ELEKTRONICA-ICT
Project Ontwerpen

Soldering Station

Author Seppe Budenaers

1 Introduction 2
2 Material and methods 2
2.1 Materials: 2
2.1.1 THT Versus SMT: 2
2.1.2 Power Supply: 3
2.1.3 Connector 3
2.2 Methods 3
2.2.1 PCB Designing Software 3
2.2.2 3D Designing Software 3
3 Results 3
3.1 Schematic 3
3.1.1 Power Entry Schematic (Appendix A, Fig. [4]) 3
3.1.2 Output Schematic (Appendix A, Fig. [5]) 4
3.1.3 Microcontroller Schematic (Appendix A, Fig. [6]) 4
3.1.4 Display Schematic (Appendix A, Fig. [7]) 4
3.1.5 Temperature Sensor Schematic (Appendix A, Fig. [8]) 4
3.2 PCB 4
3.3 Electronic Test 5
4 Discussion 5
5 Bibliography 6
6 Appendix A 7
7 Appendix B 10

1 Introduction

The purpose of this project is to build a soldering station able to fit the JBC C245 soldering iron. The design relies on the soldering station described in the Elektor magazine (issue 507) (Elektor Magazine, 2021), which provided a good basis to start from. However, some modifications were brought in to enable it to suit the JBC C245. For instance, replacing the power supply by a bigger one and adding a Hirose connector.

"Elektor's PCB (Printed Circuit Board) leans more towards hobbyists as it utilizes only THT (Through-Hole Technology) components. For this project, the PCB was designed with SMT (Surface-Mount Technology) in mind to simulate the way the electronic industry designs their PCB.

2 Material and methods

2.1 Materials:

2.1.1 THT Versus SMT:

Through Hole Technology is a technique where holes are drilled into the PCB to enable the soldering of the PTH (Pin-Through Hole) components. These components are first mounted (axial or radial) then, they get hand soldered using a soldering iron and a soldering tin. (Niclas, 2021)

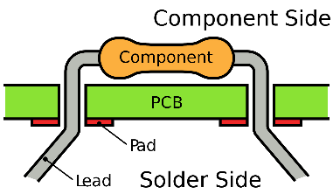

Figure 1 – THT (Tamari, 2017)

Pros of THT (Tamari, 2017) *:*

- High mechanical and heat resistance.
- Does not require specialty equipment.

Cons of THT (Tamari, 2017)*:*

- Requires a lot of manual labour.
- THT soldering results in less reliable soldering connections.
- Loss of routing capabilities.

Surface-mounted Technology is a method to solder SMD (Surface-Mounted Device) components using a process known as re-flow soldering. During the re-flow soldering process, operators apply solder paste with a stencil onto every SMD pad. Then, the SMD components are manually or automatically placed onto the PCB. Once that is done, the PCB goes into a re-flow oven or onto a hotplate. In this stage, the soldering paste will melt and form the soldering joint (candorblog, 2021).

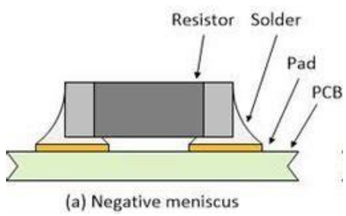

Figure 2 – SMT (Maxfield, 2018)

Pros of SMT (Neoden USA, 2019)*:*

- More compact design.
- Not labour intensive.
- Reliable soldering connections.

Cons of SMT (Neoden USA, 2019)*:*

- Requires specialty equipment.
- Not compatible with every component.
- Low mechanical and heat resistance.

After consideration, SMT was chosen to simulate the industry standard. In fact, it encompasses all the key features needed for this project (compacter design, properly soldered connections).

2.1.2 Power Supply:

The soldering station design uses a 150 VA 2 x 12 V toroidal instead of a 65 VA 2 x 12 V toroidal. This choice enables to suite the JBC T245 soldering iron better as it has a peak consumption of 130W (JBC, sd). As a result, from that choice, some changes needed to be made to the original PCB design: enlarging the track width to 170mills and using a MOSFET (Metal-Oxide-Semiconductor Field-Effect Transistor) with a higher current and gate to source rating.

