Spring 2024

Mechatronics System Design Project

Technical Report

Team 12

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Abstract

This report details the project of the mechatronics system design course showcasing an automated production line with sorting and assembly. The line features a machine vision system using Python for intelligent component sorting, a multi-functional robotic arm for handling, assembly, and storage, and an Arduino-based control system for seamless operation. This project demonstrates the potential for automating manufacturing processes through integrated design, control systems, and machine vision.

- Introduction
- Project overview & Specifications
- Each system= Design
- Control = Electronics used, PCB, actuators used, micro controllers used, communication, PID How it was implemented and why

INTRODUCTION

The relentless march of automation in manufacturing necessitates the development of increasingly sophisticated production lines.

Figure 1

This report presents a mechatronics project that tackles this challenge by showcasing a fully functional, automated production line with integrated sorting and assembly capabilities.

The line incorporates several key features that demonstrate the power of automation and intelligent systems.

MACHINE VISION WITH PYTHON

At the heart of the intelligent material handling system lies a camera coupled with machine vision software powered by Python.

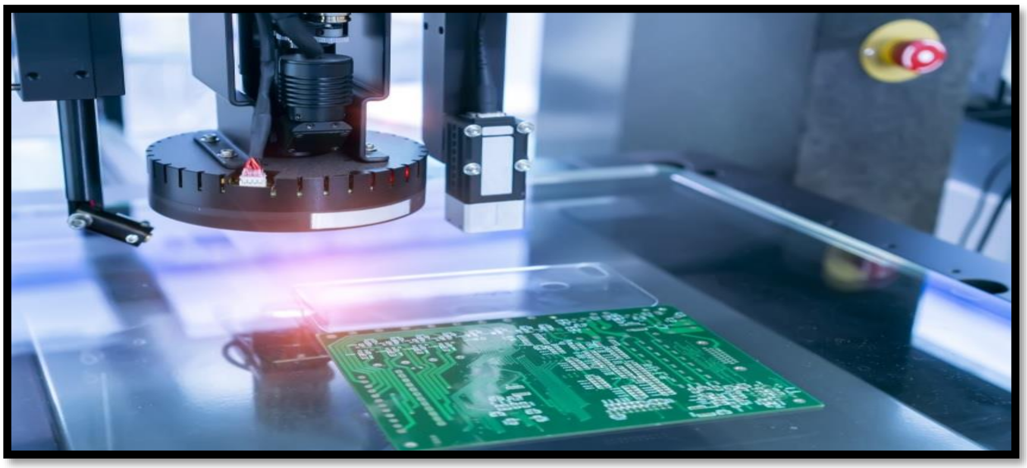


Figure 2

This software utilizes sophisticated image processing algorithms to identify and sort components based on predefined parameters, such as size, shape, or color. This ensures accurate material flow throughout the production process, minimizing errors and maximizing efficiency.

MULTI-FUNCTIONAL SCARA ROBOTIC ARM

The workhorse of the line is a complex robotic arm programmed for a trio of critical tasks: handling, assembly, and storage.

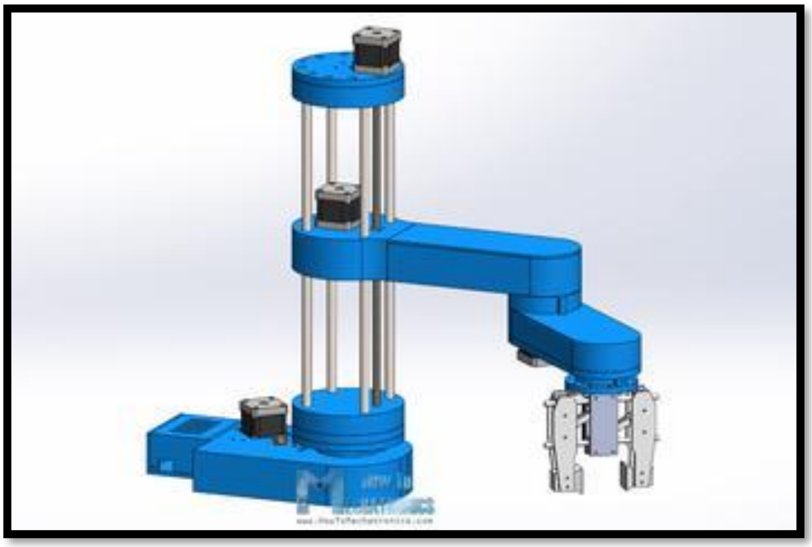


Figure 3

This eliminates the need for manual intervention across these critical stages, enhancing production line consistency and minimizing human error. The arm's design and programming allow for precise movements and manipulation of components, ensuring a smooth and reliable assembly process.

SEAMLESS CONTROL SYSTEM WITH ARDUINO AND PYTHON

An Arduino-based control system acts as the brain of the line, managing conveyor, triggering real-time camera-based sorting, and seamlessly integrating with the robotic arm's programming.

Python may further enhance control with data logging and performance monitoring, optimizing overall production flow.

SYSTEM DESIGN

INITIAL DESIGN STAGE

Requirements & Initial System Design

GENERAL INITIAL LAYOUT

In the beginning, after several meetings the team agreed on the following design layout in fig.4 as the cornerstone for the whole project.

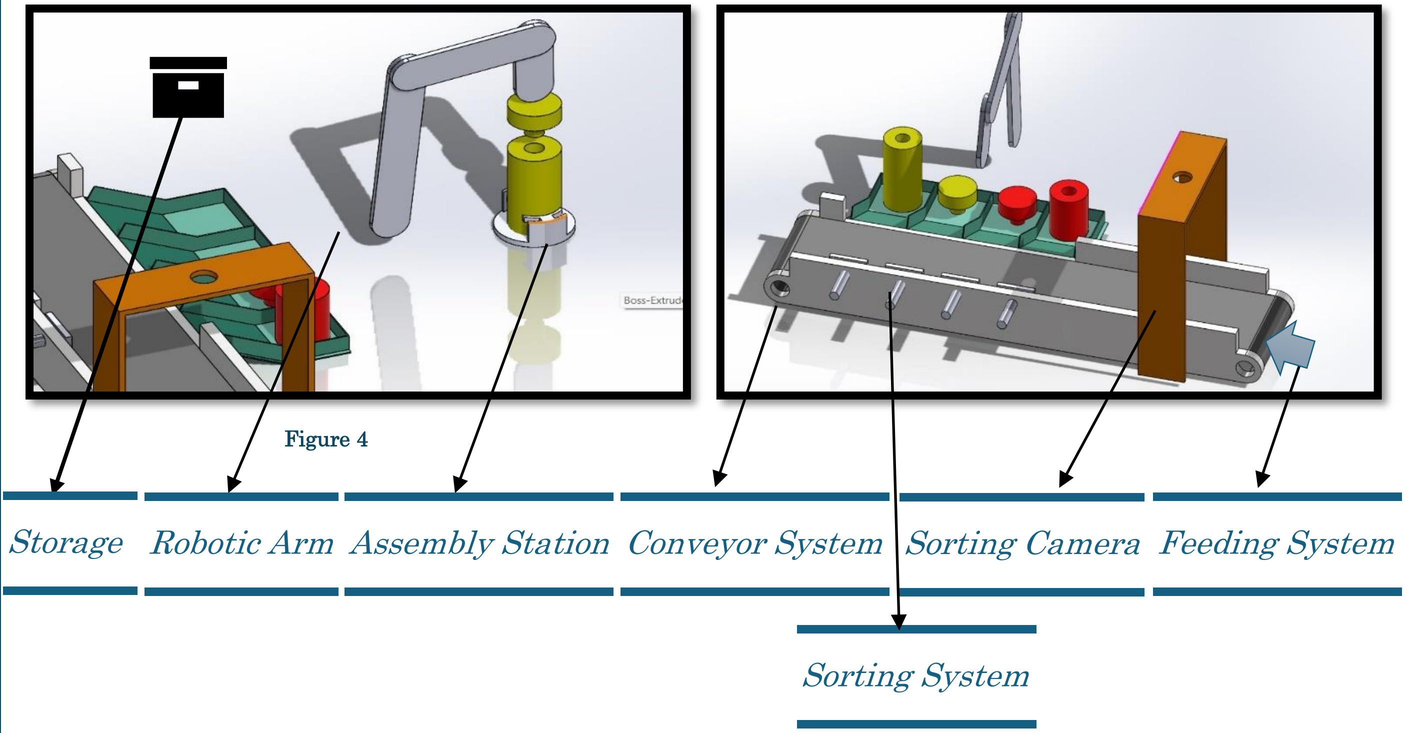


Figure 4

ADDITIONAL CONSTRAINS

After that, it was imperative to determine the constrains that is needed to facilitate the design procedure, these constraints were:

I. Product Dimensions, Shape & Material

II. Degrees of freedom needed for the robotic arm.

III. Speed of the conveyor.

IV. Total time of the process.

CHOSEN INITIAL SPECIFICATIONS

- ***Product Specification:*** Cylinder, 40 mm diameter, 70 mm length, Made of two parts: Lid & Base
- ***Degrees of Freedom Needed:*** 4 DOF, SCARA Robotic Arm
- ***Speed of the conveyor:*** 0.25 m/s
- ***Total Time of the process:*** Can only be adjusted in the Control Phase but ideally 2 minutes (for every 2 products).

