Assignment 3

1 Design Exercises

1.1 (5 points)

Using Kirchhoff's laws, derive a formula for the total capacitance of two capacitors in parallel and a formula for the total capacitance of two capacitors in series. (Hint: pretend that you are working with an AC signal of frequency ω).

1.2 (5 points)

Using Kirchhoff's laws, derive a formula for the total inductance of two inductors in parallel and a formula for the total inductance of two inductors in series. (Hint: pretend that you are working with an AC signal of frequency ω).

1.3 (10 points) Can be done after the lab

In class we discussed the behavior of charging capacitor in RC circuit shown in figure 1 (note that V_{out} is the same as V_C). Derive current (I) and voltage drop across capacitor (V_C) as functions of time for the case of discharging capacitor: $V_{in}(t<0)=V_o$ and $V_{in}(t>0)=0$. It is safe to assume that capacitor was fully charged and no current was flowing at t<0.

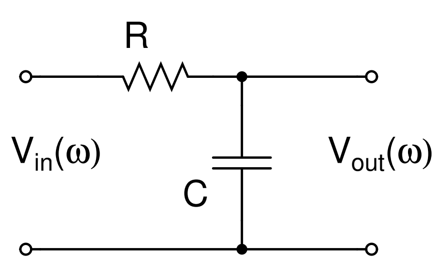

Figure 1: A RC circuit.

2 Lab 3: Oscilloscope, AC signals, and Phase

Always start with a circuit diagram and only then build it in hardware.

Your notebooks must be complete, understandable, and address all activities, design exercises, observations, and questions noted in the laboratory's procedures. Remember to use your notebook as a laboratory journal and record your data, design calculations, notes and scratch work. *Make sure to write a conclusion for each exercise and each week.*

Task 0

Demand a tutorial on Oscilloscopes and Function generators! Pay special attention to the trigger concept.

Task 1 (5 points)

Connect an oscilloscope to the output of function generator. **Make sure the oscilloscope is DC coupled.** Function generator often has more than one outputs. One typically outputs square looking signal with a fix amplitude (we will call it trigger) synchronous to another functional signal (you can change the shape of the signal coming from it). Understand which is which by probing with the scope. Make a sketch with labels in your logbook.

You will probably have trouble with triggering: the signal will not be stable on the screen of the scope. This is not time to be shy, ask instructors for help and explanation.

By watching functional output understand the behavior of the amplitude, frequency, offset, and shape (settings). Keep your signal triggered.

Task 2 (10 points)

Set the function generator to about 1 kHz frequency sine wave with a 0.5V amplitude. Set about 2 V offset for the signal. It is good idea to watch the scope to control the signal (in fact this is the must, do not trust function generator labels). Learn how to use the oscilloscope to measure amplitude, DC offset, period and frequency of the signal.

Switch the oscilloscope input from DC to AC coupling. What changed? What is the measured offset of the signal? Switch back to DC coupling.

Tune the function generator amplitude to the smallest value (you might have to pull the amplitude knob) while maintaining abut 2 V offset. Try to measure the amplitude of such signal. What input coupling should you use AC or DC?

Task 3 (7 points)

Make a comparison between oscilloscope and multimeter readings.

Connect the same signal to a multimeter. Measure DC and AC voltages. How are they related to the oscilloscope measured offset and amplitude of the signal.

Task 4 (20 points)

Set the function generator to about 1 kHz frequency sine wave with a 0.5V amplitude. Set 2 V offset for the signal.

Measure the **output impedances** for DC and AC (at the above frequency) of the signal generator.

Do not use multimeter for current reading. Think how to infer current measurements with only oscilloscope and load resistors. Do not connect resistors with values below 50 Ω.

Task 5 (8 points)

Get two capacitors and measure their individual capacitances. Measure the total capacitance with a capacitance meter when they are in series, and when they are in parallel. Is it in agreement with your expectation?