Department of Electronic & Telecommunication Engineering, University of Moratuwa, Sri Lanka.

Pick and Place Robot Arm

Design Of The Prototype

Discussion Group C
Group 8
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EN2160 Electronic Design Realization

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Contents

1 Abstract

The project aims to revolutionize the electronic component assembly process through the development of a Pick and Place Robot Arm. Focusing on precise assembly, the system targets components like rivets, washers, and transistors. The objectives span multiple engineering domains, incorporating design, mathematical modeling, control systems, and practical skills acquired during university studies. The device architecture includes horizontal and vertical conveyor systems, a gripper mechanism, and a user-friendly controller interface. The research explores solutions from industry leaders, and the proposed system seeks to integrate the best features observed, providing a state-of-the-art solution for H-Bridge component assembly.

2 User Requirements

User requirements for the project are as follows:

1. Precision in Assembly:

   The system must be capable of precisely assembling H-Bridge components, including rivets, washers, and transistors.

2. Automation and Efficiency:

   The robotic mechanism should automate the assembly process to enhance efficiency and accuracy in electronic component manufacturing.

3. Modular and Customizable Gripper Mechanism:

   The gripper must be adaptable to securely hold and manipulate different electronic components during the assembly process.

4. User-Friendly Controller Interface:

   The system should have an intuitive interface, allowing users to easily control and monitor the robotic arm's operations. This may include physical buttons, touchscreen displays, or a computer interface.

5. Safety Features:

   The robotic mechanism should incorporate safety features to prevent accidents and protect users from harm during operation. This may include emergency stop buttons, motion sensors, and protective barriers.

6. Cost-Effective Design:

   The system should be designed with cost-effectiveness in mind, utilizing affordable components and materials without compromising performance or reliability.

7. Scalability and Flexibility:

   The design should be scalable and adaptable to accommodate future upgrades or modifications based on evolving assembly requirements or technological advancements.

8. Maintenance and Support:

   The system should be easy to maintain and repair, with readily available spare parts and technical support to ensure continuous operation and longevity.

9. Integration with Existing Systems:

   The robotic arm should be compatible with existing manufacturing systems and processes, allowing seamless integration into the production line without significant modifications or disruptions.

3 Review Existing Solutions

The investigation extends to solutions showcased in YouTube videos, covering pick and place mechanisms, screw robots, and innovative approaches like bolt and washer insertion.

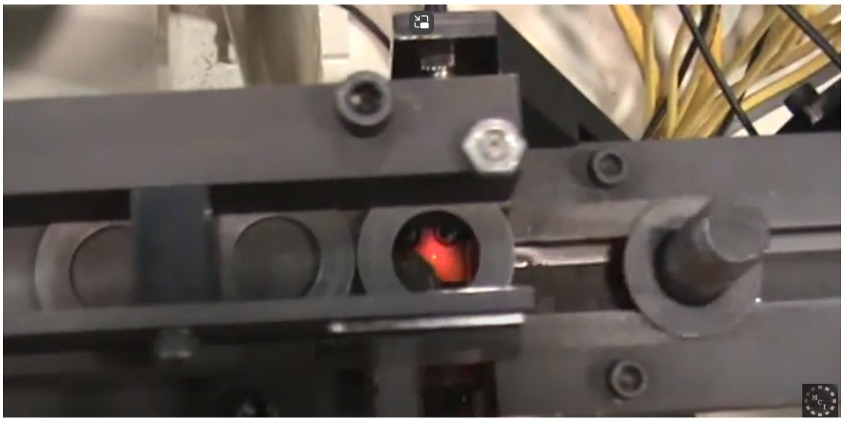


Figure 1: Delivery with Screw and Washer Assembly

Notable technologies, such as Yaskawa Motoman's 3D Vision Picking, are highlighted for advanced manipulation techniques.

This comprehensive review serves as a foundation for the proposed robotic arm system. The project aims to incorporate the best features observed during the research, leveraging the strengths of existing solutions to develop a state-of-the-art robotic arm tailored to the specific requirements of the H-Bridge component assembly process.

4 Stakeholder Map

A stakeholder map has been created to identify and categorize key stakeholders involved in the project. The map includes:

Figure 2: Stake Holder Map

5 Conceptual Design

5.1 Robot Arm Concepts

5.1.1 Multi Axis Robot Arm

A multi-axial robot arm is an advanced robotic design characterized by its ability to move in multiple directions or axes, offering increased degrees of freedom (DOFs) compared to traditional robotic arms. This enhanced flexibility enables the robot to perform complex and intricate tasks with precision and adaptability.

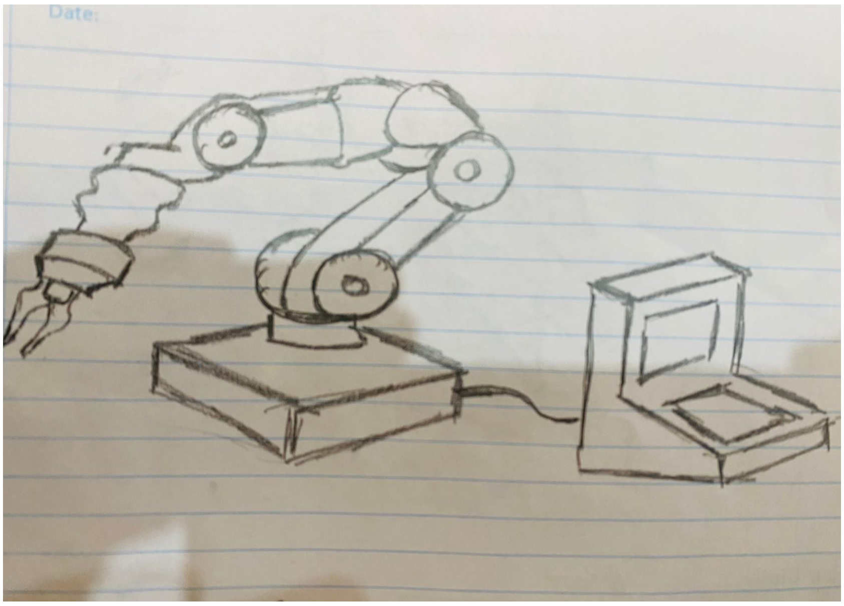


Figure 3: Multi Axial Robot Arm Concept Design

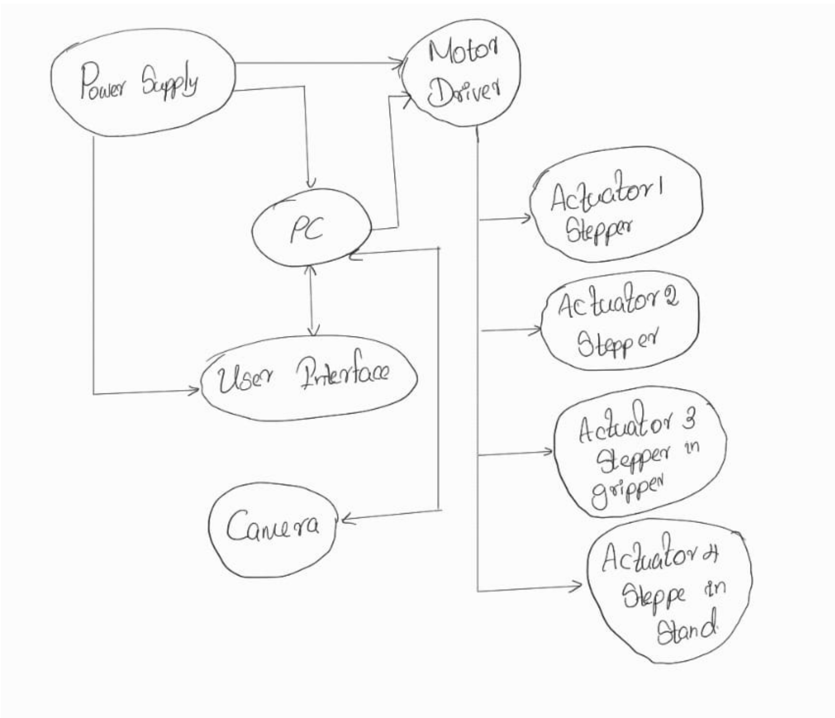


Figure 4: Multi Axial Robot Arm Block Diagram

5.1.2 Screw-Rod Based Robot Arm

A Screw-Rod Based Robot Arm is a specialized robotic design that utilizes a screw or rod mechanism for its motion, enabling it to move vertically and horizontally with precision. This type of robot arm design is particularly effective in applications where linear motion along specific axes is crucial.