2.1.3 Connector

The connector used in this project is the Hirose RPC1-12-RB-6P (71) (jbc-soldering-iron-stand-wiring, 2014). The reason for this choice is that it can fit a T210 or a T245 series of handle without any modifications. The T245 series has a higher power consumption which makes it a general-purpose soldering. Meanwhile, the T210 has a lower power consumption (40 W) which makes it the ideal choice for precision work (JBC, sd).

2.2 Methods

2.2.1 PCB Designing Software

Altium was chosen as the PCB designing software for this project due to its popularity in professional work environments. Its widespread adoption among engineers, designers, and manufacturers confirms its quality. Altium's powerful platform offers comprehensive tools and libraries for efficient and accurate PCB design. While it may have a steeper learning curve than other designing software, it provides a lot more resources to design PCBs.

2.2.2 3D Designing Software

Fusion 360 is a 3D CAD (Computer-aided design) software providing a good balance between user friendliness and more advanced features. The software targets both prosumer and professionals. One notable advantage of Fusion 360 is its extensive toolset that you do not get with a cheaper CAD software. For example, rendering, simulations, CAM (Computer-aided manufacturing), generative design and parametric design. (Autodesk, sd)

3 Results

3.1 Schematic

The Elektor schematic was difficult to decipher. To improve clarity and assist in the PCB design process, the schematic was split into five distinct separate schematics.

3.1.1 Power Entry Schematic (Appendix A, Fig. [4])

In the power entry schematic, the schematic transforms a 2 x 12 VAC into a 5 V line and a VCC line (which can be 12 V or 24 V depending on the soldering iron). This is possible thanks to the RE1. When powered with a 5 V signal from the microcontroller, the RE1 places the two 12 VAC in series to make a 24 VAC. VCC gets rectified by B1 and is then filtered by C1 (the 4700 uf capacitor). B2 rectifies the 12 VAC into 12 V. After that, it gets electronically switched into 5 V which creates the 5v line.

3.1.2 Output Schematic (Appendix A, Fig. [5])

In the output schematic, the output power is controlled by the P-MOSFET (Positive Metal-Oxide-Semiconductor Field-Effect Transistor) (T3). A small transistor circuit turns the 5 V from the GPIO (General Purpose in and Output) pin on the microcontroller into Vcc and turns 0 V into 0 V at the gate of T3. This GPIO pin will send a PWM signal to the transistor circuit, which will transmit it to the P-MOSFET. The P-MOSFET will then turn on or off the soldering iron to regulate the temperature.

3.1.3 Microcontroller Schematic (Appendix A, Fig. [6])

The microcontroller schematic involves filtering the 5 V line before supplying it to the microcontroller. In the Elektor schematic, numerous open connections are present, but they got cut to streamline the design. 13 pins were kept in the design. The temperature regulation utilizes PWM (Pulse Width Modulation), which is transmitted through GPIO pin 1. Pins 9 and 10 measure the analog signal from the soldering iron's thermistor while pin 11 detects if there is voltage on the VCC line. Pins 27 to 30 are reserved for microcontroller programming. Pins 35 and 36 establish I2C communication with the seven-segment display driver and pins 37 to 39 read input from the rotary encoder.

3.1.4 Display Schematic (Appendix A, Fig. [7])

There are two main components of the Display schematic. The seven-segment display driver (tm1637) and the rotary encoder.

The display driver turns the I2C signal from the microcontroller into a four digit seven-segment display matrix. The matrix is connected to four rows of 1x8 DuPont male headers. Pin 2 to 8 are connected in series among the four headers and every first pin of the connector is wired to a different enable pin to create the matrix.

The rotary encoder is used to navigate through the menu’s and to set the soldering iron on the desired temperature. To make this work, 5 V pull up resistors are connected to the input pins of the rotary encoder and the output pins are connected to GND. The GPIO 37 to 39 are used to detect the change in voltage between the pull up resistor and the rotary encoder.

