EN2160 – Electronic Design Realization

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Project Evidence Submission

3D mapping with LIDAR

(Partial fulfilment of the requirements for the module EN2160 Electronic Design Realization)

Contents

1. Introduction

This report presents the finalized conceptual design chosen from three potential options for our 3D mapping project utilizing LiDAR technology. The document encompasses detailed SolidWorks designs, essential mold designs, and the printed 3D parts integral to our project. Additionally, it includes the PCB layout and the ordered PCBs necessary for the system's functionality. Through meticulous planning and design, this project aims to leverage advanced 3D mapping capabilities to achieve our specified objectives

2. Enclosure and Mechanical parts Design

2.1 Conceptual Design

After careful consideration and evaluation, we have proceeded with the third conceptual design as the selected design for our 3D mapping project using LiDAR technology. This decision was based on a thorough evaluation of all three conceptual designs against several critical criteria, including data rate, resolution, price, weight, and ease of use. Additionally, we assessed factors such as power consumption, durability, scalability, integration with existing systems, and overall performance. The third conceptual design emerged as the most suitable option, meeting our project's specific requirements and ensuring optimal functionality. Below is the Conceptual design that we chose to proceed our project,

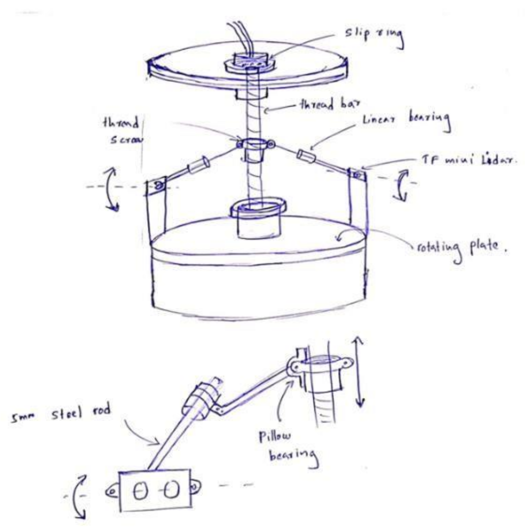


Fig 2.1 : Overall concept

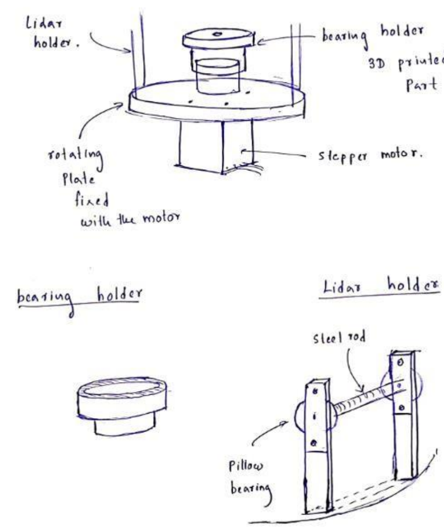


Fig 2.2 : Main functional

2.2 SolidWorks Modeling

We used SolidWorks to design our enclosure and key mechanical parts for the project. The main outer enclosure, which houses and protects the LiDAR system, was carefully created to ensure it is durable and easy to assemble. These designs are crucial for our 3D mapping project.

