CREATIVE ELECTRONICS REPORT

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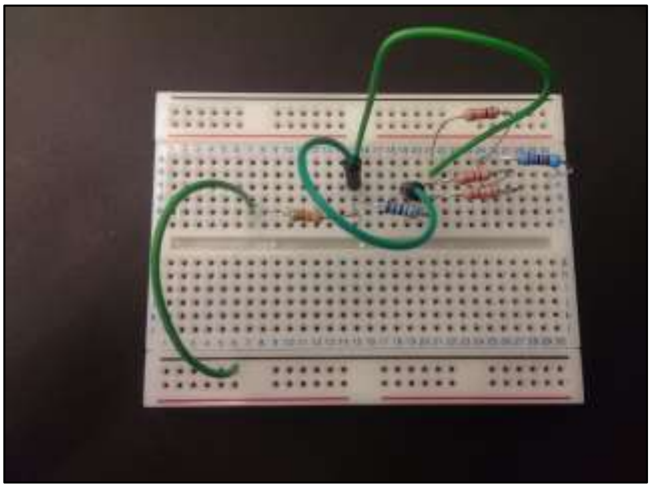
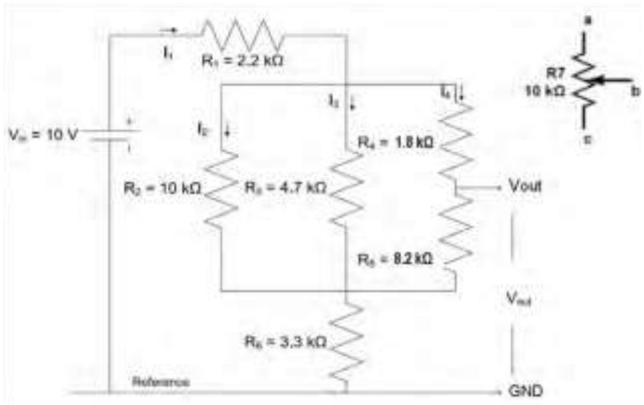
Practical assignment 1





The electrical circuit we built

1. See the photo above

2. Measured:

R_{tot}=7,5 kΩ
I_1=1,3 mA
I_2=0,29 mA
I_3=0,5 mA
I_4=0,6 mA
V_{out}=6,05 V

6. The resistance value we measured between B and C is R=3Ω
The resistance value we measured between A and C is R=10,1Ω

7.

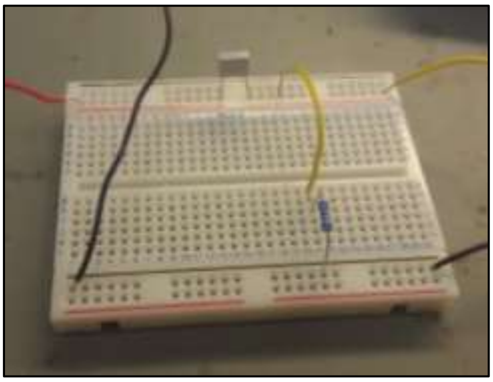
R_{45}=3+10,1=13,1kΩ
R_{2345}=2,56 kΩ
R_{tot}=2,2 +2,56+3,3=8,06 kΩ

I_{tot}=I1=10/8,06=1,24mA
V_1=1,24·2,2=2,73 V
V_6=1,24·3,3=4,09 V
V_{2345}=10-2,73-4,09=3,18 V

$I_4=I_5=V_{45}/R_{45}$=3,18/13,1=0,25 mA

$V_5=I_5 \cdot R_5$=0,25·3,0=0,75 V
V_6=4,09 V
$V_{out}=V_5+V_6$=4,84 V

Practical Assignment 2



We set up the function generator and split it output signal to both the oscilloscope (channel 1) and to our circuit on our breadboard. We then connected the Vout of our circuit to channel 2 of the oscilloscope. We adjusted the function generator so that we generated a 2V top-top sine wave.

We then measured Vout of circuit (a), (b) and (c) with the oscilloscope. These results are visible in the table below.