3.1.5 Temperature Sensor Schematic (Appendix A, Fig. [8])

In the temperature sensor schematic, there are two non-inverting amplifiers circuits with different gain levels. This is due to the differences in thermocouples used by different manufacturers. The base signal of the Op-Amp (Operational amplifier) is 5 V and gets lowered to the voltage of the thermocouple when the microcontroller is trying to measure it. This will then lower the signal at the output of the Op-Amps and send it to the microcontroller where pin 9 or 10 will read it depending on the configuration chosen.

3.2 PCB

The five schematics were imported into the PCB editor of Altium. They were all routed separately and designed as compact rooms. After that, the rooms were dragged onto the PCB area, where they got fitted together and connected. Finally, the board shape of the PCB was fitted to contain the components.

To avoid design problems in the next steps of the process, the traces from the microcontroller are ten mils wide to comply with the manufacturing capabilities. The power schematic and VCC line have a width of 170 mils to manage the high current that will be going through it. All other traces are routed with a width of twenty mils.

3.3 Electronic Test

At first sight, the electronic test was nominal, but T2 got damaged when supplying it with maims voltage. That was caused by the footprints of the PNP (positive Negative Positive) and NPN (Negative positive Negative) transistors which were not configured properly in the footprint library. This problem was effortlessly solved by rotating T1, T2, T4, T5 by 120 degrees counter clockwise. After that small error was solved, the test was nominal again. However, 24 volts got accidentally supplied to the PWM signal which resulted in shorting the microcontroller.

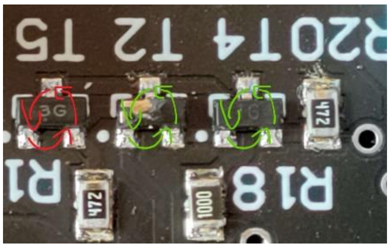

Figure 3 – transistor error

4 Discussion

When reviewing the process, some "mistakes" can be outlined. The misconfiguration of the footprints (NPN & PNP) and the 24V applied to the PWM signal line while testing.

The misconfiguration could have been avoided by checking the footprint library and spotting the error before the beginning of the production process.

The other mistake also results from a moment of inattention. the lab power supply was set on 24V for the testing of the VCC line. After which it did not get change to 5V for the triggering of the MOSFET which led to the shorting of the microcontroller.

A good addition in the testing process was the test points as they made measuring easier, more efficient, and more reliable. The test points made it easier to attach a scope probe to the traces of the board. However, some test points were too close to each other which created a risk for unwanted connections when measuring. In addition, test points on the PWM signal line and the ground plane could be a great addition to make the general testing easier.

A big challenge of the project was to design a compact PCB. Which was successfully done through smart choices. For example, the use of as many SMD components as possible and the splitting of the schematics. In fact, the use of SMD components makes the overall components density higher and the schematics enables a better overview when split into different rooms.

In conclusion, every goal that was set in the introduction was achieved. The changes to the power supply and connector worked as predicted and SMT was a powerful addition to make a smaller PCB footprint.

5 Bibliography

Autodesk. (n.d.). *fusion-360 features*. Retrieved from autodesk.com: https://www.autodesk.com/products/fusion-360/features

candorblog. (2021, 5 100). *What Is Reflow Soldering*. Retrieved from candorind: https://www.candorind.com/what-is-reflow-soldering/

Elektor Magazine. (2021, May/June). issue 507. *Elektor Magazine*, pp. 30-36.

JBC. (n.d.). *CDB Station*. Retrieved from jbctools: https://www.jbctools.com/cdb-soldering-product-1605.html

jbc-soldering-iron-stand-wiring. (2014, 1 26). Retrieved from eevblog: https://www.eevblog.com/forum/reviews/jbc-soldering-iron-stand-wiring/

Maxfield, M. (2018, 7 18). *Hand-Soldering Surface-Mount Devices*. Retrieved from eeweb: https://www.eeweb.com/hand-soldering-surface-mount-devices/

Neoden USA. (2019, 8 19). *What is SMT / Surface Mount Technology?* Retrieved from neodenusa: https://neodenusa.com/blog/what-is-smt

Niclas. (2021, 11 29). *Through Hole Technology*. Retrieved from Sino voltaics: https://sinovoltaics.com/learning-center/inverters/through-hole-technology/

