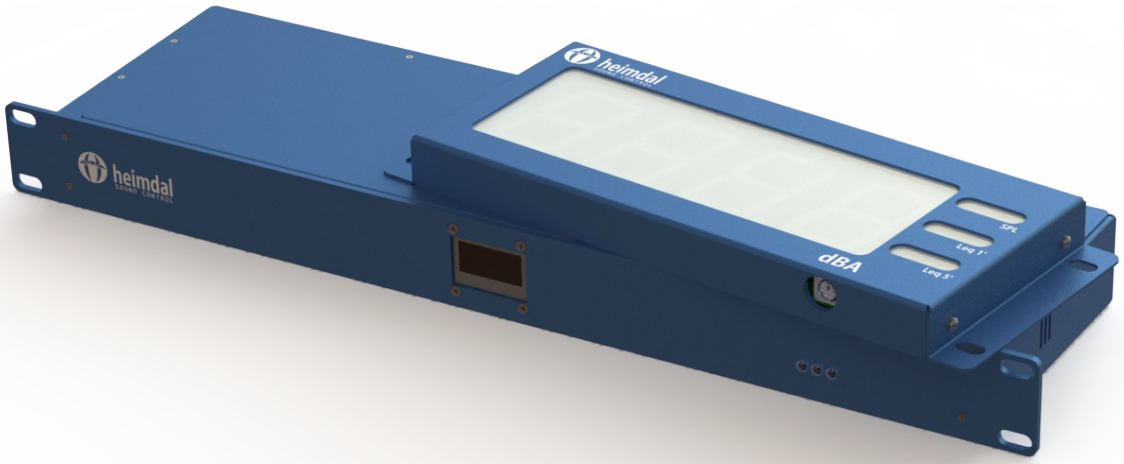
Bachelor's Thesis | 2022/2023 Course | Sep 12th, 2023

Bachelor's Degree in Telecommunication Engineering

EMC control for electro-acoustic Product



Bachelor's Degree in Telecommunication Engineering

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Contents

1. Introduction

1.1 Motivation

- This Thesis is the result of the knowledge acquired in the Bachelor's Degree in Telecommunications Engineering
- Focussed on the engineering process behind the hardware development of a product
- Main objective is to improve a previous hardware design of a sound limiter to obtain a functional product at an advanced prototype stage
- Improve development efficiency
- Collaboration between UGR, GranaSAT and Heimdal Sound Control

Motivations:

- To succesfully develop an electronic product
- To become skilled and confident in the use of professional EDA (Electronic Design Automation) and CAD (Computer-aided Design)
- To acquire the skills to handle electronic instruments
- To demonstrate the student's competence
- To showcase the knowledge acquired during the Bachelor's studies
- To engage actively within the GranaSat laboratory for further training
- To successfully complete the Bachelor's Degree