Calculations

$X_c = \frac{1}{2\pi \cdot f \cdot C}$, $R_{re} = R_1 + R_2$, $Z = \sqrt{R_{re}^2 + X_c^2}$, $V_{out} = \frac{R}{Z} \cdot V_{in}$ and

$$V_{out} = \frac{X_c}{Z} \cdot V_{in}$$

Circuit (b):

$$100hz\text{: } V_{out} = \frac{R}{Z} \cdot V_{in} = \frac{1000}{\sqrt{1000^2 + \left(\frac{1}{2\pi * 100 * (1{,}0 \cdot 10^{-7})}\right)^2}} \cdot 2 = 0.125\ V$$

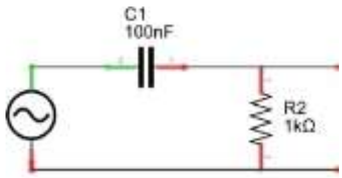


Figure 1Circuit b

$$1{,}000hz\text{: } V_{out} = \frac{R}{Z} \cdot V_{in} = \frac{1000}{\sqrt{1000^2 + \left(\frac{1}{2\pi * 1000 * (1{,}0 \cdot 10^{-7})}\right)^2}} \cdot 2 = 1.06\ V$$

$$100{,}000hz\text{: } V_{out} = \frac{R}{Z} \cdot V_{in} = \frac{1000}{\sqrt{1000^2 + \left(\frac{1}{2\pi * 100000 * (1{,}0 \cdot 10^{-7})}\right)^2}} \cdot 2 = 2.00\ V$$

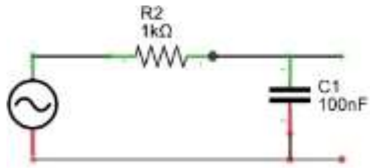


Figure 2 Circuit c

Circuit (c):

$$100hz\text{: } V_{out} = \frac{X_c}{Z} \cdot V_{in} = \frac{\frac{1}{2\pi * 100 * (1{,}0 \cdot 10^{-7})}}{\sqrt{1000^2 + \left(\frac{1}{2\pi * 100 * (1{,}0 \cdot 10^{-7})}\right)^2}} \cdot 2 = 2.000\ V$$

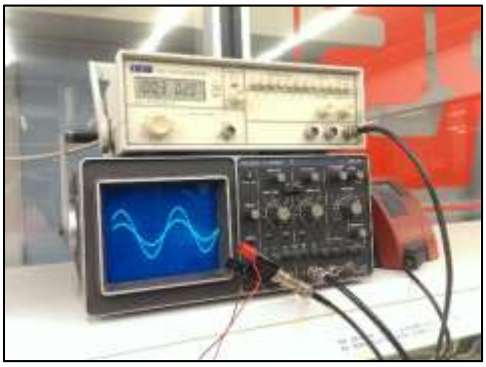
$$1{,}000hz\text{: } V_{out} = \frac{X_c}{Z} \cdot V_{in} = \frac{\frac{1}{2\pi * 1000 * (1{,}0 \cdot 10^{-7})}}{\sqrt{1000^2 + \left(\frac{1}{2\pi * 1000 * (1{,}0 \cdot 10^{-7})}\right)^2}} \cdot 2 = 1.06\ V$$

$$100{,}000hz\text{: } V_{out} = \frac{X_c}{Z} \cdot V_{in} = \frac{\frac{1}{2\pi * 100000 * (1{,}0 \cdot 10^{-7})}}{\sqrt{1000^2 + \left(\frac{1}{2\pi * 100000 * (1{,}0 \cdot 10^{-7})}\right)^2}} \cdot 2 = 0.0318\ V$$

Measurements

To measure the voltage, we multiplied the amount of divisions between the tops in the y-axis by the volts/div setting. These measurements were very similar to our calculations.

High or low pass filter?



