DE-41(MTS) Afzal Jawaad Fahad

Design and development of a Multipurpose Agri-bot

COLLEGE OF
ELECTRICAL AND MECHANICAL ENGINEERING NATIONAL
UNIVERSITY OF SCIENCES AND TECHNOLOGY RAWALPINDI
2021

COLLEGE OF ELECTRICAL AND MECHANICAL ENGINEERING

DE-41 MTS
PROJECT REPORT

Design and Development of a Multipurpose Agri-bot

Submitted to the Department of Mechatronics Engineering
in partial fulfillment of the requirements
for the degree of
Bachelor of Engineering
in
Mechatronics
2023

Sponsoring DS:
Dr. Anas Bin Aqeel
Dr. Umar Shahbaz Khan

Submitted By:
Afzal Khan
Jawaad Asim
Fahad Kaleem

ACKNOWLEDGMENTS

First, we would like to begin by expressing our profound gratitude to Allah Almighty for His abundant blessings that have made the successful completion of this project possible. We are also immensely thankful to our supervisor, Dr. Anas bin Aqeel, and our co-supervisor Dr Umar Shahbaz Khan for their invaluable guidance, support, and mentorship throughout the project, which has been instrumental in shaping our ideas and enhancing our skills. We would like to acknowledge the assistance of the National Center for Robotics and Automation (NCRA) and the Robot making lab (RML), particularly Mr. Abdulrahim Khan, for their assistance in the fabrication of our modules. Moreover, we would like to extend our heartfelt appreciation to our parents for their unwavering moral and financial support and constant prayers. Finally, we would like to acknowledge the Pakistan Science Foundation (PSF) for their generous funding under grant number PSF/NSLP/C-NUST (746), which has facilitated the realization of our project goals.

ABSTRACT

In the agricultural field, understanding the yield of crops after harvesting is crucial. One of the primary factors contributing to low crop yields is the inefficiency of planting and seeding methods. Insufficiently efficient practices during these processes can hinder optimal crop growth and development, resulting in lower overall yields. Therefore, improving the efficiency of planting and seeding techniques is essential for maximizing crop productivity and achieving higher yields in agriculture. The purpose of this project is to first reconstruct the Agribot with precision, adhering to calculated measurements. We manufactured and optimized various components, including retaining clips, nuts, axles, and other essential elements, ensuring their optimal functionality and performance. Then we aimed to enhance the capabilities of the Agribot by designing and manufacturing 3 extension beams to increase the bot's stability. Additionally, a holder for the drill was designed and fabricated, incorporating a motor and an auger drill obtained after careful design and simulation, this drill ordinarily incorporates a pivoting helical screw edge called a 'flighting' to travel aboutas a screw transport to eliminate the penetrated-out material. The turn of the sharp edge makesthe material move out of the opening being bored. An extension rod was developed and manufactured using a milling machine to connect the drill to its motor. The holder was then installed with the Drill module. Furthermore, optimization of the seeder module was conducted, followed by the installation of both the seeder and drill modules onto the Agribot. The project also involved the manufacture of holders for the electronics, which were then installed onto the Agribot. Extensive testing was performed on the motor drivers, including the CYTRON MD and ESCON 70/10. The CYTRON MD motor driver offers high-current driving capabilities and precise speed control, making it suitable for robust motor control applications the other hand, the ESCON 70/10 motor driver provides advanced control features such as closed-loop speed control and can bus communication, making it ideal for precise and dynamic motor control. Based on the testing results, the appropriate motor drivers were selected and integrated into the Agribot system. This included the use of the BTS 7960 motor driver,

Arduino Uno microcontrollers, and the HC05 BT module for communication. The BTS 7960 motor driver offers efficient and reliable driving capabilities for the various motors used in the Agribot. The Arduino Uno microcontrollers provided a flexible and programmable platform for controlling the motor drivers and other electronic components. The HC05 BT module facilitated wireless communication between the Agribot and the control application. The complete wiring of the Lenoir actuators, four tire motors, drill motor, drill module motor, and seeder motor, along with their respective motor drivers and batteries, was carried out using Proteus simulation software and implemented on Agribot. An application was developed using MIT App Inventor to control the Agribot and enable it to move in all directions while performing drilling and seeding operations. The application communicated with the Arduino board, providing control and monitoring functionalities for the Agribot project. Successfully demonstrated the design, manufacturing, integration, and control of various modules on the Agribot, expanding its capabilities in terms of drilling and seeding operations. The developed system, utilizing motor drivers with advanced features, holds significant potential for agricultural applications, promoting efficiency and precision in farming practices.

TABLE OF CONTENTS

TABLE OF FIGURES

TABLE OF TABLES

CHAPTER 1- INTRODUCTION

1.1.Project Background:

The rapid growth of the world population has presented significant challenges, including the increasing demand for food supply and the escalating impact of climate change. These factors have exacerbated the frequency and severity of natural disasters, leading to detrimental effects on agricultural productivity and the environment. Furthermore, deforestation and urbanization have intensified the need for innovative solutions in the agricultural sector. In response, organizations worldwide have turned to robotics and automation to revolutionize traditional practices and address these pressing issues.

Traditional techniques often result in uneven seed distribution and inadequate seeding depths, leading to suboptimal crop growth and reduced yields. Additionally, seed dispensing is a time-consuming and intricate process that calls for a more streamlined and automated approach. By integrating cutting-edge technologies, mechanical innovations, and intelligent automation, the Agribot project strives to revolutionize agriculture in Pakistan. It aims to enhance productivity, promote sustainable practices, and address the challenges posed by population growth, environmental concerns, and the need for efficient food production. Ultimately, the Agribot project aims to contribute to a more prosperous and sustainable agricultural sector in Pakistan, ensuring food security and economic growth.

1.2.Problem Statement

The conventional methods currently practiced require an experienced workforce and a lot of resources. Introducing the trends of robotics will make the process economical as well as environment-friendly. The Agribot will undertake such a task and make it more advantageous for our farming communities.

1.3.Objectives

The Objectives are as follows:

- Optimization and Development of the mechanical body.
- Design and development of extension rods and drill platform.
- Development and installation of drilling and seeding modules.
- Bluetooth controls to enable linear and angular motion of the agricultural robot to follow simple paths.

1.4.Scope

To develop the Agribots into a market-ready robot capable of motion controlled remotely via a Bluetooth app many designs were considered back and forth for the modules, based on the data gathered by the research and according to the project needs, a prototype Auger Drilling model for the Agribot has been designed. The model has been analyzed in the simulation software in which we will be discussing the design, stability, and stresses on the structure and failure points.

1.5.Chapter Conclusion

This chapter summarizes the intent and scope of the undertaken project. The underlying agricultural requirements are looked at briefly.

CHAPTER 2- LITERATURE REVIEW

In this chapter, different types of Agribots, their farming operations, and their designs will be discussed. A primary focus will be made on the work being done internationally in this fieldwhile a spotlight will be given to the work being done by Pakistani researchers in this field.

2.1.Brief Overview of the Study and Research

In this part, various kinds of Agribots, their cultivating tasks, and plans will be examined. An essential center will be made upon the work being done globally in this field while a spotlight will be given to the work being finished by Pakistani specialists in this field.

Seeding is the way toward planting. A locale or thing that has had seeds established in it will be portrayed as a cultivating district. In additional carefully prepared methods for cultivating, a field is at first set up with a wrinkle to a movement of straight cuts known as wrinkles. The field is then developed by tossing the seeds over the field as found in Figure 1. Seeds that land in the wrinkles have better security or manual raking will cover them while leaving some revealed. There are a few drawbacks to this approach. The most obvious is that because they are planted too shallowly in the soil, seeds that fall outside of furrows won't cause plants there to grow. A sizable portion of the seed remains on the surface, where they are defenseless against being consumed by birds or carried away by the wind. Given that broadcasting distributes seeds consistently and that the furrows only cover a small portion of the field's zone, this results in severe seed loss.

Figure 1. Seeding by Hand[1] and Animals[2]

2.2.Practicality of Drilling Agribot

The goal is to create a robot capable of completing all jobs quickly and effectively while requiring little to no human involvement. This objective can only be met if the robot gives the controller accurate data and the HRI: Human-Robot Interface is simple to use. The following are the primary prerequisites for an efficient flow of operations.

2.2.1.Communication About Agriculture

Smooth field navigation is necessary for the robot, and this is only feasible when the robot is near the human controller. Wi-Fi in particular, and in certain circumstances Cloud Computing, have been the only means of connecting to the outside world thus far.

2.2.2.Regarding Wi-Fi

The field of operation was constrained by the Wi-Fi signal range, making it unable to cover an area larger than a few acres. The Wi-Fi booster option is being thought about [3], but so far no activity has been noted.

2.2.3.With Regards to Cloud Computing

In this instance, a mobile device linked to a computer cloud allowed the farmer and the robot to interact, and the robot itself was linked to the same data cloud. The main issue with this practice was the poor internet signal on farms, a serious issue in rural Pakistan.

2.2.4.Handling Specific to Agriculture

We need to create a frame that can maintain the robot's stability in this uneven terrain to ensure its smooth operation since the mobility of the robot is challenged by the agricultural land, which can impair both its efficiency in operation and the rate of labor.

2.3.Drilling & Seeding Study & Research

Different types of drilling mechanisms were studied which are given as follows. Auger Drilling Mechanism was chosen to be made as per the instructions and was fabricated. The research and brief study are given as follows.

2.3.1.Wi-Fi Integrated Solution For Agribots

This machine has six legs and a design like a spider. This Agribot's acrylic main body is constructed of lightweight material. This robot employs two distinct mechanisms to finish the seeding process—one for drilling the soil and the other for dispensing the seeds. The drilling mechanism on this robot features a sharp, spade-like edge at the bottom tip. This device, which is mounted to the bottom of the robot and operated by a dc motor, functions. This drilling mechanism is rotated by the dc motor; therefore, it is essentially a rotary drilling type drilling mechanism. This mechanism's upward and downward motion is connected to the robot's extremities.

2.3.2.Direct Drilling

Reduced shallow tillage and direct drilling both provide similar results. The size of volunteer machinery is lowered, weed management is improved, crop rot is postponed, and insects like slugs are less affected by developing agricultural practices. When the conditions are suitable, farms that cultivate or practice reduced farming will engage in direct digging with seed-sowing soil. As shown in Figure 3, direct drilling with increasing seed lift steel has the same result as a smaller shallow depth reduction. The separation of growth tactics appears to lower the amount of volunteer equipment and weed control, delay yield rot, and have a very small influence on issues, such as slugs. Direct drilling is a seed-laying method where crop remnants are left on the surface from harvest until planting, leaving the soil intact. The seeds are carried in a disc or chisel-shaped receptacle.

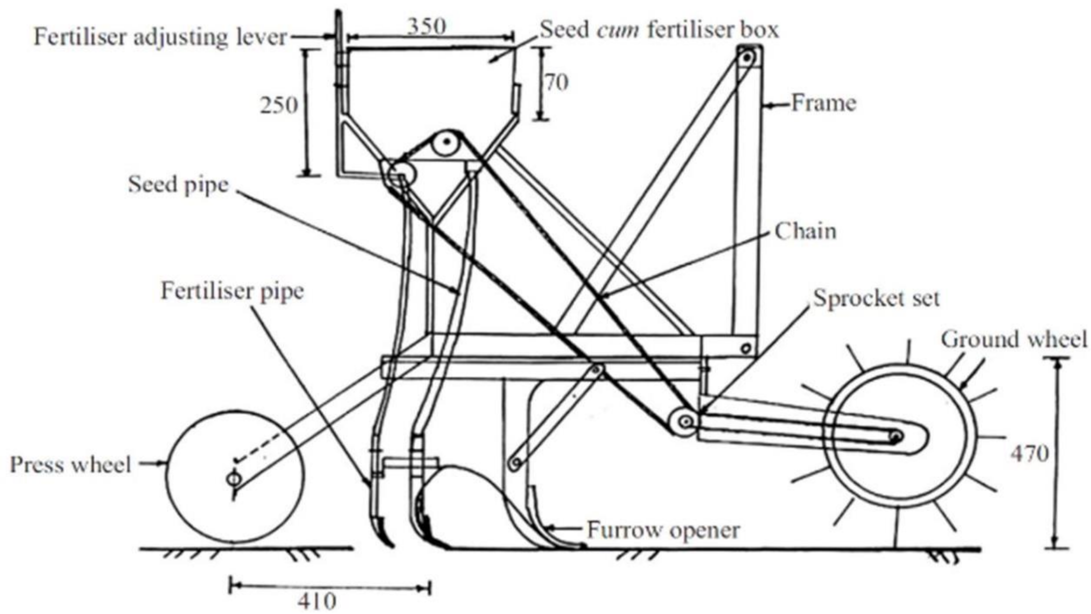

Figure 2. Direct Drilling[4]

2.3.3.Using Cultivation Tines to Drill

Drilling using cultivation tines refers to a method of soil preparation and seed planting commonly used in agriculture and gardening. Cultivation tines, also known as cultivator tines or cultivator's teeth, are sharp metal tools attached to a cultivator or tiller machine. These tines are designed to break up and loosen compacted soil, preparing it for planting.

Here's an overview of the process of drilling using cultivation tines:

1. Soil Preparation: Before using cultivation tines, it's important to prepare the soil by removing any large debris, rocks, or weeds. This can be done using a rake or by hand.
2. Attach the Tines: Attach the cultivation tines to a cultivator or tiller machine according to the manufacturer's instructions. The number and spacing of tines may vary depending on the specific machine and the desired planting pattern.
3. Adjust Depth and Width: Set the desired depth and width of the tines based on the requirements of the crop or plant you are planning to grow. This can typically be adjusted using the controls on the machine.

4. Start the Machine: Start the cultivator or tiller machine and carefully guide it over the area you want to drill. The tines will penetrate the soil, breaking it up and creating furrows or rows.
5. Seed Planting: Once the soil has been properly tilled by the cultivation tines, you can proceed with seed planting. Place the seeds in the furrows or rows created by the tines, following the recommended spacing and depth for the specific crop.
6. Cover and Finish: After planting the seeds, use a rake or another tool to cover the seeds with soil. Lightly compact the soil to ensure good seed-to-soil contact.
7. Water and Maintain: Water the newly planted seeds as needed, following the watering requirements for the crop. Continue to care for the plants by providing appropriate sunlight, nutrients, and protection against pests and diseases.

By using cultivation tines, you can effectively break up compacted soil, create optimal conditions for seed germination and root growth, and facilitate the planting process. However, it's important to consider the specific requirements of your crops and consult local agricultural guidelines for best practices in your region.

Figure 3. Cultivation Tines[5]

2.3.4.Individual-Row Cultivator

A single-row cultivator is a type of agricultural implement used for soil cultivation in small-scale farming or gardening. It is designed to work with a single row of crops and helps to remove weeds, break up soil crust, and create furrows for planting seeds or transplants. Here are some key features and functions of a single-row cultivator:

Construction: A single-row cultivator typically consists of a long frame or beam that connects to a hitch, allowing it to be pulled by a tractor or manually pushed by an operator. The frame is fitted with various cultivation tools or attachments.

Cultivation Instruments: The cultivation tools or attachments attached to the frame can vary depending on the specific model and purpose. Common tools include:

Sweeps: Also known as shovels or blades, sweeps are curved metal blades that cut through weeds and break up the soil.

Hillers: These attachments are used to create ridges or hills around plants for hilling crops like potatoes.

Cultivator teeth: These are tines or teeth that penetrate the soil to break up compacted soil and uproot weeds.

Adjustability: Many single-row cultivators offer adjustable features to adapt to different crop spacing and cultivation requirements. The frame width can be adjusted to match the row spacing of the crop being cultivated. The depth of the cultivation tools can often be adjusted as well to control the depth of tillage.

Weed Control: One of the primary purposes of a single-row cultivator is weed control. By cultivating the soil around the crop row, the cultivator disrupts the growth of weeds, uproots them, and buries them beneath the soil surface, preventing competition for resources.

Soil Aeration and Moisture Conservation: Cultivating the soil with a single-row cultivator helps break up compacted soil, improve aeration, and enhance water infiltration. It also assists in the conservation of soil moisture by creating a loose soil mulch layer that reduces evaporation.

Seedbed Preparation: Before planting, a single-row cultivator can be used to prepare the seedbed. It loosens the soil, removes debris, and helps create furrows or raised beds for sowing seeds or setting transplants.

Single-row cultivators are particularly useful in small-scale farming operations, market gardens, or backyard vegetable gardens where the cultivation is done in narrow rows. They offer efficiency, ease of use, and versatility in maintaining the health of crops and reducing weed competition.

2.3.5.Harrow Cultivator

The Harrow Cultivator is a type of agricultural implement used for soil preparation and weed control in farming. It is commonly used in the cultivation of crops and gardens. The cultivator is designed to break up and aerate the soil, remove weeds, and create a suitable seedbed for planting. The Harrow Cultivator consists of a series of metal tines or blades that are attached to a frame. The tines are usually curved and pointed, allowing them to penetrate the soil easily. The cultivator can be either drawn by a tractor or operated manually, depending on its size and design. When in use, the cultivator is dragged or driven through the field, and the tines penetrate the soil, breaking up clumps and incorporating organic matter. The action of the tines also helps to uproot and bury weeds, reducing weed competition and improving the overall condition of the soil. Harrow Cultivators come in different sizes and configurations to suit various farming needs. Some models have adjustable tine spacing or depth control, allowing farmers to customize the cultivation process based on their specific requirements. Overall, the Harrow Cultivator is a versatile tool used in agriculture to prepare the soil for planting, control weeds, and improve soil health. It is commonly employed in both large-scale farming operations and smaller garden plots.

Figure 4. Cultivators: - Harrow[6] and John Deere[7]

2.3.6.John Deere Cultivator

John Deere is a well-known manufacturer of agricultural equipment, including cultivators. A cultivator is a farm implement used for loosening and aerating the soil, removing weeds, and preparing the soil for planting. John Deere offers a range of cultivators designed for different farming needs. These cultivators are typically designed to be attached to tractors and pulled behind them. Some of the popular cultivator models by John Deere include the 2210 Field Cultivator, 2310 Mulch Finisher, and 2230 Field Cultivator. The 2210 Field Cultivator is a versatile implement that helps in seedbed preparation, residue management, and weed control. It features a heavy-duty frame, flexible gang design, and a range of shank and spacing options to suit various soil types and conditions. The 2310 Mulch Finisher is designed for seedbed preparation and residue management. It incorporates features like an adjustable gang angle, floating hitch, and finishing attachments to provide a smooth and level seedbed after primary tillage. The 2230 Field Cultivator is a durable and productive implement used for seedbed preparation, weed control, and incorporating fertilizers. It features a floating hitch, a heavy-duty frame, and a variety of shank and attachment options to meet specific farming requirements. These are just a few examples of John Deere cultivators, and the company offers many more models with different specifications and features. If you have any specific requirements or need more information about a particular cultivator model, it would be helpful to provide additional details.

2.3.7.Blade-Type Cultivator

A blade-type cultivator is a type of agricultural implement used for soil cultivation in farming. It consists of multiple curved or straight blades mounted on a frame, which is usually attached to a tractor or another power source. The primary purpose of a blade-type cultivator is to break up and loosen the soil, remove weeds, and incorporate crop residues or organic matter into the soil. The blades penetrate the soil and cut through the surface, stirring and turning the soil to create a favorable seedbed for planting. Blade cultivators are available in various designs and configurations to suit different cultivation needs. Some common types of blade cultivators include:

Disc cultivators: These cultivators have multiple circular or concave metal discs that cut through the soil. They are efficient at cutting through residue and incorporating it into the soil while creating a level seedbed.

Chisel plows: Chisel plows have straight, knife-like blades that penetrate the soil without inverting it. They are often used for deep tillage and breaking up compacted soil layers.

Rotary hoes: These cultivators have multiple rotating blades or tines that stir and weed the soil. They are particularly useful for controlling small weeds in row crops.

Spring-tooth cultivators: These cultivators have flexible, spring-loaded teeth that penetrate the soil and lift it. They are effective at breaking up clods and preparing seedbeds in lighter soils.

Spike-tooth harrows: Spike-tooth harrows consist of spike-like teeth that scarify the soil surface, breaking up clods and leveling the field.

