Steam4Climate Worksheet for students

Project: Sustainable housing for older students

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EU Project Consortium

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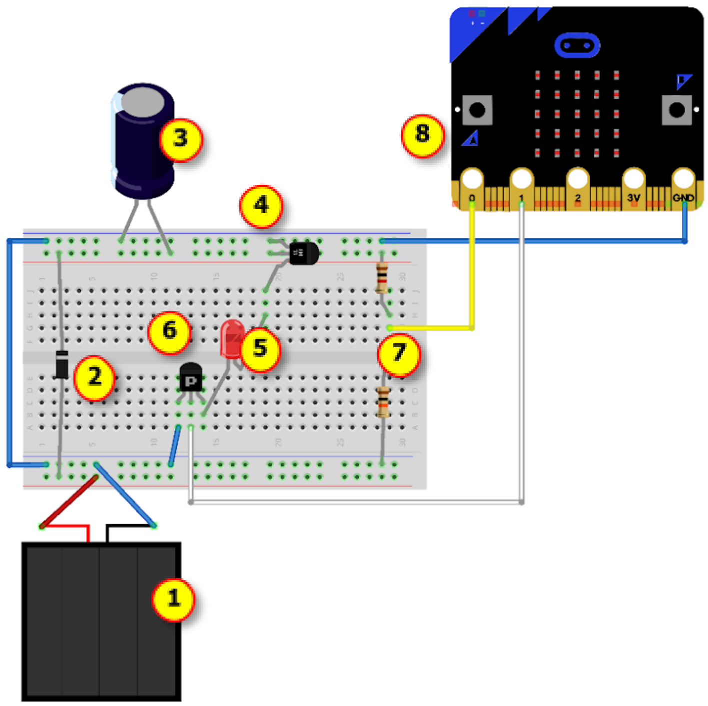
1.6 Solar Panel for Older Students (Technology Lessons from Grade 9)

A small solar storage system is to be built **step by step**! To do this, we first create a simple model, which is to be refined further and further. Here is **the final result** in full expansion stage with all the necessary materials:



(1) Solar panel ***(5V, 300mA)***

(2) Schottky diode ***(1N5817)***

(3) Electrolyte cond. ***(10mF)***

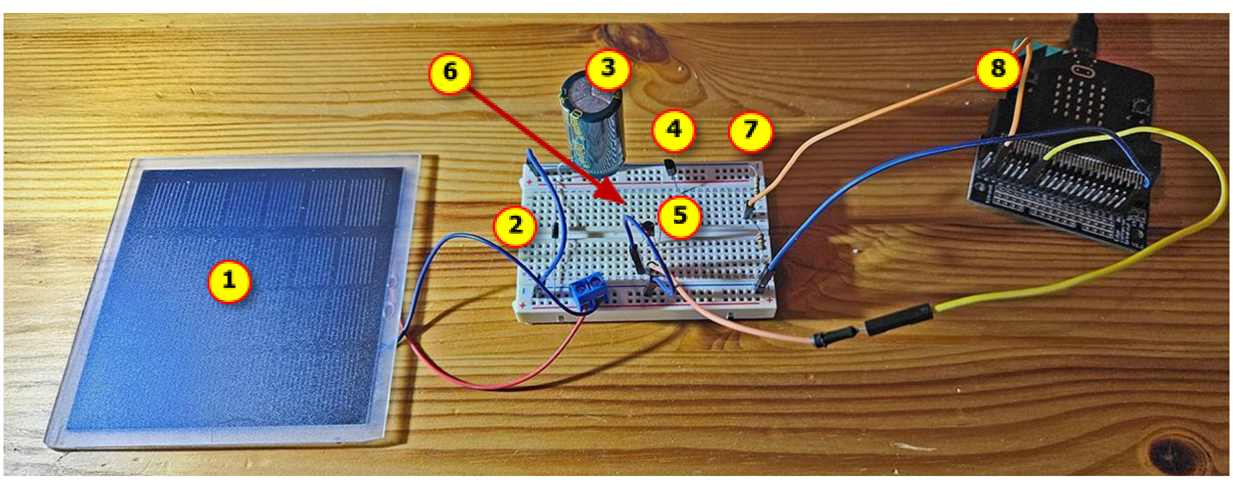
(4) LDO ***(MCP1700-3302E)***

(5) LED / Motor ***(low current)***

(6) N-Channel Mosfet ***(2N7000)***

(7) Voltage divider ***(10kΩ)***

(8) Microbit



Explanation of the circuit:

(1) The solar panels generate a voltage of 0 to 5 volts, depending on the light intensity. You can't operate an electrical system with this alone.