PROJECT PHASES

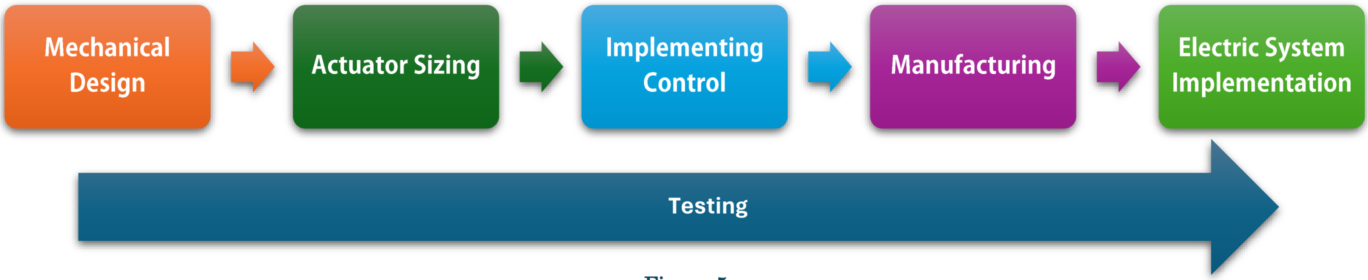


Figure 5

PRODUCTION LINE WORKING PROCEDURE

1) Product parts are placed in the magazine.
2) The Feeding System Introduces the part to the conveyor.
3) The conveyor transports the part to the sorting camera.
4) The Sorting Camera Designates the place of the part.
5) The conveyor keeps transporting the part.
6) The Sorting System introduces barriers to make the part reach its designated location.

(The previous processes are from 2 to 6 are repeated until 2 parts of the same product are in the sorting station)

7) The robotic arm moves the base on to the assembly station then assembles the lid on the base.
8) The Robotic arm handles the assembled product and stores it in the storage station.

FEEDING SUB-SYSTEM

DESIGN CONSIDERATIONS

During the design phase of this subsystem the following considerations were considered.

A. Max product part dimension.

B. How many types of products?

C. How many copies of the same product?

D. What mechanical mechanism should be used?

E. What will be used to control the mechanism?

F. Of what material will the sub-system be made of?

RESULTS AND CONCLUSIONS

a) **The max dimension of a part is 40mm diameter and 40mm length.**

b) **There are two types of products.**

c) **Each product has 2 copies.**

d) **The chosen mechanism was the "Rake & Pinion" to provide good pushing forces and easier to control the by a servo motor.**

e) **An Arduino will be used to control the system.**

f) **The Sub-System will be mostly made of laser cut wood of 3 mm and 6mm thickness.**

DESIRED WORKING PROCEDURE OF THE SUB-SYSTEM

1) Parts are loaded in the magazine in any order.

2) An IR sensor senses for the condition ***There is a next part in place.***

3) On activation the Arduino sends a signal to the servo motor to move be a certain angle to push the product to the conveyor.

4) Then the Arduino sends a signal to the servo motor to move by a certain angle to make the mechanism return to original position.

5) This will make the next part in the magazine move in the required position on its own.

6) The processes from 2 to 5 are repeated 3 more times.

SUB-SYSTEM LAYOUT

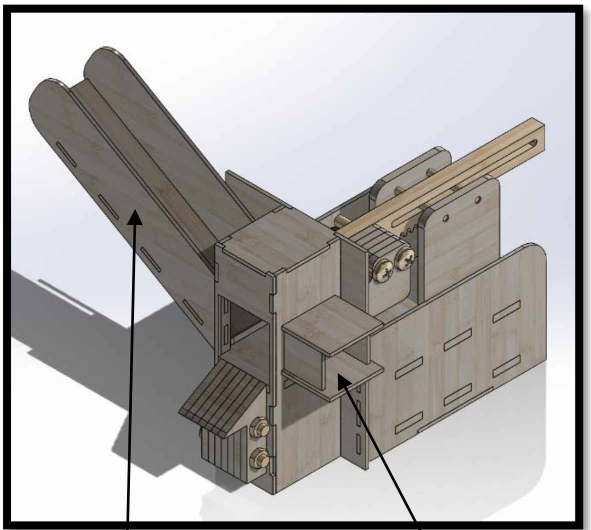


Figure 8

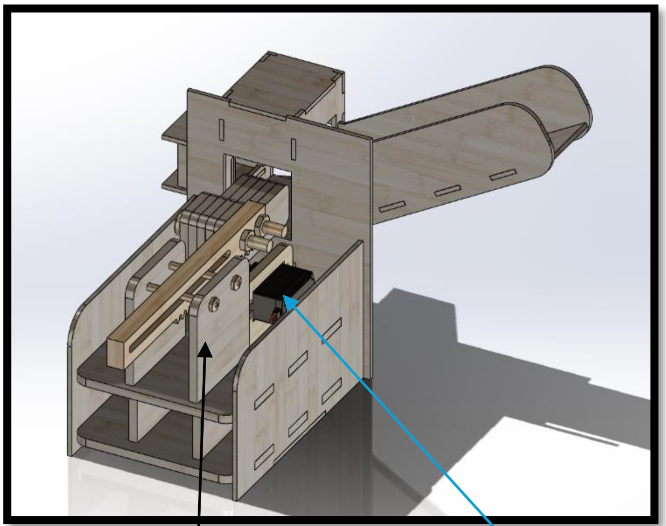


Figure 7

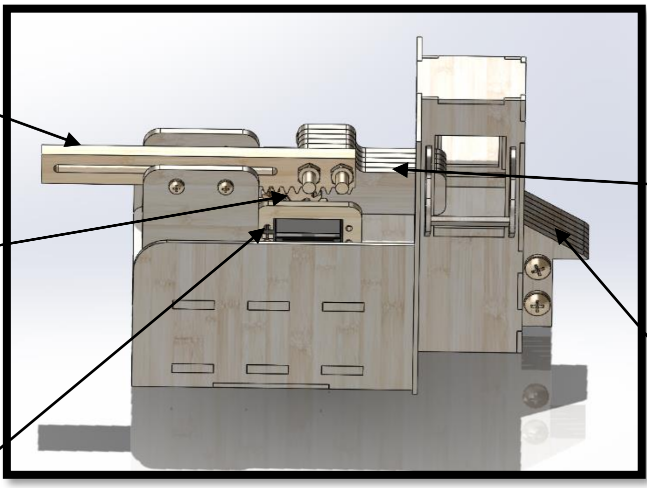


Figure 6

CONVEYOR SUB-SYSTEM

DESIGN CONSIDERATIONS

During the design phase of this subsystem the following considerations were considered.

A. Max product part dimension.

B. How Long should the conveyor be?

C. How many rollers are needed?

D. What materials should be used in this sub-system?

E. What type of power transmission should be used?

F. What bearing types and fixations methods should be used?

G. What will be used to control the sub-system?

H. How to adjust the required tension for optimal performance of the conveyor.

RESULTS AND CONCLUSIONS

a. **The max dimension of a part is 40mm diameter and 40mm length. So, the conveyor internal width should be about 50 mm wide.**

b. **50 cm length, to be able to provide the part with enough momentum to ease the sorting process and the length is suitable for the application.**

c. **By referring to a certain equation, it was concluded that 4 rollers are needed.**

d. **Laser cut wood of 3mm thick for conveyor body and artelon for rollers & end shaft and iron for the power shafts (As it will be subjected to high torque).**

e. **Transmission using flexible coupler; cheaper & more dependable.**

f. The 4|2 method of fixation using normal ball bearings and using the conveyor's body as housing for the bearings. Thus, it was concluded that the outer width of the conveyor should be about 60mm wide.

g. An Arduino will be used to control the system by controlling the DC motor that would drive the conveyor.

h. A tension mechanism will be used to adjust the tension of the conveyor.

DESIRED WORKING PROCEDURE OF THE SUB-SYSTEM

1) Upon the start of the entire system the conveyor starts to move
2) The conveyor only stops when an IR sensor close to the inspection camera detects an object (product part)
3) When the camera is done analyzing the conveyor continues to move.

SUB-SYSTEM LAYOUT

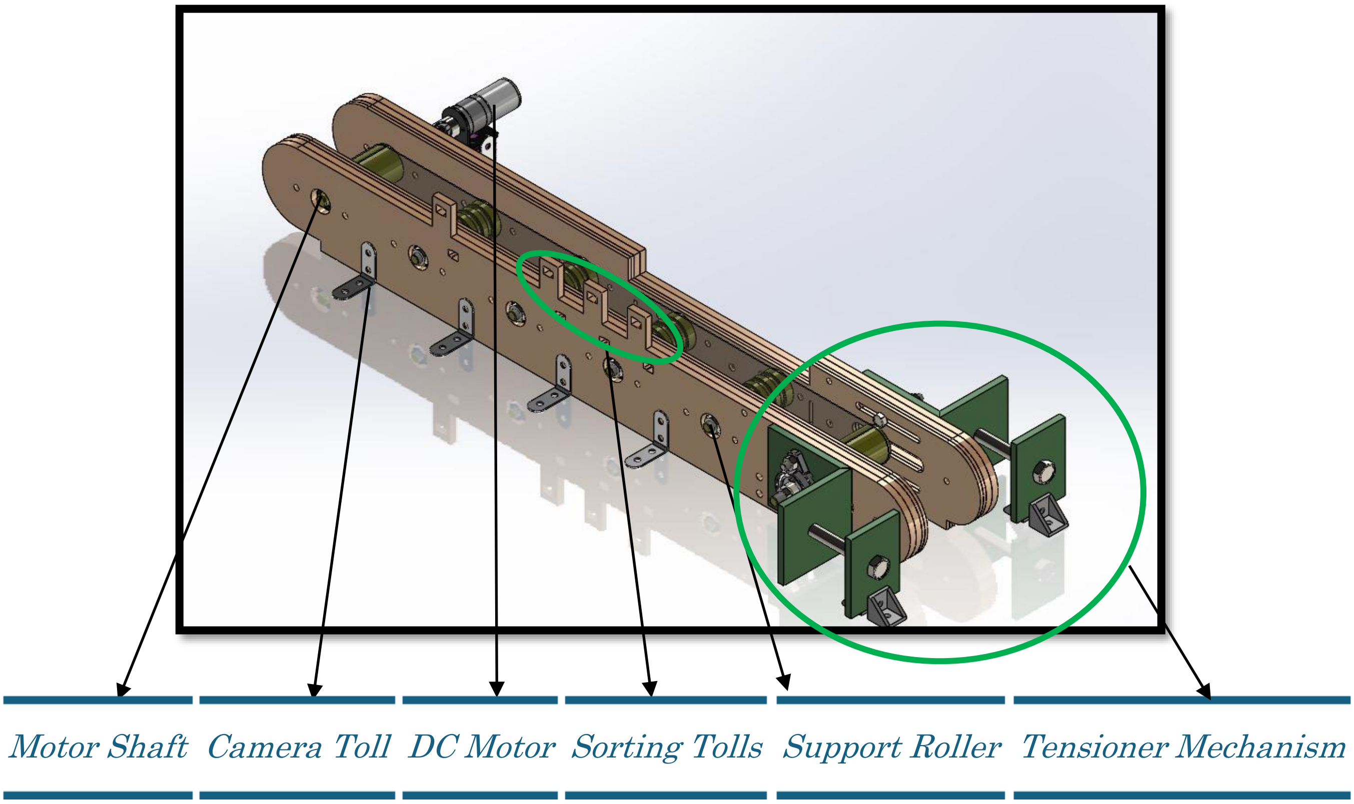


Figure 9

SORTING SUB-SYSTEM

DESIGN CONSIDERATIONS

During the design phase of this subsystem the following considerations were considered.