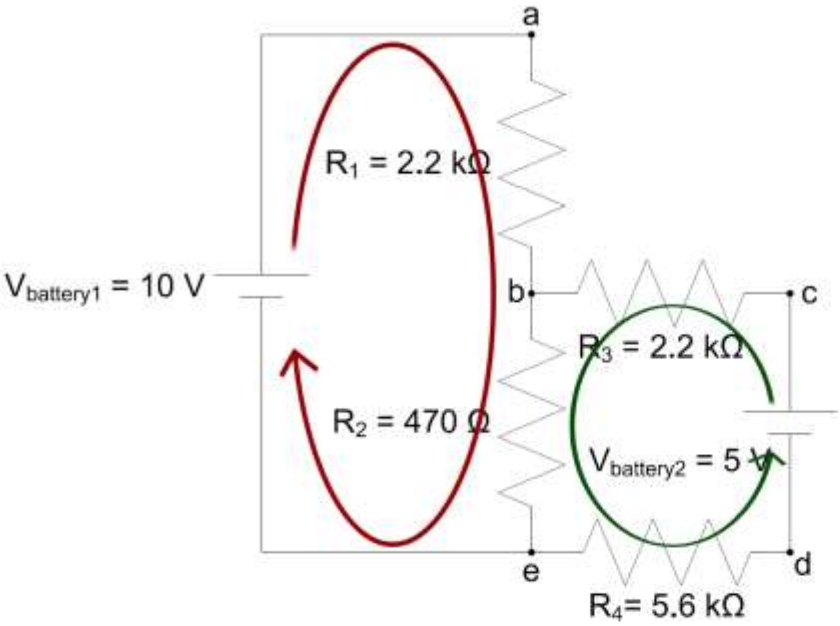
Circuit b is a high pass filter. When the frequency increases, the voltage across R_2 increases, and thus V_{out}. This means the circuit literally “passes high frequencies through”.

Circuit c is a low pass filter. When the frequency decreases, the voltage across R_2 increases, and thus V_{out}. This means the circuit literally “passes low frequencies through”.

Cut off frequency

$$f_c = \frac{1}{2\pi RC} = \frac{1}{2\pi \cdot 1000 \cdot 1{,}0 \cdot 10^{-7}} = 1592\ Hz$$

Practical assignment 3



Loop 1, Loop 2

Loop 1

$$V_{r1} + V_{r2} - V_{bat} = 0$$

$$R_1 \cdot I_1 + R_2(I_1 + I_2) - 10V = 0$$

$$2200\ \Omega \cdot I_1 + 470\ \Omega(I_1 + I_2) - 10V = 0$$

$$2200 \cdot I_1 + 470 \cdot I_1 + 470 \cdot I_2 - 10 = 0$$

$$I_1 = \frac{10 - 470 \cdot I_2}{2670}$$

Loop 2

$$V_{r3} + V_{r2} + V_{r4} - V_{bat} = 0$$

$$R_3 \cdot I_2 + R_2(I_1 + I_2) + R_4 \cdot I_2 - 5\ = 0$$

$$2200 \cdot I_2 + 470 \cdot I_1 + 470 \cdot I_2 + 5600 \cdot I_2 - 5\ = 0$$

$$8270 \cdot I_2 + 470 \cdot I_1 - 5 = 0$$

Substituting $I_1 = \frac{10-470 \cdot I_2}{2670}$ *yields:*

$$8270 \cdot I_2 + 470 \cdot \frac{10 - 470 \cdot I_2}{2670} - 5 = 0$$

$$I_2 = 0.4\ mA$$

Now we know I_2, we can also calculate I_1:

$$I_1 = \frac{10 - 470 \cdot I_2}{2670}$$

$$I_1 = \frac{10 - 470 \cdot 0.0004}{2670} = 3.7\ mA$$

Now current I_1 and current I_2 are known, the voltage drops across the resistors are easy to calculate:

V_{r1} $\quad V_{r1} = R_1 \cdot I_1 = 2200 \cdot 0.0037 = 8.14\ V$

V_{r2} $\quad V_{r2} = R_2(I_1 + I_2) = 470 \cdot (0.0004 + 0.0037) = 1.93$

V_{r3} $\quad V_{r3} = R_3 \cdot I_2 = 2200 \cdot 0.0004 = 0.88\ V$

V_{r4} $\quad V_{r4} = R_4 \cdot I_2 = 5600 \cdot 0.0004 = 2.24V$

Verification:

Loop1:

$$V_{r1} + V_{r2} - V_{bat} = 0$$

$$8.14 + 1.93 - 10 \approx 0\ (due\ to\ rounding)$$

Loop 2:

$$V_{r3} + V_{r2} + V_{r4} - V_{bat} = 0$$

$$0.88 + 1.93 + 2.24 - 5 \approx 0\ (due\ to\ rounding)$$

Conclusion: calculations are correct.

