Lab 07 Inductions and Capacitors

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Abstract

In lab 07 the students tested the theory of inductors and capacitors equivalency in circuit, both parallel and in series. The students used voltage and current calculations to calculate the theoretical values of their inductance and capacitance, these values were used to compare to the measured values that they received. The students built two different circuits and changed the components used in order to use the theoretical equations to calculate the values, initially they students built their own resistor, capacitor and inductor. Then they used current and voltage to measure the theoretical value and a LCR meter to measure the inductance to calculate the error value, this was then done with the capacitor as well. Once all of that was measured they were tasked with building a voltage divider and asked to change the values of the input to see what the effects were on the output.

Lab 07 Inductions and Capacitors

In this lab the students used a function generator, an oscilloscope, and a digital multimeter to help get measured values. The importance of this lab is to verify the theoretical equations for further use, and also to fully understand why they equations are used.

Task 7.8.1

Objective: In task one the objective is to build a resistor using graphite, a capacitor using paper and an inductor using a metal screwdriver.

Procedure: A stick of 0.7mm graphite was used for the resistor, which was then appropriately measured using the digital multimeter, while this was being done the students also calculated the resistance using the equation $R = \frac{S*L*L}{A*A}$. Next the students built a capacitor using two plate capacitors and a piece of 0.1mm paper, R value of 2, they measured and calculated the capacitance using a digital multimeter and the equation $C = \varepsilon 0 * \varepsilon r * A/d$. Finally the students built an inductor using wire, 26 AWG, wrapped 20 times around a screw driver, again this was measured and calculated using the LCR meter and the equation $L = N^2 * \mu 0 * \mu r * R * \left[\ln\left(\frac{8R}{r}\right) - 2\right]$.

Results: For error calculations the equation , Error = (|Vtrue - Vobserved|/ Vtrue) * 100, is used, the calculated value for the graphite is 1.1699 and the measured value was 1.26 for an error of 7.7%. For the paper capacitor the calculated capacitance was 2.00 nF and the measure value was 2.15 nF for an error of 7.5%. The inductor had a calculated value of 7.18 µH and a measured value of 6.65 µH for an error of 7.38%.

Conclusions: The error encountered across each was around 7% which is a workable amount and is not enough to disprove the theoretical equations. This could be due to a few factors it could be from taking the diameter of the graphite for granted and just stating that it was 0.7 mm instead of measuring it. For the capacitor a similar issue could be the case, we assumed that only the 0.1mm paper was the only space in between the capacitor, once we tried to measure, we noticed that you had to push the plates together due to the gap between the plate and the paper on each side. The reason for error on the inductor was due to something different, when the permeability of stainless steel was researched we noticed that there was not one single value but a range possible to use. Which could also be a big source of error we decided to use a lower middle value but also realized when a higher value was used the error was much higher.

Task 7.8.2

Objective: The Objective for task 2 is to prove the theoretical equations for inductors this time using current and voltage measurements.

Procedure: For this task the students build a circuit figure 1 from the lab manual and for Rsense they used a 100Ω resistor and the DUT was the built inductor. 20V peak to peak at 100 kHz was used as a sine wave to measure voltage across the DUT and Rsense to calculate the inductance of the built inductor. To double check their values the students were then to use the same input and replace their DUT with a 1 mH inductor and a 1 kΩ resistor.

Results: For the first part of the task we received a 14V drop across Rsense however, we accidentally skipped the LCR measurement which means that we can not measure the error for that. For the second part with the 1mH inductor we for a drop of 1.4229 and an LCR reading of 0.9797 mH for error of 2.13%.

Conclusions: Unfortuneatly for the first part of the task I am unable to calculate the error due to negligence on my part. On the second part we measured error and it was low, which could be due to improper connections, loose connections. The theoretical equations for this task seem to hold up and there is not enough evidence to prove otherwise.

Task 7.8.3

Objective: The objective of task three is to prove the theoretical calculation methods of a capacitor using current and voltage through a capacitor.