A. Make it easier to direct parts from the conveyor to the sorting station.

B. Material to be used.

C. Product part max size

D. Control?

RESULTS AND CONCLUSIONS

a. The Tolls are curved to ease the sorting of the parts.

b. Laser cut wood of 3mm thickness.

c. Cylinder 40 mm diameter, 40 mm length

d. Via Arduino and servo motors + Sorting Camera & Laptop

DESIRED WORKING PROCEDURE OF THE SUB-SYSTEM

1) On product discovery near the camera an IR sends a signal to the Arduino
2) The Arduino commands a servo motor to close the path of the product for inspection.
3) After the camera is done inspecting and designated the part to a particular lane. The path is opened.
4) The toll corresponding the designated lane is closed which makes the product enter its designated place in the sorting station.
5) Memory of that product part entry is stored.

6) When two parts of the same product are in the assembly station, the Arm receives a signal to start assembling those parts.

SUB-SYSTEM LAYOUT

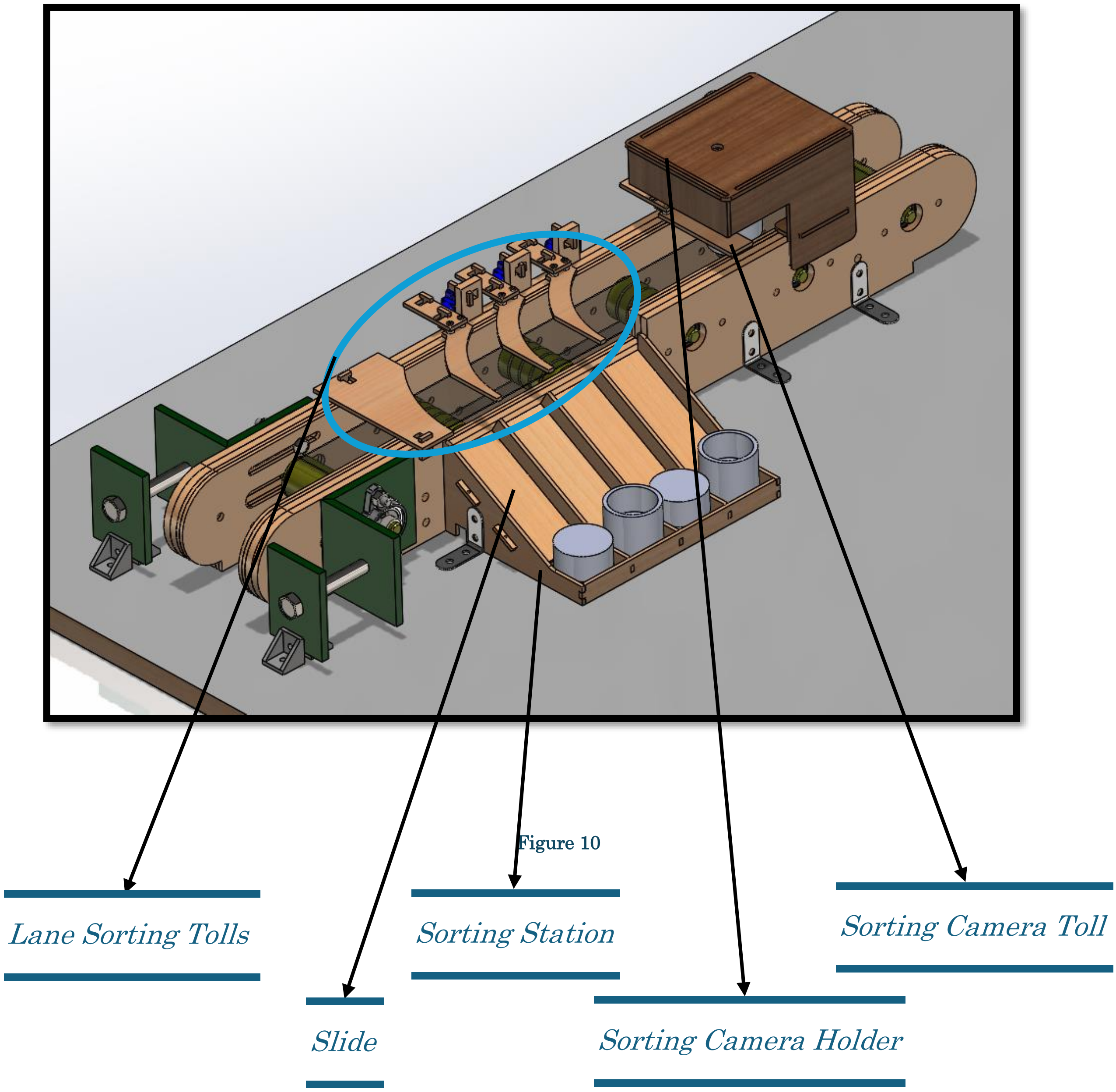


Figure 10

ROBOTIC ARM SUB-SYSTEM

DESIGN CONSIDERATIONS

During the design phase of this subsystem the following considerations were considered.

A. Degrees of Freedom Needed?

B. Functions to be done?

C. Max Angles to rotate by & Max elevation to reach from ground, weight?

D. Materials and Bearings needed?

E. Controlled by?

RESULTS AND CONCLUSIONS

a. 4 DOF

b. Handling → Gripper , Assembly → End Effector to rotate.

c. About 230° of rotation, about 40 cm of elevation.

d. Acrylic, artelon for body and some shafts respectively, steel for some joints and support shafts and leadscrew. Normal Ball bearing with 4|2 method of fixation, thrust bearing to support the leadscrew.

e. Arduino UNO, 3 Stepper Motors & 2 potentiometers, 2 DC motors. The DC motors are equipped with **encoders.** The encoders and the potentiometer serve to provide feedback to the control system.

DESIRED WORKING PROCEDURE OF THE SUB-SYSTEM

1) Two parts of the same product are in the sorting station.

2) The Arm takes the base and put it in the assembly station where its clamped.

3) The arm then takes the lid and assembles the lid with the base to form the complete product.
4) The clamping is released.
5) The arm takes the finished product and stores it in the storage station.

SUB-SYSTEM LAYOUT

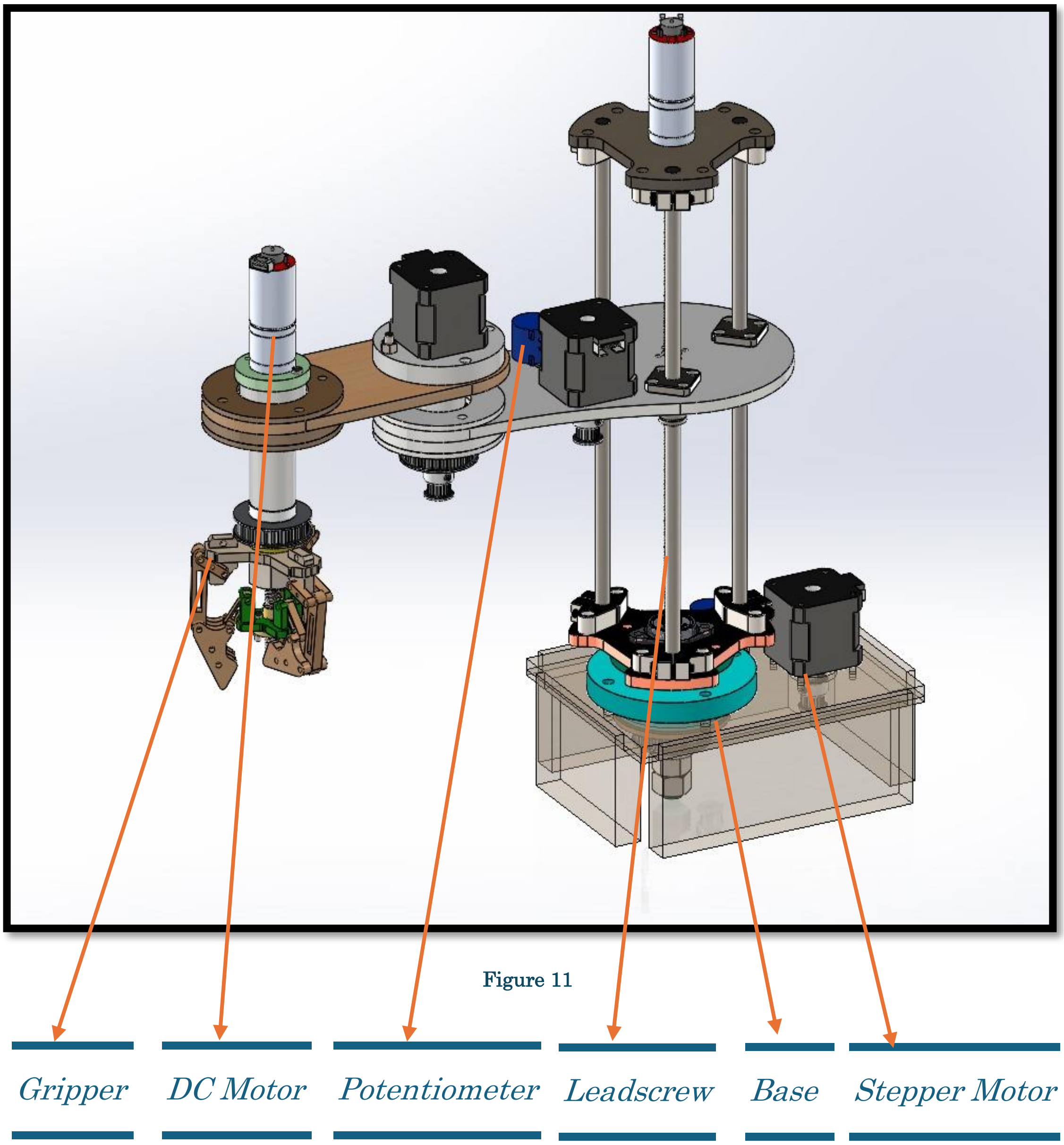


Figure 11

ASSEMBLY STATION

DESIGN CONSIDERATIONS

During the design phase of this subsystem the following considerations were considered.