Blade cultivators can be adjusted for different depths and widths of cultivation, depending on the specific requirements of the crop and soil conditions. They are commonly used in row crop cultivation, such as for preparing fields for planting corn, soybeans, cotton, or vegetables.

It's worth noting that there are many other types of cultivators available, including tine cultivators, sweep cultivators, and more. The choice of cultivator depends on the specific farming practices, soil types, and crop requirements.

Figure 5. Blade Type Cultivator[8]

2.3.8.Auger Drilling Mechanism

Auger drilling is a drilling mechanism commonly used in various industries, such as construction, mining, geotechnical engineering, and environmental drilling. It involves the use of an auger, which is a helical screw-like tool designed to create boreholes or excavate materials. The basic components of an auger drilling mechanism typically include:

Auger Bit: The auger bit is the main part of the mechanism and consists of a helical screw-shaped drill that is attached to a solid shaft. The size and design of the auger bit can vary depending on the specific application and the type of material being drilled.

Shaft: The shaft is a long, cylindrical rod that provides stability and support to the auger bit. It is usually made of steel and is connected to the drilling equipment.

Motor or Power Source: Auger drilling mechanisms are powered by motors or other power sources, such as hydraulic systems or engines. The motor provides the rotational force required to turn the auger bit.

Drilling Rig: A drilling rig is used to hold and support the auger drilling mechanism. It provides the necessary stability and control during the drilling process. The rig can be mounted on a truck, excavator, or other equipment depending on the application.

The operation of an auger drilling mechanism typically involves the following steps:

Preparation: The drilling site is selected and prepared by removing any obstacles or debris. The drilling rig is positioned in the desired location.

Auger Assembly: The auger bit is attached to the shaft, and the shaft is connected to the drilling rig. The power source is connected to the mechanism.

Drilling Procedure: The motor or power source is activated, providing rotational force to the auger bit. As the auger bit rotates, it cuts into the ground or material, creating a borehole. The excavated material is carried upward along the helical flighting of the auger and is usually discharged onto the ground or into a collecting system.

Control and monitoring: During the drilling process, operators monitor the drilling parameters, such as depth and speed, to ensure the desired results are achieved. The drilling process may involve adjusting the rotational speed or applying additional force, depending on the encountered material or drilling conditions.

Finishing and cleaning up: Once the desired depth is reached or the drilling operation is completed, the auger drilling mechanism is lifted out of the borehole. The borehole is inspected, and any necessary cleanup or further actions are performed, such as sampling or installing casing if required. Auger drilling mechanisms offer advantages such as versatility, cost-effectiveness, and efficiency, making them suitable for a wide range of applications. However, the specific design and operation of auger drilling mechanisms can vary depending on the equipment and requirements of each particular application.

Figure 6. Auger Drill and Seeder

(a) Auger Drill Bits[9] (b) Automatic Seed Sower[10]

2.3.9.Semi-Automatic Seeding Machine

A semi-automatic seed Sower is an innovative agricultural tool designed to simplify and expedite the process of sowing seeds. It combines manual control with automated mechanisms to increase efficiency and accuracy in planting crops. This device is particularly useful for large-scale farming operations where time and precision are crucial. The semi-automatic seed sower consists of a sturdy frame with a seed hopper attached at the top. The hopper can hold a significant quantity of seeds, reducing the need for frequent refilling. A metering mechanism, such as an auger or conveyor belt, controls the flow of seeds from the hopper into the planting mechanism. The planting mechanism is equipped with multiple seed dispensing units that can be manually adjusted for different seed types and planting densities. These units are positioned at regular intervals along a bar or drum, ensuring consistent seed spacing. The operator can easily adjust the spacing by changing the settings on the device. To operate the semi-automatic seed sower, the user simply pushes or pulls the device across the field, allowing the seed dispensing units to release the seeds into the soil. Some models may also have a wheel or roller system to facilitate smooth movement and maintain a consistent planting depth. The automated aspects of the seed sower significantly reduce human effort and ensure uniform seed distribution, improving crop emergence and yield. By minimizing human error and fatigue, the device helps farmers cover larger areas in less time, maximizing productivity. Overall, the semi-automatic seed Sower is a valuable tool for modern agriculture, streamlining the sowing process and empowering farmers to achieve optimal planting conditions. Its efficiency, precision, and ease of use make it an indispensable asset for enhancing crop production and contributing to food security.

2.3.10.Automatic Seeder

Rotatory picker wheels are connected to the sidewalls of the seed hopper on this automated cedar. Along with the ground wheel, the pickle wheel also spins. The seeds are taken out of the seed hopper by the cam-operated picker arms, dropped into the seed pipe, and then dropped again into the ridge's furrow. A vertical bucket conveyor is included with the cup-style automated cedar. The number of rows the planter needs to plant is equal to the number of cup conveyors. The conveyor takes the seeds from the hopper's bottom-most movable hole. The cup on the conveyor picks up individual seeds, which are subsequently dropped into the ridge through the seed pipe.

2.3.11.Intercrop Seeder

Figure 7. Automatic Seeder[11]

An intercrop seeder is a specialized agricultural machine designed to facilitate intercropping practices. Intercropping is a farming technique where two or more crops are grown simultaneously in the same field, to maximize land productivity and optimize resource utilization. The intercrop seeder plays a crucial role in this process by enabling farmers to sow different types of crops simultaneously. The seeder consists of a seed hopper, distribution mechanism, and planting units. The seed hopper holds the seeds of the different crops to be intercropped. The distribution mechanism ensures that the seeds are evenly and accurately dispensed during the sowing process. The planting units, which can be adjustable or interchangeable, are responsible for placing the seeds in the ground at the appropriate depth and spacing. Using an intercrop seeder offers several advantages to farmers. Firstly, it allows for efficient utilization of land, as multiple crops can be grown in the same field simultaneously. This maximizes the use of available space and enhances overall productivity. Secondly, intercropping helps in weed suppression and pest control, as different crops can naturally repel pests or inhibit weed growth. Additionally, intercropping promotes biodiversity and reduces soil erosion, contributing to sustainable farming practices. Farmers need to consider various factors while using an intercrop seeder, such as the compatibility of the crops, their growth requirements, and the timing of planting. Proper planning and crop selection are essential to ensure harmonious growth and optimal yields. Furthermore, regular maintenance and calibration of the intercrop seeder are crucial for accurate seed placement and uniform germination. In conclusion, an intercrop seeder is a valuable tool for farmers practicing intercropping. It enables them to efficiently sow different crops simultaneously, maximizing land productivity and resource utilization. By adopting intercropping techniques and utilizing intercrop seeders effectively, farmers can enhance sustainability, biodiversity, and overall agricultural productivity.

Table 1. Comparison of Different Agribots Studied

Sr No.	Names of Agribot	Purpose/Type	Functionality
1	Vinobot and Vino [12]	Crop Surveillance	Vinoculer and Vinobot readings are collected for precise agricultural growth monitoring.
2	Farmbot [13]	Plant Nursing	Controlling the quantity of water and fertilizer used for plant development, as well as autonomous seed planting.
3	Hortibot [14]	Weeding	Weeding the crop selectively after a thorough examination of the crop.
4	Apple Harvester[15]	Fruit Picking Robot	Suction techniques are used to pick fruits off trees.
5	Ag-Bot II [16]	Farming helping Robot	Helps farmers choose fertilizers, herbicides, and insecticides.
6	Drones for assessing soil health [17]	Farming Drones	Drones are being used to collect data on the availability of certain elements in soil and to analyze soil health.
7	Multipurpose Agribot [18]	-	Functions such as seeding, drilling, weeding, planting, watering, and fertilizer application are available.

2.4.Patents Studied

Many patents from various published research publications and studies were examined in order to learn information that would aid in the creation and design of a superior drilling mechanism. The patents examined for the project's study are listed below.

2.4.1.Agribot Design and Development for Seeding

The construction of a robot that can measure investment without human assistance is the focus of the current article. The robot is intended to prepare the soil for a certain seed before dropping the seeds into the same hole and sealing the mud. A microcontroller stops the cycle from continuing. The inefficiencies of a normal planting approach, such as seed loss, high labor costs, low land utilization, etc., are solved by a well-designed robot.

2.4.2.Seed Planting Robot

The goal of this project is to build high-quality equipment that farmers may use for a reasonable price and that also allows for the simultaneous planting of many crops. The usage of this work's improved mechanical system, which can be used to plant seeds for a range of rural techniques and the absence of suitable domestic work, has made it popular in India's dry areas. The right planting of these crops with decreased farm activity is essential for the success of the harvest. The advancement of computer hardware is used in the straightforward seed-planting approach to accomplish direct seed dispersal throughout the line.

2.4.3.GPS-Directed TED Smart Agribot (G-SAB)

The GPS-Directed TED Smart Agribot (G-SAB) is an advanced agricultural robot designed to optimize farming operations using GPS (Global Positioning System) technology. It is equipped with various features and functionalities to enhance efficiency, productivity, and sustainability in agriculture.

Here are some key aspects of the GPS-Directed TED Smart Agribot (G-SAB):

1. GPS Guidance: The G-SAB utilizes GPS technology to precisely navigate through fields and perform targeted agricultural tasks. This allows for accurate positioning and precise execution of farming activities.
2. Task Execution and Automation: The G-SAB is capable of autonomously performing a range of agricultural tasks, such as seeding, planting, fertilizing, spraying, and harvesting. It follows pre-programmed instructions or real-time data inputs to execute these tasks efficiently and effectively.
3. Sensor Integration: The G-SAB incorporates various sensors to gather data and make informed decisions. These sensors can include soil moisture sensors, temperature sensors, humidity sensors, and crop health sensors. By collecting and analyzing this data, the G-SAB can optimize resource allocation and adjust its operations based on crop requirements.
4. Precision Farming: By leveraging GPS guidance and sensor data, the G-SAB enables precision farming techniques. It can apply inputs (water, fertilizers, pesticides) with high accuracy, targeting specific areas in the field where they are needed most. This reduces waste, increases crop yields, and minimizes environmental impact.
5. Real-Time Monitoring and Analysis: The G-SAB continuously monitors and analyzes various parameters related to crop health, soil conditions, and environmental factors. It can transmit this data to a central system or farmer's device in real-time, enabling timely decision-making and proactive intervention if required.
6. Connectivity and Integration: The G-SAB is designed to connect with other farming equipment and systems, enabling seamless integration into existing agricultural workflows. It can communicate with farm management software, weather data services, and other IoT devices, creating a unified ecosystem for optimized farm management.
7. Safety Features: The G-SAB incorporates safety features to protect crops, humans, and itself. It can detect obstacles, adjust its speed, and avoid collisions using built-in sensors and intelligent algorithms.

The GPS-Directed TED Smart Agribot (G-SAB) represents a significant advancement in agricultural technology, aiming to increase productivity, reduce costs, and promote sustainable farming practices. By leveraging GPS guidance, automation, and real-time data analysis, it empowers farmers with efficient and precise farming operations.

2.4.4.Agriculture Automation

Automation in agriculture refers to the use of advanced technologies and systems to automate various tasks and processes involved in agricultural production. It encompasses a wide range of technologies, from simple machines to sophisticated robotic systems, to increase productivity, efficiency, and sustainability in farming operations.

Here are some examples of automation in agriculture:

1. Robotic Farming: Robots can be used for tasks such as planting seeds, harvesting crops, and applying fertilizers and pesticides. These robots are equipped with sensors, cameras, and artificial intelligence to perform their tasks accurately and efficiently.
2. Precision Agriculture: This involves the use of sensors, GPS technology, and data analytics to optimize farming practices. Automated systems collect data on soil conditions, weather patterns, crop health, and other factors, allowing farmers to make informed decisions about irrigation, fertilization, and pest control.
3. Drones: Unmanned aerial vehicles (UAVs) or drones are increasingly being used in agriculture. They can monitor crops from the air, capturing images and collecting data on plant health, irrigation needs, and pest infestations. Drones can also be used for precision spraying, delivering fertilizers or pesticides precisely where needed.
4. Autonomous Vehicles: Self-driving tractors and other autonomous vehicles are being developed and deployed in agriculture. These vehicles can perform tasks such as plowing, seeding, and spraying without human intervention. They are equipped with GPS, sensors, and advanced navigation systems to operate safely and efficiently.
5. Indoor Farming: Automation plays a crucial role in vertical farming and greenhouse operations. Systems for temperature and humidity control, nutrient delivery, and lighting are automated to create optimal growing conditions. Robots can also be used to handle tasks like planting, harvesting, and packaging in these controlled environments.

The benefits of automation in agriculture include increased productivity, reduced labor costs, optimized resource usage, improved crop quality, and minimized environmental impact. It can also help address labor shortages in rural areas and make farming more attractive to the younger generation by incorporating advanced technologies.

However, it's important to note that the adoption of automation in agriculture may require initial investments in technology and infrastructure, as well as training for farmers and workers to operate and maintain these systems effectively.

2.4.5.An Agricultural Robot with Multiple Functions

A robot named Agribot is intended for residential use. It attempts to lessen farmers' workloads while also accelerating the precision of the task. It performs fundamental planting duties, such as weeding the soil, sowing the seeds, and covering the seeds with dirt. The self-contained robot enables the office to switch out the system drainage as necessary. The robot may be controlled with a programmable System on Chip controller from Cypress Semiconductor, USA.

2.4.6.Agribot-An Agriculture Robot

Agribot is a robot made specifically for farming. A broad variety of agricultural robots have been studied to produce various agricultural products in many nations as one of the patterns of automation development and understanding of agricultural equipment in the 21st century. Important chores like picking, harvesting, weeding, trimming, planting, and weeding may all be accomplished by this bot.

2.4.7.Automatic Ploughing and Seeding Agricultural Robot

An agricultural robot for automatic plowing and seeding is an advanced technology that aims to automate and optimize farming processes. These robots are designed to perform tasks traditionally carried out by humans, such as plowing the soil and seeding crops. They leverage robotics, artificial intelligence, and other cutting-edge technologies to enhance efficiency and productivity in the agricultural industry. Here's a general overview of how such a robot would work:

1. Navigation and Mapping: The robot utilizes various sensors, including GPS, cameras, and LiDAR, to navigate the field accurately and create a map of the area. This map helps the robot understand its position and plan its path effectively.
2. Soil Preparation: The plowing process begins with the robot using its robotic arm equipped with plowing tools to break up and turn over the soil. The plowing depth and pattern can be programmed based on specific crop requirements.
3. Seeding: After plowing, the robot moves on to the seeding phase. It can be equipped with a seed dispenser or a robotic arm with a seed-planting mechanism. The robot follows a predetermined pattern to distribute seeds evenly across the field.
4. Real-time Monitoring: The robot incorporates sensors to monitor important parameters such as soil moisture, temperature, and nutrient levels. This data is collected and analyzed in real-time, allowing farmers to make informed decisions about irrigation, fertilization, and crop health.
5. Autonomous Operation: Once the robot is set up and programmed, it can operate autonomously, reducing the need for constant human intervention. However, it can also be monitored remotely by farmers or agricultural experts who can make adjustments or take control if necessary.
6. Data Analysis and Reporting: The robot collects vast amounts of data during its operation, including field conditions, crop growth, and performance metrics. This data can be analyzed to gain insights into farming practices, optimize resource usage, and make informed decisions for future planting seasons.

Benefits of Agricultural Robots for Ploughing and Seeding:

- Increased Efficiency: Robots can work continuously without fatigue, allowing for faster and more precise plowing and seeding operations, thereby increasing productivity.
- Reduced Labor Costs: By automating labor-intensive tasks, farmers can reduce their dependency on manual labor and allocate resources to other essential activities.
- Precision Agriculture: The robots' sensors and data analysis capabilities enable precise monitoring and targeted interventions, leading to optimized resource utilization and improved crop yields.

- Environmental Impact: With precise control over seed placement and optimized use of resources, agricultural robots contribute to reducing chemical usage, water consumption, and soil erosion.

It's worth noting that while agricultural robots have made significant advancements, their deployment and adoption may vary based on factors such as farm size, crop type, and economic considerations. Additionally, the availability and affordability of such robots may vary depending on the region and market conditions.

2.4.8.Agricultural Robot

Indeed, robots are becoming increasingly important in the independent-scale farming sector of agriculture. Crops of any sort are often planted, watered, fertilized, monitored, and harvested as part of the rate of planting. These cycles do not just apply to robots. The suggested strategy concentrates on employing a recently installed robot to complete the whole planting cycle on a single onion plant in a container. The ATMEGA 2560 professional controller, ATMEGA 8 microcontroller, IR, capture system, and many more special characteristics are used in the game "feather creature vs. Robot." By holding the robot, the sensors on it allow it to locate the planting place and identify the seeds that will be sown there. The remainder of the investment cycle should proceed as a result of going ahead. Farmers may use this robot to help them set up a direct planting cycle.

2.4.9.Agricultural Robot with Several Functions

The design, development, and development of a robot that can seed, apply mud sealant, and purify water are all discussed in this study. These robot systems all operate on battery and solar power. More than 40% of people in the globe choose agriculture as a major career, and recently, financing for the creation of private agricultural vehicles has surged. Using an IR sensor input, a relay switch is used to drive the vehicle. The development of these robots is possible with hands-on functions for fast data entry. A test was conducted to see if a tiny, effective machine might do better than bigger farm trucks and human capacity in the area of private horticulture vehicles.

Table 2. Comparison of Agribot Designs

Sr No.	Design	Design Type	Pros	Cons
1	SLRV, Marshokhod	Articulated Body	Body segmentation aids in keeping all wheels on the ground at all times. Six engines and six wheels generate a great deal of power and traction. Work well in steep terrain.	Many resources are required. Use a lot of energy.
2	Spirit	Rocker-Bogie system	High ability to overcome problems. Maintains optimum traction and power by keeping all wheels on the ground. Ideal for extremely uneven terrain. They were created for this reason.	Many resources are required. Overkill for projects that should work on relatively flat terrain. Slow and susceptible to damage at greater speeds.
3	Ratler Nomad	Four-Wheeled Design Ideas	Fewer resources are required. Low price. To modify properties, a hybrid type can be constructed. Provide enough capability to overcome problems. Work on typical to somewhat uneven surfaces.	In rough terrain, movement is limited.

2.4.10.Robotic Agriculture

Robotic agriculture, also known as Agri-robotics or robotic farming, refers to the use of robotic systems and automation technology in agricultural practices. It involves the application of robotics, artificial intelligence (AI), and other advanced technologies to streamline and enhance various agricultural processes.

Here are some key aspects and benefits of robotic agriculture:

1. Field Operations: Robots can be employed for various field operations, such as planting seeds, transplanting seedlings, applying fertilizers and pesticides, and harvesting crops. These robots are designed to perform repetitive tasks with precision, accuracy, and efficiency, reducing labor requirements and increasing productivity.
2. Machined Pest Control: Robotic systems equipped with computer vision and machine learning algorithms can identify and selectively target weeds and pests, minimizing the need for chemical interventions. This approach, known as robotic welding, reduces the environmental impact of agriculture and decreases the reliance on herbicides and insecticides.
3. Crop Monitoring and Management: Drones and ground-based robots equipped with sensors and cameras can monitor crops by collecting data on plant health, growth rates, and nutrient deficiencies. This data can be analyzed to optimize irrigation, nutrient application, and disease management, leading to more efficient resource utilization and improved crop yields.
4. Autonomous Vehicles: Self-driving vehicles, such as autonomous tractors, are becoming increasingly common in agriculture. These vehicles can navigate fields, perform tasks like plowing or seeding, and transport harvested crops without human intervention. Autonomous vehicles enhance efficiency, reduce labor costs, and minimize soil compaction by following pre-determined paths.
5. Greenhouse Automation: In greenhouse environments, robots can automate tasks like seedling transplantation, temperature and humidity control, and monitoring of plant health parameters. These systems ensure optimal growing conditions, reduce energy consumption, and provide real-time data for better decision-making.
6. Data-Driven Farming: Robotic agriculture generates vast amounts of data through sensors, cameras, and other monitoring devices. This data can be analyzed using AI algorithms to

derive insights about crop performance, resource utilization, and yield predictions. Such data-driven farming enables farmers to make informed decisions, optimize operations, and increase overall productivity.

7. Labor Shortage Mitigation: Robotic agriculture can address labor shortages in the farming industry, which is a growing concern in many regions. By automating labor-intensive tasks, robots help fill the gaps, increase operational efficiency, and reduce dependence on manual labor.