(2) The Schottky diode prevents stored electricity from flowing back into the solar cell in the dark.

(3) The capacitor serves as an uncomplicated energy storage device.

(4) The LDO ("Low Drop Out") linear regulator produces a fixed output voltage of 3.3 volts, regardless of the input voltage. This applies as long as the input voltage is about 0.1 volts above the 3.3 volt output voltage. This protects both the LED and the motor – but there is a power loss.

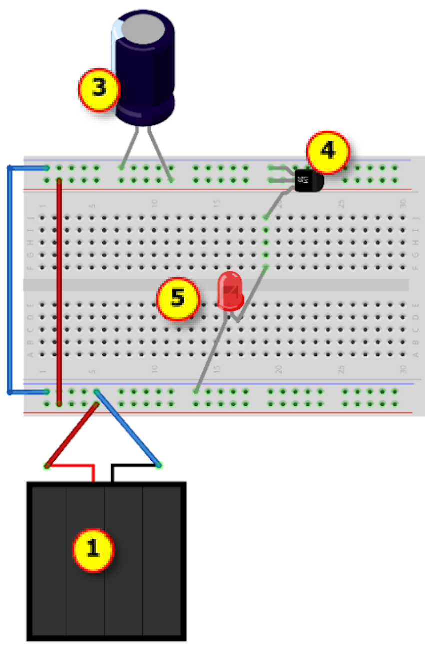
(5) The load to be powered, i.e. either an LED or a low-voltage motor with a nominal voltage of 3 volts.

(6) The mosfet serves as a switch. It requires the programming of the microbit as a control unit. Imaginary functionality: The microbit measures the voltage at the capacitor and thus its energy charge. Above a threshold, the microbit turns on the mosfet, causing the LED or motor to start running.

(7) Voltage divider circuit: The Microbit as a control unit can only measure a voltage up to a maximum of 3.3 volts; if the voltage exceeds this, the microbit is destroyed. Therefore, the voltage is reduced to half.

(8) In the last, highest expansion stage, the microbit serves as a control computer.

Circuit 1: Make an LED light up:



(1) Solar panel ***(5V, 300mA)***

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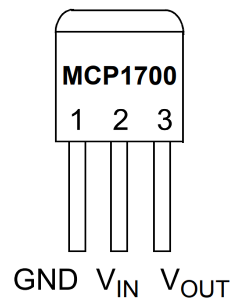
(4) LDO ***(MCP1700-3302E)***

(5) LED / Motor ***(low current)***



Build the circuit as shown above. The following things are important:

- The polarity of the solar cell. It has a + and a – side

- The polarity of the capacitor is particularly important! **If the polarity is wrong, the component can explode,** so always take special care when working with it. Do you see the slight notches on top of the component? There, if the worst comes to the worst – if you are careless – the capacitor would burst first

- The LED has a long and a short leg. The long leg has to be on the + side, i.e. on the side of the LDO. You connect the - page to Ground.

- The LDO has a flat front. When you look at it, connect the legs as shown in the picture above. GND means
  : to the negative pole, **VIN:** to the capacitor side, **VOUT:** to the LED side

  Answer the following questions about Circuit 1 by experimenting with it:

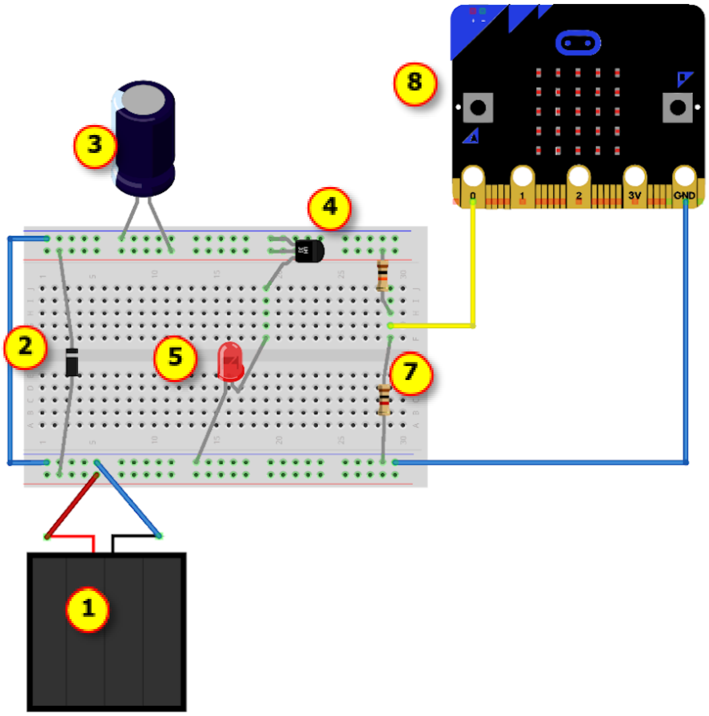
- What changes if you tilt or cover the solar cell differently? Can you explain why this happens?