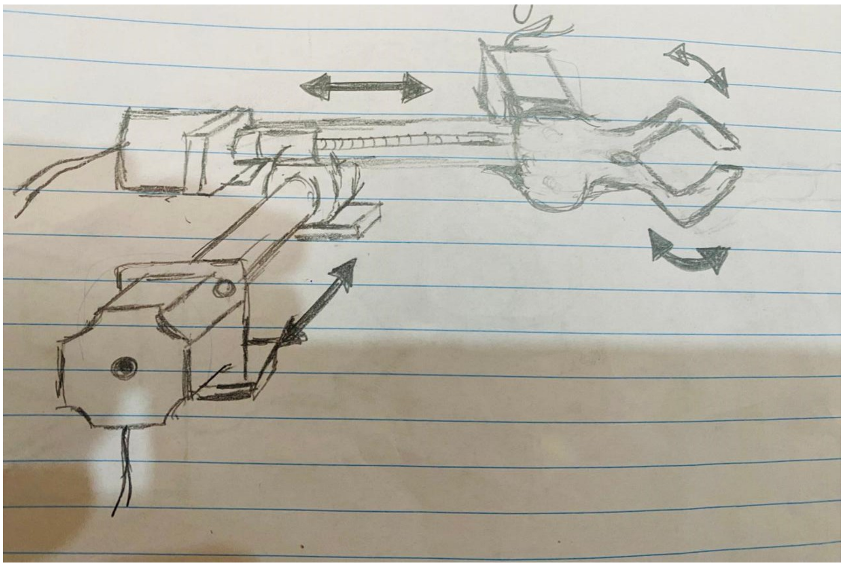


Figure 5: Screw-Rod Based Robot Arm Concept Design

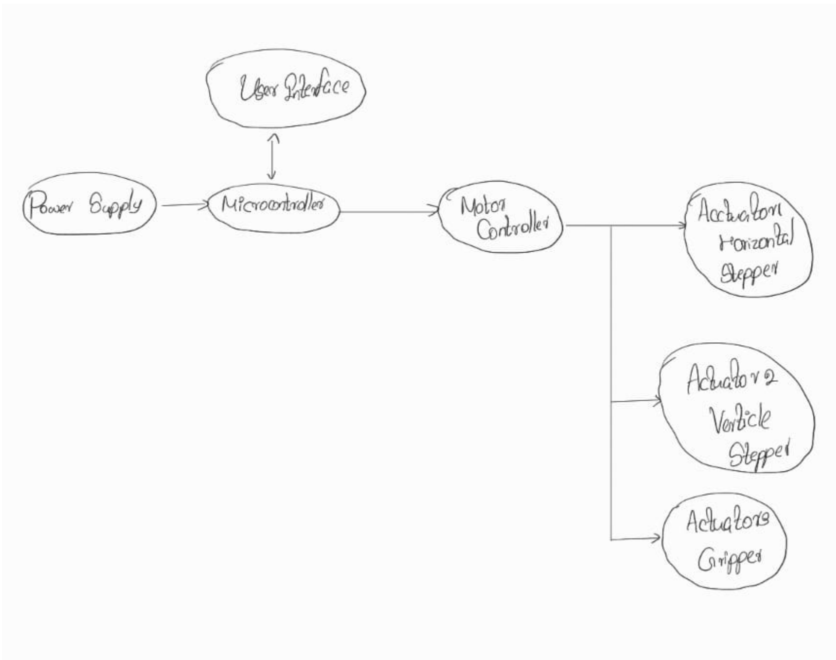


Figure 6: Screw-Rod Based Robot Arm Block Diagram

5.1.3 Feeder Assembler System

A Feeder Assembler System is a sophisticated automation solution designed to efficiently gather components from multiple conveyors and assemble them at a centralized point. This system is widely used in manufacturing and assembly lines to streamline production processes and enhance overall efficiency.

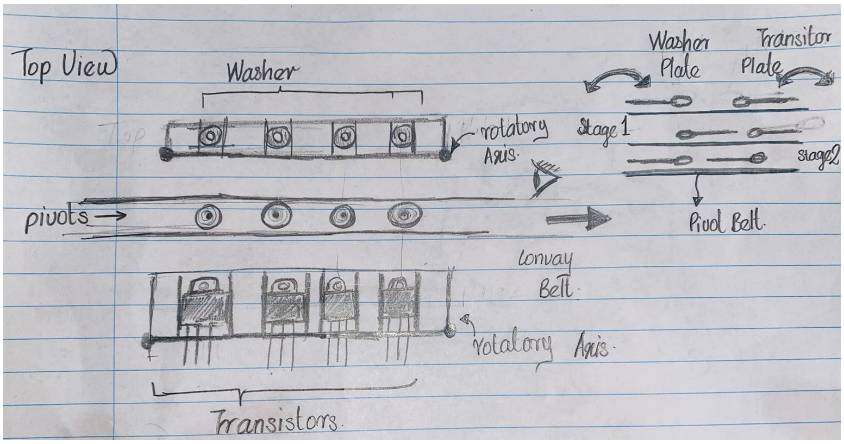


Figure 7: Feeder Assembler System Concept Diagram

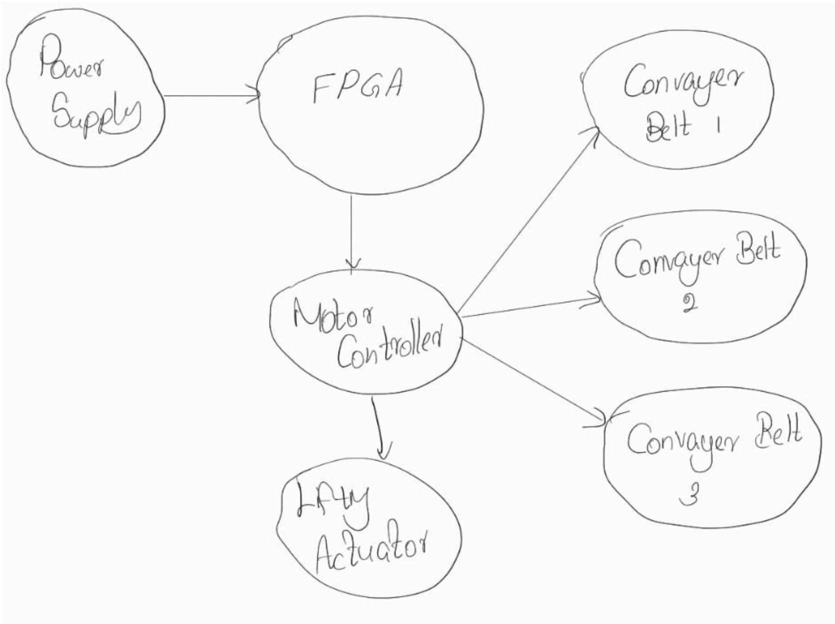


Figure 8: Feeder Assembler System Block Diagram

5.2 Gripper

5.2.1 Mechanical Gripper

This is a concept of the gripper that uses stepper motor and mechanical system for gripping

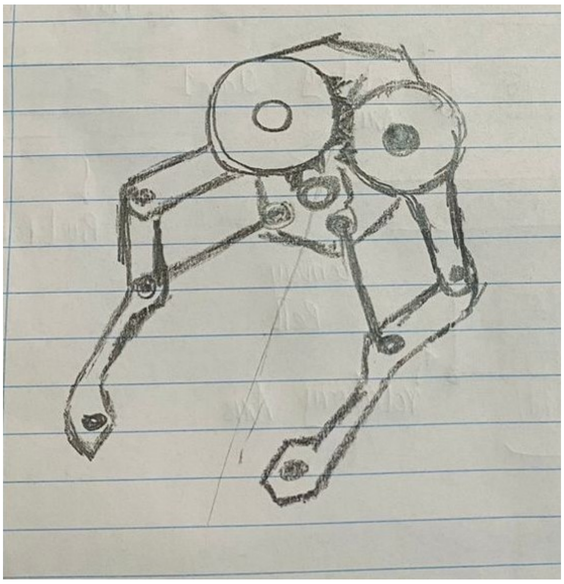


Figure 9: Mechanical Gripper Concept

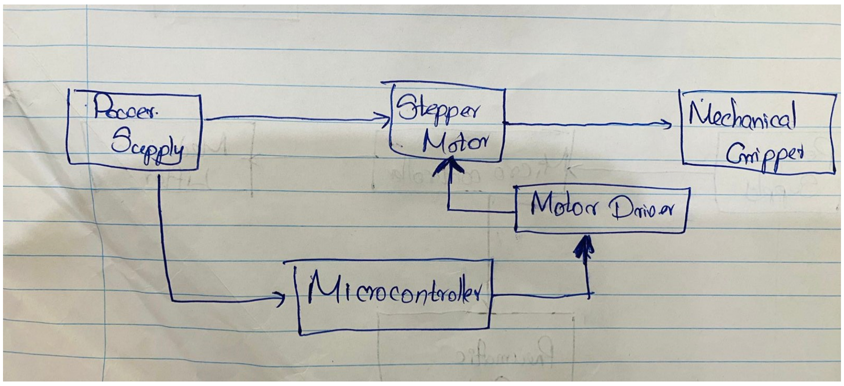


Figure 10: Mechanical Gripper Block Diagram

5.2.2 Suction Gripper

This is a concept of the gripper that uses pneumatic vacuum concepts to suck the components and grip them.

