

RLC Assignmentnt

by Matthew Barnard

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1702418

Electrical and Electronic Principles

RLC Circuit theory

Dr. Steve Mosey

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Introduction

In this report we will be discussing the difference between the theory of a circuit and the practical circuit. The theory circuit will be done on Proteus. We will change the frequency so that the voltages across the Resistor, Inductor and Capacitor. Once we have completed the circuit on Proteus we will then construct the circuit on a bread board and conduct the same tests on the bread board. And then comparing the two together.

Circuit Explanation

We constructed the circuit using a piece of software called Proteus which lets us construct the RLC circuit and then taking results using voltmeters and ammeters. The circuit consists of a Resistor which helps to resist the flow of current the higher the resistor the less current flow, an inductor which instantly charges up and then starts discharge at first it discharges quickly and then discharges slowly, lastly a capacitor is also connected which charges up slowly and once it reaches full capacity it starts to discharge it discharges quickly before slowing down.

The individual components

Resistor

A resistor is a component that restricts the flow of current the higher the value of the resistor the less current will flow through the circuit in this case a 10Ω resistor is used, which a very low value and doesn't limit the current very much. There are also tolerances to the device which limits the resistor even more by it being either 5% or 10% of the resistor you can get higher tolerances as well but only on the higher resistive devices can these be found.

 1

Inductor

An inductor is a device that when power is applied to it creates an electric field that charges itself to full power once this has happened and the input power has been disconnected it slowly starts to dissipate its power, so the electrical field is no longer there. Inductors are also used in step-up and step-down transformers for this they use 2 inductors with different number of coils. The more coils in an inductor means the stronger the electric field.

 2

 3

Capacitor

A capacitor is a component that when power goes into the device it charges up slowly once it has reached maximum capacity it will start to discharge the power the higher capacity rating the more power will be stored within the capacitor. A capacitor is made up of two

metal plates separated by a insulating material which is called a dielectric. The dielectric material is what holds the charge whilst it charges up. The value of the capacitor is directly proportional to the surface area of the dielectric material. It is also inversely proportional to the space between the two plates and the dielectric material.

What the circuit can show us

The circuit produced can produce a few different figures that we can use to determine certain factors within the circuit these will detailed below.

Inductive Reactance

The inductor has its own resistance which is used to limit the current, the inductive reactance depends on the frequency of the circuit and the value of the inductor so as the frequency reaches infinity so does the inductor but if the frequency starts to drop to 0 or DC so does the reactance. The equation for this is shown below. [1]

$$X_l = 2\pi fL$$

Capacitive reactance

Capacitive reactance is the opposition of alternating current, capacitive reactance varies depending on the frequency, the same can be said for the Inductive reactance as well, but where the inductive reactance increases with frequency capacitive reactance decreases and them when the frequency decreases the capacitive reactance increases in size. [2]

$$X_c = \frac{1}{2\pi fC}$$

Resonant frequency

The resonant frequency is the optimal frequency point where the Inductive reactance and the capacitive reactance are at the same value the equation for resonant frequency is stated below. So, when $X_l = X_c$ is when the resonant frequency is produced. Series resonance circuits is one of the most important circuits used in electrical and electronic systems. They can be found in radio and television tuning circuits, AC mains filters and noise filters. By receiving different frequency channels, they produce a very selective tuning circuit. [1]

$$f_{res} = \frac{1}{2\pi\sqrt{CL}}$$

Bandwidth

Bandwidth is defined by looking at the upper and lower frequencies on a graph and taken the lowest frequency and taking it away from the highest frequency within a circuit. One way to do this is through filters which are explained below.

Filters

Band-pass filter – Band-pass filters have a cut-off frequency, so they only let a set of frequencies through the filter. Any frequency out of the range will be rejected and not used within the frequency.

Low pass Filter – A low pass filter only lets a frequency below a specified frequency to go through the filter after that specified frequency nothing will happen.

High-pass filter – A high pass filter is the opposite to a low-pass filter where nothing below the specified frequency will be allowed to pass the filter.