A. Simple Design

B. Easy to be certain of the location of the product on clamping.

C. Material?

D. Control?

RESULTS AND CONCLUSIONS

a. A simple clamping mechanism will be used.

b. The V-shaped block.

c. Artelon and wood.

d. Using Arduino and servo motor.

DESIRED WORKING PROCEDURE OF THE SUB-SYSTEM

1) The robotic arm takes the base from the sorting station and puts it between the jaws of the mechanism.
2) The Arduino of this system gets a signal via communication that the arm put the part between the jaws.
3) The Arduino signals the servo motor to move with a certain angle to close the jaws.
4) After the arm is done with the assembly process, a signal is sent to this sub-system's Arduino.
5) The Arduino signals the servo motor to move with a certain angle to open the jaws.

6) The robotic arm takes the product and stores it in the Storage station.

SUB-SYSTEM LAYOUT

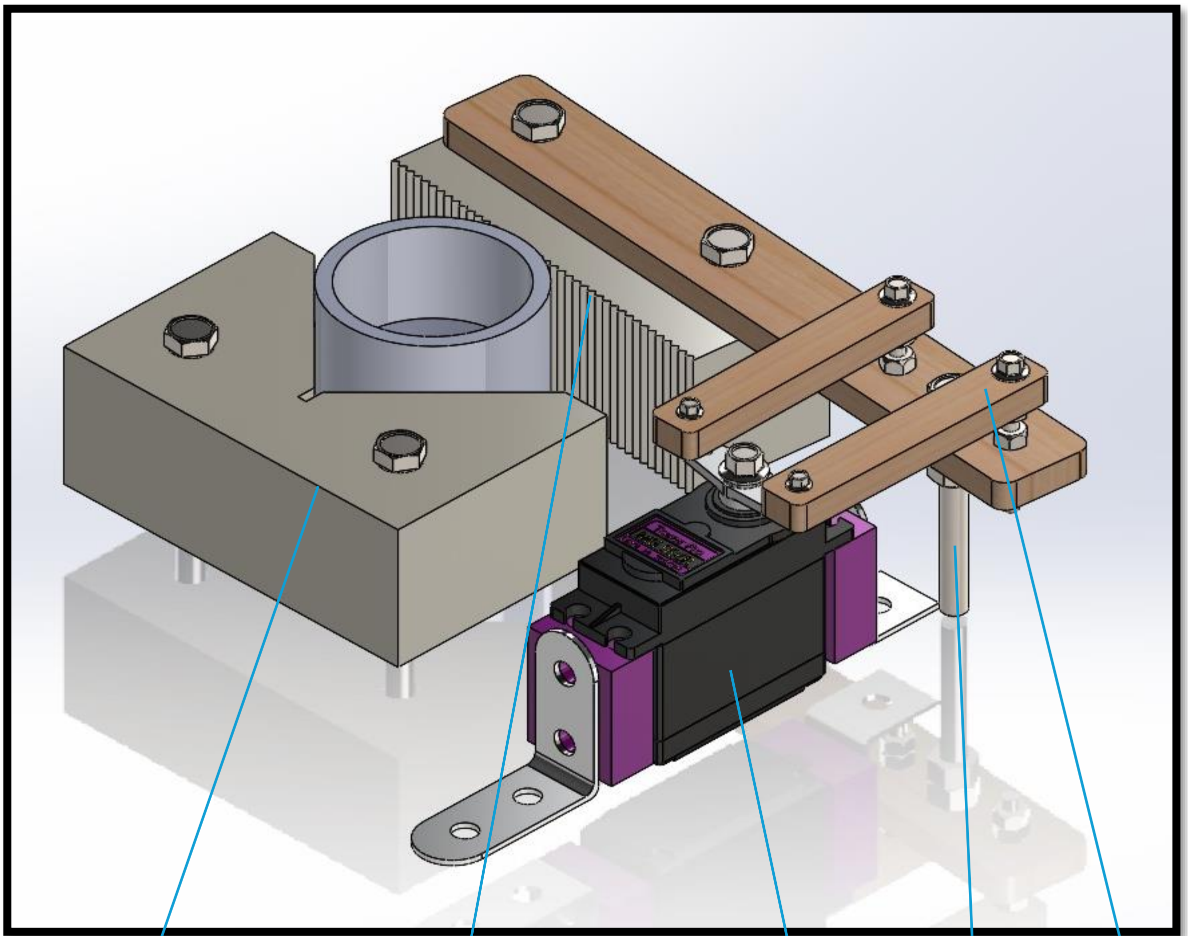


Figure 12

Lower Jaw (V-Block)

Upper Jaw

Servo Motor

Wooden Joints

Fixing Post

STORAGE STATION

DESIGN CONSIDERATIONS

During the design phase of this subsystem the following considerations were considered.

A. Max Product Dimension

B. No. of products

C. Make the movement of the robotic arm easier

D. Simple design

E. What material to use

RESULTS AND CONCLUSIONS

a. The Cylinder is 40 mm diameter 70 mm length.

b. 4 Products

c. Avoid Making Curved Edges and make the elevations simple.

d. Considered and made simple in appearance and assembly.

e. Laser Cut wood of 3mm thickness.

STATION LAYOUT

Figure 13

SYSTEM MODELING

MECHANICAL MODELING

Mechanical modeling refers to a simulation of the mechanical systems movements and their reactions. **<u>This was done on each relevant system, But here are the most notable systems.</u>**

SORTING

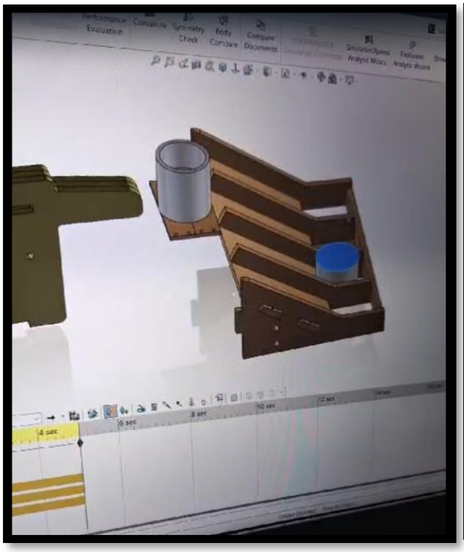


Figure 15

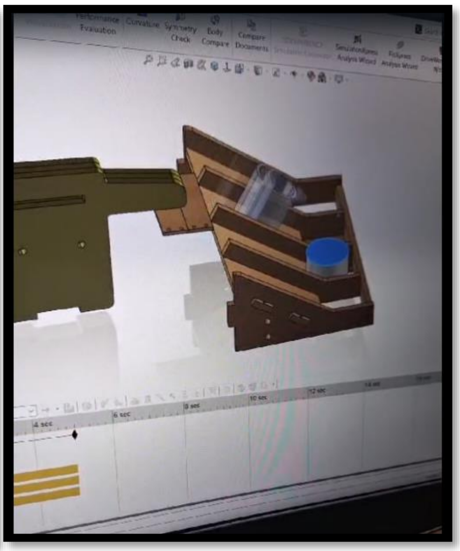


Figure 16

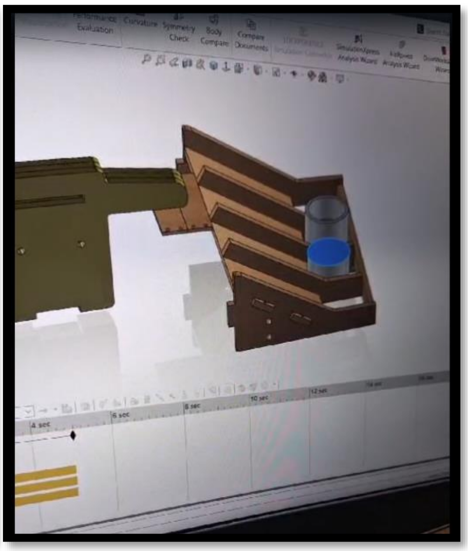


Figure 14

It was concluded that
the part needs at least an angle of 30° to slide comfortably.