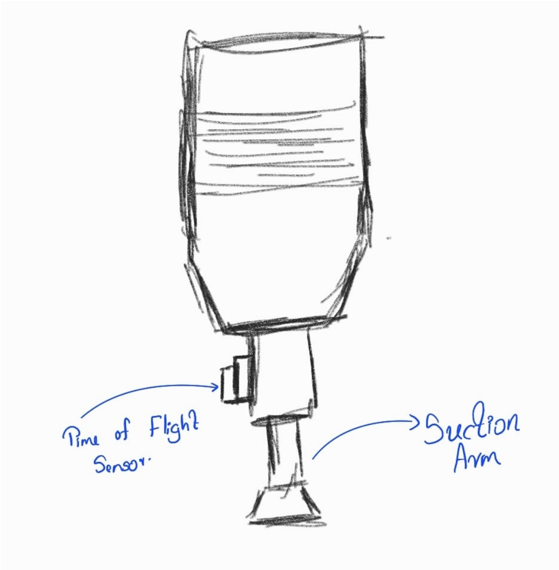


Figure 11: Pneumatic Suction Gripper Concept Diagram

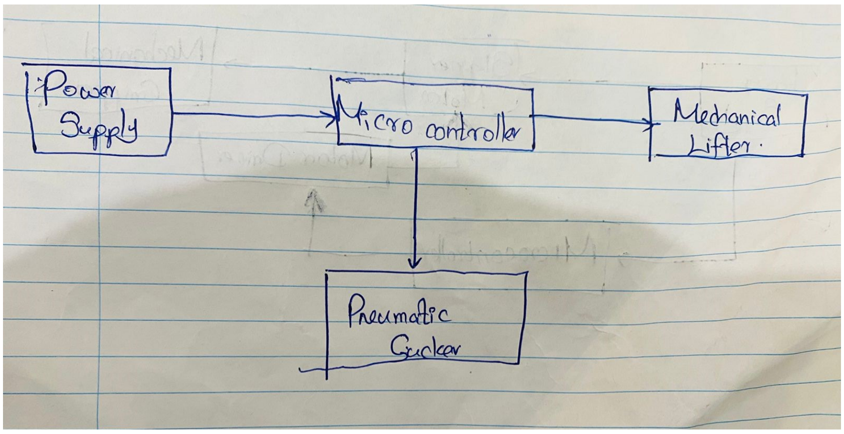


Figure 12: Pneumatic Suction Gripper Block Diagram

5.2.3 Mechanical + Electromagnetic Gripper

After considering some scenarios, we thought of a mechanical gripper using electromagnet to grip one of the stacked washers.

Figure 13: Mechanical + Electromagnetic Based Gripper

5.3 Design Comparison

Concept Number		Concept 1	Concept 2	Concept 3
Newly added features		Multiple degrees of freedom Increased dexterity Vission Camera	Linear motion vertical and horizontal axes, high positional accuracy, simple mechanical design.	Automated component feeding from multiple conveyors centralized assembly point
Envisioned Design		Single axis arm A robotic arm with multiple rotational joints and linkages	A robotic arm using a lead screw or rod mechanisms to achieve linear extension/retraction motions	A system with several feeder conveyors converging to a shared workspace where components are robotically assembled.
Comparison between Mechanical part	Functionality	7	9	7
	Assembly	6	9	7
	Serviceability	5	9	7
	Simplicity	5	9	7
	Durability	8	9	8
	Ergonomics	8	8	8
Comparison between Functional block diagram	Functionality	8	9	7
	User experience	6	9	7
	Feasibility	6	9	6
	Cost(neg.effect)	6	7	5
	Performance	7	8	7
	Power(neg.effect)	6	8	6
Total		78	103	82

Figure 14: Deisgn Concept Comparisopn

5.4 Enclosure Design Criteria

1. **Functionality**: How well the design supports the main functionalities?
2. **Aesthetics**: How much eye-catching and overall appeal of the user?
3. **Heat Dissipation**: How much heat is generated and how well it has been managed?
4. **Assembly and Serviceability**: How easily does the assembly and disassembly is done?
5. **Ergonomics**: How well does the design fit in the user's hand and allow easy interaction?
6. **Durability**: How well does the design withstand impacts and environmental conditions?
7. **Simplicity**: How simple is the design?

5.5 Functional Block Diagram Criteria

1. **Functionality**: How well the circuit design meets functional requirements?
2. **User Experience**: How intuitive and user-friendly is the interaction?
3. **Manufacturing Feasibility**: Evaluate the feasibility of manufacturing the design.
4. **Cost**: Evaluate the overall cost-effectiveness for the provided functionality.
5. **Performance**: Evaluate signal quality, resolution, and bandwidth range?
6. **Future Proofing**: To what extent does the design allow for easy replacement or upgrade of individual components?
7. **Power Efficiency**: How effectively does the device manage power consumption?

6 Selected Design

Based on above concepts, the selected design is a Screw-Rod Based Robot Arm with a Pneumatic Suction Gripper. This design combines the precision and flexibility of a screw-rod mechanism with the gripping efficiency of a pneumatic suction system, offering a comprehensive solution for the assembly of H-Bridge components. The system architecture includes a multi-axis robot arm with vertical and horizontal motion capabilities, a feeder assembler system for component collection, and a user-friendly controller interface for operation and monitoring. The gripper mechanism utilizes a pneumatic vacuum concept to securely hold and manipulate electronic components during the assembly process, ensuring accuracy and efficiency in manufacturing operations.

6.0.1 Screw-Rod Based Robot Arm

A Screw-Rod Based Robot Arm is a specialized robotic design that utilizes a screw or rod mechanism for its motion, enabling it to move vertically and horizontally with precision. This type of robot arm design is particularly effective in applications where linear motion along specific axes is crucial.

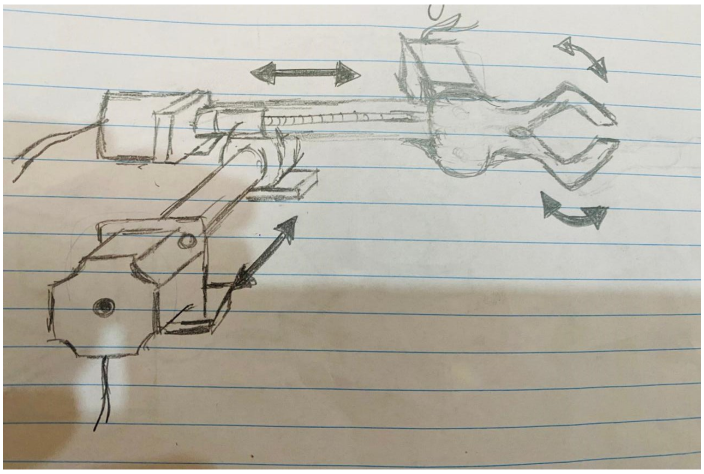


Figure 15: Screw-Rod Based Robot Arm Concept Design

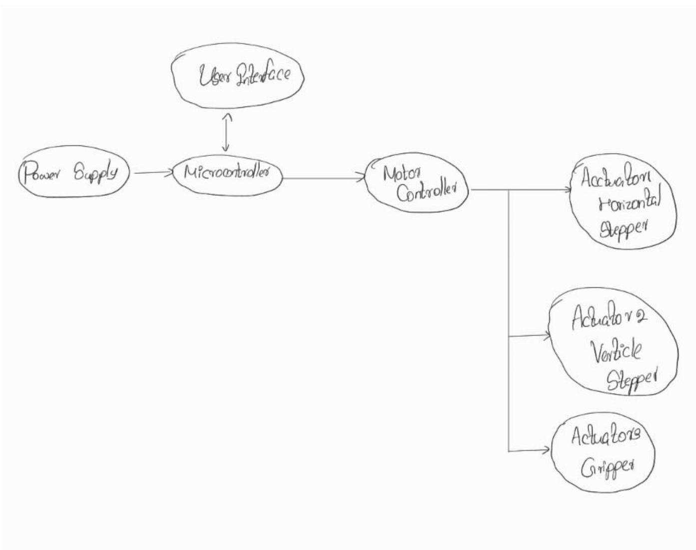
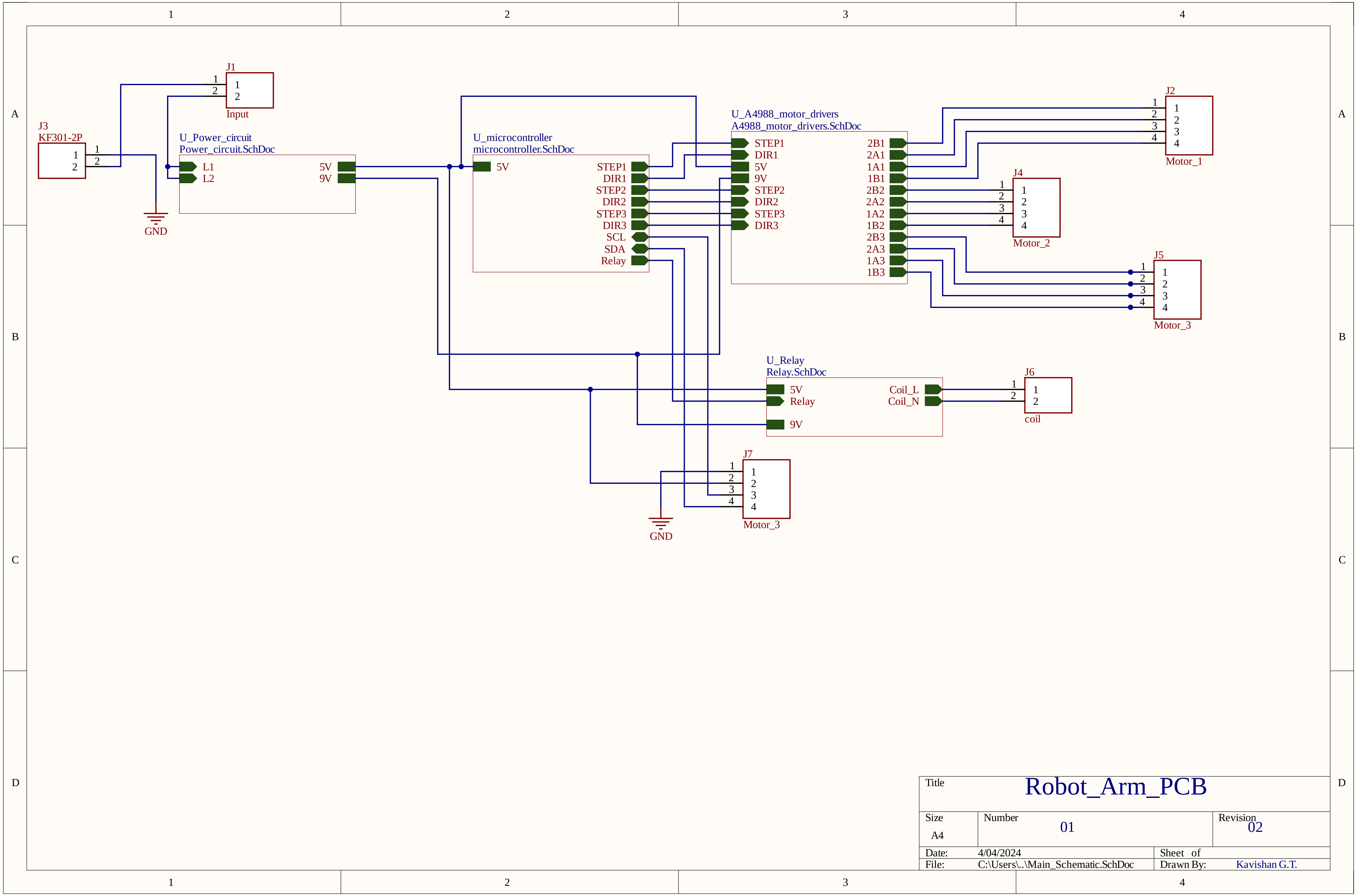


