Black Box - Hamish Sams

by Hamish Sams

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Introduction

Background:

In this lab we were given two black boxes with no way of directly identifying what component inside is other thank knowing it was a capacitor or a inductor. We had access to general basic electronic measurement equipment and knew that one of the components was a resistor.

Aims:

To an average degree of accuracy find the value of the components inside the black boxes via external measurements.

Theory

Laws and equations:

An inductors voltage drop is directly proportional to the rate of change of current flowing across [1].

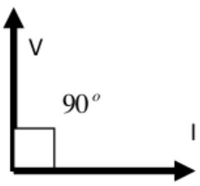
$$\frac{|V|}{|I|} = X_L = \omega L = 2\pi f L$$

An alternating current passing through a wire creates a magnetic field which interacts with the current through the wire opposing the motion increasing the reactance (resistance).

$$|Z| = \sqrt{R^2 + X_L^2} \text{ [2]}$$

Due to the fact the voltage is directly proportional to the rate of change of current flowing through the wire and following lenz's law the voltage creates a field that is opposing the change that created it creating a phase difference of pi/2 with the current lagging behind voltage. Diagrammed as such:

$$f_c = \frac{R}{2\pi L}$$

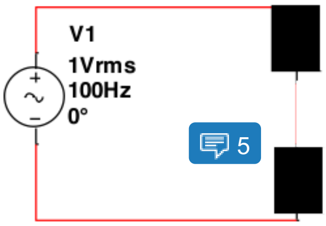


Method

Description:

First of all we define the boxes randomly as box 1 and box 2.We measure the resistance of both boxes on dc p[illegible] immediately we can tell if we have a capacitor or an inductor depending on if there is a component with infinite resistance. We then connect the boxes in series with the function generator starting with a sine wave of voltage 1Vpp and a frequency of 100 Hz. We ground the oscilloscope to the negative of the circuit and measure the voltage wave a[illegible] both and then only the second black box. After this repeat incrementing frequency in reasonable steps.

Circuit diagrams:



[3]

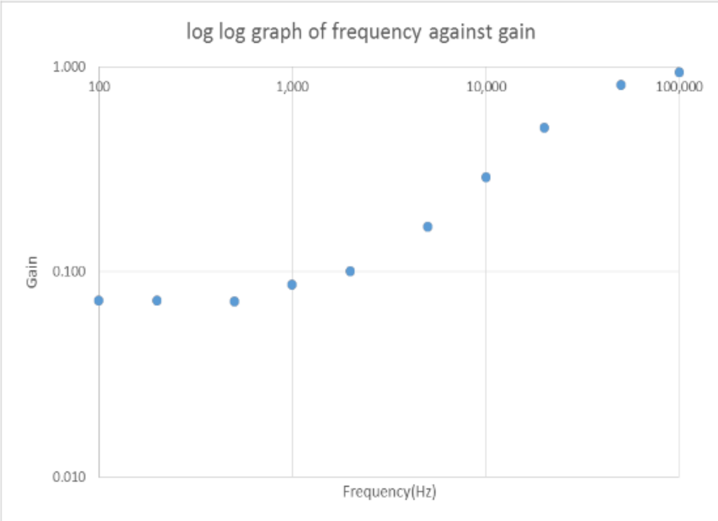
Results

Measured (12/10/16)

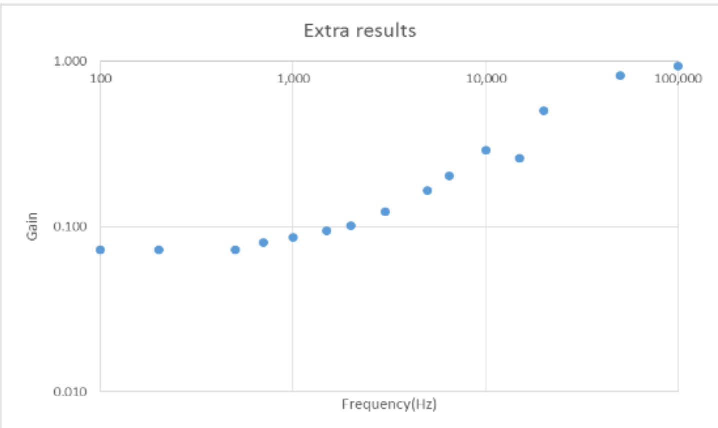
f(Hz)	V(i)(V)	V(m)(V)	Gain
100	1.38	0.10	0.072
200	1.38	0.10	0.072
500	1.39	0.10	0.072
1,000	1.39	0.12	0.086
2,000	1.39	0.14	0.101
5,000	1.45	0.24	0.166
10,000	1.45	0.42	0.290
20,000	1.51	0.76	0.503
50,000	1.75	1.43	0.817
100,000	1.95	1.83	0.938

Ex[illegible]

