

R McDonnell - Assignment 1 - ACDA5001 - AC Response in an RLC Circuit

by Ricky Andrew McDonnell

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Electrical Engineering

ACDA5001

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Assignment Report – AC Response of an RLC Network

Contents

Abstract	3
1- Introduction	4
2- Method	5
2.1 Task 1	5
2.2 Task 2	6
3- Results	8
3.1 Task 1	8
3.2 Task 2	10
4- Discussion	12
4.1 Task 1	12
4.2 Task 2	12
4.3 Task 3	12
5- Conclusion	13
6- References	13

Abstract

Within this report will be the contents of tasks set out in assignment one.

Assignment one consists of 3 tasks. Tasks one and two outlining the information described in the introduction of this report with RLC circuits in relations to resonance and phase angle.

First use

The results in section 3 indicate premeditated results in the introduction supported by the findings in section 4 discussion.



1- Introduction

An RLC Circuit consists of a resistor, inductor and capacitor. They can be found in various forms such as in AC mains filters, noise filters and also in radio and television tuning circuits producing a very selective tuning circuit for the receiving of the different frequency channels [2]

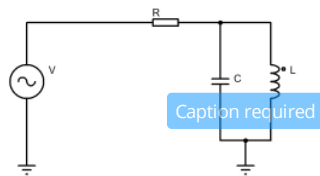
The RLC circuit principles are used during power factor correction on electrical systems such as large industrial systems with a large load such as a motor. As this is an inductive reactance this can be balanced by a capacitive reactance of equal magnitude in opposite direction (phase angle). Whilst inductive and capacitive reactance equal zero we achieve maximum power transfer due to no reactive power being used.

A power factor correction unit is made up of a series of capacitors that switch in and out depending on inductive load.

I am going to identify the characteristics of the following in respect to a changing frequency with the same supply voltage:

Supply current (I)
Voltage drop of components (VD)
Active, Reactive & Apparent Power (P, Q, S)
Power factor

Below is the RLC circuit I will use to demonstrate the above along with the values I will use for each component.



Inductor value = 201mH
Resistor value = 78 Ω
Capacitor value = 02 μ F
Supply Voltage = 10V AC

2- Method

2.1 Task 1a

To begin I am required to calculate the Impedance of the LC branch of the circuit.

Use of 1st Person Voice

To do this I need to calculate the reactance of each reactive component individually. I used the following formulas:

For Inductor: $X_L = 2\pi fL$

For Capacitor: $X_C = \frac{1}{2\pi fC}$ Caption required

I then calculated the total impedance of these components by using the product over sum formula: $Z_{LC} = \frac{(X_L * X_C)}{(X_L + X_C)}$

I then calculated total impedance of the circuit using: $Z = R + j(X_L - X_C)$

From calculating this total impedance, I was able to calculate total current using: $I = \frac{V}{R}$

Using the total current I was able to plot a graph of Current change depending on frequency.

2.2 Task 1b

To carry out task 1b of plotting voltage drop (VD) over frequency I was required to calculate voltage drop of the resistor and voltage drop of the LC branch of the circuit separately.

To do this I simply used the formula $V = IR$ to calculate the VD across the resistor.

I also used the formula $V = IR$ to calculate the VD of the LC branch where R is the total impedance of the LC branch thus turning my formula into $V = I(Z_{LC})$

Use of 1st Person Voice

With the values from the calculations above I was able to plot a graph detailing the characteristics of VD across the components with respect to frequency.

2.3 Task 1c

Use of 1st Person Voice

Following from the previous tasks, I used the results from them to calculate the following using the below formula:

Active Power - $P = |I|^2 R$

Reactive Power - $Q = |I|^2 X$ Caption required

Apparent Power - $|S| = \sqrt{P^2 + Q^2}$

From these results I can then plot the change in Active, reactive & apparent power over frequency.