Procedure: For this task the students re-used the circuit from task two, figure 1, but this time for the DUT they used their built capacitor with a 1 kΩ resistor. The same function is generated and used to measure the voltage. Once the measurements and error calculations are done they are to try it again using different set ups, one 10 nF capacitor, two 10 nF in parallel and two 10 nF in series.

Results: For this task we recorded the voltage drop across the resistor, but again we failed to gather an LCR reading for any of the capacitors, due to this gross negligence we cannot calculate error.

Conclusions: The sources of error for this part of the lab are very large due in part to the fact that we neglected to pay full attention to the lab manual and did not do everything that was asked of us. Possible sources of error in this task could be due to improper connections or connecting the measuring connections wrong which would result in the wrong output.

Task 7.8.4

Objective: The objective of this task is to discover how a voltage divider works for both the voltage input and output measurements.

Procedure: The students were to construct the diagram in task 4, figure 2, with C1 = 0.47 µF and C2 = 0.1µF. The function generator is set to sine wave with 5V peak to peak at 10 kHz. The oscilloscope was connected to the input and the output and the output was plotted, figure 3. Then C1 and C2 were swapped and the new output was plotted, figure 4, the students then altered the frequency to see what, if anything would change with the frequency. The students were also tasked to change the voltage from AC to DC and see what happened as well.

Results: For task 4 the theoretical values of the capacitors were 470 nF and 100 nF, with a measured value of 481 nF and 104.7nF respectively. After the measurements we see that in figure 3 and figure 4 changing the capacitors around does alter the output generated. Once we started changing the frequency of the input we noticed that under 1 kHz the input stops looking like a since wave and looks more like a very fuzzy line, on the other end the closer to 10 kHz we got the input looks more and more like a sine wave. Then when the input was changed to DC the circuit no longer worked.

Conclusions: Our conclusions were that these answers seem to make sense, since the attenuation ratio does seem to be affected on further research we found that it is linearly dependent on frequency which would account for this change. DC current did not work because DC cannot work as a voltage divider for capacitors so that is the reason for the circuit no longer working.

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Figures title:

