University of Moratuwa, Sri Lanka

Faculty of Engineering

Department of Electronics and Telecommunication Engineering
Semester 4 (Intake 2021)

EN2160 - Electronic Design Realization

Industrial End Effector - Final Report

Group B

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This report is submitted as a partial fulfillment for the module EN2160 - Electronic Design Realization, Department of Electronic and Telecommunication Engineering, University of Moratuwa.

Contents

1 Introduction

In our end effector's conceptual design phase, our focus is on brainstorming and prototyping different ideas. We aim to create a comprehensive solution by combining various circuits, enclosures, and functional parts. Using design-driven innovation, we prioritize creativity over existing user demands, presenting consumers with fresh concepts. Through sketches and innovative thinking, we strive to develop an optimal solution that meets both functional needs and consumer preferences. This approach fosters innovation within our team and ensures our end effector stands out in the market.

2 Review Progress

Since the inception of the project, our team has explored multiple technological approaches, including the use of LiDAR sensors, machine vision techniques, and Time-of-Flight (ToF) sensors. After thorough research and review of existing literature and videos, we determined that ToF sensors offer the best solution for our requirements.

We have progressed significantly from the conceptual phase to practical implementation. We have completed the design phase, which included detailed layouts for the ToF sensors. We found a way to transmit data through the Modbus protocol and have implemented this in our design. The PCB has been designed and printed, and the enclosure for the end effector has been fabricated. After assembling the components, we are now in the PCB testing stage.

During this testing phase, we are conducting laboratory tests to ensure the functionality and reliability of the printed circuit boards (PCBs). We are verifying that the ToF sensors accurately detect box orientations and transmit the correct data to the robot control panel. Our focus is on ensuring that the sensor readings are precise and that the Modbus protocol facilitates seamless data communication.

Our next steps involve measuring distances and orientations using the ToF sensors and plotting this data to establish a mathematical relationship between sensor readings and box orientation. We will then convert the sensor data into coordinates relevant to the robot control panel. Following this, we will conduct further tests to validate the accuracy and reliability of the integrated system in various conditions. Based on the test results, we will refine the design to enhance performance and reliability. By following these steps, we aim to ensure that our end effector is fully functional and ready for practical industrial applications.

3 Identification of the stakeholders

1. **Project Team:** The core group responsible for the design, testing, and implementation of the end effector.

2. **University of Moratuwa:** Provides guidance, resources, and ensures academic standards are maintained throughout the project.

3. **Industrial Clients:** Potential end-users who represent the practical application and market for the end effector, requiring the tool to meet industry standards and needs.

4. **Suppliers:** Companies supplying components and materials crucial for constructing the end effector, affecting its quality and functionality.

5. **Classmates and Academic Community:**Collaborators and peers who provide feedback, fostering a collaborative learning environment and contributing to the project's iterative improvement.

4 Observe users

To better understand the practical application and user interaction with similar technologies, we examined several existing projects and case studies. Notable examples include:

1. **ABB Robotics - Palletizing Cartons:** Demonstrates the use of robotic palletizers in handling various box orientations, highlighting efficiency and precision.

2. **ABB Robotics - Palletizing Drums of Paint:** Shows how robotic systems manage heavy and unwieldy objects, emphasizing the robustness required in industrial settings.

3. **Palletizing Robot Handling a Variety of Boxes:** Illustrates the versatility of robotic systems in adapting to different shapes and sizes of boxes, which is critical for our design.

These observations provided valuable insights into the operational contexts, challenges, and requirements that our end effector needs to address, ensuring our design aligns with real-world industrial applications.

5 Need list

To ensure our end effector design meets the diverse needs of all stakeholders, we compiled a comprehensive list of requirements:

1. **Functional needs**
   (a) Accurate detection of box orientation using ToF sensors.
   (b) Real-time data transmission to the robot control panel via the Modbus protocol.
   (c) Adaptability to various box shapes and sizes without manual adjustments.
2. **Accessibility Needs:**
   (a) User-friendly interface for easy integration and operation.
   (b) Clear documentation and support for troubleshooting and maintenance.
3. **Usability Needs:**
   (a) Intuitive sensor placement and calibration process.
   (b) Reliable performance with minimal downtime and errors.
4. **Technical Needs:**
   (a) Robust and durable sensor hardware capable of withstanding industrial environments.
   (b) Compatibility with existing robotic systems and control panels.
5. **Business Needs:**
   (a) Cost-effective design that provides significant ROI through improved efficiency and reduced product damage.
   (b) Scalable solution that can be adapted for various industrial applications.

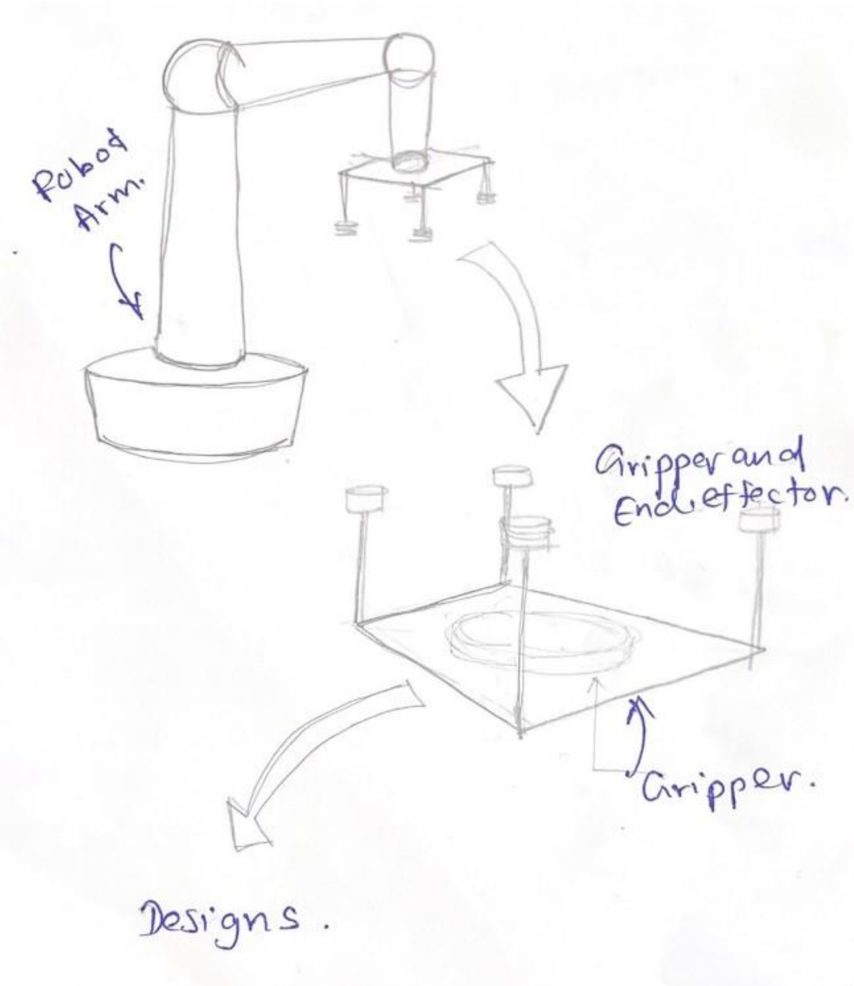
6. **Regulatory Needs:**
   (a) Compliance with industry standards for safety and performance.
   (b) Adherence to environmental regulations for sustainable operation.

7. **Contextual Needs:**
   (a) Effective operation in diverse industrial environments, including varying lighting and space constraints.
   (b) Integration with existing workflows to enhance productivity without significant disruptions.

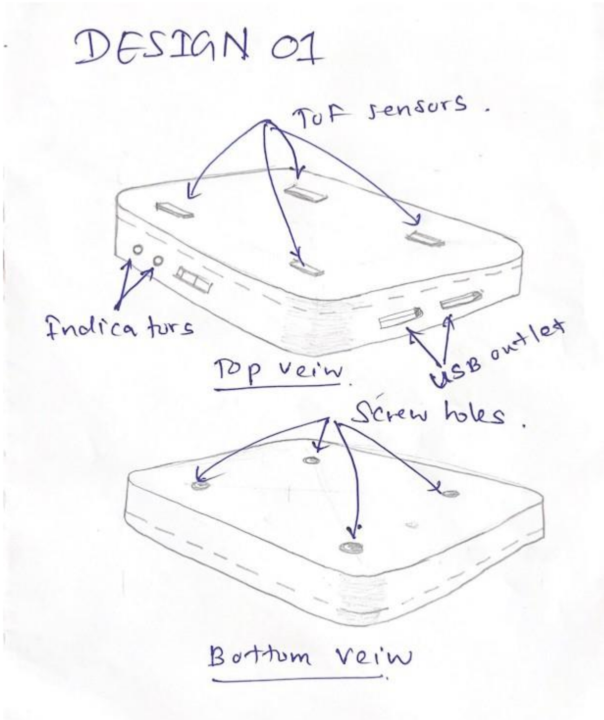
By addressing these needs, we aim to develop an end effector that not only meets the technical and functional requirements but also enhances the overall efficiency and reliability of industrial automation processes.

6 Conceptual Designs drawn by Peers

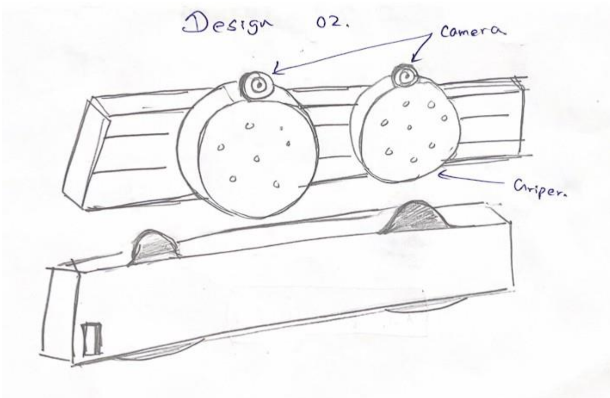
The following three conceptual designs were developed by the group members after having several brainstorming sessions and discussions within the group.



