Lab in IF1330 and IE1206 VT2020

In the lab you will analyse circuits using the circuit simulation software QUCS (Quite Universal Circuit Simulator, you can download QUCS from http://qucs.sourceforge.net/index.html).

In QUCS you build your circuit by creating a schematic of the circuit through a graphical user interface. In the same graphical user interface you also define what simulations to be performed and in the lab you will use DC, Transient and ac simulations. After the simulation is finished you can display the simulation results in the same graphical interface.

You can find tutorials on QUCS at http://qucs.sourceforge.net/docs.html and a video lecture in CANVAS where the relevant parts of QUCS for the lab is introduced.

After you have analysed the circuits in the lab you should write a lab report that shows the schematic of the circuits and the simulation results together with text describing your analysis and conclusions. Please use the schematics and table/graph results from QUCS in your report. The report should be written in a way so that the reader of the report can understand what was done. Make sure to show the results that illustrate your analysis and supports your conclusions. The intent of the report is to briefly report your work but clearly describe your analysis and conclusions. You can write the report in English or in Swedish and the lab report should be submitted in CANVAS as a pdf. There is no template for the lab report but do include a cover sheet with your name, program, email and personal number.

The lab consist of analysing 4 circuits, one circuit per module in the course.
The overall purpose of the tasks is given below and it should guide your analysis and your conclusions in the lab report.

Task 1: Perform a DC simulation of a resistive net containing independent sources and resistors. Show that KCL is fulfilled in all nodes and that KVL is fulfilled in all loops of the circuit. Also show that the power is balanced in the circuit.

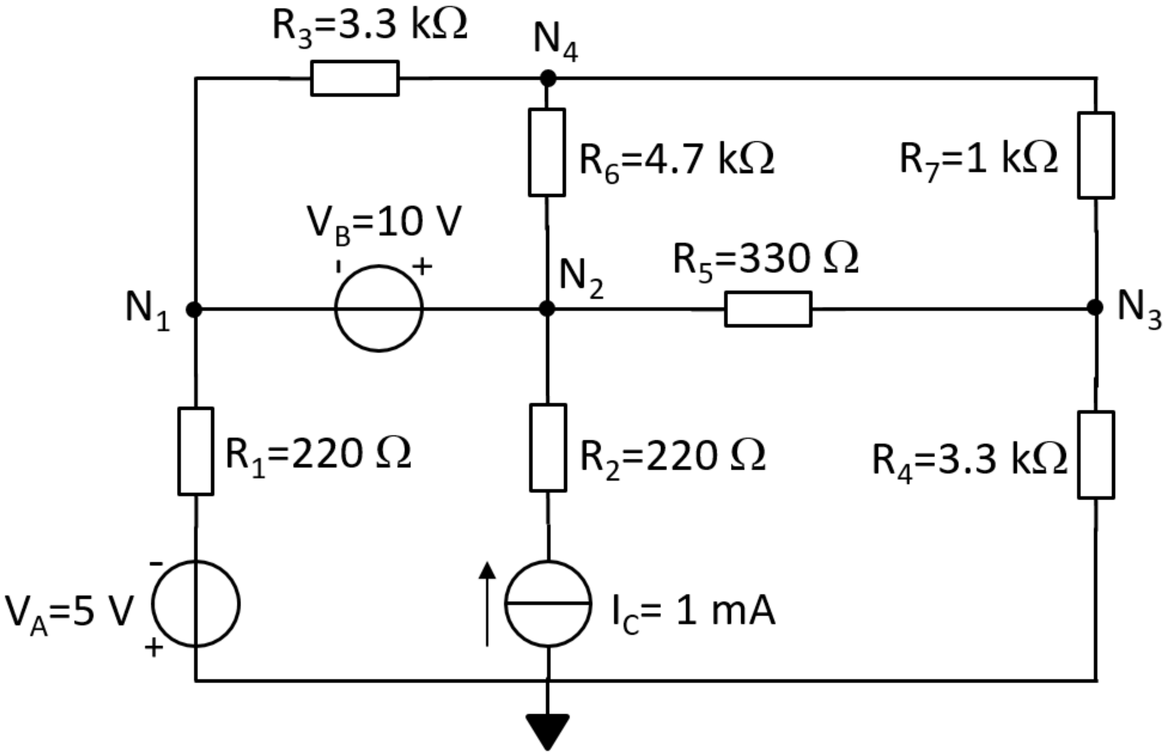
Task 2: Perform Transient simulation of a rectifying circuit using a diode and a capacitor. The circuit has a sinusoidal (AC) input voltage that the circuit should convert into a constant voltage i.e. a DC voltage. Analyse and show how well the circuit delivers a constant voltage and what the constant voltage is.