Results

Voltage drop across	Calculation (V)	Measurement (V)
V_{r1}	8.14	7.98
V_{r2}	1.93	2.03
V_{r3}	0.88	0.72
V_{r4}	2.24	2.72

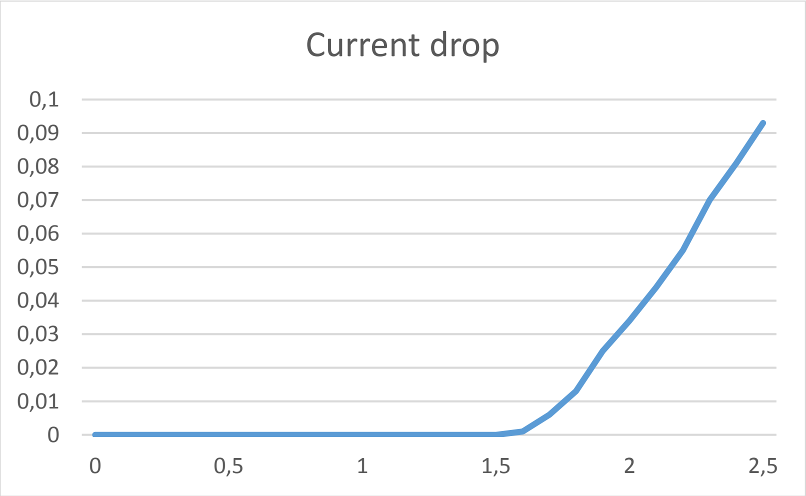
Current through	Calculation (mA)	Measurement (mA)
Loop 1	3.7	3.58
Loop 2	0.4	0.23

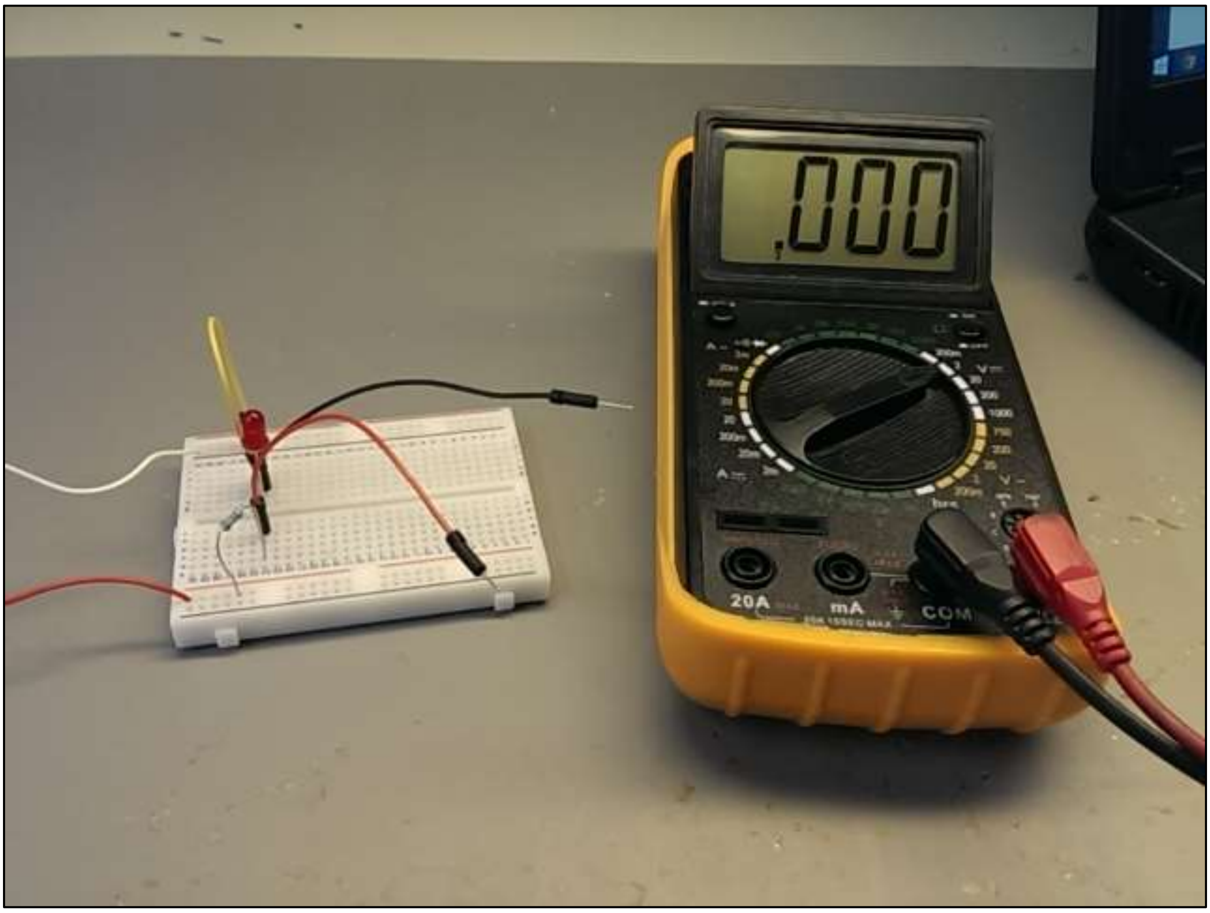
Conclusion: calculations are correct.