Figure 16: Screw-Rod Based Robot Arm Block Diagram

7 Final schematic and PCB design

Below 6 pages will show the PCB and Schemetic design. we considered about the cost and the efficiency of the design. We have used seven 2 pin JSTs connect switches and one 2 pin JST for electromagnet. We have used four 4 pin JSTs to connect stepper motors to motor drivers. One relay module for get 230 volts to electromagnet. We have used Atmega 328p as our microcontroller. We have planned to get 12V input from power pack and regulate that to 5V and 9V. Also we used flyback diodes to eliminate the damage happen because of the flyback diodes.


J3
KF301-2P
J1
Input
GND
U_Power_circuit
Power_circuit.SchDoc
L1
L2
5V
9V
U_microcontroller
microcontroller.SchDoc
5V
STEP1
DIR1
STEP2
DIR2
STEP3
DIR3
SCL
SDA
Relay
U_A4988_motor_drivers
A4988_motor_drivers.SchDoc
STEP1
DIR1
5V
9V
STEP2
DIR2
STEP3
DIR3
2B1
2A1
1A1
1B1
2B2
2A2
1A2
1B2
2B3
2A3
1A3
1B3
J2
Motor_1
J4
Motor_2
J5
Motor_3
U_Relay
Relay.SchDoc
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Relay
9V
Coil_L
Coil_N
J6
coil
J7
Motor_3
GND
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Robot_Arm_PCB
Size
A4
Number
01
Revision
02
Date:
4/04/2024
File:
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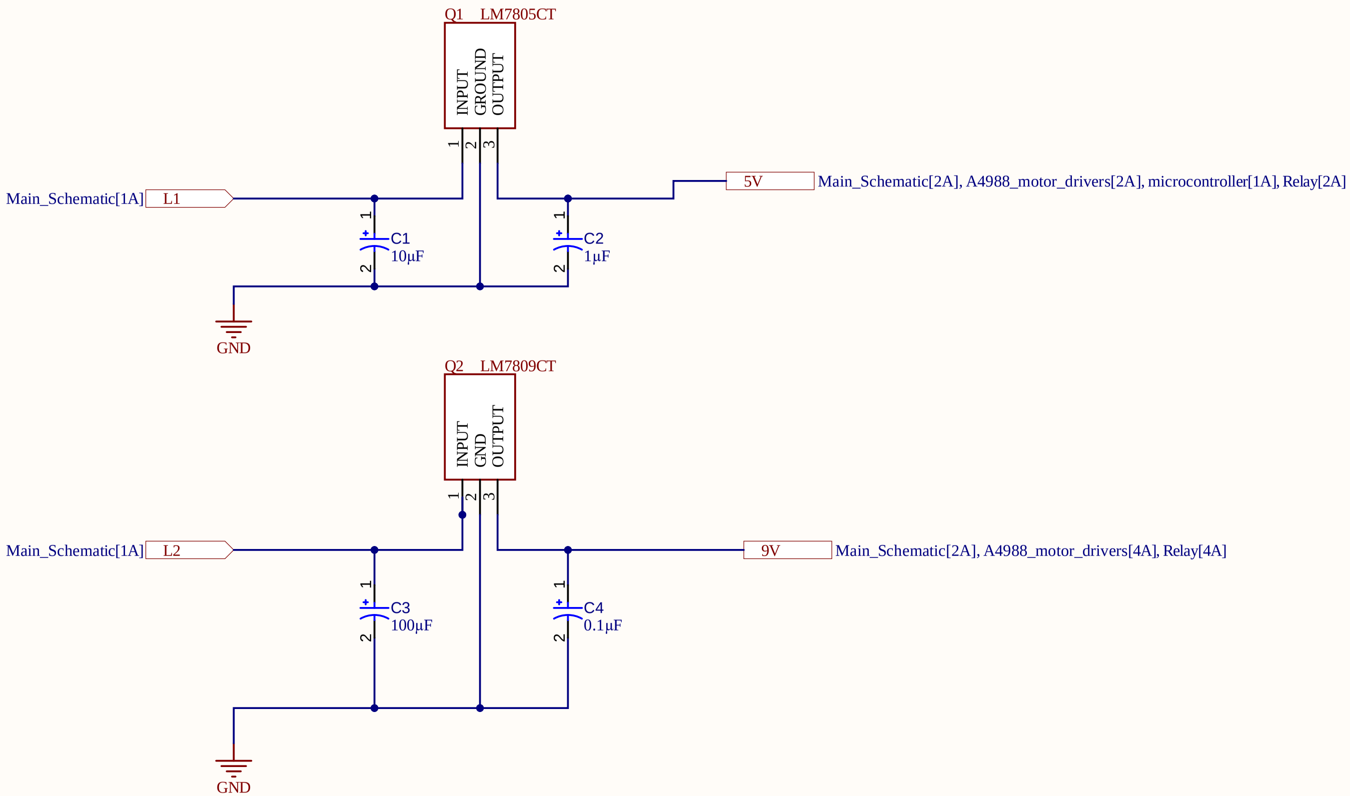
Sheet of
Drawn By:
Kavishan G.T.



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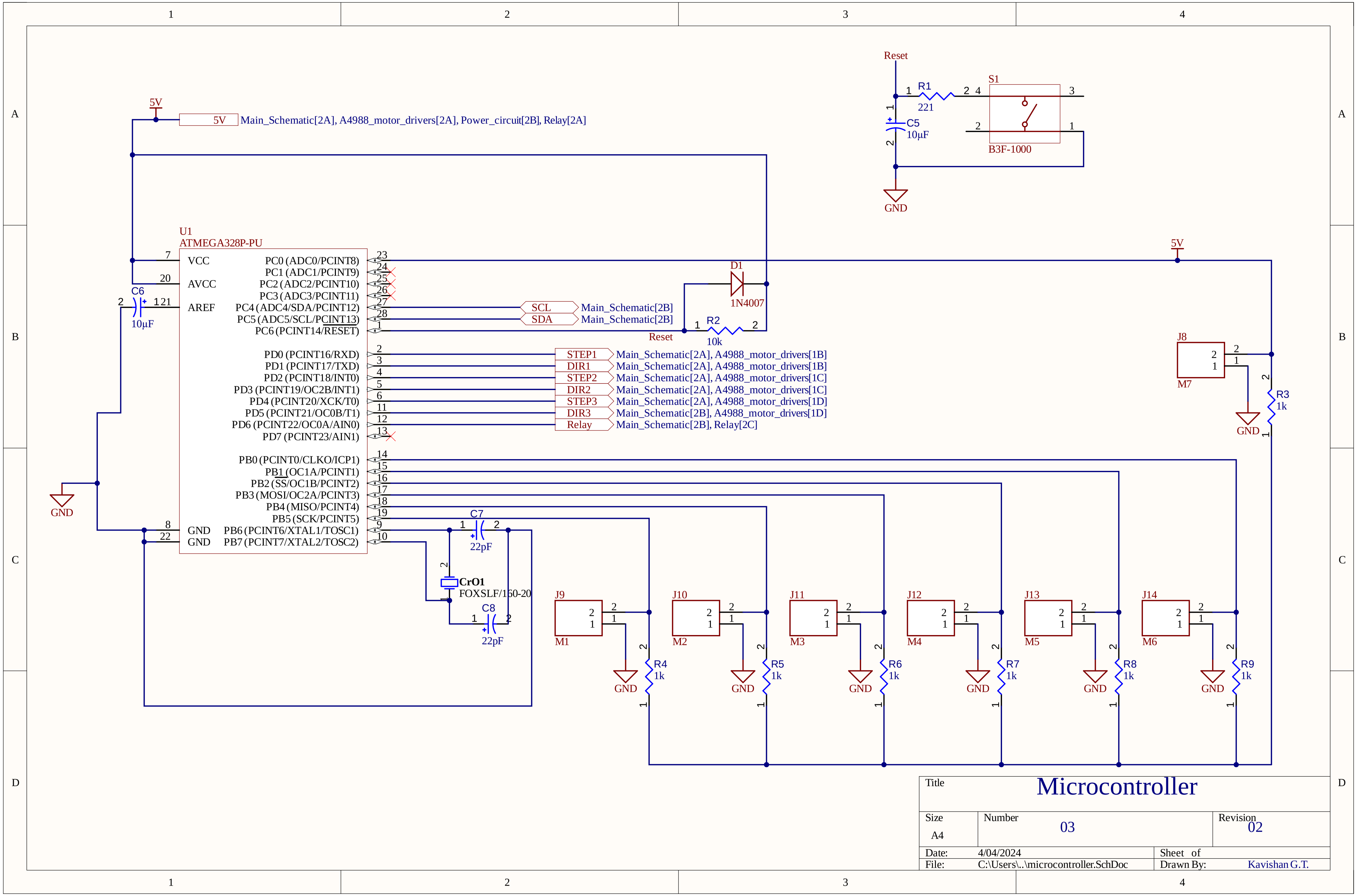

