Exercise 1:
Thévenin Equivalent & RC-Circuits

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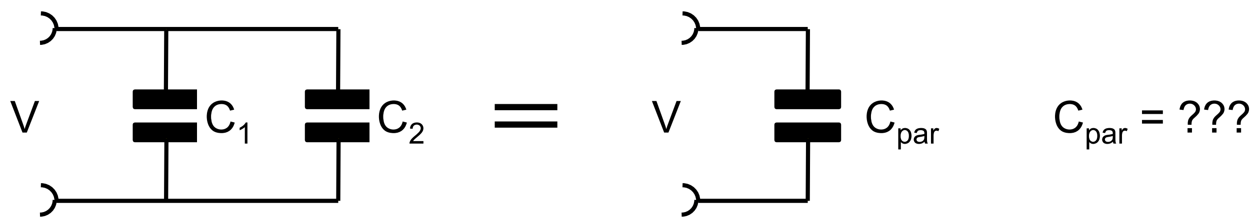
Recommendations

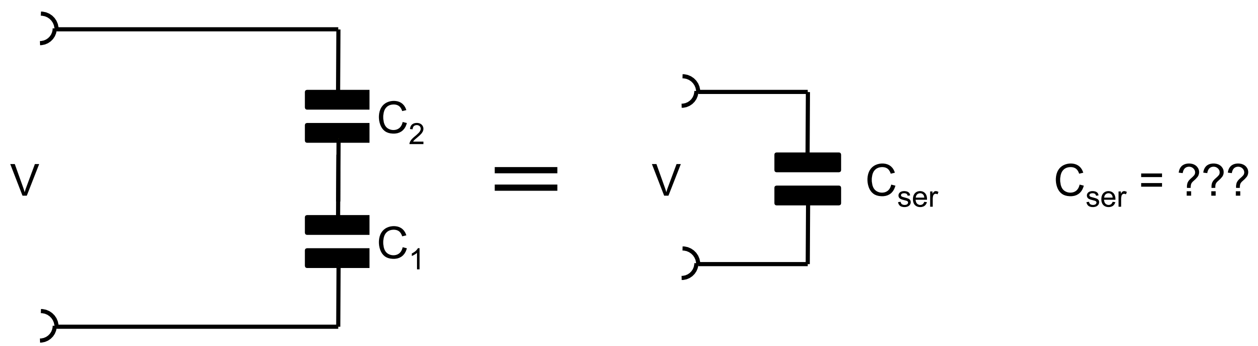
- I strongly recommend to use a mathematical program (Mathematica, Maple, SageMath,..) to solve the exercises

- Inspect each result:
  - What happens for $\omega \rightarrow 0,\infty$?
  - What happens if component values go to 0 or ∞?

Exercise 1.0

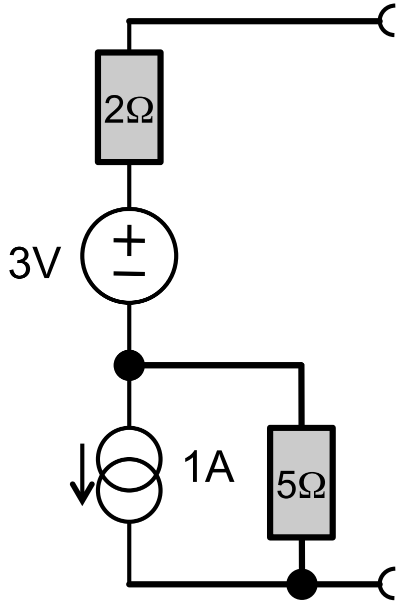
- Derive the expressions for the series and parallel connection of capacitors using
  - Charge conservation
  - Complex impedance & Kirchhoff's law





Exercise 1.1

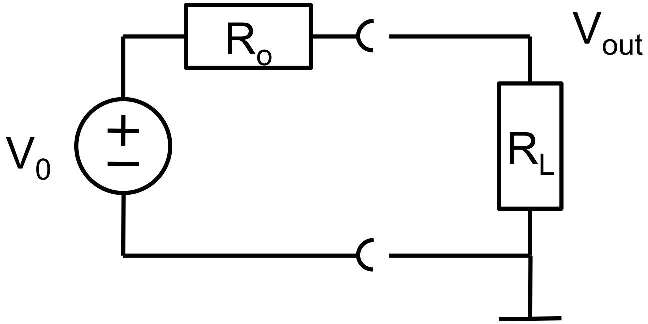
- Derive the Thévenin Equivalent for the following circuit:



- Try two different methods:
  - Use the Open/Short method with Kirchhoff's rules
  - Convert the I-source part to a voltage source first…

Exercise 1.2

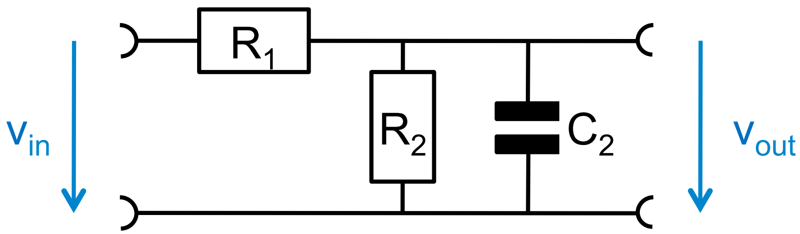
- A voltage source with voltage V_0 and output resistance R_0 is loaded by a resistor R_L:



- What is the output voltage V_{out} ?
- Which current flows in R_L ?
- What power is dissipated in R_L ?
  - Check that noting is dissipated for R_L=0 and $R_L \rightarrow \infty$
- For which value of R_L is the dissipation maximized?
  - What is the dissipation?