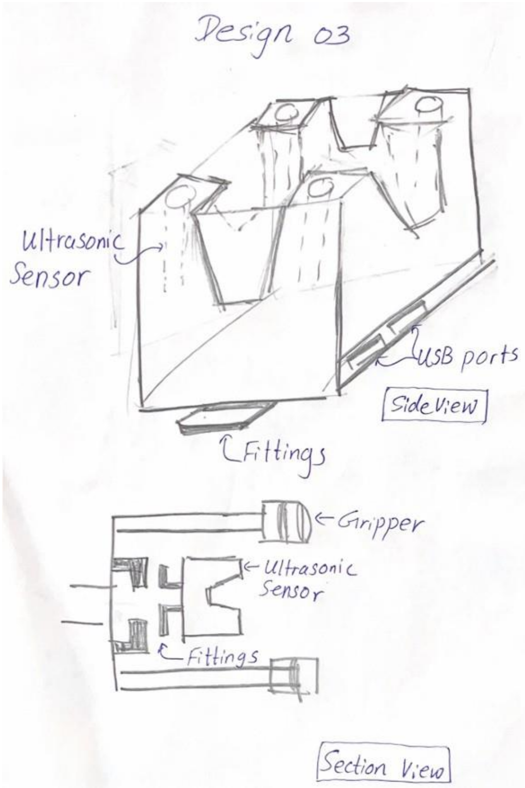
6.1 Design 1



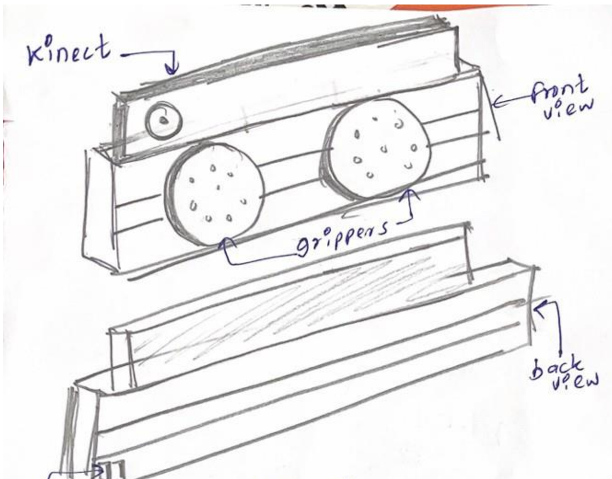
6.2 Design 2



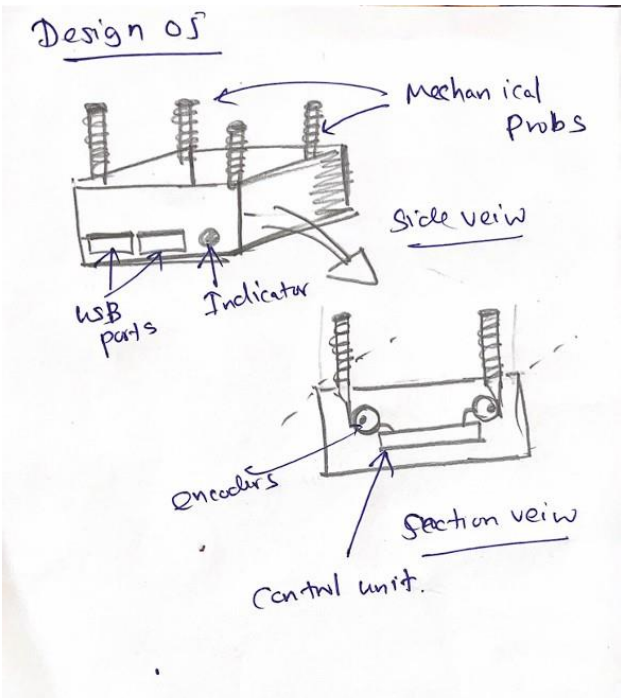
6.3 Design 3



6.4 Design 4

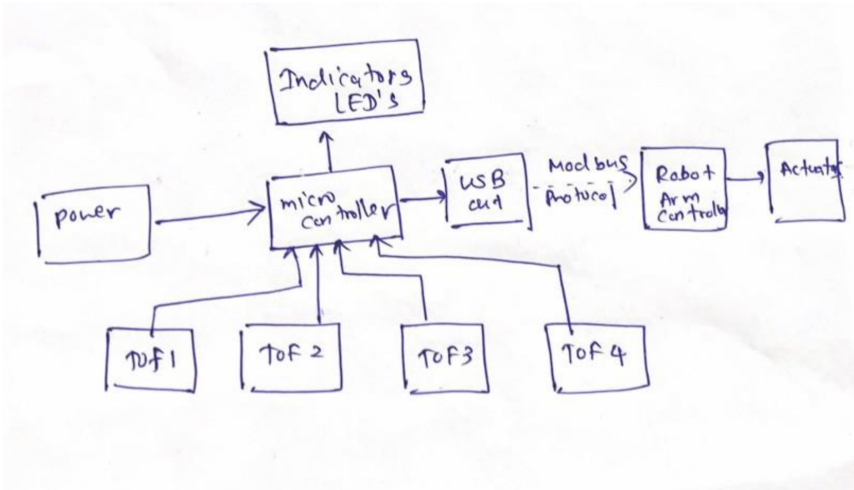


6.5 Design 5

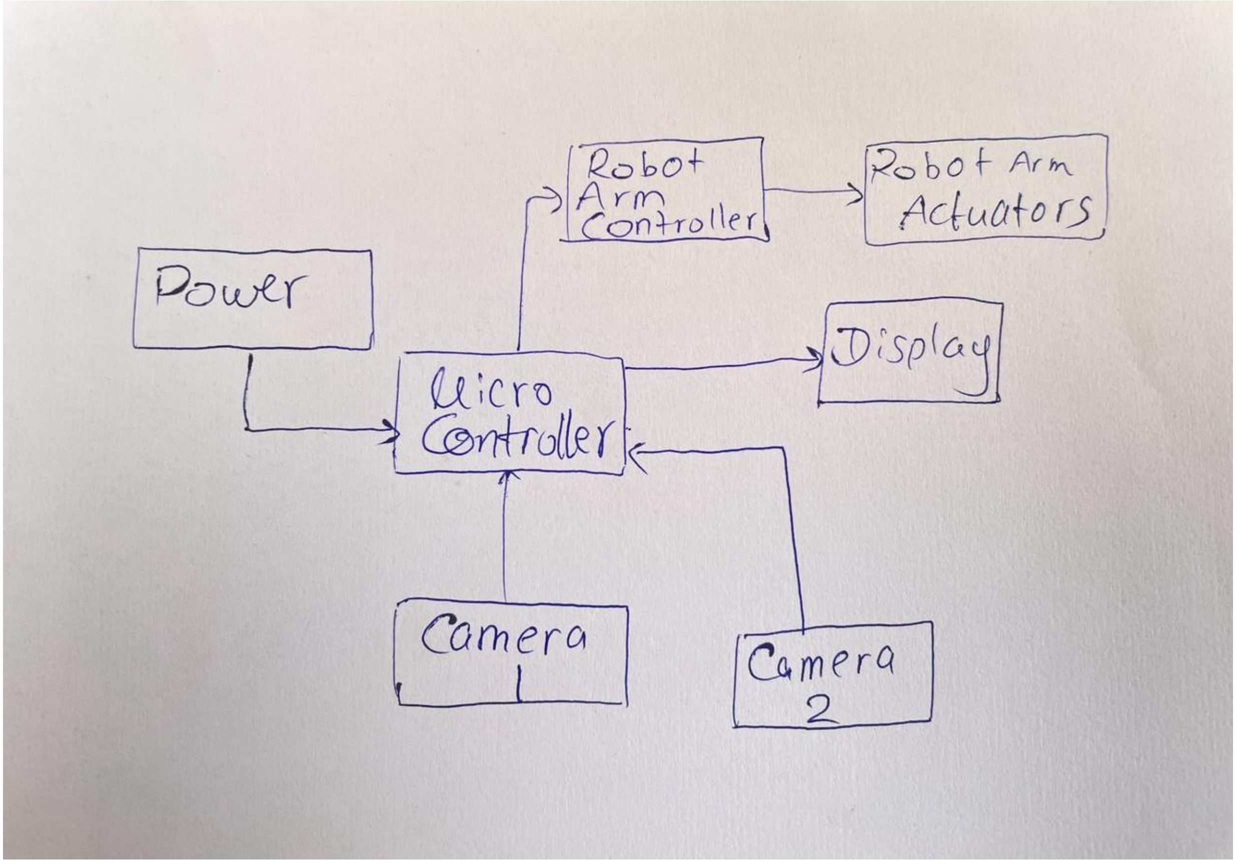


7 Block Diagrams Drawn by Peers

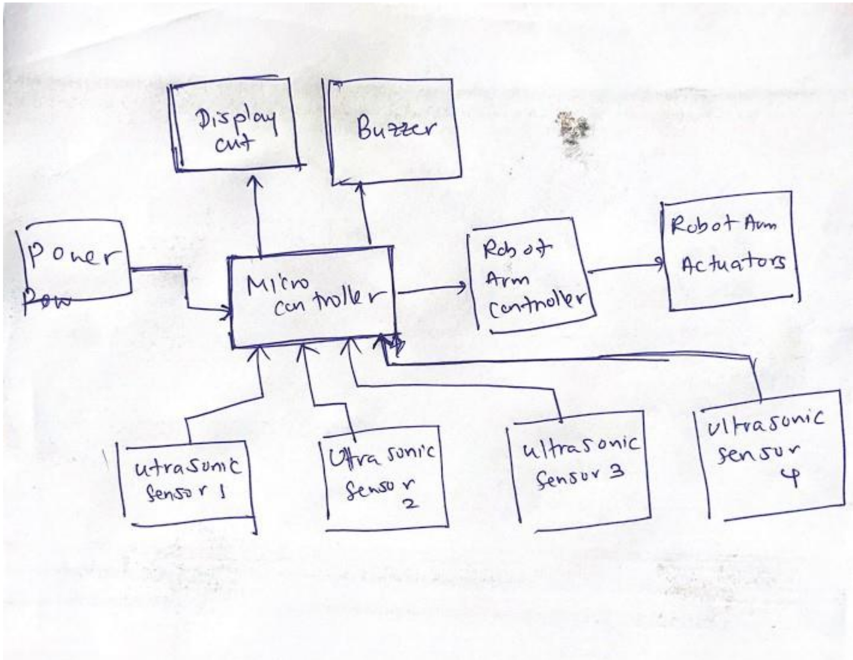
7.1 Functional block diagram 1



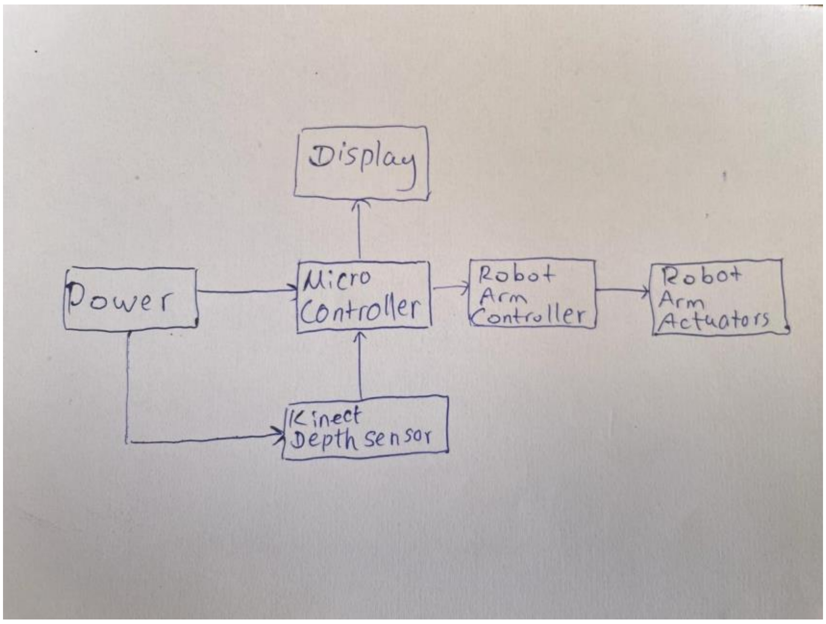
7.2 Functional block diagram 2



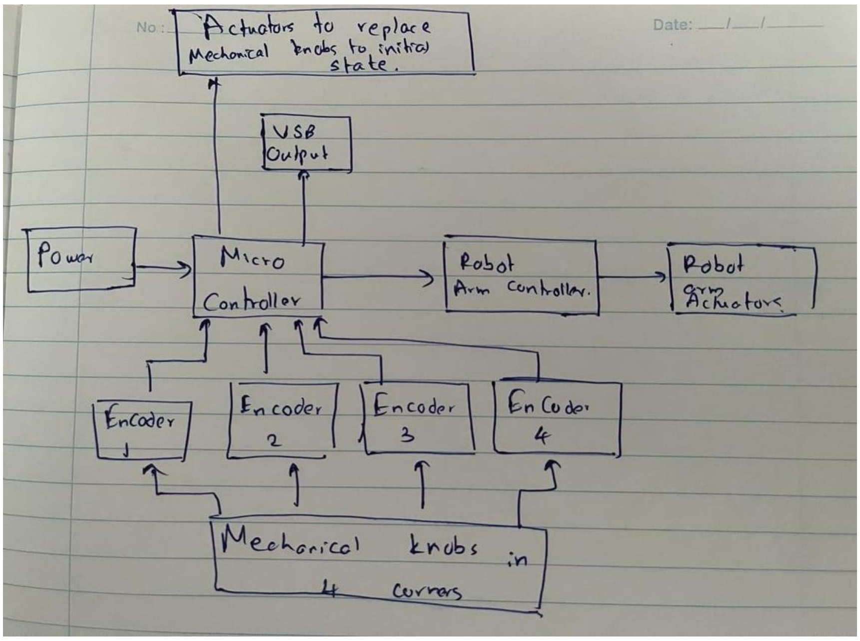
7.3 Functional block diagram 3



7.4 Functional block diagram 4



7.5 Functional block diagram 5



These block diagrams were designed based on the basic functionality of the product by the group members to decide an optimal functional design for the product.

8 Evaluation of the designs

		Design 1	Design 2	Design 3	Design 4	Design 5
Newly added features		Indicator LEDs USB Outputs Communication through Modbus Protocol	Display output. 2 Cameras	Display Output Buzzer output Ultrasonic Sensors	Kinect Sensor Display Output	Mechanical Probes Encoders USB Output
Removed features		Buzzer Output Display Output	LED Indicators Modbus Protocol	USB Outputs	USB Outputs Buzzer	Display Output
Enclosure design criteria comparison	Functionality	9	9	8	8	7
	Aesthetics	7	8	7	8	6
	Heat dissipation	7	9	7	8	9
	Assembly and serviceability	8	7	8	6	8
	Ergonomics	8	8	7	8	7
	Simplicity	9	7	9	7	8
	Durability	9	7	8	8	7
Functional block design criteria comparison	Functionality	9	9	8	9	6
	User experience	8	9	7	9	6
	Manufacturing feasibility	9	7	9	7	8
	Cost	8	6	9	4	8
	Performance	9	8	7	9	6
	Future prolongs	8	9	7	9	6
	Power	8	7	8	7	7
Total		118	108	117	117	107

8.1 Enclosure design criteria

1. **Functionality:**How well-supported are the primary functionalities by the design?
2. **Aesthetics:**To what extent is the user visually appealing overall?
3. **Heat dissipation:**How much heat is produced and how effectively is it controlled?
4. **Assembly and serviceability:**To what extent is it easy to assemble and disassemble?

5. **Ergonomics:**How easily can the user engage with the design and how well does it fit in their hand?

6. **Simplicity**

8.2 Functional block diagram criteria

1. **Functionality:**To what extent do functional needs get met by the circuit design?
2. **User experience:**To what extent is the interaction intuitive and user-friendly?
3. **Manufacturing feasibility:**Determine whether the design can be manufactured.
4. **Cost:**Analyze the total cost-effectiveness of the capability offered.
5. **Performance:**Assess the bandwidth range, resolution, and signal quality.
6. **Future proofing:**How easily can individual components be upgraded or replaced in the design?
7. **Power Efficiency:**To what extent is the device's power usage managed effectively?

9 Design selection

9.1 Features of the design

The choice of Conceptual Design 01 was a strategic decision, primarily due to its combination of compact size and durable construction. This compact and easily mountable design ensures seamless integration into the robot arm with vacuum gripper, optimizing space utilization.
Furthermore, the integration of Time-of-Flight (ToF) sensors within Conceptual Design 01 offers a significant advantage by providing more accurate and reliable measurements. Maintaining a sufficient distance between ToF sensors ensures that the percentage error remains below 1%, guaranteeing precise results and enhancing the overall accuracy of our system.

The inclusion of a USB port facilitates both power input to the circuit and communication with the robot, streamlining the setup process and enhancing connectivity.

In addition, the deliberate choice to utilize only essential indicator LEDs while removing buzzers and displays enhances the industry suitability of Conceptual Design 01. By prioritizing simplicity and functionality, we ensure that our solution meets industry standards and requirements without unnecessary distractions or complexities.

10 Component Selection

The components were selected based on their functionality, compatibility, market availability, feasibility, robustness, ease of soldering, and cost-effectiveness. Alternative options were considered to ensure optimal performance and cost-effectiveness.

10.1 Micoconntroller

- *The selected microcontroller is the **ATMEGA2560-16AU**, an 8-bit AVR microcontroller operating at 4.5-5.5V with a 16MHz clock speed. It features 256KB of Flash memory, 4KB of EEPROM, 8KB of SRAM, and 86 GPIO pins, housed in a 100-pin TQFP package. It is industrial grade, with an operating temperature range of -40°C to 85°C, and is Pb-Free. This microcontroller serves as the main processing unit, handling data from TOF sensors and managing communication. It was chosen for its high number of GPIO pins, ample memory, and robust industrial-grade specifications, making it suitable for demanding applications. The ATMEGA2560-16AU is widely available from major suppliers, ensuring high feasibility due to its common use. It is also cost-effective, offering a good balance of features and performance compared to alternatives. An alternative considered was the PIC18F46K22, another 8-bit microcontroller with 64KB of Flash, 4KB of RAM, and 38 GPIO pins in a 64-pin TQFP package. However, the ATMEGA2560 was preferred for its higher number of GPIO pins and larger memory, which were necessary for the application.*

Figure 1: ATMEGA2560-16AU

10.2 Multiplexer

- *The selected multiplexer is the **PCA9546ADG4, a 4-channel I2C and SMBus multiplexer** with reset functions, operating at 2.3 to 5.5V and rated for temperatures between -40°C and 85°C. It comes in a 16-pin SOIC package and is RoHS compliant, free of Sb/Br. This component is used for multiplexing I2C signals from multiple TOF sensors to the microcontroller, providing efficient channel management for I2C communication in a compact package. It is widely available, ensuring high feasibility due to its common use in I2C applications. The PCA9546ADG4 is also cost-effective, offering the needed functionality at a reasonable price. **An alternative considered was the TCA9548A**, an 8-channel I2C multiplexer, but it was not selected as the additional channels were unnecessary for this application, making the PCA9546ADG4 a more cost-effective and sufficient choice.*

Figure 2: PCA9546ADG4

10.3 Distance Measurement Sensor

- *The selected component is the **VL53L0X**, a Time-of-Flight (ToF) Laser Rangefinder Module. This sensor is chosen for its ability to provide accurate distance measurements up to 2 meters, making it ideal for applications requiring precise ranging and object detection, such as robotics, drones, and proximity sensing. The VL53L0X is compact, easy to integrate, and performs reliably in various lighting conditions with immunity to ambient light interference. It is widely available from major suppliers like Digi-Key and Mouser, ensuring high feasibility and support for its implementation. The sensor is cost-effective, balancing performance and price, and its extensive documentation further enhances its practicality. While an **alternative like the VL6180X** offers proximity and ambient light sensing, it is less suitable for long-distance ranging, reaffirming the VL53L0X as the optimal choice for precise distance measurement applications.*