While robotic agriculture offers numerous advantages, there are also challenges to overcome. These include high initial costs of robotic systems, integration with existing agricultural practices, technical complexities, and the need for farmer training and support. However, ongoing advancements in robotics and AI technologies are steadily driving the adoption of robotic agriculture, leading to increased sustainability, productivity, and profitability in farming operations.

2.5.Chapter Conclusion

The designs are taken into account from the beginning and all market research is done with the understanding that the module must adhere to environmental standards, must make sure the method is economical as well as fast and efficient, and must help the growers achieve the determined goals.

CHAPTER 3- DESIGN AND SIMULATION

This chapter focuses on the manufacturing, mechanical design, and analysis of the individual components of the Agribot. It provides a comprehensive discussion of the materials, techniques, and software employed to achieve the desired results throughout the process. Moreover, the chapter offers a detailed explanation of the results, supporting all claims and outcomes with clear justifications.

The primary objective of this project was to design a remote-controlled mobile agricultural robot equipped with an auger drilling and seeding mechanism, capable of performing various tasks in the field as outlined in the abstract. The specific tasks assigned to the Agribot depend on the situational requirements. Consequently, the design needed to be flexible and adaptable, satisfying the necessary task specifications. Furthermore, the design had to be well-suited for diverse terrains, particularly the fields where the Agribot would be deployed. Ensuring that the resulting design could withstand the stresses and strains imposed on its structure during the operation was crucial, and we incorporated all the essential factors into the design process. The design needed to effectively address these challenges and adhere to the conditions it may encounter in the field. Through a systematic series of steps in the design and manufacturing process, we developed a model that could endure the demanding forces encountered during the drilling and seeding procedures.

3.1.Data Collection for the Design

Extensive research has been conducted on Agribot mining methods as mentioned in the previous chapters. These findings have played a crucial role in making informed decisions based on comprehensive research. The data collected from various drilling methods have also helped in designing robust and consistent drilling mechanisms for the Agribot utilizing the researched techniques. The design of these machines depends on factors such as machine type, functionality, operating environment, and various other environmental factors that have also been taken into account during the design.

Motor selection is tailored to specific construction and operational requirements, ensuring driving motors possess the capability to navigate Agribot and its equipment effectively including the drilling and seeding or any other attached component with it. Specialized drilling motors are chosen for efficient ground excavation. To sustain optimal performance, careful consideration is given to selecting the batteries, ensuring it offers sufficient power, voltage, and endurance to support all components and processes for extended periods of operation.

Long-term performance is a key consideration in the design as well. Data collection for Long-term performance mainly focuses on durability, efficiency, and maintenance of the model. By understanding performance characteristics, informed decisions have been made which ensures the longevity and productivity of our Agribot. In this, we made sure to keep the points of selecting robust materials, optimizing parameters, and implementing preventive maintenance strategies in mind. And this will now result in long-term performance with maximized effectiveness and minimized downtime.

3.2.Mathematical Approach

This is the mathematical approach to the design of our auger drilling mechanism for the Agribot. It involves the necessary calculations required for achieving an optimal design of the Auger Drilling Mechanism as shown below:

Torque Calculations for the Motor Lifting the lead screw and the Auger Mechanism:

$$\text{Lead Screw Diameter (d)} = 16mm$$

$$\text{Lead Screw Radius (ldr)} = 20mm$$

$$\text{Lead Screw Pitch (p)} = 4mm$$

$$\text{Total Mass} = 100KG$$

$$Coefficent\ of\ friction\ (mild\ steel) = 0.61$$

$$\boldsymbol{Velocity\ ratio = \pi * d/p} \text{..........}\mathbf{Eq(1)}$$

$$Velocity\ ratio = 12.56$$

$$\boldsymbol{E = Efficiency = tan(a)/tan(a + b)} \textbf{.........Eq(2)}$$

$$a = \tan\,(v_r - 1) = 4.55^0$$

$$b = \tan\,(0.6) = 31.38^0$$

$$E = tan\,(4.55)/tan\,(4.55 + 31.38) = 10.98\%$$

$$\boldsymbol{Mechanical\ Advantage = v_r * E} \textbf{.........Eq(3)}$$

$$MA = 12.56 * 0.1098 = 1.3798$$

$$\boldsymbol{MA = f_l/f_e} \textbf{............Eq(4)}$$

$$\boldsymbol{f_e = F_l/MA} \textbf{...........Eq(5)}$$

$$f_e = (100 * 9.8)/1.3798 = 710.04N$$

$$\boldsymbol{T = f_e * ldr} \textbf{.........Eq(6)}$$

$$710.04 * 20E - 3 = 15Nm$$

Torque Calculations for the Motor of the Auger Bit:

$$Power = 180\text{Watt}$$

$$RPM = 50\text{rpm}$$

$$\textbf{Torque} = \frac{60 * P}{2\Pi * v} \textbf{.........Eq(7)}$$

$$\text{Torque} = \frac{60 * 180}{2\Pi * 60}$$

$$Torque = 34Nm$$

3.3.Design and Simulations for the Mechanism

An appropriate Agribot design was developed based on research and information from the data collected. The design was done with the help of CAD/CAE technology and SolidWorks software. The design is designed while taking into consideration pre-collected readings and the ability to operate smoothly in various field conditions. The design was also made so that the Agribot can move smoothly to any type of field. It is designed such that it is easy to uninstall or install the parts of the Agribot or any other specific Mechanism that we need to replace despite the installed mechanisms. Much of the research and design involved structural analysis of the Agribot mechanism. Based on the data collected in the simulation software, a stable and robust Agribot sound structure was built, and all the modules were installed on it after conducting a detailed analysis of every individual component. The simulation software used for the analysis of the components of the Agribot is ANSYS.

3.4.Material Information

The material used for manufacturing the components or the individual Agribots for our project is Mild Steel. We have used it due to its desirable properties and characteristics. It offers excellent strength, durability, and weldability, making it suitable for structural components. Mild Steel also exhibits corrosion resistance, making it suitable for outdoor applications. Its affordability and wide availability make it a practical choice for our project. Its properties are discussed as under:

Table 3. Properties of Mild Steel

Sr No.	Physical Property	Metric Value
1	Density	8050 kg/m³
2	Young’s Modulus	21e+10 Pa
3	Poisson’s Ratio	0.30
4	Bulk Modulus	1.6e+11 Pa

5	Shear Modulus	7.93e+07 Pa
6	Tensile Yield Strength	2.4e+09 Pa
7	Compressive Yield Strength	1.52e+08 Pa
8	Tensile Ultimate Strength	5.5e+08 Pa
9	Compressive Ultimate Strength	250e+06 Pa

3.5.Mechanical Models:

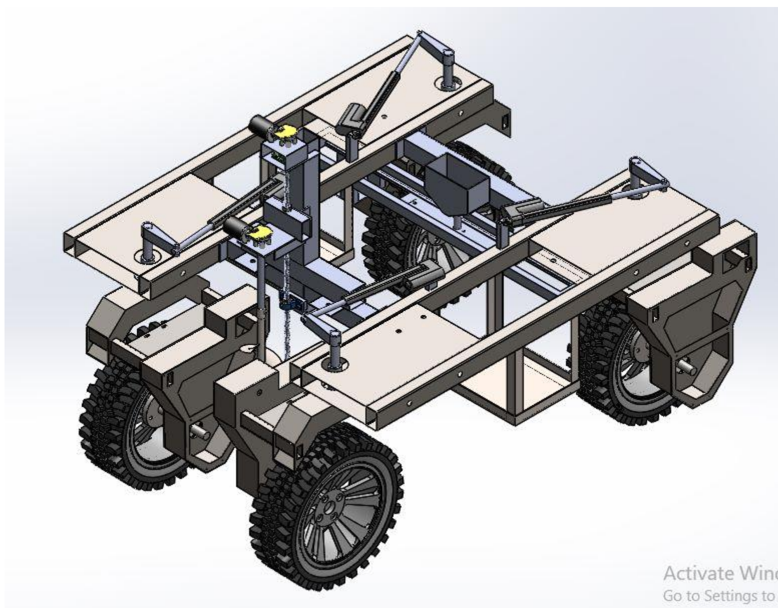

Figure 8. Complete Agribot Assembly

In this section, we will discuss the mechanical design of our Agribot, specifically focusing on the drilling and seeding mechanism. As mentioned earlier, we have developed a robust design for our Agribot that incorporates the necessary components for efficient and precise drilling and seed dispersal. We have used CAD/CAE technology and SolidWorks software to carefully design the Agribot, ensuring the effective and relevant forces that can affect its working in the field. To ensure stability and durability, we have conducted a structural analysis using ANSYS software. The selection of Mild Steel has been based on its mechanical properties. We aimed to create a reliable Agribot that performs optimally in all agricultural applications.

The above Figure shows the mounting of our Drill and Seeder Module on the Agribot. Every individual component designed by us will be explained in the upcoming pages.

3.5.1.Auger Drilling Mechanism

This section focuses on the mechanical model of the drilling module, which serves the purpose of drilling a 10cm deep hole with a diameter of 15.5cm. The drilling module consists of various components that work together to facilitate the drilling operation. The main motor, situated at the top of the frame, plays a crucial role in driving the drilling module. It is responsible for rotating the lead screw, which, in turn, enables the vertical motion of the lead screw coupler. The lead screw coupler is equipped with the auger drill coupler, which serves the purpose of holding and supporting the Viper motor.

The Viper motor, also known as the drill motor, is coupled with the connecting rod which is further linked to the auger bit. To secure the auger bit in place, a pin is utilized to prevent rotation or vibration, allowing it to rotate in conjunction with the drill motor. These components work in conjunction to ensure the successful drilling operation of a hole with the specified dimensions. All the components of this drilling Module are explained on the upcoming pages.

Drill Module components include:

- Drill Module Frame
- Auger Drill Main Motor
- Motor Housing
- Lead Screw
- Lead Screw Coupler
- F206 Pillow Block Bearing
- UCP Bearing
- Auger Bit Coupler Mount
- Auger Drill Motor
- Auger Bit / Drill

- Connecting Rod
- Support Pin
- Frame Mount

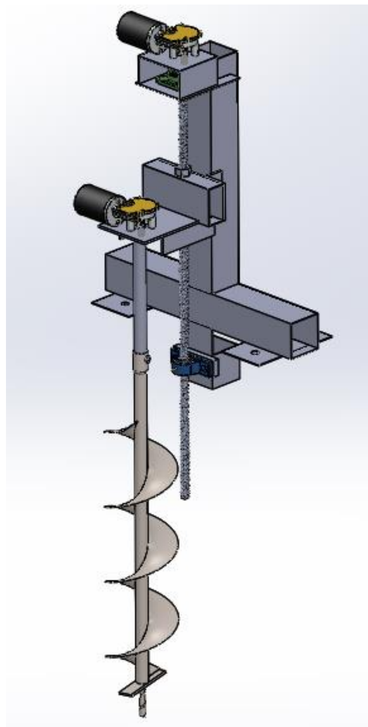

Figure 9. Drill Module

3.5.1.1.Drill Module Frame / Support Beam:

The drill module frame or the support beam, is the foundation or support that holds all the components of the module in place. It provides a stable platform for the entire assembly. The frame is designed to withstand and distribute the various stresses and shear forces that are applied to it during operation. It resists loads that are primarily applied laterally to the axis of the beam. When subjected to these loads, the frame experiences deflection primarily through bending.

As external forces are applied to the beam, they result in reaction forces at the support points of the beam. The combined effect of all the forces acting on the beam generates shear forces and bending moments within the beam itself. These internal forces induce stresses, strains, and deflections within the beam. The drill module frame plays a critical role in ensuring the structural integrity and stability of the entire assembly. Additional details are:

- The frame is made of steel or aluminum. It is designed to be strong and lightweight by making the support rod hollow.
- The frame is typically welded together. This ensures it is a single, strong unit.
- The frame is typically painted to prevent corrosion and damage.

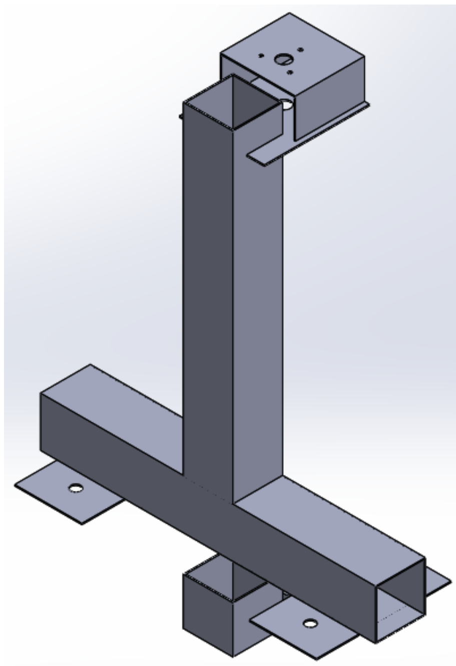

Figure 10. Support Beam

3.5.1.2.Drill Module Main Motor

Viper motors are high-performance motors that are used in high torque and speed applications. They are used in a variety of applications, including drilling, milling, sawing, robotics, automation, and medical equipment. Viper motors are reliable and efficient and are used where high accuracy and performance are essential.

In the Drill Module, this Viper motor is the main motor which is located at the top of the assembly. It is responsible for driving the Auger Bit vertically. The Viper motor allows for precise control over the position, speed, and acceleration of the Auger Bit.

The Viper motor is connected to a lead screw, which is a 76-centimeter-long metallic rod. The lead screw is an integral component for the vertical motion of the Auger bit. The rotation of the lead screw, controlled by the Viper motor, enables the vertical motion of the auger bit.

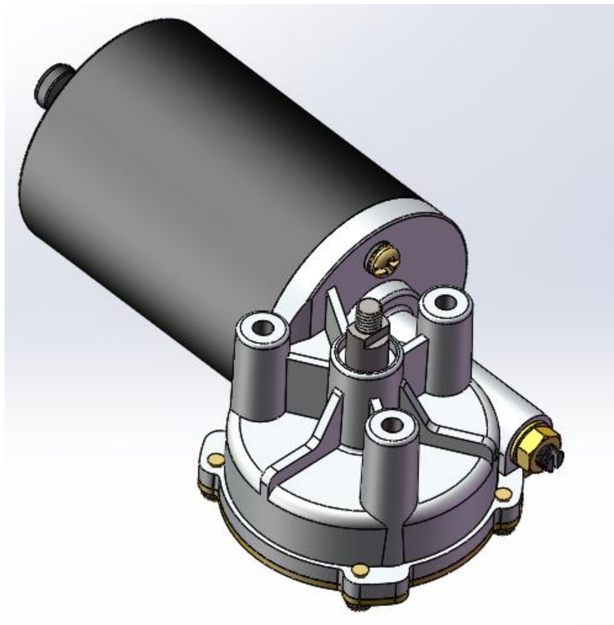

Figure 11. Drill Module Main Motor

3.5.1.3.Motor Housing Main Motor

The motor housing is a crucial component of the motor. It protects the motor from dust, debris, and potential damage. It also provides a secure and stable mounting platform for the motor so that there is no vibration of the lead screw or the drill module. The motor housing prioritizes the safe and reliable operation of the motor. It not only offers protection but also ensures the appropriate installation and positioning of the lead screw which is used for vertical motion. This housing plays an important role in enhancing the mechanism's overall performance and functionality through appropriate and fixed installation.

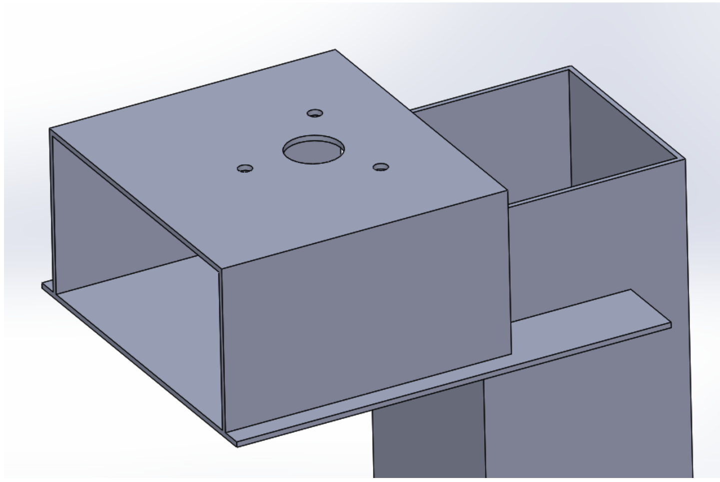

Figure 12. Housing

3.5.1.4.Lead Screw

A lead screw is a screw that is used to translate turning motion into linear motion. It is a common component in many machines, such as linear actuators, machine slides, vises, presses, and jacks. These are typically made of steel or aluminum and are available in a variety of sizes and pitches. Lead screws are not typically used to carry high power, but they are well-suited for intermittent use in low-power actuator and positioner mechanisms. This is because lead screws have larger frictional energy losses compared to other linkages. However, lead screws are a very efficient way to convert turning motion into linear motion.

In this drill Module, the lead screw is used to move the auger bit up and down. The lead screw is connected to the motor, which turns the screw. As the screw turns, it moves the auger bit up and down. This allows the user to drill holes of a specific depth in the ground which is about 10cm. The lead screw is typically made of steel and has a pitch of about 1.5 cm. It is attached to an F206 pillow block and a UCP bearing to hold it in position.

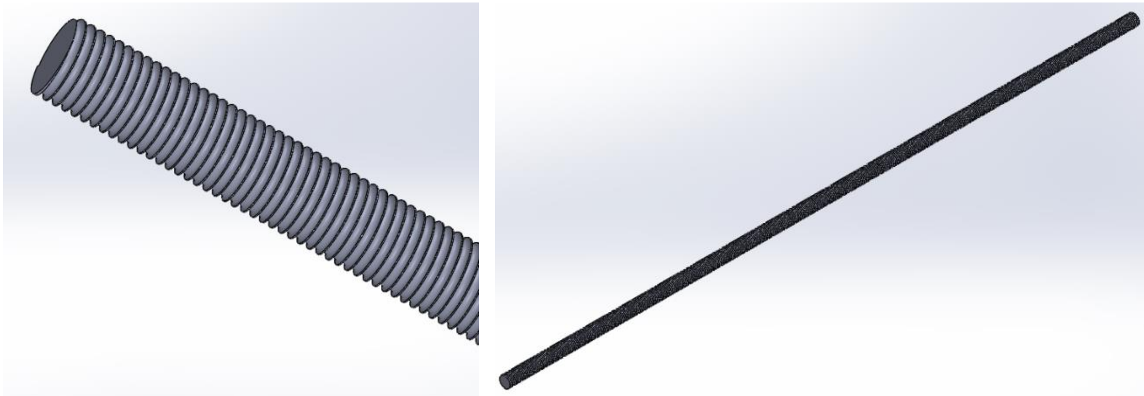

Figure 13. Lead Screw

3.5.1.5.Lead Screw Coupler

Couplings are simply used to convert a motor's rotational motion to translational by using a lead screw or other sorts of shaft. It is a key component in the drill module and is responsible for converting the rotational motion of the main motor into the vertical motion of the Auger bit.

The coupler contains a nut that has threading on it opposite to that on the lead screw for perfect meshing. When the motor turns, the coupler is rotated by the lead screw, which in turn moves the auger bit up and down essential for drilling the hole at a specific depth.

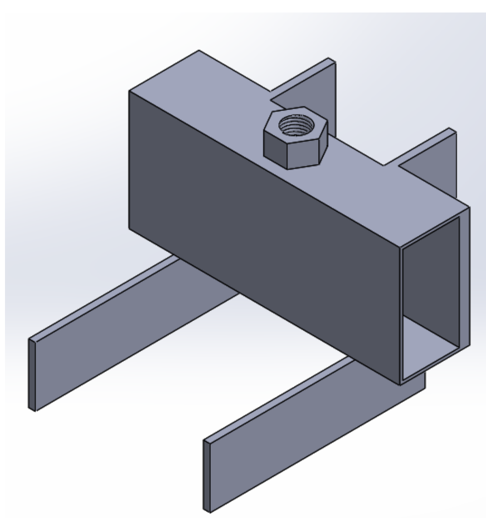

Figure 14. Lead Screw Coupler

3.5.1.6.UCP Bearing

A UCP bearing is a machine element that serves to limit relative motion to a specified direction while minimizing friction between moving parts. Its design enables various forms of motion, such as free linear movement or unrestricted rotation around a fixed axis. Alternatively, it can restrict motion by controlling the vectors of normal forces acting on the moving parts. In mechanical systems, rotary bearings play a crucial role in carrying rotating objects, such as shafts or axles, and transferring axial and radial loads from the load source to the supporting structure. Among the different types of bearings, the simplest form is the plain bearing, which comprises a rotating shaft within a fixed hole. A soft material is applied to reduce friction in this setup. In applications where slipping needs to be minimized, such as in ball or roller bearings, rolling objects like spheres or cylindrical balls are placed between races or journals within the bearing housing. The design of load-bearing mechanisms varies to cater to specific application requirements, ensuring optimal performance, reliability, durability, and efficiency.

