



Exercise: Abstract Circuits

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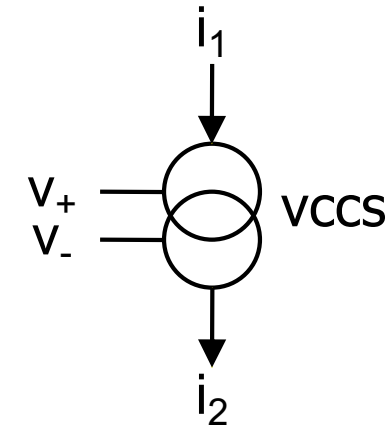
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Exercise 1: voltage controlled current source

- The drain current in a transistor depends on the gate voltage. It can therefore be considered as a **voltage controlled current source** 'vccs'
- In the analogLib, the vccs has a differential input and two outputs of opposite signs:

$$i_1 = G (v_+ - v_-), i_2 = -i_1$$
- Set up the following circuit
 - Use a vccs with gain = 100 μ S
 - Connect v_- to ground and v_+ to a dc voltage V_{IN}
 - Connect the i_1 and i_2 outputs to $V_{OUT1} = 1V$ and $V_{OUT2} = 1V$
- Now
 - Sweep V_{IN} (DC sweep, for instance from -1V to 1V) and observe the currents in the output voltage sources. Change the gain of the vccs and observe the effect.
 - Does the output **current** for a given V_{IN} depend on the V_{OUT} ?





Exercise 2: Idealized Amplifier 1

- Implement the following circuit:

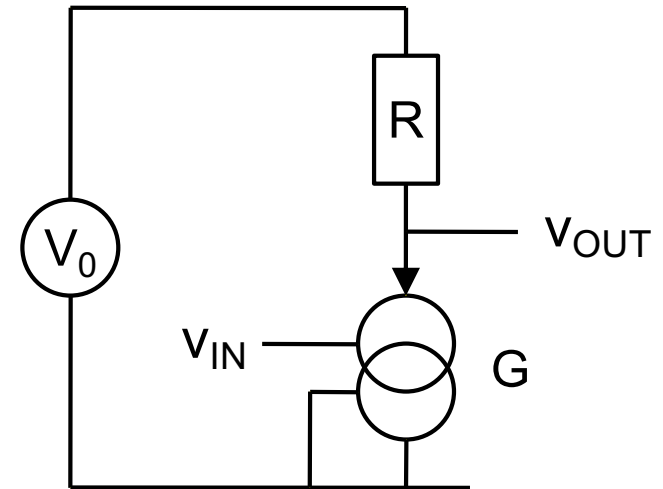
- The current from the v_{CCS} is sent to a resistor R

- Start with

- $G = 100 \mu S$
- $R = 2 k\Omega$
- $V_0 = 1 V$

- Simulate:

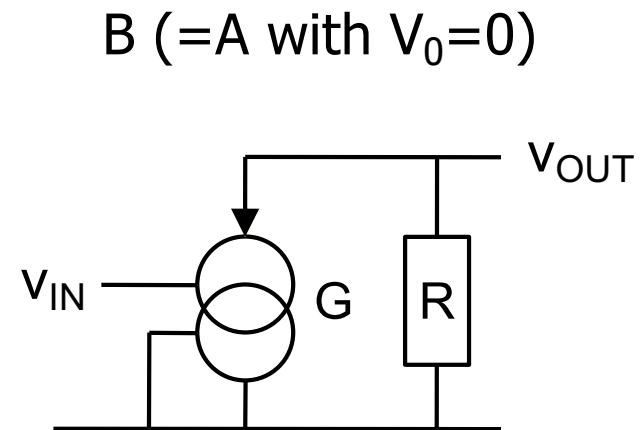
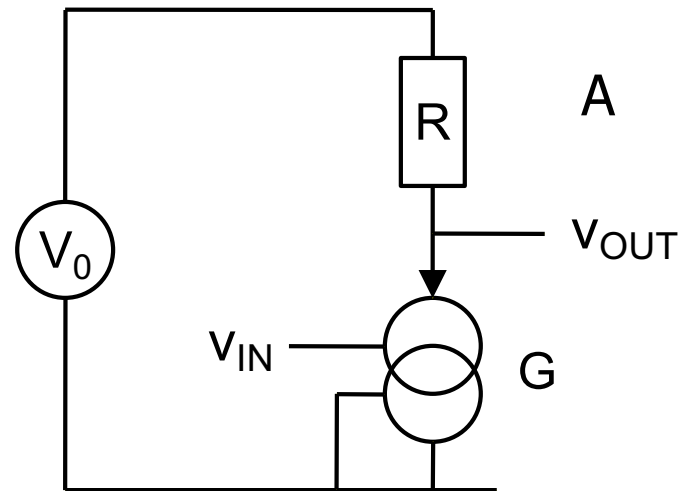
- How does v_{OUT} change when v_{IN} changes (e.g. from 0 to 1 V) ?
- Explain (Calculate) ! Write down the current equation at node v_{out} and use $i_{VCCS} = G v_{in}$
- What is the gain of the circuit dV_{OUT} / dV_{IN} ?
- Change R and G in your simulation. Is the effect as expected (as calculated)?



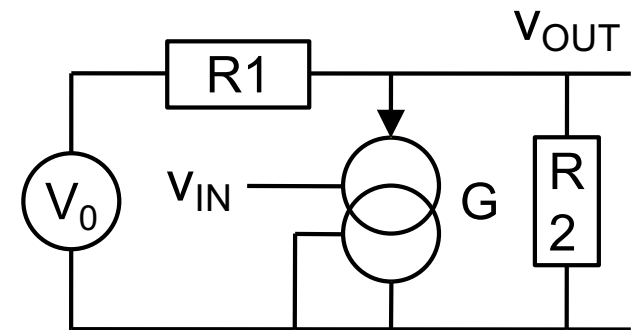


Exercise 3: Idealized Amplifier 2

- In the previous circuit, change V_0 . What happens with the *DC offset* of the output and with the *gain*? Explain!
- So, what is the difference between the following two circuits A,B ?