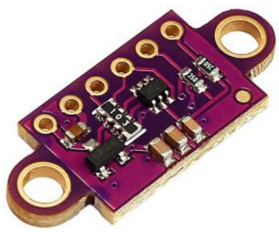


Figure 3: VL53L0X

10.4 Oscilators

- *The selected crystal oscillator is the **ABLS2-16.000MHZ-D4Y-T**, a low-profile, surface-mount HC/49US (AT49) microprocessor crystal. This component is chosen to provide the clock signal for the microcontroller, ensuring reliable frequency stability in a compact package. It is easily available in the market, making it highly feasible as a standard component for microcontroller applications. The ABLS2-16.000MHZ-D4Y-T is also cost-effective, offering a good balance of reliability and performance for its price.*

10.5 USB Connectors

- *The selected USB connector is the USBA1HSW6, a USB-A (USB Type-A) receptacle connector with 4 positions. This component is intended to provide USB connectivity for data transfer or power supply. It was chosen for its standard design and through-hole mounting, which ensures a robust mechanical connection. The USBA1HSW6 is readily available on the market, making it a highly feasible option as a standard component. It is also cost-effective, offering reliable performance at a reasonable price due to its common use.*

10.6 Capacitors

- *The selected capacitor is the **C1206C104K2RACTU**, a 0.1F 0.3F, 200V, 10% tolerance, X7R ceramic capacitor in a 1206 package. This component is chosen for general-purpose decoupling and filtering to ensure a stable power supply to various components. The X7R dielectric material provides stable capacitance across a wide temperature range, and the 1206* *footprint is suitable for compact PCB designs. It is widely available from major suppliers such as Digi-Key and Mouser, making it highly feasible due to its common use and availability. The C1206C104K2RACTU is also cost-effective, offering a good balance between performance and price compared to alternatives. An alternative component is the* ***GRM31CR61A106KE15L****, a 10F, 35V, X5R ceramic capacitor in a 1206 package. However, it was not selected due to its different dielectric material, which is not suitable for decoupling purposes.*

10.7 Resistors

- *The selected component is the RC0805JR-070RL, a chip resistor with an Ohm jumper, ±5% tolerance, and a power rating of 0.125W in an 0805 (2012 metric) package. This RoHS-compliant resistor comes in tape and reel packaging. It is used as a jumper resistor for circuit configuration, chosen for its standard 0805 size which facilitates easy placement and soldering. The RC0805JR-070RL is widely available, ensuring high feasibility due to its common use in various applications. It is also cost-effective, benefiting from standardization and broad availability.*

10.8 Connectors

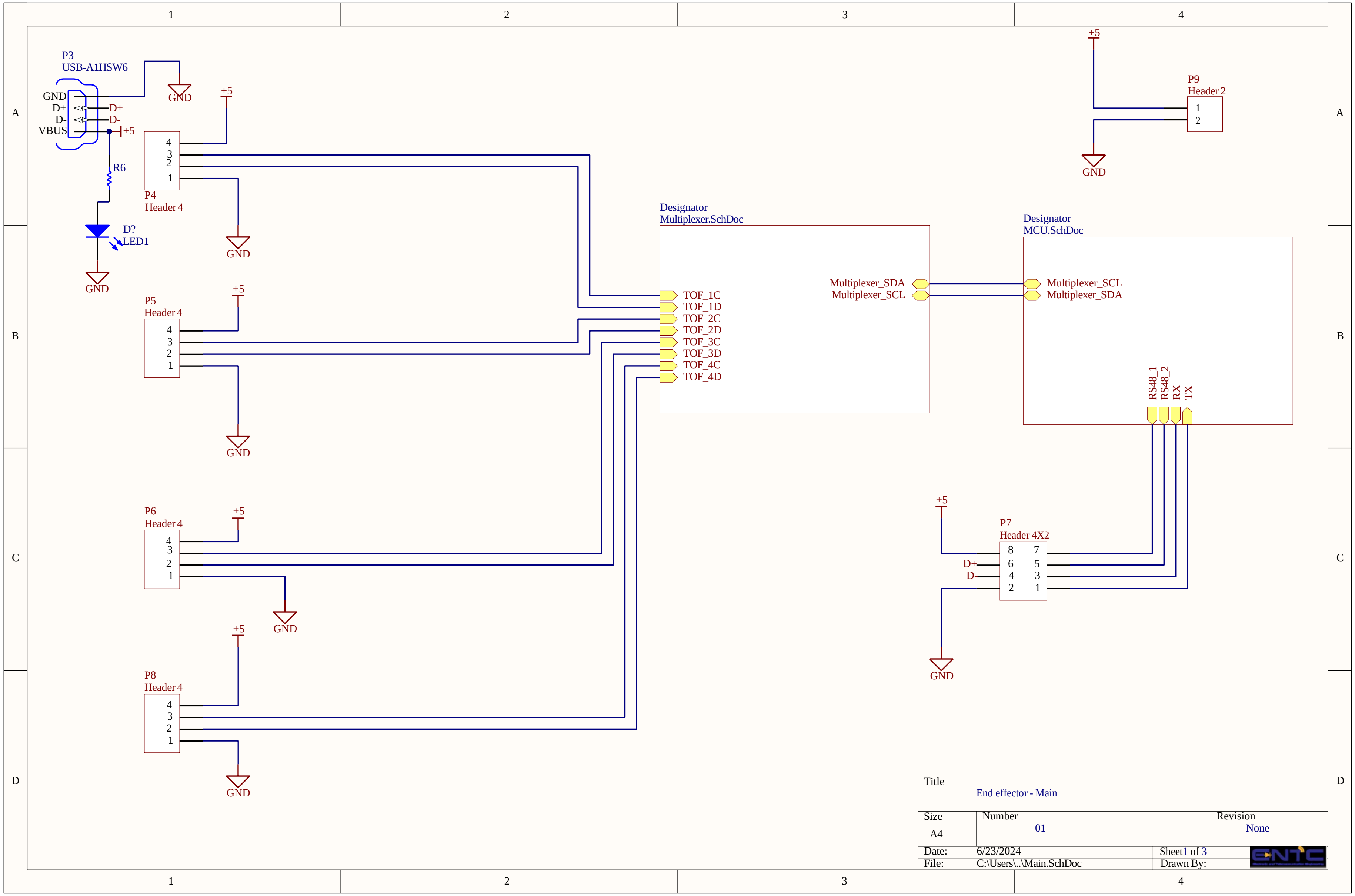
- *The selected header is the M22-5320305R, a dual-row 3-pin header used as a connection interface for external components or programming purposes. This component was chosen for its standard design, ensuring reliable connections in various applications. It is widely available in the market, making it highly feasible due to its standardization and broad availability. Additionally, the M22-5320305R is considered cost-effective, offering a balance between reliability and affordability, which is advantageous for both prototype and production environments.*

10.9 LED

- *The selected component, CMP-1488-00009-1, is a typical RED GaAs LED chosen for status indication purposes. It is known for its reliability, widely used in various applications, and offers good visibility with low power consumption. This LED is readily available in the market, making it a feasible choice for most projects. Additionally, it is a cost-effective option, balancing both reliability and performance efficiently.*

11 Schematic Design

The schematic design was created using Altium Designer, with a hierarchical structure focused on the microcontroller unit and multiplexer. Each component and connection was carefully annotated for clarity. The design was thoroughly verified to ensure it works correctly. The resulting schematic is reliable and meets high standards for advanced electronic projects.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USB-A1HSW6
GND
D+
D-
VBUS
+5
R6
D?
LED1
P4
Header 4
P5
Header 4
P6
Header 4
P8
Header 4
P9
Header 2
P7
Header 4X2
Designator
Multiplexer.SchDoc
TOF_1C
TOF_1D
TOF_2C
TOF_2D
TOF_3C
TOF_3D
TOF_4C
TOF_4D
Multiplexer_SDA
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Multiplexer_SCL
Multiplexer_SDA
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RS48_2
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Revision
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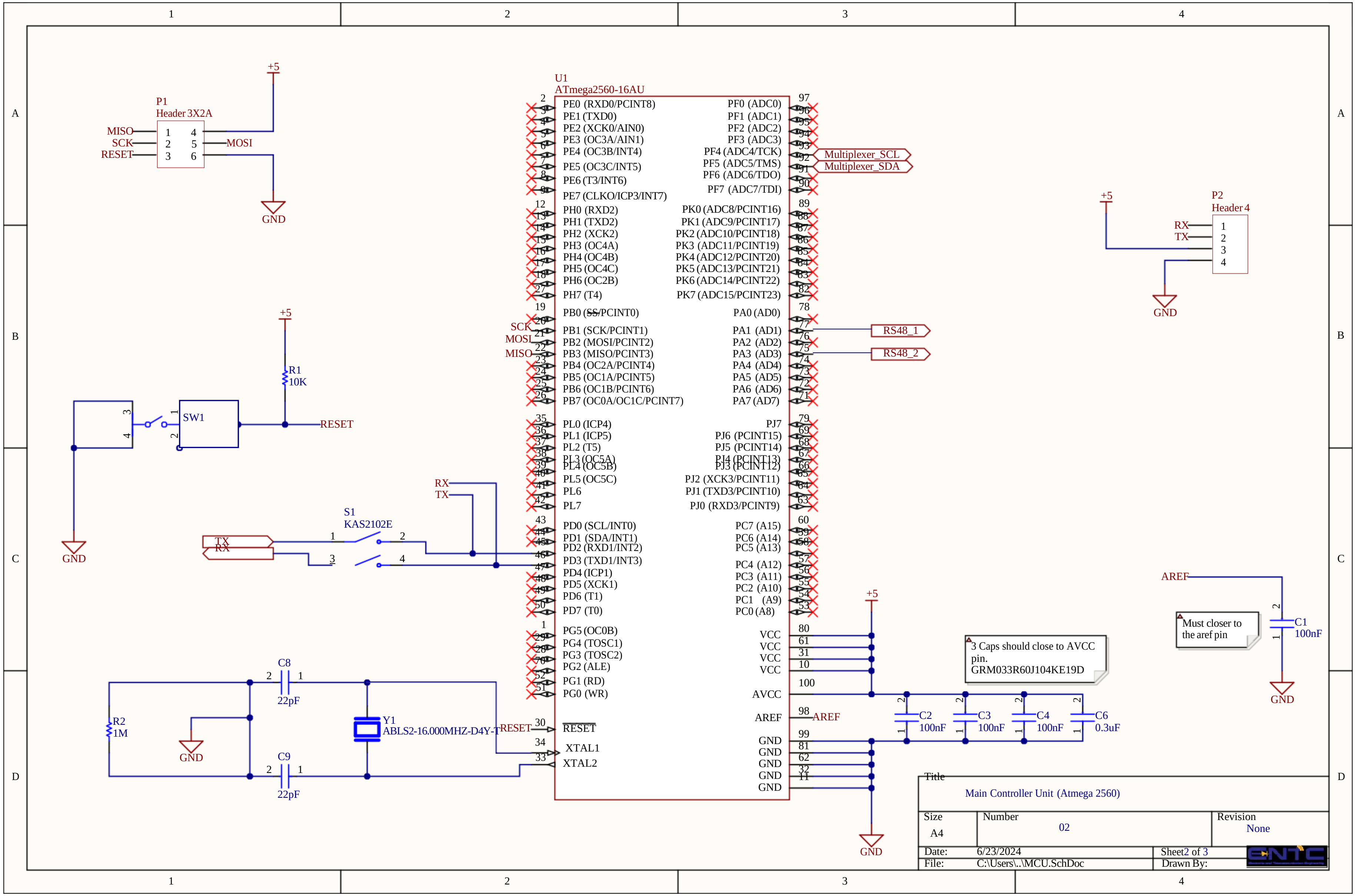
U1
ATmega2560-16AU
PE0 (RXD0/PCINT8)
PE1 (TXD0)
PE2 (XCK0/AIN0)
PE3 (OC3A/AIN1)
PE4 (OC3B/INT4)
PE5 (OC3C/INT5)
PE6 (T3/INT6)
PE7 (CLKO/ICP3/INT7)
PH0 (RXD2)
PH1 (TXD2)
PH2 (XCK2)
PH3 (OC4A)
PH4 (OC4B)
PH5 (OC4C)
PH6 (OC2B)
PH7 (T4)
PB0 (SS/PCINT0)
PB1 (SCK/PCINT1)
PB2 (MOSI/PCINT2)
PB3 (MISO/PCINT3)
PB4 (OC2A/PCINT4)
PB5 (OC1A/PCINT5)
PB6 (OC1B/PCINT6)
PB7 (OC0A/OC1C/PCINT7)
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PL1 (ICP5)
PL2 (T5)
PL3 (OC5A)
PL4 (OC5B)
PL5 (OC5C)
PL6
PL7
PD0 (SCL/INT0)
PD1 (SDA/INT1)
PD2 (RXD1/INT2)
PD3 (TXD1/INT3)
PD4 (ICP1)
PD5 (XCK1)
PD6 (T1)
PD7 (T0)
PG5 (OC0B)
PG4 (TOSC1)
PG3 (TOSC2)
PG2 (ALE)
PG1 (RD)
PG0 (WR)
RESET
XTAL1
XTAL2
PF0 (ADC0)
PF1 (ADC1)
PF2 (ADC2)
PF3 (ADC3)
PF4 (ADC4/TCK)
PF5 (ADC5/TMS)
PF6 (ADC6/TDO)
PF7 (ADC7/TDI)
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PK1 (ADC9/PCINT17)
PK2 (ADC10/PCINT18)
PK3 (ADC11/PCINT19)
PK4 (ADC12/PCINT20)
PK5 (ADC13/PCINT21)
PK6 (ADC14/PCINT22)
PK7 (ADC15/PCINT23)
PA0 (AD0)
PA1 (AD1)
PA2 (AD2)
PA3 (AD3)
PA4 (AD4)
PA5 (AD5)
PA6 (AD6)
PA7 (AD7)
PJ7
PJ6 (PCINT15)
PJ5 (PCINT14)
PJ4 (PCINT13)
PJ3 (PCINT12)
PJ2 (XCK3/PCINT11)
PJ1 (TXD3/PCINT10)
PJ0 (RXD3/PCINT9)
PC7 (A15)
PC6 (A14)
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PC1 (A9)
PC0 (A8)
VCC
VCC
VCC
VCC
AVCC
AREF
GND
GND
GND
GND
GND
Multiplexer_SCL
Multiplexer_SDA
RS48_1
RS48_2
P1
Header 3X2A
MISO
SCK
RESET
MOSI
+5
GND
P2
Header 4
RX
TX
R1
10K
RESET
SW1
R2
1M
C8
22pF
C9
22pF
Y1
ABLS2-16.000MHZ-D4Y-T
S1
KAS2102E
TX
RX
C1
100nF
Must closer to the aref pin
3 Caps should close to AVCC pin.
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C2
100nF
C3
100nF
C4
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C6
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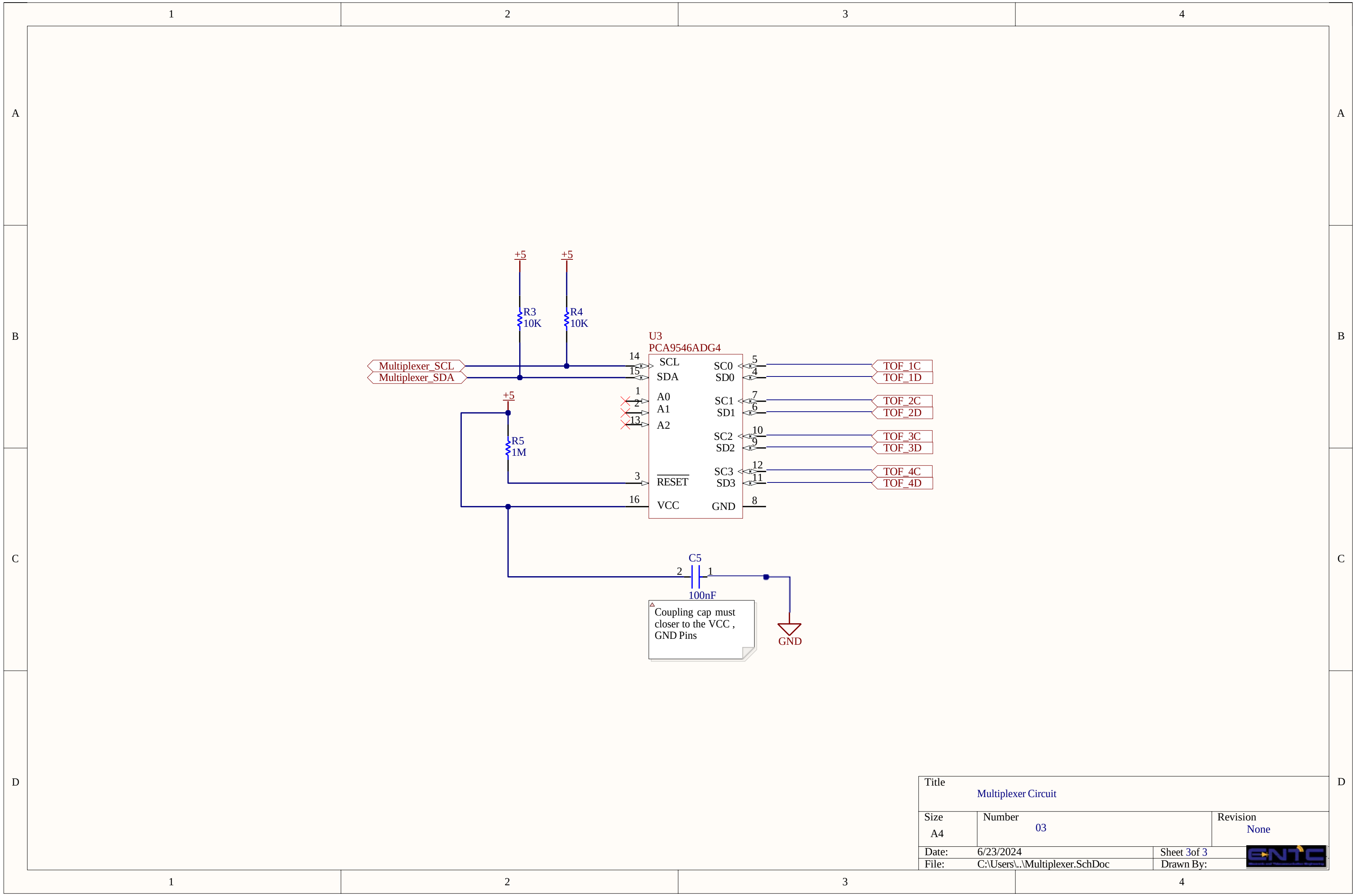
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2
3
4
A
B
C
D
+5
+5
R3
10K
R4
10K
U3
PCA9546ADG4
Multiplexer_SCL
Multiplexer_SDA
14
15
SCL
SDA
SC0
SD0
5
4
TOF_1C
TOF_1D
+5
1
2
13
A0
A1
A2
SC1
SD1
7
6
TOF_2C
TOF_2D
R5
1M
SC2
SD2
10
9
TOF_3C
TOF_3D
3
RESET
SC3
SD3
12
11
TOF_4C
TOF_4D
16
VCC
GND
8
C5
2
1
100nF
Coupling cap must closer to the VCC , GND Pins
GND
Title
Multiplexer Circuit
Size
A4
Number
03
Revision
None
Date: 6/23/2024
Sheet 3of 3
File: C:\Users\..\Multiplexer.SchDoc
Drawn By:

12 PCB Design

Once the components placement and schematic routing were validated, footprints were generated for the PCB design, integrating a microcontroller alongside multiplexers to gather data from time-of-flight (TOF) sensors. The design process occurred in two stages, with the second stage focusing on compactness and adhering to specific design rules and ethics, particularly ensuring efficient use of space and minimal footprint. The PCB layout was crafted according to the established standards of JLC PCB Design Rules, the selected manufacturer for producing the PCB board. This intricate integration aims to efficiently collect data from TOF sensors and transmit it via Modbus protocol, enhancing the functionality and versatility of the final product.

After routing the whole PCB, design rule check was implemented to check any erroneous points in the design.Then Gerber files and NC drill files were generated to send for the manufacturer to manufacture the PCB.

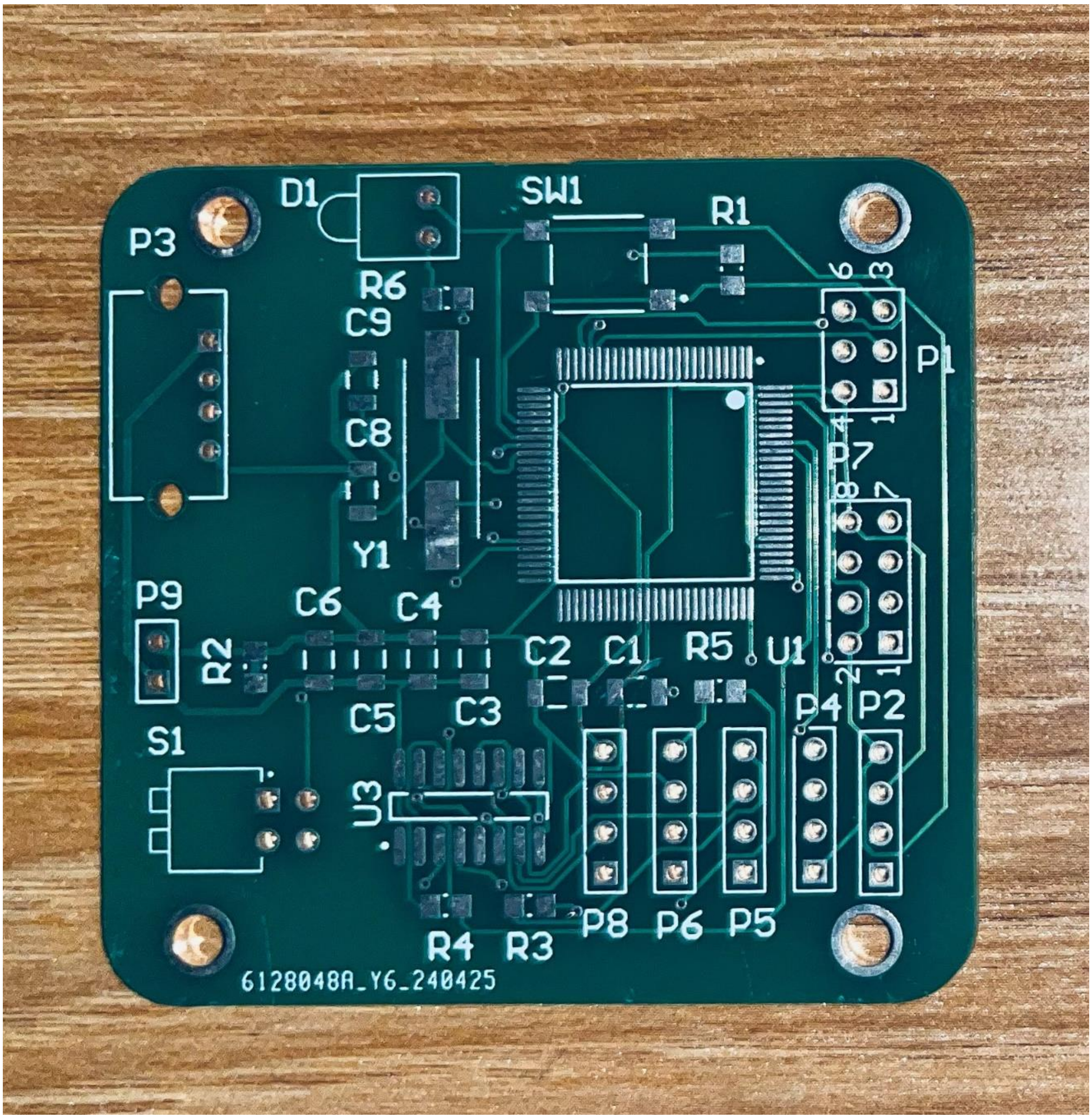


Figure 4: Before Soldering

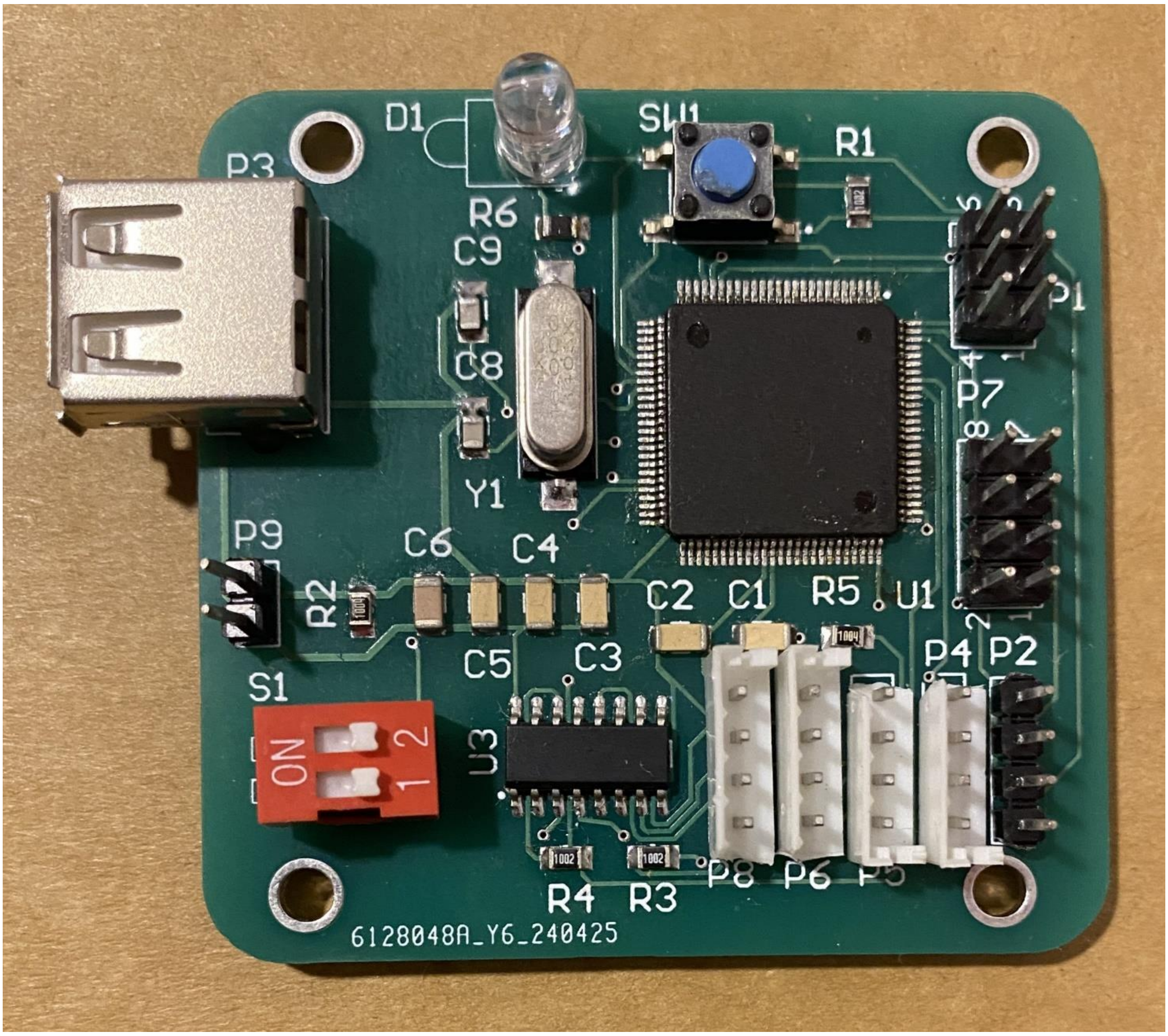


Figure 5: After Soldering

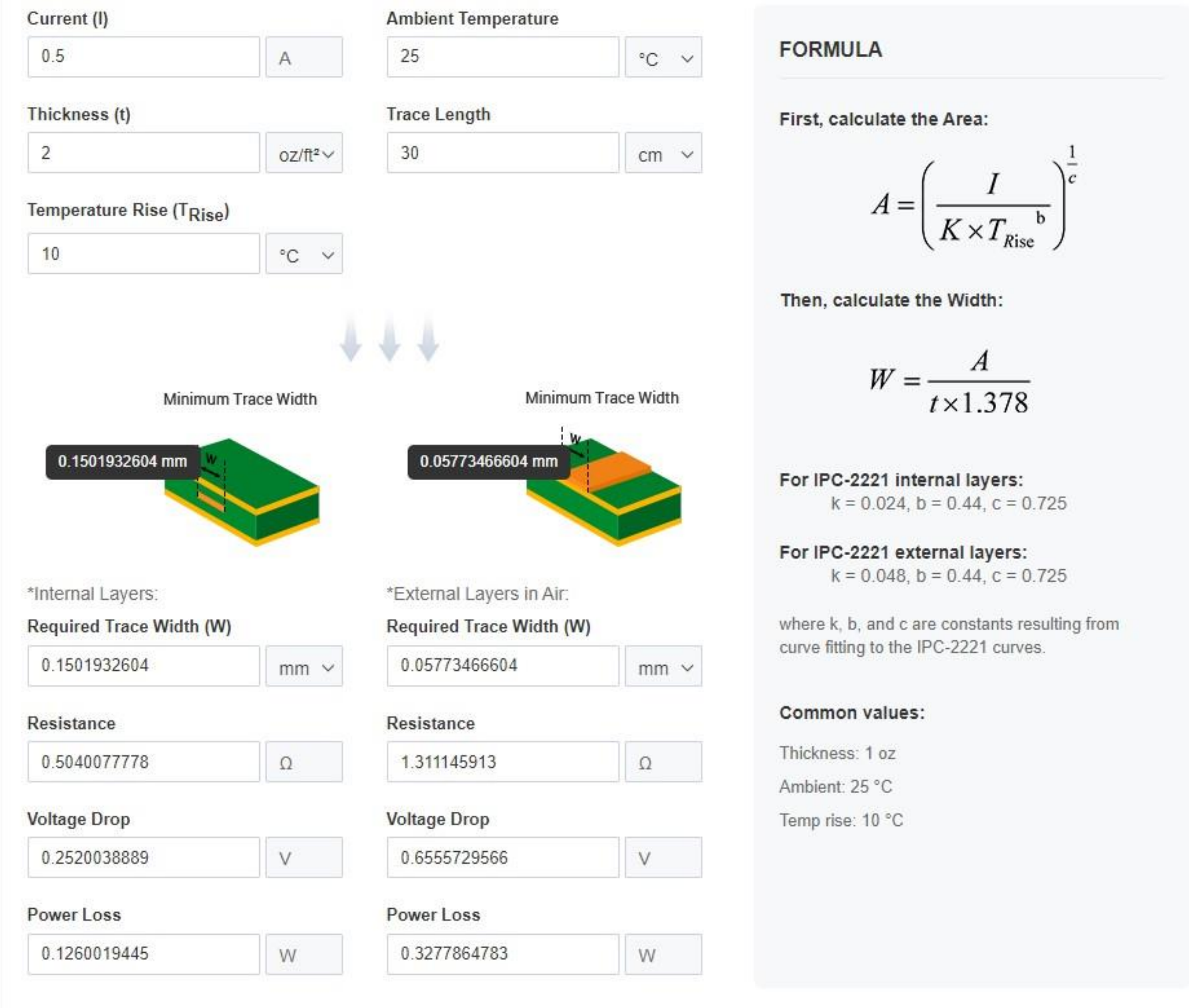


Figure 6: Trace width Calculations

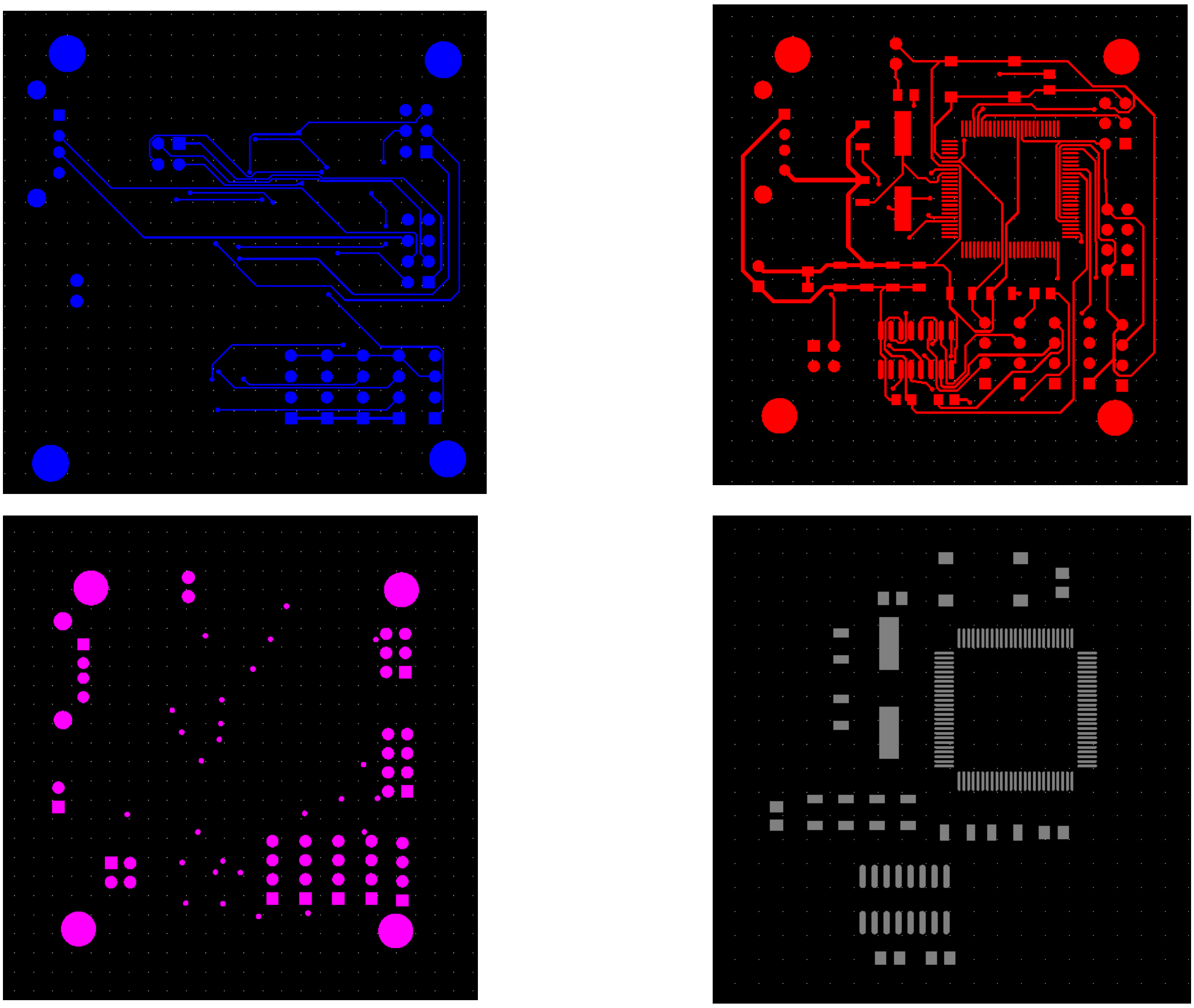
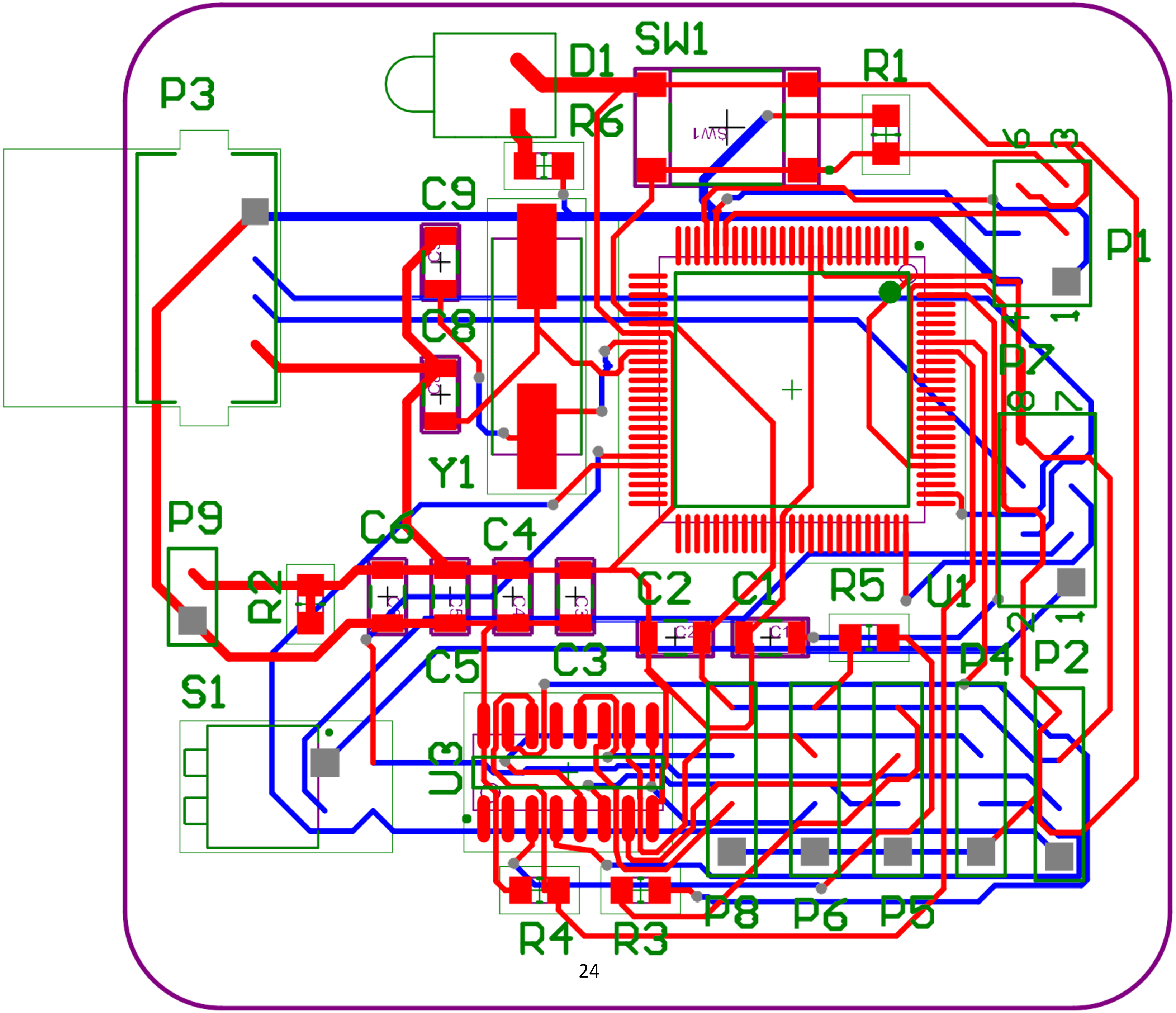


Figure 7: Gerber Files


P3
D1
SW1
R1
R6
C9
C8
P1
P7
Y1
P9
C6
C4
R2
C2
C1
R5
U1
C5
C3
P4
P2
S1
U3
P8
P6
P5
R4
R3

12.1 Bill of Materials

Comment	Description	Designator	Footprint	Quantity
C1206C104-K2RACTU	CAPCER 0.1UF200V 10%X7R1206	C1, C2, C3, C4, C5, C6, C8, C9	C1206C104K2RACTU	8
LED1	Typical RED GaAsLED	D1	CMP-1488-00009-1	1
Header-3X2A	Header, 3-Pin,Dual row	P1	M22-5320305R	1
Header 4	Header, 4-Pin	P2, P4, P5, P6, P8	JST-B4B-PH-K-S$_V$	5
USBA1HSW6	USB-A(USB TYPE-A)-Receptacle Connector 4 Position ThroughHole,Right Angle	P3	USBA1HSW6	1
Header 4X2	Header, 4-Pin, Dual row	P7	M22-5320305R	1
Header 2	Header, 2-Pin	P9	JST-B2B-PH-K-S$_V$	1
Header 4X2	Header, 4-Pin, Dual row	P7	M22-5320305R	1
RC0805JR-070RL	ChipResisto 0Ohm, Jumper, +/- 5%, 0.125W 55to155 degC, 0805 (2012Metric RoHS Tape and Reel	R1, R2, R3, R4 R5, R6	RC0805JR-070RL	6
KAS2102E	SWITCH SLIDE DIP SPST 0.025A 24V	S1	KAS2102E	1
PTS645SM43-SMT92LFS	SWITCH TACTILE SPSTNO0.05A12V	SW1	PTS645SM43-SMTR92LFS	1