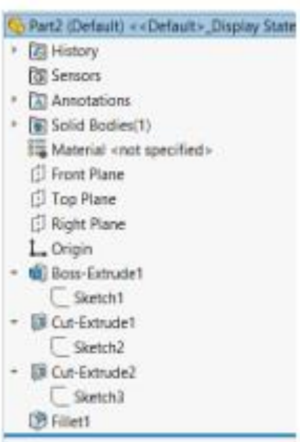
2.3 Designed parts with model trees

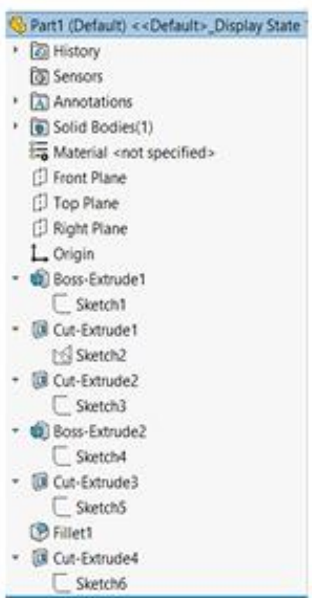
Fig 2.3 : Lidar sensor

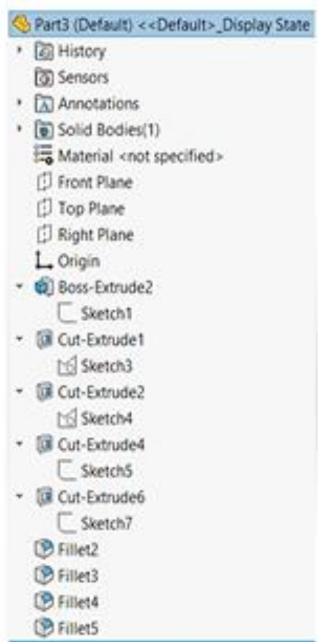
Fig 2.4 : Lidar sensor

Fig 2.5 : Shaft Holder

Fig 2.6 : Shaft Holder







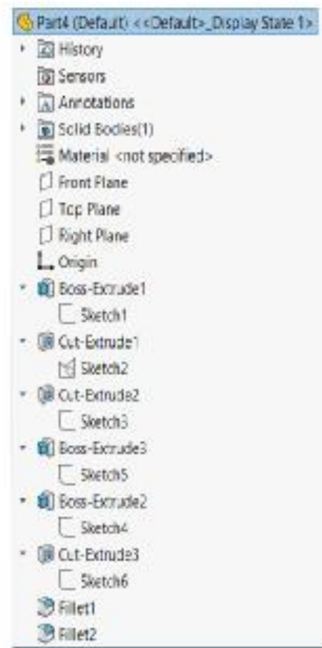


Fig 2.7 : Lead screw Holder

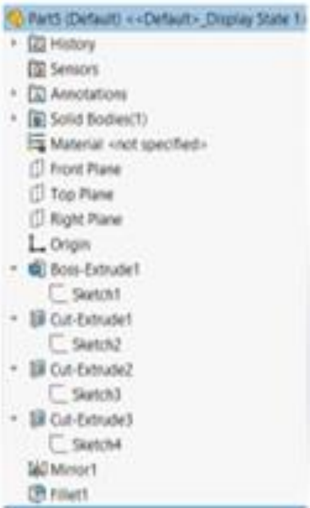


Fig 2.8 : Rotating mount

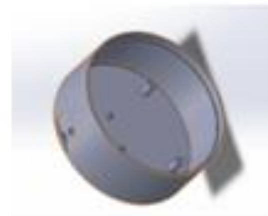


Fig 2.9 : Base

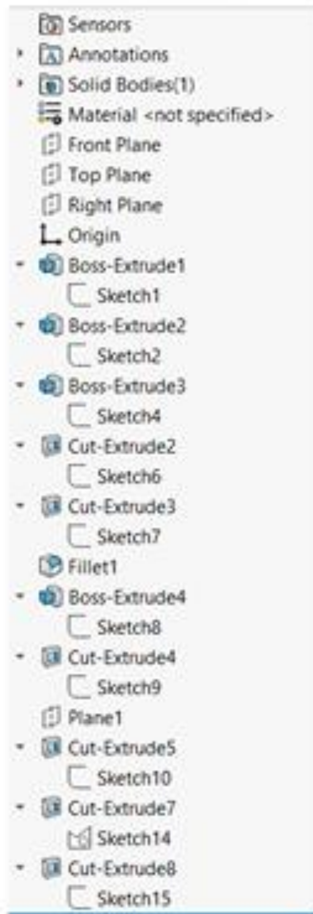


Fig 2.10 : Top

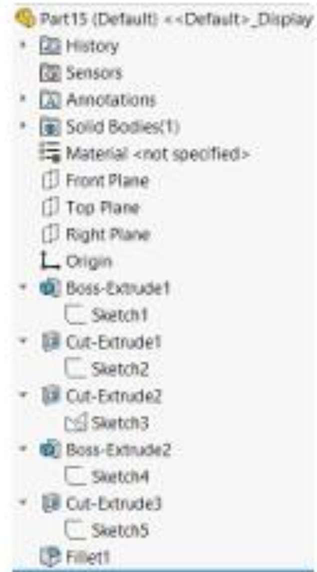


Fig 2.11 : Stepper motor

- **Lidar Sensor mount :** To hold the bearings and the shaft holding the LIDAR sensor .
- **Lidar Sensor Holder:** To hold the LIDAR sensor.
- **Shaft Holder 1, Shaft Holder 2 :** To hold the linear bearings and the shafts for motions.
- **Lead Screw Holder:** To Guide the path of the vertical motion along the lead screw.
- **Rotating mount:** most of the sub-assemblies are mounted on this, and this is the rotating part.
- **Base :** To hold the PCB and the Stepper motor mount .
- **Top:** Covering and Holding the Screw shaft stationary .
- **Stepper motor Mount :** To Hold the stepper motor .

2.2 Overall integration of the parts

We assembled all the designed parts in SolidWorks to visualize our final device for our 3D mapping project. This process allowed us to integrate each component, ensuring they fit together seamlessly and function as intended. Visualizing our device in SolidWorks provided a clear understanding of how each part interacts within the overall structure, from the sensor mounts to the protective housings. This digital assembly not only verified the compatibility and functionality of our design but also enabled us to make precise adjustments before manufacturing. It was a crucial step in refining our concept into a cohesive and effective solution for our 3D mapping endeavors.