Impedance

The impedance is effective resistance of the entire circuit, to calculate the impedance you will first have to calculate the total reactance of the circuit the equation for this displayed below. Once you have found the total reactance then you can calculate the total impedance of the circuit.

$$X_t = X_l - X_c$$

$$Z = \sqrt{(R^2 + X_t^2)}$$

Q factor

The Q factor or Quality factor of the circuit is used to determine whether the circuit is decent quality so the less bandwidth you have the better the circuit which will give a higher Q factor value. Formally, Q factor is the ratio between the power dissipated and the resistance.

$$Q = \frac{X}{R}$$

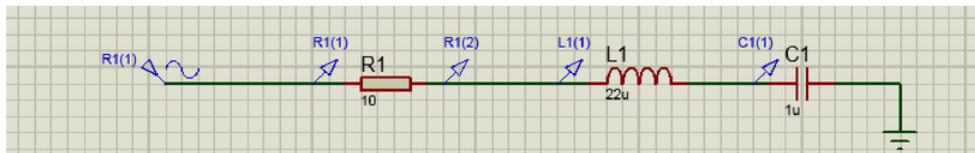
Theory

Method

The circuit was built using a programme called Proteus, the construction of the circuit was done by connecting a function generator to a resistor which was connected to an inductor which is connected to a capacitor which is finally connected to ground to finish the circuit off. The resistor value was set to 10Ω , the inductor value was set to $22\mu\text{H}$ and finally the capacitor value was set to $1\mu\text{F}$. Each of the values affect the values of each individual component separately.

Circuit

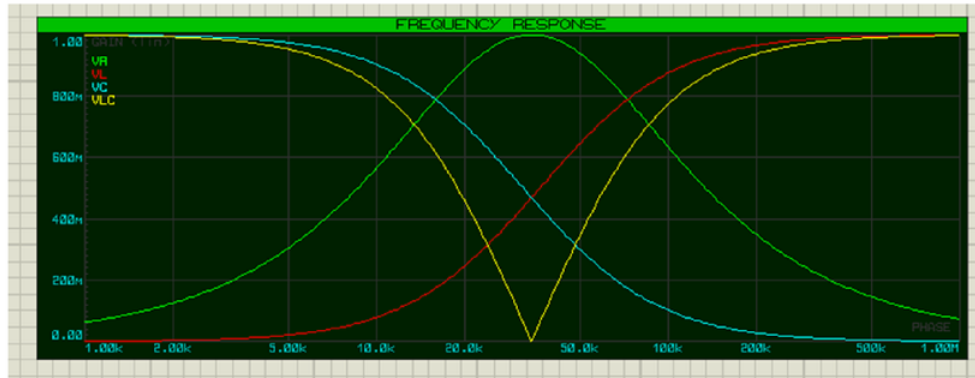
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Results

The results are shown below they show that the voltage across the resistor starts low and then as the frequency increases the voltage increases until you reach 35kHz and then starts to decrease as the frequency continues to increase. For the voltage across the inductor starts to increase and then once it reaches roughly 350kHz it rounds off and stays at 1V . Finally, for the capacitor the voltage starts off high at full capacity, after 3.5kHz it starts to

decrease heading to 0V it does this at about 350kHz. To calculate the Impedance, Capacitive reactance, inductive reactance and resonant frequency you use the equations stated above.



