Project Work at MPIK

Temperature control system

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1 Experimental setup

A temperature sensor, a heater and a cooler are to be connected to a Arduino board. In order for it to work we need to have shifters for the voltage range to fit the inputs/outputs on the Arduino. This was first done by Vanessa Scheller using cables and a breadboard, I took her design and reworked it to be used on a milled circuit board and SMD parts.

1.1 Temperature sensor circuit

The circuit for the temperature sensor looks as follows:

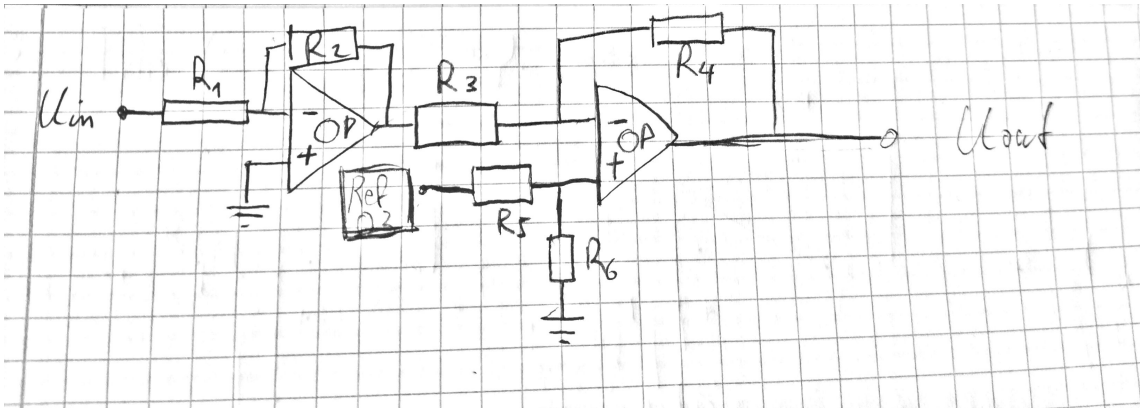

Figure 1: Temp. sensor shifter circuit

The input range from the temperature sensor we are interested in is

$$-1.6V < U_{in} < 1.6V$$

The supply voltage of the op-amps is 15V. We want to have a cutoff after the first op-amp at the input range boundaries. This can be achieved with setting the amplification factor with R_1 and R_2. The output range should equal the input range of the Arduino analogue input which goes form 0-3.3V. The values found for the resistances are as follows (in $k\Omega$):
$R_1 = 15k\Omega$
$R_2 = 133k\Omega$
$R_3 = 133k\Omega$
$R_4 = 12k\Omega + 10k\Omega$ potentiometer
$R_5 = 10k\Omega$
$R_6 = 15k\Omega + 5k\Omega$ potentiometer