2.4 Task 1d

Having all the above calculation's for power I can calculate the phase angle (φ) for the circuit using $\varphi = \cos^{-1} \frac{P}{S}$

Use of 1st Person Voice

With the phase angle calculation, I can place into the power factor (pf) formula $pf = \cos \varphi$ to provide me with the power factor. I can then plot the trend in this over frequency.

2.5 Task 2

To create Phasor diagrams to represent phase angle at three different frequencies, I was required to calculate the phase angle for component voltage and current for the circuit. I was able to do this using the "imargument" function in Microsoft excel which will return the argument φ which is the angle required but expressed in radians. To calculate this in degrees I use "=degrees()" excel function.

Use of 1st Person Voice

Use of 1st Person Voice

My overall formula used to calculate the angle of VR is
=DEGREES(IMARGUMENT(VR))

First use

The formula used to calculate the angle of VLC is
=DEGREES(IMARGUMENT(VLC))

VR & VLC being imaginary numbers (j)

Next I was required to calculate the angle the current was in relation to voltage. To do this I used the same formula above but for current. This formula then was
=DEGREES(IMARGUMENT(I))

Again "I" being a complex number and not absolute.

Use of 1st Person Voice

As I had my values for VR and VLC I was able to make these into absolute values to give my magnitude.

With the above angles and magnitudes calculated I was able to plot these as X and Y coordinates to display on my phasor.

To calculate the X axis position I used the cos function following SOH CAH TOA.

The formula I used was =|VLC|*COS(radians(ThetaVLC+ABS(ITheta)))

3

4 |VLC| being my magnitude

*COS function as identified by SOH CAH TOA as my Hypotenuse is known and I'm looking for the adjacent

(radians function is used to convert my angle into radians

(ThetaVLC) is the angle in relation to the "x" axis.

5

+ABS(ITheta) is to take into account the angle of current but convert into an absolute value before adding to thetaVLC)

With my X value being calculated I now needed the Y values. This was calculated again using SOH CAH TOA. From this I derived I needed the Sin function as my Hypotenuse is known and opposite required. My formula was as follows:

$$=|VLC|*\sin(\text{radians}(\text{ThetaVLC}+\text{ABS}(I\text{Theta})))$$

This was repeated for VR with formulas shown:

X Axis

$$=|VR|*\cos(\text{radians}(\text{ThetaVR}+\text{ABS}(I\text{Theta})))$$

Y Axis

$$=|VR|*\sin(\text{radians}(\text{ThetaVR}+\text{ABS}(I\text{Theta})))$$

This method was used to plot phasor diagrams for the frequencies:

25hz Below Res = 226.019295hz

At Res = 251.019295

25hz Above Res = 276.019295

2.6 Task 3

If we look at this circuit at resonance, we know that $X_L = X_C$.

X_L is given by $X_L = 2\pi fL$

This will give me a value of my inductive reactance.

I can then use this value to place into the formula: $X_C = \frac{1}{2\pi fC}$ To give me a value of C

This formula can be converted to $C = \frac{1}{2\pi fX_C}$

If we assume a resonant frequency of 50hz and substitute this into $X_L = 2\pi fL$ we get:

$$X_L = 2 * \pi * 50 * 0.00015$$

$$X_L = 0.04712389$$

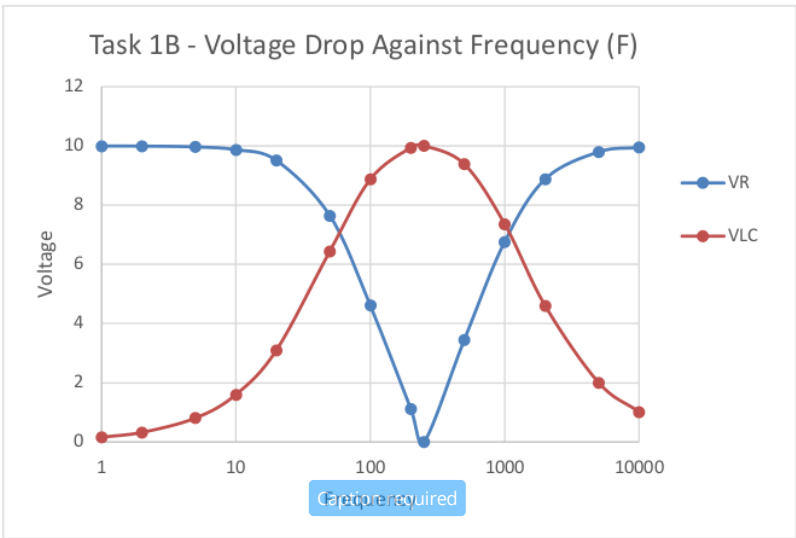
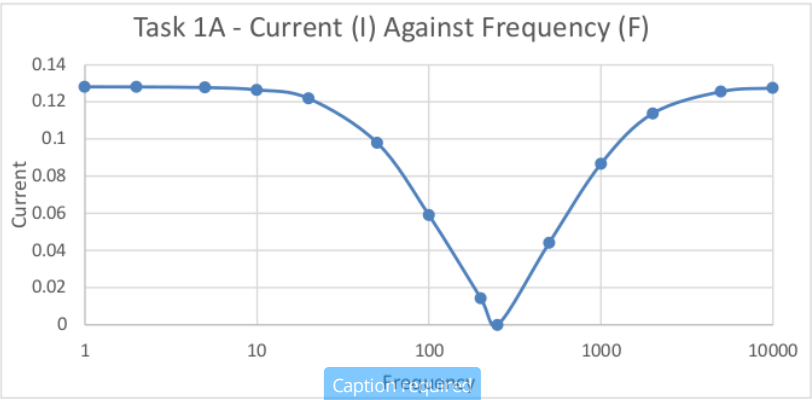
We know at resonance $X_L = X_C$ therefore $X_C = 0.04712389$

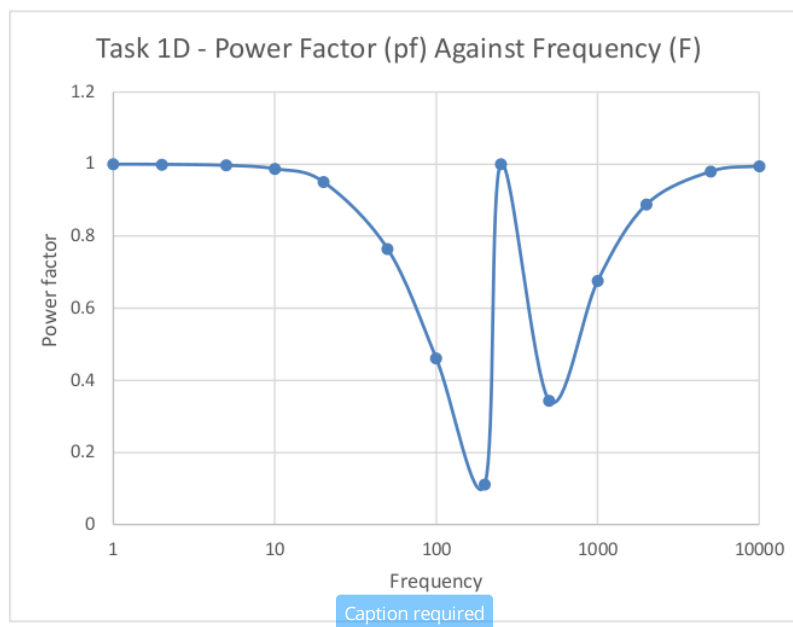
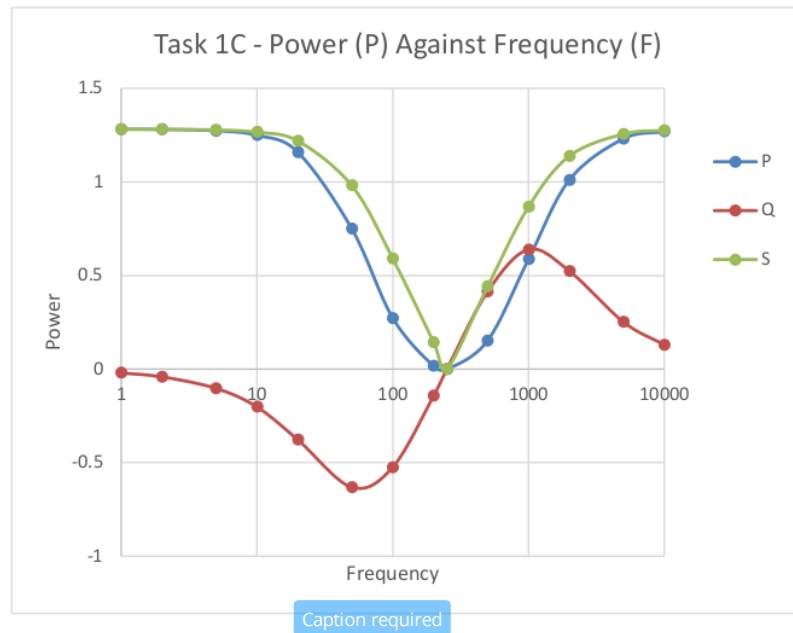
So if we substitute this into the above formula we get $C = \frac{1}{2 * \pi * 50 * 0.047}$