Practical assignment 4

The ‘knee’-voltage is approximately 1.6 volt as you can see in the measurements below.

V_{source}(in V)	I_d(in mA)
0-1.4	0
1.5	0
1.6	0.001
1.7	0.006
1.8	0.013
1.9	0.025
2.0	0.034
2.1	0.044
2.2	0.055
2.3	0.070
2.4	0.081
2.5	0.093

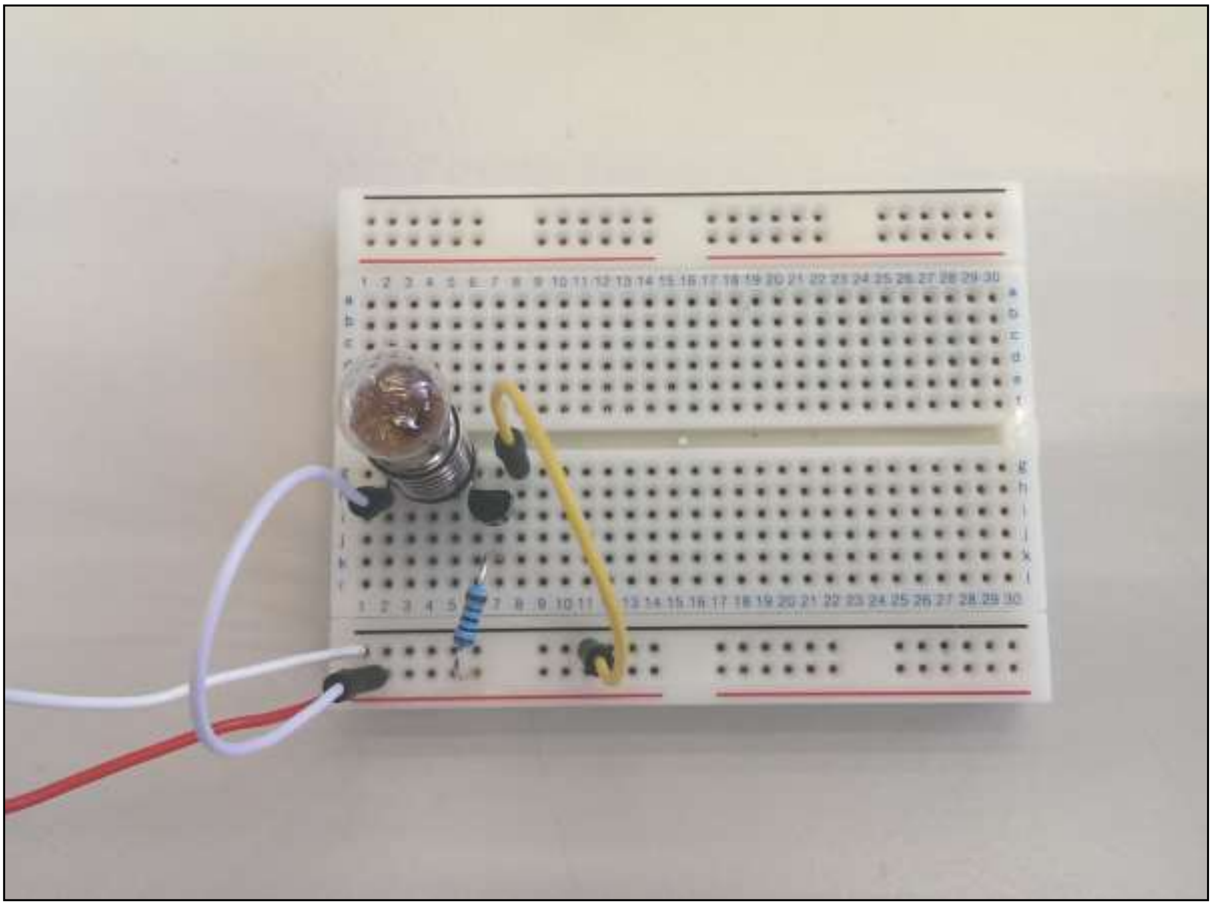




Practical assignment 5

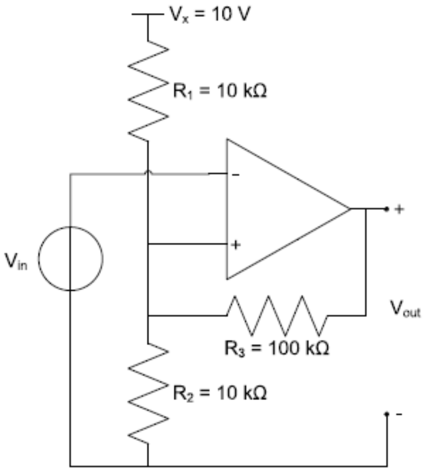
R_b(in kΩ)	I_c(in mA)	V_{ce}(in V)	V_{be}(in V)
100	22	3,53	0,70
10	42	1,37	0,72
4,7	48	0,62	0,75