This gives to following response to the input Voltage U_{in}

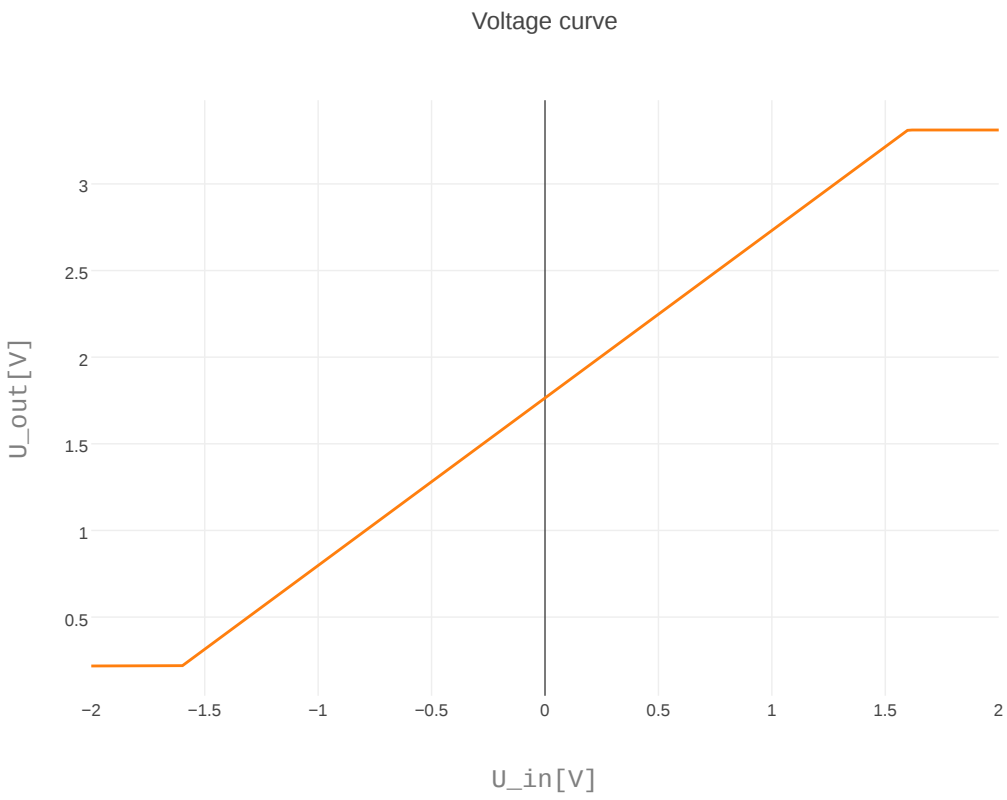

Figure 2: Theoretical response of temp. shifter

1.2 Heater, cooler circuit

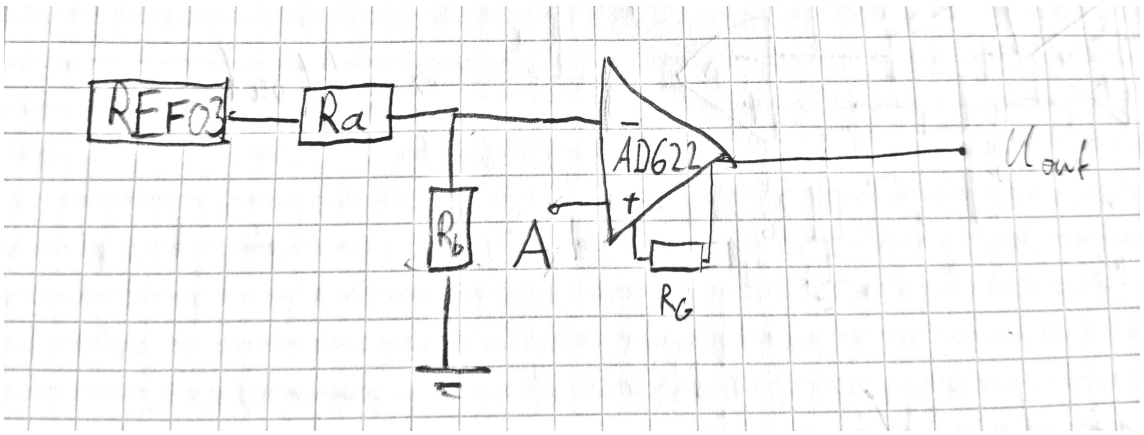

Figure 3: Heater/cooler shifter circuit

The output range from the Arduino's DAC is

$$0.55V < U_{DAC} < 2.75V$$

The regulation voltage from the heater and cooler is 0 to 10V. First the voltage from the DAC out needs to be reduced by 0.55V and then amplified such that the maximum out from the DAC corresponds to the maximum in from the heater/cooler. The amplification is set with the resistance RG. The values found by Vanessa are (in $k\Omega$):
$R_a = 3.92k\Omega + 5k\Omega$ potentiometer
$R_b = 1k\Omega$
$R_G = 27k\Omega + 10k\Omega$ potentiometer

The output here can be described by the amplified difference of the two input voltages. The amplification factor was adjusted such that it gives the needed output range. To both circuits many capacitances are added, which are only for filtering the input +15V/-15V and the ref03 voltages from AC parts. This is done with 10nF and 100nF capacitances in parallel.

1.3 Realization of the circuitboard

All of the circuits were realized using a smd board. The circuitboard was constructed using EAGLE Professional and made with a circuit board cutter. It has the same proportions as the used arduino due, such that it fits into the enclosure thats already existing.