The value for our capacitor is: 0.067F

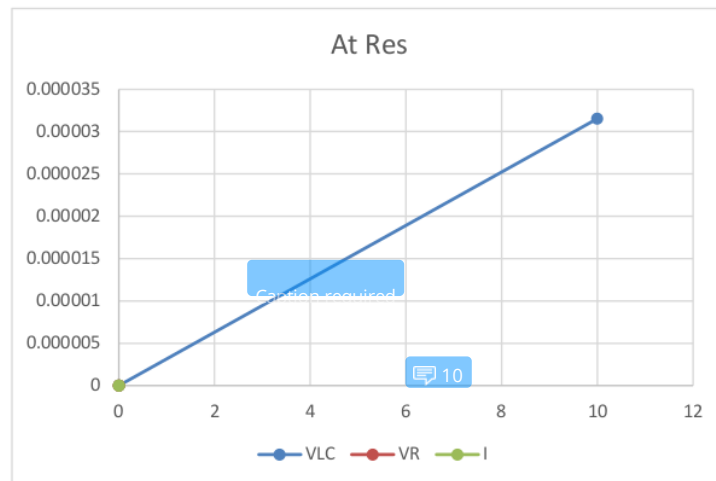
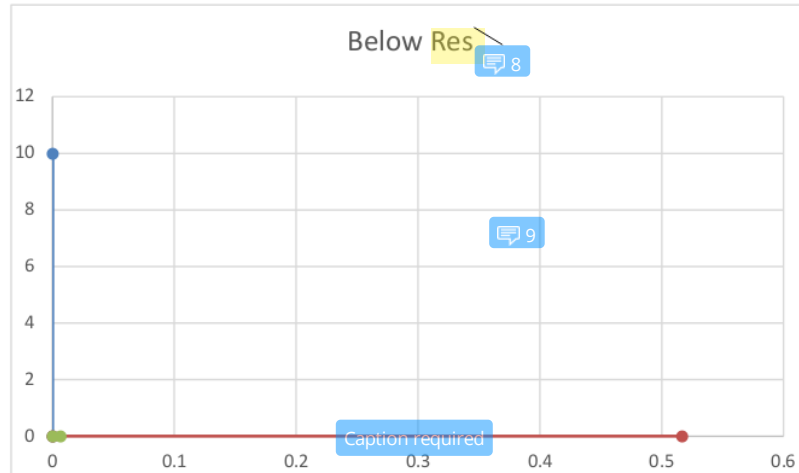
3- Results