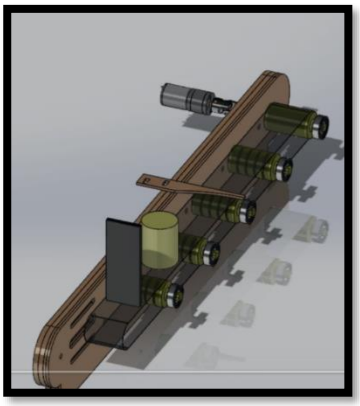


Figure 17

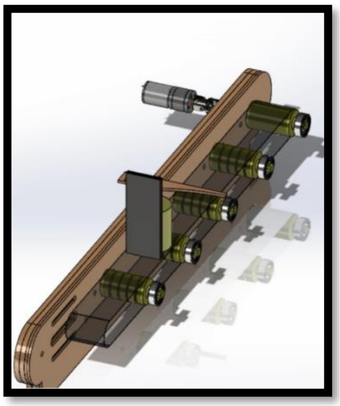


Figure 18

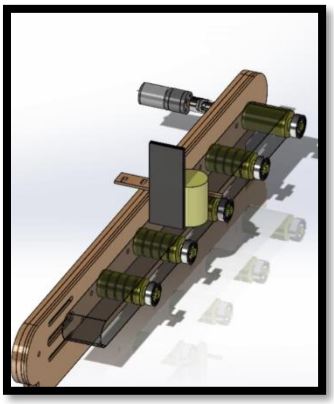


Figure 19

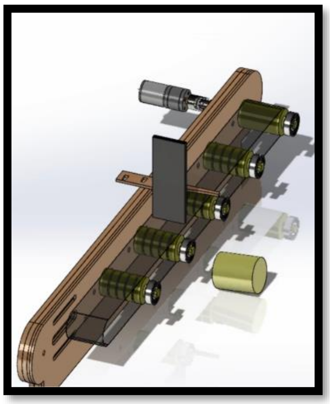


Figure 20

Mechanical simulation to test the angle of sorting toll.

ROBOTIC ARM

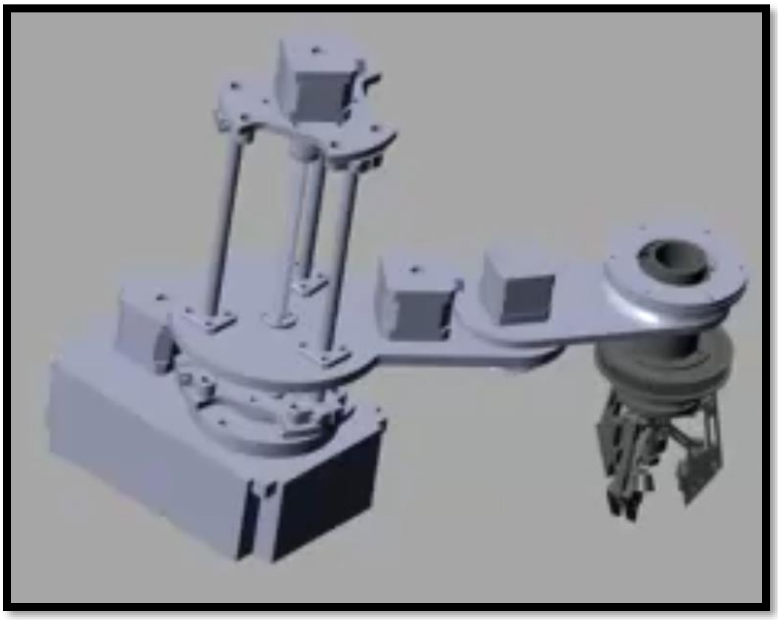


Figure 24

Figure 23

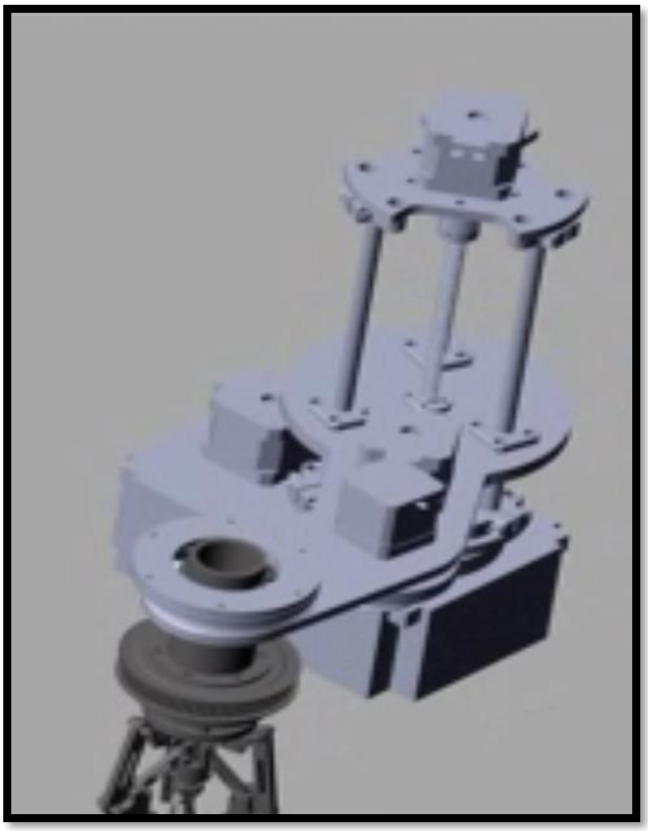


Figure 22

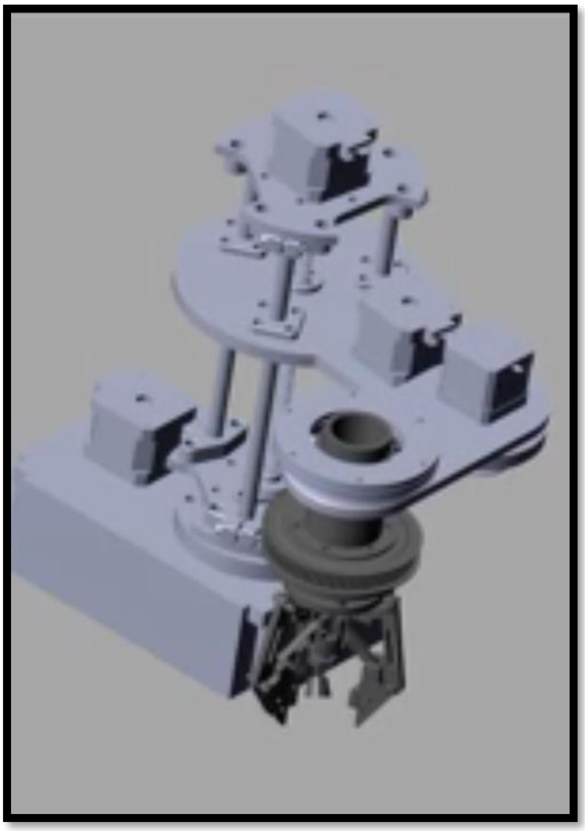


Figure 21

The arm moves in XYZ directions comfortably.

ASSEMBLY STATION

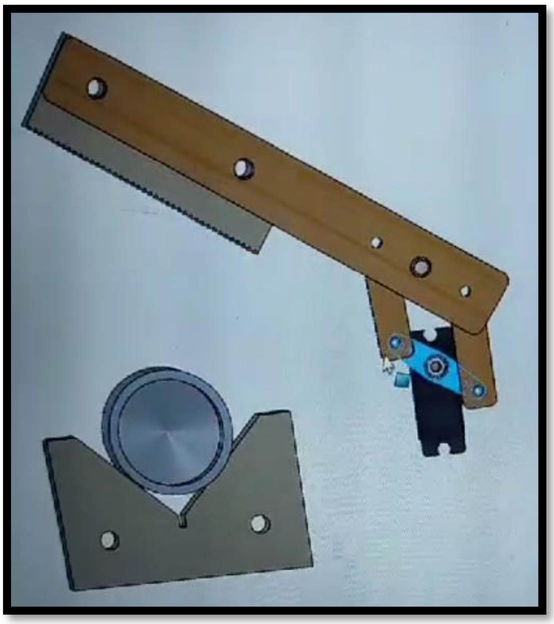


Figure 25

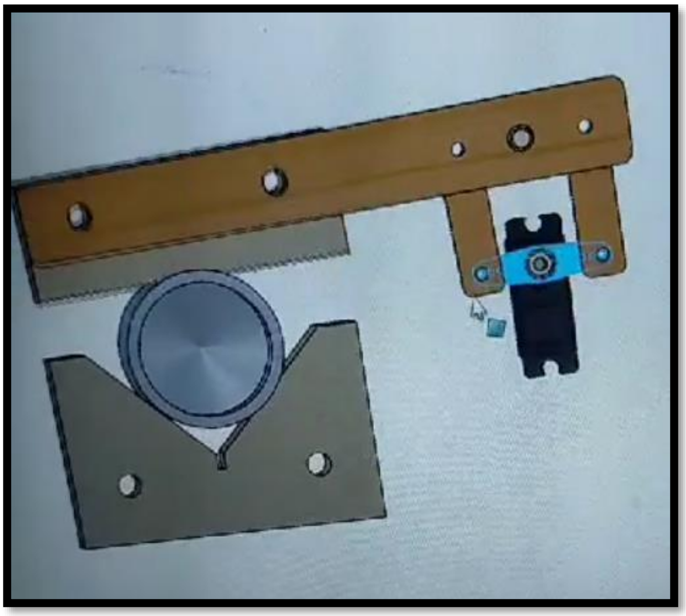


Figure 26

GRIPPER

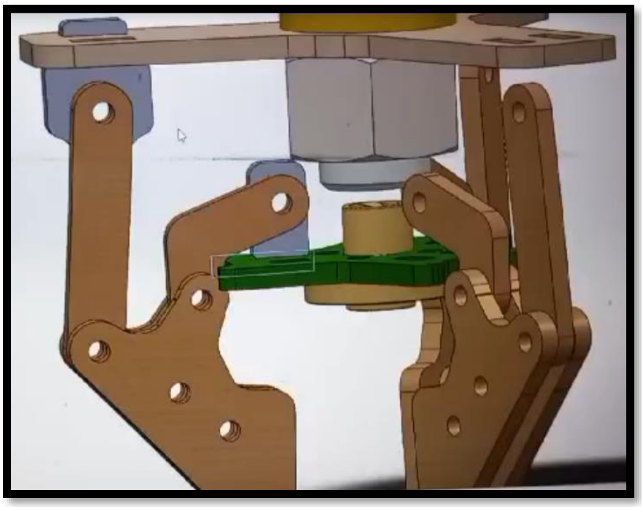


Figure 28

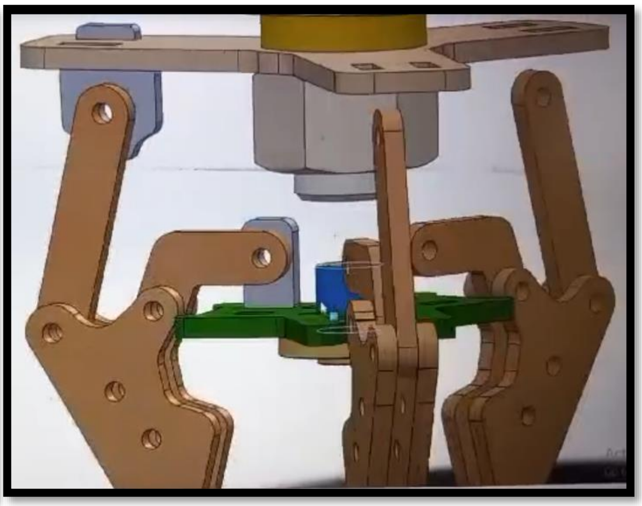


Figure 27

The Gripper opens comfortably and can hold the parts.