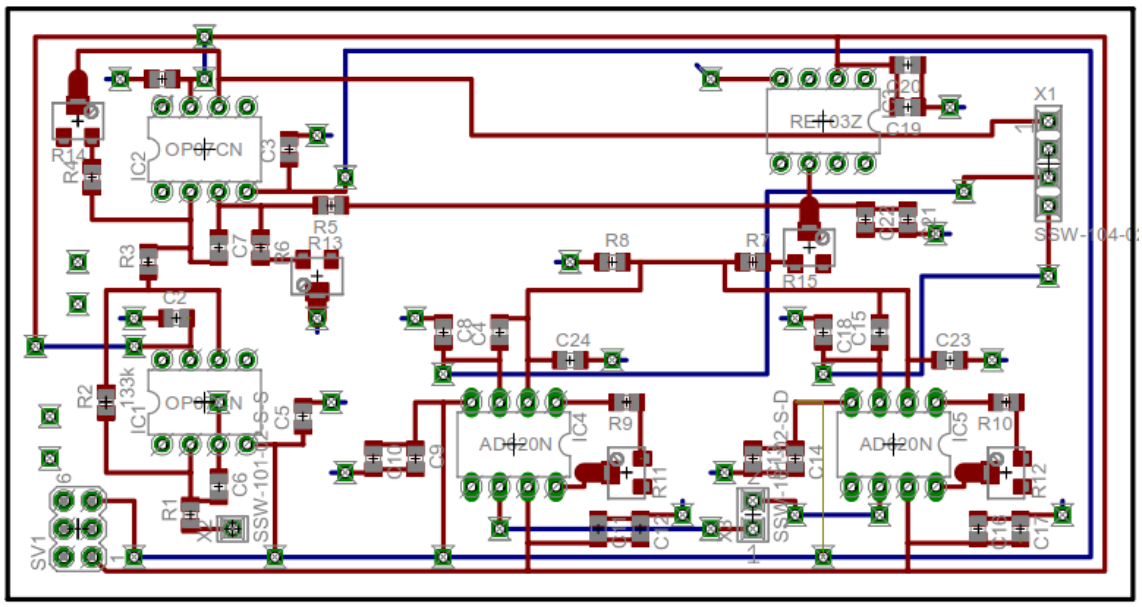

Figure 4: Circuitboard layout

The resistors and the capacitances are directly soldered onto the board, while the OP07 and the AD622 (not 620 as on the image) are put onto headers. The complete board is shown here in fig. 5.
Notice that the header for the left AD622 was placed in the opposite direction, such that the marker for the top is actually on the other side than the top is supposed to be.
Also some of the capacitances were not soldered in, on the design of the board they were made as a precaution.
It was found that the heater/cooler cables add a capacitance which lead to oscillations on the temperature measurement. We added 100Ω resistors on the heater/cooler output to resolve the issue.
In fig. 6 we see the board connected to the Arduino with the Ethernet Shield 2 on top.