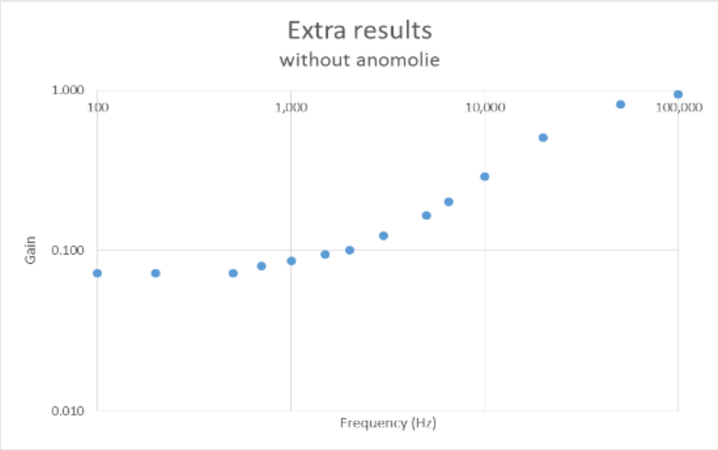
700	1.37	0.11	0.080
1,500	1.38	0.13	0.094
3,000	1.38	0.17	0.123
6,500	1.39	0.28	0.201
15,000	1.43	0.37	0.259



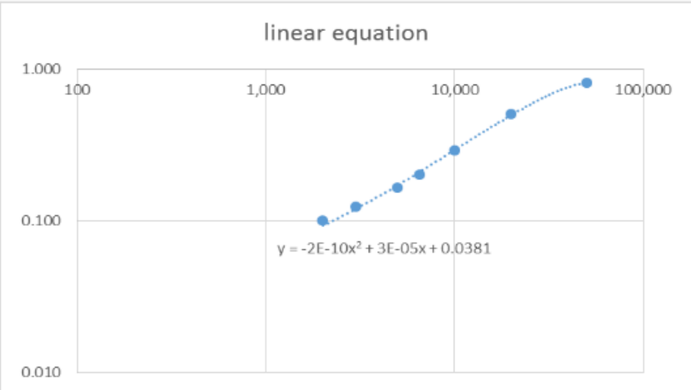
In this graph there is a curve at the beginning and end of the graph with a linear sequence joining the two, with large gaps it is hard to tell where this linear cut off is and so more results were taken. Because the graph curves upwards and we know we have a resistor and a inductor in that order. Due to the value of the resistor bein 100 ohm which is quite small for measuring an inductor value the curves are interacting over a large frequency meaning the linear section is smaller and harder to measure impacting my calulations accuracy.



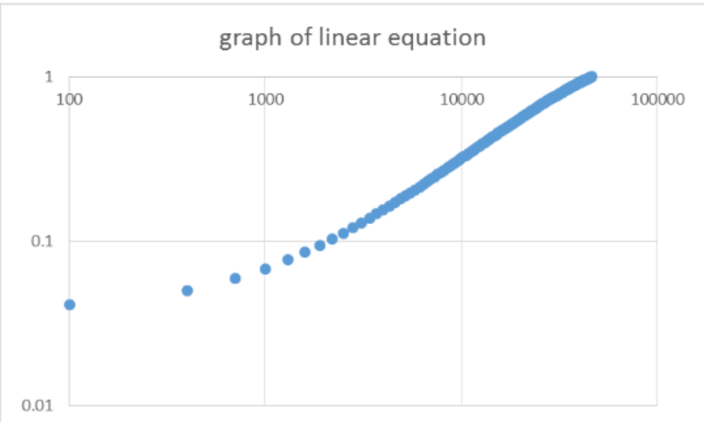
In this next graph we added some extra results and straight away the first thing we see is the blatant anomaly I could use calculations to find out if this is an anomaly but at this point there isn't much benefit of keeping it due to the un necessary high precision of my calculation. We do start to see the function in a bit more light now though.



Without the anomolie in the graph I find It now much easier to see the shape of the graph and at what point the cut off is, unfortunately this anomolie is neer the cut off point and so in heinsight it would've been usefull to take double or tripple measurements just so we have a value for this.



Next I decided to take away the curve section of the graph and let software try to make an equation to fit these and the closest is marked above this mathod allows me to then map the equation and measure where the frequency cut off is (gain =1) I could also find it out mathematically. You can see that at the top point the equation starts to round off and so I expect my answer here to be a tad too high and for the final inductance result too low.



Personally I trust my own work more than a computer and so I am going to use the value off my graph of 3.75E4 which is remarkably different to that that the equation gives us.

Calculations:

$$f_c = \frac{R}{2\pi L} \qquad \frac{R}{2\pi f_c} \quad \frac{100}{3.75\times10^{4}} \approx 4.5\times10^{-4}$$

Discussion

Errors:

Tolerance – The tolerance of the device

Magnetic field – the magnetic fields in the room interacting with that of the inductor

Equipment – The uncertainty in the function generated and the tools used to measure that function.