2,2	52	0,25	0,77
1	51	0,16	0,80
470	53	0,14	0,81

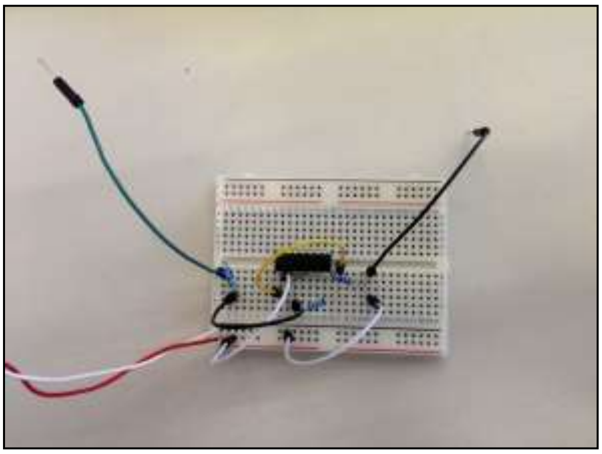
Vce becomes close to 0 V when there is saturation. Now it becomes close to 0 because it is an ideal switch and Vbe is above the saturation point.



Practical assignment 6

Question 1





Question 2

$$V_{\text{max}} = 10 \text{ V}$$
$$V_{\text{min}} = 0 \text{ V}$$
$$R_1 = 10.000\ \Omega$$
$$R_2 = 10.000\ \Omega$$
$$R_3 = 100.000\ \Omega$$
$$V_{\text{out}} = 10\ V$$