- How does the circuit behave when you take out the capacitor? And then plug it in again? What does the capacitor do?

- What does the LDO do? Take it out and connect the LED directly to the capacitor. Attention: The LED may break here, so do not work with bright light!

- Remove the LED and install the motor instead. What do you observe? Explain the behavior compared to the LED.

Circuit 2: "If you measure, you don't have to guess"



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(4) LDO ***(MCP1700-3302E)***

(5) LED ***(low current)***

(7) Voltage divider ***(10kΩ)***

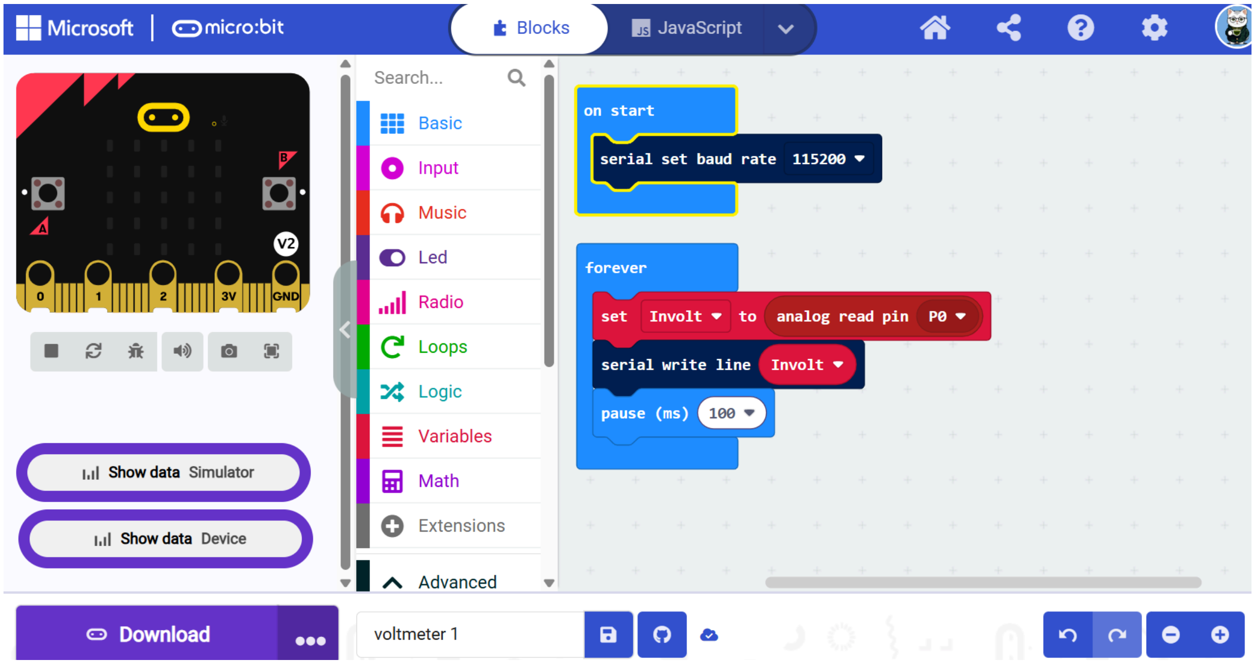
(8) Microbit

Build the circuit as shown above. The following things are important:

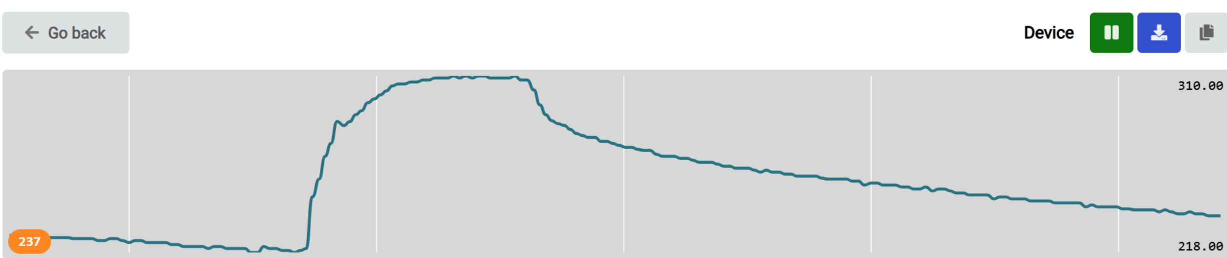
- The Schottky diode must point away from the solar cell with the silver ring towards the + pole of the electrolytic capacitor. Their purpose is to act as an outlet. Solar cells can absorb the electricity supplied in the dark. Therefore, a valve must be interposed. But this comes at a price: In order to be able to work, the Schottky diode takes a little bit of voltage and thus energy away from the solar cell voltage, and a little less energy arrives.

- The voltage divider protects the microbit: The solar panel generates a maximum of 5 volts, but the microbit is destroyed above 3.3 volts. The voltage divider reduces the voltage that the microbit sees.

Program the microbit to circuit 2 with the Makecode project.



If you have downloaded the code to your Microbit, then by clicking on "Show Data Device" under the Microbit image, you can see a measurement curve that looks similar to this one:



Answer the following questions about Circuit 2 by experimenting with it:

Then measure the voltages on your circuit.

- How do the measured values change when the solar panel is covered, when the solar panel is tilted? Or in the shade? Explain your observations

- Remove the Schottky diode from the circuit and replace it with a cable. If you now cover the solar cell completely, how does the temporal voltage curve that you measure with the microbit change?

- Can you use a multimeter to measure the voltage drop on the Schottky diode? Assess "how expensive" the diode is. Is it worth it?

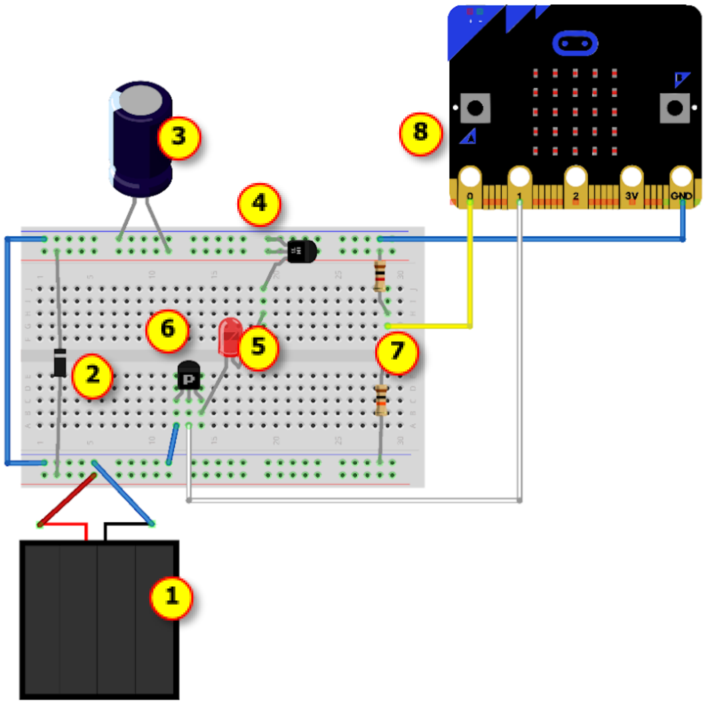
- How does a voltage divider actually work? What maximum voltage does the microbit measure with the current circuit?

- Could the voltage divider perhaps be improved with other resistance values: The goal is to have the largest possible measuring range, in the best case from 0 to 3.3 volts

- Charge and discharge curve: Draw the measurement curve in your notebook that your microbit measures. If you then cover the solar cell, you can see the discharge curve. Describe the curve shape in your own words.

- Replace the LED with the motor. What changes do you see in the behavior of the circuit? Can you explain that?