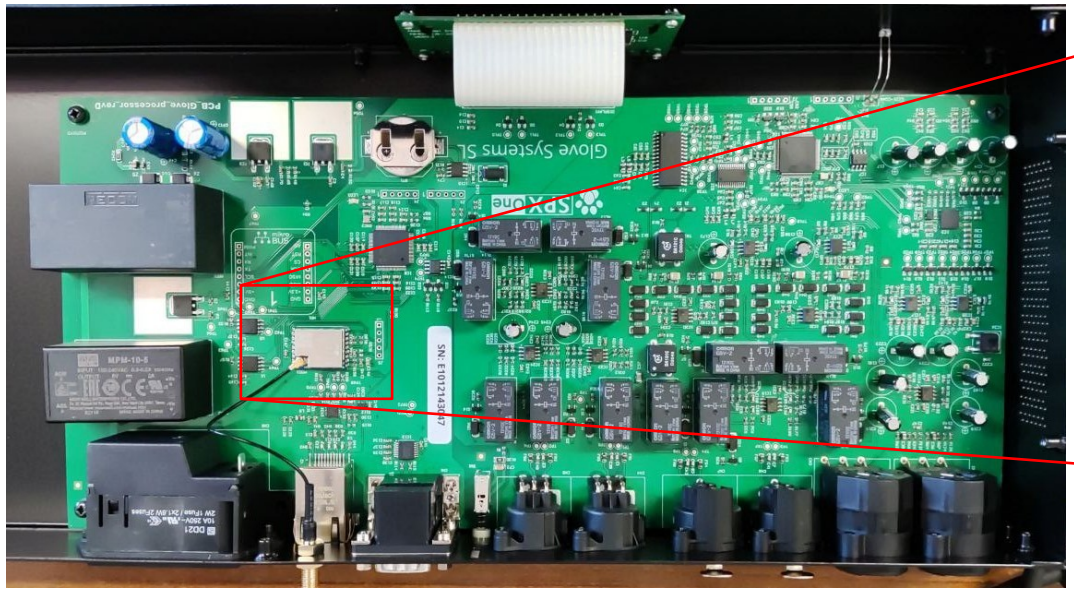
1.1. State of the Art

1.2 Scope of the Thesis

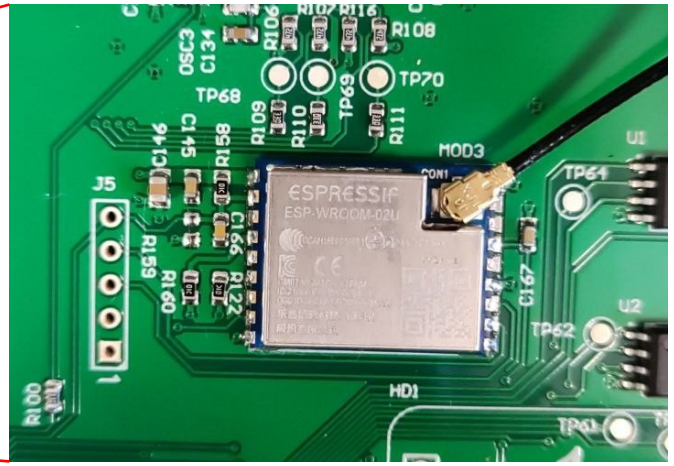
2 System Analysis

2.1 Reverse Engineering

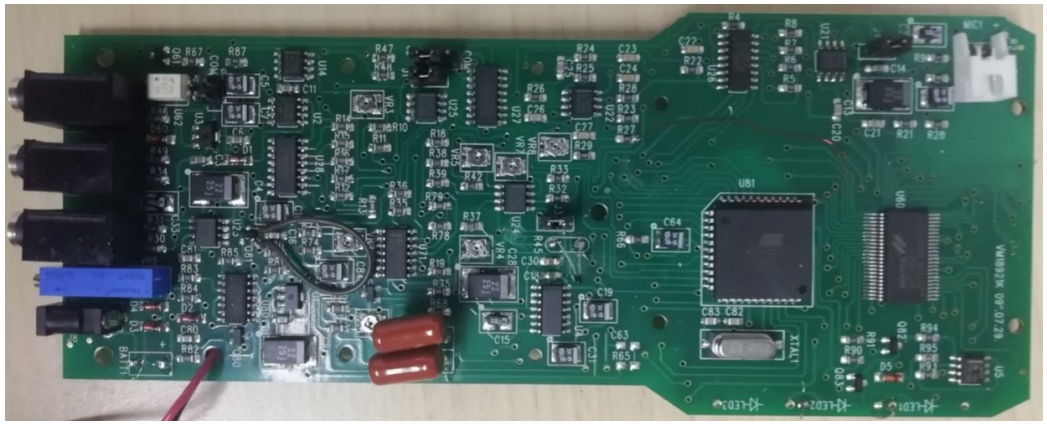
Glove SPX One Audio Limiter



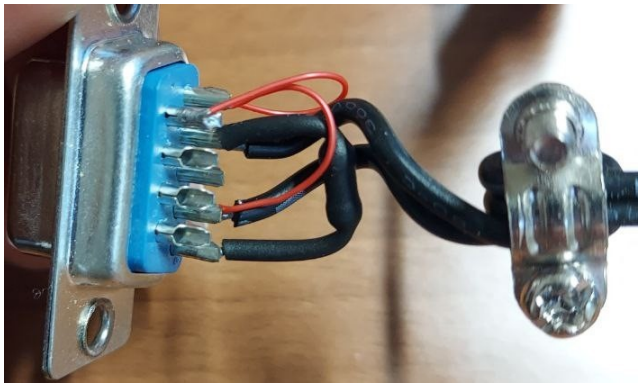
ESP32-WROOM32D



AZ8922 Sonomer PCB Bottom



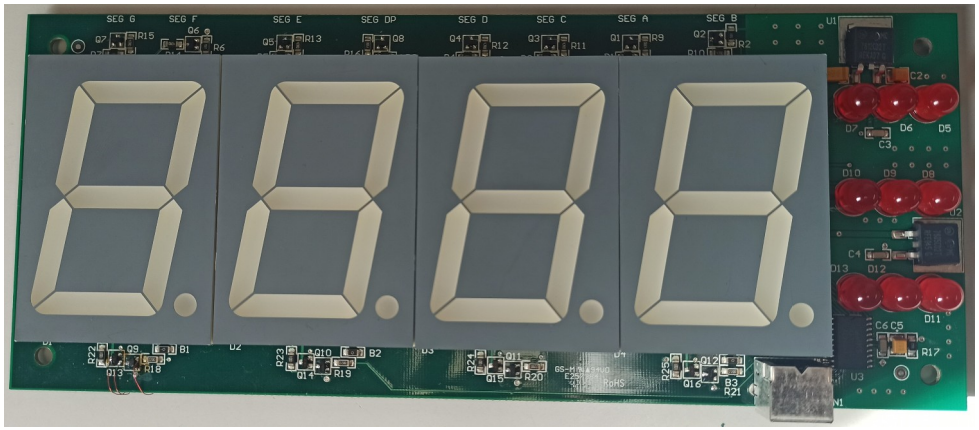
AZ8922 RS232-Jack Connector



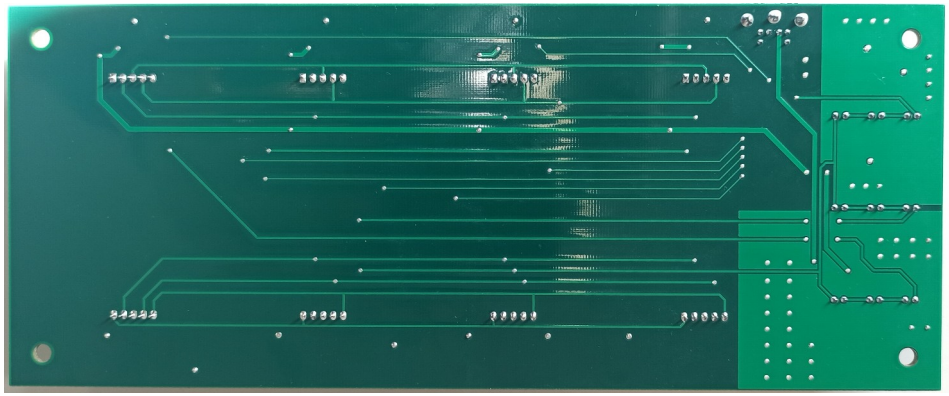
2 System Analysis

2.1 Reverse Engineering

CAP21 External Display PCB Top

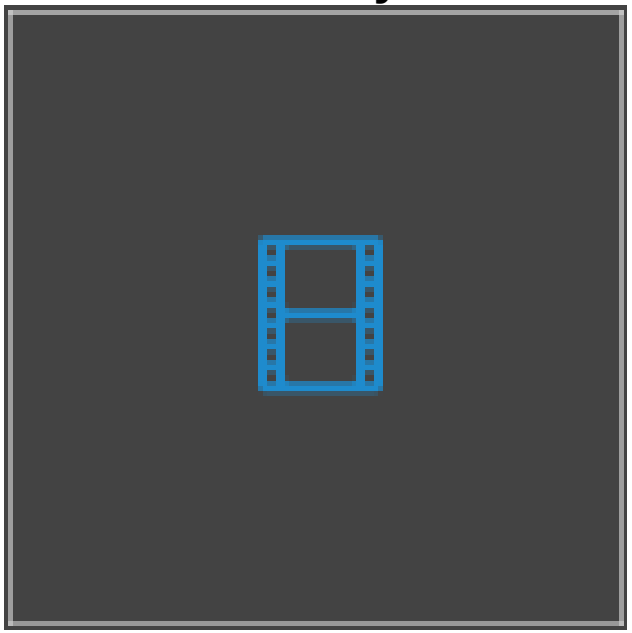


CAP21 External Display PCB Bottom

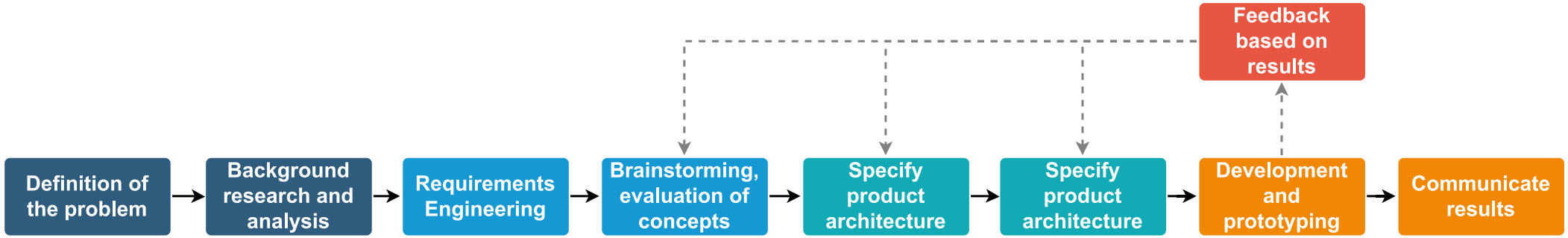


CAP21 External Display Box Bottom

Functionality Test



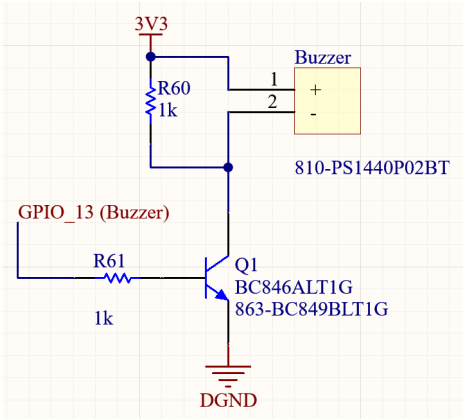
2.2 Engineering Design Process



2.3 System Requirements

Electronic Requirements:

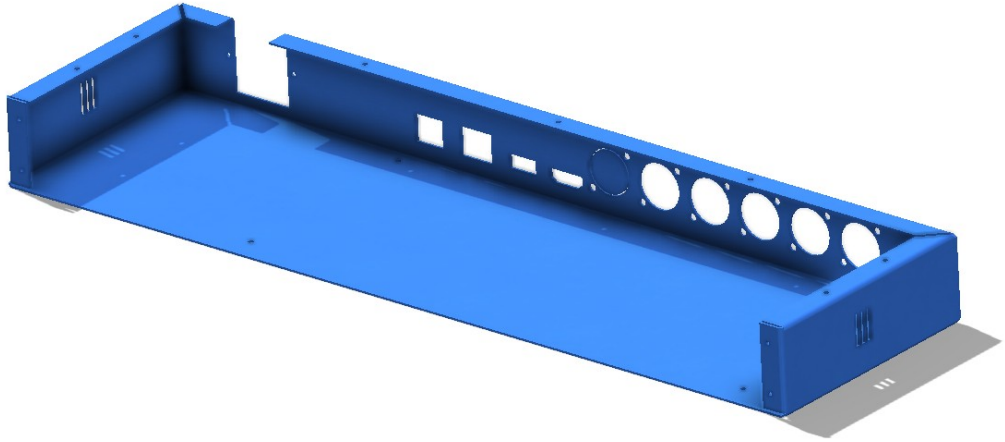
- **Move all schematic sheets to DIN A4**
- **Improve the layout of the components, add sheet descriptions, page numbers of the modules, add information of the connection lines between modules, add symbols for better identification of the modules, etc**
- **Add a photo of the package of all components**
- **Move wireless communications away from the sound zone of the Heimdal sound limiter PCB (improve ESD Integrity)**
- **Add a connector for an external display**
- **Develop the electronics of an external display to show the SPL recorded by the limiter in dBA, Leq1' and Leq5'**
- **Add a connector for a test display on the limiter**
- **Change the USB type B to type A, which is more common**
- **Add protections on the new external display and USB connector**
- **Upgrade the ESP8266-12E to a newer model or better device**
- **Change the BJT of the buzzer to a mosfet**
- **Add display on the front**

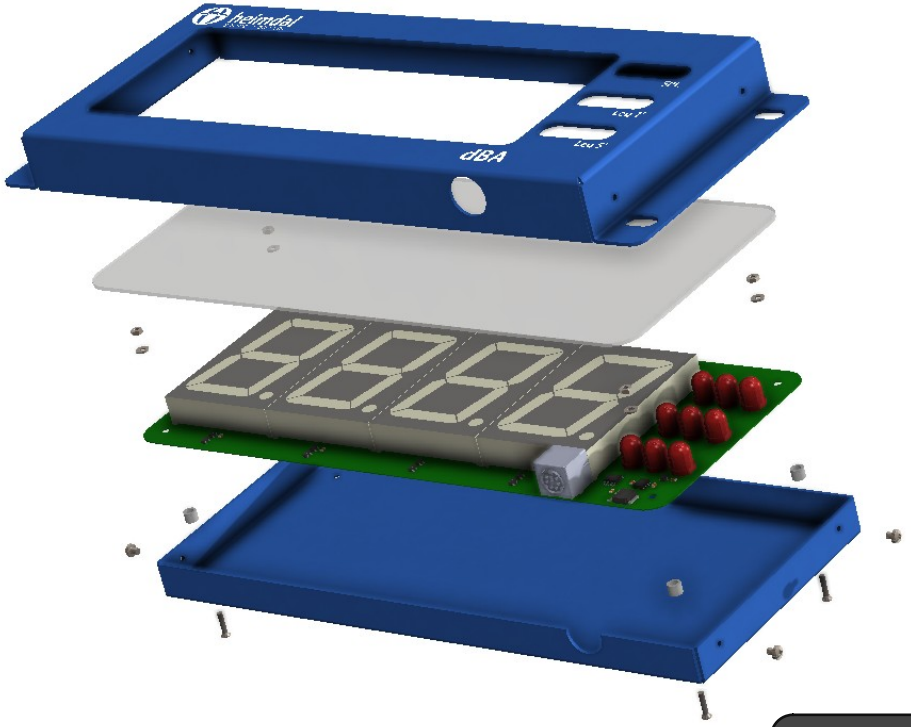


2.3 System Requirements

Mechanical Requirements:

- **Add lightpipes on the addressable RGB LEDs to drive the light to the front**
- **Develop a new version of the limiter box with the recesses for the new front displayDevelop a new version of the limiter box with the recesses for the new front display, connectors and Lightpipes**
- **Develop a new box for the external display electronics**

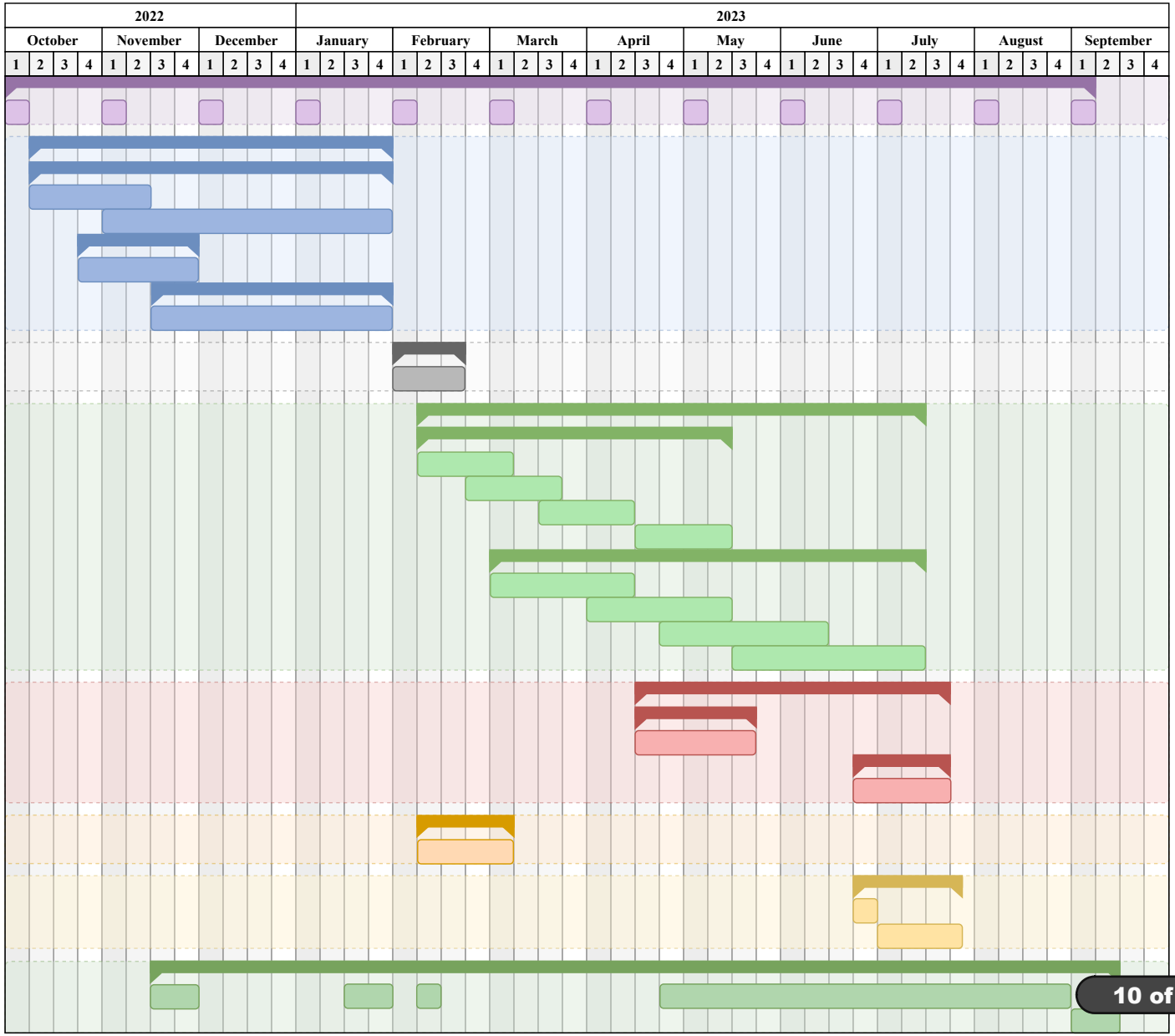




2 System Analysis

2.4 Schedule

MEETINGS AND PROJECT CONTROL	
1	Supervision and meetings in GranaSAT's laboratory
GROUNDWORK	
Formation and research	
2	Documentation reading
3	Solidwork's course
Equipment testing	
4	Stencil machine, PCB milling machine, THT-plating machine
Schematics improvements and project restructuration	
5	Heimdal Sound Limiter Project
REVERSE ENGINEERING	
6	Reverse engineering of competitors' equipment
ELECTRONIC DEVELOPMENT	
Heimdal External Display and Arduino Module Tester	
7	Choice of components
8	Generation and/or revision of design libraries
9	Circuit schematics, mechanical drawings, documentation
10	PCB Design
Heimdal Sound Limiter	
11	Choice of components
12	Generation and/or revision of design libraries
13	Circuit schematics, mechanical drawings, documentation
14	PCB Design
MECHANICAL DEVELOPMENT	
Heimdal External Display and Arduino Module Tester	
15	3D modeling of the case and assembly
Heimdal Sound Limiter	
16	3D modeling of the case and assembly
FIRMWARE DEVELOPMENT	
17	dBelectronics External Display Arduino library
FABRICATION AND TESTING	
18	PCB check, electronic assembly and case assembly
19	Testing
PROJECT REPORT AND DEFENSE	
20	Documentation and writing of this Bachelor's Thesis
21	Defense preparation



Task	NºHours	Cost at 16 € / hour
Meetings	40	640
Documentation and formation	60	960
System Analysis	37	592
System Design	398	6368
System Fabrication	7	112
System Testing	35	560
Writing the Bachelor's Thesis Document	294	4704
Defense preparation	25	400
	Total Hours	Engineer's payment (€)
	896	14336

Table 2.1 – *Junior engineer's costs.*

Expenditure	Cost (€)
Junior engineer' services	14336
Senior engineer's services	4600
Materials	589
Software Licences	6600
Equipment Rental	2600
Total	28725