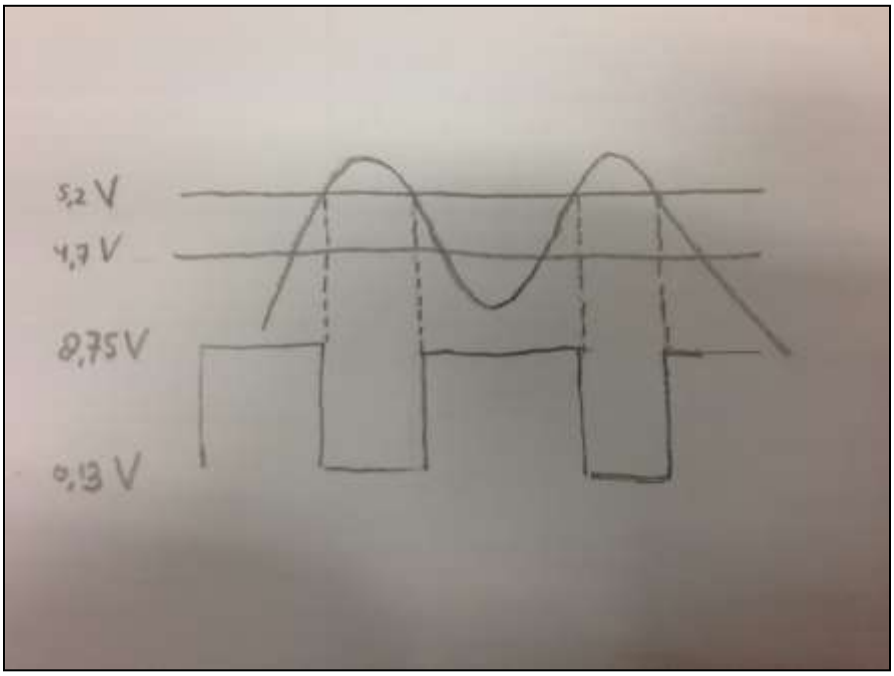
$$V_{\text{in+}} = \frac{R_2}{R_2 + \frac{R_2 \cdot R_3}{R_2 + R_3}} \cdot V_{out}$$

$$V_{\text{in+}} = \frac{10000}{10000 + \frac{10000 * 100000}{10000 + 100000}} \cdot 10 = 5{,}24\ V$$

$$V_{\text{in}} = 0 \text{ V}$$

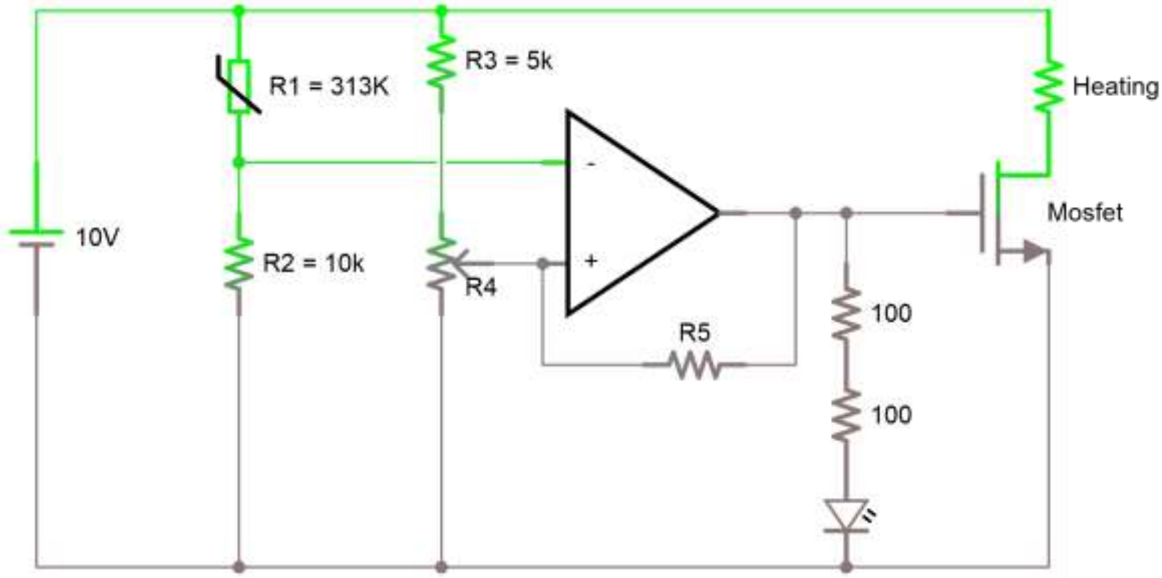
$$V_{in} = \frac{\frac{R_2 \cdot R_3}{R_2 + R_3}}{R_1 + \frac{R_2 \cdot R_3}{R_2 + R_3}} \cdot V_{out} = \frac{\frac{10000 \cdot 100000}{10000 + 100000}}{10000 + \frac{10000 \cdot 100000}{10000 + 100000}} \cdot 10 = 4{,}76\ V$$

Question 3



Measurements: V_{out} differed from 0,13 V to 8,75 V

Final assignment



We started to make the circuit of the central heating system. We used a few different components to get the desired situation. So we included a mosfet to function as a switch for the heating system and control LED and included hysteresis, which prevents quick commuting between high and low signals. After that we still had to calculate the resistance values. The source gives 5 volt because of the limits of the amplifier; the comparator op amp has a maximum input voltage of 5.5 volts.