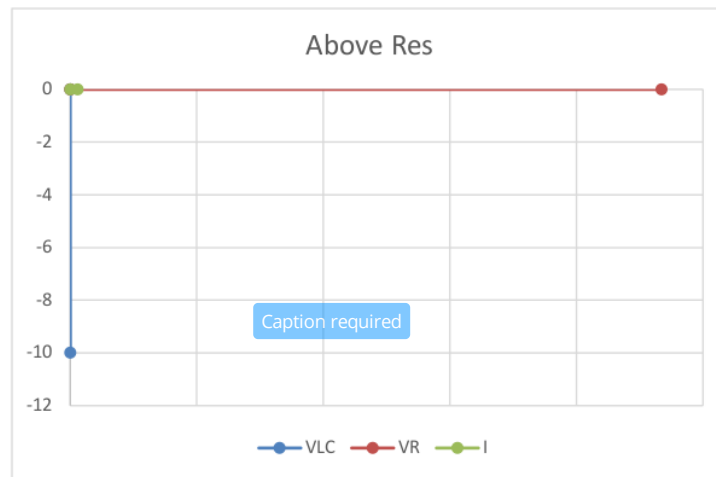
3.1 Task 1





3.2 Task 2





4- Discussion

4.1 Task 1

Shown in the first graph we can see as described in our introduction the relationship current has over frequency. At resonance we can see the current drops to zero in our circuit. This occurs when the inductive reactance (XL) is equal to the Capacitive Reactance (XR).

In our second chart we can see the voltage drop of the resistor (VR) decreases as the voltage drop of the LC branch (VLC) increases. This is due to the

Our third chart indicates Power (P) against Frequency (F). It illustrates clearly the drop in reactive power whilst at resonance. In turn this brings the apparent power down.

Our final chart for task 1 indicates our power factor for the circuit. At resonance we achieve perfect power factor correction of 1. This indicating all the energy supplied from the source is being utilised by the load. This meaning the voltage and current are in phase.

At resonance the capacitive energy stored as a static energy in the capacitor discharges at the same rate of inductance from the inductor. As these amounts are equal value and opposite angle to each other they are in balance. Meaning as the capacitor discharges the inductor induces the same current. This creates a purely resistive circuit balancing out reactive losses of inductance and impedance.

4.2 Task 2

The three charts in this task clearly indicate the voltage drop of the components in relation to phase angle.

In our first task before resonance, we can see that the voltage in the LC branch (VLC) is leading the voltage of the resistor (VR). This is a difference in phase angle of 90 degrees.

In our second chart both VLC & VR are in phase which each other indicating they are now at resonance.

In our final chart (after resonance) we see the voltage of the LC branch (VLC) is now lagging the voltage of our resistive branch (VR)

4.3 Task 3

Maximum power transfer occurs at resonance. This is when the capacitive reactance and inductive reactance are equal and opposite to each other. This bring the total impedance of the circuit to be purely the load resistor providing maximum power transfer.

The task we completed was introducing a capacitor to an inductive load to create power factor correction and in turn reduce reactive power.

With the addition of the capacitor of the value we calculated we made the circuit more towards resonance and balanced out the reactive loads.

5- Conclusion

From carrying out this assignment, we can conclude that:

- Current draw drops at resonance due to zero reactive power.
- At resonance the capacitive reactance is equal to inductive reactance. This causes the circuit to be a purely resistive circuit. This occurs due to equal  16
- Maximum power transfer occurs at resonance due to no reactive power being present.
- We can achieve maximum power transfer of an inductive circuit by adding capacitors to a value of reactance equal to the inductive reactance. This is called Power Factor Correction.
- At resonance we achieve Power Factor Correction of 1.
- Voltage and Current are in phase at resonance.