5V
Main_Schematic[2A], A4988_motor_drivers[2A], Power_circuit[2B], Relay[2A]
Reset
R1
221
S1
B3F-1000
C5
10µF
GND
U1
ATMEGA328P-PU
VCC
AVCC
AREF
GND
GND
PC0 (ADC0/PCINT8)
PC1 (ADC1/PCINT9)
PC2 (ADC2/PCINT10)
PC3 (ADC3/PCINT11)
PC4 (ADC4/SDA/PCINT12)
PC5 (ADC5/SCL/PCINT13)
PC6 (PCINT14/RESET)
PD0 (PCINT16/RXD)
PD1 (PCINT17/TXD)
PD2 (PCINT18/INT0)
PD3 (PCINT19/OC2B/INT1)
PD4 (PCINT20/XCK/T0)
PD5 (PCINT21/OC0B/T1)
PD6 (PCINT22/OC0A/AIN0)
PD7 (PCINT23/AIN1)
PB0 (PCINT0/CLKO/ICP1)
PB1 (OC1A/PCINT1)
PB2 (SS/OC1B/PCINT2)
PB3 (MOSI/OC2A/PCINT3)
PB4 (MISO/PCINT4)
PB5 (SCK/PCINT5)
PB6 (PCINT6/XTAL1/TOSC1)
PB7 (PCINT7/XTAL2/TOSC2)
C6
10µF
D1
1N4007
R2
10k
SCL Main_Schematic[2B]
SDA Main_Schematic[2B]
STEP1 Main_Schematic[2A], A4988_motor_drivers[1B]
DIR1 Main_Schematic[2A], A4988_motor_drivers[1B]
STEP2 Main_Schematic[2A], A4988_motor_drivers[1C]
DIR2 Main_Schematic[2A], A4988_motor_drivers[1C]
STEP3 Main_Schematic[2A], A4988_motor_drivers[1D]
DIR3 Main_Schematic[2B], A4988_motor_drivers[1D]
Relay Main_Schematic[2B], Relay[2C]
J8
M7
R3
1k
C7
22pF
CrO1
FOXSLF/160-20
C8
22pF
J9
M1
R4
1k
J10
M2
R5
1k
J11
M3
R6
1k
J12
M4
R7
1k
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M5
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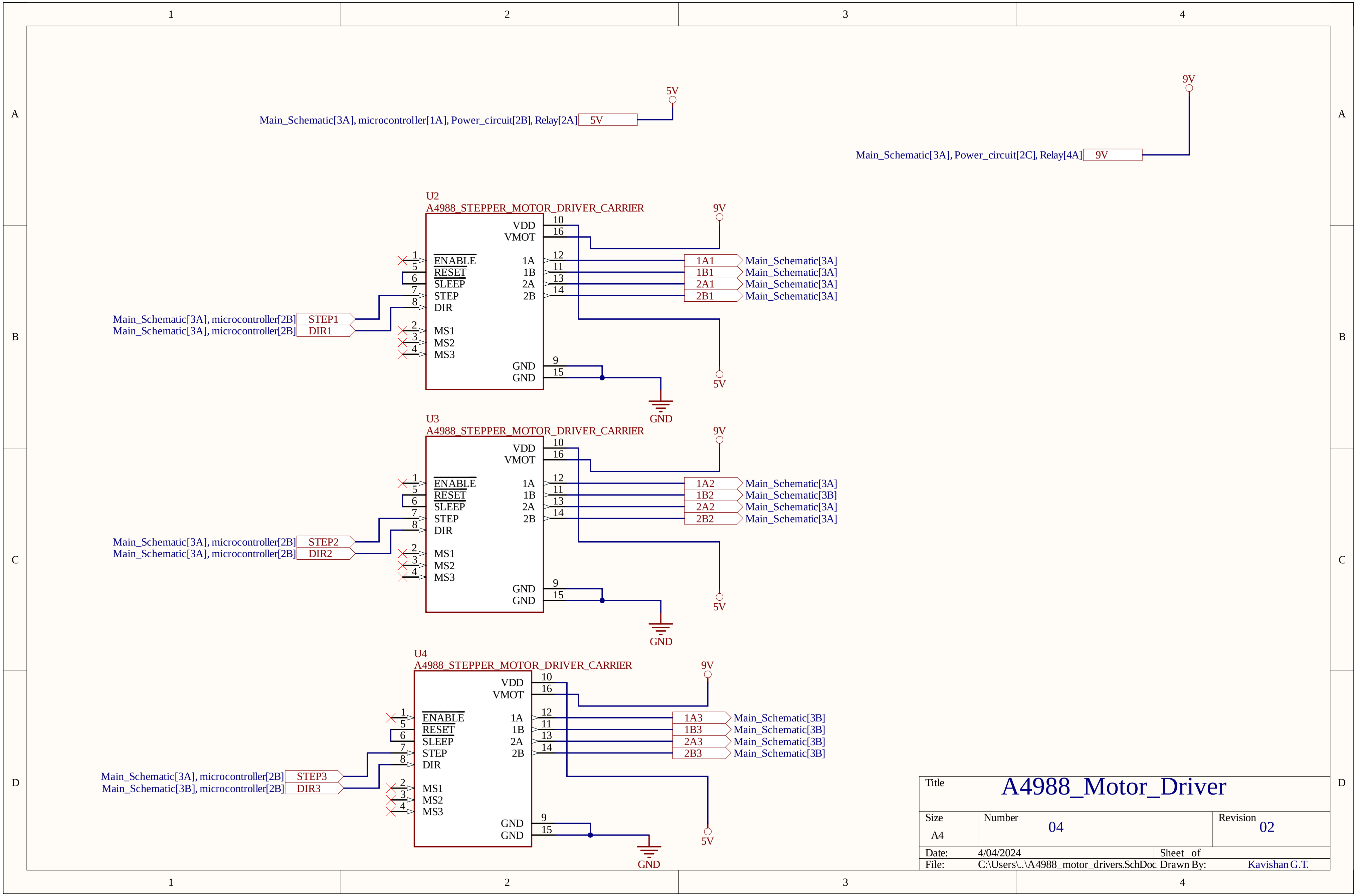
Drawn By:
Kavishan G.T.