Circuit 3: "Turn on and off at the right moment"



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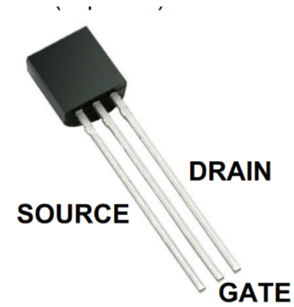
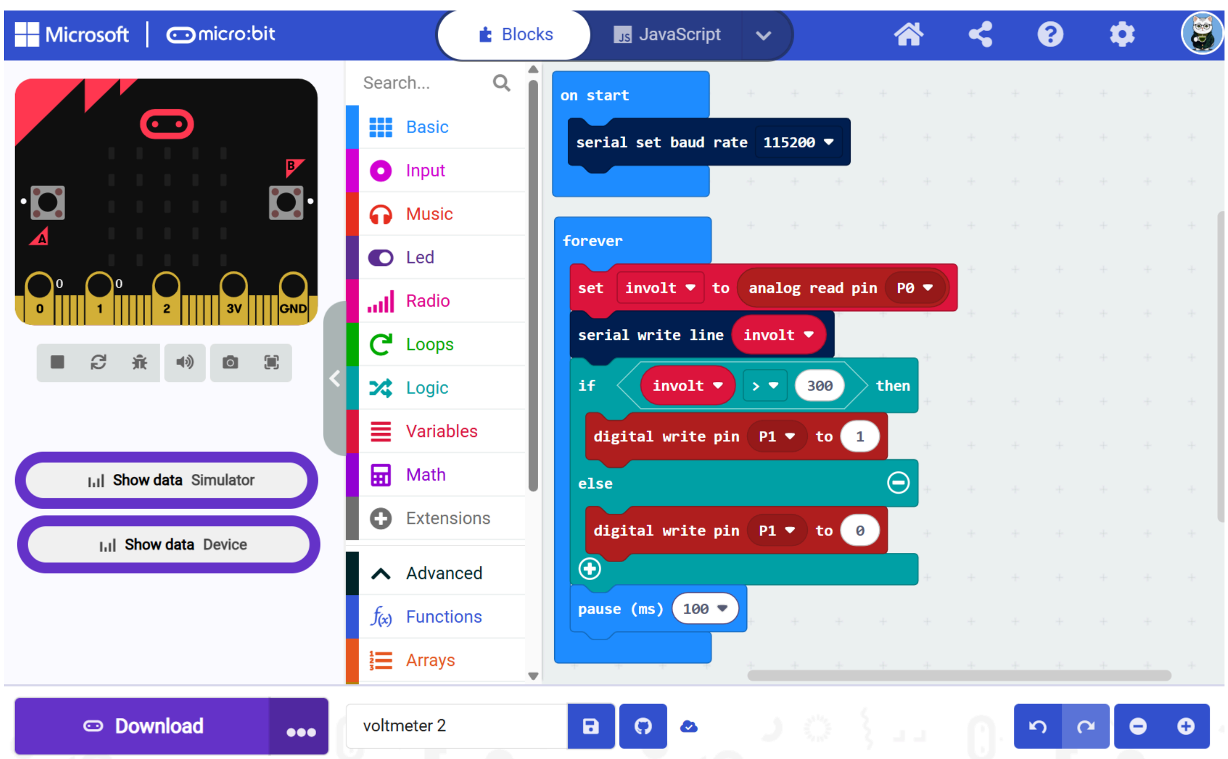
Build the circuit as shown above. The following things are important:



The energy supply of your capacitor does not last forever, but your LED should always receive the same voltage. So if the voltage of the capacitor collapses, the LED must be switched off. The microbit decides this through its measured values: If the measured value falls below a value reasonably determined by you, it is switched off. If the measured values rise again, it can be switched on again.

This function is done by the mosfet (an electronic switch): **Source** is connected to Minus (GND), **Gate** to Pin2 of the Microbit, **Drain** to the + side (on the LED)

Program the microbit to circuit 3 using the Makecode project.



Pin 0 on the microbit is again used for data acquisition. Pin 1 controls the mosfet and thus the circuit state of the entire circuit. In order for the circuit to be properly controllable, a decision must be made depending on the measured value. **Which programming construct or command enables this decision**?

Answer the following questions about Circuit 3 by experimenting with it:

- First, explain the programming. What is the 'If' branch for?

- Change the numerical value in the 'If' condition. What does it do?
  Can the value be optimized? What optimization criteria did you choose?

- Remove the LED and replace it with the motor. How does the circuit behave now?
  How can you optimize now?

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