

final draft

by Gomer Morgan-Gray

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Gomer Morgan-Gray
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Abstract

In this report I will simulate and construct a RLC band pass filter circuit, which I will then test the frequency response of and plot the gathered data on a graph, data can then be pulled and analysed from the graph, allowing for further comparison of the 2 circuits and calculation of the q factor which shows the effectiveness of the circuits.

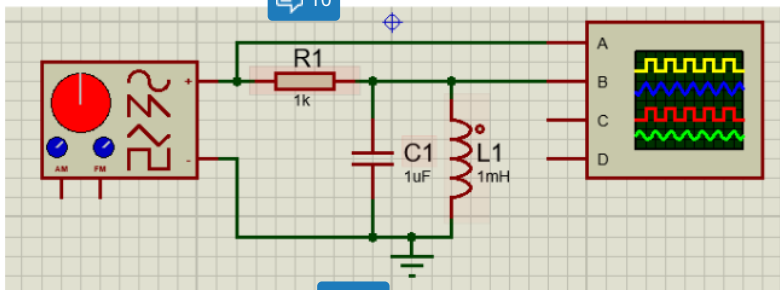
Introduction

The circuit being tested is a band pass filter, a band pass filter can be used to isolate or remove certain frequencies these frequencies are within a specific range that is determined by the values of the components used [1], they can be constructed from several different arrangements of components, they can be active or passive allowing for gain above 1 [2]

Band Pass filters can be used in many different electronic circuits such as wireless transmitters to isolate the desired frequency in which to communicate on, audio equipment and medical/seismology [3]

Simulation

To get an idea of the practical results a simulation was performed of the circuit, this was done by using the software proteus, proteus is a SPICE simulator which allows for circuits to be tested and measurements to be made without having to assemble them and attach test equipment in real life [4]



This is the setup I used to simulate the circuit in proteus, it consists of a function generator, oscilloscope, 1k Ohm resistor, 1uF capacitor and 1m Henry inductor, the inductor and capacitor are wired in parallel with the resistor in series with that parallel pair. The oscilloscope is then attached to measure the voltage across the inductor and to measure the incoming waveform from the function generator, the function generator is attached to the other side of the resistor. All test equipment is then attached to the same ground reference point that being the opposite side of the capacitor inductor parallel pair.

An oscilloscope is a piece of test equipment which allows voltage to be plotted against time, it is used to visualise and measure the voltages of the input signal, this is done by making use of the automatic measurement functions or it is possible to making use of the divisions on the screen where each division refers to a specific value controlled by the knobs on the front of the device, the oscilloscope measures the voltage between the tip of the probe and the ground lead for a real oscilloscope however in proteus it measure between the input voltage and the ground net this means it is vital to include a ground net reference to the circuit as otherwise no voltage will be measured on the oscilloscope.

The function generator is another highly useful piece of test equipment used to test circuits, it allows for a waveform to be generated with a specified frequency and amplitude, the device is also capable of generating different waveforms such as sign, square, saw and noise, for this test I set the function generator to a sign wave.

The oscilloscope was attached to the circuit to measure the voltage across the inductor and to measure the input voltage to the circuit coming from the function generator.

The function generator was set to 2v peak-to-peak and an initial frequency of 100Hz this was then increased in 1000Hz steps up to 20000Hz, however a calculation was performed to work out the expected resonant frequency and more readings were done around that point,

the calculation used was $\frac{1}{2\pi\sqrt{LC}}$ the calculated frequency from this was 5032Hz

due to this I extra reading from 4500 to 5500Hz going up in 100Hz steps to be able to more accurately read the peak which is expected to be at the resonant frequency of the circuit.

Breadboard Test

The same circuit was then also tested on breadboard this allows for the circuit to be quickly connected together and tested, this is because breadboard contains strips of contacts allowing for components to be inserted into it which physically holds the components in place and provides the necessary electrical connections.

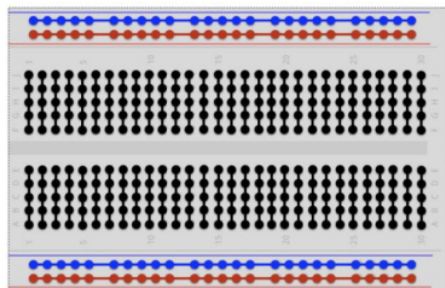




Fig 3

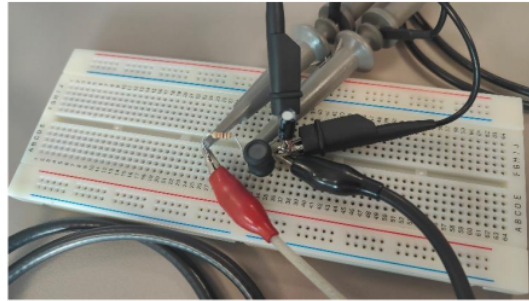


fig 4



Shown in figure 4 and 5 is the setup I used to gather real life data from the circuit, the same equipment was used as in the simulation , this included a function generator and the oscilloscope these were then directly connected to the leads of the components to keep the circuit as simple as possible and to reduce any impact they may have on the circuit if long wires were used to connect them.