ATmega2560-16AU	8-bit AVR Microcontroller, 4.5-5.5V, 16MHz, 256KB Flash, 4KB EEPROM, 8KB SRAM, 86 GPIOpins, 100- pinTQFP, Industrial Grade(-40°C to85°C), PbFree	U1	ATMEGA2560-16AU	1
ABLS2-16.000M HZ-D4Y-T	HC/49US (AT49)LOW PROFILE SURFACE MOUNT MICROPROCE SSORCRYSTAL& noSb/Br)	Y1	ABLS2- 16.000M HZ-D4Y-T	1

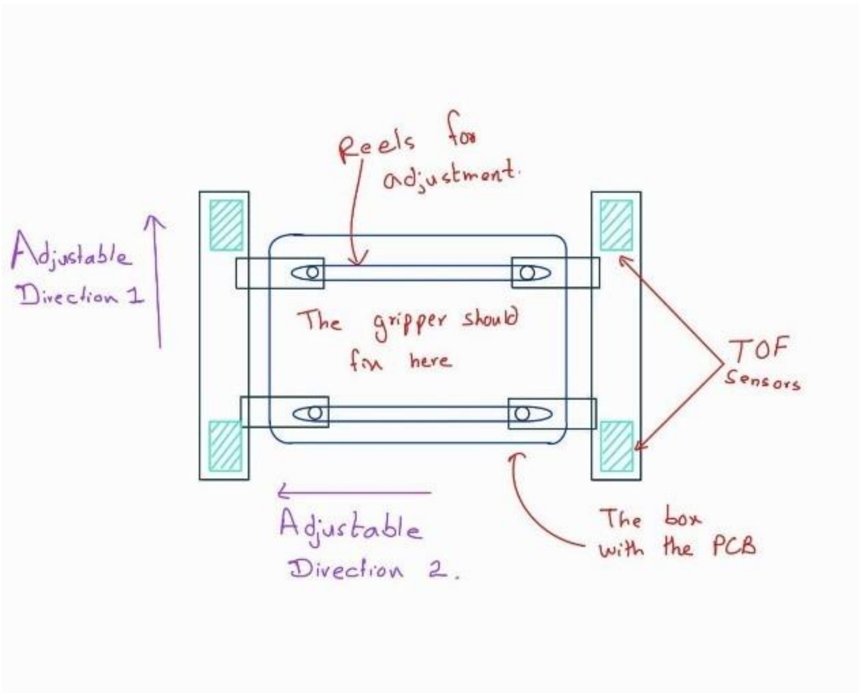
13 Enclosure

13.1 Initial approach

In the enclosure design phase, the primary challenge was to develop an enclosure suitable for the product while ensuring it integrates seamlessly with a vacuum gripper used to grab boxes. The design had to accommodate four Time-of-Flight (TOF) sensors (VL5310X) for detecting the orientation of the object. It was crucial that the gripper's presence did not interfere with the overall size and functionality of the product.

Initially, we considered creating an adjustable enclosure. The concept was to enable users to modify the product components according to the dimensions of the vacuum gripper. This adaptability would primarily involve the four TOF sensors, allowing them to be repositioned as needed. Additionally, a box housing the PCB would be affixed to the gripper. We explored several methods to achieve this adjustability to ensure our end effector could be compatible with a wide range of vacuum grippers.

This approach aimed to provide flexibility and versatility, ensuring that the orientation detection system could be easily integrated with various grippers without compromising on performance or increasing the overall footprint of the device.



13.2 Design Challenges and Decisions

However, we encountered several issues with this adjustable design approach:

1. **Variable Vacuum Gripper Sizes:**Vacuum grippers vary significantly in size, necessitating a high degree of adjustability for the TOF sensors.
2. **Attachment Method:**We needed a reliable method to attach the end effector to the gripper. Due to the varying designs of grippers, finding a universal attachment method proved difficult.
3. **Sensor Movement:**The TOF sensors needed to move in two directions, adding complexity to the design.

4. **Mechanical Strength:**The mechanical parts required high strength to ensure durability and stability.

