and compared. There is a difference between the two sets of results acquired and there are a number of reasons why this could be:

The components could have a +/- tolerance, so the Resistor, **I**nductor and the **C**apacitor may have different values to what is stated earlier in the report however the simulation software will not take this into account.

For the **P**practical use of **S**signal generators and **O**scilloscopes, these need to be calibrated. If they are not calibrated at the regular intervals, and then used in a practical experiment the readings could be different to that of a calibrated machine. This would then potentially give you data that isn't true to form.

During the Practical experiment As well the fluctuations were observed within the oscilloscope, this meant there was a $\pm$ in tolerance when tuning to the required frequencies, where as on the Simulation software the frequencies values were set at the required frequency.

So, in summary comparative data has been obtained from the two experiments. However, in both experiments there are factors on why the results vary. As the Practical experiment doesn't take into account human errors when it comes to the components or tuning the of the Oscilloscope. The same can be said for the Simulated experiment as this does not take into account the any differences between the $\pm$ tolerances.

7.0

References.

[1] ~~1~~ - https://www.google.co.uk/url?sa=i&rct=j&q=&esrc=s&source=images&cd=&cad=ria&uact=8&ved=2ahUKEwIzOrktK7gAhU6BWM8BYHnBhIQjhx6B8AgBEAM&url=https%3A%2F%2Fwww.upsbatterycenter.com%2Fblog%2F5-things-to-know-about-tesla-coils%2F&psig=AOvVaw2OmBLiGkZ7ZDQp_rCY_6KF&ust=1549793466392528

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[2] ~~2~~ - <https://its.bldrdoc.gov/fs-1037/dir-031/4576.htm>

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[3] ~~3~~ - https://www.electronics-notes.com/articles/basic_concepts/q-quality-factor/basics-tutorial-formula.php

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[4] ~~4~~ - <https://www.electronics-tutorials.ws/accircuits/series-resonance.html>

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[5] ~~5~~ - <https://www.allaboutcircuits.com/textbook/alternating-current/chpt-6/q-and-bandwidth-resonant-circuit/>

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[6] ~~6~~ - <https://moodle.uwtsd.ac.uk/course/view.php?id=5757> S Mosey

12

Electrical resonance

GRADEMARK REPORT

FINAL GRADE

GENERAL COMMENTS

Instructor

57 / 100

PAGE 1



Comment 1

I assume you did not intend on leaving track changes switched on. I'll try to ignore all the text which is crossed out, as much as I can.

You should take care in future when submitting reports that you do not leave track changes on as it is unprofessional and will lose you marks.

PAGE 2



Comment 2

electric field



Comment 3

Resonance occurs when the inductive reactance is equal to the capacitive reactance. At this frequency, the energy contained in the electric field within the capacitor is equal to the energy contained within the magnetic field of the inductor. This energy is transferred between the components as the polarity of the supply voltage changes direction, allowing its transfer.

PAGE 3



Comment 4

No, you were right the first time.

In this sentence, mathematical should have a lower case 'm'.



Comment 5

See comment on 'mathematical' above.

Comment 6



Unlike resistance, reactance can be negative. When it is negative the circuit is said to be capacitive.

Therefore: $X_t = X_L - X_C$



Comment 7

I find this an odd choice of word.

'Enlarged' tends to conjure images of objects becoming larger, or increasing in volume. When we talk about a single valued parameter getting larger, frequency in this case, generally people would use words like 'increase(d)', 'rise', 'raise(d)'.

PAGE 4



Comment 8

The word 'indiscriminate' means the opposite of what you are describing. You should have stuck with selective. 'Selective' is the correct engineering term used to describe narrow bandwidth tuning circuits such as this one.

I think you may have selected the antonym from the synonym menu in Word by mistake.

PAGE 5

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Comment 9

The X axis of this graph should be Log(frequency) not just frequency.



Comment 10

Using a graph, it is far easier to identify trends in the data than reading a table of numbers. You have included a graph which, if I really wanted to, allows me to read off values and recreate the data in the table (not that anyone would want to)

PAGE 12

**Comment 11**

Please check your document before uploading. It is very difficult to read parts of your text because you still have track changes showing your markup.

You should take pride in your writing, not rush to submit, and always check everything.

**Comment 12**

You should apply correct referencing styles here too.

Each reference should list the title of the work cited, its author, when and where it was published, not just a hyperlink.

There are documents on the university library website which can help show you how this list should be constructed.

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SCOTT LING

57.05

ENGAGEMENT WITH LITERATURE

including reading, referencing, academic conventions and academic honesty



References to a range of relevant sources. You should look to use more credible sources such as peer reviewed papers and text books etc.

Referencing conventions evident though not applied consistently.

2.25

KNOWLEDGE & UNDERSTANDING

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



Knowledge is accurate with a good understanding of the field of study, although if you are going to continue to use the thesaurus in MS Word please try to select appropriate synonyms, not antonyms. Make sure the sentence makes sense, and if you're not sure about the word - look it up, or don't use it.

17.7

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.



Evidence of some logical, analytical thinking and synthesis. Can analyse new and abstract data. An ability to use evidence to support your arguments. Valid conclusions

17.7

PRACTICAL APPLICATION SKILLS

Different approaches to solving problems in particular contexts.



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

17.4

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 in a suitable format but with some room for improvement. Work lacks coherence in places due to track changes being left on, odd synonyms used in places where they did not need to be used, and capitalisation of random words. As a rule a word only needs a capital letter when: 1. It is at the start of a sentence. 2. It is a proper noun - the name of a person or place. 3. It is in a heading and not a small word (a, and, the, it, is, so, as, or, if etc.)

2