Soft Quad

Project Report

Eklavya Mentorship Programme

SOCIETY OF ROBOTICS AND AUTOMATION,

VEERMATA JIJABAI TECHNOLOGICAL INSTITUTE, MUMBAI

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Acknowledgement

The project was a wonderful opportunity for us to explore new domains and enhance our knowledge further. Throughout the project, we enjoyed every stage of it. We are very grateful to our seniors, who guided and helped us overcome the challenges we faced. They taught us skills that would help us a long way in our engineering career. We would like to express our sincere gratitude to SRA for providing us with this golden opportunity.

Special thanks to our mentors **Chinmay Mundane** and **Vaidic Gupta** for guiding us for the entire duration of the project and helping us achieve our goal.

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1. Project Overview

1.1 Description of Use Case

Our project focuses on developing a Quadruped Robot which is capable of overcoming obstacles using soft materials. By using advanced sensors, intelligent algorithms and working on mechanical and PCB design, we can enable the robot to achieve seamless collaboration and efficient navigation within the environment.

1.2 Technologies Used

1.Solid works

It is a solid modeling computer-aided design (CAD) and computer-aided engineering (CAE) computer program. Here it’s used to design the Robot.

2.Ultimaker Cura

It is an open source slicing application for 3D printers. We used it for 3D printing the parts of our bot.

3.KiCAD

We used this software for the simulation and design of our PCB.

4.Altium

Since we required a flexible PCB for the bot, we used this to design the flex PCB.

5.ESP-IDF Framework

ESP-IDF (Espressif IoT Development Framework) is the official software development environment for the hardware based on the ESP32 chip by Espressif. We use ESP-IDF for menu configuration, then for building and flashing firmware onto an ESP32 board.

2. Introduction

2.1 Brief Idea

Basically, in our project, we use flex material instead of rigid materials such as PLA. We used Ecoflex Dragon skin material for the body. A Flex PCB will enable our SoftQuad robot to become more flexible, improving its capacity to scale higher obstacles.

2.2 Basic Project Domains

1.Mechanical design

The mechanical design and fabrication aspect of the project involve creating a design which is durable, flexible and lightweight to enable efficient movement. This design ensures both agility and robustness, allowing the robot to traverse challenging terrains while maintaining stability and precision.

2.Embedded design

In the core of the system, we use ESP32, a powerful microcontroller with built-in Wi-Fi and Bluetooth capabilities. It is programmed using the ESP-IDF (IoT Development Framework), which provides the tools and libraries necessary to develop applications for the microcontroller.

3.PCB design

The PCB (Printed Circuit Board) design involves creating a custom circuit board that has various electronic components such as microcontrollers, motor drivers, sensors, communication modules, and power management units. The PCB design needs to consider factors such as compactness, efficient power distribution, noise mitigation, and ease of assembly.

4.Soft robotics

Unlike traditional rigid robots, this project utilizes soft robotics principles to create a robot with a pliable and deformable structure. This inherent flexibility allows the robot to adapt its shape to various obstacles, enhancing its ability to traverse complex terrain.

3. Stages of Progress

3.1 Understanding Solidworks basics

Parts are the basic building blocks in the SOLIDWORKS software. Assemblies contain parts or other assemblies, called subassemblies. A SOLIDWORKS model consists of 3D geometry that defines its edges, faces, and surfaces.
The SOLIDWORKS software lets you design models quickly and precisely.

SOLIDWORKS models are:

- Defined by 3D Design
- Based on components

SOLIDWORKS uses a 3D design approach. As you design a part, from the initial sketch to the final result, you create a 3D model. From this model, you can create 2D drawings or mate components consisting of parts or subassemblies to create 3D assemblies. You can also create 2D drawings of 3D assemblies.