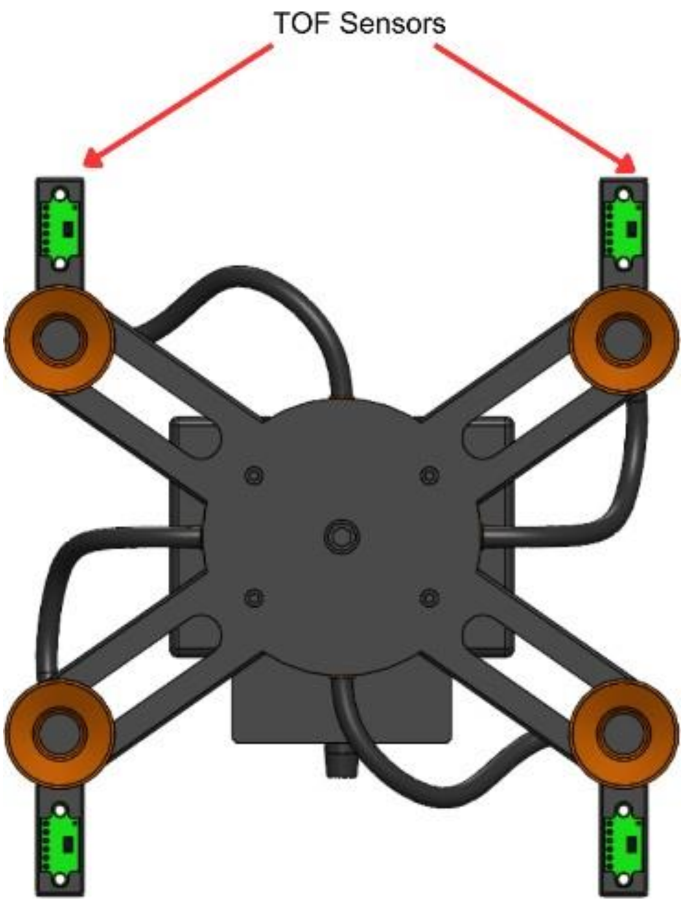
Considering these challenges, we concluded that an adjustable design was not practical. Instead, we decided to design the end effector enclosure for a specific vacuum gripper model. This approach allows us to focus on creating a robust and efficient solution tailored to one type of gripper, ensuring optimal performance and reliability.

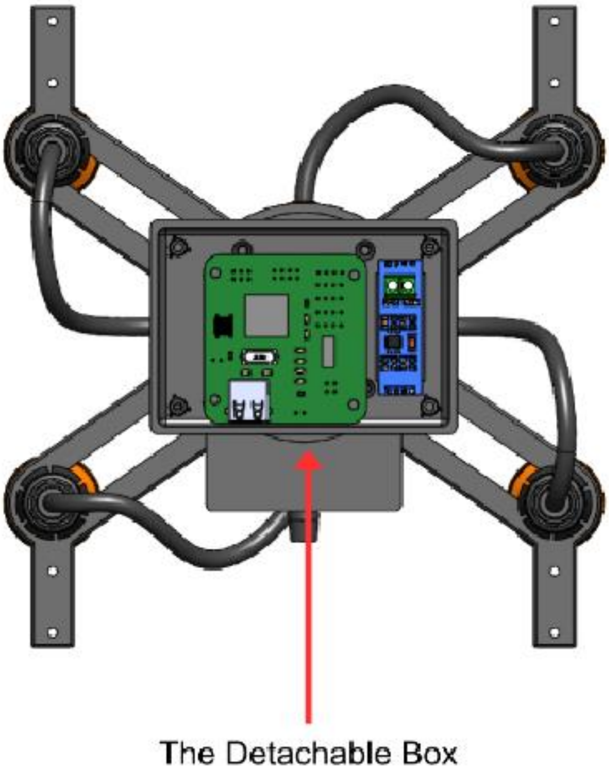
13.3 Final design implementation

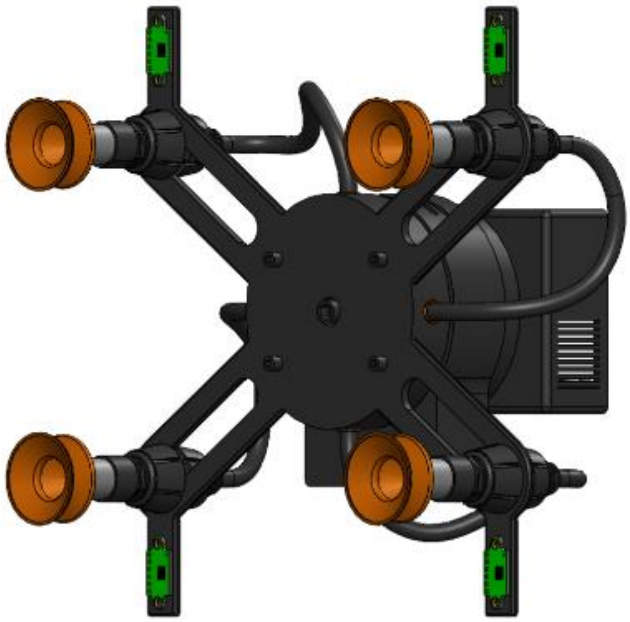
We designed a sample vacuum gripper with dedicated mounting places for the TOF sensors. This setup allows the sensors to be mounted without affecting the gripper's functionality, ensuring that the sensors' line of sight is not obstructed by the gripper.

Additionally, we created a separate box for the PCB. The box features a USB port for easy connection to the PCB, allowing users to retrieve output data. The TOF sensors are connected separately to the PCB housed within this box. The box itself can be securely attached to the gripper using nuts, providing a stable and reliable mounting solution.

This design ensures that the sensors operate effectively while maintaining the integrity and performance of the vacuum gripper.




The Detachable Box

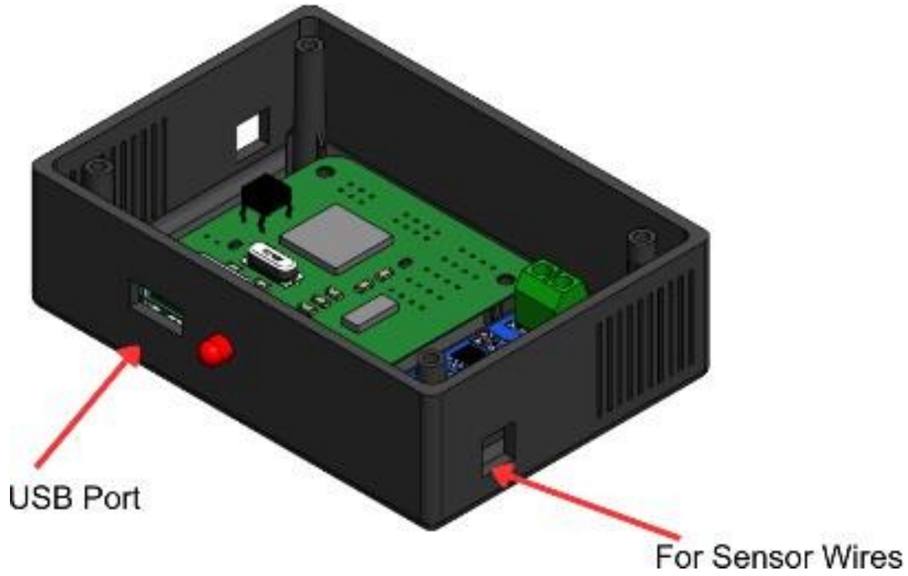


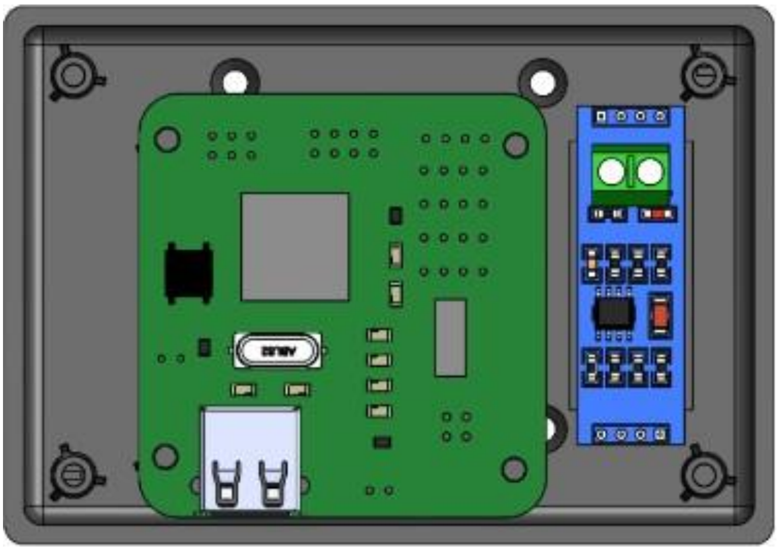
13.4 Demonstration and final design features

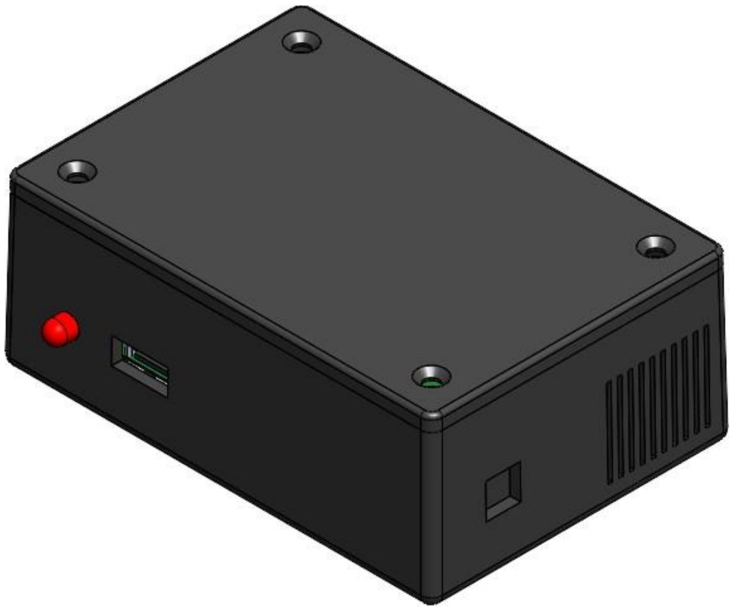
Since we are currently unable to prepare a gripper, we will print only the box part for demonstration purposes. The TOF sensors will be mounted on a board, spaced 10 cm apart.

The enclosure will house the PCB and an RS485 module. Additionally, the enclosure features an LED indicator to show power status and air vents for heat dissipation. Mounting bosses are included to securely fix the PCB inside the enclosure. The design includes a separate lid for the box, which can be mounted using M3 screws.

This setup allows us to demonstrate the functionality of the TOF sensors and the enclosure without needing the actual gripper. The printed box will showcase the enclosure's design, including the placement of sensors, the PCB, and other components.