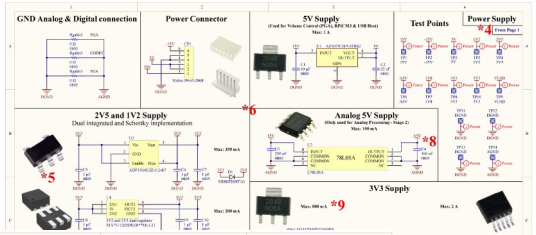
Table 2.2 – *Total Project Budget.*

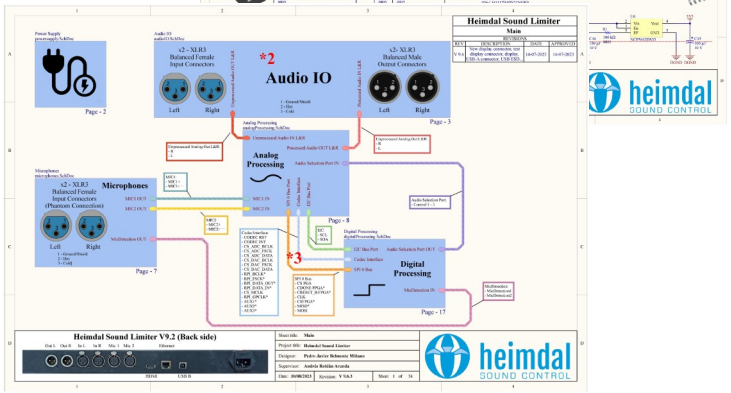
3 System Design

3.1 Electronic Design

Document Page 16-23

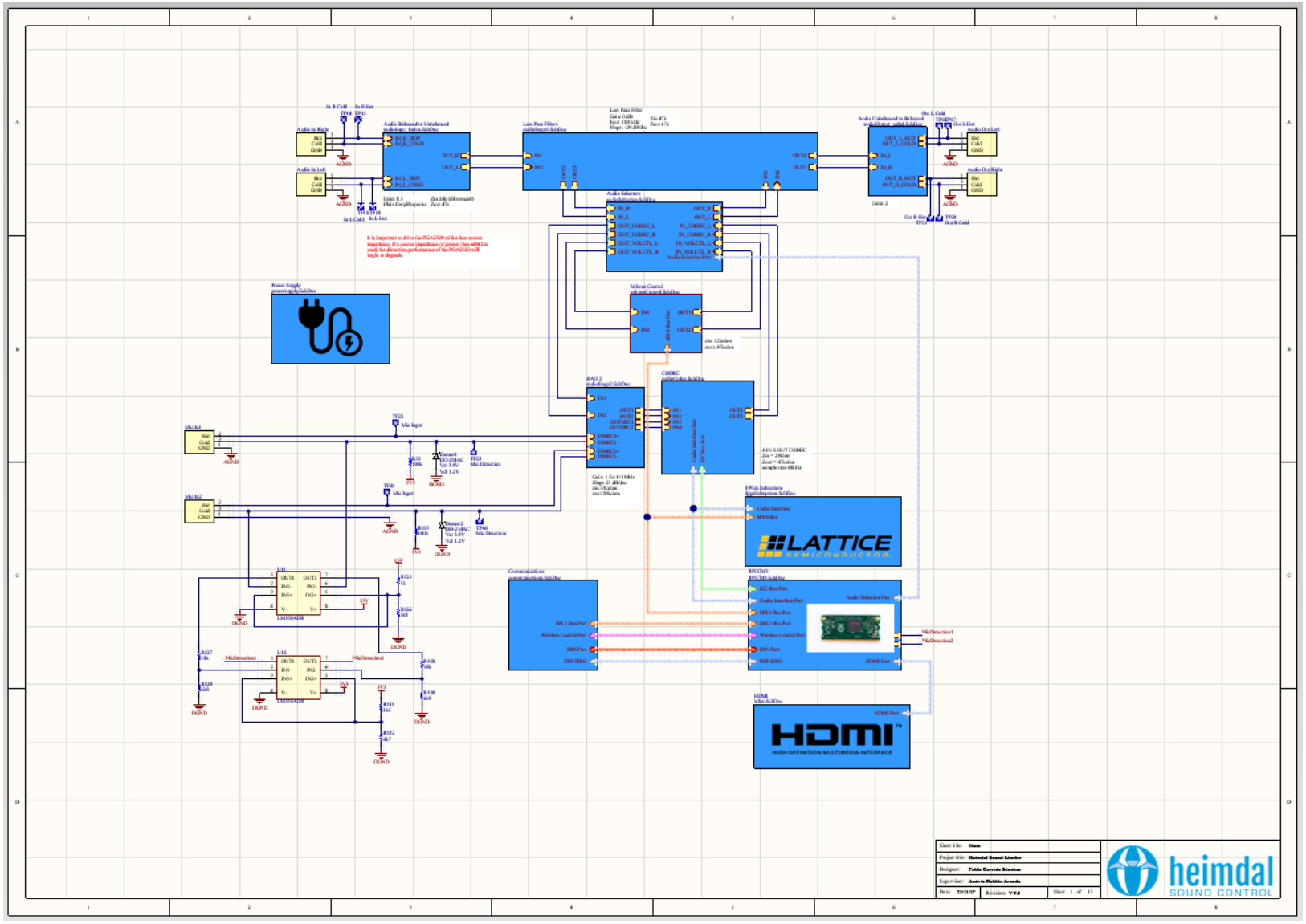
1) Keep all schematics and PCBs on A4 whenever possible
2) Include names, images, description if necessary of each block
3) Colour to differentiate and include information on harness lines
4) Add on each schematic page in the top right corner the title, description and page where it is referenced
5) Add an image of the integrated package
6) Separate each part of the schematic into boxes with title and description.
7) Align everything in a way that is more pleasing to the eye
8) Include on components such as resistors and capacitors the units, package size...
9) Add characteristics of the integrated components
10) Include the schematic of the internal circuit of the integrated circuit
11) If there are double implementations, indicate them and how to use
12) Try to use the most of the space on each sheet
13) Add pinout images whenever possible





3 System Design

3.1 Electronic Design



3 System Design

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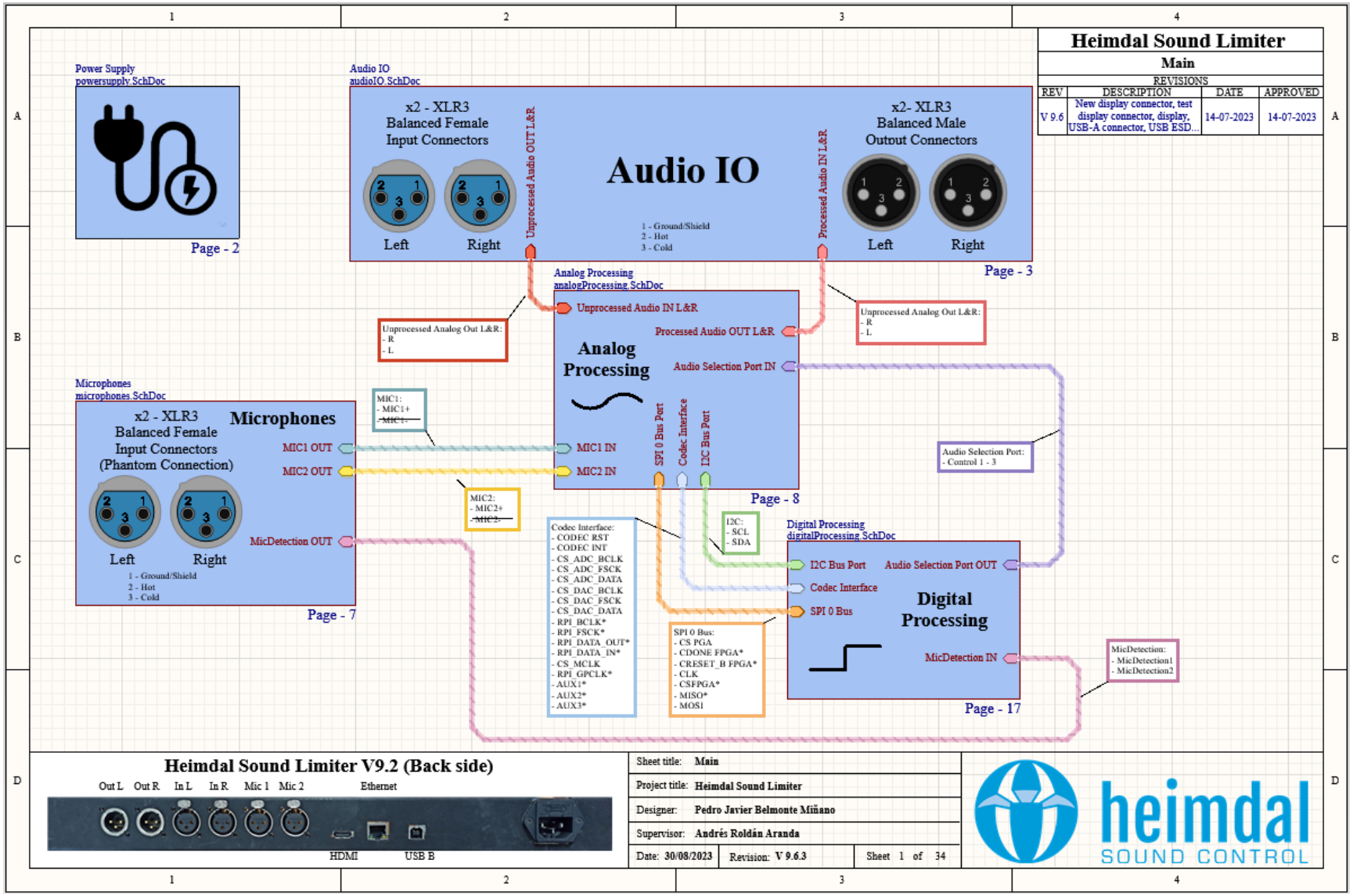
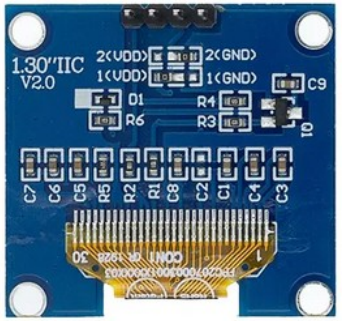


3 System Design

3.1 Electronic Design

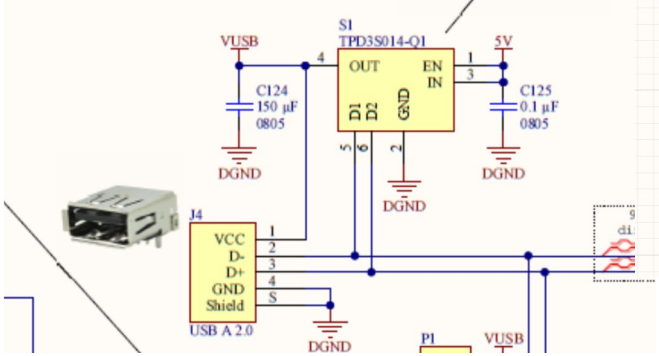


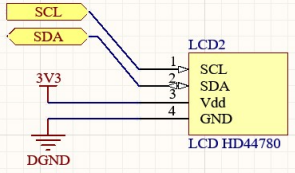
MF-R090 Ressetable Fusse
Specifications:
- Hold Current: 900 mA
- Max Voltage: 60 VDC
- Trip Current: 1.8 A
- Current Rating (Max): 40 A
- Resistance: 310 mΩ
- Min Op. Temperature: -40ºC
- Max Op. Temperature: + 85ºC
- Power Dissipation: 1 W

PIN	
NAME	NO.
D1	5
D2	6
EN	1
GND	2
IN	3
OUT	4

TPD3S014-Q1 Current Limit Switch and D+/D- Protection for Automotive USB Host Ports