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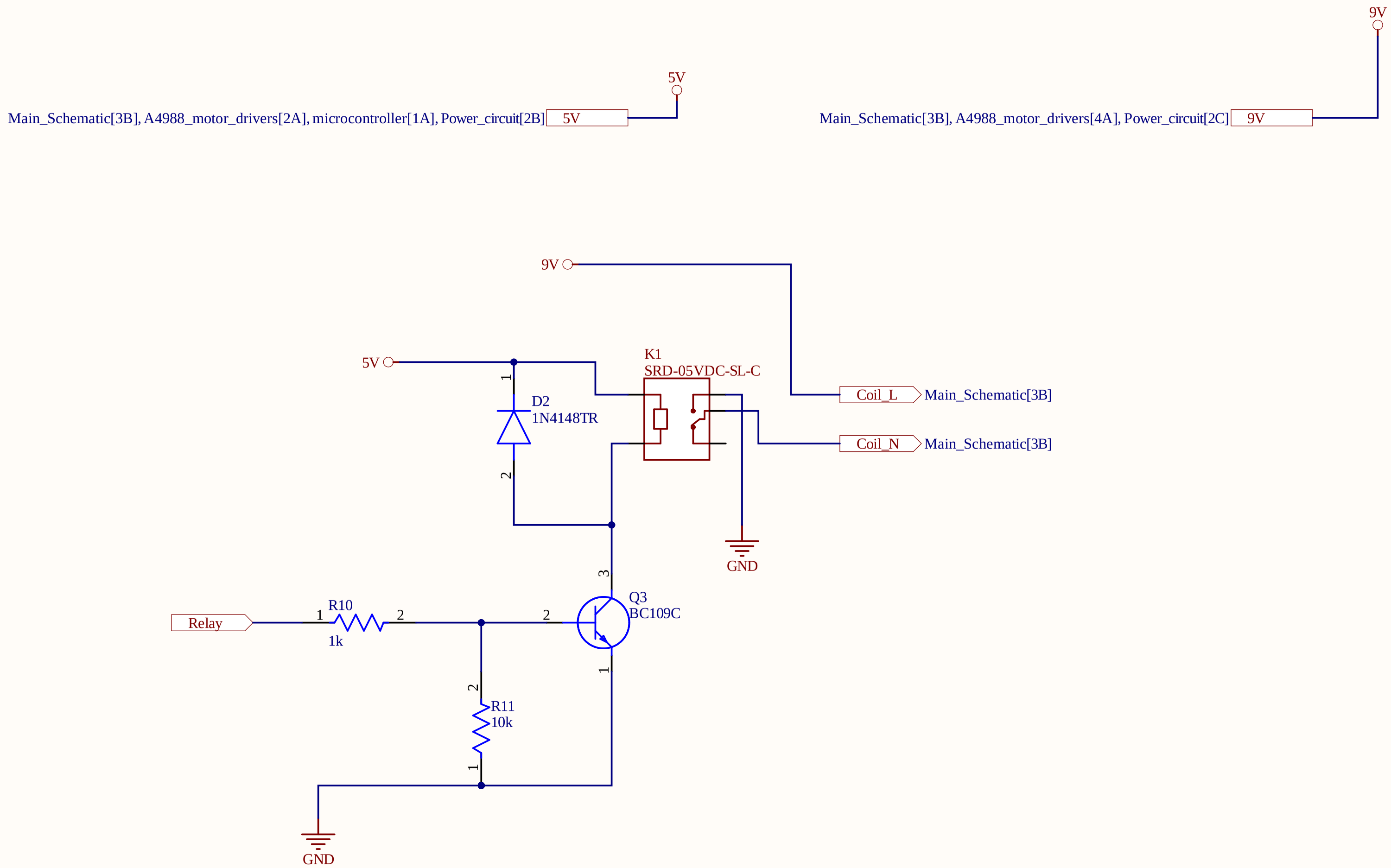

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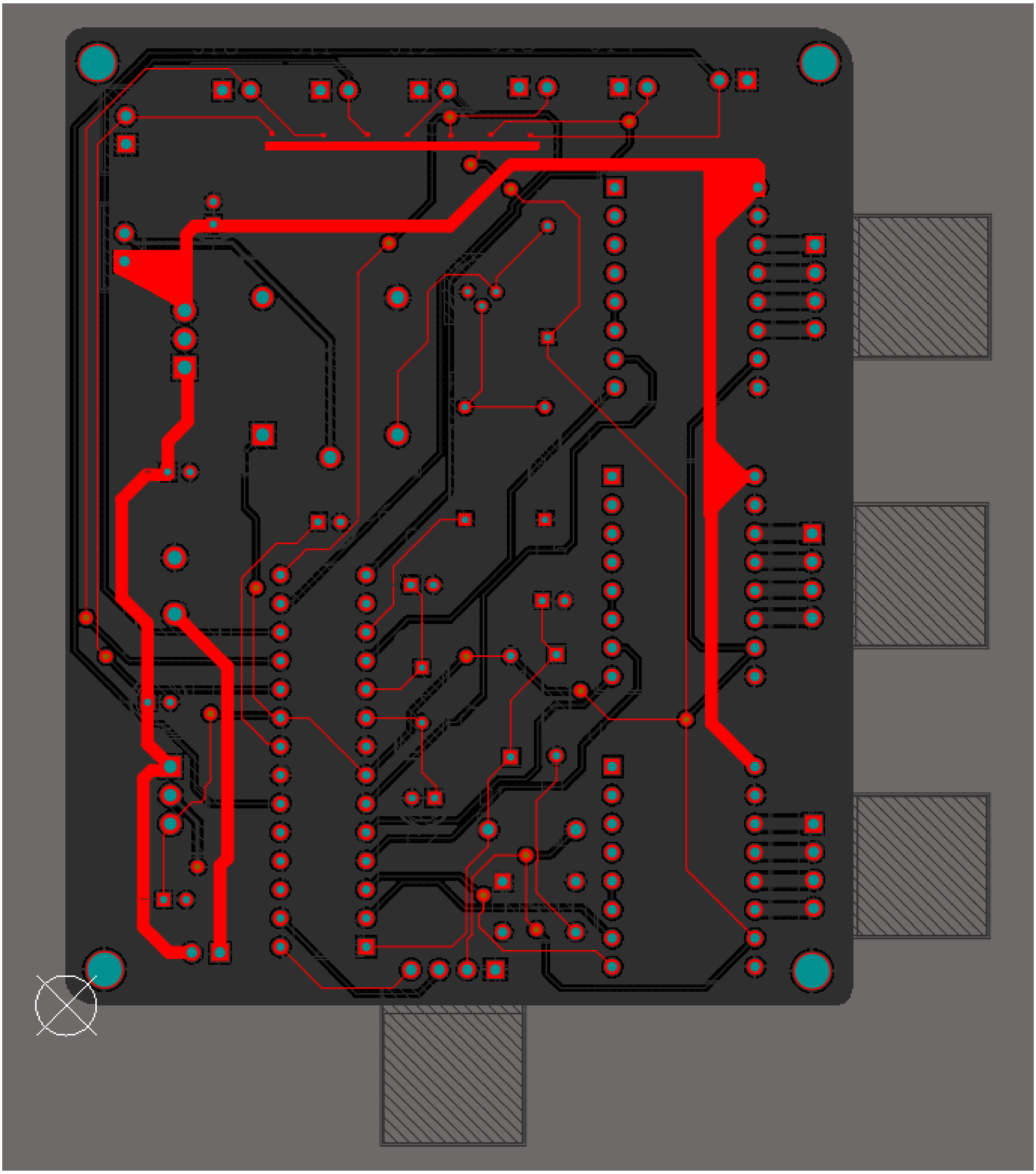