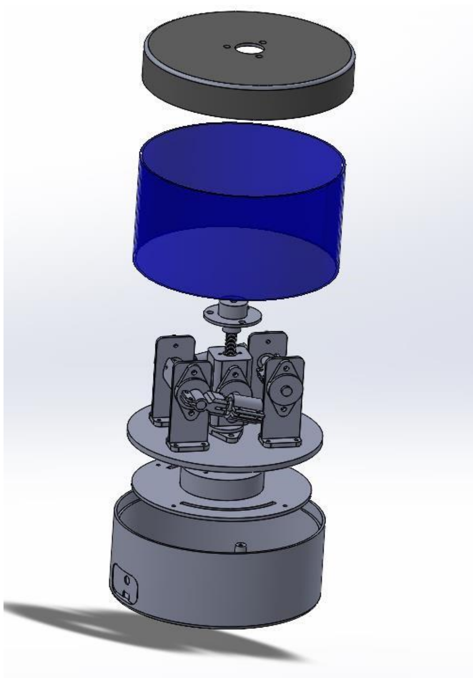


Fig 2.12 : Exploded view

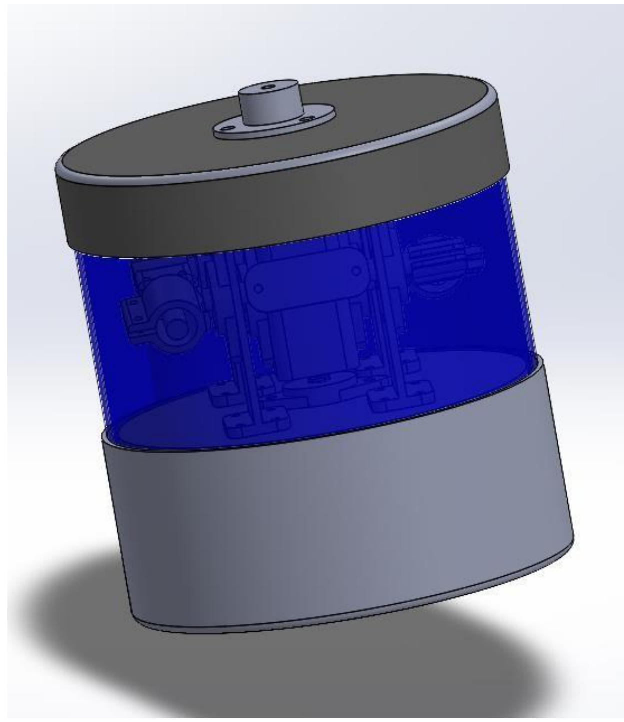


Fig 2.13 : Assembled isometric view

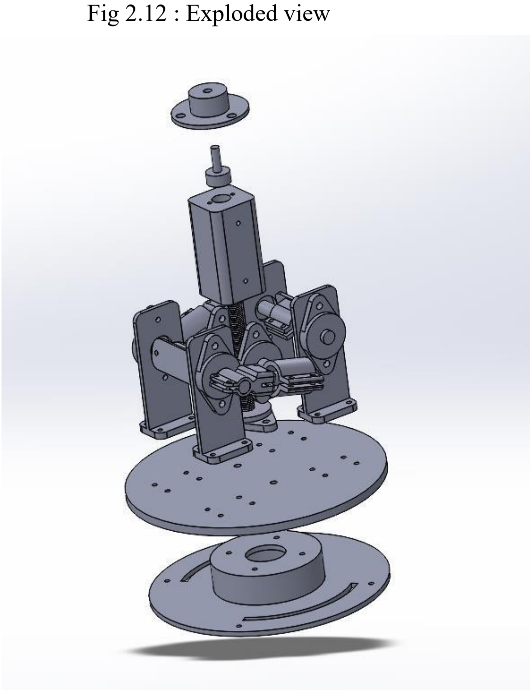


Fig 2.14 : Internal view 1

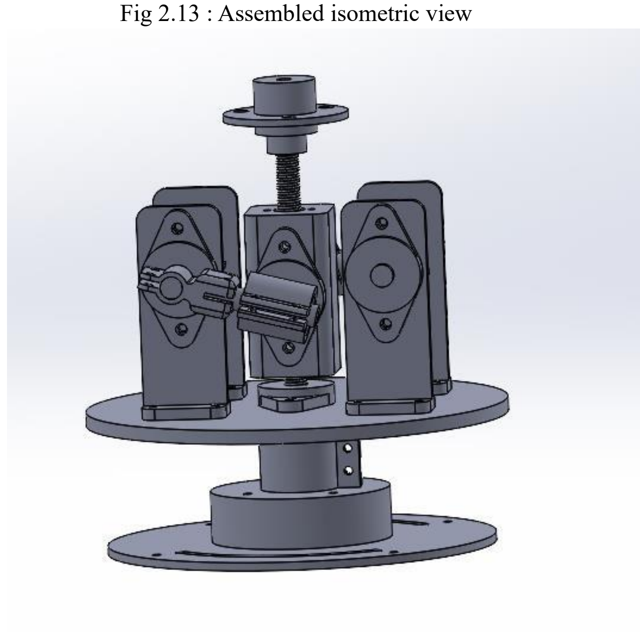


Fig 2.15 : Internal view 2

2.3 Design Considerations

Several critical factors were taken into account during the design phase:

- **Material Selection**: PLA was chosen for its ease of use in 3D printing and its favorable mechanical properties.

- **3D Printing Accuracy**: High accuracy was essential for this design to ensure smooth rotation and perfect compatibility between 3D printed parts and other components such as bearings and the threaded wheel.

- **Structural Stability**: The design needed to remain static and free of vibrations when the upper part, including the laser module, rotates at full speed. To achieve this, higher-density materials were used for the lower parts of the design, while lower-density materials were utilized for the upper parts.

- **Friction Reduction**: Bearings and threaded rods were incorporated to eliminate unnecessary friction, ensuring smoother and more efficient operation of the mechanical system.

2.4 Functional mechanical parts

Fig 2.16 : KFL bearing Fig 2.17 : Linear bearing Fig 2.18 : Motor Coupler Fig 2.19 : 8mm steel rod and thread rod

Our mechanism includes several functional mechanical parts to ensure smooth and precise operation. We use bearings and linear bearings for reducing friction and allowing smooth movement. Motor couplers connect the motor to other components, ensuring efficient power transfer. The 8mm steel shaft provides a strong, stable axis for rotation, while the 8mm steel threaded rod is used for precise linear motion, critical for the accuracy and reliability of our 3D mapping project.