The UCP bearing plays a vital role in Drill Module for maintaining the position and stability of the lead screw. It ensures the smooth and reliable vertical motion of both the Lead Screw Coupler and Auger Bit. By securely holding the lead screw in place, the UCP bearing enables precise control and accuracy with increased precision during drilling operations. This mechanism ensures that the vertical movement of the lead screw coupler and auger bit remains consistent, allowing for efficient and effective drilling processes by reducing friction and vibration.

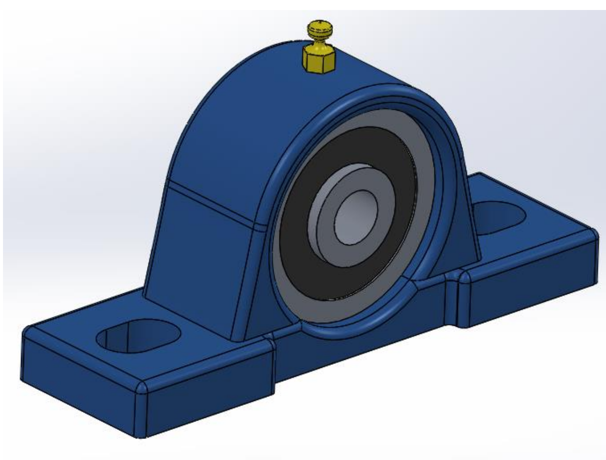

Figure 15. UCP Bearing

3.5.1.7.F206 Pillow Block Bearing

The F206 pillow block bearing is a type of bearing that is used to support and align rotating shafts. It is a very versatile bearing and can be used in a variety of applications, including drilling machines. In Drill Module it is used to support the lead screw. The F206 pillow block bearing helps to keep the lead screw in place and prevents it from wobbling or vibrating. This ensures that the drill bit digs a smooth, straight hole. The F206 pillow block bearing is made of a durable material that can withstand the high loads and pressures that are generated during drilling. It is also a low-maintenance bearing, which means that it requires little lubrication or replacement.

Some of the benefits of using an F206 pillow block bearing are:

- Increased precision
- Reduced maintenance
- Increased efficiency

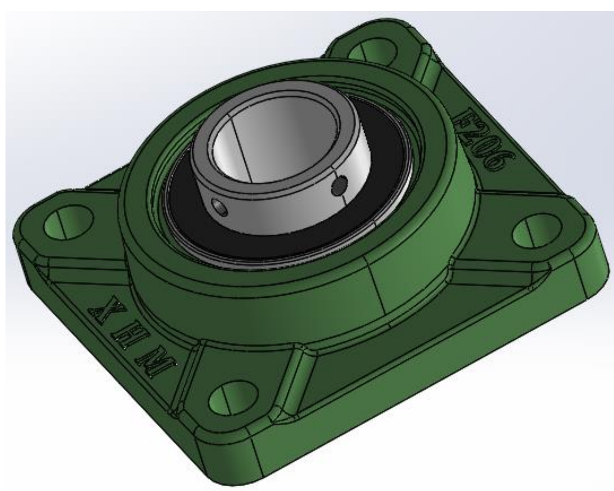

Figure 16. F206 Pillow Block Bearing

3.5.1.8.Auger Bit Coupler Mount

The Auger Bit Coupler Mount is an important part of the auger drilling mechanism, responsible for securely mounting the auger bit onto the drilling mechanism. It is designed to ensure a strong and prominent attachment of the auger bit motor, providing stability during drilling. The mount is welded to the auger bit coupler, which is connected to the lead screw. The mount is a straight support structure that serves as a solid foundation for mounting the auger bit motor. Fixing the auger bit motor on the mount allows for the auger bit to be coupled to the motor, ensuring a synchronized rotation. This arrangement minimizes vibrations and enhances the stability of the drilling module during operation.

The mount is equipped with motor mounting holes that ensure the precise positioning of the auger bit motor. The center hole in the mount is designed for the connection between the motor and the auger bit, using a connecting rod. This connection enables the power transfer from the motor to the auger bit, allowing for efficient drilling.

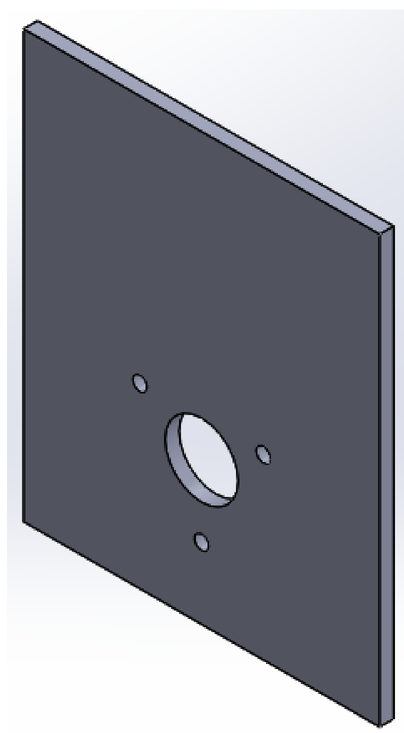

Figure 17. Auger Drill Coupler Mount

3.5.1.9.Auger Drill Motor

The Auger Drill Motor is the same Viper motor mentioned earlier. It is known for its reliability and performance. It plays an essential role in the drilling mechanism by providing precise control over the angular velocity and acceleration of the auger bit, contributing to accurate and efficient drilling operations. This level of control is essential for achieving the desired drilling depth and ensuring consistent and uniform digging. Additionally, the motor enables us to have precise control over the acceleration of the auger bit. This means that the drilling process can be carefully controlled and optimized for various soil conditions and drilling requirements. By adjusting the acceleration, we can ensure smooth and controlled penetration of the drill in the ground, minimizing potential disruptions and vibrations.

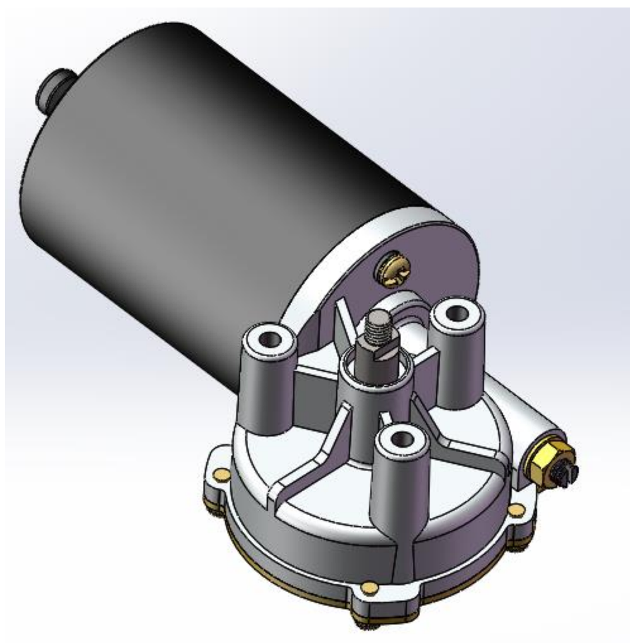

Figure 18. Auger Drill Motor

3.5.1.10.Connecting Rod

The connecting rod is a vital component in the drilling mechanism. It connects the drill bit to the auger motor, ensuring synchronized rotation and minimizing vibrations during drilling. It is typically a solid rod, with a threaded end that fits onto the auger motor and a smooth end that fits into the drill bit.

It is installed using lathe tapping and drilling techniques. The rod is first tapped with the appropriate size tap and then is screwed onto the Auger Motor. It is then drilled with the appropriate size drill bit and is attached to the Drill bit using the connecting pin.

Unwanted vibrations in the system can lead to inaccuracies or damage to the equipment therefore it plays an additional role in stabilizing the drilling operation by absorbing vibrations and preventing the drill bit from wobbling, which can help to improve the accuracy of the hole.

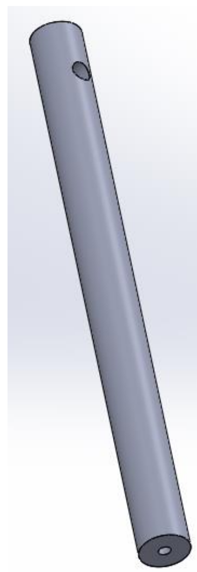

Figure 19. Connecting Rod

3.5.1.11.Auger Drill

An auger drill is a widely used tool that is used to drill holes in the ground. The design of our drill consists of a rotating metal rod with two blades attached to the bottom. The blades cut or scrape the soil as the rod turns.

The top end of the auger bit contains a small sector that supports the connecting rod. The connecting rod connects the drill to the auger motor. This ensures that the power from the motor is directly transferred to the drill bit for an efficient drilling process. A pin is attached to hold the drill and the connecting rod in position and maintain a firm connection between them. This prevents any loose contact and ensures stability during operation.

It also contains a helical screw blade, known as flight, that winds around the lower part of the shaft. This screw blade plays a vital role in the drilling process. The lower edge of the screw blade scrapes the soil at the bottom of the hole, while the rest of the blade acts like a screw conveyor, lifting the loose soil out of the way. Once the desired hole depth is reached, the tool is pulled out. The screw blade efficiently removes the remaining loose dirt from the hole. In some designs, the rod may end with a sharp point protruding below the screw blade, aiding in penetrating the soil.

Applications include digging holes for fence posts, planting trees, or installing signs. Its efficient design makes it a more reliable choice for soil excavation tasks, and this is the reason we used it.

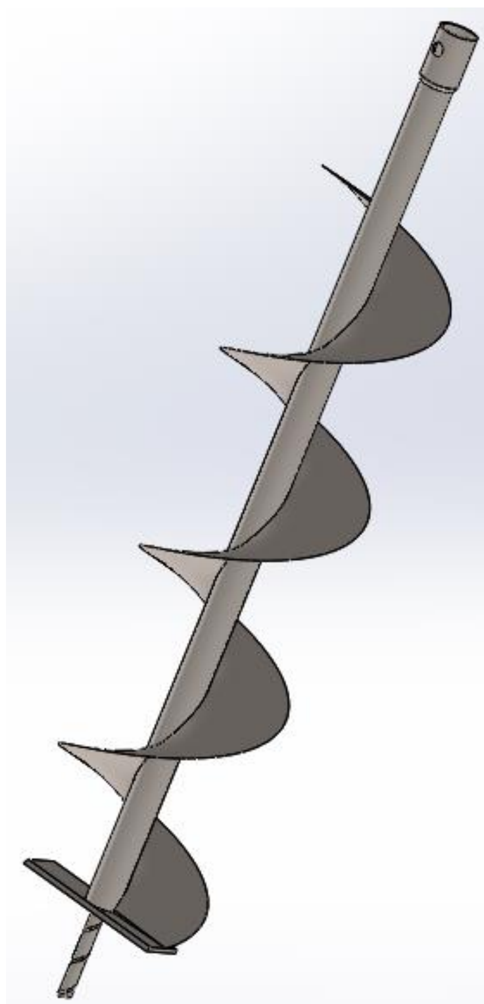

Figure 20. Drill Bit

3.5.1.12.Support Pin

The support pin is a small, but important component of an auger drill. It is used to join the connecting rod and the drill bit, ensuring perfect alignment, and preventing movement or disengagement. The support pin is a relatively simple component, but it plays an important role in the drilling process by ensuring that the drill bit is aligned properly and preventing it from wobbling. It ensures accurate and aligned drilling.

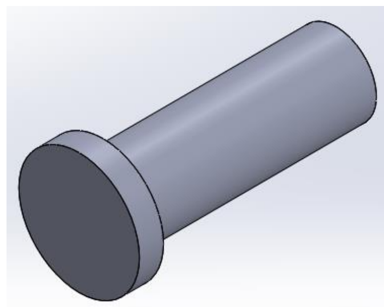

Figure 21. Support Pin

3.5.1.13.Frame Mount

Mounts are basic parts that allow us to attach components or delicate parts to them so that parts will not move from their place as required. Its primary function is to provide a secure and stable attachment point for the drilling Module. By fixing the frame mount to the support beam of the Agribot, we can ensure the stability and integrity of the entire drilling system. This allows for reliable and efficient drilling operations without any unwanted movement or displacement of components. It also enables us to attach the components to the drilling mechanism.

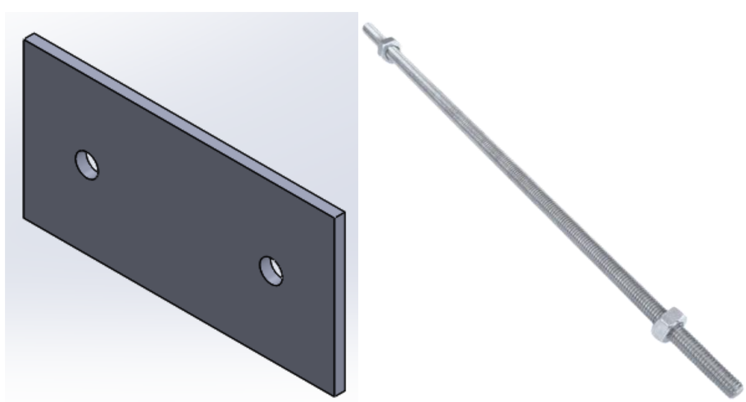

Figure 22. Mount

3.5.2.Seeder Module

The overall hardware assembly of our Seeder consists of several parts connected with the help of nuts and bolts. The Seeder module is fixed with the Agribot's body with the help of Frame Mounts and Bolts.

The funnel is the main part of the system that carries the seeds that need to be distributed in the field. The seed hopper plate is carrying a funnel while it is moving on the Seeder rail. This mechanism works in the same principle as of a train track where the track is used to carry the train in a direction where it is needed to go similar to this the Seeder Rail is used to carry the Seed Hopper Plate and Seeder. And they undergo the to and fro motion where they disperse the seeds from the funnel onto the field. It consists of the following components:

- Funnel
- Seed Hopper Plate
- Seeder Rail
- Motor
- Long Connecting Rod
- Elevator

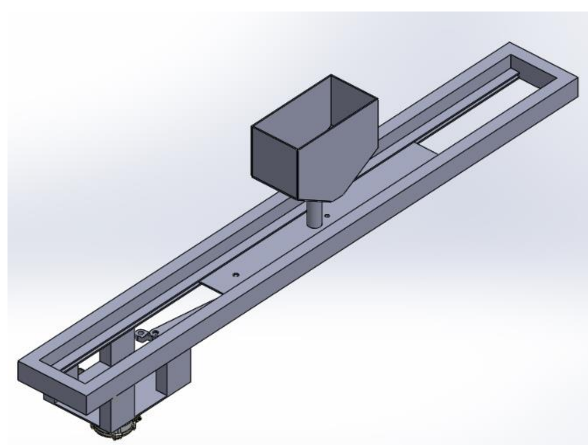

Figure 23. Seeder Assembly

3.5.2.1.Funnel

The funnel in the Seeder Module is a device that facilitates the distribution of seeds. A funnel can be a tube or a pipe that is wide on top and has a narrow opening at the bottom, used for guiding liquid or small components into a small opening. Funnels are commonly made of materials such as stainless steel, aluminum, glass, or plastic. It is positioned on the Hopper Plate and serves the purpose of guiding the seeds from the top into a small opening at the bottom of the Hopper Plate. The funnel is filled with seeds before initiating the seeding process and these seeds are then dispersed accordingly.

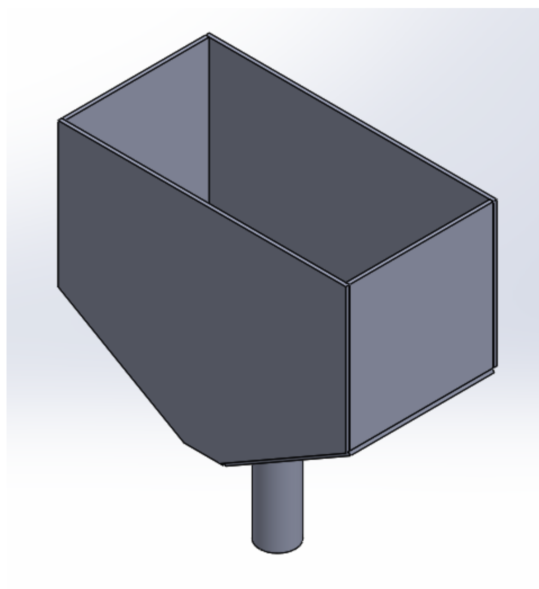

Figure 24. Funnel

3.5.2.2.Seed Hopper Plate

The Seed Hopper Plate is an integral component of the seeding process as it will be utilized to spread seeds in the field. It is a moving plate that serves as a platform for securely holding the seeder or funnel at the top. The plate features a hole where the Seeder is welded, and beneath it is the stopper plate. One end of the hopper plate is free, while the other end is connected to the motor. To provide elevation to the motor’s rotation, a curved metallic sheet is attached to this end. This elevation then transfers the motion to the hopper plate, which is positioned at a certain height relative to the motor using a connecting rod and an Elevator mechanism. The movement of the hopper plate serves a vital role in opening and closing the seeder by utilizing the stopper plate. In one cycle the seeder drops the seeds when the hole is not aligned with the stopper plate and in the second cycle there is no seed dropping as the seeder is directly above the stopper plate.

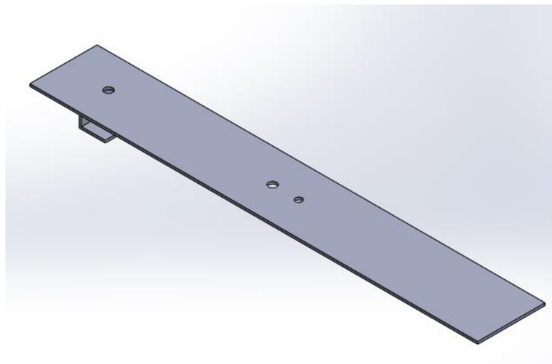

Figure 25. Seed Hopper

3.5.2.3.Seeder Rail

The seeder rail is the foundational frame for the seeder module. It is used to firmly mount the entire seeder assembly onto the Agribot's body. It can also be said as the skeleton for the Seeder module is the main component that enables the movement of the hopper plate and as a result the seeder as well. By allowing the hopper plate to move freely with the motor, the seeder rail provides us with the ability for the controlled and efficient spreading of seeds during the seeding process. It ensures the proper movement of the hopper plate and increases the stability and functioning of the seeder module, contributing to effective seed distribution in the field.

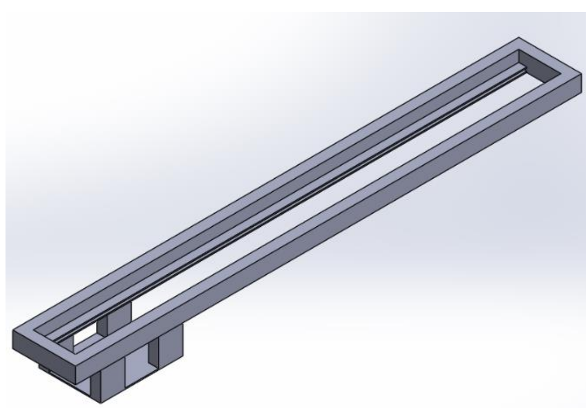

Figure 26. Seeder Rail

3.5.2.4.Seeder Module Motor

The seeder module motor, specifically a Viper motor, is located at the bottom of the seeder rail. It serves the purpose of driving the movement of the hopper plate through the connecting rod and the elevator. Similar to the motors in the drill module, the seeder module motor is responsible for converting the rotational motion generated by the motor into linear motion of the seeder rail and the Seeder. By providing the necessary power and control, the motor enables smooth and precise operation for the even and efficient distribution of seeds during the seeding process.