- USB 2.0 and 3.0
- Continuous Current Rating: 0.5 A
- Integrated Output Discharge
- Reverse Current Blocking
- Short-Circuit Protection
- Over Temperature Protection
- IEC 61000-4-2 Level 4 ESD Protection
- Fixed, Constant Current Limits: 0.85 A





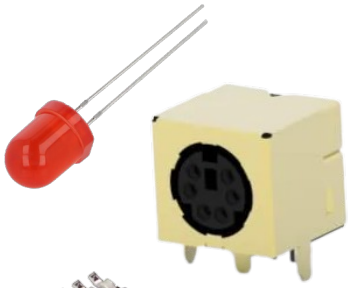
HD44780U with I2C adapter

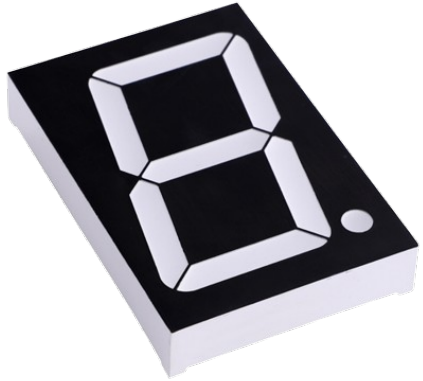
Interface: I2C (adapter)
Backlight: Blue

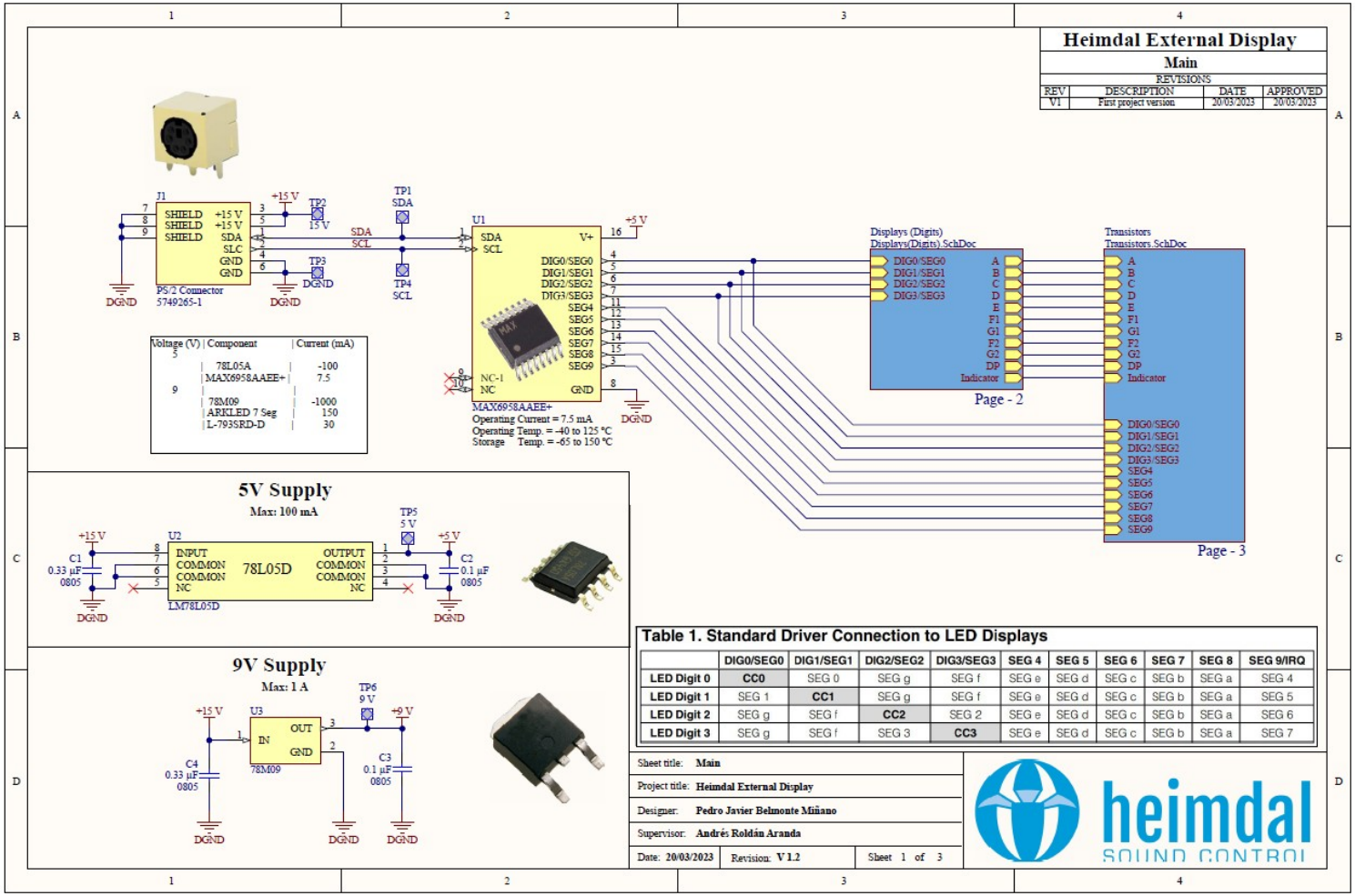
Supply Voltage: 2.7 - 5.5 V
Operating Temp: -20 - 70 ºC
Storage Temp: -30 - 80 ºC

3 System Design

3.1 Electronic Design

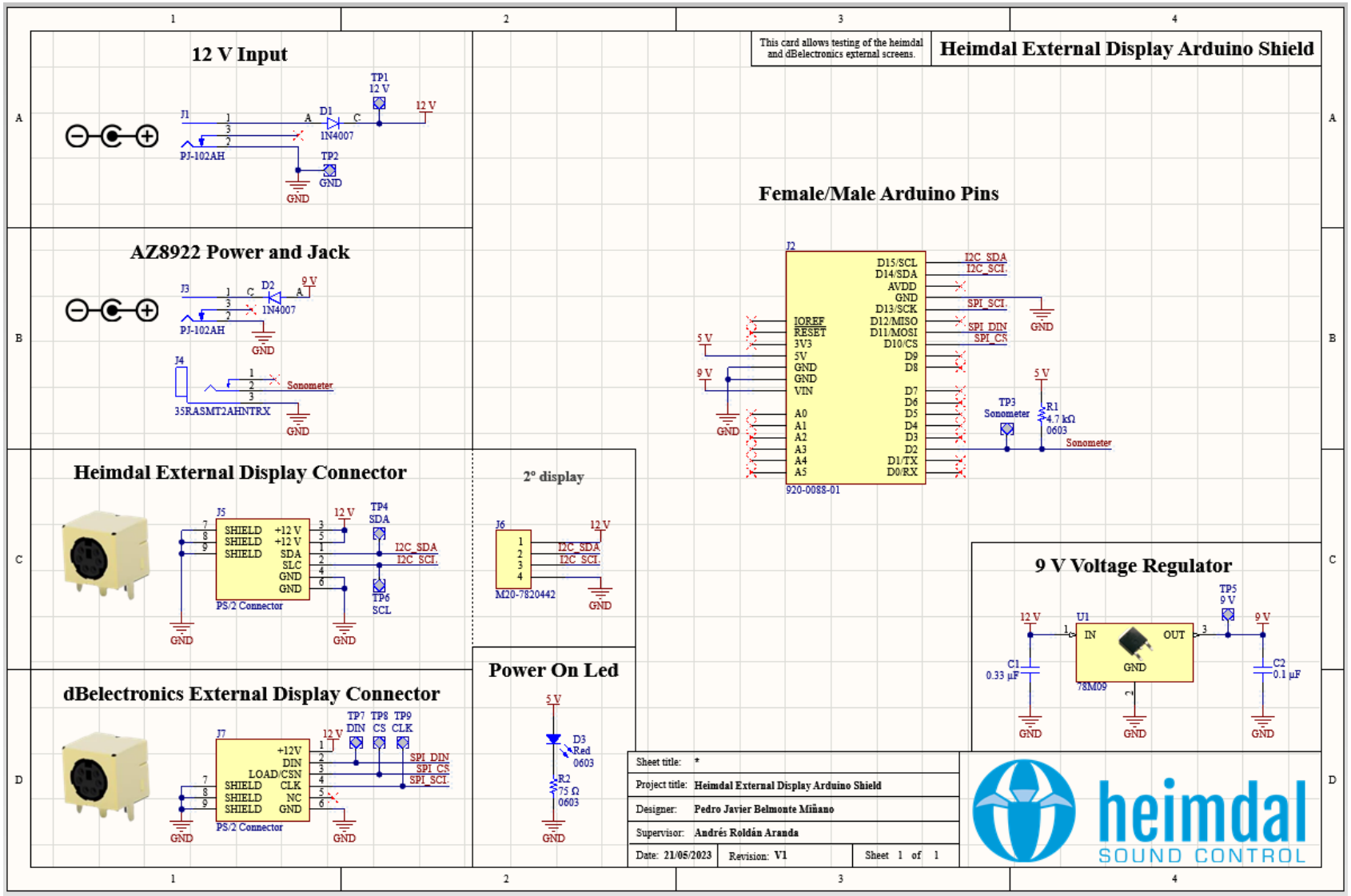






3 System Design

3.1 Electronic Design



3 System Design

3.2 PCB Design

1) Routing tries to avoid unnecessary bends, trying to carry through the same layer, with a sufficient width for the current to be handled

2) Try to align components of the same type to facilitate their manufacture

3) Do not overdrive the silkscreen on the pads, vias or holes

4) Always use ground plane on both layers with the option to remove isolated islands activated to identify areas without ground plane

5) Use via-stiching to interconnect the ground planes and remove isolated islands. Improving current return and avoiding loops that may radiate

6) Star routing of power tracks whenever possible.