Tamari, A. (2017, 3 28). *Why Use Plated Through Hole Technology in PCB Design?* Retrieved from Altium: https://resources.altium.com/p/why-use-through-hole-technology-in-pcb-design

6 Appendix A

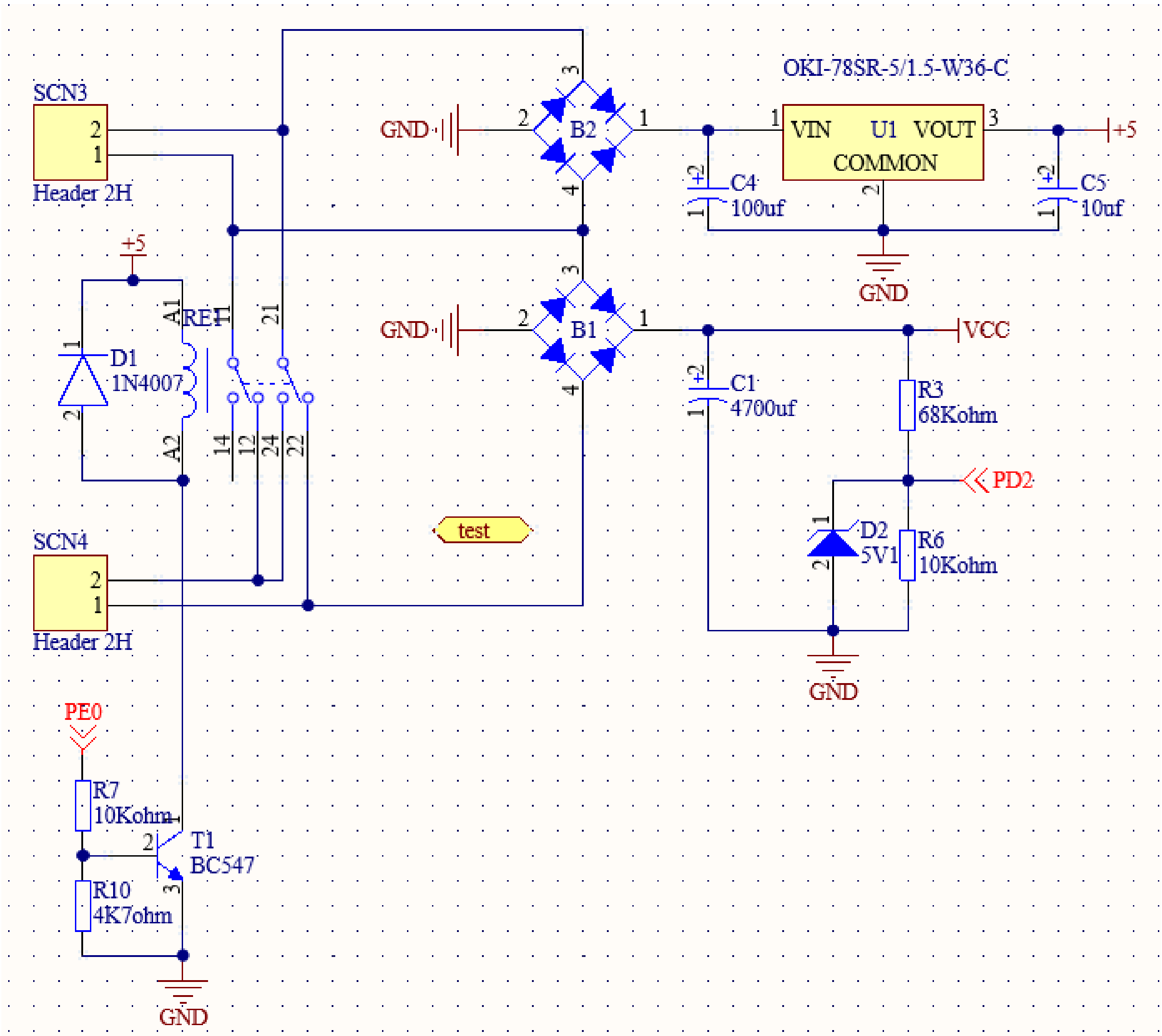

Figure [4] - Power Entry Schematic

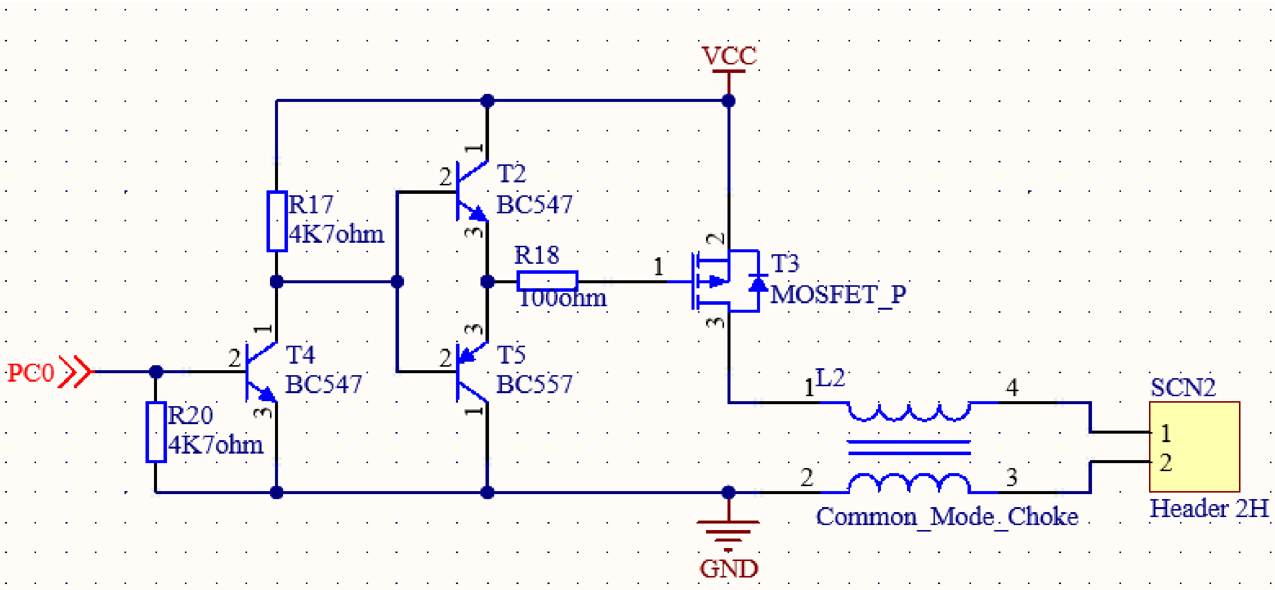

Figure [5] - Output Schematic

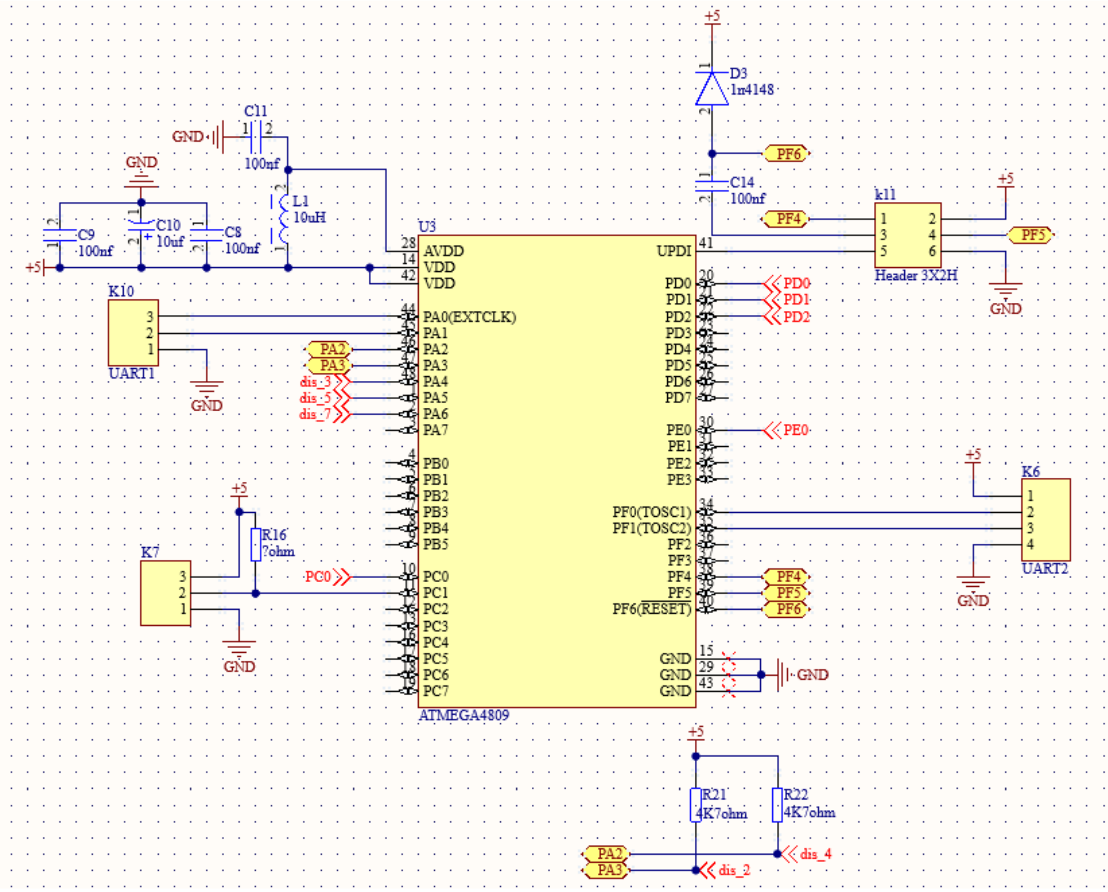

Figure [6] - Microcontroller Schematic

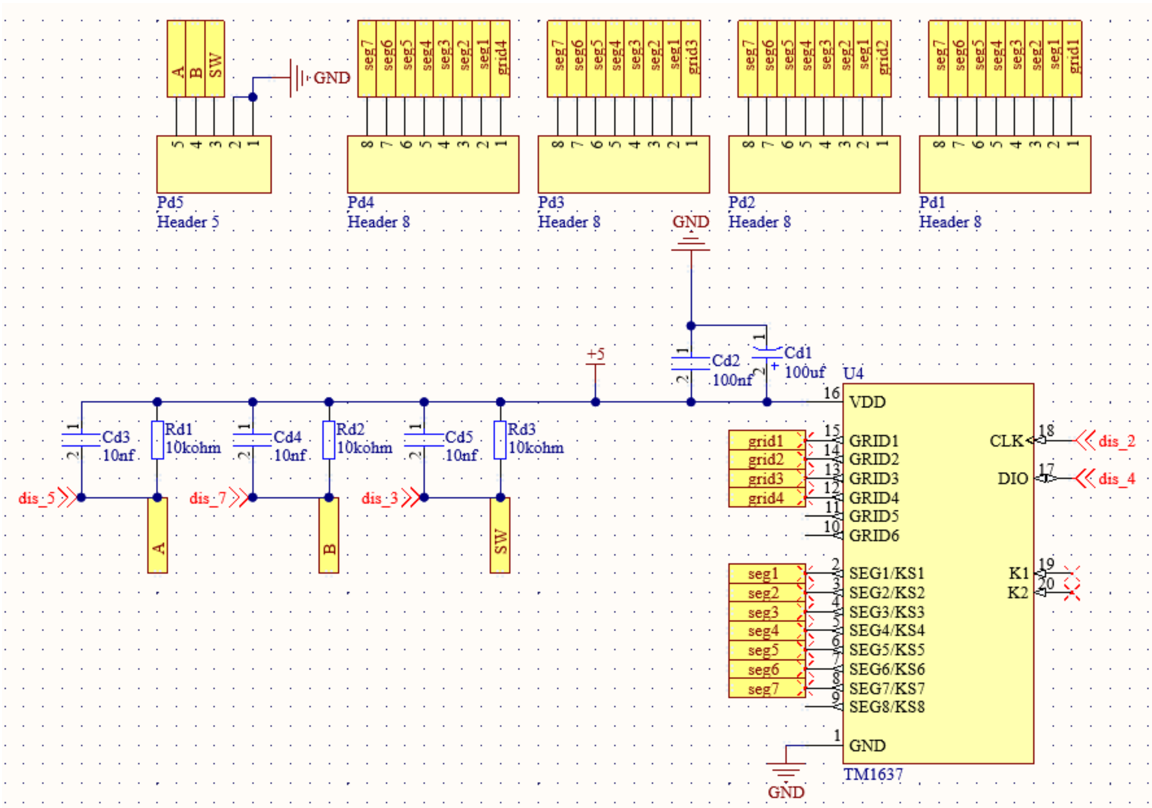

Figure [7] - Display Schematic

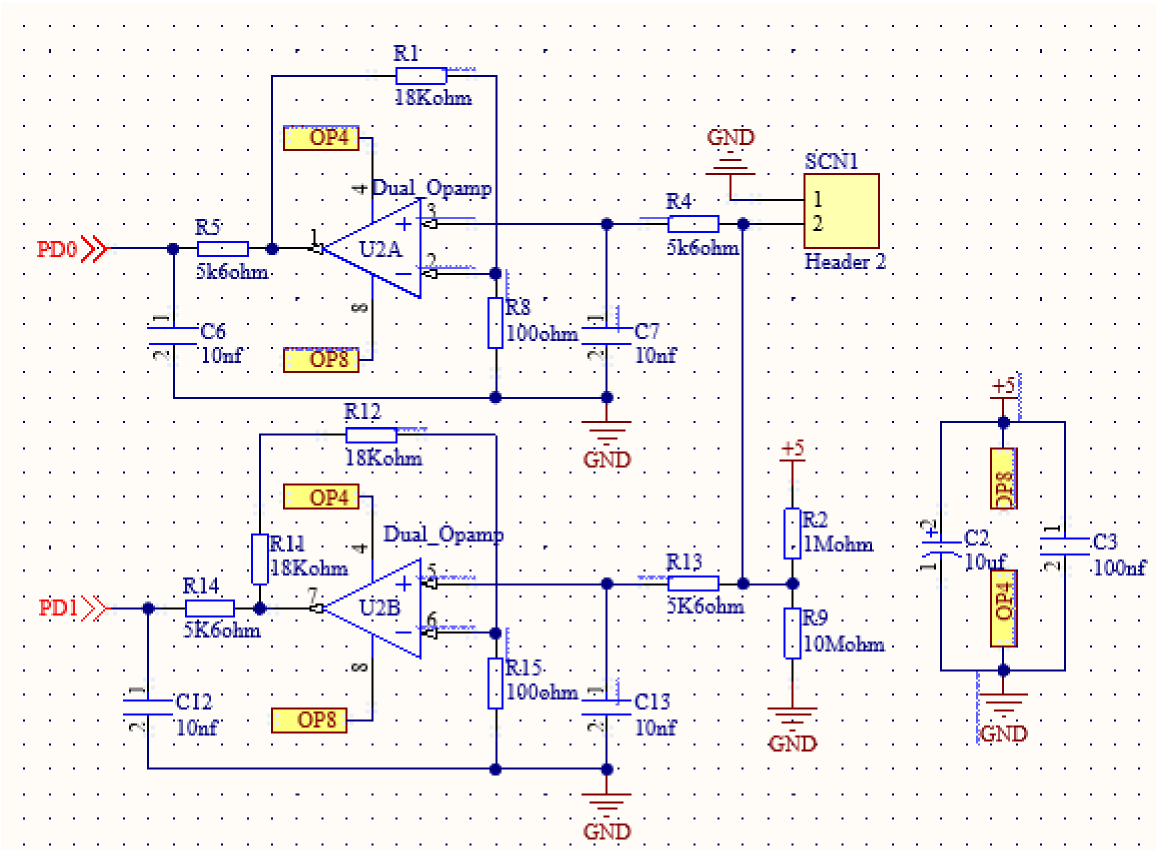