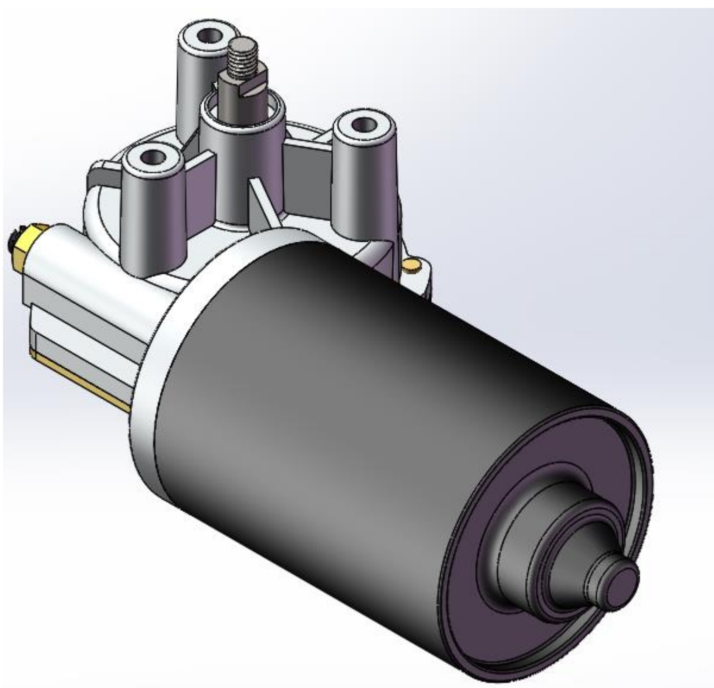

Figure 27. Seeder Module Motor

3.5.2.5.Long Connecting Rod

The long connecting rod is used to connect the elevated end of the hopper plate to the elevator bar. It plays a key role in transferring the rotational motion of the Viper motor to the Hopper Plate, which results in the horizontal displacement of the hopper plate and the seeder. The long connecting rod keeps the hopper plate stable, which allows it to move smoothly and under controlled conditions.

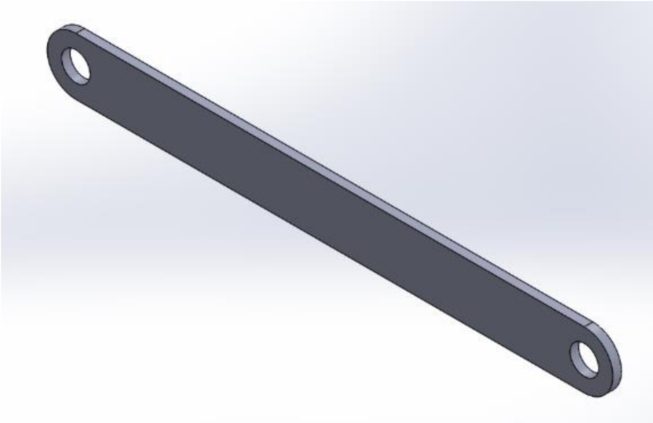

Figure 28. Long Connecting Rod

3.5.2.6.Elevator

The elevator in the mechanism serves two main purposes. Firstly, it converts the rotational motion of the Viper motor into the horizontal (or side-to-side) motion of the hopper plate. Secondly, it elevates the rotational motion of the Viper motor to transfer it effectively to the hopper plate via the connecting rod. This enables the precise and controlled linear movement of the hopper plate.

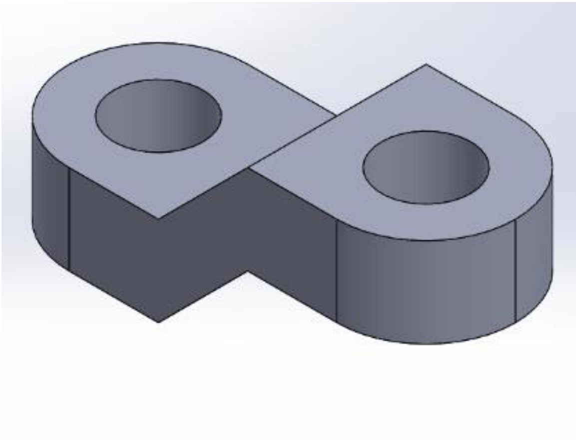

Figure 29. Elevator

3.6.ANSYS Analysis

We will be discussing the ANSYS analysis performed on the parts of the robot it is important to note that different parameters were calculated and analyzed in order to get the bestreserves out of the analysis on the parts of the robot.

3.6.1.Support Beam

This is the ANSYS Analysis of the support beam that is being used to support all the structures of the auger drilling mechanism of the mobile Agribot. the support room analysis wasperformed on ANSYS software and a force of 1000N was applied the total deformation seemed to be very minimal due to the strong and resilient structure of the support mean.

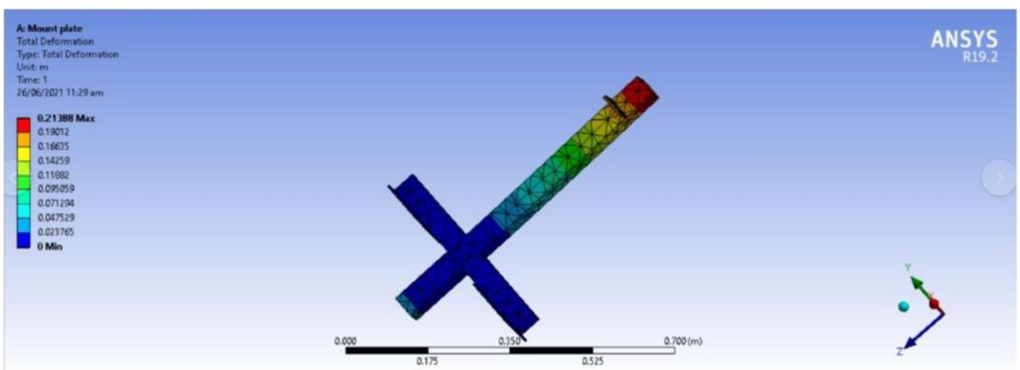

Figure 30. ANSYS of Support Beam

In the following table, we are going to describe the minimum and maximum, and other parameters of the ANSYS analysis performed on the support beam. The total deformation is around 0.21 meters after applying a force of 1000 newtons, which is a very hectic force, so it can be said that our part has successfully passed the Ansys analysis.

Table 4. ANSYS Data of Support Beam

Type	Total Deformation
Minimum Value	0 m
Maximum Value	0.21388 m
Minimum at Point	Near the Cross
Maximum at Point	Isolated Edge of the Beam
Fail/Pass	Pass

3.6.2.Drill Bit

Help yeah from the ANSYS analysis of the drill bit of the auger drilling mechanism. torque and forces were applied, and the results were taken After Earth deep analysis. the part did not show any kind of bending or major deformation and did not break which means that itis safe to use, and it has passed or liability test.

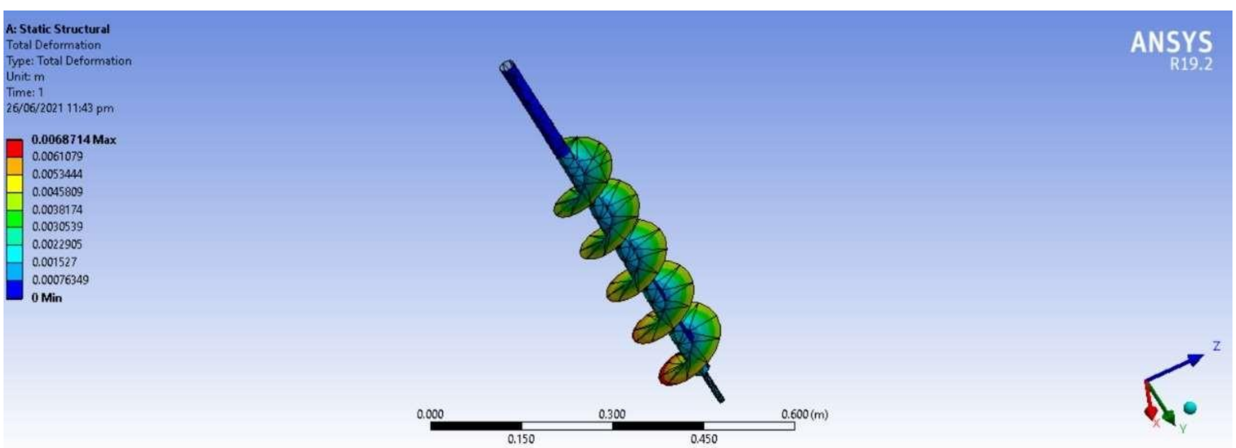

Figure 31. Ansys of Drill Bit

Here we can see that the Deformation is low as much as 0 to 0.006m which is quite lowas we applied a force of 1000N on the drill and applied Torque on it too.

Table 5. ANSYS of Drill

Type	Total Deformation
Minimum Value	0 m
Maximum Value	0.0061079 m
Minimum at Point	Edges of the Blades
Maximum at Point	The screw of the drill
Fail/Pass	Pass

3.6.3.Auger Drill Coupler Mount

For the ANSYS analysis of the Auger Drill Coupler Mount torque and weight were applied on the mount, and the results were taken After Earth deep analysis. The part did not show any kind of bending or major deformation and did not break which means that it is safe to use, and it has passed our liability test.

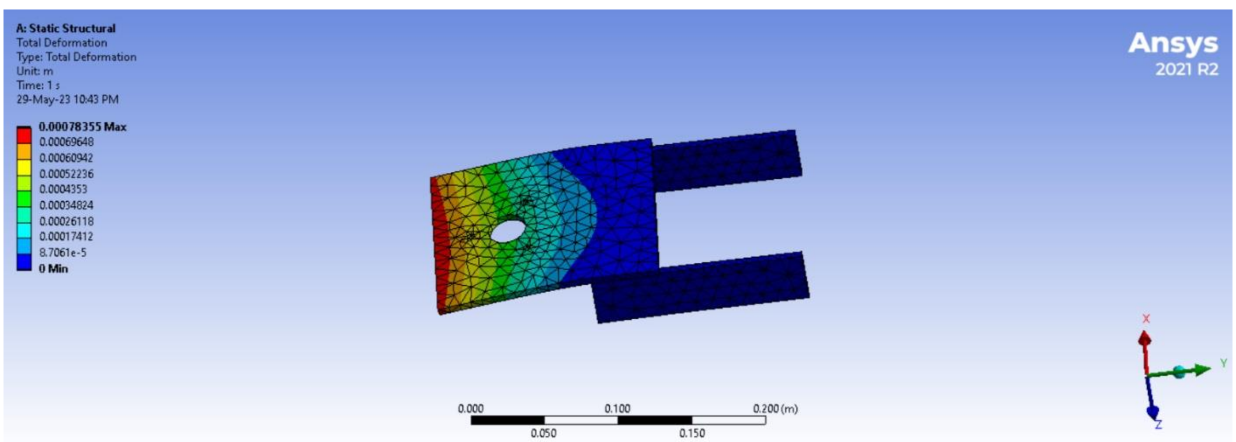

Figure 32. Auger Drill Coupler Mount

Here we can see that the Deformation is low as much as 0 to 0.07mm which is quite low as we applied a force of 1000N of weight and a torque of 400N on each of its holes.

Table 6. Analysis of Auger Drill Coupler Mount

Type	**Total Deformation**
Minimum Value	0 m
Maximum Value	0.00069448 m
Minimum at Point	The base of the plate
Maximum at Point	Edge of the plate
Fail/Pass	Pass

3.6.4.Connecting Rod

For the ANSYS analysis of the Connecting Rod, torque and weight were applied on the rod, and the results were taken After Earth deep analysis. The part did not show any kind of bending or major deformation and did not break which means that it is safe to use, and it has passed our liability test.

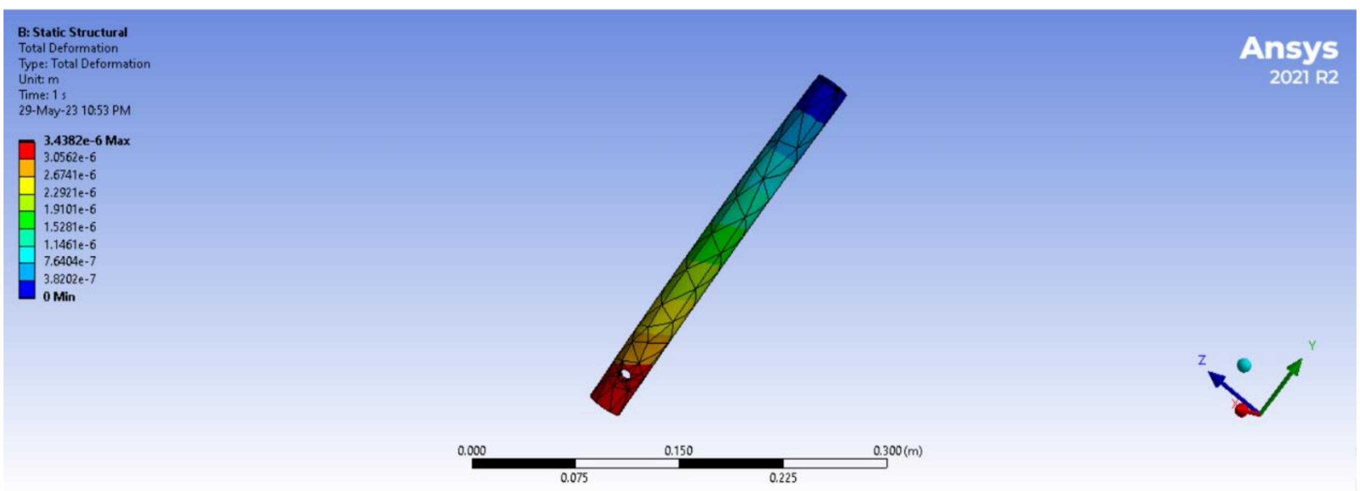

Figure 33. Connecting Rod

Here we can see that the Deformation is really low as much as 0 to 0.00003mm which is negligible as we applied a force of 1000N of weight and a torque of 400N on it.

Table 7. Analysis of Auger Bit Connecting Rod

Type	**Total Deformation**
Minimum Value	0 m
Maximum Value	0.0003482 mm
Minimum at Point	Motor-to-rod connection
Maximum at Point	Drill-to-rod connection
Fail/Pass	Pass

3.6.5.Seeder Rail

For the ANSYS analysis of the Seeder Rail weight was applied on both the mount for the motor and the rail, and the results were taken After Earth deep analysis. The part did not show any kind of bending or major deformation and did not break which means that it is safe to use, and it has passed our liability test.

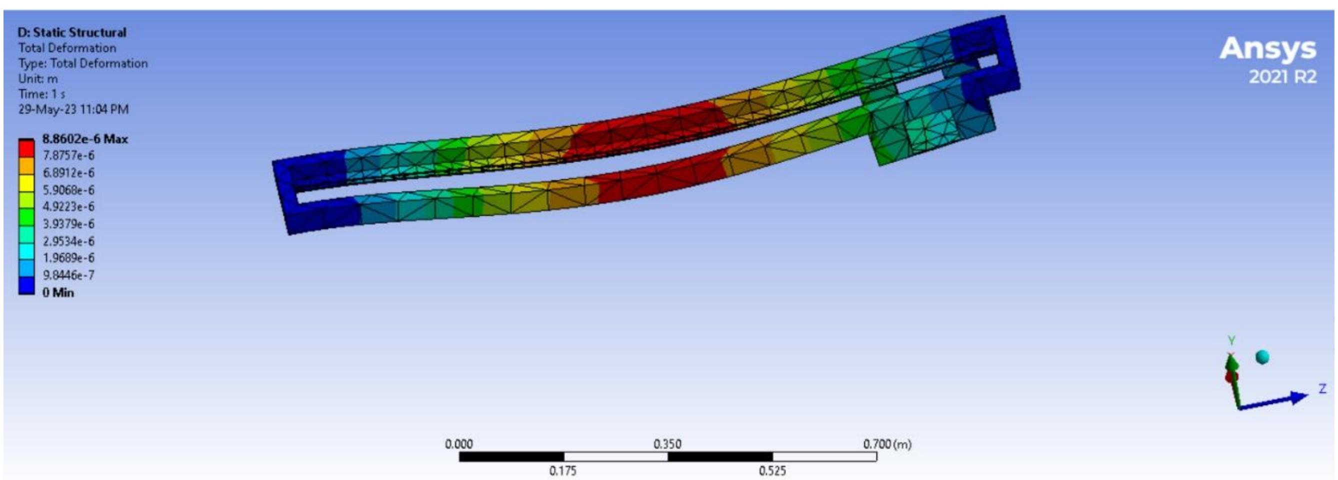

Figure 34. Seeder Rail

Here we can see that the Deformation is really low as much as 0 to 0.0008mm which is very low as we applied a force of 100N as the weight of the seeds is to be 10kg.

Table 8. Analysis of Seeder Rail

Type	Total Deformation
Minimum Value	0 m
Maximum Value	0.00088602 mm
Minimum at Point	Edges of Rail
Maximum at Point	Middle of the Rail
Fail/Pass	Pass

3.6.6.Seeder Funnel

For the ANSYS analysis of the Seeder Funnel, weight was applied on each of its walls and base, and the results were taken After Earth deep analysis. The part did not show any kind of bending or major deformation and did not break which means that it is safe to use, and it has passed our liability test.

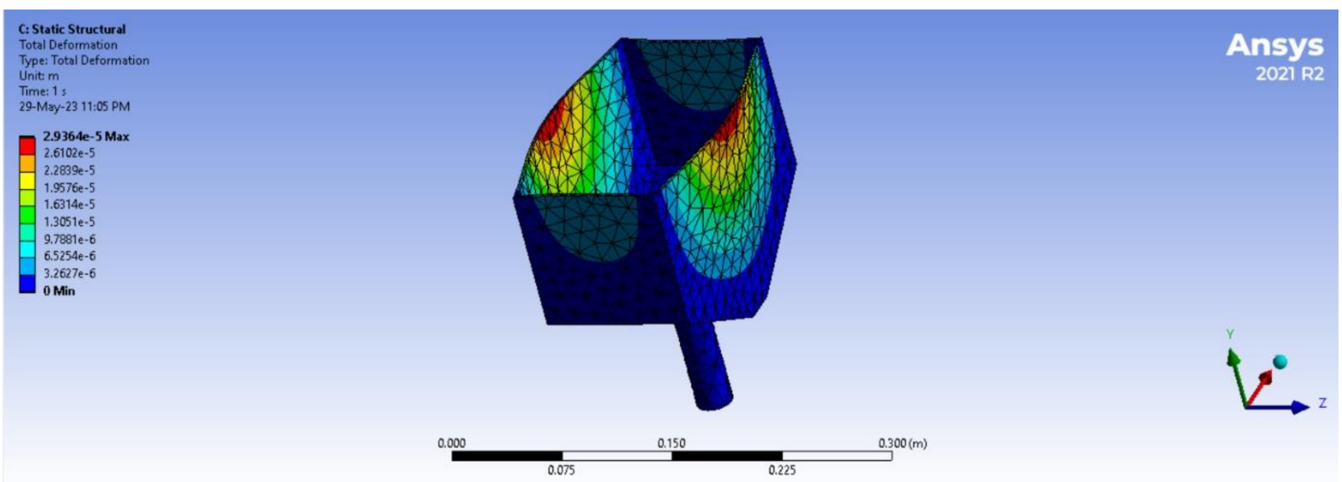

Figure 35. Seeder Funnel

Here we can see that the Deformation is really low as much as 0 to 0.0002mm which is quite low as we applied a force of 100N of force considering the weight of its seeds to be 10kg.

Table 9. Analysis of Seeder Funnel

Type	Total Deformation
Minimum Value	0 m
Maximum Value	0.00029364 mm
Minimum at Point	Base of funnel
Maximum at Point	Top Edges of the Funnel
Fail/Pass	Pass

3.6.7.Central Beam

For the ANSYS analysis of the Central Beam, weight was applied on each beam, and the results were taken After Earth deep analysis. The part did not show any kind of bending or major deformation and did not break which means that it is safe to use, and it has passed our liability test.