Task 3: Perform Transient simulation of a circuit containing a resistor and capacitor. The circuit has a square wave input voltage. Analyse and show how the voltage over the capacitor varies as a function of time and also what effect the frequency of the square wave have on the voltage over the capacitor.

Task 4: Perform an ac simulation of a circuits with resistor, capacitor and inductor in series. The input voltage is a sinusoidal (AC) voltage. Vary the frequency of the input AC voltage and analyse how the voltage amplitude and phase over the resistors varies as a function of frequency. Also show what filter functions the circuit performs with only RC, only RL or RLC in series in the circuit.

Task 1. Resistive net with independent current and voltage sources

Use QUCS to perform a DC simulation of the circuit below. Use Voltage and Current Probes in QUCS to find the relevant current and voltages.



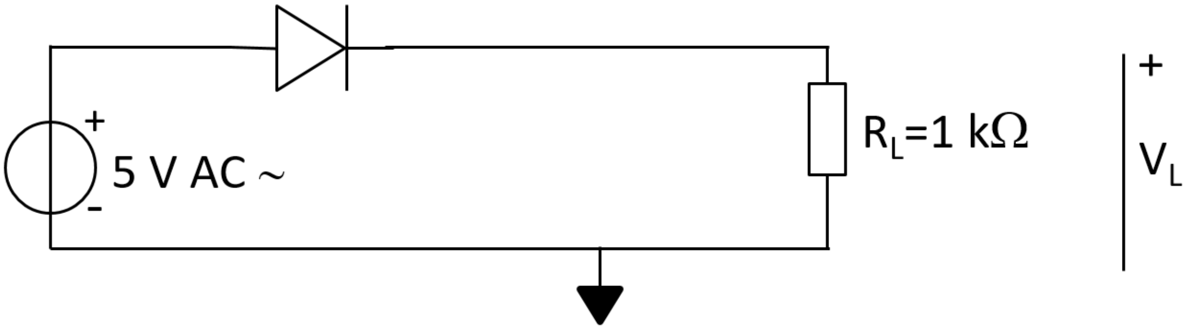
(A) Show that Kirchhoff's Current Law holds in the five nodes (GND, N1, N2, N3 and N4) in the circuit.

(B) Show that Kirchhoff's Voltage Law holds in the four loops of the circuit.

(C) Show that power is balanced in the circuit i.e. that the sum of the delivered power (from the circuit elements that deliver power to the circuit) is equal to the consumed power (by the circuit elements that consume power).

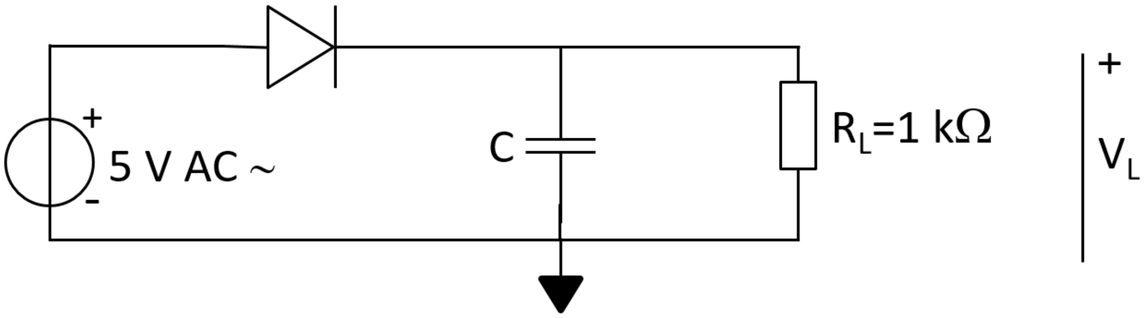
Task 2: Analysis of a rectifying diode circuit

Perform a transient simulation from t=0 s to t=20 ms of the circuit containing a diode below. The circuit has a sinusoidal AC voltage source with an amplitude of 5 V and a frequency of 220 Hz. The diode is 1N4148 and can be find in the Libraries/Diodes in QUCS. The circuit is designed to convert a varying (AC) sinusoidal voltage into a constant positive voltage (DC) over a load. The resistor R_L=1 kΩ represents the load.