Figure [8] - Temperature Sensor Schematic

7 Appendix B

item	store	Package	price/unit	amount	total price
Resistors					
47 ohm	lcsc	805	€ 0,0015	28	€ 0,0420
18 Kohm	lcsc	805	€ 0,0010	3	€ 0,0030
1 Mohm	lcsc	805	€ 0,0015	1	€ 0,0015
68 Kohm	lcsc	805	€ 0,0016	1	€ 0,0016
5,6 Kohm	lcsc	805	€ 0,0014	4	€ 0,0056
10 Kohm	lcsc	805	€ 0,0010	6	€ 0,0060
100 ohm	lcsc	805	€ 0,0018	3	€ 0,0054
10 Mohm	lcsc	805	€ 0,0014	1	€ 0,0014
4,7 Kohm	lcsc	805	€ 0,0015	6	€ 0,0090
Capacitor					
4700 uF	lcsc	D25xL25mm plugin	€ 0,8289	1	€ 0,8289
10 uF	lcsc	D4XL5,4	€ 0,0237	3	€ 0,0711
100 nF	lcsc	805	€ 0,0023	6	€ 0,0138
100 uF	lcsc	SMD,D8xL10mm	€ 0,1362	2	€ 0,2724
10 nF	lcsc	805	€ 0,0033	7	€ 0,0231
Semiconductors					
1n4007	lcsc	SOD-123Fl	€ 0,0048	1	€ 0,0048
Zener	lcsc	SOD-123Fl	€ 0,0127	1	€ 0,0127
1n14148	lcsc	SOD-123Fl	€ 0,0064	1	€ 0,0064
Brug	lcsc	TTF	€ 0,3166	2	€ 0,6332
BC847C	lcsc	SOT-23	€ 0,0146	3	€ 0,0438
MOSFET-P 30v	Mouser	TO-263-3(DPAK)	€ 1,2900	1	€ 1,2900
MOSFET-P 20V	lcsc	TO-252-2(DPAK)	€ 0,2785	1	€ 0,2785
BC857C	lcsc	SOT-23	€ 0,0231	1	€ 0,0231
DC/DC	Mouser	OKI78SR8	€ 7,0500	1	€ 7,0500