Figure 17: PCB Top Layer

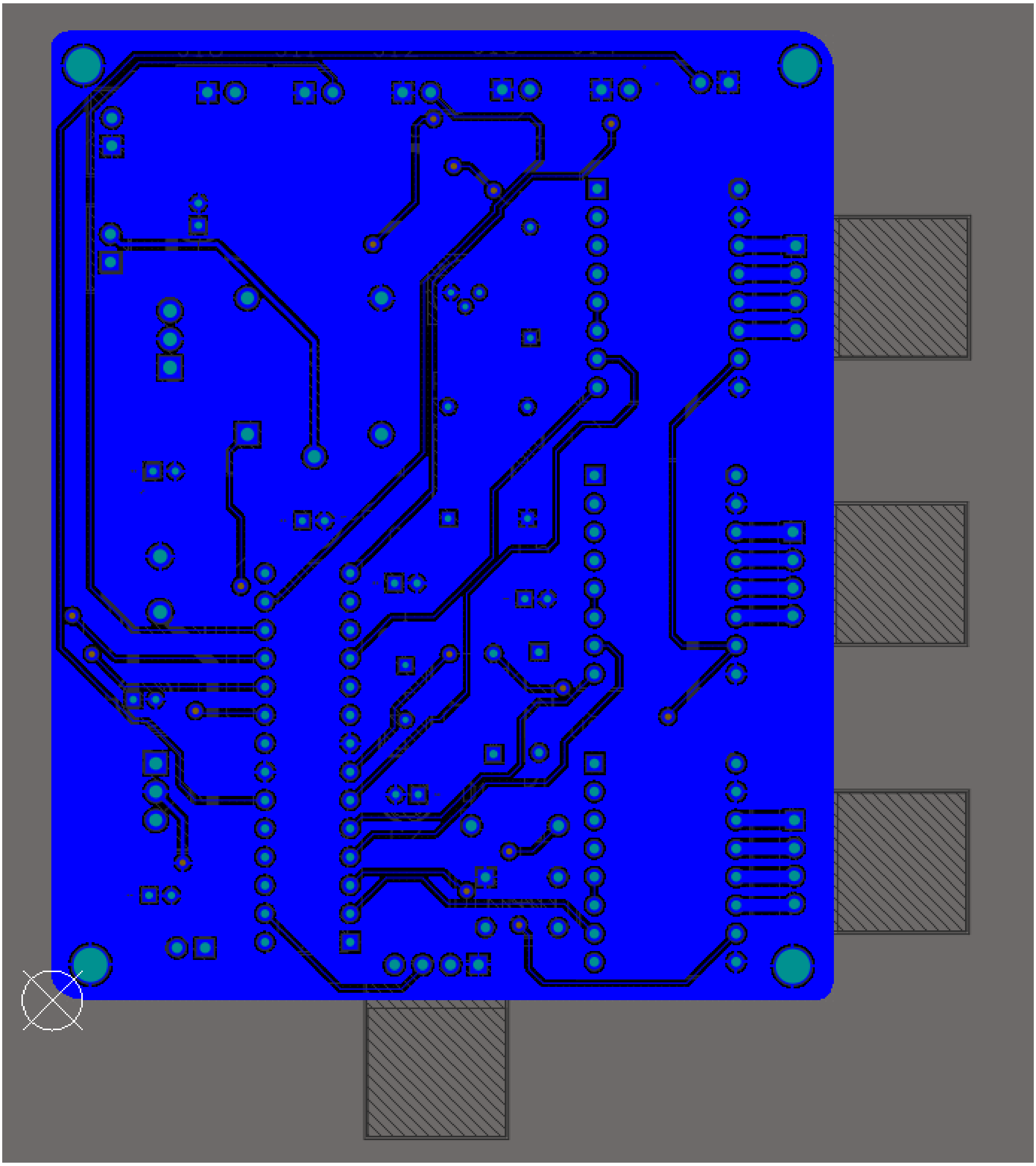


Figure 18: PCB Bottom Layer

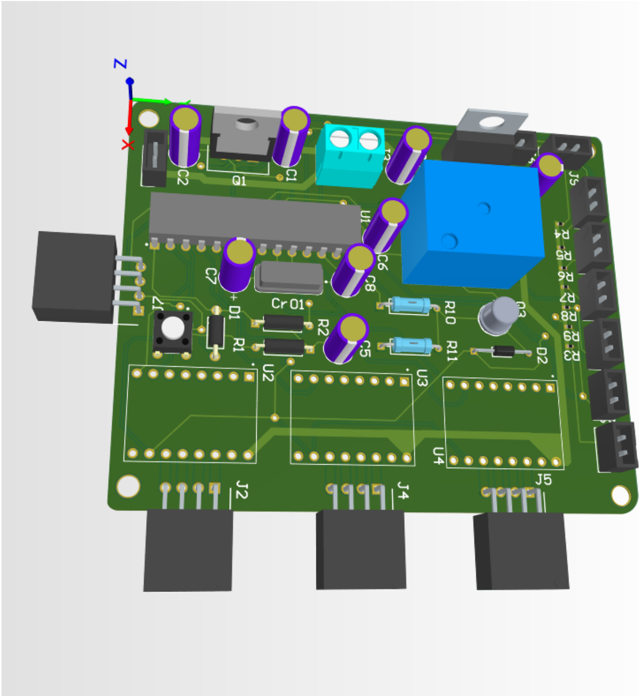


Figure 19: 3D Image of PCB Layout

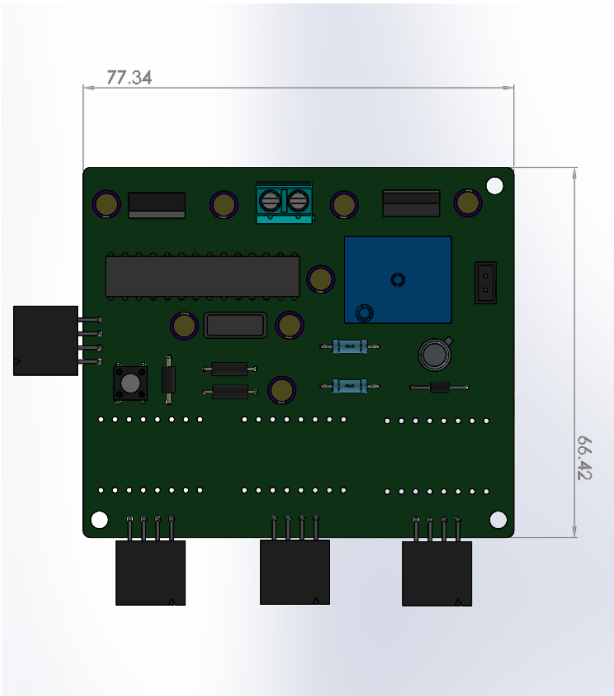


Figure 20: PCB with Dimenssions

8 Final Solidwork Design

These images shows the final solidworks design of the enclosure. Ventilation holes are provided to dissipate the heat generated by the components. The design user-friendly, ensuring easy interaction and operation. The enclosure is durable and robust, capable of withstanding impacts and environmental conditions. The overall design is simple and cost-effective, meeting the functional requirements while providing an aesthetically pleasing appearance. We have added holes to insert buttons to control the stepper motors, electromagnet, display, and other components.

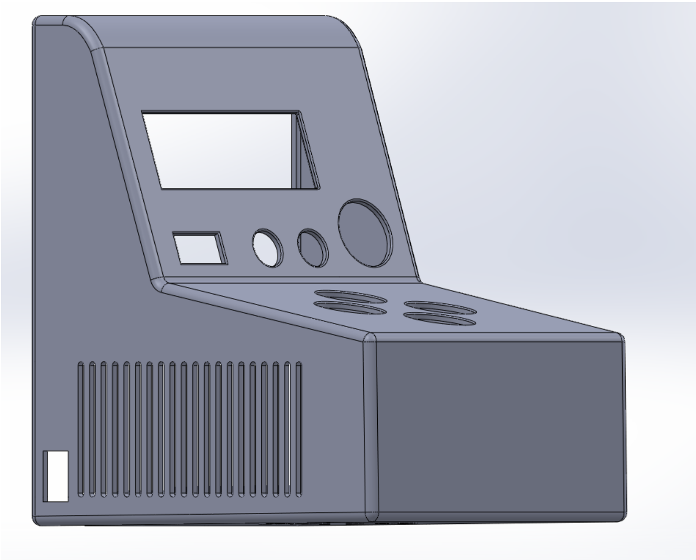


Figure 21: Front View of the Enclosure

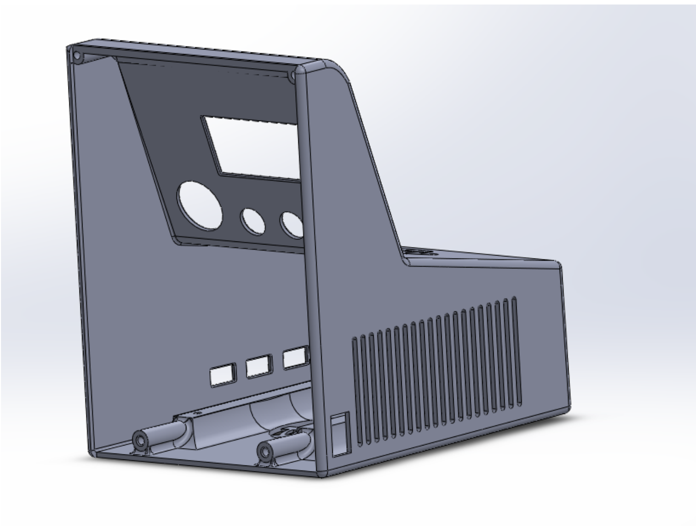
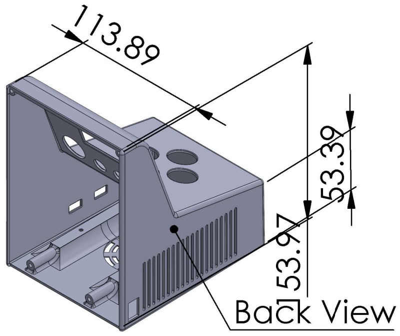
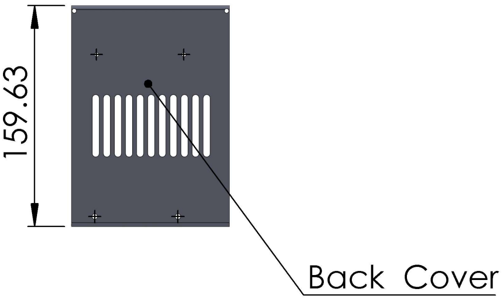
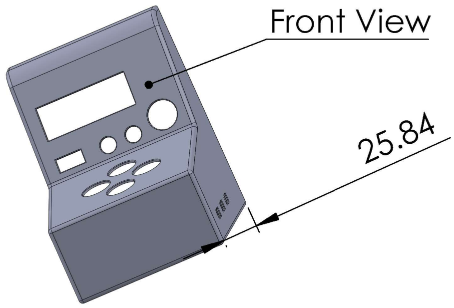


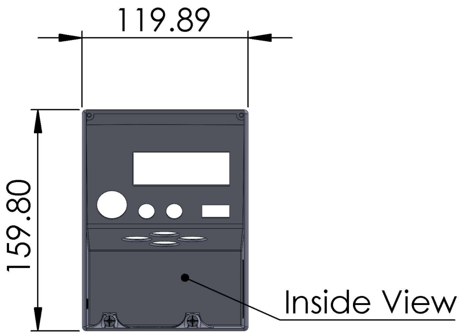
Figure 22: Front View of the Enclosure

Figure 23: Design Tree of Front part









UNLESS OTHERWISE SPECIFIED:
DIMENSIONS ARE IN MILLIMETERS
SURFACE FINISH:
TOLERANCES:
LINEAR:
ANGULAR:

FINISH:

DEBURR AND BREAK SHARP EDGES

DO NOT SCALE DRAWING

REVISION

	NAME	SIGNATURE	DATE
DRAWN	Jayamadu		
CHK'D			
APPV'D			
MFG			
Q.A			

TITLE:

Controller Device

MATERIAL:

DWG NO.