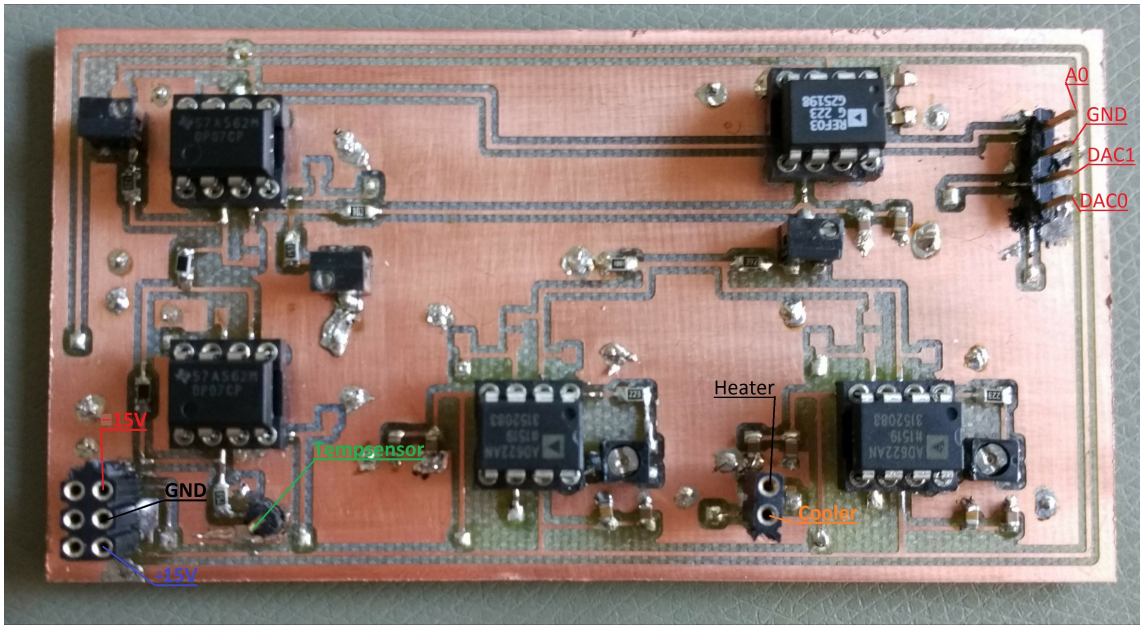

Figure 5: Circuitboard picture

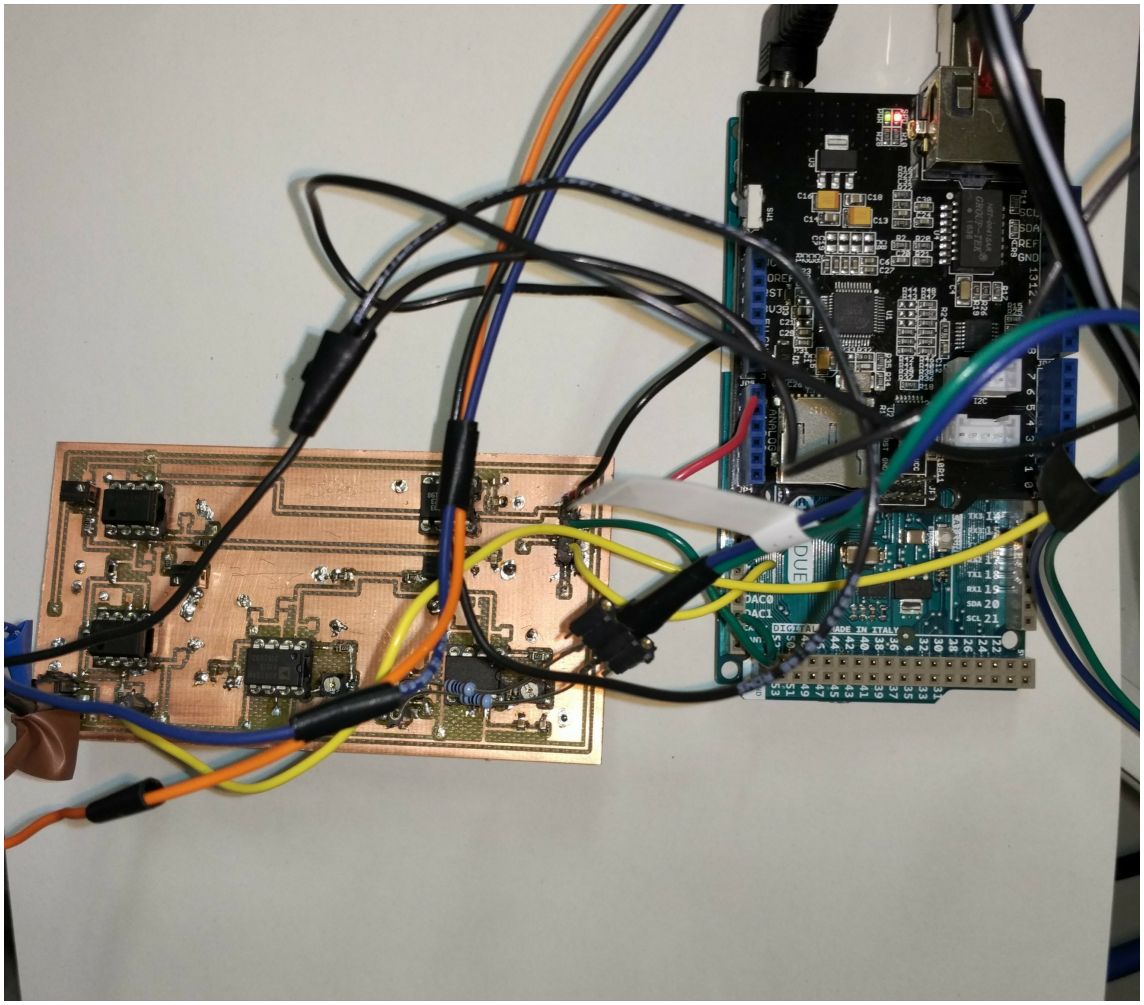

Figure 6: Board connected to Arduino