Frequency/kHz	X_L	X_C	X_T	Z	AMP	V_R	V_L	V_C	Watts
5	0.69	31.83	31.14	32.71	0.31	3.06	0.21	9.73	3.057533
5.5	0.76	28.94	28.18	29.90	0.33	3.34	0.25	9.68	3.344607
6	0.83	26.53	25.70	27.57	0.36	3.63	0.30	9.62	3.626648
6.5	0.90	24.49	23.59	25.62	0.39	3.90	0.35	9.56	3.903333
7	0.97	22.74	21.77	23.96	0.42	4.17	0.40	9.49	4.174352
7.5	1.04	21.22	20.18	22.53	0.44	4.44	0.46	9.42	4.439444
8	1.11	19.89	18.79	21.28	0.47	4.70	0.52	9.35	4.698364
8.5	1.17	18.72	17.55	20.20	0.50	4.95	0.58	9.27	4.950902
9	1.24	17.68	16.44	19.24	0.52	5.20	0.65	9.19	5.196875
9.5	1.31	16.75	15.44	18.40	0.54	5.44	0.71	9.11	5.436127
10	1.38	15.92	14.53	17.64	0.57	5.67	0.78	9.02	5.668532
10.5	1.45	15.16	13.71	16.97	0.59	5.89	0.86	8.93	5.893991
11	1.52	14.47	12.95	16.36	0.61	6.11	0.93	8.84	6.112427
11.5	1.59	13.84	12.25	15.81	0.63	6.32	1.01	8.75	6.323791
12	1.66	13.26	11.60	15.32	0.65	6.53	1.08	8.66	6.528056
12.5	1.73	12.73	11.00	14.87	0.67	6.73	1.16	8.56	6.725215
13	1.80	12.24	10.45	14.46	0.69	6.92	1.24	8.47	6.915282
13.5	1.87	11.79	9.92	14.09	0.71	7.10	1.32	8.37	7.098291
14	1.94	11.37	9.43	13.75	0.73	7.27	1.41	8.27	7.27429
14.5	2.00	10.98	8.97	13.43	0.74	7.44	1.49	8.17	7.443345
15	2.07	10.61	8.54	13.15	0.76	7.61	1.58	8.07	7.605535
15.5	2.14	10.27	8.13	12.89	0.78	7.76	1.66	7.97	7.760952
16	2.21	9.95	7.74	12.64	0.79	7.91	1.75	7.87	7.909699
16.5	2.28	9.65	7.36	12.42	0.81	8.05	1.84	7.77	8.05189
17	2.35	9.36	7.01	12.21	0.82	8.19	1.92	7.67	8.187645
17.5	2.42	9.09	6.68	12.02	0.83	8.32	2.01	7.56	8.317095
18	2.49	8.84	6.35	11.85	0.84	8.44	2.10	7.46	8.440373
18.5	2.56	8.60	6.05	11.69	0.86	8.56	2.19	7.36	8.557622