The circuit was connected to the function generator making use of a BNC to crocodile clip connector, this could have an impact on the circuit at higher frequencies but for the range being tested in this experiment this will not be an issue.

When gathering results from the physical circuit there were many different things that I had to ensure were correct, firstly the oscilloscope probes have a switch on the to select between 1x and 10x, this switch selects the attenuation of the probe, and this must be set to the same as is set on the oscilloscope itself otherwise readings will be greatly off. 

When assembling the circuit on breadboard it is important to ensure that the correct component values are used, for the capacitor and inductor it is labelled on the side of the component whereas for the resistor the value must be read from the band of colour printed on the side of them, a chart as shown in figure 8 where each band corresponds to the significant figures and the final band meaning the multiplier, there is also a band signifying the tolerance of the component this will be important later in the report, special care also needs to be taken whilst installing the capacitor as it is polarised, the resistor and inductor are not polarised and therefore can be inserted in either direction.

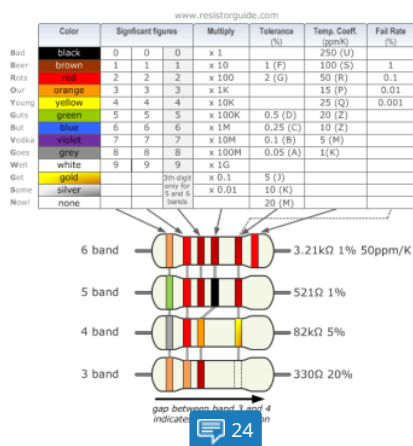


Fig 8

Results

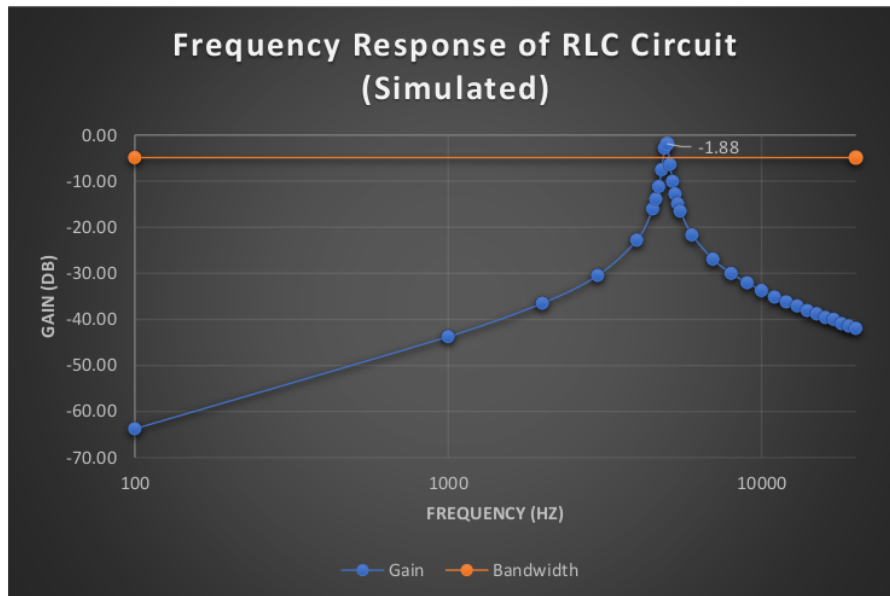


Fig 5



This graph shows the values gathered from the simulated circuit; the resonant frequency was at 5000 Hz this correlates with the theoretical, calculated value of 5032Hz the and the attenuation was -1.88dB at this frequency.