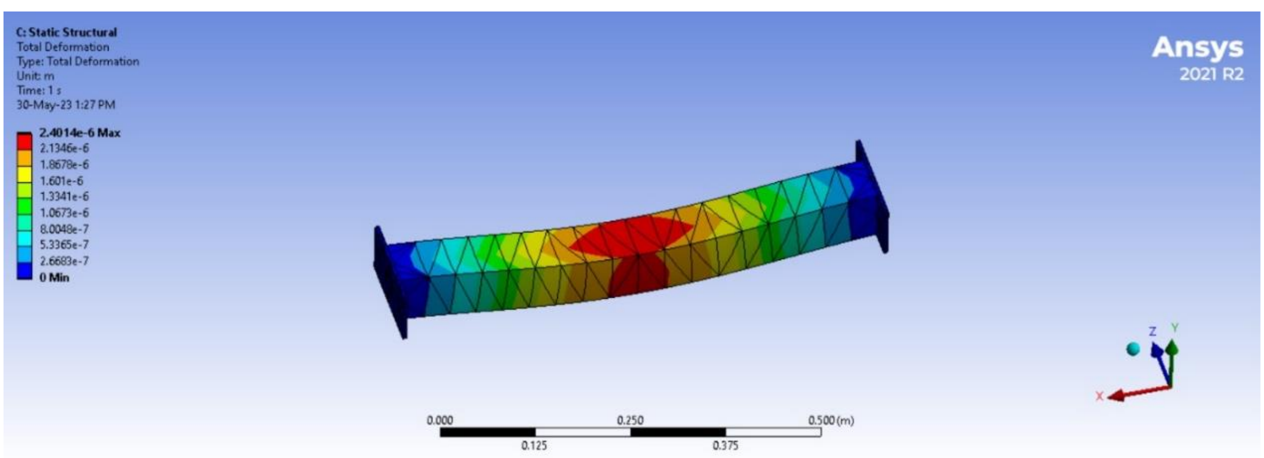

Figure 36. Central Beam

Here we can see that the Deformation is really low as much as 0 to 0.0002mm which is quite low as we applied a force of 300N of force considering the weight of the drill module to be 30kg.

Table 10. Analysis of Central Beam

Type	Total Deformation
Minimum Value	0 m
Maximum Value	0.00024014 mm
Minimum at Point	Edges of Beam
Maximum at Point	Center of the beam
Fail/Pass	Pass

3.7.Software Used

Agribot is a robot developed for agricultural purposes. This bot is specially designed to perform agricultural tasks. The Agribot presented will have 2 main functions, seeding, and drilling. The robot will be able to drill and seed on a given agricultural land. Before the bot is designed, the required analysis of the model of the robot will be performed. The main analysis will be performed on ANSYS. Mainly it will be a static and dynamic analysis of different componentsand parts of the robot. Stress will be applied to the said components and different parts of the robot. The topology will also be optimized without compromising the strength-to-weight ratio of therobot. We will be studying the geometrical properties and spatial relations that will be unaffectedby the continuous change of shape or size of figures. The coding of the robot will be done on the software named Raspberry Pi. The software used is as follows:

3.7.1.SOLIDWORKS:

SOLIDWORKS is employed to develop mechatronics systems from start to end. Atthe initial stage, the software is employed for planning, visual ideation, modeling, feasibility assessment, prototyping, and project management. The software is then used for the design and building of mechanical, electrical, and software elements. The SOLIDWORKS software solutions are employed by mechanical, electrical, and electronics engineers to make a connecteddesign. The suite of programs is aimed toward keeping all engineers in communication and ready to answer design needs or changes. We have used this software to design the parts of theAuger Drilling mechanism of the robot.

3.7.2.ANSYS:

Ansys Mechanical finite element analysis software is employed to simulate computer models of structures, electronics, or machine components for analyzing the strength, toughness, elasticity, temperature distribution, electromagnetism, fluid flow, and other attributes Ansys is employed to work out how a product will function with different specifications, without buildingtest products or conducting crash tests] for instance, Ansys software may simulate how a bridge will decay after years of traffic, the way to best process salmon during a cannery to scale back waste, or the way to design a slide that uses less material without sacrificing safety.

3.8.Chapter Conclusion

Learn the design and perform on the 3D design that we have made for our Agribot two designs that we have considered are this railing seeding design and the other design thatwe have performed an analysis in depth is the auger drilling mechanism.

CHAPTER 4- ELECTRICAL SYSTEM INTEGRATION AND CODING

We examine the vital facets of electrical wiring and the incorporation of electrical components inside the Agribots in this chapter. We also examine the students' coding strategy, defending and elaborating on the methodology that underlies it. We also go over the tools that were used to develop, analyze, and run our system. It is crucial to remember that all potentially dangerous wiring was installed precisely following the recommended safety precautions. We'll look at each component in depth to give you a thorough understanding of how our electrical system works.

4.1.Electrical Components and System Overview

In this section, we present an overview of the electrical components that constitute the backbone of the Agribot system. The electrical system plays a crucial role in enabling the precise control and operation of various functionalities. It encompasses a range of components carefully selected and integrated to ensure optimal performance and efficiency. In the following subsections, we will delve into the details of each component, highlighting their respective roles and contributions to the overall functionality of Agribot.

4.1.1.Batteries

The electrical components of our Agribot primarily operate on DC power. For our power source, we selected the Narada AG12V100F valve-regulated polymer Gel battery. This high-quality battery offers a rated voltage of 2.25Vpc and an equalization voltage of 2.35Vpc at 25°C. With a maximum charge current of less than 25A, the battery ensures safe and efficient charging. Its terminal hardware torque is rated at 8-10N.m, providing secure connections for our system. By utilizing the Narada AG12V100F battery, we were able to meet the power demands of our Agribot while maintaining reliable performance.

4.1.2.Wheel Motors

The Agribot is equipped with four powerful wheel motors to facilitate efficient movement across various terrains. We have employed four 24V 300W motors with a rotational speed of 130 revolutions per minute (RPM). These motors provide robust propulsion capabilities, allowing the Agribot to navigate through agricultural fields effectively. Additionally, each wheel motor is integrated with a 100 CPR (counts per revolution) encoder, which enables precise control and feedback for accurate positioning and motion control. The combination of high power, optimal RPM, and encoder feedback ensures smooth and reliable locomotion of the Agribot during their farming operations.

4.1.3.Linear Actuators

To achieve precise tire steering capabilities, we have incorporated four FY022-254-394-12-10-1500 linear actuators into the Agribots' design. These actuators are specifically chosen for their suitability in agricultural applications. Operating at a voltage of 12 volts with a power rating of 35 watts, they deliver sufficient force to effectively control the steering of each tire. The actuators are designed to withstand the demanding conditions of agricultural environments and are equipped with a duty cycle of 2 minutes, ensuring their reliable and continuous operation. By employing these linear actuators, the Agribot can achieve individual tire steering, enabling enhanced maneuverability and precise navigation across the fields.

4.1.4.Drill Module, Drill, and Seeder Motor

We have utilized a 12-volt wiper motor manufactured by MITSUBA for multiple functionalities in our Agribot. This wiper motor, known for its durability and reliability, serves as the driving force behind our drill module, seeder module, and main drill motor. Its robust construction and compatibility with the Agribots' power system make it suitable for handling drilling and seeding operations. The wiper motor's versatile design and 12-volt power supply allow a seamless integration into our agricultural robotic system, ensuring efficient and precise performance in the field.

4.1.5.CYTRON SmartDriveDuo-60

The CYTRON SmartDrive Duo-60 motor driver plays a vital role in controlling the movement of our Agribot. With dual channels for independent motor control, it offers robustness and versatility. This compact motor driver provides peak currents of up to 60A and a continuous current rating of 30A, ensuring reliable and high-power performance. It supports analog, digital, and RC control modes, allowing flexible control options. The integrated protection features, including overcurrent and thermal protection, safeguard against voltage fluctuations. With its easy integration with Arduino and wireless RC control capability, the SmartDrive Duo-60 enables precise and convenient control over the Agribots' movement. It is an essential component of our agricultural robotic system, delivering superior performance, reliability, and adaptability.

4.1.6.BTS 7960 Motor Driver

The BTS 7960 motor driver plays a crucial role in our Agribots' motor control system. Designed to control a single motor, it offers reliable and efficient performance. The motor driver features a dual H-bridge configuration, allowing bi-directional control for precise movement. With a peak current rating of 43A and a continuous current rating of 20A, it provides ample power for our agricultural applications. The BTS 7960 includes essential protection mechanisms, such as overcurrent and overtemperature protection, ensuring safe and reliable operation. The motor driver supports various control modes, including analog and PWM control, offering flexibility in motor control strategies. Its compact size and compatibility with Arduino simplify the integration process. The BTS 7960 motor driver delivers reliable performance and contributes to the overall efficiency of our Agribots' motor control system.

4.1.7.Arduino Uno

At the heart of our Agribots' control system lies the Arduino Uno microcontroller board. The Arduino Uno serves as the main control unit, responsible for executing the coded instructions and coordinating the various components. With its ATmega328P microcontroller, the Arduino Uno offers a powerful and versatile platform for our automation tasks. It provides a wide range of digital and analog input/output pins, enabling seamless integration with sensors, actuators, and motor drivers. The Arduino Uno's user-friendly development environment and extensive library support simplify the coding process. We utilized the Arduino IDE (Integrated Development Environment) to write and upload our code, allowing us to implement complex control algorithms and customize the system behavior. The Arduino Uno's compact size, reliability, and robust performance make it an ideal choice for our Agribots, facilitating precise control and seamless communication with the peripherals.

4.1.8.HC-05 BT Module

To enable wireless communication and remote-control capabilities, we incorporated the HC-05 Bluetooth module into our Agribots' control system. The HC-05 module is a versatile and cost-effective solution for establishing Bluetooth connections between Agribot and external devices such as smartphones or tablets. With its robust range and reliable performance, the HC-05 module allows us to wirelessly transmit and receive data, providing a convenient interface for controlling the Agribot remotely. The module operates in the 2.4GHz ISM band and supports the Bluetooth 2.0+EDR (Enhanced Data Rate) specification, ensuring stable and efficient communication. We utilized the Serial Port Profile (SPP) of the HC-05 module, which simplifies the integration process and allows seamless serial communication with the Arduino. By establishing a Bluetooth link with our custom-developed mobile application, users can intuitively control the Agribots' movements, activate specific modules, and monitor the system's status. The HC-05 Bluetooth module significantly enhances the usability and versatility of our Agribots, enabling efficient wireless control and expanding their range of applications.

4.2.Wiring and Connections

The electrical wiring and connections within the Agribot form the backbone of its functionality, ensuring seamless communication and control between the components. In this section, we will explore the intricate wiring process and connection setup that was employed to integrate the Arduino, Bluetooth (BT) module, motor drivers, and other vital components. Emphasis was placed on maintaining electrical integrity, optimizing power distribution, and adhering to safety standards throughout the wiring process. Furthermore, we will discuss the power supply configuration, including the utilization of both of the 12-volt power sources, to meet the specific voltage requirements of different components. Let us now delve into the details of the wiring and connections implemented within the Agribot system.

4.2.1.Power Supply Wiring

For efficient power management and distribution, we implemented a well-designed wiring system for the Agribot. The primary power source for our system consisted of two 12-volt batteries connected in series, providing a combined voltage of 24 volts. This higher voltage was utilized to power the wheel motors, ensuring optimal performance and torque. Additionally, we utilized one of the batteries to supply power to the microcontrollers and motor drivers, which operated at a lower voltage of 12 volts. This arrangement allowed us to segregate the power supply for different components, ensuring stable and reliable operation. Careful attention was given to proper wiring techniques, such as using appropriate gauge wires, ensuring secure connections, and implementing necessary safety measures. By adopting this power supply configuration, we achieved efficient utilization of power resources and maintained a robust and reliable electrical system for the Agribots.

4.2.2.Wiring for CYTRON SmartDriveDuo-60

For efficient power management and distribution, we implemented a well-designed wiring system for the Agribots. The primary power source for our system consisted of two 12-volt batteries connected in series, providing a combined voltage of 24 volts. This higher voltage was utilized to power the wheel motors, ensuring optimal performance and torque. Additionally, we utilized one of the batteries to supply power to the microcontrollers and motor drivers, which operated at a lower voltage of 12 volts. This arrangement allowed us to segregate the power supply for different components, ensuring stable and reliable operation. Careful attention was given to proper wiring techniques, such as using appropriate gauge wires, ensuring secure connections, and implementing necessary safety measures. By adopting this power supply configuration, we achieved efficient utilization of power resources and maintained a robust and reliable electrical system for the Agribots.

4.2.3.Wiring for MD BTS 7960

To establish the necessary wiring connections between the Arduino and the MD BTS 7960 motor driver, we utilized Arduino pins 12 and 13 as LPWM (left PWM) and RPWM (right PWM) respectively. These pins were connected to the corresponding input pins of the MD BTS 7960 motor driver, enabling the Arduino to send PWM signals for controlling motor speed and direction. Additionally, we used a breadboard powered by the Cytron motor driver to connect the enable pins of the MD BTS 7960. The breadboard provided a convenient platform to connect and control the enable pins of the motor driver, while also providing a 5V and GND connection from the CYTRON motor driver.

The MD BTS 7960 motor driver itself was powered by a 12-volt supply obtained from the battery. This 12-volt power source was utilized to drive the linear actuators, enabling precise control over their movements. By connecting the Arduino, the MD BTS 7960 motor driver, and the linear actuators in this manner, we established a reliable and effective control system for the Agribots, allowing for accurate motor control and manipulation of the linear actuators

4.2.4.Arduino and BT Module Wiring

To establish the wiring connection between the BT (Bluetooth) module and the Arduino, we utilized Arduino pins 8 and 9 as Rx (Receiver) and Tx (Transmitter) respectively. Pin 8 (Rx) of the Arduino was connected to the Tx pin of the BT module, while pin 9 (Tx) of the Arduino was connected to the Rx pin of the BT module. This connection allowed for bidirectional communication between the Arduino and the BT module, facilitating wireless communication with external devices.

Through this wiring setup, we established a reliable connection between the BT module and the Arduino, allowing for wireless communication and control of the Agribots using a Bluetooth-enabled device.

4.2.5.Breadboard Setup for Voltage Divider

To power the BT module, we employed a breadboard. The breadboard served as a convenient platform for connecting and powering the BT module. We provided power to the BT module

through the breadboard's power rails, ensuring a stable power supply for its operation.
In addition, to enable communication between the Arduino and the BT module, we incorporated a voltage divider circuit on the breadboard. The voltage divider consisted of a 200 KΩ and a 400 KΩ resistor, which formed a 3:1 ratio. This voltage divider was connected between the Arduino's Tx pin and the Tx pin of the BT module. By using this voltage divider, we reduced the voltage level from the Arduino's Tx pin to the acceptable range (around 3.3 volts) required by the BT module, enabling proper communication between the two devices.

4.2.6.Schematic for Complete Wiring

The schematic provided below illustrates the comprehensive wiring setup of our project, showcasing the interconnections among various key components. This schematic serves as a visual representation of how the motor drivers, Arduino, BT module, Cytron, drill, drill module, seeder module, linear actuators, and tire motors are all linked together. It provides an invaluable reference for comprehending the overall system architecture and serves as a guide for troubleshooting potential wiring-related challenges. By referring to this schematic, we can easily identify and understand the intricate connections that enable the smooth operation of our project.

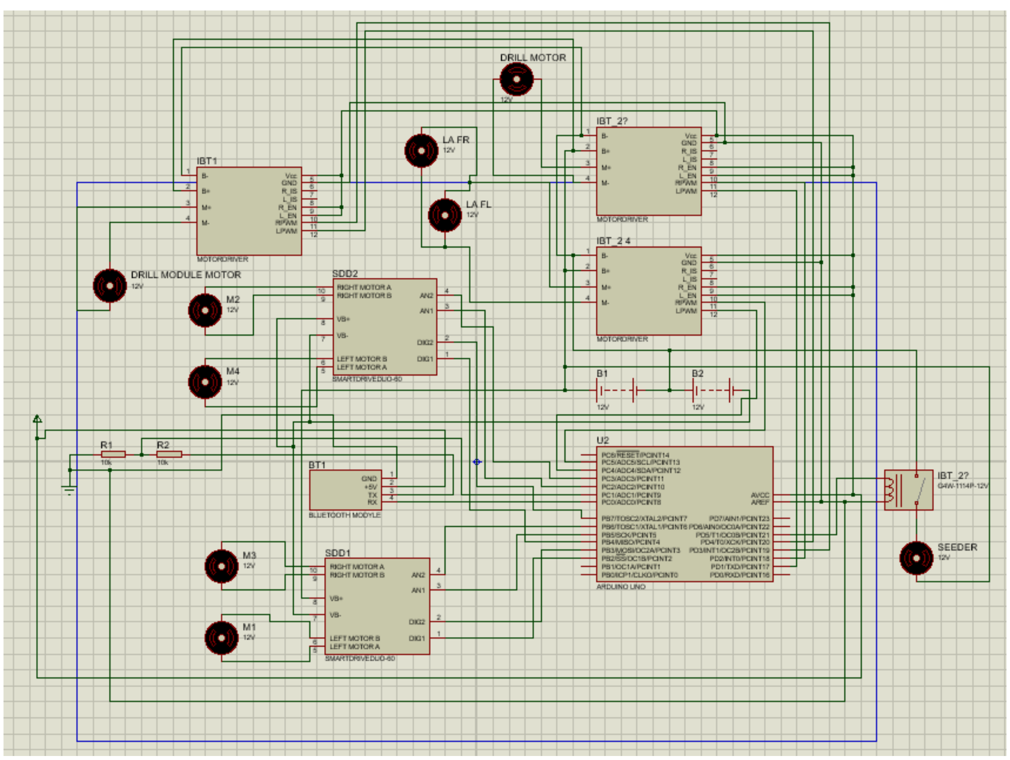

Figure 37. Complete Bot Wiring

4.3.Motor Control and Coding

The motor control of the Agribot is the fundamental driving factor that enables our bot to move and execute its tasks efficiently. By writing code for the Arduino microcontroller, we can coordinate and synchronize the actions of the various motors and actuators employed in our Agribot. This chapter explores the programming techniques and software tools utilized to control motors effectively. We will also discuss the coding logic behind each movement and functionality, enabling the Agribot to perform tasks such as forward and backward motion, turning, drill operation, seeder activation, and more.

4.3.1.Overview of Motor Control System

The motor control system in our Agribot project encompasses various types of motors, each serving specific purposes. We have incorporated DC motors for the wheel propulsion system, providing the necessary driving force for maneuverability across the field. Additionally, linear actuators, such as the FY022-254-394-12-10-1500 model, are utilized to control the movement of individual tires for enhanced flexibility and precision. To effectively control these motors, we employ motor drivers like the Cytron SmartDrive Duo-60 and the BTS 7960. These motor drivers act as intermediaries between the microcontroller and the motors, enabling us to regulate their speed, direction, and power output accurately. Furthermore, the motor control system incorporates encoders to provide feedback on motor position and velocity, allowing for precise control and movement coordination. All these components are powered by a robust and reliable battery system, delivering the necessary voltage and current to ensure efficient motor operation throughout Agribot's tasks.

4.3.2.Control Signals and Wiring

In the Agribot project, the control signals for various components, including the motor drivers, sensors, and modules, are centralized and processed through the Arduino microcontroller. The Arduino acts as the main control unit, receiving input signals and generating appropriate output signals to control Agribot's movements and functionalities.

4.3.3.Programming Environment

The Arduino IDE (Integrated Development Environment) is the primary software tool used for programming and uploading code to the Arduino microcontroller in the Agribot project. It offers a user-friendly interface, supporting the C/C++ programming language. With a simple code editor and a rich library of pre-built functions and examples, the IDE simplifies code development. Its seamless integration with the Arduino board allows for quick prototyping and testing, with the ability to compile and upload code directly. The IDE includes a built-in serial monitor for real-time communication and debugging. Additional libraries and tools can be installed to extend functionality. Overall, the Arduino IDE provides a robust programming environment for developing and fine-tuning the control systems of the Agribot project.

4.3.4.Code Structure and Libraries

The Agribot project utilizes two key libraries for its functionality. The first library is "Arduino. h," which is a standard library that provides essential functions and methods for core Arduino operations. This library allows for pin control, analog and digital I/O, and other fundamental features required for Agribot's control system. The second library used is "SoftwareSerial," which enables software-based serial communication with the Bluetooth module. It facilitates data exchange between the Arduino microcontroller and the Bluetooth module, allowing for wireless control and communication.