19	2.63	8.38	5.75	11.54	0.87	8.67	2.28	7.26	8.668986
19.5	2.70	8.16	5.47	11.40	0.88	8.77	2.37	7.16	8.774614
20	2.76	7.96	5.19	11.27	0.89	8.87	2.45	7.06	8.874657
20.5	2.83	7.76	4.93	11.15	0.90	8.97	2.54	6.96	8.969266
21	2.90	7.58	4.68	11.04	0.91	9.06	2.63	6.87	9.058597
21.5	2.97	7.40	4.43	10.94	0.91	9.14	2.72	6.77	9.142804
22	3.04	7.23	4.19	10.84	0.92	9.22	2.80	6.67	9.222041
22.5	3.11	7.07	3.96	10.76	0.93	9.30	2.89	6.58	9.296461
23	3.18	6.92	3.74	10.68	0.94	9.37	2.98	6.48	9.366217
23.5	3.25	6.77	3.52	10.60	0.94	9.43	3.06	6.39	9.431462
24	3.32	6.63	3.31	10.53	0.95	9.49	3.15	6.29	9.492343
24.5	3.39	6.50	3.11	10.47	0.95	9.55	3.23	6.20	9.549009
25	3.46	6.37	2.91	10.41	0.96	9.60	3.32	6.11	9.601604
25.5	3.52	6.24	2.72	10.36	0.97	9.65	3.40	6.02	9.650272
26	3.59	6.12	2.53	10.31	0.97	9.70	3.48	5.93	9.695151
26.5	3.66	6.01	2.34	10.27	0.97	9.74	3.57	5.85	9.736379
27	3.73	5.89	2.16	10.23	0.98	9.77	3.65	5.76	9.774091
27.5	3.80	5.79	1.99	10.20	0.98	9.81	3.73	5.68	9.808415
28	3.87	5.68	1.81	10.16	0.98	9.84	3.81	5.59	9.839481
28.5	3.94	5.58	1.64	10.13	0.99	9.87	3.89	5.51	9.867412
29	4.01	5.49	1.48	10.11	0.99	9.89	3.97	5.43	9.892329
29.5	4.08	5.40	1.32	10.09	0.99	9.91	4.04	5.35	9.91435
30	4.15	5.31	1.16	10.07	0.99	9.93	4.12	5.27	9.933589
30.5	4.22	5.22	1.00	10.05	1.00	9.95	4.20	5.19	9.950157
31	4.29	5.13	0.85	10.04	1.00	9.96	4.27	5.12	9.964162
31.5	4.35	5.05	0.70	10.02	1.00	9.98	4.34	5.04	9.975708
32	4.42	4.97	0.55	10.02	1.00	9.98	4.42	4.97	9.984897
32.5	4.49	4.90	0.40	10.01	1.00	9.99	4.49	4.89	9.991825
33	4.56	4.82	0.26	10.00	1.00	10.00	4.56	4.82	9.996588
33.5	4.63	4.75	0.12	10.00	1.00	10.00	4.63	4.75	9.999278
34	4.70	4.68	-0.02	10.00	1.00	10.00	4.70	4.68	9.999982
34.5	4.77	4.61	-0.16	10.00	1.00	10.00	4.77	4.61	9.998787
35	4.84	4.55	-0.29	10.00	1.00	10.00	4.84	4.55	9.995775
35.5	4.91	4.48	-0.42	10.01	1.00	9.99	4.90	4.48	9.991026
36	4.98	4.42	-0.56	10.02	1.00	9.98	4.97	4.41	9.984617
36.5	5.05	4.36	-0.68	10.02	1.00	9.98	5.03	4.35	9.976622
37	5.11	4.30	-0.81	10.03	1.00	9.97	5.10	4.29	9.967112
37.5	5.18	4.24	-0.94	10.04	1.00	9.96	5.16	4.23	9.956157
38	5.25	4.19	-1.06	10.06	0.99	9.94	5.22	4.16	9.943824
38.5	5.32	4.13	-1.19	10.07	0.99	9.93	5.28	4.11	9.930175
39	5.39	4.08	-1.31	10.09	0.99	9.92	5.35	4.05	9.915274
39.5	5.46	4.03	-1.43	10.10	0.99	9.90	5.41	3.99	9.899179
40	5.53	3.98	-1.55	10.12	0.99	9.88	5.46	3.93	9.881948
40.5	5.60	3.93	-1.67	10.14	0.99	9.86	5.52	3.88	9.863635

41	5.67	3.88	-1.79	10.16	0.98	9.84	5.58	3.82	9.844294
41.5	5.74	3.84	-1.90	10.18	0.98	9.82	5.64	3.77	9.823976
42	5.81	3.79	-2.02	10.20	0.98	9.80	5.69	3.71	9.80273
42.5	5.87	3.74	-2.13	10.22	0.98	9.78	5.75	3.66	9.780602
43	5.94	3.70	-2.24	10.25	0.98	9.76	5.80	3.61	9.757638
43.5	6.01	3.66	-2.35	10.27	0.97	9.73	5.85	3.56	9.733882
44	6.08	3.62	-2.46	10.30	0.97	9.71	5.91	3.51	9.709376
44.5	6.15	3.58	-2.57	10.33	0.97	9.68	5.96	3.46	9.684159
45	6.22	3.54	-2.68	10.35	0.97	9.66	6.01	3.42	9.658271
45.5	6.29	3.50	-2.79	10.38	0.96	9.63	6.06	3.37	9.631749
46	6.36	3.46	-2.90	10.41	0.96	9.60	6.11	3.32	9.604627
46.5	6.43	3.42	-3.01	10.44	0.96	9.58	6.16	3.28	9.576941
47	6.50	3.39	-3.11	10.47	0.95	9.55	6.20	3.23	9.548723
47.5	6.57	3.35	-3.22	10.50	0.95	9.52	6.25	3.19	9.520005
48	6.64	3.32	-3.32	10.54	0.95	9.49	6.30	3.15	9.490817
48.5	6.70	3.28	-3.42	10.57	0.95	9.46	6.34	3.10	9.461187
49	6.77	3.25	-3.53	10.60	0.94	9.43	6.39	3.06	9.431145
49.5	6.84	3.22	-3.63	10.64	0.94	9.40	6.43	3.02	9.400717
50	6.91	3.18	-3.73	10.67	0.94	9.37	6.48	2.98	9.369927
55	7.60	2.89	-4.71	11.05	0.90	9.05	6.88	2.62	9.047125
60	8.29	2.65	-5.64	11.48	0.87	8.71	7.22	2.31	8.709711
65	8.98	2.45	-6.54	11.95	0.84	8.37	7.52	2.05	8.37048
70	9.68	2.27	-7.40	12.44	0.80	8.04	7.78	1.83	8.037472