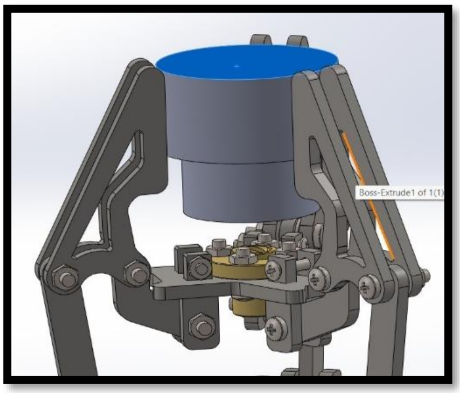


Figure 29

MATHEMATICAL MODELING

ACTUATOR SIZING

CONVEYOR

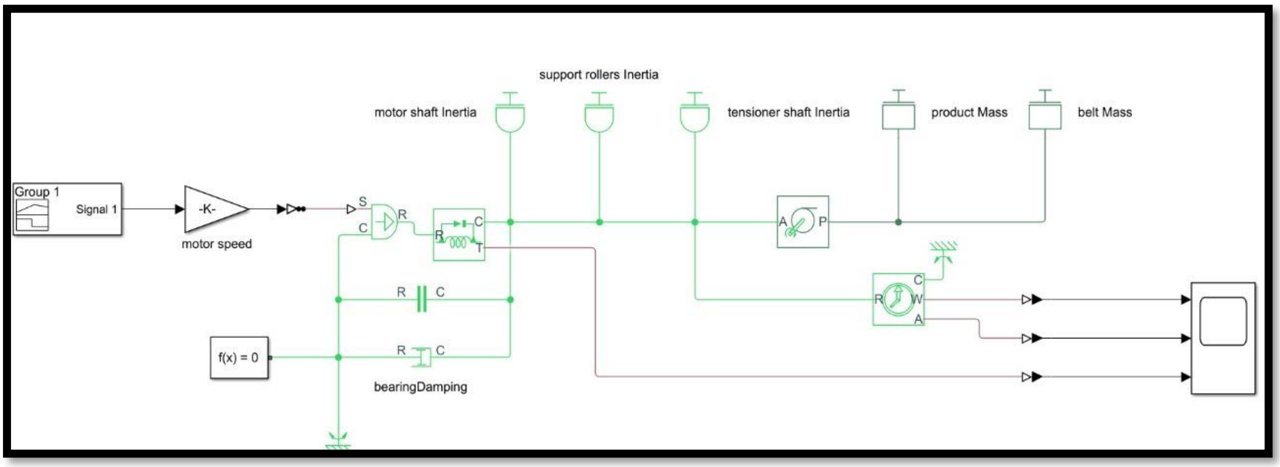


Figure 30

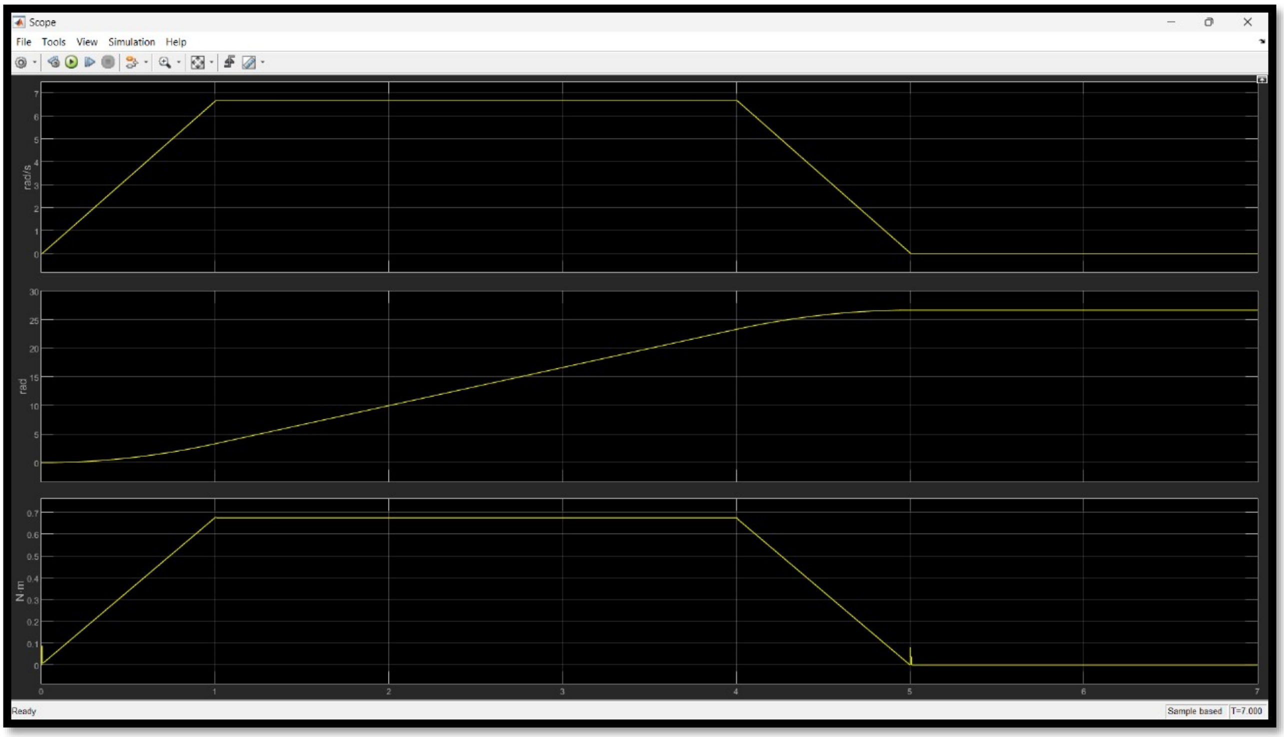


Figure 31

Editor - D:\Solid Works\mechatronics sys design\final project\conveyor\conveyor matlab\belt_tensic

belt_tension.m

```
E = 61e+05; %N/m^2
length = 1100; %mm
width = 50;
u = 0.01;
r=0.015; %mm
required_conveyor_speed = 0.1 ;%m/s

k = E*width / length ;
tensioned_distance = 1 ; %mm
belt_tension_force = k * tensioned_distance * 2 / 1000 ;
static_friction = belt_tension_force * u ;
rotational_static_friction = static_friction * r ;

conveyor_motor_speed = required_conveyor_speed / r ;
```

