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Exercise 5:
Abstract Circuits

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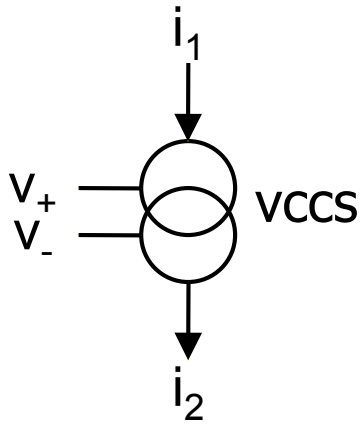
Exercise 5.1: voltage controlled current source

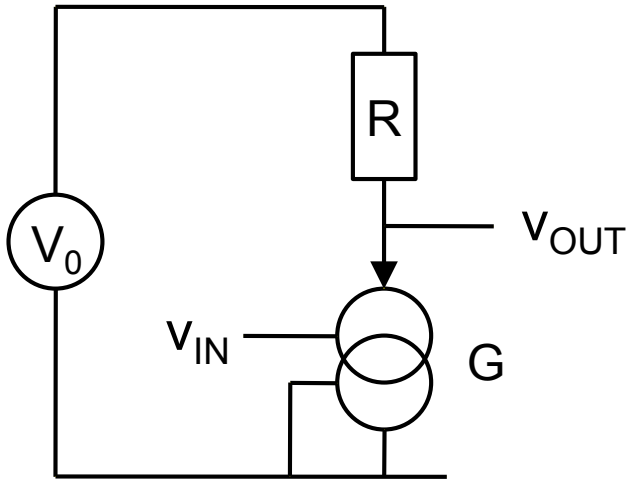
- The drain current in a transistor depends on the gate voltage. It can therefore be considered as a **v**oltage **c**ontrolled **c**urrent **s**ource 'vccs'



- 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 µS
  - 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 VIN (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} ?

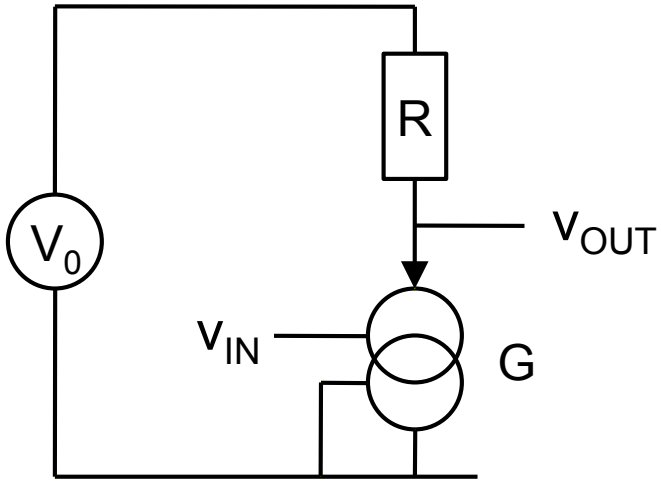
Exercise 5.2: Idealized Amplifier 1

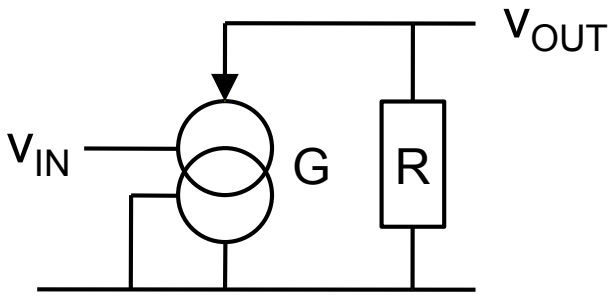
- Implement the following circuit:
  - The current from the vccs is sent to a resistor R
- Start with
  - G = 100 µS
  - R = 2 kΩ
  - V_0 = 1 V
- Simulate:
  - How does v_{OUT} change when v_{IN} changed (e.g. from 0 to 1 V) ?
  - Explain (Calculate) ! Write down the current equation at node v_{out} 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)?



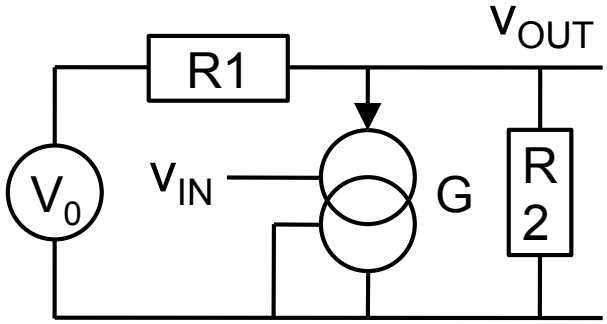
Exercise 5.3: Idealized Amplifier 2

- 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 ?