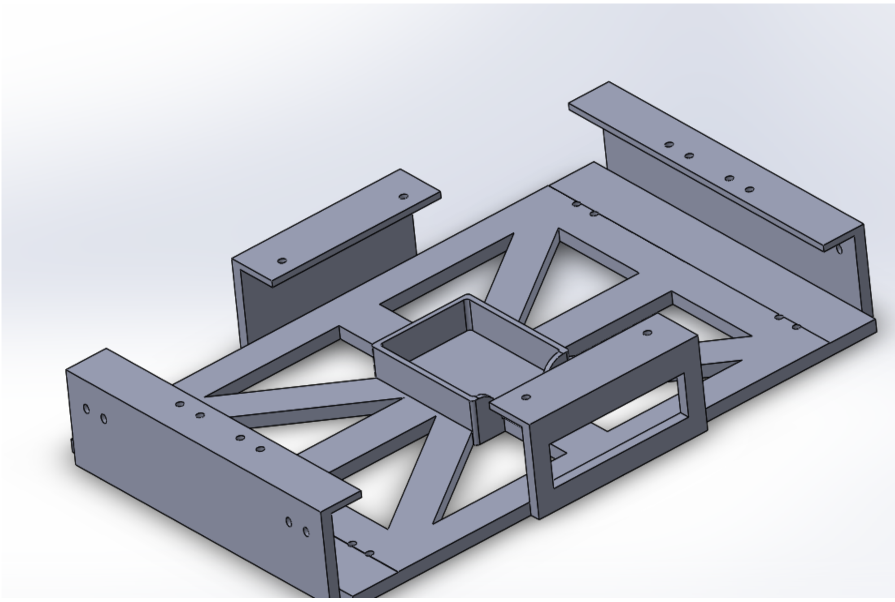
When designing a model using SOLIDWORKS, you can visualize it in three dimensions,the way the model exists once it is manufactured.

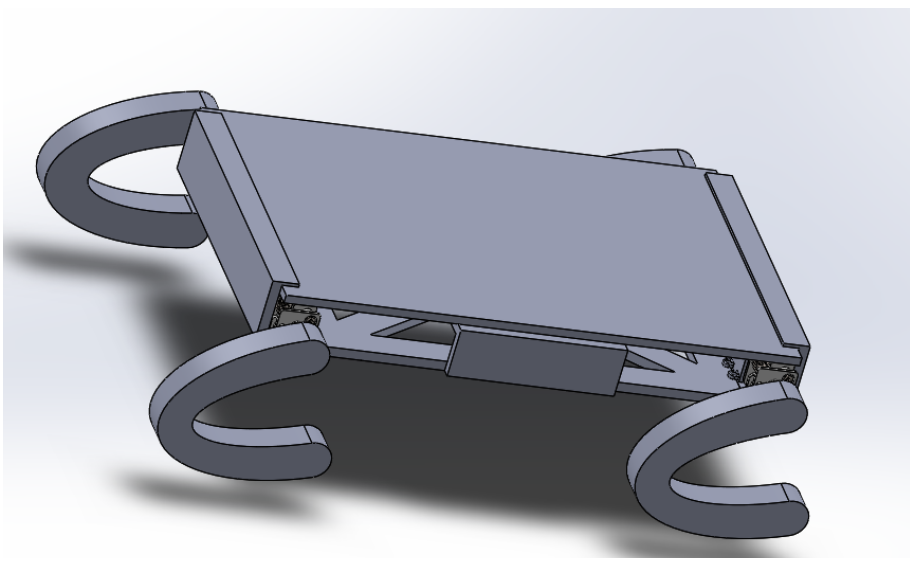
3.2 Basics of Chassis design

Parts Which were Designed for assembly:

- Body with Integrated battery holder
- L shaped Brackets for holding Motors
- C shaped Wheels
- Connector for connecting motor shaft to wheels

3.3 CAD Model of Bot





3.4 Understanding KiCAD Basics

KiCad is a powerful electronic design automation (EDA) software tool that is instrumental in creating printed circuit boards (PCBs). In KiCad, the design process revolves around electronic components, schematics, and PCB layouts.