The code structure of the Agribot project follows a modular approach. It begins by importing the necessary libraries, including "Arduino.h" and "SoftwareSerial." The pin configurations for the Bluetooth module, Arduino pins, motor drivers, and other components are defined. The setup function initializes the pin modes and serial communication baud rates. The main loop function continuously checks for incoming Bluetooth data and executes the corresponding functions based on the received commands. These functions control the movement and operation of the Agribot, such as forward, backward, left, right, stop, drill module movement, seed module activation, and drill rotation in different directions. Serial communication is utilized to provide feedback messages to the Bluetooth terminal and display them in the serial monitor.

The combination of these libraries and the modular code structure allows for effective control and coordination of Agribot s various components. It provides a flexible and expandable platform for implementing agricultural operations and enables wireless control and monitoring through the Bluetooth module.

4.3.5.Motor Control Functions

The Agribot code includes a set of motor control functions that dictate the movements and tasks of the robot. These functions are essential for controlling the Agribot's various motions, and functions and ensuring precise navigation. The motor control functions defined in the code include:

4.3.5.1.Forward Movement

This function sets the digital control pins of the Agribot's motors to a high state and applies a maximum analog voltage, resulting in forward movement.

4.3.5.2.Backward Movement

The back() function sets the digital control pins to a low state, causing the motors to rotate in the opposite direction and enabling backward movement.

4.3.5.3.Stopping

The Stop() function stops all motor movements by setting the analog voltage to zero for all motor control pins thereby stopping all types of motion and tasks.

4.3.5.4.Turning and Rotation

The turning and rotation of our Agribot are done using the Left() and Right() functions.

- **Left()**

  This function gives the signal to the BTS 5960 to extend the linear actuators and subsequently turn the Agribot to the Left
- **Right()**

This function gives the signal to the BTS 5960 to Retract the linear actuators and subsequently turn the Agribot to the Right

4.3.5.5.Drilling

The drilling of our Agribot was done using four functions namely the DrillModuleUp(),DrillModuleDown(),DrillCW() and DrillACW().

- **DrillModuleUp()**
  The DrillModuleUp() function Controls the BTS 5960 MD pins to move the drill up once the drilling has been completed.
- **DrillModuleDown()**
  The DrillModuleDown() function Controls the BTS 5960 MD pins to move the drill down into the earth.
- **DrillCW()**
  The DrillCW() function controls the BTS 5960 MD pins to rotate the drill in a clockwise direction.
- **DrillACW()**
  On the other hand, the DrillACW() function rotates the drill module in an anti-clockwise direction.

4.3.5.6.Seeding

Lastly, the SeederModule() function activates the seeding module by setting the designated pin to HIGH for a duration of 2 seconds and then set it to LOW, enabling us to drop a couple of seeds at a time.

4.3.6.Bluetooth Module Integration

The code includes the integration of a Bluetooth module for wireless communication with Agribot. A SoftwareSerial library is imported to establish a serial communication interface with the Bluetooth module. The RX and TX pins are configured to establish the communication channel. In the setup() function, the pin modes for the Arduino and Bluetooth module are set accordingly.

Using AT commands the name and password of the BT module are changed, moreover, the baud rate is set to 9600 and is configured as a Slave to enable a seamless connection with the Arduino. The BTSerial is also initialized with a baud rate of 9600 for Bluetooth communication, The Serial monitor is also initiated. A brief delay is added to ensure stability. In the main loop, the code continuously checks for incoming data from the Bluetooth module. Once data is received, the appropriate function is called based on the received command, enabling control of the Agribot's movement and other functionalities. The received message is printed to the Serial monitor, and a response is sent back to the Bluetooth terminal to acknowledge the received command. This integration allows for convenient wireless control and operation of the Agribot using a Bluetooth-enabled device.

4.3.7.Testing and Validation

Thorough testing and validation procedures were conducted to ensure Agribot s reliable performance. The motor control functions, including forward movement, backward movement, stopping, turning and rotation, drilling, and seeding, were individually tested multiple times to verify their accuracy and reliability. Additionally, the integration of the Bluetooth module was extensively tested by sending commands from a Bluetooth-enabled device and observing Agribot's response.

The turning speed was checked by measuring the linear speed of the linear actuators to ensure that each actuator’s speed is the same. Similarly, the wheel motors and the modules were tested repeatedly for their speed accuracy and reliability. The Agribot's movement capabilities, maneuverability, and precision were evaluated during tasks such as drilling and seeding. Battery life was also assessed to ensure uninterrupted operation during prolonged usage. Data logging and monitoring were employed to collect performance metrics, including motor speed, power consumption, and movement accuracy. Any identified issues or discrepancies were addressed to enhance the overall functionality and reliability of the Agribot.

Overall, the testing and validation procedures confirmed the successful integration of motor control functions and the Bluetooth module, ensuring Agribot's ability to perform agricultural tasks accurately and efficiently in real-world conditions.

4.4.Mobile Application Development

Mobile applications have transformed industries by enabling convenient control and monitoring of remote devices. In agriculture, a mobile application can significantly enhance productivity and efficiency. This section explores the development of a mobile application for remote control and monitoring of an Agribot. The app empowers users to wirelessly operate Agribot, enabling precise navigation, motor control, and agricultural tasks. By leveraging mobile technology, farmers can optimize operations, increase automation, and improve resource utilization. This section delves into the app's development process, button functionality, user interface design, and the tools employed, providing a comprehensive understanding of how it enhances Agribot’s capabilities.

4.4.1.Mobile Application Development Tools

MIT App Inventor was a valuable tool used to develop the mobile application for Agribot. With its visual development environment, we could easily design a user-friendly interface tailored to control the robot. The intuitive drag-and-drop functionality allowed us to arrange buttons and components, such as the stop, directional, drill, and seeder buttons, in a strategic layout. By customizing their colors and positioning, we created a clear and intuitive control scheme.

4.4.2.User Interface Design

The mobile application's user interface was thoughtfully designed using MIT App Inventor. The interface featured a central, red-colored stop button, serving as the focal point for immediate robot halting. Surrounding the stop button were directional buttons, each one represented by their respective symbols, allowing users to control the robot's movement in different directions. To the top left and bottom left of the stop button, there are two blue-colored buttons for clockwise and anticlockwise rotation of the drilling module. Similarly, the top right and bottom right of the stop button house buttons for raising and lowering the drilling module. Lastly, a seeder button was placed below all other buttons. The interface also included a dropdown menu at the top for selecting the desired device to establish a Bluetooth connection with Agribot. This well-organized and visually appealing interface provided users with an intuitive and efficient means of controlling Agribot's movements and functionalities.

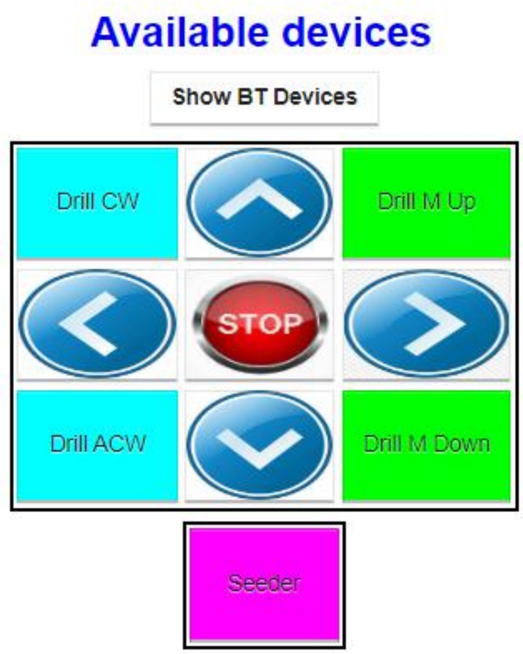

Figure 38. App UI

4.4.3.Button Functionality

The Agribot app includes a set of motor control buttons that dictate the movements and tasks of the robot. These buttons are essential for controlling the Agribot's various motions, and functions and ensuring precise navigation. The motor control buttons defined in the app include:

4.4.3.1.Forward, Backward, Left, and Right Buttons

These four buttons are used to dictate the motion of the Agribot in all directions as well as its turning and rotation. Each button calls its function which executes the code that executes the required motion.

4.4.3.2.Stop Button

The stop button calls the stop function which stops all motor movements by setting the analog voltage to zero for all motor control pins thereby stopping all types of motion and tasks.

4.4.3.3.Drill Module Buttons

The drill module buttons are donated either by “D M Up” or “D M Down” which call the respective functions to move the drill module up or down.

4.4.3.4.Drill Buttons

The Drill buttons denoted by the “Drill CW” and “Drill ACW” call the drill clockwise and Drill Anticlockwise functions to turn the drill clockwise and anticlockwise respectively.

4.4.3.5.Seeder Button

The seeder button is used to call the seeder function which would further activate the seeding module by setting the designated pin HIGH for a duration of 2.5 seconds and then setting it LOW, enabling us to drop a couple of seeds at a time.

Figure 39. Button Funtionality

4.5.Bluetooth Integration

MIT App Inventor allowed seamless integration of Bluetooth functionality into the mobile application. By utilizing the Bluetooth component available in the visual programming interface, the application was able to establish a wireless connection between the mobile device and the Agribot. This enabled us to control the Agribot remotely by sending commands from the app to the robot. The app utilized Bluetooth communication protocols to transmit data and instructions, ensuring reliable and real-time communication. The integration of Bluetooth technology provided a convenient and efficient means of establishing a wireless link between the mobile application and the Agribot, enabling users to control the robot's movements and functionalities effortlessly.

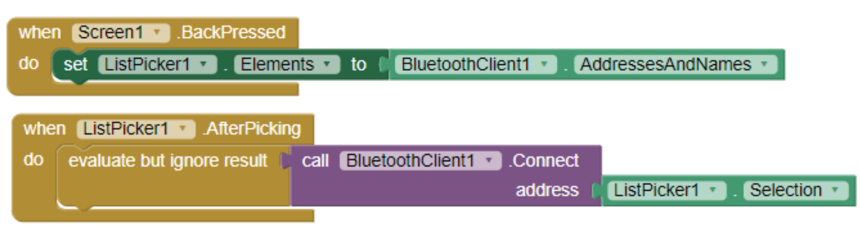

Figure 40. Bluetooth integration

4.6.Testing and Validation

The mobile application underwent rigorous testing and validation to ensure its functionality and reliability. The app was tested on various mobile devices to ensure compatibility and responsiveness across different screen sizes and operating systems. Functional testing was conducted to verify that all the buttons and controls worked as intended, allowing users to control the Agribot effectively. The app's integration with the Bluetooth module was thoroughly tested to ensure a stable connection and reliable data transmission between the mobile device and the Agribot. Real-world scenarios were simulated to validate the app's performance in controlling the robot's movements and executing different functionalities. User feedback was collected and incorporated to refine the user interface and enhance the overall user experience. The testing and validation process ensured that the mobile application met the required standards of functionality, usability, and performance, providing users with a seamless and reliable interface to control Agribot.

4.7.Complete Arduino Code

The complete Arduino code for the Agribot enables seamless control of Agribot's movements and functionalities using an Arduino board and a Bluetooth module. It incorporates motor control functions, Bluetooth communication, and integration with different modules such as drilling and seeding mechanisms. The code has been developed to ensure the efficient and precise operation of the Agribot while providing flexibility for customization and expansion. By following this code, users can effectively control Agribot using a mobile application and leverage its capabilities for optimizing agricultural processes.

4.8.Software Tools and Simulation

In the process of developing the Agribot, two software tools played a crucial role: the Arduino IDE and Proteus. The Arduino IDE served as the primary platform for writing and uploading the code to the Arduino microcontroller, while Proteus provided a simulation environment for testing and validating the circuit connections virtually. Let's explore these software tools in more detail:

4.8.1.Arduino IDE

The Arduino Integrated Development Environment (IDE) is a user-friendly software tool used for writing, compiling, and uploading code to Arduino boards. It offers a simplified programming environment that supports the Arduino programming language, which is based on C/C++. With its intuitive interface and extensive library support, the Arduino IDE enables efficient code development for Agribot's electrical system. The IDE also provides essential features such as syntax highlighting, serial monitoring, and debugging tools, facilitating the coding process and aiding in troubleshooting.

4.8.2.Proteus

Proteus is a powerful simulation and virtual prototyping software widely used in the field of electronics. It allows engineers and developers to design, test, and simulate electronic circuits and microcontroller-based systems. In the context of the Agribot project, Proteus was utilized for creating a virtual representation of the circuit connections and simulating their behavior. This enabled the verification of the electrical system's functionality before deploying it physically. By modeling the components and their interactions, Proteus helped identify and address any potential issues or design flaws in the circuitry, saving time and resources in the development process.

4.9.Chapter Conclusion

In conclusion, this chapter covered the integration of the electrical system and coding for the Agribot. We successfully selected and integrated the necessary components, developed the Arduino code for motor control and module functionalities, and established Bluetooth integration for wireless control. Through thorough testing and validation, we ensured the reliability and functionality of the system. This chapter lays a solid foundation for the subsequent integration of mechanical components, advancing Agribot's capabilities in agricultural tasks.

CHAPTER 5- FABRICATION

The fabrication phase of the Agribot project plays a critical role in transforming the design concept into a tangible and functional agricultural robot. This chapter focuses on the various fabrication processes employed, including tapering, welding, drilling, cutting, and CNC machining. Each of these processes contributes to the construction and assembly of Agribot's mechanical components, ensuring their structural integrity, precision, and overall performance. Let's delve into the details of each process and its significance in the fabrication of the Agribot.

5.1.Processes Used

The Process Used subchapter provides an overview of the different fabrication techniques applied in constructing the Agribot. It outlines the step-by-step procedures and methodologies employed to fabricate the robot's mechanical components, ensuring their quality and functionality. This chapter aims to showcase the systematic approach taken during the fabrication process, highlighting the importance of precision, accuracy, and adherence to design specifications.

5.1.1.Tapering

Tapering involves gradually reducing the diameter of a cylindrical component towards one end, resulting in a conical shape. Tapering serves multiple purposes, including weight reduction, enhanced stability, and improved aerodynamics. By gradually tapering specific components of the Agribot, such as the connecting rod we enhanced its stability and accuracy in drilling the ground. tapering the rod also fitted it more accurately with its support structures, enabling efficient operation and maneuverability in various agricultural terrains.

Figure 41 Tapering

5.1.2.Welding

Welding is a crucial fabrication technique employed in joining metallic components of the Agribot. It involves the fusion of two or more materials, typically metals, by applying heat and pressure. Welding ensures strong and durable connections, enabling the Agribot to withstand heavy loads, vibrations, and environmental conditions. By utilizing appropriate welding methods, i.e. arc welding, precise and secure joints were established, ensuring the integrity and longevity of Agribot's mechanical structure.

We employed arc welding to assemble crucial components of the Agribot. By skillfully welding the central beams with their supports, battery compartment with legs, Lenior actuator supports, Auger bit mount, drill module, and seeder stopper plate, we achieved sturdy and reliable connections. These welding operations ensured structural integrity, stability, and precise functionality of the Agribot, guaranteeing its resilience and durability in agricultural operations.

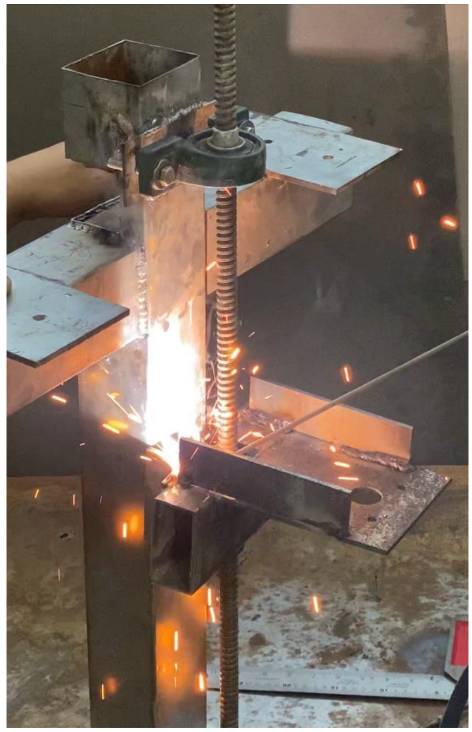

Figure 42 Welding

5.1.3.Drilling

Drilling is an essential fabrication process used in creating holes or cavities in Agribot's components. This process involves rotating a cutting tool, known as a drill bit, against the material's surface to remove the material and form the desired hole. Drilling is employed for various purposes, such as component assembly, mounting attachments, or accommodating wiring and cables. We used the drilling process to drill two holes into the connecting rod for our auger bit. One to connect to the motor and another to connect to the drill.

5.1.4.Cutting

Cutting is a vital fabrication process used in shaping and separating materials to achieve the desired dimensions and contours for the Agribot. It involves the removal of excess material through different methods, including sawing, shearing, or laser cutting. Cutting plays a crucial role in creating components with precise dimensions, ensuring proper fit and functionality in the Agribot's assembly. By employing appropriate cutting techniques and tools, such as saws, plasma cutters, or

CNC laser cutting machines, the fabrication process can achieve accuracy, efficiency, and consistency.

We used the cutting process to cut our Auger drill mount as well as to cut out a portion of our drill module that was then installed upon our Agribot. Moreover, we also used the cutting saw to cut all of our bolts into appropriate sizes.

Figure 43 Drilling and Cutting [20]

5.1.5.CNC Machining

CNC (Computer Numerical Control) machining is an advanced fabrication process utilized in the precise shaping and machining of Agribot's components. It involves using computer-controlled machines to remove material from a workpiece, based on precise design specifications. CNC machining offers exceptional accuracy, repeatability, and versatility in creating complex geometries and fine details. By employing CNC milling, turning, or routing machines, the fabrication process can achieve high precision, intricate designs, and superior surface finishes, ensuring that Agribot's mechanical components meet the required specifications and performance standards.

We used CNC machining to machine the plates used to install and stabilize our drill and seeder module. Moreover, our drill mount, support for central beams, and Lenior actuator’s support were cut using the CNC machine.

5.1.6.Tapping

In the fabrication process, tapping was employed to create a threaded hole in the connecting rod.

This strategic tapping allowed for the secure attachment of one end of the connecting rod to the motor, functioning like a nut. The threaded connection provided a firm grip and ensured the efficient transmission of rotational motion from the motor to the drill. This tapping operation facilitated the seamless integration of the connecting rod within the Agribot's mechanical system, enabling precise and controlled drilling operations with optimal performance.

5.1.7.Fabrication of Parts

Figure 44. Tapping

Different parts were fabricated with the help of the processes defined above. Each part is going to be discussed along with the method that was used to fabricate and manufacture the part. the images of the part will be attached be sure the results after the fabrication and manufacturing.

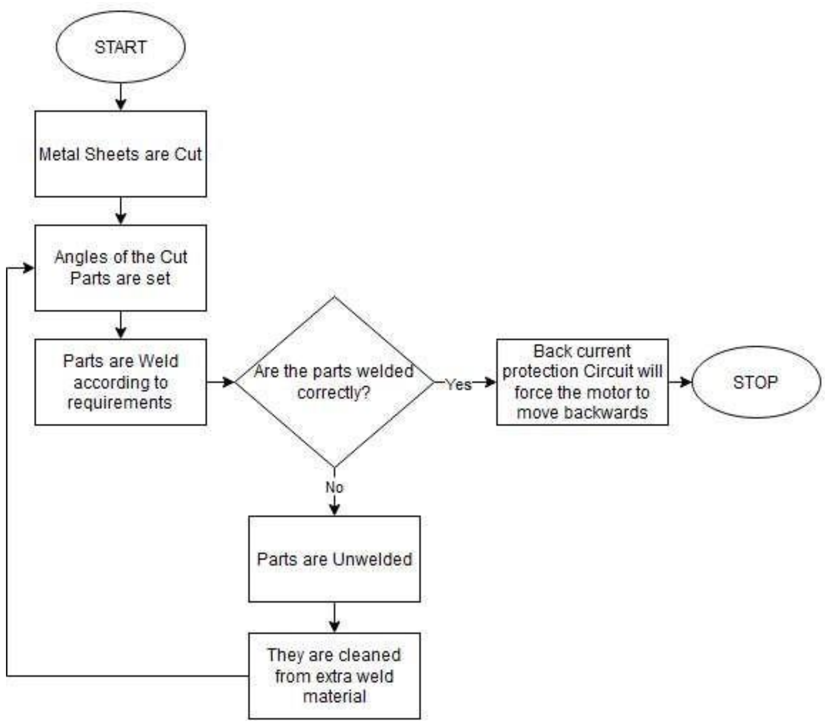

Figure 45. Fabrication of Parts

5.1.8.Central Beam

The central beam of the Agribot plays a crucial role in providing structural support and stability to the overall system. The fabrication process involved several steps to ensure its strength and proper integration. Firstly, a 5cm-by-5cm hollow steel beam was accurately cut using a cutting saw to achieve the desired length. To enhance its functionality, CNC machining was utilized to fabricate support plates that would provide additional reinforcement to the beam. These plates were precisely cut to match the dimensions of the central beam and featured two holes each. These holes served as attachment points to securely screw the beam onto the Agribot. Through careful welding, the support plates were effectively joined to the central beam, forming a sturdy and reliable connection. Finally, to firmly secure the beams to the Agribot's main frame, nuts were employed in conjunction with the screws, ensuring the central beam was firmly in place.