7) Place decoupling capacitors as close as possible to the ICs

8) Include logos, board information such as author name, project name, company name, date, version...

9) Add a white box for small notes on the prototypes, e.g. software version

3 System Design

3.2 PCB Design

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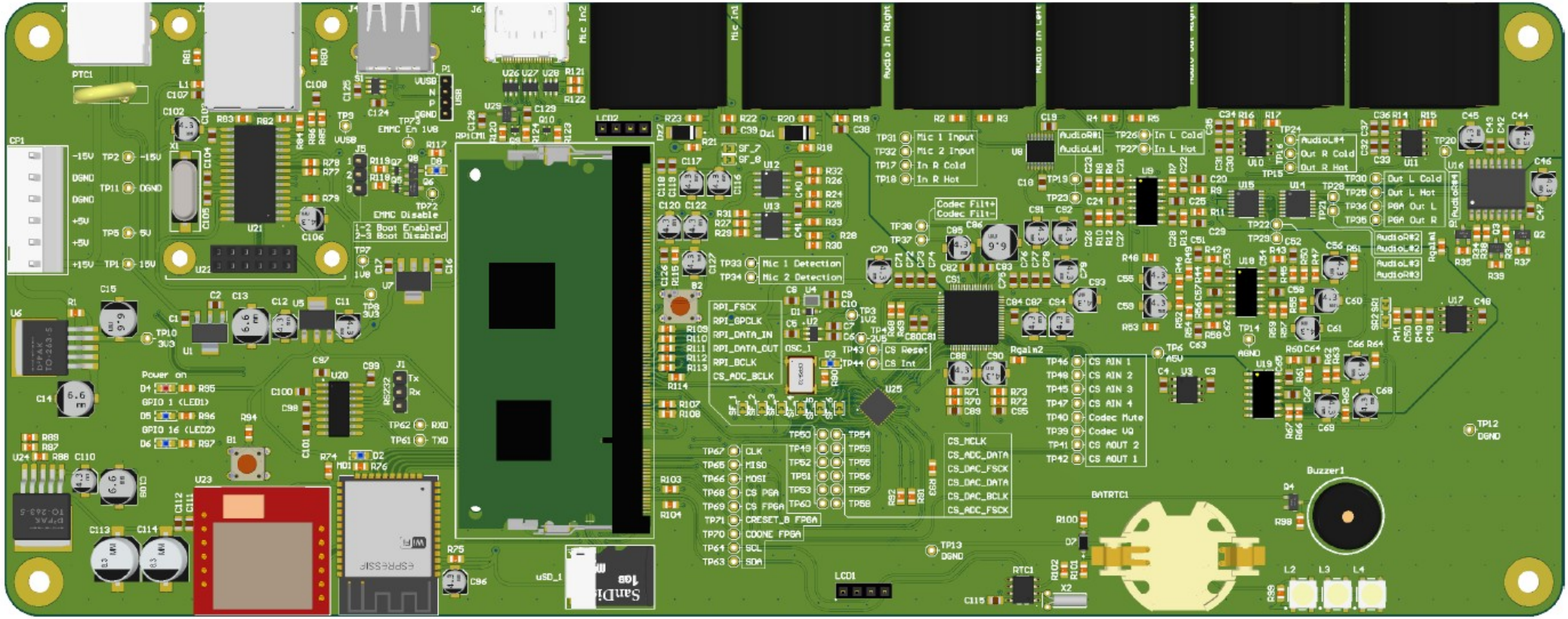

3 System Design

3.1.2 PCB Design

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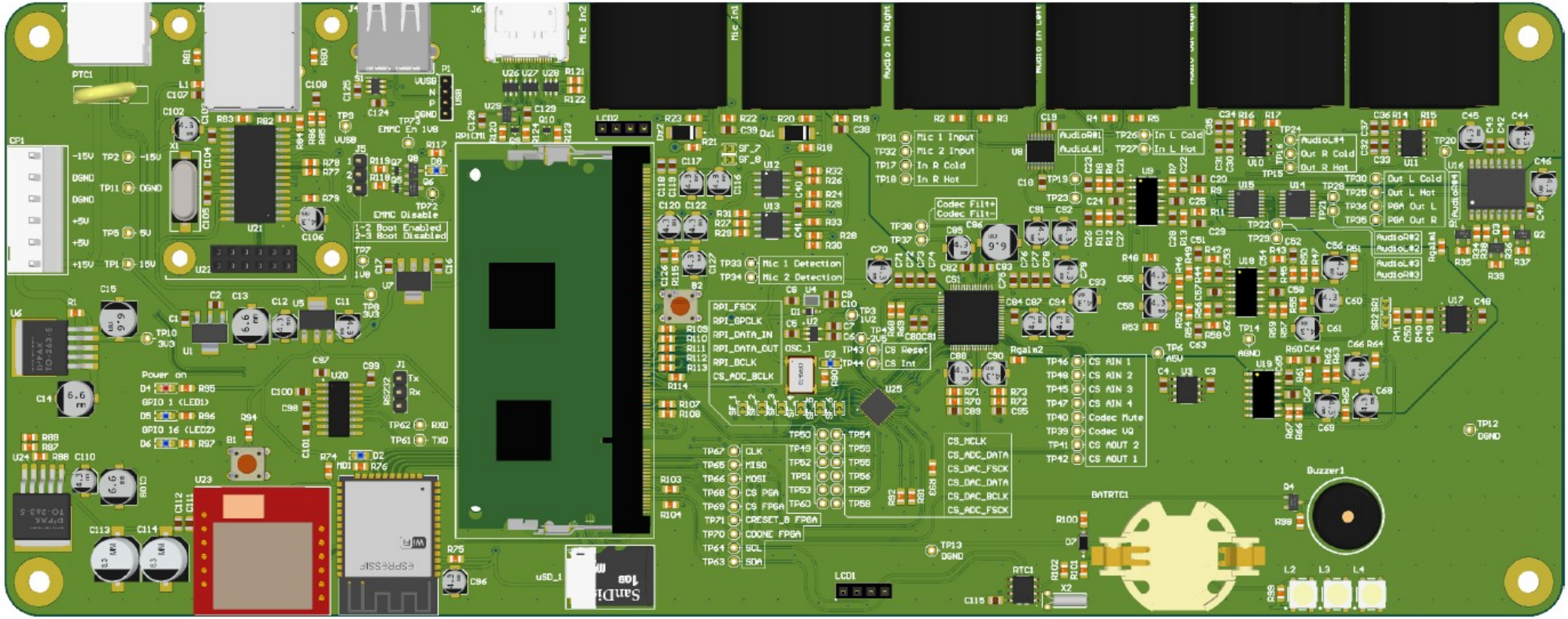

3 System Design

3.1.2 PCB Design

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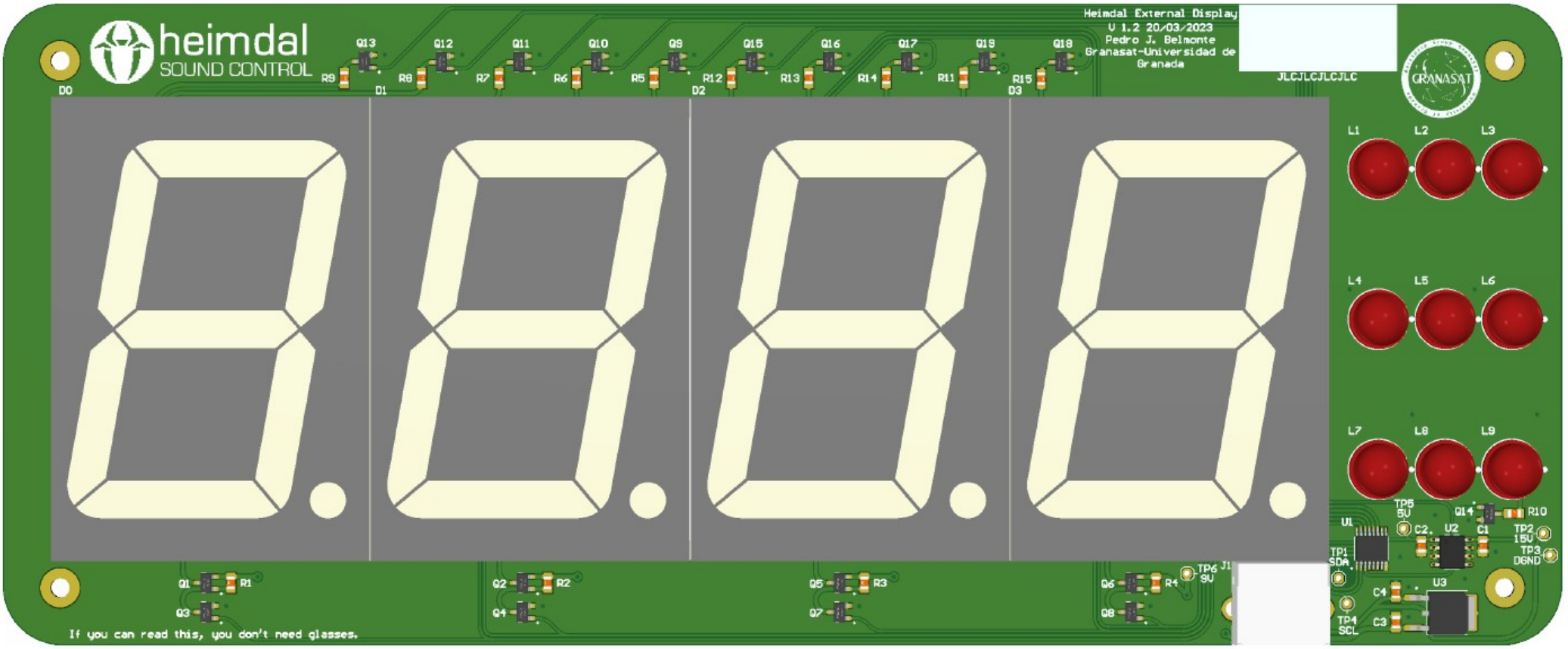