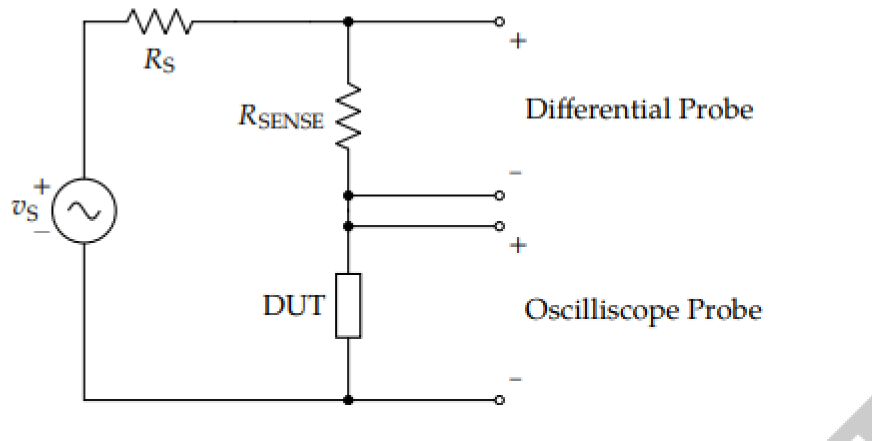

Figure 1. This is the circuit used for task two and three

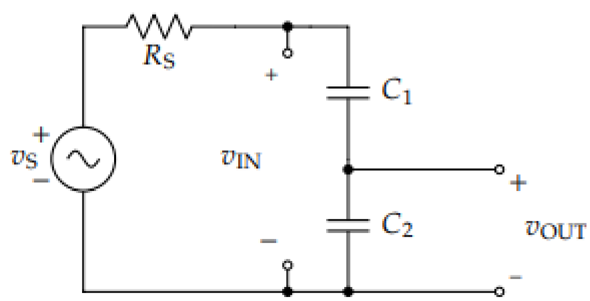

Figure 7.5: Capacitor voltage divider

Figure 2. This is the circuit used for task 4

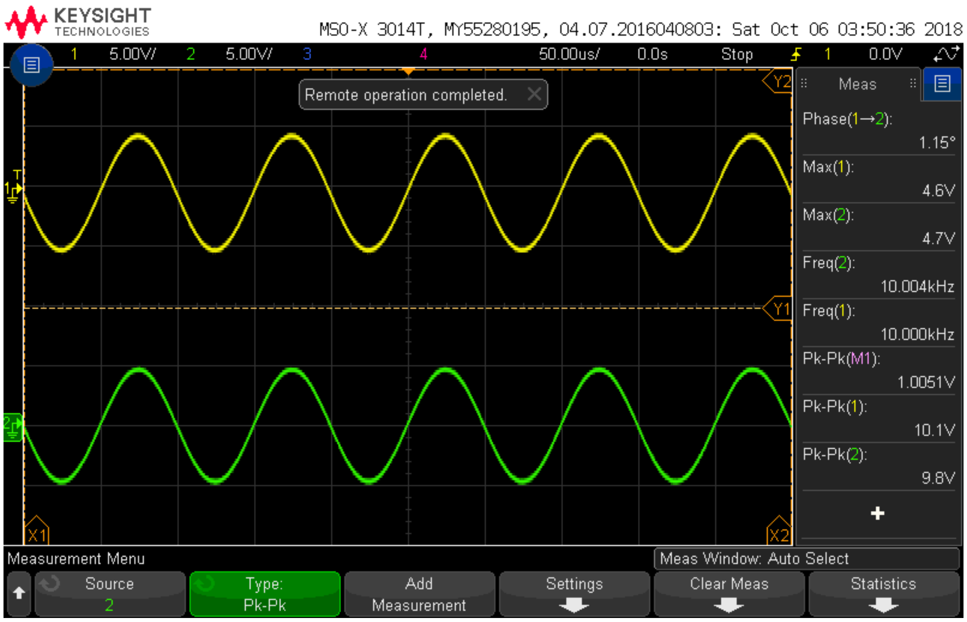

Figure 3. This is the first screen shot for task four

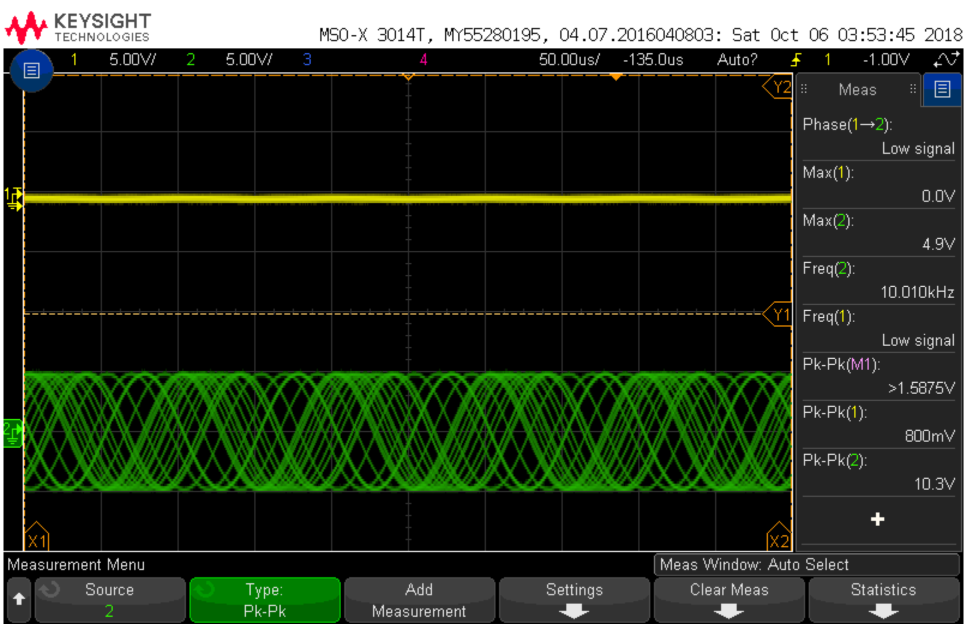

Figure 4. This is the Second screen shot for task 4