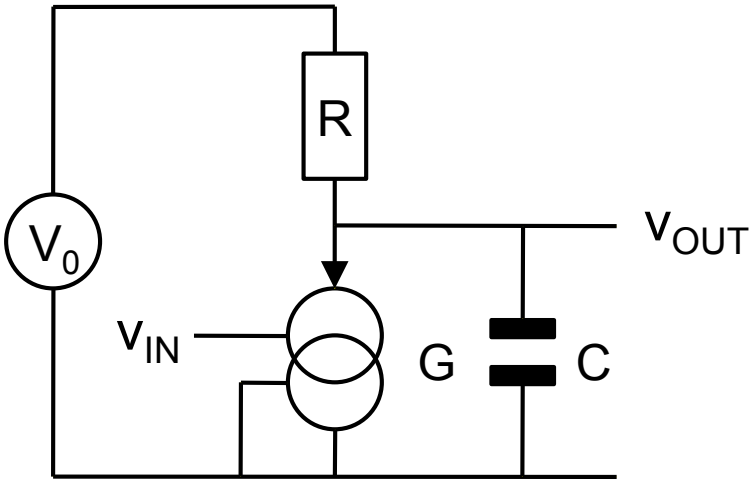


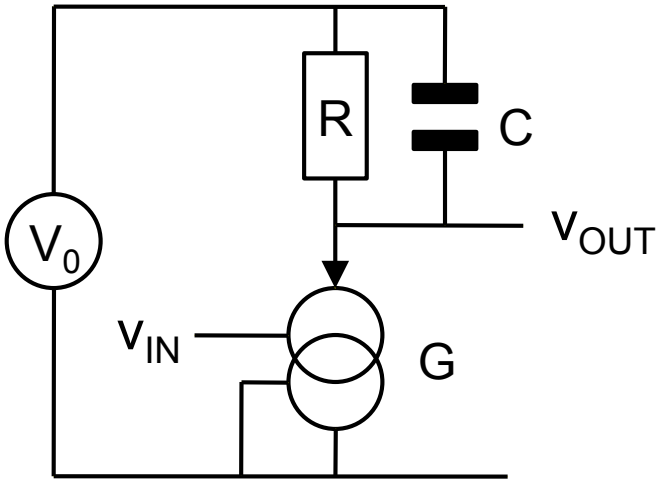
- PREDICT the gain ($V_{IN} \rightarrow V_{OUT}$) of the following circuit (Thénevin!):
- Verify this by simulation (for instance R1 = 1 kΩ, R2 = 2 kΩ)
- What happens when you exchange R1 and R2?



Exercise 5.4: 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?

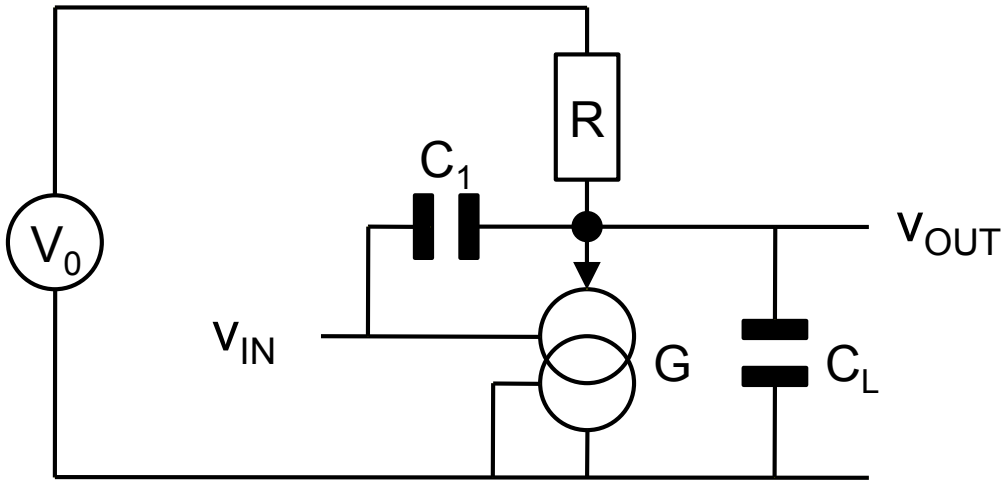




- Now try the right circuit. Is there a difference? Explain!
- Draw an equivalent circuit without V_0!

Exercise 5.5 (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