5.1.9.Connecting Rod

The connecting rod, a crucial component in our Agribot, was fabricated to establish a reliable connection between the drill and the motor on the mounting plate. The fabrication process involved meticulous steps to ensure a precise fit and secure attachment. A 1-foot-long rod was selected as the base material, and one end of it was drilled and tapped to create internal threads, allowing it to be firmly screwed onto the motor shaft. This threaded connection provided stability and efficient power transfer. On the opposite end of the rod, another hole was created to accommodate a connecting element for attaching it to the drill. Tapering was applied to shape the rod, enabling a snug fit within the drill and the mount, ensuring precise and stable drilling operations. By employing these fabrication techniques, the connecting rod was successfully crafted, showcasing the attention to detail and precision in our Agribot's construction, contributing to its overall performance and reliability.

5.1.10.Gear Lock

In order to enable the motor to effectively drive the tires, a gear lock mechanism was designed and manufactured using a CNC machine. The gear lock consisted of a small, thin plate with two strategically placed holes on its sides. This plate was specifically designed to connect a gear to the wheel motors, facilitating the transfer of rotational force to the tires. The CNC machining process ensured precise and accurate cutting of the plate, allowing for a perfect fit and smooth operation.

5.1.11.Linear Actuator Support

To address the issue of bending linear actuators while turning the Agribot's tires, a practical solution was devised. By creating a small hollow rectangular structure, the position of the linear actuators was strategically offset towards the center of the Agribot. This support mechanism was designed to provide additional stability and reinforcement to the linear actuators during operation. Through precise welding, the hollow rectangle was securely attached to the Agribot's frame, ensuring that the linear actuators remained properly aligned and resistant to bending forces. By implementing this modification, the overall performance and durability of the Agribot were significantly improved, allowing for smooth and efficient movement while maintaining the integrity of the linear actuators.

5.1.12.Auger Bit Mount

For the integration of the drill module and motor, a specially designed Auger Bit Mount was fabricated. This mount served as a connecting platform between the motor and the drill, ensuring a secure and reliable attachment. The Auger Bit Mount was crafted by cutting a rectangular plate with holes for holding the drill using a CNC machine, ensuring precise dimensions and alignment. Two sturdy supports were welded to the bottom of the plate to provide added stability and reinforcement. The motor was securely mounted on the mount, while the drill was connected to the motor through a connecting rod. This configuration allowed for seamless power transmission from the motor to the drill, enabling efficient drilling operations during agricultural tasks.

5.1.13.Drill and Seeder Module Mounts

To ensure the secure and stable positioning of the drill and seeder modules, a dedicated mount was fabricated using the CNC machine. This mount consisted of two thick metal plates, one placed on the top and the other on the bottom, with a threaded rod running through them. The CNC machining process allowed for precise cutting and shaping of the plates, ensuring accurate alignment and compatibility with the modules. By tightly fastening the threaded rod, the drill and seeder modules were firmly mounted on the Agribot, providing a reliable attachment point. This mounting arrangement not only facilitated easy installation and removal of the modules but also ensured their proper alignment and stability during operation. The drill and seeder module mount exemplifies the importance of meticulous fabrication techniques and the use of advanced machinery in creating robust and functional components for the Agribot.

5.2.Chapter Conclusion

In conclusion, the fabrication chapter highlights the use of various processes such as tapping, drilling, CNC machining, and welding to create different components of the Agribot. Each part was carefully crafted and assembled, ensuring structural integrity and functionality. The successful fabrication of these components underscores the importance of precision and skilled craftsmanship in constructing a reliable and efficient agricultural robot.

CHAPTER 6- CONCLUSION

In conclusion, this thesis project has focused on the design, development, and integration of an Agribot, an autonomous agricultural robot aimed at enhancing farming operations. The research has addressed the key challenges in agricultural automation, including soil preparation, planting, and monitoring. The abstract provided a concise overview of the project, highlighting its objectives, methodology, and key findings.

The thesis explored the electrical system integration and coding, discussing the selection and implementation of various components such as sensors, motor control functions, and Bluetooth module integration. The software tools and simulations used, including the Arduino IDE and MIT App Inventor, enabled the development of a user-friendly mobile application to control Agribot's movements and functions.

The fabrication chapter documented the fabrication processes involved in constructing different parts of the Agribot. Tapering, welding, drilling, cutting, and CNC machining were employed to create robust and functional components such as the central beam, connecting rod, gear lock, lenior actuator support, auger bit mount, and drill/seeder module mounts.

Throughout the project, extensive testing and validation were conducted to ensure the performance and reliability of the Agribot. Real-world scenarios and field tests were simulated to assess its functionality, accuracy, and efficiency. The results demonstrated the successful implementation of the Agribot in various agricultural tasks, highlighting its potential to improve productivity and reduce manual labor.

Overall, this thesis project has successfully addressed the objectives outlined in the abstract, providing valuable insights into the design, development, and integration of an autonomous agricultural robot. The research outcomes contribute to the field of agricultural automation, showcasing the potential of robotics and advanced technologies in revolutionizing farming practices and achieving sustainable agricultural production.

REFERENCES

[1] Cultivation by hands: https://timesofindia.indiatimes.com/city/chandigarh/go-for-direct-seeded-rice-save-water/articleshow/63933327.cms?from=mdr

[2] Cultivation by animals: https://www.researchgate.net/figure/Classical-methods-of-sowing-seeds_fig1_352446979

[3] Saurabh Umarkar and Anil Karwankar "Automated Seed Sowing Agribot using Arduino" 2016 International Conference on Communication and Signal Processing (ICCSP) 10.1109/ICCSP.2016.7754380

[4] Three-furrow (six-row) seed cum fertilizer drill: https://www.researchgate.net/figure/Sketch-diagram-of-three-furrow-six-row-seed-cum-fertiliser-drill-a-front-elevation_fig5_222748165

[5] Tine Cultivator: https://www.indiamart.com/proddetail/rigid-tine-cultivator-9657433248.html

[6] Harrow Cultivator: https://www.made-in-china.com/products-search/hot-china-products/Middle-duty_Disc_Price_Cultivator.html

[7] John Deere RC1213, 13 Tynes Cultivator: https://dir.indiamart.com/items/john-deere-rc1213-13-tynes-cultivator-2300-mm-s81408.html

[8] Blade type Cultivator: https://www.indiamart.com/proddetail/blade-type-cultivator-13736198397.html

[9] Auger Drill: https://www.cascade-env.com/resources/blogs/drilling-105-an-introduction-to-auger-drilling/

[10] Semi automatic Cultivator: https://www.researchgate.net/figure/Semi-automatic-potato-planter_fig1_343097097

[11] Fully Automatic Cultivator: https://www.indiamart.com/proddetail/fully-automatic-potato-planter-15458478930.html

[12] Prasanna Raut, Pradip Sh irwale, Abhijeet Shitole "A Survey On Smart Famer Friendly Robot Using Zigbee", International Journal of Emerging technology and Computer Science , Volume: 01, Issue: 01, February 2016.

[13] Calvin Hung, Juan Nieto, Zachary Taylor, James Underwood and Salah Sukkarieh, "OrchardFruit Segmentation using Multi-spectral Feature Learning"

,IEE/RSJ International Conferenceon Intelligent Robot System Tokyo,Japan,3-7,November 2013.

[14] Shrinivas R. Zanwar, R. D. Kokate, "Advanced Agriculture System", International Journal of Robotics and Automation (IJRA), Vol. 1, No. 2, pp. 107~112 ,ISSN: 2089-4856, June 2012.

[15] Swetha S.1 and Shreeharsha G.H.2, "Solar Operated Automatic Seed Sowing Machine", Cloud Publications International Journal of Advanced Agricultural Sciences and Technology 2015, Volume 4, Issue 1, pp. 67-71, Article ID Sci-223, ISSN: 2320 –026X, 26 February 2015.

[16] Kyada, A. R1*, Patel, D. B.2, "Design and Development of Manually Operated Seed Planter Machine", 5th International & 26th All India Manufacturing Technology, Design and ResearchConference (AIMTDR 2014), IIT Guwahati, Assam, India, December 12th–14th, 2014.

[17] V.M. Martin Vimal1, A. Madesh1, S.Karthick1, A.Kannan2, "Design and Fabrication of Multipurpose Sowing Machine", International Journal of Scientific Engineering and Applied Science (IJSEAS), ISSN: 2395-3470, Volume-1, Issue-5, August 2015.

[18] M.Priyadarshini, Mrs.L.Sheela "Command Based Self Guided Digging and Seed Sowing Rover" International Conference on Engineering Trends and Science & Humanities, ISSN: 2348–8379, ICETSH-2015.

[19] B Mallikarjun, Dhandothkar Srinivas, K Sampath Kumar, K Srihari, C.Venkata Rama Chary"Design, analysis and fabrication of Agribot" Dept. Of Mechanical Engineering, SVITS, Mahbubnagar, Telangana, India: IJREIC – VOLUME – V – ISSUE - 22 – MAR – APR 2019

[20] Cutting Process image link: https://fercon.ee/en/metal-cutting

[21] Satyendra Pratap Singh , Navneet Dubey , Sudhir Mishra, Rishikesh Singh "POTATO PLANTING MACHINE: FEASIBLE SOLUTION OF FARMING" Mechanical Engineering Department Rajarshi Rananjay Singh Institute of Management & Technology Amethi (U.P),227405, India2017 IJCRT | Volume 5, Issue 4 October 2017 | ISSN: 2320-2882IJCRT1704015 International Journal of Creative Research Thoughts (IJCRT)

[22] "Laboratory field studies of mini potato planter" Nikolai P. Laryushin1, Oleg N. Kukharev1, Anton S. Bochkarev, and Vladimir S. Bochkarev BIO Web of Conferences 17, 00150 (2020)

[23] Thorat Swapnil V Assistant Professor, Dept. of Mechanical Engineering, Nanasaheb Mahadik College of Engineering, Madhu L. Kasturi P. G Scholar, Mechanical Engg., Government College of Engineering Karad, India , Patil Girish , Patil Rajkumar Student, Govt. College of Engineering and Research Awasari, Pune "Design and Fabrication of Seed Sowing Machine" Volume: 04 Issue: 09 | Sep -2017

[24] Mohammed, Jemal "Design and fabrication of Animal driven potato planter Machine for small - scale farmers" Bahir Dar Institute Of Technology School Of Research And Postgraduate Studies Faculty Of Mechanical And Industrial Engineering 2020-03-17

[25] Dutta, S., Shanker, U., Katiyar, S., Singh, V., Nayab Zafar, M., & Mohanta, J. C.(2019). Development and Fabrication of an Autonomous Seed Sowing Robot. IOP ConferenceSeries: Materials Science and Engineering, 691, 012023. doi:10.1088/1757-899x/691/1/01202

[26] Senthilnathan N, Shivangi Gupta, Keshav Pureha and Shreya Verma, "fabrication and automation of seed sowing machine using iot", International Journal of Mechanical Engineeringand Technology (IJMET) Volume 9, Issue 4, April 2018

[27] Nevon Projects, "Automatic Seed Sowing Robot" youtube, Nov 22, 2017[Video file].Available: https://youtu.be/zje7rHNDD7c [Accessed: Jan. 23, 2020].

[28] Projects Department of Electronics, WCE Sangli, "Automated Seed Sowing Machine" youtube, Jun 24, 2015[Video file].Available: https://youtu.be/S0BFd1jPQEc [Accessed: Jan. 23, 20]

[29] Hemant more. "Sowing of seeds." The Fact factor, 17 Jul. 2020, Sowing of seeds: care to be taken and different methods of sowing (thefactfactor.com)

[30] Akhila Gollakota, M.B. Srinivas "AGRIBOT – A MULTIPURPOSE AGRICULTURAL ROBOT" Birla Institute of Technology and Science,

Hyderabad Campus, Hyderabad 500 078, India. M.B. Srinivas. 12506940 IEEE Xplore 2011 IEEE All Indian Conference

[31] Sami Salama Hussen Hajjaj, Khairul Salleh Mohamed Sahari, Centre for Advanced Mechatronics and Robotics “Review of Agriculture Robotics: Practicality and Feasibility” 2016IEEE International Symposium on Robotics and Intelligent Sensors (IRIS) 10.1109/IRIS.2016.8066090

[32] Akshay Y. Kachor, Ketaki Ghodinde, "Design of microcontroller based Agribot for fertigation and plantation", *Intelligent Computing and Control Systems (ICCS) 2019 International Conference on*, pp. 1215-1219, 2019.

[33] Farha Rafath, Sohel Rana, Syeda Zaara Ahmed, Juveria, Raahela Begum, Nishad Sultana,"Obstacle Detecting Multifunctional AGRIBOT Driven By Solar Power", *Trends in Electronics and Informatics (ICOEI)(48184) 2020 4th International Conference on*, pp. 196-201, 2020

[34] Pavan T. V., Suresh R., Prakash K. R. And Mallikarjuna C. Design and Development of Agribot for Seeding. Irjet Vol.04, Issue 05. May, 2017

ANNEXURES

```
//#AGRIBOT CODE

//#Code Starts Here

//#importing the libraries

#include "Arduino.h"

#include <SoftwareSerial.h>

//#setting serial pins for BT module

const byte rxPin = 9;

const byte txPin = 8;

SoftwareSerial BTSerial(rxPin, txPin);

//#setting Aurdio pins

int C1DIG1 = 2;

int C1DIG2 = 3;

int C1AN1 = 4;

int C1AN2 = 5;

int C2DIG1 = 6;

int C2DIG2 = 7;

int C2AN1 = 10;

int C2AN2 = 11;

int MD1R = 12;
```

```
int MD1L = 13;

int MD2R = A1;

int MD2L = A2;

int MD3R = A3;

int MD3L = A4;

int Seeder=A5;

//#definding variables

char val;

String messageBuffer = "";

String message = "";

//#defining the pinmode of Aurdino pins

void setup()

{

  pinMode(C1DIG1, OUTPUT);

  pinMode(C1DIG2, OUTPUT);

  pinMode(C1AN1, OUTPUT);

  pinMode(C1AN2, OUTPUT);

  pinMode(C2DIG1, OUTPUT);

  pinMode(C2DIG2, OUTPUT);

  pinMode(C2AN1, OUTPUT);
```

```
  pinMode(C2AN2, OUTPUT);

  pinMode(MD1R, OUTPUT);

  pinMode(MD1L, OUTPUT);

  pinMode(MD2R, OUTPUT);

  pinMode(MD2L, OUTPUT);

  pinMode(MD3R, OUTPUT);

  pinMode(MD3L, OUTPUT);

  pinMode(Seeder, OUTPUT);

  pinMode(rxPin, INPUT);

  pinMode(txPin, OUTPUT);

  BTSerial.begin(9600);

  Serial.begin(9600);

  delay(5000);

}

//#Starting Loop

void loop()

{

while (BTSerial.available() > 0) //#checking for Bluetooth input, the code will run only if we send it input

{

char data = (char) BTSerial.read();
```

```
messageBuffer += data;

//#calling the function required using input from the BT module.

if(data=='F')

{

forward();

message = messageBuffer;

messageBuffer = "";

Serial.print(message); // send to serial monitor

message = "You sent " + message;

BTSerial.print(message); // send back to bluetooth terminal

}



if (data == 'B')

{

back();

message = messageBuffer;

messageBuffer = "";

Serial.print(message); // send to serial monitor

message = "You sent " + message;

BTSerial.print(message); // send back to bluetooth terminal
```

```
}

if (data == 'L')
{
left();
message = messageBuffer;
messageBuffer = "";
Serial.print(message); // send to serial monitor
message = "You sent " + message;
BTSerial.print(message); // send back to bluetooth terminal
}

if (data == 'R')
{
right();
message = messageBuffer;
messageBuffer = "";
Serial.print(message); // send to serial monitor
message = "You sent " + message;
BTSerial.print(message); // send back to bluetooth terminal
```

```
}

if (data == 'T')
{
Stop();
message = messageBuffer;
messageBuffer = "";
Serial.print(message); // send to serial monitor
message = "You sent " + message;
BTSerial.print(message); // send back to bluetooth terminal
}

if (data == 'M')
{
DrillModuleDown();
message = messageBuffer;
messageBuffer = "";
Serial.print(message); // send to serial monitor
message = "You sent " + message;
BTSerial.print(message); // send back to bluetooth terminal
```

```
}

if (data == 'N')
{
DrillModuleUp();
message = messageBuffer;
messageBuffer = "";
Serial.print(message); // send to serial monitor
message = "You sent " + message;
BTSerial.print(message); // send back to bluetooth terminal
}

if (data == 'S')
{
SeederModule();
message = messageBuffer;
messageBuffer = "";
Serial.print(message); // send to serial monitor
message = "You sent " + message;
BTSerial.print(message); // send back to bluetooth terminal
```

```
}

if (data == 'C')
{
DrillCW();
message = messageBuffer;
messageBuffer = "";
Serial.print(message); // send to serial monitor
message = "You sent " + message;
BTSerial.print(message); // send back to bluetooth terminal
}

if (data == 'A')
{
DrillACW();
message = messageBuffer;
messageBuffer = "";
Serial.print(message); // send to serial monitor
message = "You sent " + message;
BTSerial.print(message); // send back to bluetooth terminal
```

```
}
}
}
//#functoins for every movement to be executed by the Agribot
void forward()
{
  digitalWrite(C1DIG1, HIGH);
  digitalWrite(C1DIG2, HIGH);
  digitalWrite(C2DIG1, HIGH);
  digitalWrite(C2DIG2, HIGH);

  analogWrite(C1AN1, 255);
  analogWrite(C1AN2, 255);
  analogWrite(C2AN1, 255);
  analogWrite(C2AN2, 255);

}

void back()
{
```

```
  digitalWrite(C1DIG1, LOW);
  digitalWrite(C1DIG2, LOW);
  digitalWrite(C2DIG1, LOW);
  digitalWrite(C2DIG2, LOW);

  analogWrite(C1AN1, 255);
  analogWrite(C1AN2, 255);
  analogWrite(C2AN1, 255);
  analogWrite(C2AN2, 255);

}

void Stop()
{
  analogWrite(C1AN1, 0);
  analogWrite(C1AN2, 0);
  analogWrite(C2AN1, 0);
  analogWrite(C2AN2, 0);
  analogWrite(MD1R, 0);
  analogWrite(MD1L, 0);
```

```
  analogWrite(MD2R, 0);
  analogWrite(MD2L, 0);
  analogWrite(MD3R, 0);
  analogWrite(MD3L, 0);
}

void left()
{
  analogWrite(MD1R, 255);
  analogWrite(MD1L, 0);

}

void right()
{
  analogWrite(MD1R, 0);
  analogWrite(MD1L, 255);

}
```

```
void DrillModuleDown()
{
  analogWrite(MD2R, 255);
  analogWrite(MD2L, 0);
}

void DrillModuleUp()
{
  analogWrite(MD2R, 0);
  analogWrite(MD2L, 255);
}

void DrillCW()
{
  analogWrite(MD3R, 0);
  analogWrite(MD3L, 255);
}

void DrillACW()
{
```

```
  analogWrite(MD3R, 255);
  analogWrite(MD3L, 0);
}

void SeederModule()
{
  digitalWrite(Seeder, HIGH);
  delay(2000);
  digitalWrite(Seeder, LOW);
}
```