We used the datasheets from the K164 thermistor (NTC) to find the resistor value at a desired temperature. We used 40 degrees Celsius which had a resistance of 5074 Ω. The resistor number two, the resistor that is put in series with the K164 thermistor to create a voltage divider, could have any resistance value, so we picked a 10kΩ resistor. The potmeter, which in this circuit is resistance number 4, has a maximum value of 10kΩ. Resistance number 3 is 5kΩ, because then the pot meter can correct the resistance to either above 5kΩ or below.. So R2 is relative to the NTC and the pot meter is relative to R3. The R-value for the hysteresis depends on your requirements. The higher that value the slower the heating element will heat up and cool down. The heating element is just an extremely low resistance resistor, because then it will heat up easier. Next to the whole voltage dividing system we should have a voltage drop of 3,5 volt in front of the LED, because the LED has a maximum voltage drop of 1,5 V and a current of 20mA. Therefore, the R-value should be:

$$R = \frac{V}{I} = \frac{3{,}5}{20 \times 10^{-3}} = 175\Omega$$

Unfortunately we don't have a resistor with this value so we chose to combine two 100 Ω resistors in series to get a resistor value in front of the LED with R=200 Ω

When we finished our circuit on paper and the calculations, we started to build it on our breadboard.

Building wasn't that easy at all. We still faced a few difficulties. At first we forgot to give enough current, so the LED didn't glow nor did the heating element heat up. Next to that we also made a mistake with the connection with the mosfet. After looking for some datasheet we saw we did it the wrong way.

How it works

If the temperature decreases, the value of the NTC increases. Therefore, the voltage which is connected to the amplifier increases, and the measured value of the NTC will be higher than the adjusted reference voltage value. The heater and the LED will turn on.

If the temperature increases, the value of the NTC decreases. Therefore, the voltage which is connected to the amplifier decreases. The - output will have a lower value than the + output. Then the heater and the LED will not work because there will be a to low amount of current flowing.

That’s how the heating system works.

Reflections

Olivier van Duuren

I chose this assignment to get the opportunity to improve my knowledge about electronics. I think it's a very important quality to be able to build any electrical circuit. By following the theorem lectures I got a better view than at secondary school about what's in such an electrical circuit. But the practical assignments were the best way to learn for me. By seeing a working circuit you get much more awareness by what's actually happening. Unfortunately we had a few problems with time management and had to do our assignments hurried in a short period of time. But after all we made it.

I was a little bit surprised by the given feedback from our teacher. I didn't expect any corrections at all so that was a luck. By now I didn't made any time to look at it very carefully, but by only looking to the tips he gave, I knew what I had to do extra.

For me the final practical assignment was really hard. In the beginning I had no clue about where I should start. Fortunate, we got a little help to begin. After a few difficulties, like the hysteresis we finished the assignment in time and showed our final result to our teacher. Happily we finished our first hard electrical circuit, which gave me a lot more motivation to start such another equal assignment.

In my project I only use some resistors and that's it. So I hope that I can apply my new skills to my project next semester to improve this quality more, because this assignment is just a start. I want to do more with electronics than just these several weeks. I'm looking forward to do the mini project still included in this assignment 'creative electronics'!

Marco Putzu

I chose this assignment because I think knowledge of electronics is really important to really see something happening. In order to make your abstract thoughts more concrete, you can sketch. But in order to actually experience the product or service you have in mind, a rapid prototype can be a great help.

In this assignment I hoped I could get more insight in the various electronic components and be able to rather quickly apply them to real life situations. In my project, it hasn't been necessary, but when I go over the previous electronic circuits I have made, I realize what I could've done better and how I could even add some features by just little additions.

The creative electronics assignment, together with calculus, have helped me in translating my ideas to certain algorithms, which I can then translate to the various op-amps or other electronic components.