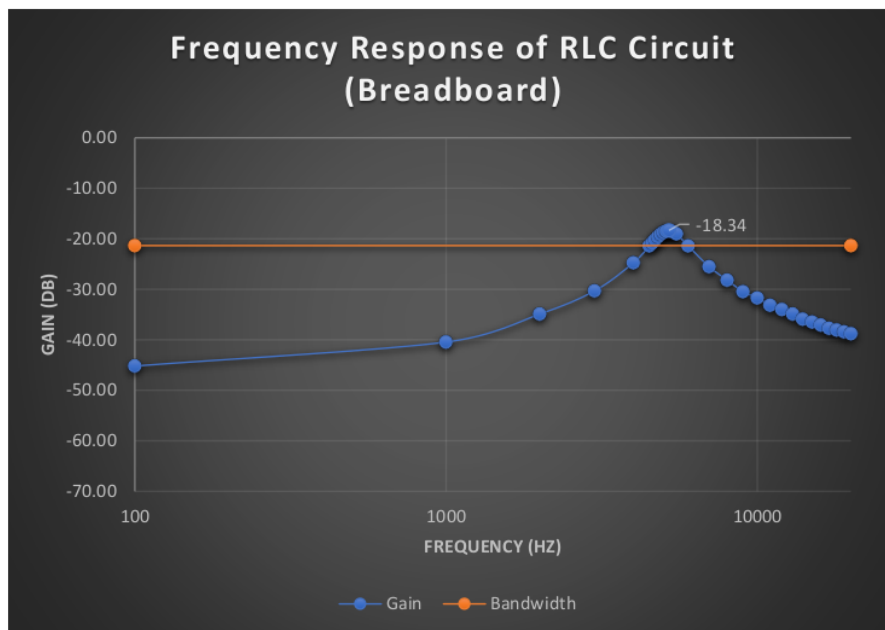


Fig 6



This second graph is of data gathered from the real-world circuit it varies from the simulated results for several reasons which I will discuss further in the report. The resonant frequency for this circuit was at 5200Hz and  attenuation of -18.34dB at that frequency.

Discussion

An RLC bandpass filter, can be tuned by varying the values of the 3 used components which selectively allows a specific range of frequencies to pass through while attenuating others. At low frequencies, the inductor and capacitor present a high impedance, blocking incoming signals. At the resonant frequency of the used inductor and capacitor their impedance is low allowing the desired frequency to pass through. At high frequencies, the capacitor then begins increasing its reactance, blocking signals again [5][6].

These properties of the bandpass filter make it useful for applications in radio communication where you would like to communicate on a specific channel, so the desired frequency is tuned for, and all the other frequencies are blocked.

This circuit is a passive filter and therefore it is only possible to have a gain theoretical gain of 1 [2] but this is not possible in practice so as little attenuation as possible would be ideal, for the simulated circuit the least attenuation measured was -1.88dB this is quite good as not a lot of the signal is lost, however for the real life circuit the lowest attenuation measured was -18.3dB which could cause issues as quite a large amount of the signal would be lost from passing through this filter and may require re-amplification to return the signal back to a suitable level.

The resonant frequency for these components was earlier calculated to be 5032Hz and the resonant frequency from the tested circuits was 5200 for the real-world circuit and 5000 Hz for the simulated circuit.

Some of the discrepancies seen may be caused by the used breadboard as using a breadboard can introduce unexpected parasitic capacitance and resistance to a circuit [7] which can cause the resonant frequency and q factor to vary from the expected, testing the circuit on a produced PCB may help to reduce these effects and give a better understanding of how the used components themselves behave.

The use of the oscilloscope and function generator on the real-life circuit may also have an impact on the circuit as the oscilloscope may load the circuit [8] this is unlikely to have an impact on this circuit as the internal impedance of the oscilloscope is high enough.

The 2 circuits tested have identical components however the simulated circuit makes use of ideal components meaning that they have the precise value specified whereas the real-life components have tolerances, and their actual value may vary from the specified value the tolerances of the components used are as follows:

Resistor – Gold tolerance band $\pm 5\%$

Capacitor - $\pm 20\%$

Inductor - $\pm 10\%$

Taking these tolerances into account the maximum and minimum values for these components would be 950 ohm and the upper value would be 1050 ohm for the capacitor the lower value would be $0.80\mu\text{F}$ and the upper value would be $1.2\mu\text{F}$ and finally for the inductor the lower value would be 0.9mH and the upper value is 1.1mH .

Taking these new values into account the maximum possible resonant frequency would be.

$$\frac{1}{2\pi\sqrt{0.9mH*0.8uF}} = 5931.3Hz$$

and the minimum possible resonant frequency would be.

$$\frac{1}{2\pi\sqrt{1.1mH*1.2uF}} = 4380.5 Hz$$

This shows that the result from the real-life circuit is likely to be correct as it lies within the expected possible value for resonant frequency, and I therefore believe the circuit was assembled correctly and there wasn't any significant [28] introduced by the previously mentioned external factors such as the parasitic capacitance caused by using the breadboard.

Q factor or quality factor is a method to differentiate and compare the effectiveness of a tuned circuit [5] the higher the quality factor the better the circuit as shown in figure 7.