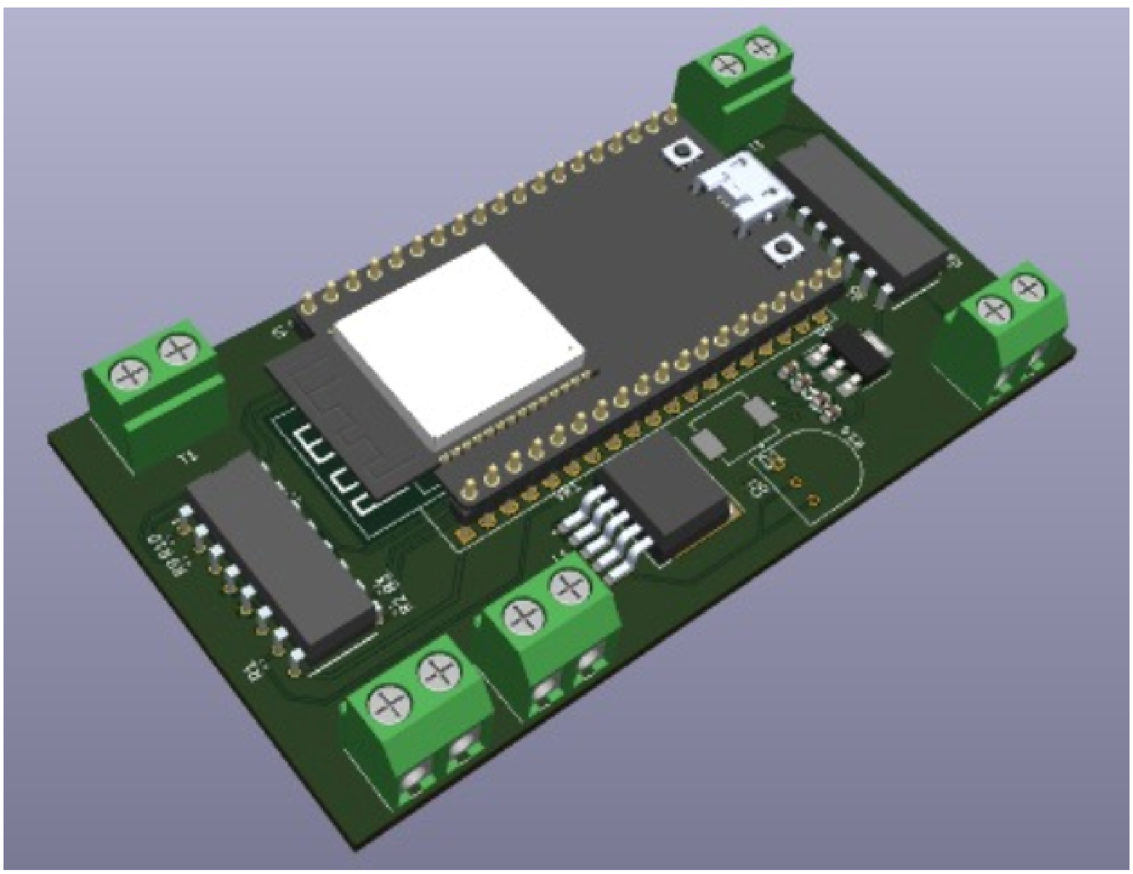
KiCad projects are structured as follows:

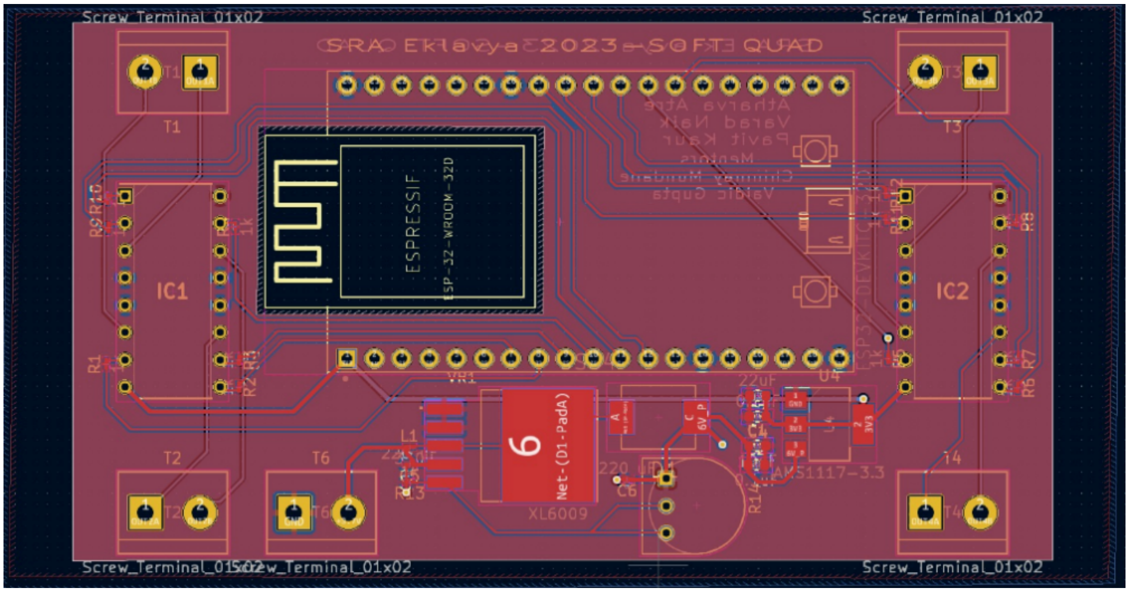
1. Components: Components are the fundamental building blocks in KiCad. We imported electronic parts such as resistors, capacitors and integrated circuits,

2. Schematics: We used these diagrams that illustrate the connectivity and functionality of the electronic components in your circuit.