Exercise 1.3

- Derive the Transfer Function of this circuit:

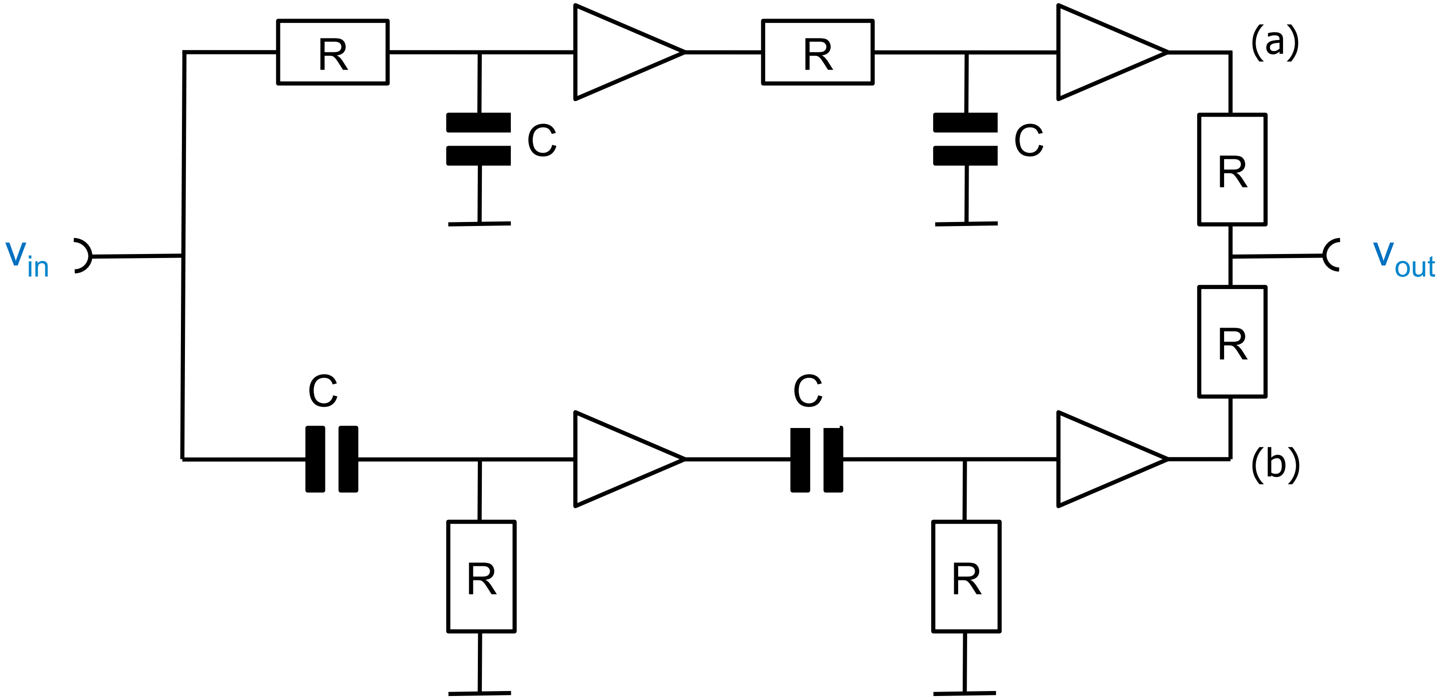


- Use 3 different approaches:
  - Treat the circuit directly (using Kirchhoff's rule)
  - Consider it as a voltage divider of two Impedances. Use R_1 for Z_1 and the parallel connection of R_2 and C_2 for Z_2
  - Replace the (resistive) voltage divider by its Thévenin equivalent and then add the capacitor

- Make a Bode Plot
  - Describe the difference to the normal Low Pass Filter

Exercise 1.4: Notch Filter

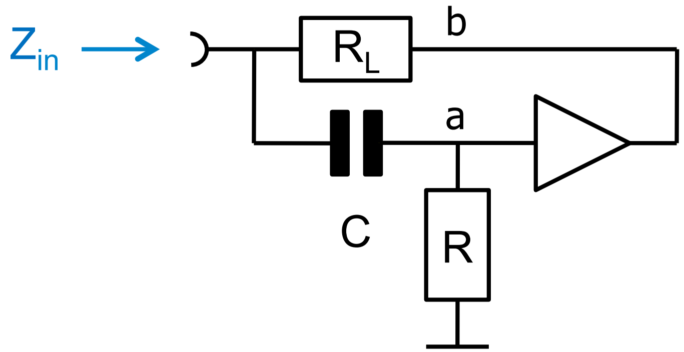
- Consider the following circuit made of cascaded High- and Low Pass stages:
  - The resistors at the output just add the signals at (a) and (b)



- What is the output signal at the corner frequency?
  - Explain this by comparing amplitudes ***and phases*** at (a) and (b)

Exercise 1.5: Gyrator

- A 'Gyrator' can mimic inductive behaviour, while using only resistors, capacitors and amplifiers
- Consider the following circuit:
  - the triangle is a voltage amplifier with gain=1 ('follower'). It forces node b to the potential of node a



- Calculate the input impedance $Z_{in} = U_{in}/I_{in}$ of the circuit
  - (Use Kirchhoff's law at the input node and node a)
- For frequencies < 1/C R_L, the denominator can be neglected.
- Compare the result to an inductor in series with R_L!