2.5 3D printed parts

For our project, we 3D printed various parts using eSUN PLA+ material, which is known for its durability and is ideal for prototyping projects. The parts were printed with a layer height of 0.15mm and an infill density of 60%, ensuring a good balance between strength and material efficiency. The entire printing process took over 20 hours to complete, resulting in high-quality components that are crucial for the successful assembly and functionality of our 3D mapping system.

Fig 2.20 : Shaft holder

Fig 2.21 : Lidar sensor holder

Fig 2.22 : Lidar sensor mount

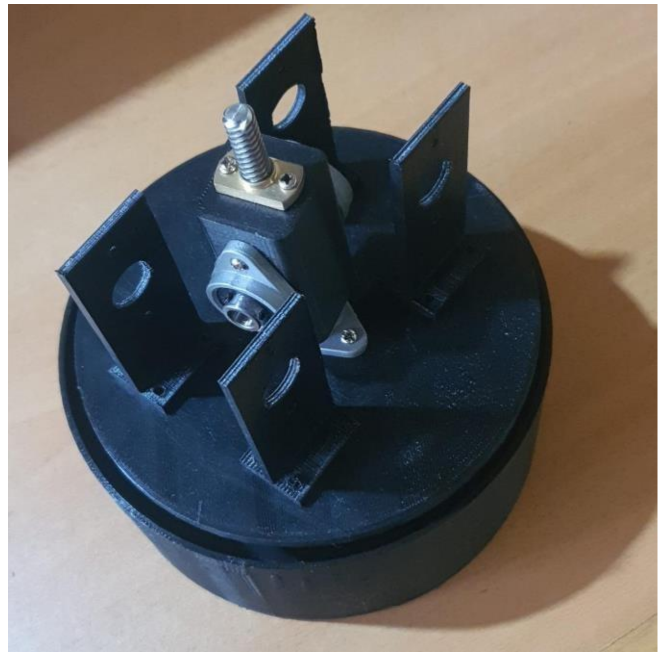
Fig 2.23 : Shaft Holder 2

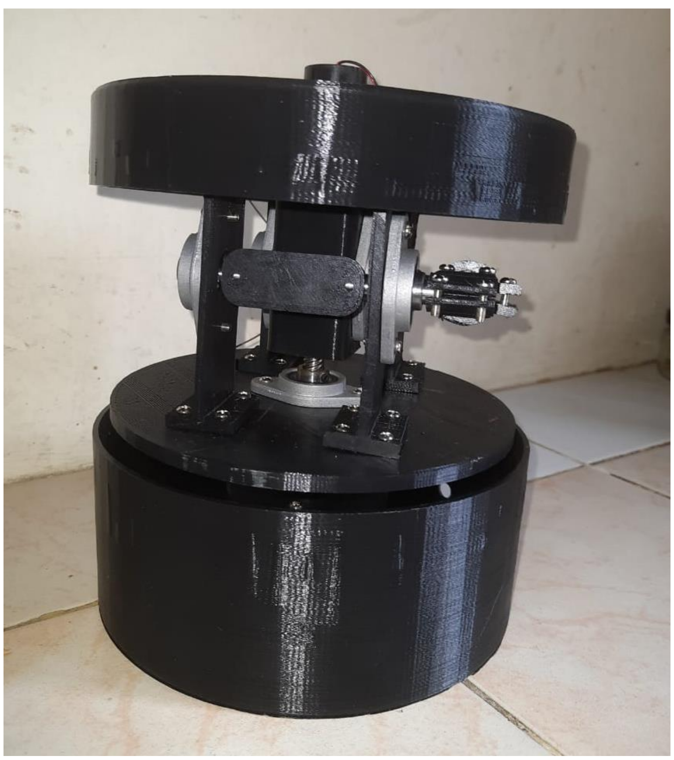
Fig 2.24 : Base

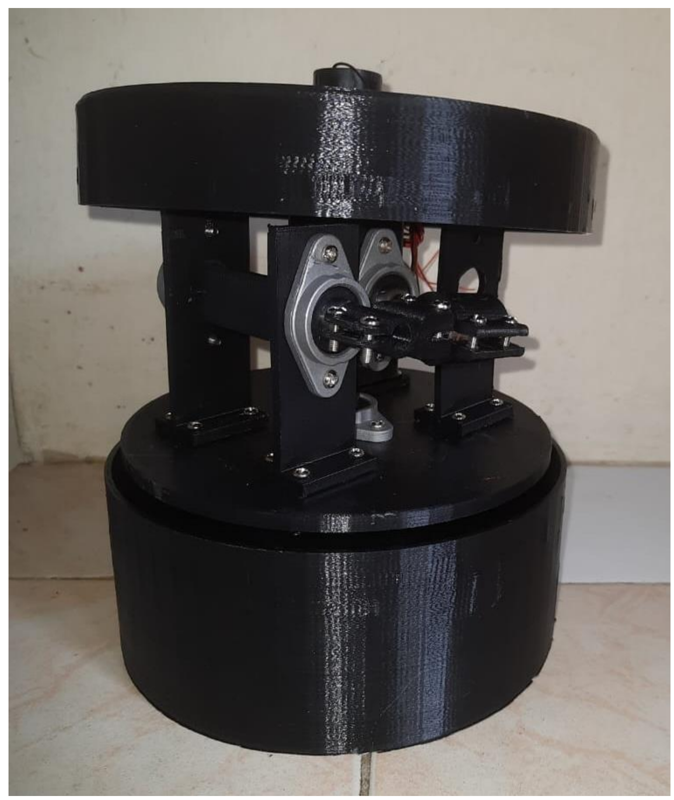
Fig 2.25 : Stepper motor Mount

Fig 2.26 : Top

2.6 Integrated Design







3. PCB Fabrication

The PCB layout consists of two layers: the top layer and the bottom layer. We implemented careful routing strategies to ensure optimal performance and reliability of the circuit.

3.1 Bear PCB

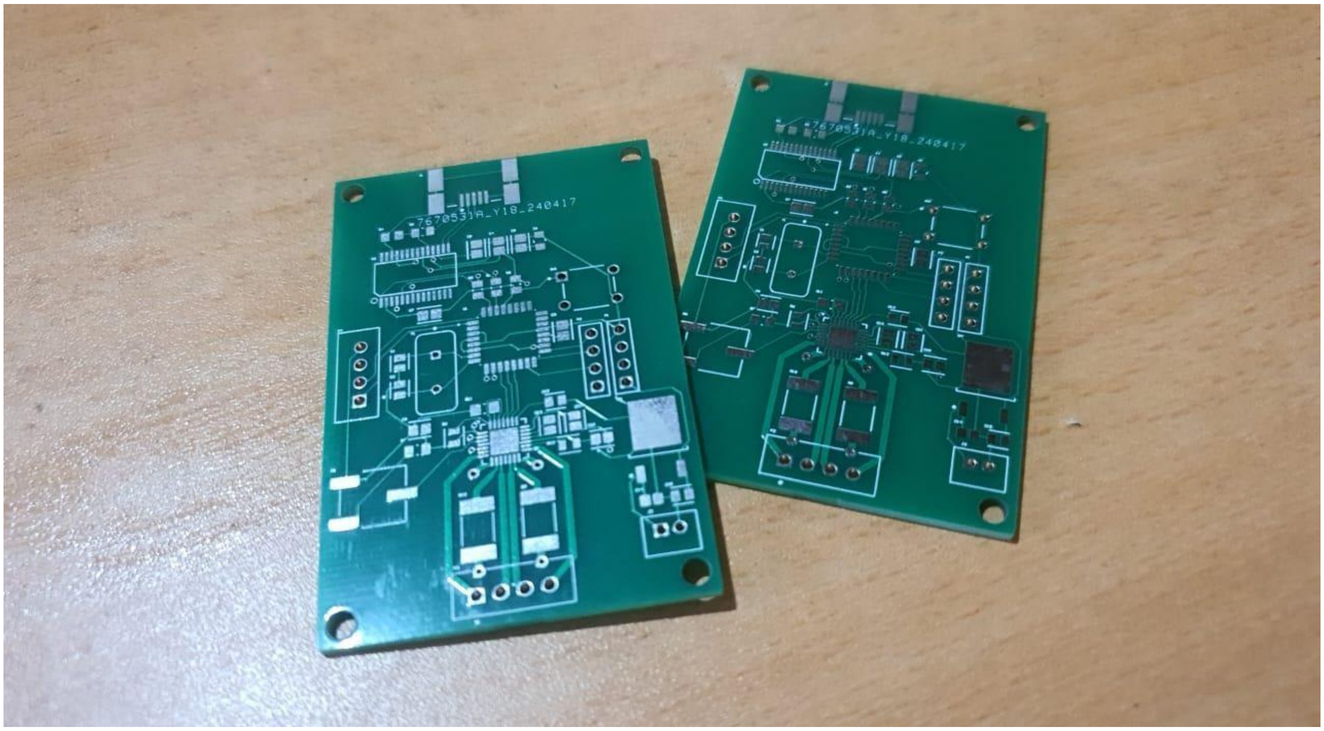


Fig 3.1 : Top

Fig 3.2 : Bottom

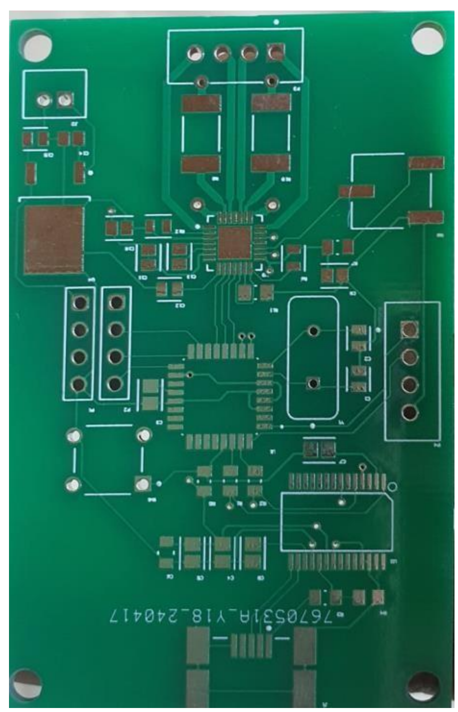
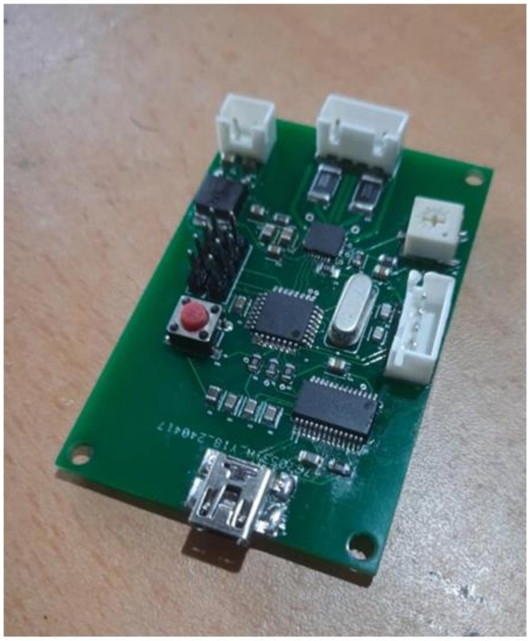