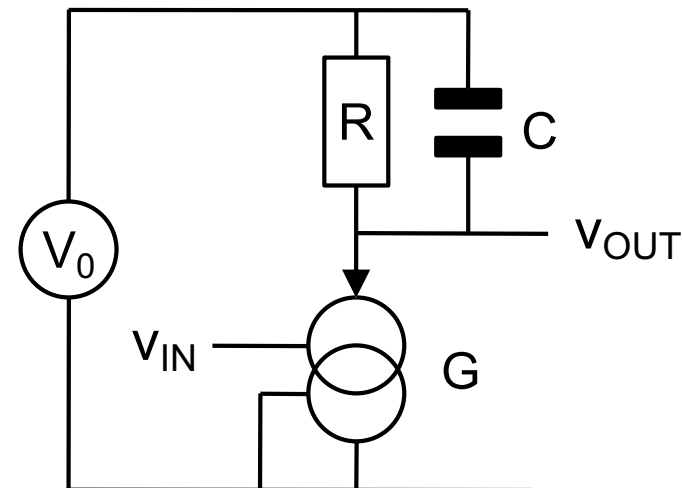
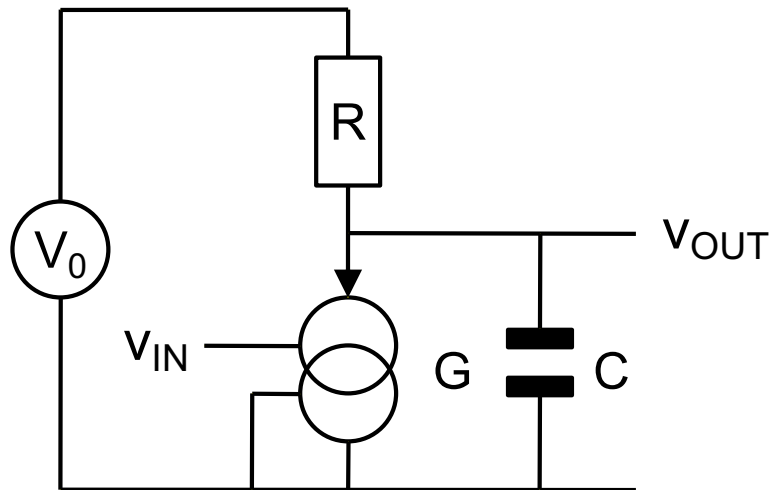
- **PREDICT** the gain ($V_{IN} \rightarrow V_{OUT}$) of the following circuit (Thévenin!):
- Verify this by simulation (for instance $R1 = 1 \text{ k}\Omega$, $R2 = 2 \text{ k}\Omega$)
- What happens when you exchange $R1$ and $R2$?





Exercise 4: Idealized Amplifier 3

- Load the output with a capacitor (1 pF) to ground (left) and make an *ac* sweep. What is the dc gain?
- Where is the corner frequency? Why?

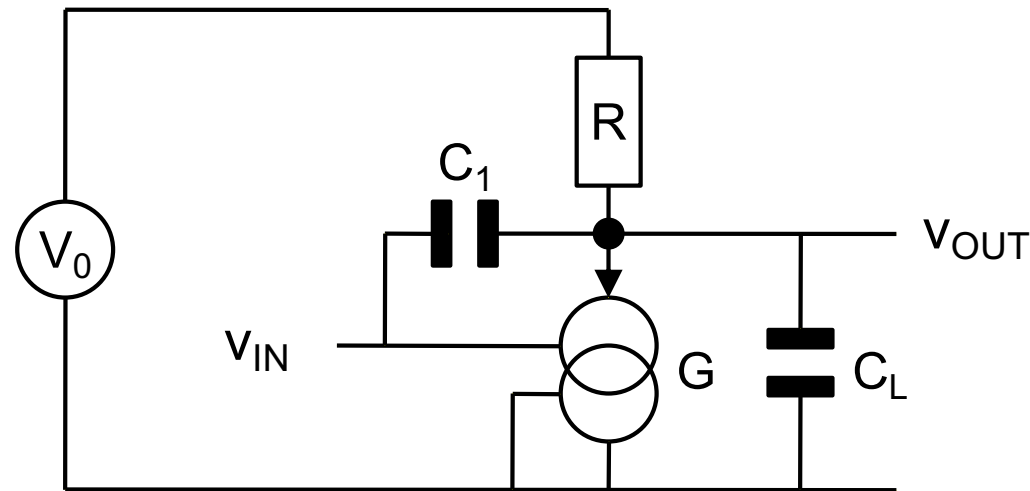


- Now try the right circuit. Is there a difference? Explain!
- Draw an equivalent circuit without V_0 !



Exercise 5 (advanced!): More capacitors

- Consider this circuit with an extra C_1 between V_{IN} and V_{OUT}



- Draw the circuit without V_0 !
- What gain do you expect at *dc* ? Sign?
- What gain do you expect for *very* high frequencies? Sign?
- Calculate the transfer function $H[s]$ and the gain
 - Verify your predictions
- Simulate the circuit



Exercise 5 cont. (For fun)

- Where is the pole, where is the zero?
- Chose the resistor value such that the pole and the zero are at the same frequency.
 - Does that always work?
 - What is the DC gain?
 - How does the transfer function look like?
 - What is the gain of the circuit vs. frequency?