LTspice – Part 1

First Steps

NETZWERK TEILCHENWELT

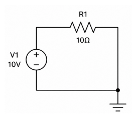
1 First Steps in LTspice

You can find the most important functions in the toolbar, or by right-clicking empty space in the schematic.

Things you should try out:
- Insert components
- Move components
- Rotate components (Shortcut: crtl+R)
- Change component values (right-click on component)
- Draw and connect wires
- Add ground and voltage sources (Shortcuts: G, V)
- Start a simulation (run)

Tips:
- Nothing works in LTspice without a ground symbol
- Before running a simulation you need to define the simulation time by adding a spice directive e.g.: .tran 500u
- After simulating, clicking on a wire shows you a voltage
- After simulating, clicking on a component shows you a current

Task:
Build a very simple test circuit consisting of a voltage source, a resistor and a ground symbol.



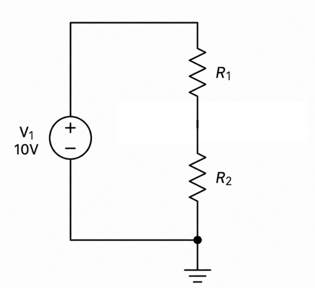
Questions:
- What voltages are present in the circuit?
- What current flows through R1=10Ω for U1=10V ?
- Why does LTspice need at least one ground symbol?

2 Exercise: Voltage Divider

Requirements:
- Voltage source: 10 V
- Resistors: 10 Ω and 10 Ω
- One ground symbol

Task:
Build a voltage divider using two resistors in series. Run a simulation and measure the voltage:
- before the first resistor
- between the two resistors

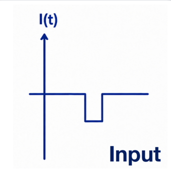
Vary the values of the resistors and evaluate again after rerunning the simulation

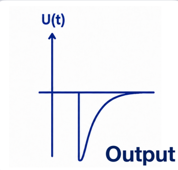


Questions:
- What voltage is present between the two resistors?
- What happens if one of the resistors becomes larger?
- Describe qualitatively how a voltage divider works.

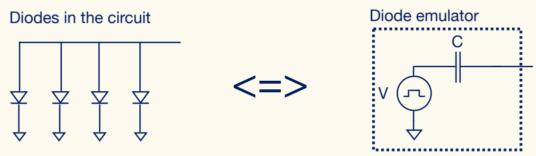
3 Completing the Detector Schematic – Concept

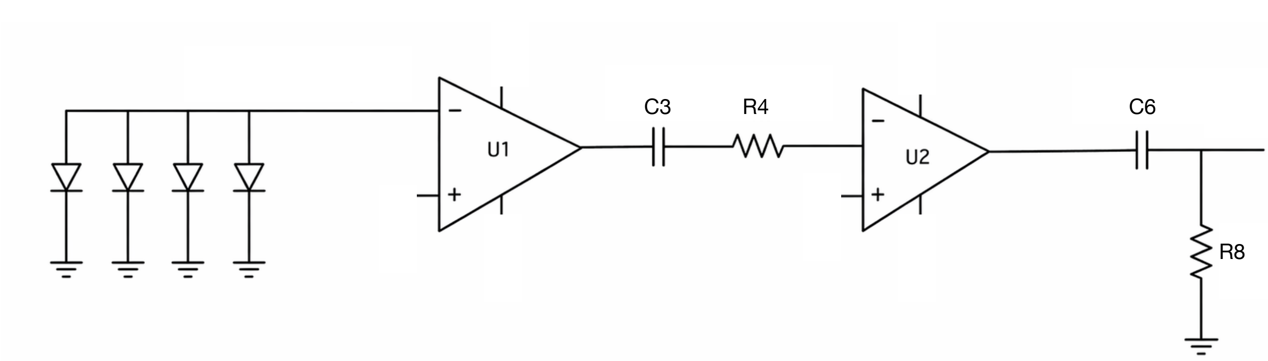
Task:
Look at the schematic and write down what components the circuit is missing to convert a current pulse to an amplified voltage pulse. You don't need to add values for now.





Hint:
In the simulation, we emulate the short current pulse of the four diodes by charging a small capacitor.





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LTspice - Part 2

Simulation

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4 Completing the Detector Schematic

Open the file circuitunfinished.asc in LTspice. It contains the circuit from Task 3. In the "Diode Emulator" box on the left, a short current pulse, similar to an event in a diode, is simulated by charging a small capacitor. Do not change the values of this voltage source and capacitor for now.

Task:
Complete the circuit diagram in LTspice based on your ideas from Task 3 in order to obtain a negatively amplified output voltage.

a) Power supply;

- Add **one** 9 V voltage source
- The negative output of the voltage source needs to be grounded
- The positive supply of U1, U2 needs 9 V
- The negative supply of U1, U2 is grounded

Questions:

- Which output voltages can an ideal OP-Amp create with these supply voltages?

b) Reference Voltage:

Use the same 9 V voltage source to apply reference voltages to the non-inverting inputs

- 8V at the non-inverting input (+) of U1
- 4.5V at the non-inverting input (+) of U2

Questions:

- Why does U1 need 8 V at the + input?
- Why does U2 need 4.5 V at the + input?

c) Feedback:

The second amplification stage still needs a feedback loop.
Add a feedback loop to get a gain of -100.

Questions:

- Which components determine the gain at U2?
- Which formula describes the gain at U2?

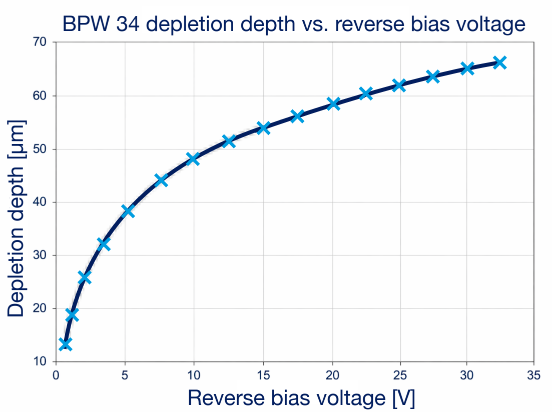
5 Detector Simulation

Task:
Run a transient simulation to test the detector function.

Questions:

- How large is the pulse amplitude after U1?
- How large is the output signal?
- Determine the conversion factor of the first stage in U/Q [V/C]
- Determine the gain factor of the second stage [V/V]
- Does the simulation agree with the theoretical expectations?
- How do the DC voltage levels behave throughout the detector?

6 MIP Signals



Task:
Adjust the capacitance in the diode emulator to generate the charge of a Minimum Ionizing Particle (MIP) from a voltage step of 50 µV.

Tips:

- A MIP creates approximately 60–80 electron-hole pairs per µm in silicon.
- Elementary charge: $e = 1.602 \cdot 10^{-19}\,C$
- In the diode emulator: Q = CU
- Typical noise level in the detector: ~+-10 mV

Task:

- How large is the output signal?
- Can we detect MIPs with the detectors?

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