Fig 3.3 : Top

3.2 Soldered PCB



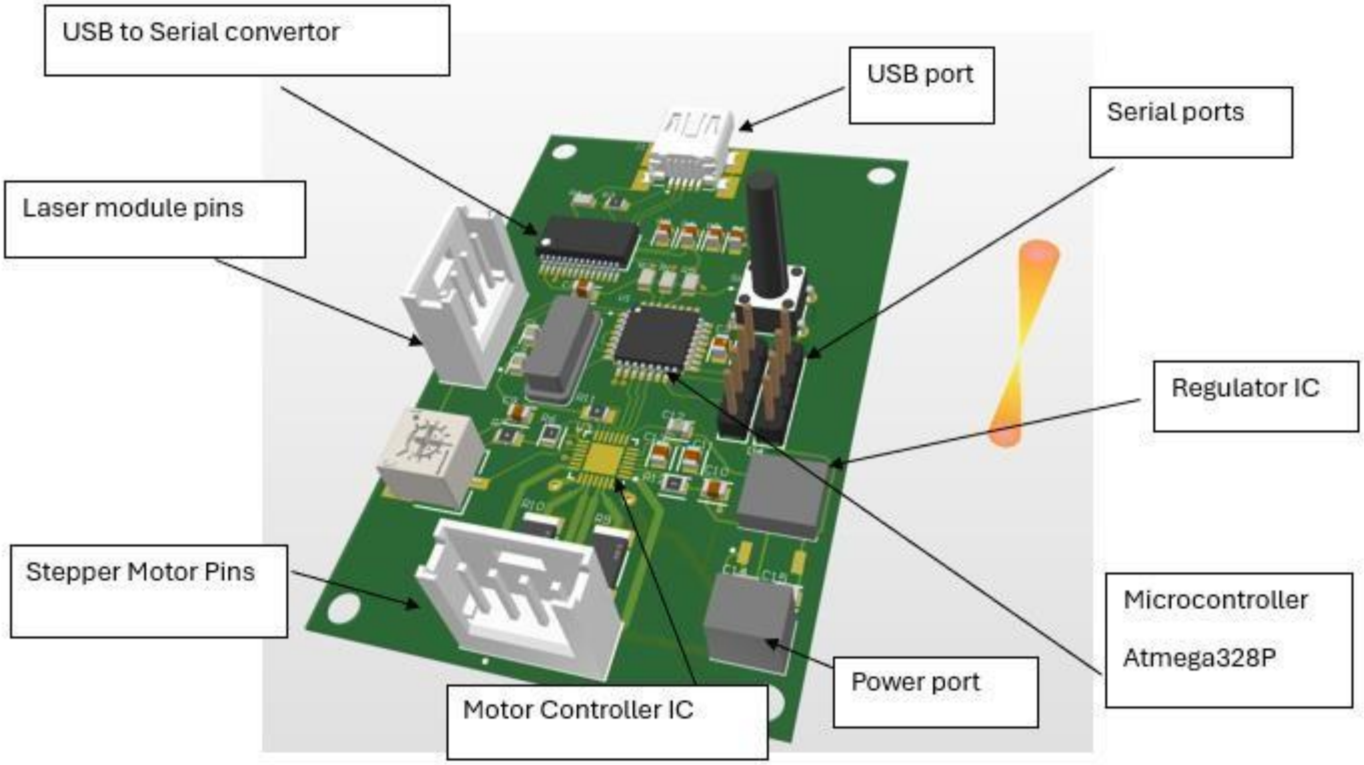
PCB soldering is typically done using a stencil provided with the PCB. The process begins by aligning the stencil over the PCB and applying solder paste to the exposed areas where components will be placed. This ensures that the right amount of solder is applied accurately to each pad.

Once the solder paste is in place, we proceed to place the components onto the board. For most components, we use a hot air gun to melt the solder paste, which securely attaches the components to the PCB. However, soldering the motor controller requires special attention. It is recommended to use lower heat or a hot plate for this component to prevent damage due to excessive heat exposure. The motor controller is sensitive to high temperatures, and using a hot plate ensures an even and controlled application of heat.