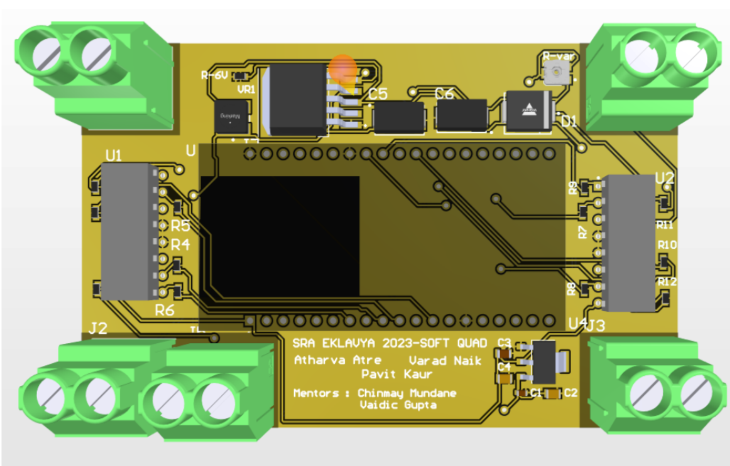
3. PCB Layout: After all this, we defined the physical placement and routing of components on the PCB. The components' footprints play a crucial role in creating the actual 3D representation of the PCB.

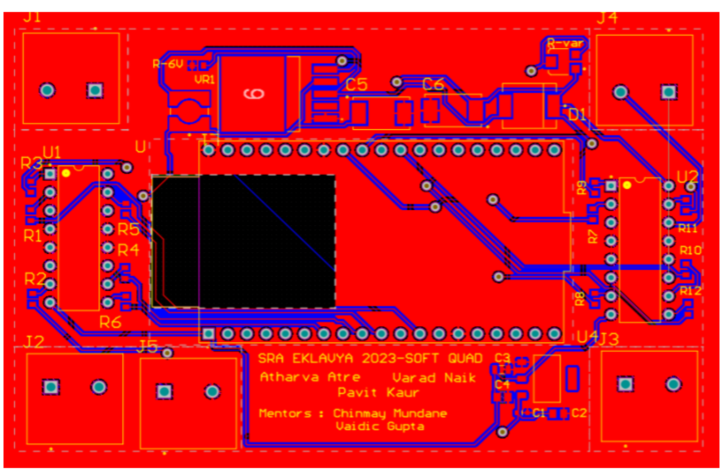
3.5 PCB Design on KiCAD





3.6 PCB Design on Altium





3.7 Hardware

Microcontroller

In this project we are using ESP32 microcontroller which is a series of low-cost, low-power systems on a chip microcontrollers with integrated Wi-Fi and dual-mode Bluetooth. ESP-IDF is the official framework and compiling and flashing code in the microcontroller.

Motor Driver

In this project we are using L293D Motor Drivers. They are simply current amplifiers. They provide the motors with a voltage of over 6V.

N20 Motors

In this project we are currently using 6V 600 rpm N20 motors.

Booster

XL6009 booster to convert 3.7V to 6V

4. Bot material Selection

4.1 Options for flex material

1. EcoFlex 00-30

- This is a soft and flexible silicone rubber with a Shore hardness of 00-30.
- Relatively soft and has good elasticity, which could be beneficial for shock absorption when the robot encounters obstacles hence less stiff than EcoFlex00-50 and may be easier to bend and conform to various shapes.

2. EcoFlex 00-50

- EcoFlex00-50 is a slightly harder silicone rubber with a Shore hardness of 00-50.

- It’s less flexible and softer than Dragon Skin, but still more flexible than many other materials, since it has a balance between flexibility and rigidity, it will be advantageous for stability during climbing and gait motion.

3. Dragon Skin

- Dragon Skin is a highly flexible, translucent, and often biocompatible platinum-cure silicone rubber used in special effects, medical simulations, and soft robotics.
- It has higher Flexibility,Elasticity and Durability making it good against wear and tear.