6- References

[1] <https://www.electrical4u.com/resonance-in-series-rlc-circuit/>

[2] <https://www.electronics-tutorials.ws/ac/circuits/series-resonance.html>

[3] https://en.wikipedia.org/wiki/Power_factor

 17

Ref Qual

Refs missing info

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GRADEMARK REPORT

FINAL GRADE

GENERAL COMMENTS

Instructor

56/100

PAGE 1

PAGE 2

PAGE 3



First use

You should introduce acronyms and symbols the first time you use them so the reader understands what you are talking about.



Comment 1

You should include a statement of your results in the abstract.

PAGE 4



Comment 2

You should not use the first person voice when writing technical reports. You should use the third person passive voice instead.

e.g. "The following characteristics were identified...."



Caption required

You should always include a caption on figures, equations and tables to allow you to refer to them in your text.

e.g. An illustration of this can be seen in figure 2. The relationship of the variables is shown in equation 2. Table 1 shows the results of the first experiment where the control variable, temperature in degrees celsius is shown in the first column....

PAGE 5

QM

Use of 1st Person Voice

When writing technical reports, do not use first person voice. Instead, use the third person passive voice.

You should not use words like "I", "you", "we" etc..

QM

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Comment 3

You should use the equation editor to produce more professional looking, easier to read equations.



Comment 4

magnitude of what? Magnitude just means "size".



Comment 5

The angle of what?

You need to be clearer in what you say, Do not let the reader assume anything. Remove all ambiguity in what you are saying.

PAGE 7



Comment 6

You do not need to explain trigonometry.



Comment 7

You should use the equation editor to write your equations. They will look more professional and easier to read.

QM

Missing Units

What units is this in?

You should always include the units for all quantities you describe in your text. Some quantities have more than one unit. Frequency, for example, can be measured in Hertz (Hz) or radians per sec (rad/s).

Make it clear for your reader and remove any ambiguity.

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PAGE 8

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PAGE 9

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PAGE 10



Comment 8

Do not abbreviate where there is no need to do so.



Comment 9

You should label the data on your graph. Which voltage or current relates to which colour line?

QM

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Comment 10

Where is VR?

PAGE 11



Caption required

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PAGE 12



Comment 11

You should caption all your figures, tables and equations so that you can refer to them by name/number in your text. This will help remove all ambiguity in what you are saying.



Comment 12

Do you mean XC?



Comment 13

caption the figures.



Comment 14

Incomplete sentence.

You should proofread your work before submitting, ensuring you identify and correct issues like this.



Comment 15

word "correction" is not needed in this sentence.

PAGE 13



Comment 16

incomplete sentence



Refs missing info

Some of your references are missing information. To understand what information should be included, see the university IEEE referencing handbook on the library website.

https://uwtsd.ac.uk/media/uwtsd-website/content-assets/documents/library-and-learning-resources/infoskills/IEEE-eng_v.1.2.pdf



Comment 17

Do not use Wikipedia as a reference. It cannot be taken as accurate as it is editable by anyone.

QM

Ref Qual

You should try to use more high quality reference sources, such as textbooks from reputable academic publishers and articles from peer reviewed journals.

GRADING FORM: SMU GENERIC_SMOSEY

RICKY ANDREW MCDONNELL

56

ENGAGEMENT WITH LITERATURE

including reading, referencing, academic conventions and academic honesty



References to a limited range of mostly relevant sources. Some omissions and minor errors. Referencing conventions evident though not always applied consistently.

4.1

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.

16.5

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/or abstract data and situations without guidance. Valid conclusions

17.4

PRACTICAL APPLICATION SKILLS

Different approaches to solving problems in particular contexts.



A very good application of a range of methods, materials, tools and techniques. Very good consideration of the context of the application, with perceptive use of examples, where relevant.

12.8

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 but could be structured better.

5.2