Figure 32

SORTING

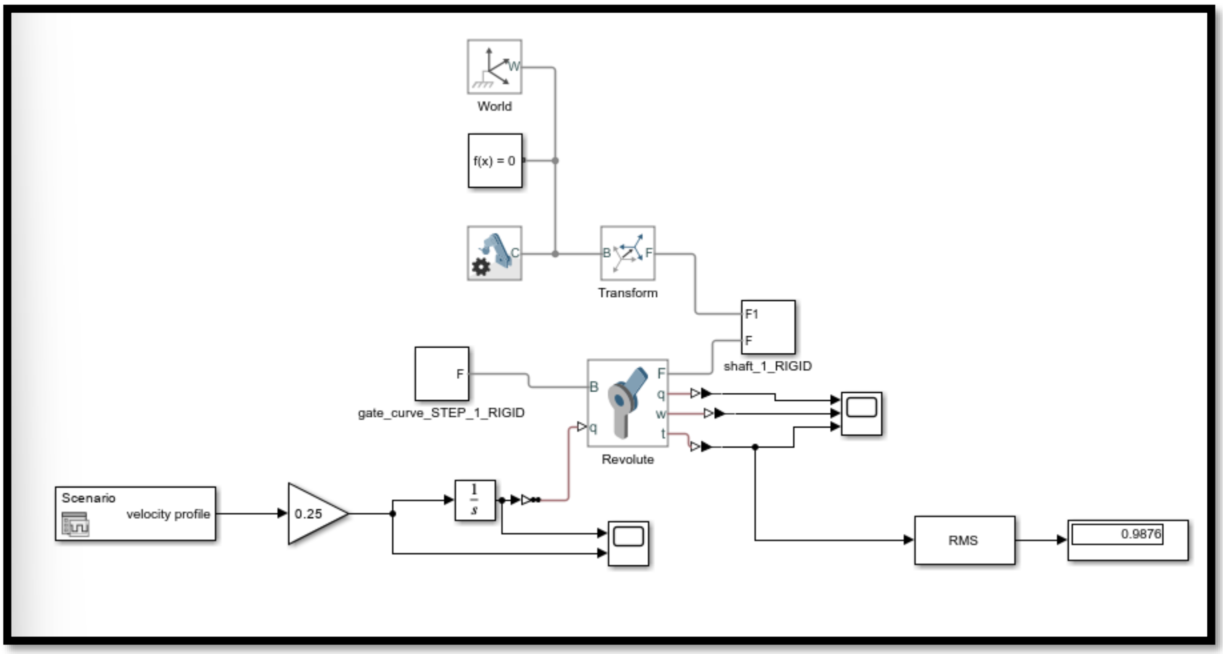


Figure 33

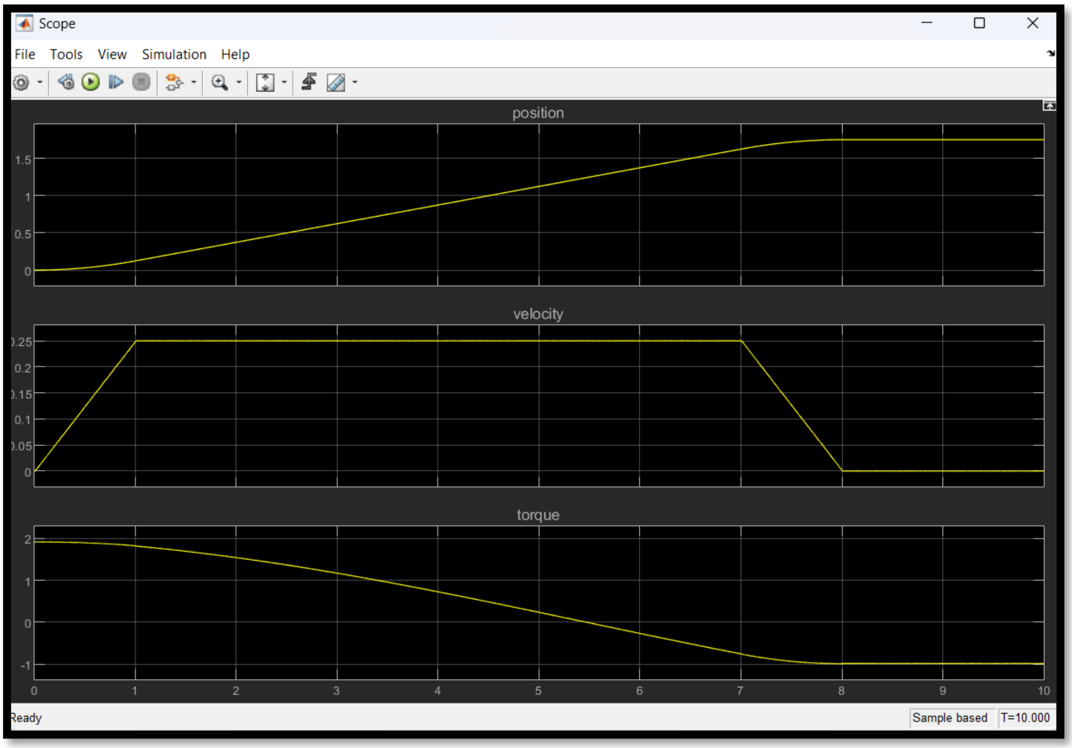


Figure 34

Max torque =2 N.mm
RMS torque =0.98 N.mm

ASSEMBLY STATION

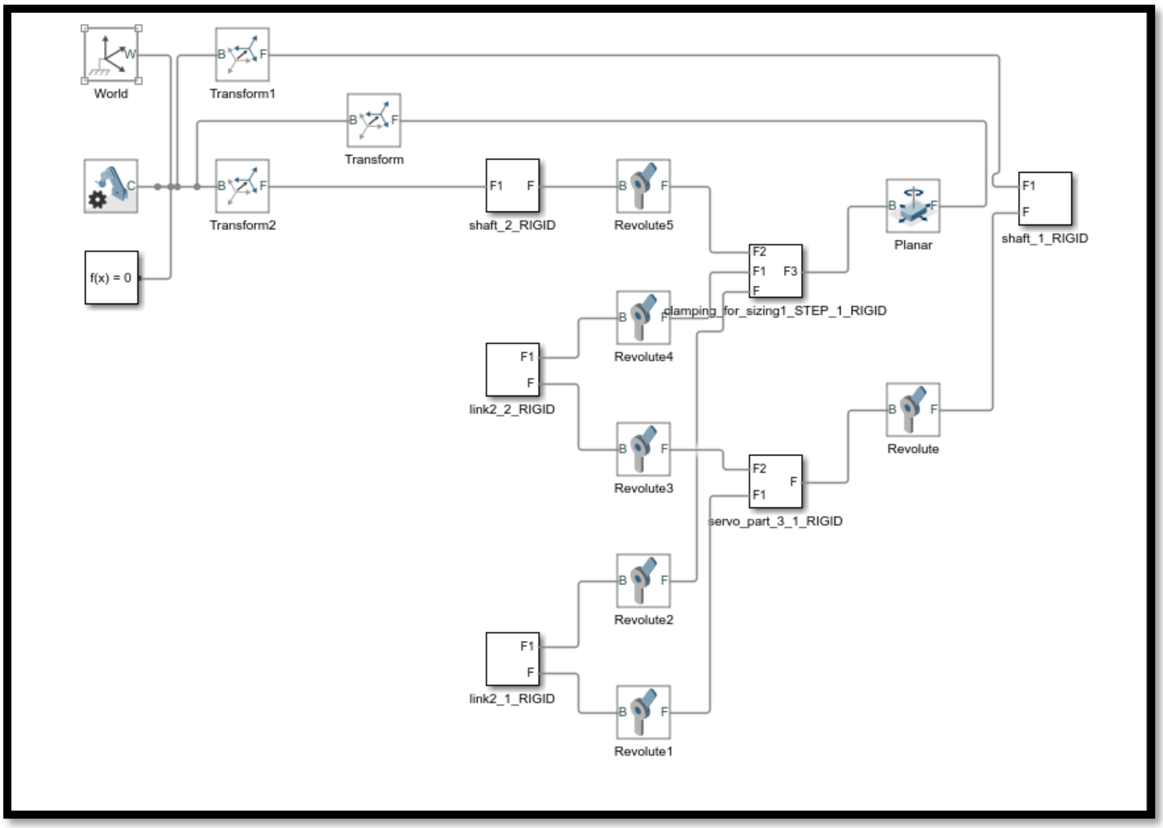


Figure 35

ROBOTIC ARM

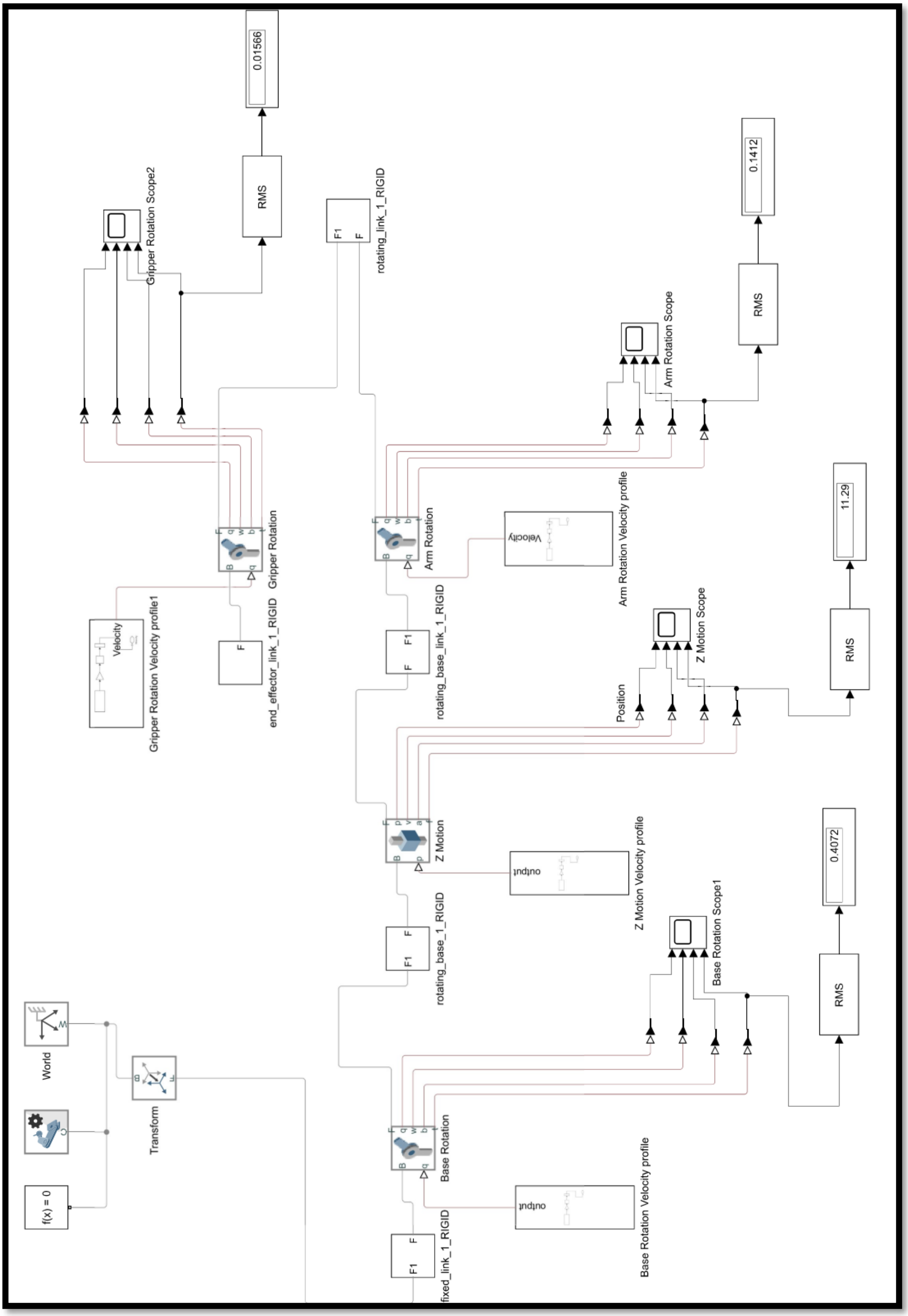


Figure 36

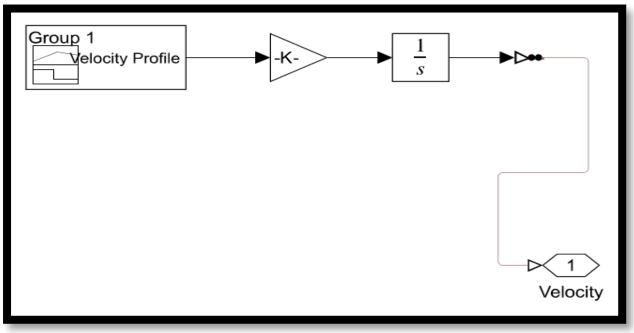


Figure 40

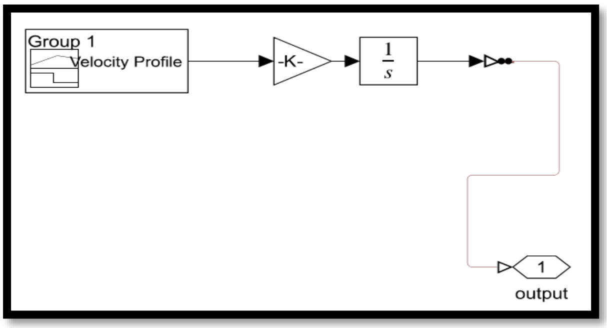


Figure 39