3 System Design

3.2 Mechanical Design

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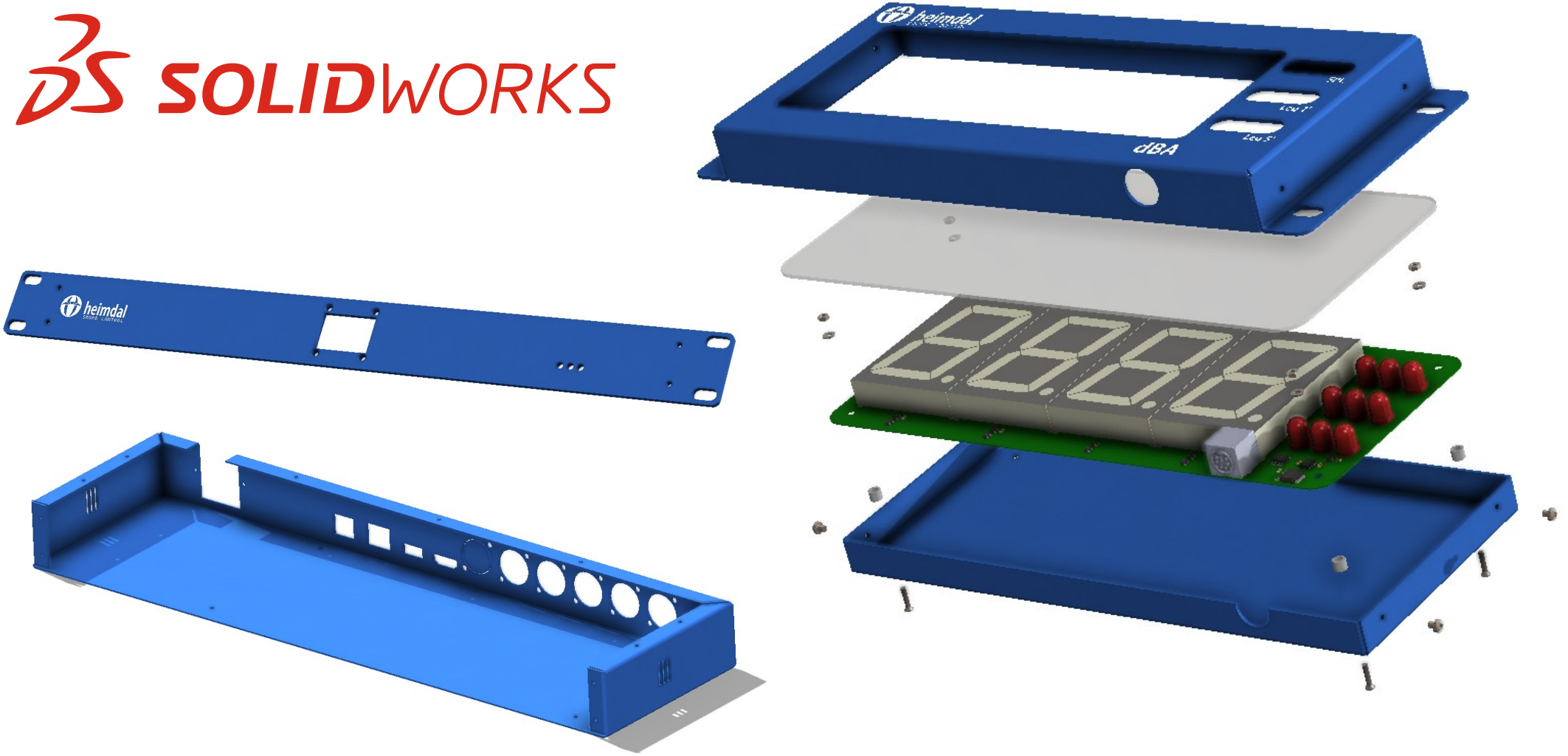
SOLIDWORKS



4. Fabrication

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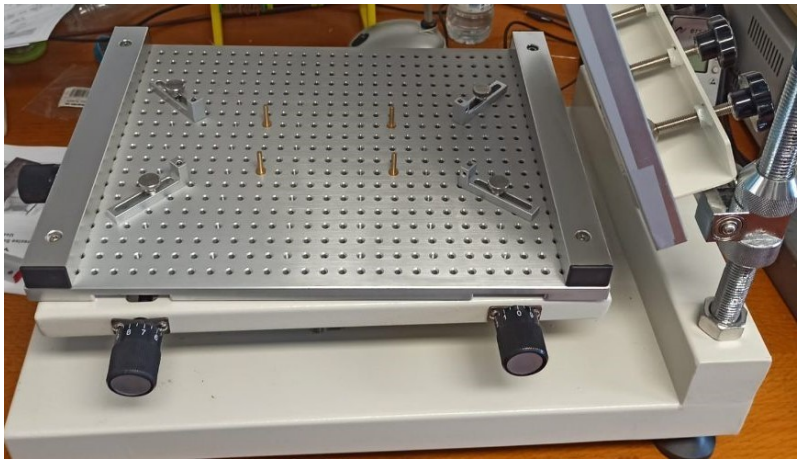
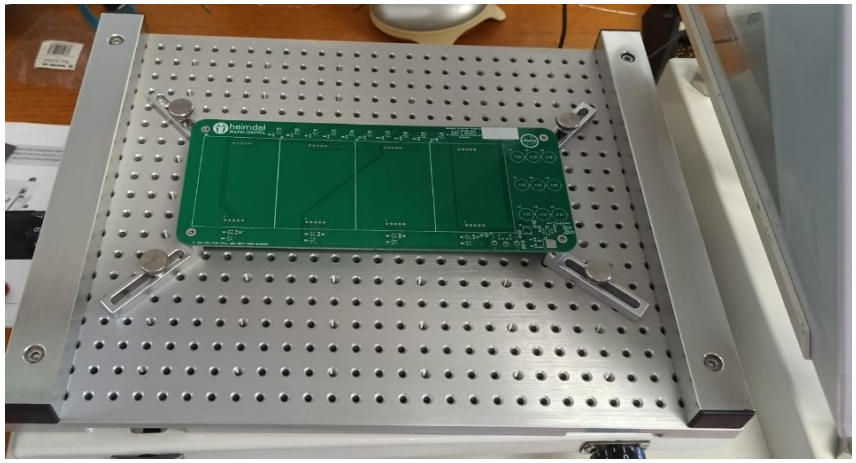
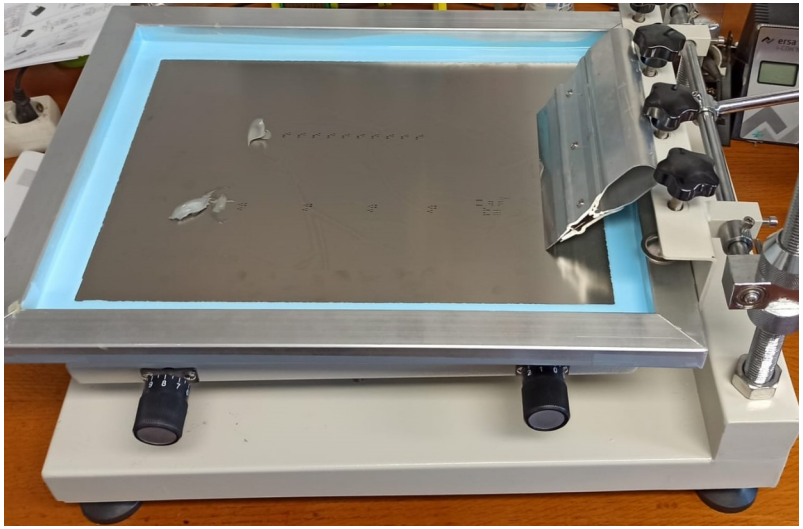
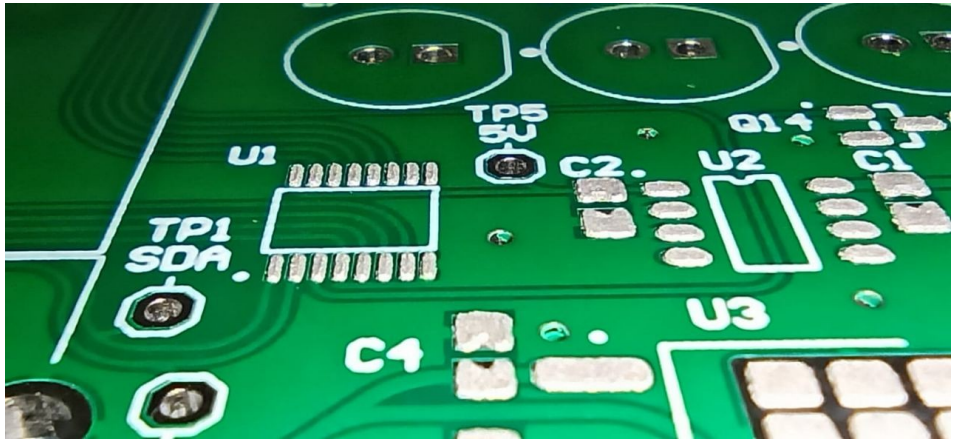
JLCPCB