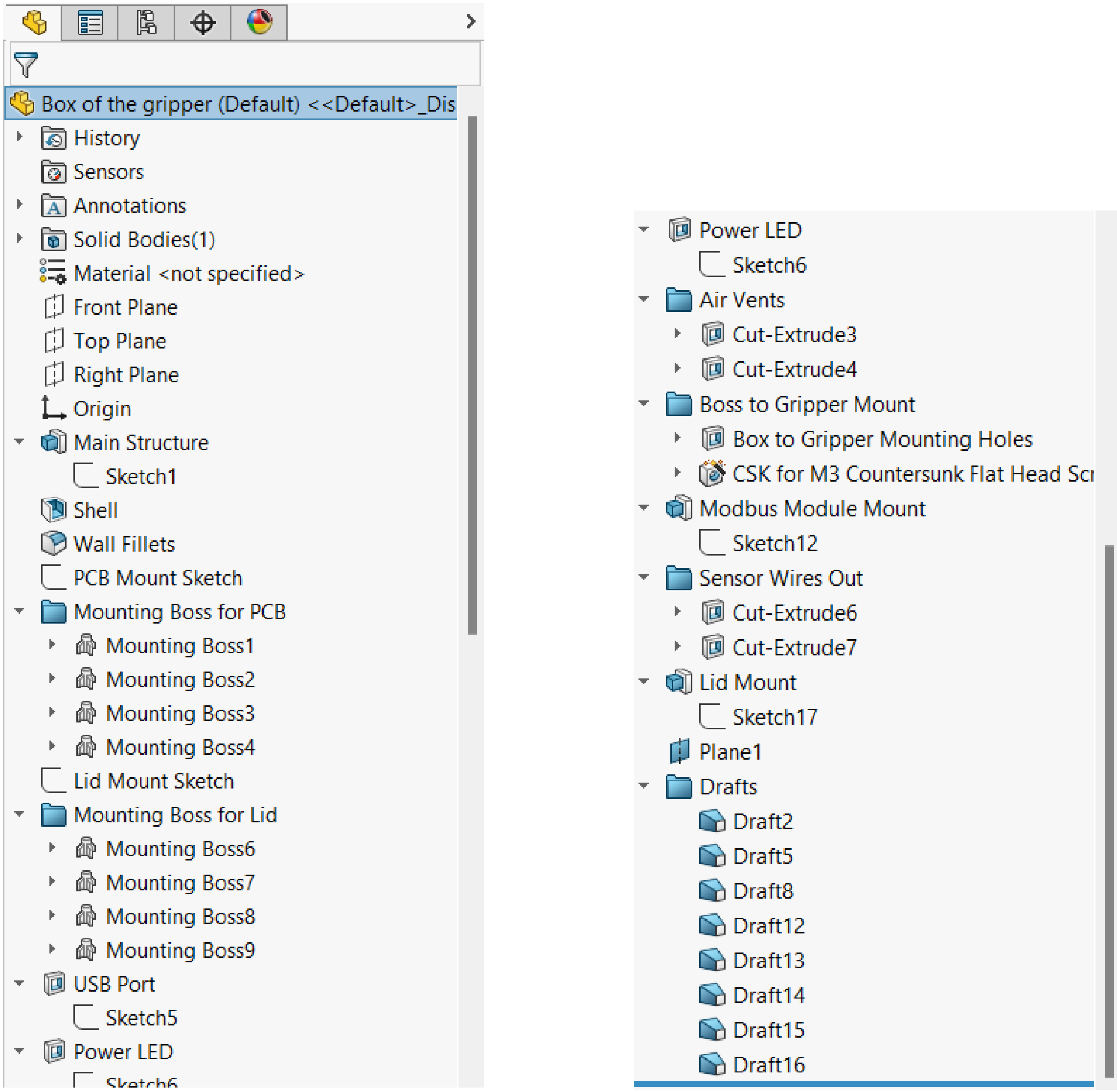


Figure 8: Model Tree for Box

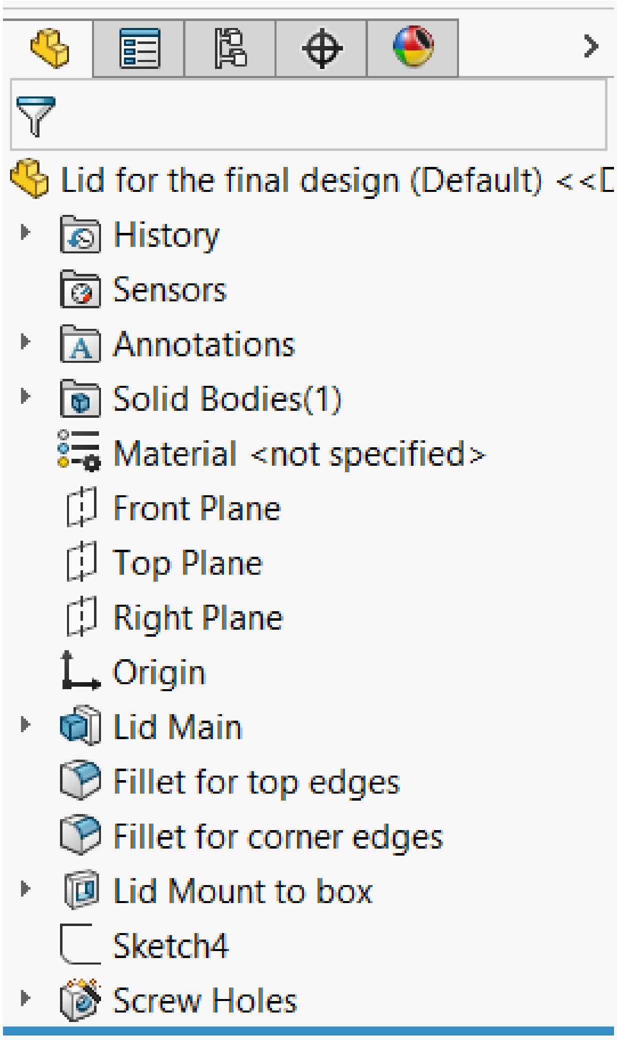
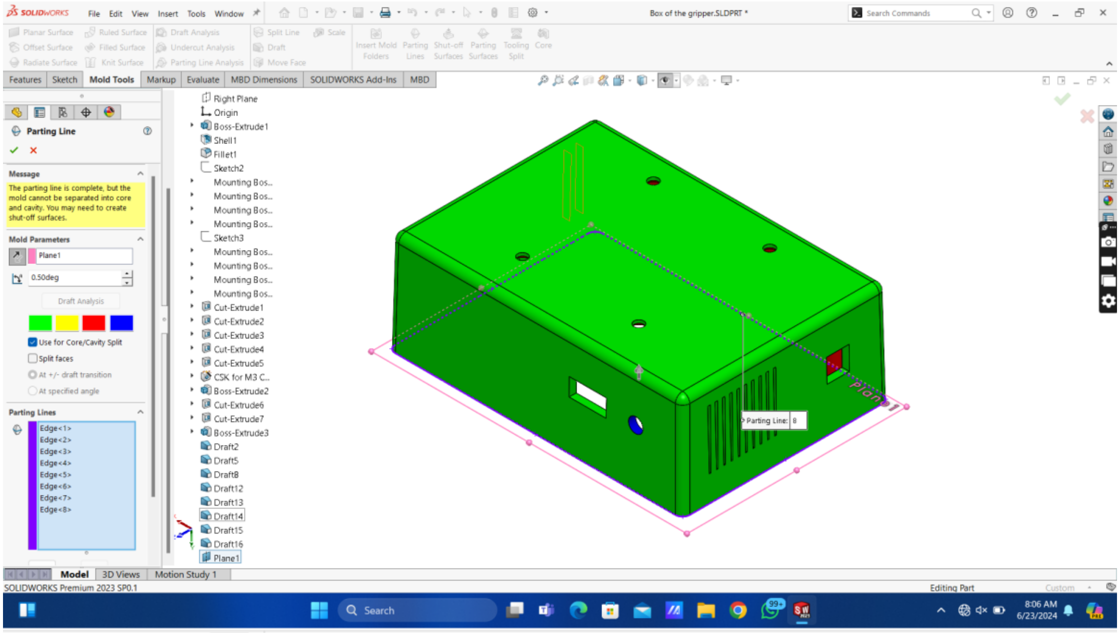
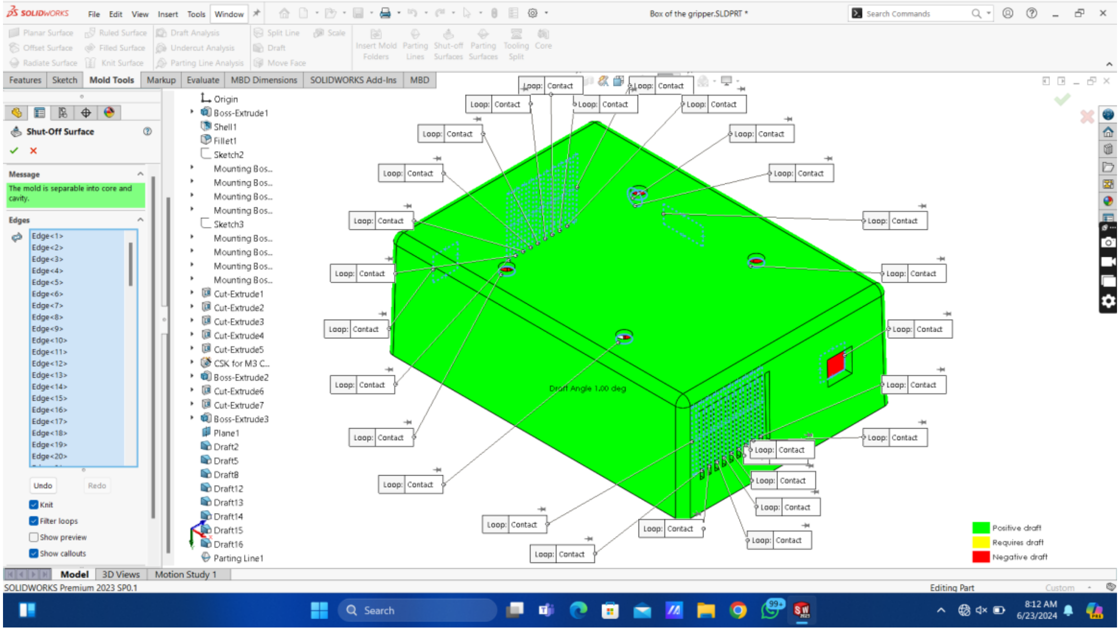
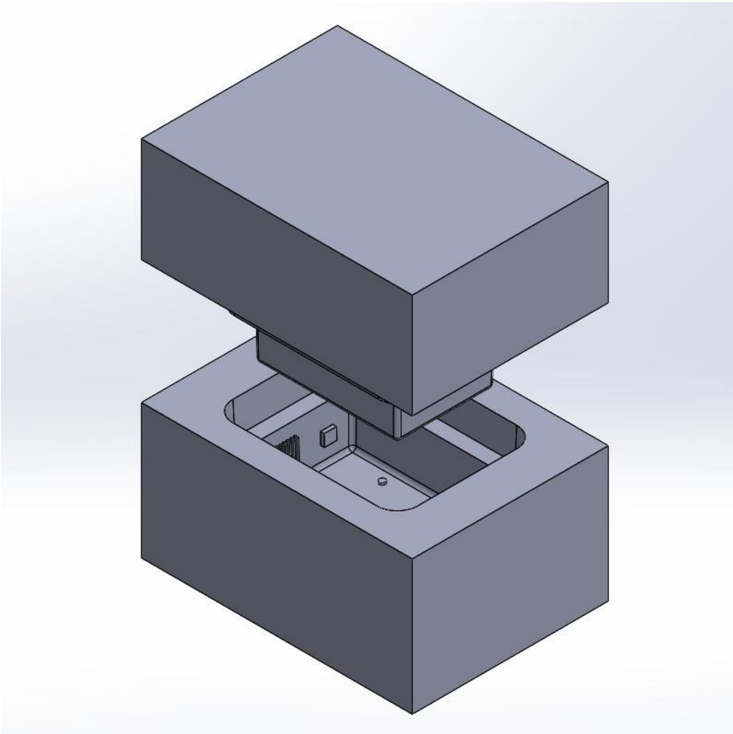