4.2 Material we chose and why

Dragon Skin is the material most comparable to PDMS in terms of its flexibility, translucency, and biocompatibility. It is often used as a substitute when PDMS like properties are required, making it a versatile and obvious choice for applications such as soft robotics. But EcoFlex 00-50 would also be a good option as it provides a balanced blend of flexibility and stability which can be beneficial in our control of bot in gait motion.

5. Flex PCB

Flex PCB is a type of electronic circuit board that is made from flexible and bendable materials instead of rigid materials like in traditional PCB’s. They offer a range of benefits due to their flexibility, allowing them to be shaped, folded, or bent to fit into various form factors and spaces that rigid PCBs cannot accommodate.

5.1 Special features

1. **Space Efficiency:** Flex PCB can be designed to fit into tight or irregular spaces, enabling more compact and creative designs for electronic devices.

2. **Weight Reduction:** Flex PCBs are typically lighter than their rigid counterparts, making them suitable for applications where weight is a concern.
3. **Reliability:** The flexible material can absorb shocks and vibrations better, reducing the risk of mechanical failures.

Using a Flex PCB will enable our SoftQuad robot to become more flexible, improving its capacity to scale higher obstacles.

6. Making the flex body

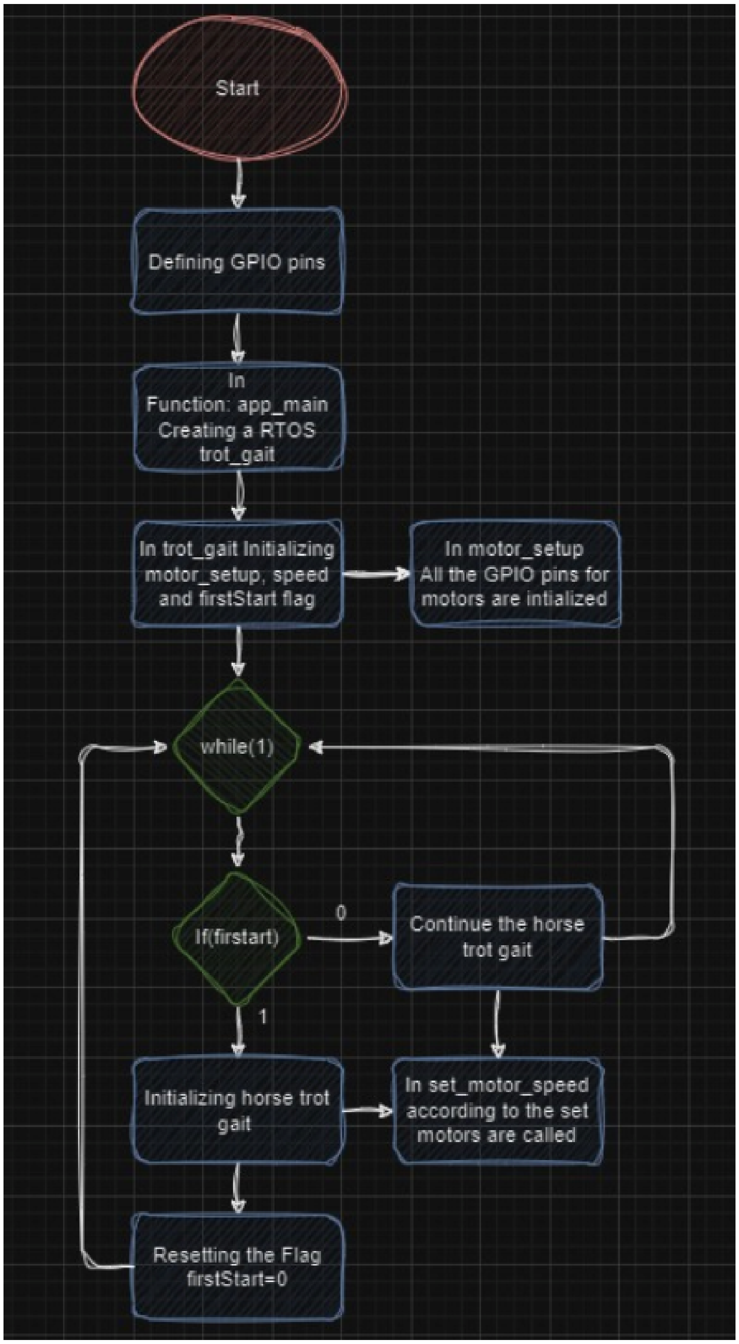
For testing purposes, we made the rigid body of the bot using 3D printing first. After finishing with testing, we made the molds for the bot and 3D printed them. Then we made the mold of the bot using Dragon Skin material. For this process, initially we mixed the material in 1:1 ratio for around 1 minute. Then we put this mixture in the mold and left it for around 2 hours.