First of we will calculate the resonant frequency:

$$f_{res} = \frac{1}{2\pi\sqrt{LC}}$$

$$f_{res} = \frac{1}{2\pi\sqrt{22\mu * 1\mu}}$$

$$f_{res} = 33.931kHz$$

Next, we will calculate the inductive reactance and capacitive reactance for this we will use the original frequency rather than a the rounded-up number above:

$$Xl = 2\pi fL$$

$$Xl = 2\pi * 33931.94788 * 22\mu$$

$$Xl = 4.69\Omega$$

Now for the capacitive reactance:

$$X_c = \frac{1}{2\pi fC}$$

$$X_c = \frac{1}{2\pi * 33931.94788 * 1\mu}$$

$$X_c = 4.69\Omega$$

Finally, to calculate the impedance at the resonant frequency:

$$X_t = X_l - X_c$$

$$X_t = 4.69 - 4.69$$

$$X_t = 0\Omega$$

$$Z = \sqrt{R^2 + X_t^2}$$

$$Z = \sqrt{10^2 + 0^2}$$

$$Z = 10\Omega$$

So, when the resonant frequency is reached the impedance of the circuit will equal the value of the resistor given above as the capacitor and the inductor will cancel each other out given a total reactance of 0Ω . This proves that the circuit has all the right theoretical values and is running smoothly.

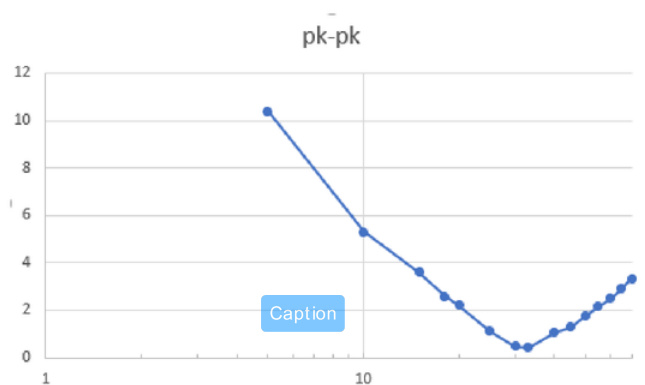
Practical

Method

As before we connected the circuit up with a resistor, inductor and resistor all in series. Instead of using Proteus, this time it was built using a bread board and then tested the same as before. Using a probe, you can check the voltage across each of the components, the current across the circuit and the resistance across the resistor and the reactance but for this report will only record the peak to peak voltages and the R.M.S. values. Once the table had been constructed and the graph was then created to display the results of the circuit.

Results

Frequency/kHz	peak-peak/V	RMS/V
5	10.4	7.211
10	5.32	3.761
15	3.6	2.545
18	2.58	1.824
20	2.22	1.57
25	1.12	0.792
30	0.479	0.339
33	0.43	0.304
40	1.07	0.756
45	1.28	0.905
50	1.75	1.237
55	2.16	1.527
60	2.51	1.775
65	2.91	2.057
70	3.33	2.354



The results show that the peak voltage is 10.4V at the first frequency which is set to 5kHz when the frequency is set to 33kHz the voltage peak to peak is at 0.43 which is the lowest value and is when the voltage starts to increase slowly back up. The RMS value is calculated by taking the peak to peak value and $\times 0.707$.