COntroller

A4

WEIGHT:

SCALE:1:1

SHEET 1 OF 1

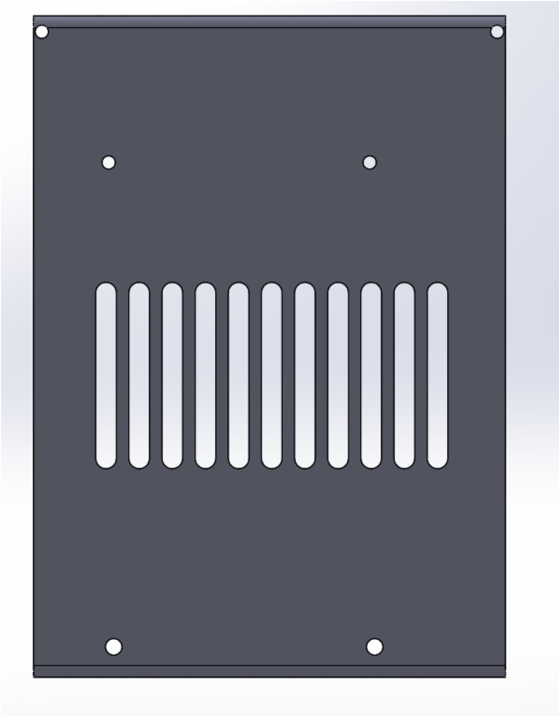


Figure 24: Closing Pad of the Enclosure

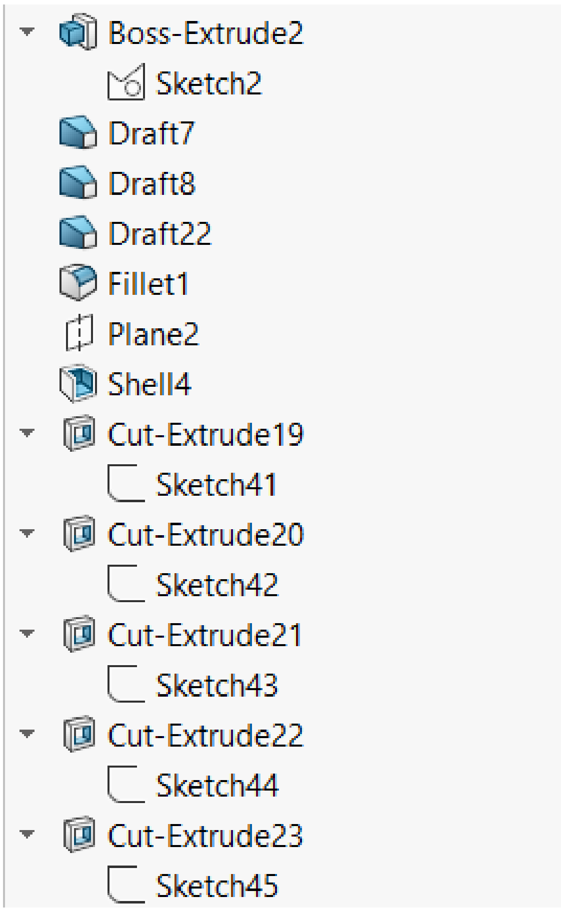


Figure 25: Design Tree of Back Part

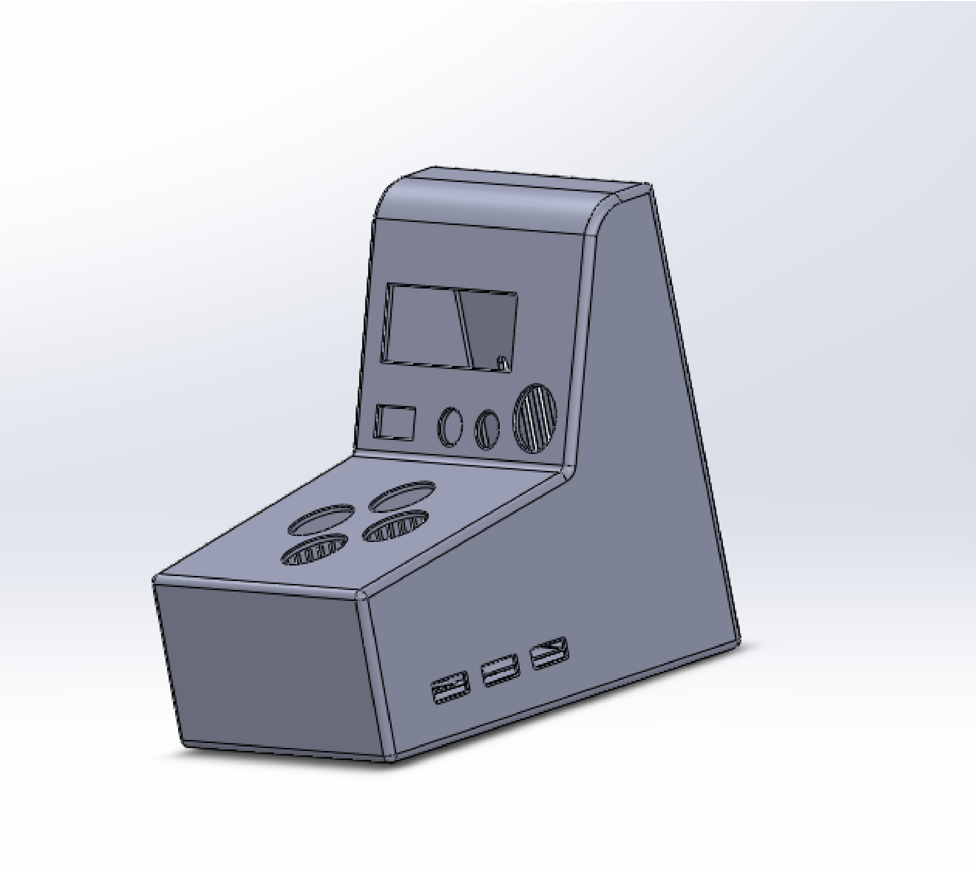


Figure 26: Assembly of the Enclosure

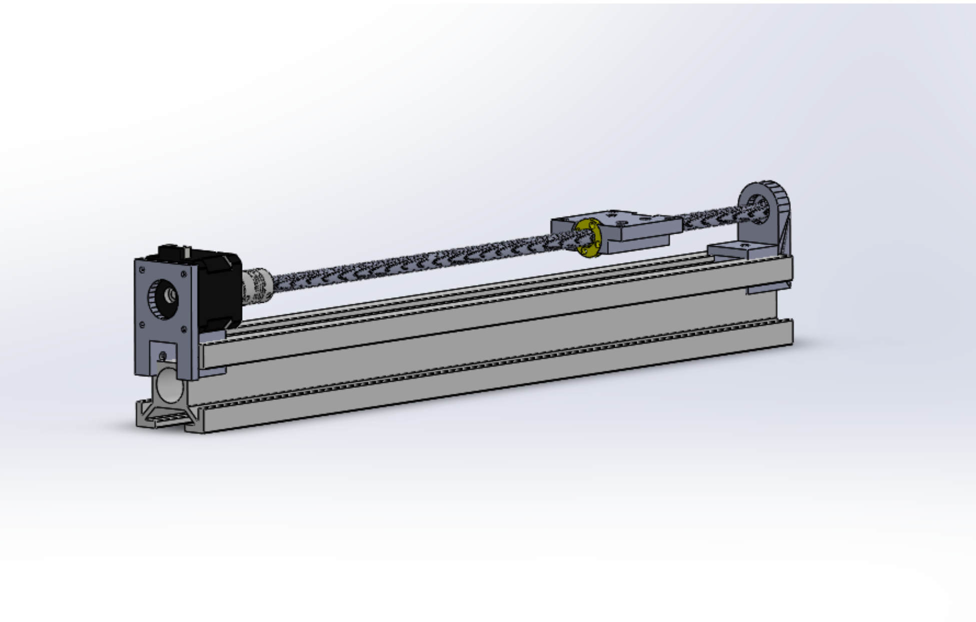


Figure 27: Slider System

References

[1] Yaskawa Motoman. *Yaskawa Motoman Official Website*. [3D Vision Picking]. Available: https://www.motoman.com/en-us/products/systems/bin-picking

[2] ”Pick and Place Robot - Circle Feeder to Press - Bottle Cap Manufacturing.” https://www.youtube.com/watch?v=xnze96qM4C0

[3] ”Pick and Place - with pneumatic tubings.” https://www.youtube.com/watch?v=xnze96qM4C0

[4] ”Screw Robot.” https://www.youtube.com/watch?v=a5kuUYbLiy0&t=27s

[5] ”Flat washer feeder.” https://www.youtube.com/watch?v=sB1bOrIo17U

[6] ”Bolt and Washer Insertion.” https://www.youtube.com/watch?v=YvI_yXXqAw8

[7] ”Pick and Place - dual stroke pneumatic cylinder.” https://www.youtube.com/watch?v=AA7OIyv2GAc