4. Fabrication

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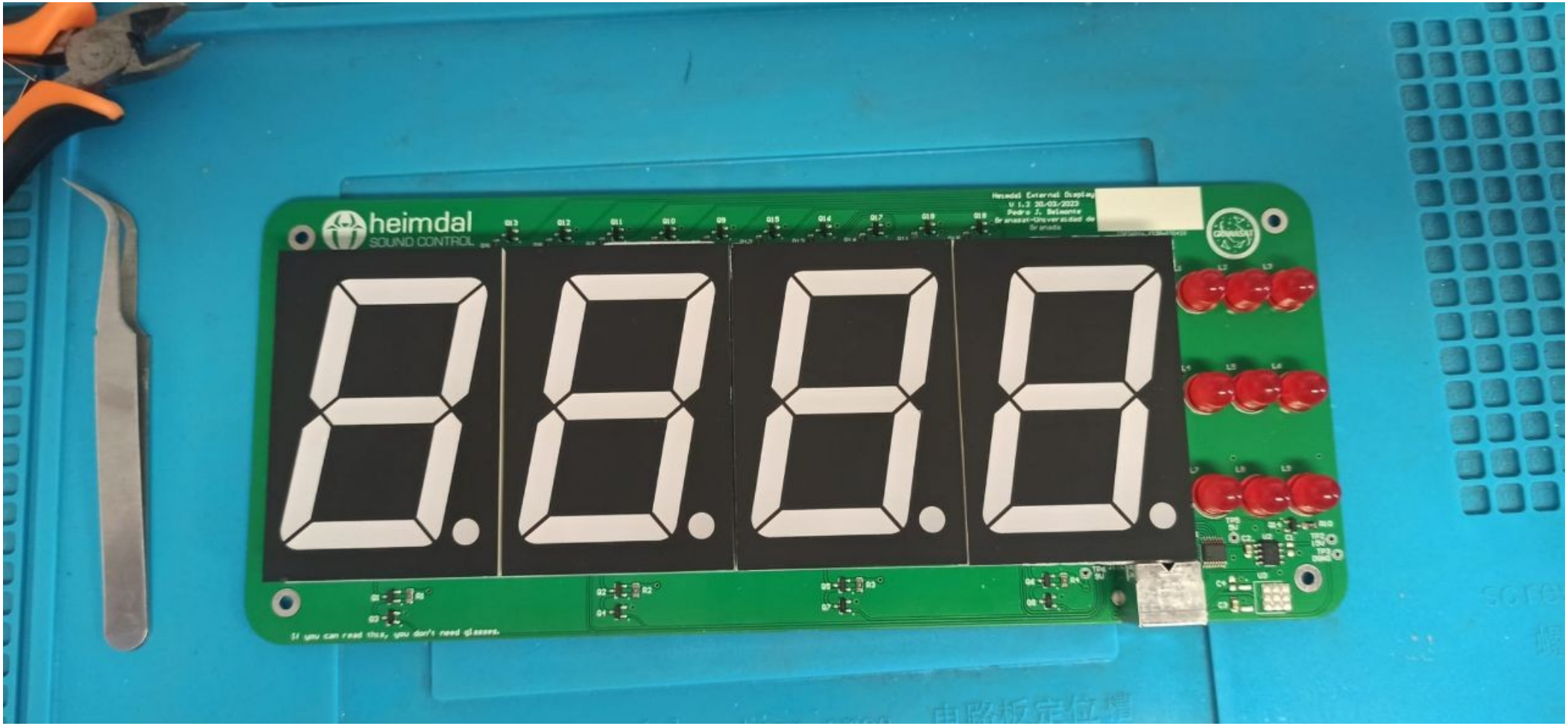

4. Fabrication

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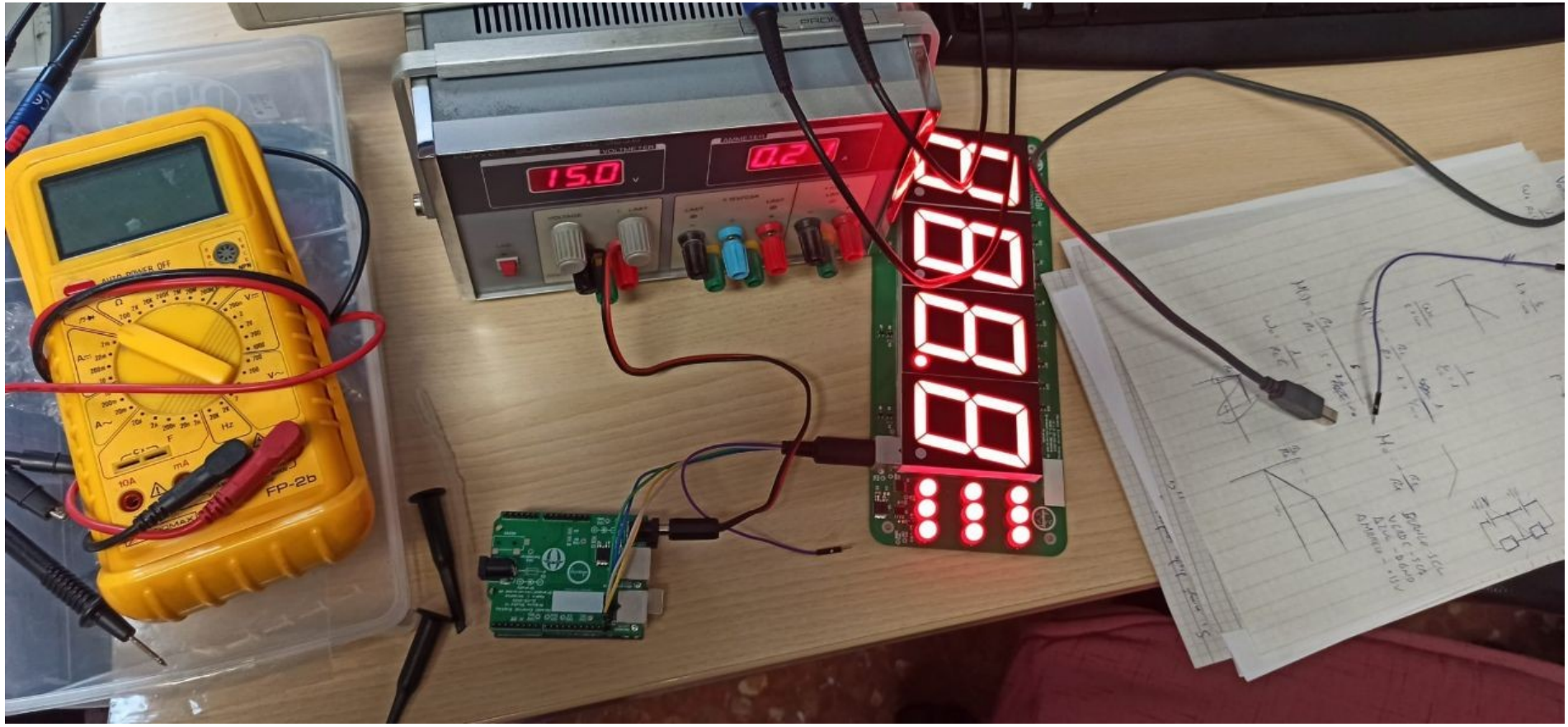
5. Testing



6. Conclusions and Future Lines

Conclusions:

- **We have been introduced to the development of electro-acoustic products, electronics, PCB and mechanical design**
- **A challenge for me as student**
- **I have mised some knowledge in the degree**
- **We have managed to develop an external display, although it is not fully functional yet, and an arduino module for testing**
- **New design of the limiter**

Future Lines:

1) Redesign and manufacture the external display with another driver or a microcontroller.

2) Manufacture a prototype of the sound limiter.

3) Create the plans and manufacture the boxes of the equipment

4) Make measurements of input impedances, output impedances, frequency ranges, noise, and harmonic distortion of the sound limiter

5) Implement the new RaspberryPi CM4

6) Create a limiter opening detection system to avoid unauthorised manipulation of the limiters

7) Create a box for the testo arduino module for external displays

¡Gracias!