(A) Analyse how well the circuit converts the AC sinusoidal voltage into a positive DC constant voltage over load resistor R_L.

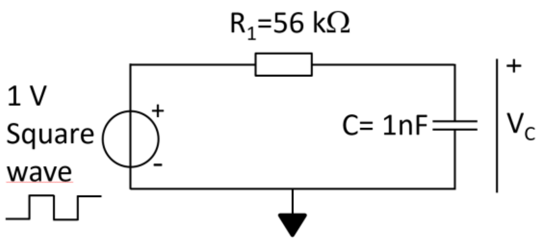
The conversion from AC to DC can be improved by adding a capacitor in parallel with the load as depicted in the schematic below.



(B) Analyse how well the circuit converts the AC sinusoidal voltage into a DC constant voltage over load resistor R_L when C=10 µF. Vary C and R_L and describe how the AC to DC conversion is affected.

Task 3: Charging and discharging of capacitor

Perform a transient simulation from t=0 s to t=5 ms of the circuit below. The circuit has a square wave voltage source with 0.5 ms at high voltage equal to 1 V and 0.5 ms at low voltage equal to 0 V. The capacitor of 1 nF will charge up (through R_1=56 kΩ) when the source voltage is high (1 V) and it will discharge (again through R_1=56 kΩ) when the source voltage is low (0 V). The circuit can be thought of as a simple model of how the node potentials in between digital gates change when the clock frequency of a digital circuit is varied.



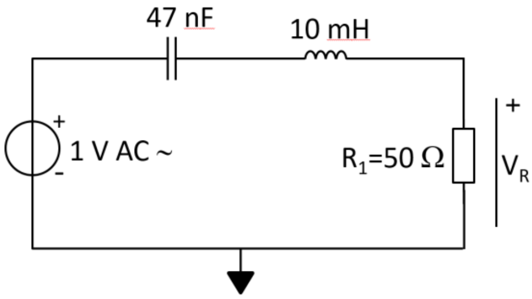
(A) Analyse how the voltage over the capacitor varies as a function of time and compare it to the square wave voltage source and the voltage over the resistor.

(B) Analyse how the voltage over a capacitor varies as a function of time when the frequency of the source voltage decrease ten times compared to Task 3A. Perform a transient simulation from t=0 s to t=50 ms and change the times at high/low voltages to 5 ms.

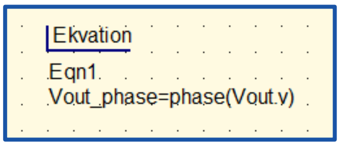
(C) Analyse how the voltage over a capacitor varies as a function of time when the frequency of the source voltage increase ten times compared to Task 3A. Perform the transient simulation from t=0 s to t=0.5 ms and change the times at high/low voltage to 0.05 ms.

Task 4. AC voltage over resistor in RLC series circuit

Perform an AC simulation from 1 Hz to 100 kHz of the circuit containing a resistor R, inductor L and capacitor C in series. The circuit has a sinusoidal voltage source with an amplitude of 1 V. In the task you should analyse how the sinusoidal voltage (amplitude and phase) over the resistor changes with the frequency of the voltage source.



After the AC simulation is finished, plot the voltage over the resistor (V_R) as a function of frequency. To analyse how V_R varies as a function of frequency it can be illustrative to use combinations of linear or logarithmic scales on the x and y-axis of the plots. Using the insert equation function in QUCS you can also find the phase of the voltage V_R by using the command phase(V_R).



Using the insert equation function in QUCS you can determine the phase of a current or voltage. In the example left Vout_phase is a variable that can be plotted in QUCS and it is the phase of the voltage Vout.

(A) Analyse what filter function is performed by the series RLC circuit by analysing what frequencies are present over R with an amplitude close to the source amplitude. Also analyse how the phase of V_R varies as a function of frequency? Describe why the amplitude and phase of V_R varies as it does.

(B) Perform the same analysis as in Task 4A but remove the inductor from the circuit so that the circuit consists of the capacitor in series with the resistor.

(C) Perform the same analysis as in Task 4A but remove the capacitor from the circuit so that the circuit consists of the inductor in series with the resistor.