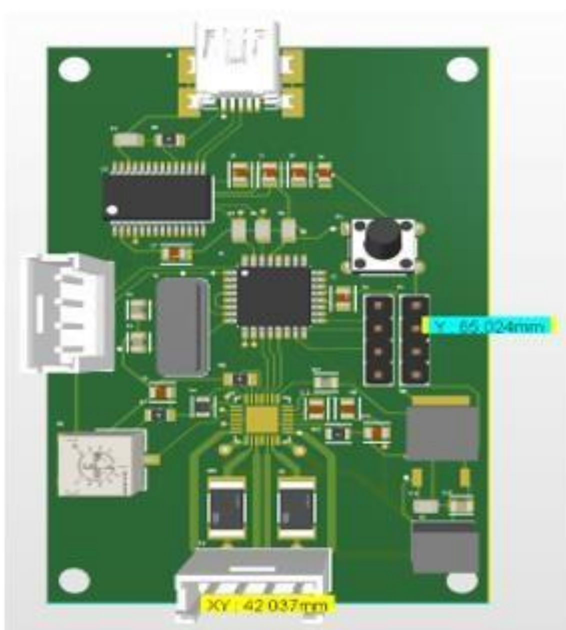
Apart from the motor controller, other components can be soldered by hand with relative ease. We use 0805 capacitors and resistors because their size strikes a good balance between ease of soldering and allowing for a compact PCB design. These components are small enough to support a streamlined design but large enough to handle manually without too much difficulty.

Overall, using a combination of solder paste, a hot air gun, and careful hand-soldering allows for efficient and precise assembly of the PCB. This approach ensures that all components are securely attached and functional, maintaining the integrity of the design and performance of the final product.

3D view of the PCB



Dimensions



4. Assembly

Our product primarily integrates the main PCB, stepper motor, and laser module. The enclosure features openings for power and data connections. We have created an assembly model in SolidWorks to visualize how these components fit together. The enclosure has designated openings for the power port and data connection port.

The design consists of several layers. The bottom layer houses the PCB, ensuring it is securely placed and well-protected. Directly above the PCB, we have the stepper motor, which serves as a crucial part of the device's mechanical structure. Most of the mechanical components and structure are situated at the level of the stepper motor, providing stability and support for the entire assembly.

The laser module is strategically positioned to work in tandem with the stepper motor and the PCB, ensuring precise functionality. This multi-layer design not only optimizes the use of space within the enclosure but also facilitates easy access to each component for assembly and maintenance.

By visualizing the entire assembly in SolidWorks, we can ensure that all components fit together seamlessly, and we can make necessary adjustments to the design before proceeding with physical prototyping. This approach helps in identifying potential issues and refining the design for better performance and ease of use.