DragonSkin material in the mold:

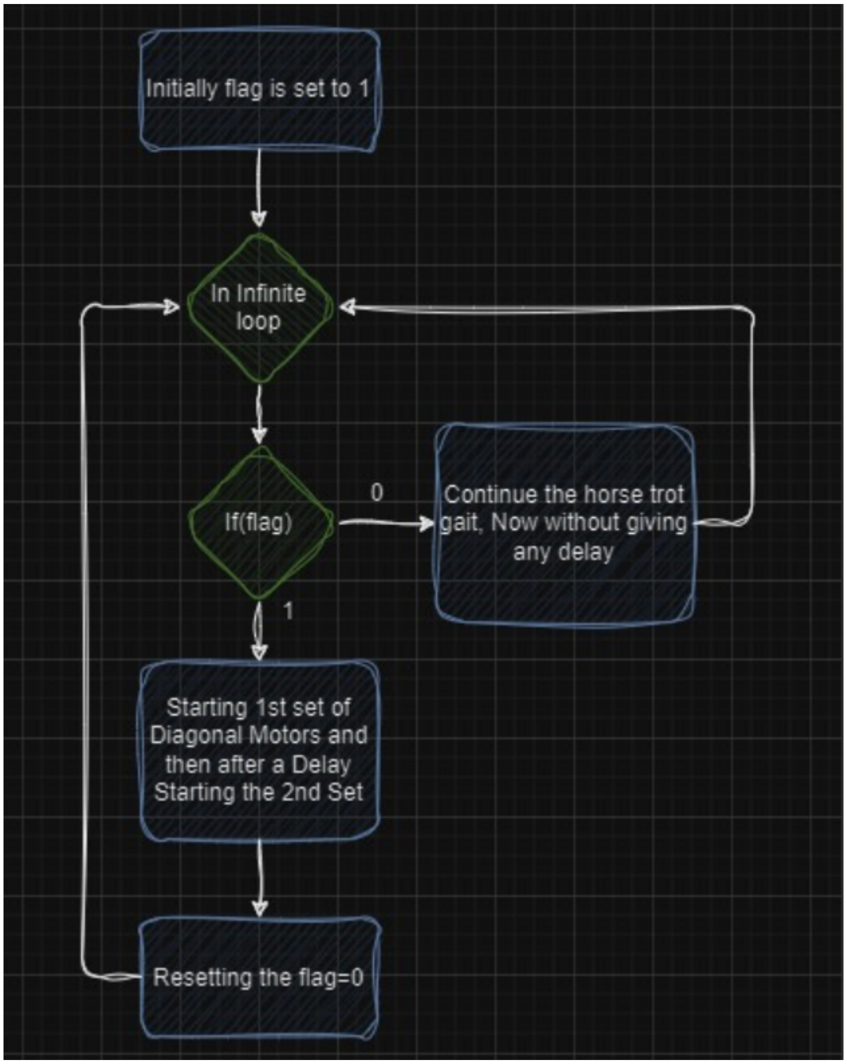
7. Controller for the bot

We controlled the movement of the bot through our ESP-32 controller. The motion that the bot follows is that of the horse trot gait.

Here is a flowchart explaining the code:



Here is a more basic explanation of the code:



8. Challenges faced and Solutions Applied

- ➢ At first, the weight of the body was bending the flex legs since they were unable to support the weight of the bot. In order to allow the legs to move, we altered the leg's measurements and added thickness.Managing the soft robotics part is taking some time.
- ➢ The main hardware and circuit problem we encountered was voltage control, or the inability to supply the appropriate and sufficient voltage to the corresponding electrical equipment.
- ➢ We were forced to move to Altium because Kicad would not allow us to define stack layers, or create a flexible PCB with stiffeners. It took some getting used to.

9. Conclusion and Future Work

9.1 Future Aspects of the project

- Debugging current circuit to address the hardware problems.
- Assembling Bot & integrating Flex PCB.
- Adding sensors,actuation techniques like pneumatics and hydraulics.
- Integrating forward and feedback control on the bot.
- To determine the most effective gait control algorithm, experiment with various gaits.

10. References

- **SoftBot Research Paper**
- **ESP-IDF Resources**