Figure 9: Model Tree for Box

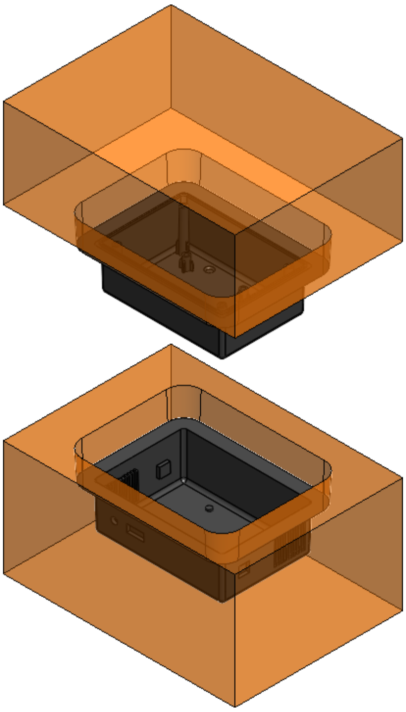
13.5 Mold Design and Draft Analysis



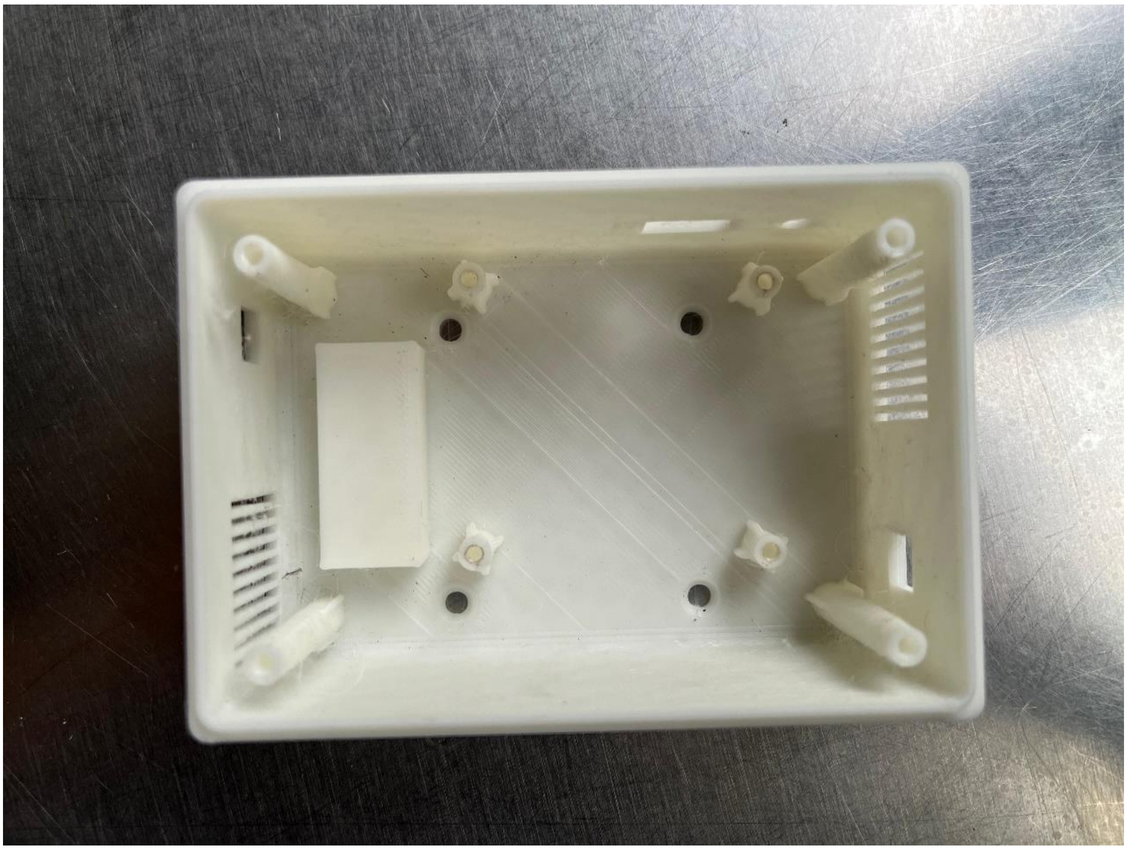


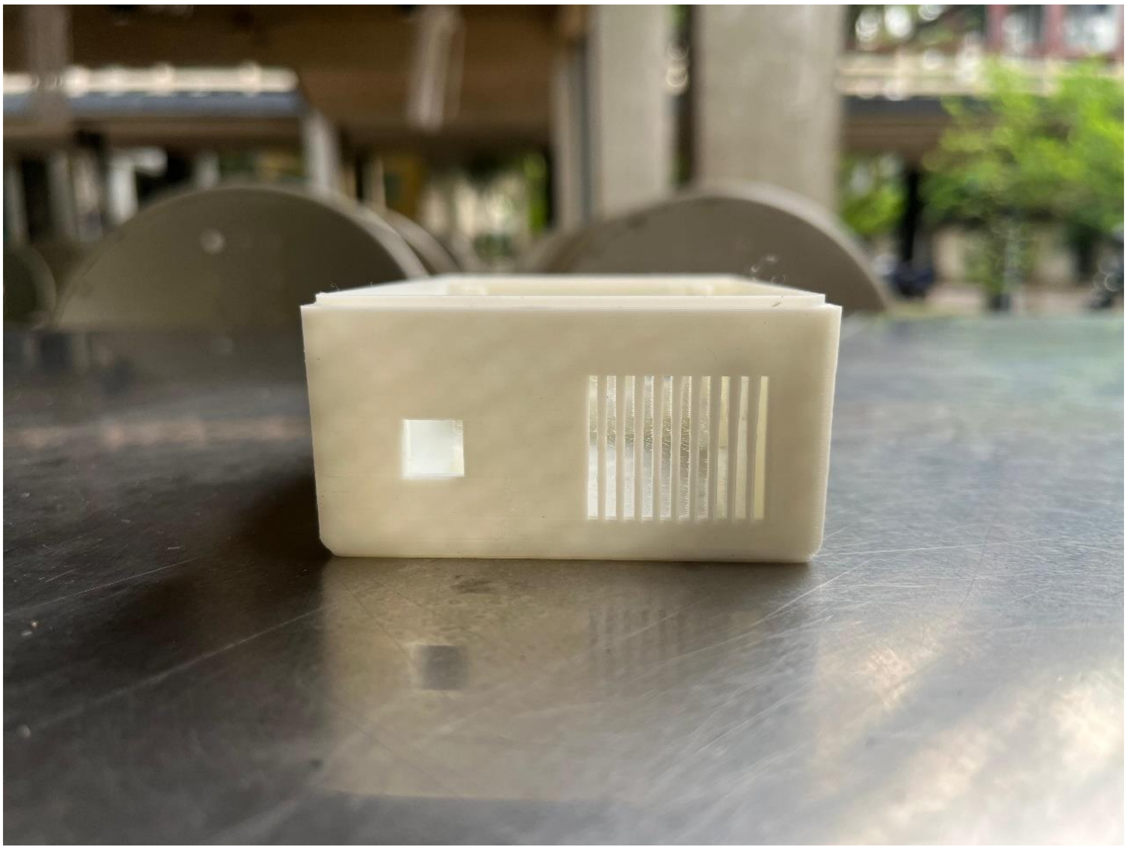


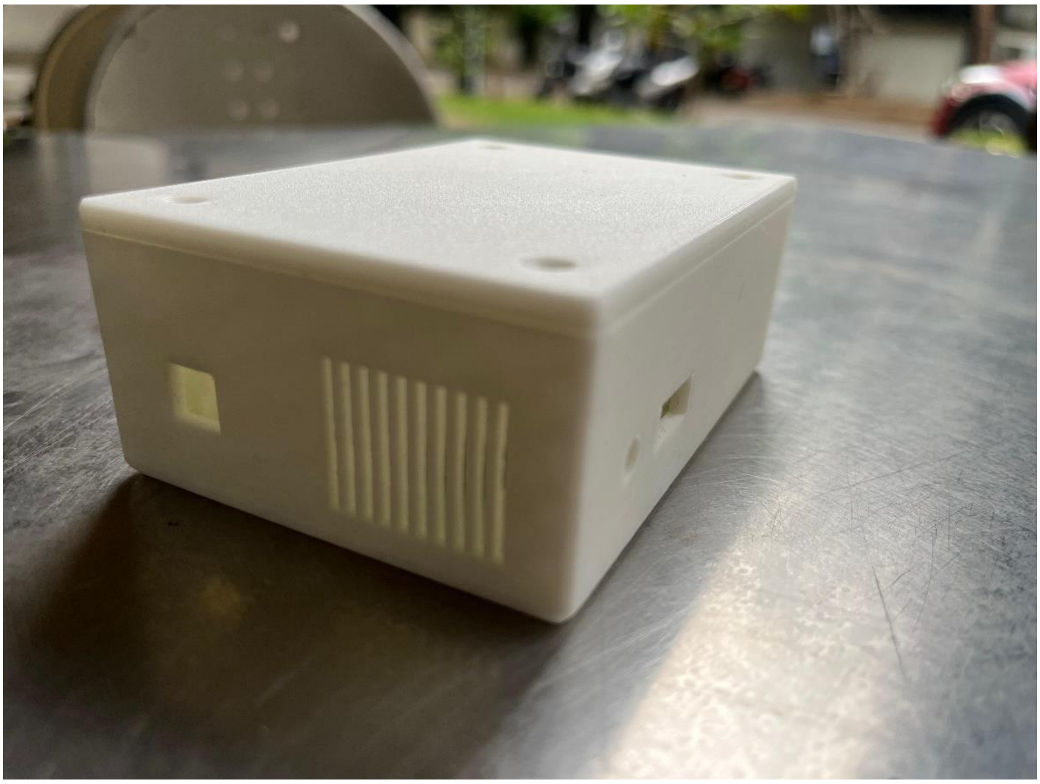
Mold Assembly



13.6 Printed Enclosure

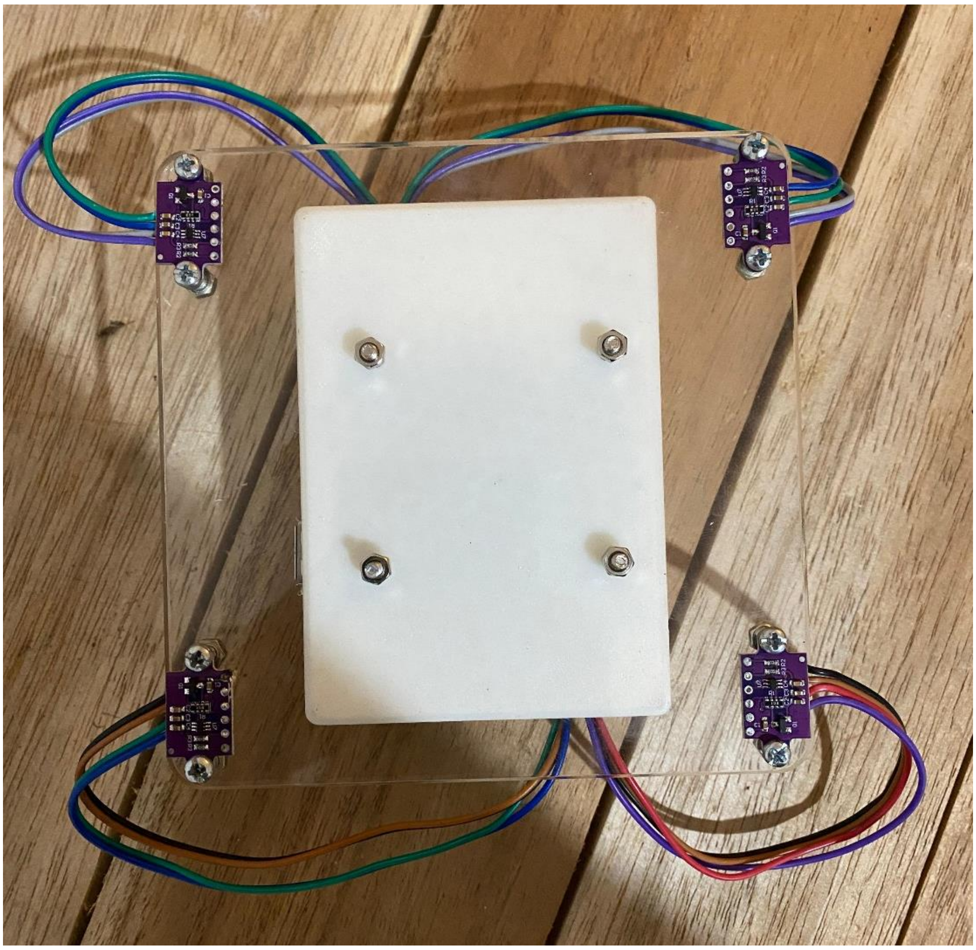


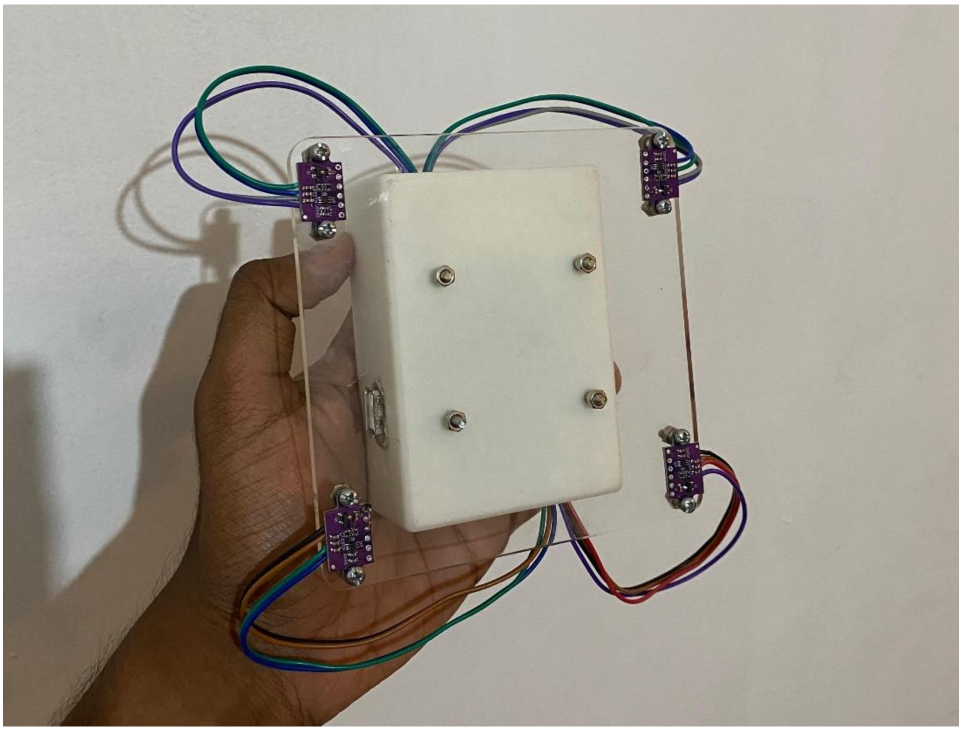


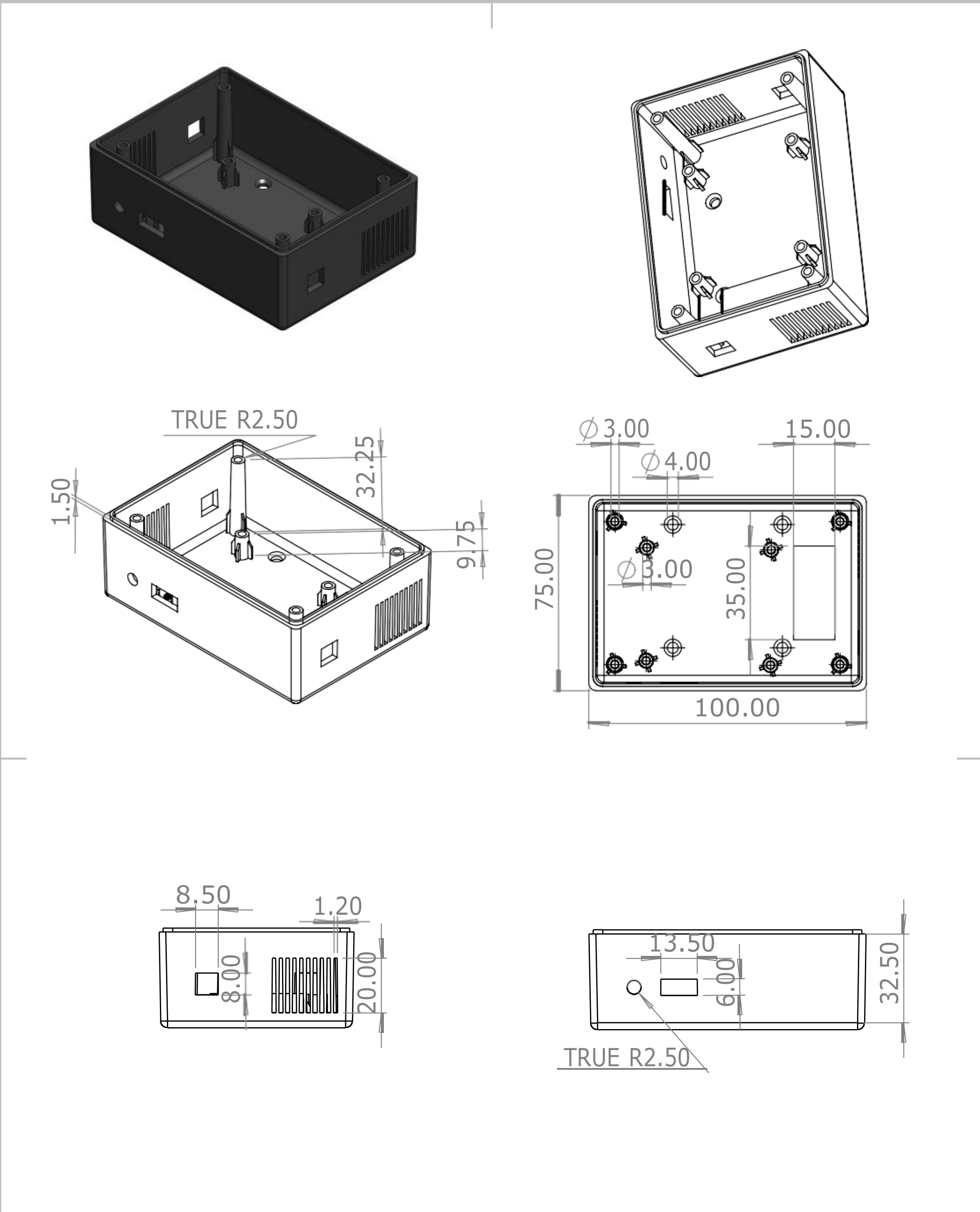


13.7 Enclosure With PCB

13.8 Demonstration Setup







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DRAWN	Mihiruth Sehara			
CHK'D				
APPV'D				
MFG				
Q.A				MATERIAL:
				WEIGHT:

TITLE:

Box for the Gripper

DWG NO. 01

A4

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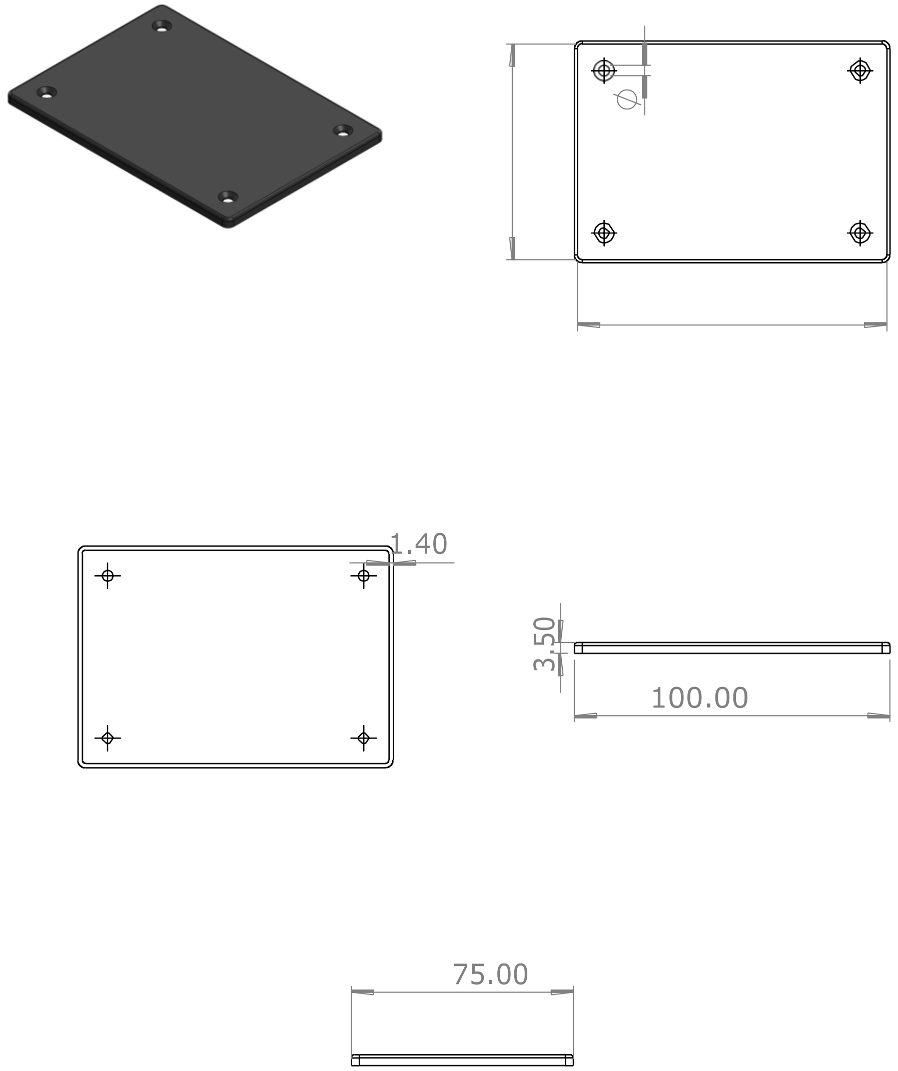
SHEET 1 OF 1



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SHEET 1 OF 1

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Data Sheets

[1] https://www.openimpulse.com/blog/wp-content/uploads/wpsc/downloadables/MAX485-Datasheet.pdf

[2] https://rishabh.co.in/uploads/product/RS485-USB_Converter1.pdf

[3] https://www.openimpulse.com/blog/wp-content/uploads/wpsc/downloadables/MAX485-Datasheet.pdf

[4] https://pdf1.alldatasheet.com/datasheet-pdf/download/107092/ATMEL/ATMEGA2560.html

[5] https://modbustools.com/download.html

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   Signature Lasitha

2. Name: W.K.D.D.D. Wijewikrama

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