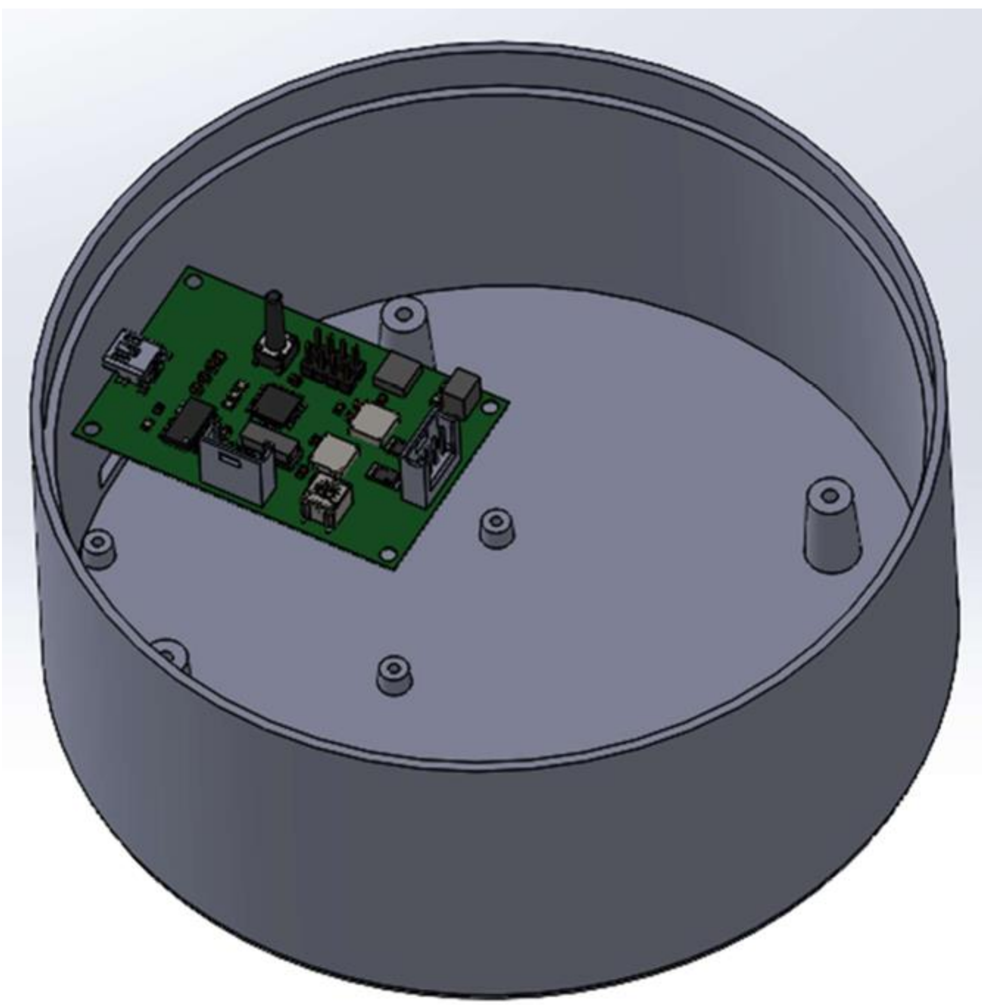


Fig 4.1

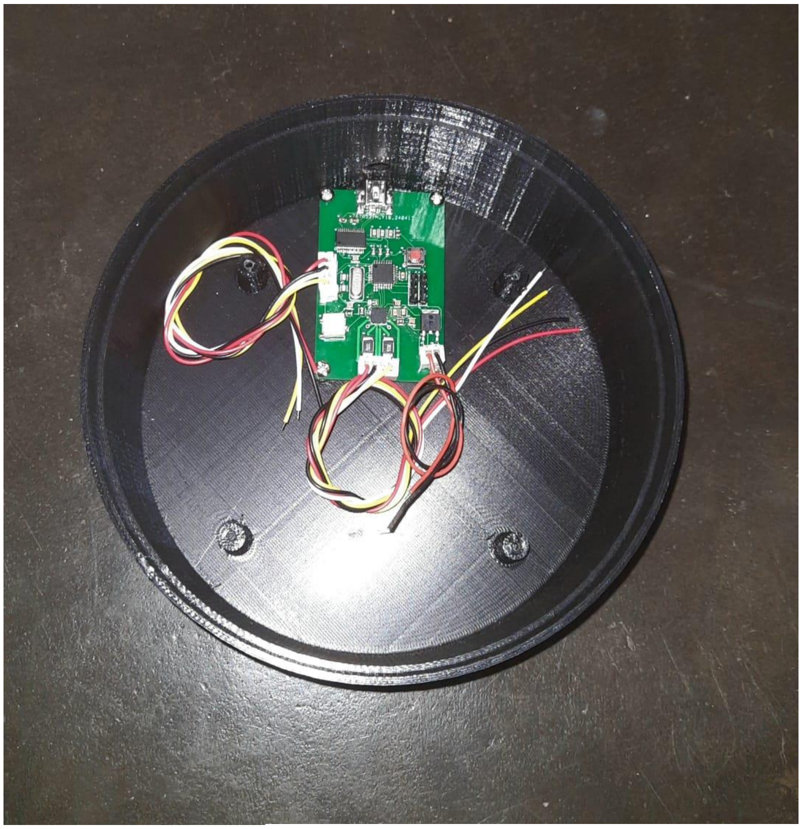


Fig 4.2 : PCB assembly

Fig 4.3 : Motor assembly

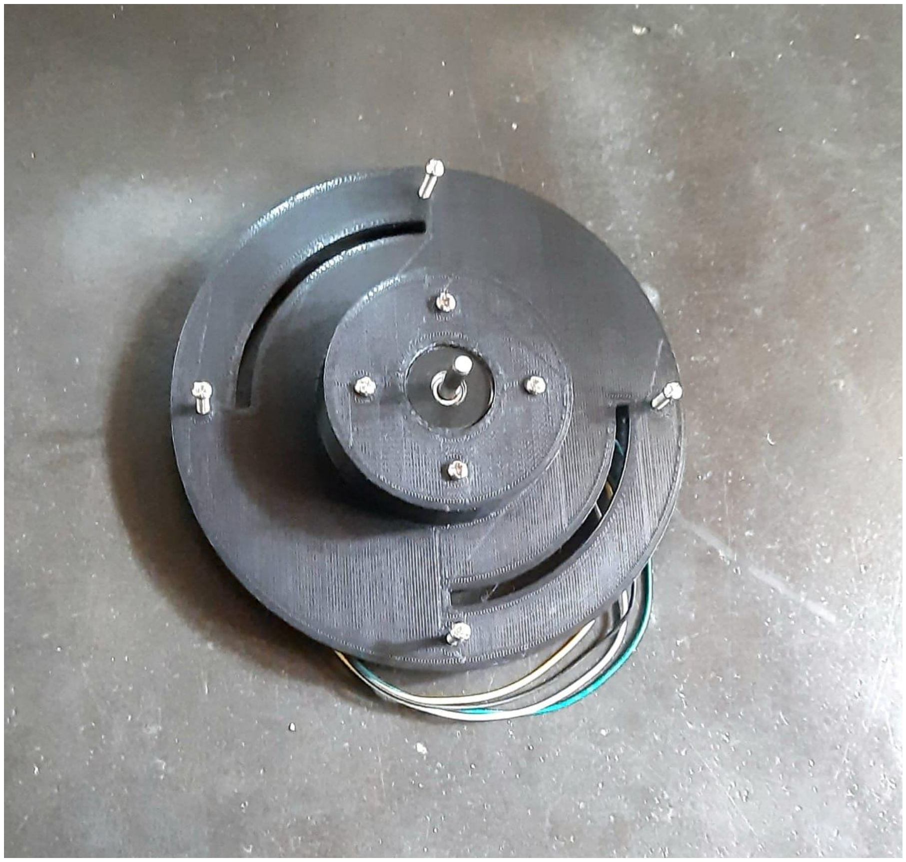


Fig 4.4 : Motor assembly

Fig 4.5 : Motor assembly