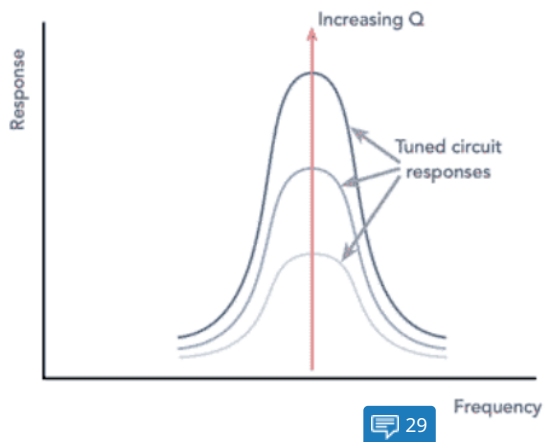


Fig 7

The q factor for these circuits was calculated from data read from the graph using the equation $\frac{Fr}{Fu - Fl} = Q$ where Fr is the resonant frequency Fl is the lower bandwidth frequency and Fu is the upper bandwidth frequency Fl and Fu are both gathered from the graph at the 2 points where the attenuation drops 3dB from the peak this frequency range is also known as the bandwidth.

For the real-life circuit, I applied the calculation as follows $\frac{5200}{6000 - 4500} = 3.467$ [30]

For the simulated circuit I again calculated q factor using the following values

$$\frac{5000}{5050 - 4850} = 25 [31]$$

As these calculations show the q factor varies greatly between the 2 circuits where the simulated circuit has a much higher q factor meaning that it has a sharper cutoff is also displayed from the graph, the simulated circuit also has a much larger final attenuation compared to the breadboard circuit meaning that it will better filter out the undesired frequency.

These differences between the 2 circuits will likely be caused due to the tolerance of the used components as discussed earlier, this issue with tolerances is also what likely causes the resonant frequency of the real-life circuit to vary from both the simulated and calculated resonant frequency.

Knowing about and planning for the discrepancies is crucial for real world applications of a filter circuit [9], failing to correctly account for the tolerance of components can lead to a circuit not behaving correctly, tolerance will always be important to consider as it is possible to get components with lower tolerance however the cost of such components increases and therefore may not be practical for use in every circumstance [9] taking the tolerance of cheaper components into account can achieve the desired balance between functionality and cost.

Conclusion

From this experiment I have determined that the used circuit simulation software is good at giving an understanding of how a circuit functions however it can't be expected to perfectly replicate the exact values of a real-life circuit, this is due to tolerances of used components not being factored into the simulator and other external factors such as parasitic capacitance caused by using a breadboard and other effects possibly introduced from the function generator and oscilloscope being connected to the circuit.

From this experiment I have also gained further knowledge and understanding of the functional operation of a band pass filter circuit making use of resonance to allow a specified frequency range to pass, I have also learnt the uses of a band pass filter and where one could be used for example in a radio system.



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PAGE 1



Comment 1

Good

Attempt, the first page or the title page of the report should have the name, student ID, Module Name, Module code, Title of the Coursework, programme of study. Most of these are in the title page, but however few are missing.

PAGE 2



Comment 2

It would have been better if table of content is included.



Comment 3

It is better to number each heading



Comment 4

Compose the report from a third-person perspective.



Comment 5

Compose
the report from a third-person perspective.



Comment 6

The outcome/output of the experiment should be included in the abstract



Comment 7

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Comment 11

It is better to add
figure title for each figure Eg: Figure 1: [Brief Description of the figure] is
appropriate and effectively communicates the content and purpose of the figure



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It is better to use the equation
editor within MS word. It will allow you to produce equations that look better
than this.



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



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Line
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Breadboard



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breadboard



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It is better to add figure title for each figure Eg: Figure 1: [Brief Description of the figure] is appropriate and effectively communicates the content and purpose of the figure



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PAGE 6



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PAGE 8



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Comment 31

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PAGE 9



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PAGE 10



Comment 34

Line
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PAGE 11

GOMER MORGAN-GRAY

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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 Electrical and Electronics Engineering. which is

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evident through the description on the experimental setups,

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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.



Sound evaluation of the underlying concepts and principles of Electrical and Electronics Engineering. Can interpret data. Ability to devise arguments using evidence to make mostly appropriate and valid judgements is evident from the description.

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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.



A very good application of a range of taught, basic methods, materials, tools and/or techniques in RLC circuit design. The context of the application is well considered, and insightful. Excellent evidence of different approaches to problem-solving in Electrical and Electronic circuits and proposes appropriate solutions, which is evident in circuit design and the generated output.

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TRANSFERABLE SKILLS FOR LIFE

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The report displays a reasonable level of structure and coherence. Presentation is generally clear, contributing to a satisfactory overall quality. Some areas may benefit from improved organisation and clarity.

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