Comparison

In comparison the 2 circuits work roughly the same with slightly different values this due to the tolerances on the devices each device has a different tolerance and affects the circuit differently. For example, at 70kHz the voltage across the resistor is at 8.04V. With The resonance frequency for the actual results the peak to peak voltage is at 0.43V and the RMS value is at 0.304V.

Conclusion

In conclusion there isn't much to compare as for the theoretical and actual results there are diverse types of results and couldn't compare them to each other very well. Using the results, it shows that in theory the results will be perfect only because the tolerances are not considered but with the actual results they are changed to include the tolerances within the devices it is done automatically so no calculations are necessary to perform any tests. In the future this experiment could be improved by having the results be the same sections which will then actually let the calculations for the actual results be calculated and processed for the paper. When the circuit is built on a bread board the results should take the theoretical results into account so that the same measurements are taken for both circuit's otherwise comparing the 2 will be near enough impossible so getting the testing to wield the same result table will make comparing the 2 circuits much easier. Something else that can be done to improve the measurements of this circuit is to use different valued components and then compare the each individual circuit results for both theoretical and actual results therefore giving a more wider spectrum of results and wielding more reliable results.

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RLC Assignment

GRADEMARK REPORT

FINAL GRADE

GENERAL COMMENTS

Instructor

55/100

PAGE 1

PAGE 2

PAGE 3

PAGE 4



Comment 1

Not sure this is true



Comment 2

a magnetic field is created from the current flowing through the coil. When the current is stopped the magnetic field collapses, as it collapses an opposing voltage is induced in the coil by the changing magnetic field.



Comment 3

They are transformers, not inductors. Transformers do have some measurable inductance but are not called inductors.

PAGE 5

PAGE 6

PAGE 7



Comment 4

Better at what?



Comment 5

Q factor describes the sharpness or the broadness of the frequency response. High Q circuits have sharp responses while low Q circuits have broad responses.

PAGE 8

QM

Caption

Caption?

**Comment 6**

Why didn't you do that?

QM

Misplaced apos.

Misplaced apostrophe:

An apostrophe can function to indicate a possessive when accompanied by an -s ("the book that belongs to Roy" = "Roy's book"). For words that already have an -s at the end, just adding the apostrophe will do ("the team belonging to the boys" = "the boys' team"). Certain exceptions to this rule apply, and possessive personal pronouns ("like ours," "yours," "hers," "his," "its") are possessive already and therefore do not take an apostrophe. It is always wrong to use a possessive apostrophe to simply make a word plural.

QM

Misplaced apos.

Misplaced apostrophe:

An apostrophe can function to indicate a possessive when accompanied by an -s ("the book that belongs to Roy" = "Roy's book"). For words that already have an -s at the end, just adding the apostrophe will do ("the team belonging to the boys" = "the boys' team"). Certain exceptions to this rule apply, and possessive personal pronouns ("like ours," "yours," "hers," "his," "its") are possessive already and therefore do not take an apostrophe. It is always wrong to use a possessive apostrophe to simply make a word plural.

GRADING FORM: SMU GENERIC_GJ

MATTHEW BARNARD**54.75****RESEARCH-INFORMED LITERATURE**

Inclusion of a range of research-informed literature,

 including sources retrieved independently.
Referencing conventions mostly consistently applied. More sources would have been nice.

2.75

KNOWLEDGE AND UNDERSTANDING

 Evidence of basic knowledge and understanding of the relevant concepts and underlying principles.

12

ANALYSIS

 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.

15.25

PRACTICAL APPLICATION AND DEP.

 A good and appropriate application of standard methods, materials, tools and/or techniques. Good appreciation of the context of the application.

16.5

SKILLS FOR PROFESSIONAL PRAC.

 Can communicate effectively in a suitable format, but may have minor errors. Mostly coherent work and is in a suitable structure. You should caption your figures to allow you to directly discuss them in your text. "...As shown in Figure 2." You should also write reports using the passive third person voice, i.e. instead of "...I did this..." you should write "... this was done..."

8.25