Unaccounted resistance – The resistance in wires and connections unaccounted for

Graph reading – lack of linear section making it difficult to measure

Conclusion

The resistance of the inductor is 4.5×10^{-4} and due to the large variance in values for the frequency cut off I believe a uncertainty of around 1×10^{-4} is fair and so are finally quoting a value of $4.5\times10^{-4} \pm 1\times10^{-4}$, this as inductor values means that this could be 36, 39, 43 ,47 or 51mH most likely being 43 or 47 mH.

Reference list

[1] - http://www.allaboutcircuits.com/textbook/alternating-current/chpt-3/ac-inductor-circuits/ (13/10/16)

[2] - http://www.electronics-tutorials.ws/accircuits/ac-inductance.html (13/10/16)

[3] – Circuit diagrams drawn using multisim

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GRADEMARK REPORT

FINAL GRADE

58/100

GENERAL COMMENTS

Instructor

PAGE 1

Comment 1
Avoid 1st person in reports

Comment 2
This seems like random snippets of theory with no context

PAGE 2

Comment 3
?? perhaps you mean "arbitrarily"

Comment 4
This should be a clear sequence of steps to follow

Comment 5
You should include voltage measurement points

Comment 6
Just include these in the main table, with text to mention why they were added

PAGE 3

Comment 7
typo

Comment 8
rather casual English for a formal report

PAGE 4

Comment 9

Which software? Curve fitting algorithms are fascinating and I could talk to you about them all day... but you must say what you actually used.

PAGE 5

Comment 10

which is why its important to document *what* you used to derive each one

Comment 11

This needs description and context

Comment 12

These should be more specific and, where possible, quantified

Comment 13

Rather brief and doesn't link to any wider context

Comment 14

This is not (quite) proper reference format for web links and you could have found textbook or publication references for this basic theory

Comment 15

Then give me a reference to multisim and cite it in the discussion section. This is one place where a web link might be appropriate

RUBRIC: BLACKBOX 2.30 / 4

INTRODUCTION (5%) 1 / 4

(0)	no introduction
SCALE 2 (1)	a basic introduction identify the aim of the experiment
SCALE 3 (2)	a well written introduction identifying aims and objectives
SCALE 4 (3)	a well written introduction with aims, objective and some justification for the experiment
SCALE 5 (4)	well written introduction identifying the aim and a justification of the need for such experiments in context

THEORY (15%) 0 / 4

(0)	no theory
SCALE 2 (1)	basic theory on R,L and C linked to frequency
SCALE 3 (2)	well described theory including formula, effect of frequency and understanding of impedance
SCALE 4 (3)	thorough theoretical knowledge linking to the equipment used to take the measurements
SCALE 5 (4)	thorough theoretical and equipment knowledge including an appreciation of complex numbers and phasor diagrams

METHOD (15%) 1 / 4

(0)	no methods
SCALE 2 (1)	a basic and logical method
SCALE 3 (2)	a well written method which would allow someone to accurately repeat the experiment
SCALE 4 (3)	well written method including a circuit diagram
SCALE 5 (4)	an excellent method and accurate circuit diagram including all measurements points and equipment symbols

RESULTS (30%) 4 / 4

(0)	no data and no graph

SCALE 2 (1)	data with correct headings and units
SCALE 3 (2)	data with correct headings and units, as well as a graph with mistakes
SCALE 4 (3)	correct data and correct graph on log-lin scale complete with headings, units and titles
SCALE 5 (4)	correct data and graph, an more data along the transition points (not equally spaced measurements)

DISCUSS (20%)	3 / 4
(0)	no discussion
SCALE 2 (1)	partial discussion, links results to some theory
SCALE 3 (2)	good discussion, links results to theory and identifies each type of unknown component
SCALE 4 (3)	excellent discussion, links results to theory and correctly calculates component values for the unknown components
SCALE 5 (4)	excellent discussion, links results to theory and correctly calculates component values for the unknown components, and also looks at the errors in the measurements

CONCLUSIONS (5%)	2 / 4
(0)	no conlcusion
SCALE 2 (1)	conclusion is basic and does not refer to data or theory
SCALE 3 (2)	conclusion is correct and clearly links to data and theory
SCALE 4 (3)	conclusion also links to errors in measurements
SCALE 5 (4)	conclusion also links to equipment errors

REFERENCES (5%)	2 / 4
(0)	no refrences
SCALE 2 (1)	referencing incorrect and citations missing
SCALE 3 (2)	uses citations but referencing is incorrect format
SCALE 4	complete and correct, but only one

(3)

SCALE 5 (4)	complete, correct and more than one

REPORT LAYOUT (5%) 2 / 4

(0)	poor layout
SCALE 2 (1)	good layout but not in third person
SCALE 3 (2)	good layout, well written and in third person
SCALE 4 (3)	good layout, third person, with figures and tables correctly labelled
SCALE 5 (4)	good layout, third person, with figures and tables correctly labelled, and linked too in the text