MCP6002-E/MS	Mouser	MSOP-8	€ 0,4400	1	€ 0,4400
Mircocontroler	Mouser	TQFP-48	€ 1,8200	1	€ 1,8200
relay	Mouser	RT424005f	€ 5,3800	1	€ 5,3800
IC2 7seg	lcsc	SOP-20	€ 0,1861	1	€ 0,1861
encoder	lcsc	PEC11R4220F	€ 1,6500	1	€ 1,6500
Ledfilament	aliexpress	20MM	€ 0,2915	28	€ 8,1620
fuse	Mouser	5x20mm	€ 0,4230	1	€ 0,4230

Inductor					
L1	lcsc	805	€ 0,1271	1	€ 0,1271
L2	Mouser	2545	€ 2,3000	1	€ 2,3000
pcb					
sevensegment	JCLPCB		€ 0,5153	4	€ 2,0613
soldeerbout	JLCPCB		€ 0,7280	1	€ 0,7280
SMT stencil	JLCPCB		€ 6,3800	1	€ 6,3800
others					
glass tube	aliexpress	D30mm	€ 0,6592	4	€ 2,6367
switch	aliexpress	29x13x54mm	€ 1,7300	1	€ 1,7300
screw terminal	aliexpress	Pitch 5mm	€ 0,0880	4	€ 0,3520
testpoints	Mouser	3,5x1,78mm	€ 0,4230	7	€ 2,9610
ac connector	Mouser	24x30mm	€ 2,3200	1	€ 2,3200
hirose connec-tor	Mouser	20x20mm	€ 2,9000	1	€ 2,9000
triplex 6mm	Makerspace Hasselt		€ 6,0000	1	€ 6,0000
shipping + tax					
mouser	mouser		€ 58,7500	1	€ 58,7500
lcsc	lcsc		€ 15,0200	1	€ 15,0200
JLCPCB	JLCPCB		€ 30,6750	1	€ 30,6750
price total					€ 163,63

Table [1] – Bill of Materials