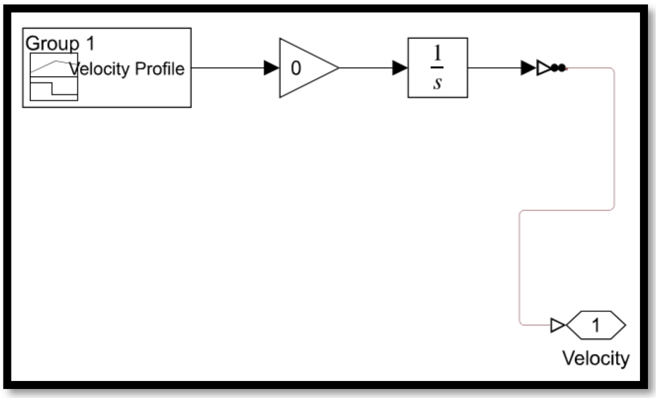


Figure 37

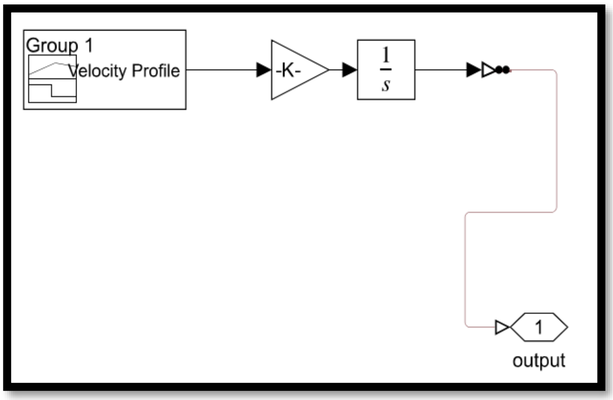


Figure 38

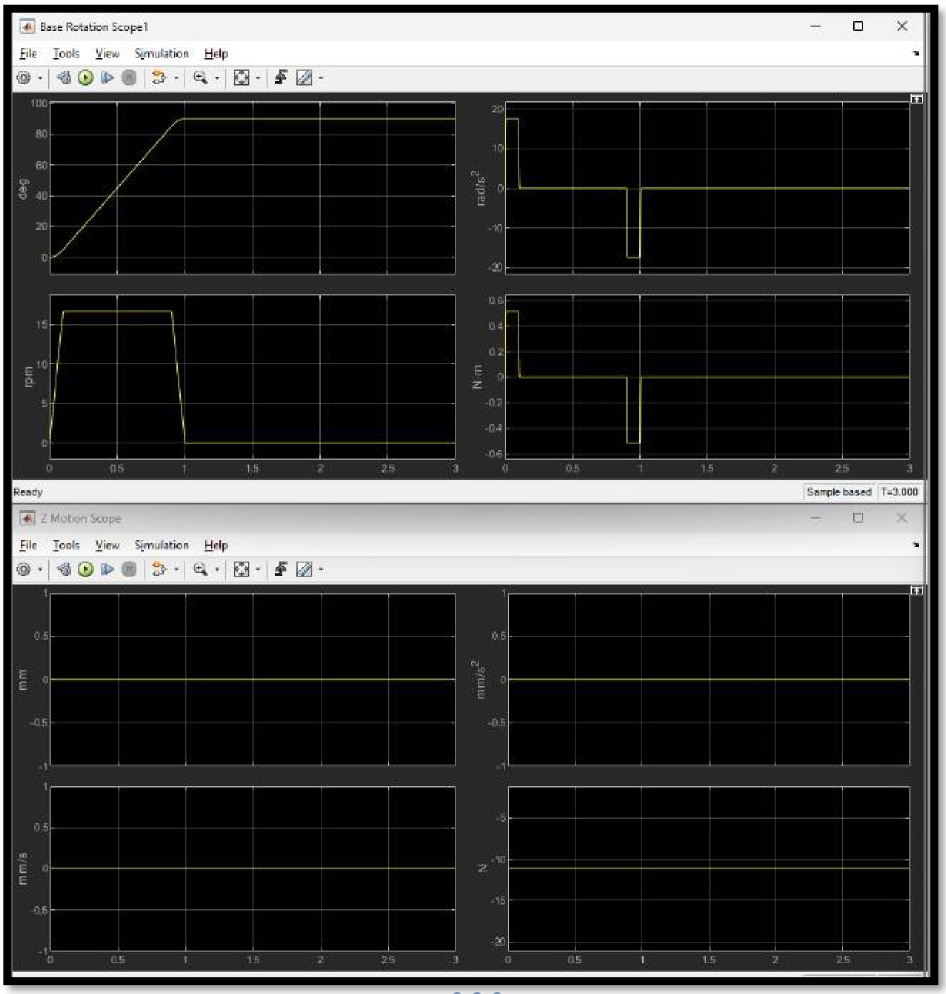


Figure 41

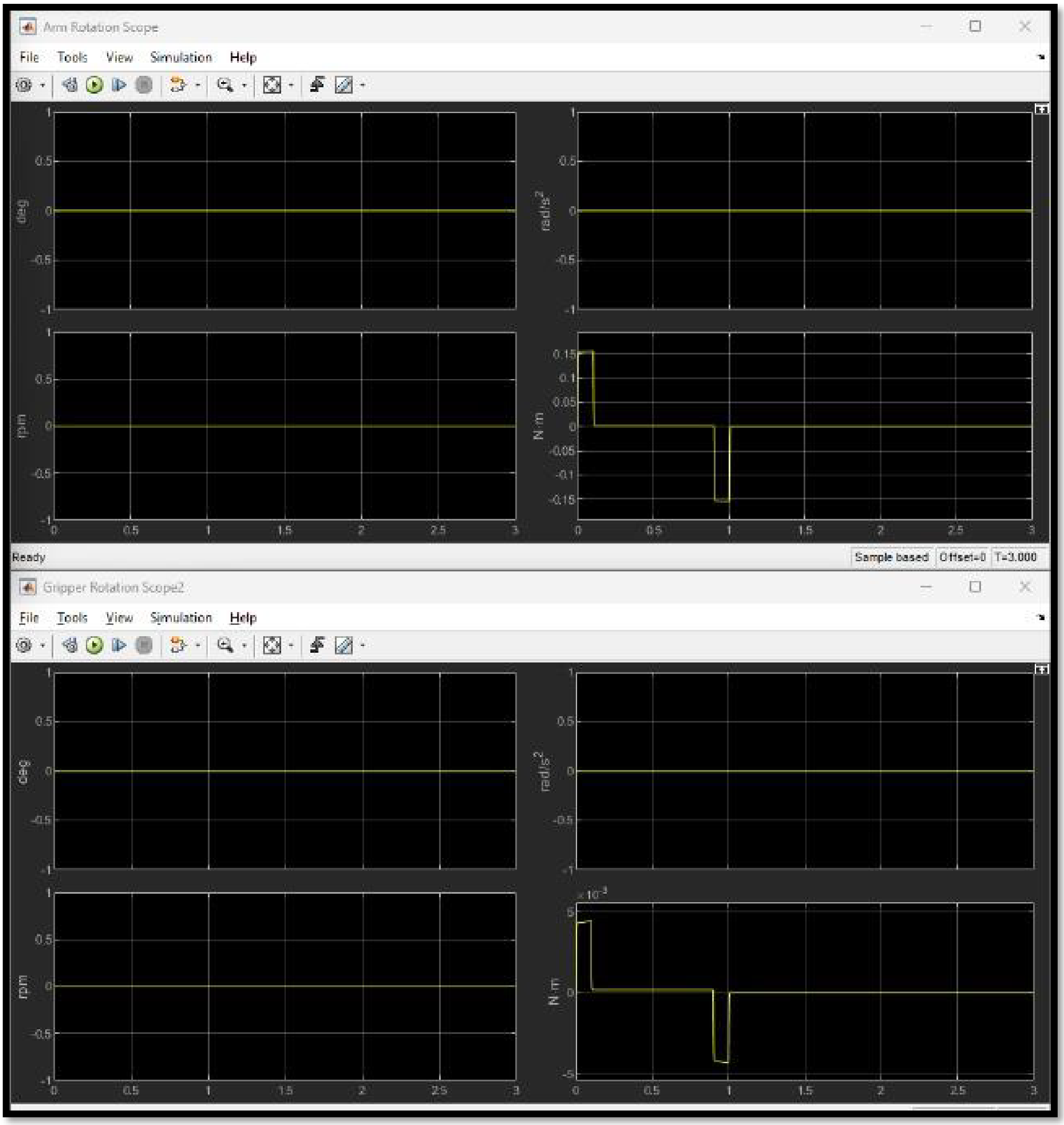

Arm Rotation Scope
File Tools View Simulation Help
deg
rad/s^2
rpm
N·m
Ready
Sample based Offset=0 T=3.000
Gripper Rotation Scope2
File Tools View Simulation Help
deg
rad/s^2
rpm
N·m

Figure 42

CONTROL

COMMUNICATION SCHEMATIC

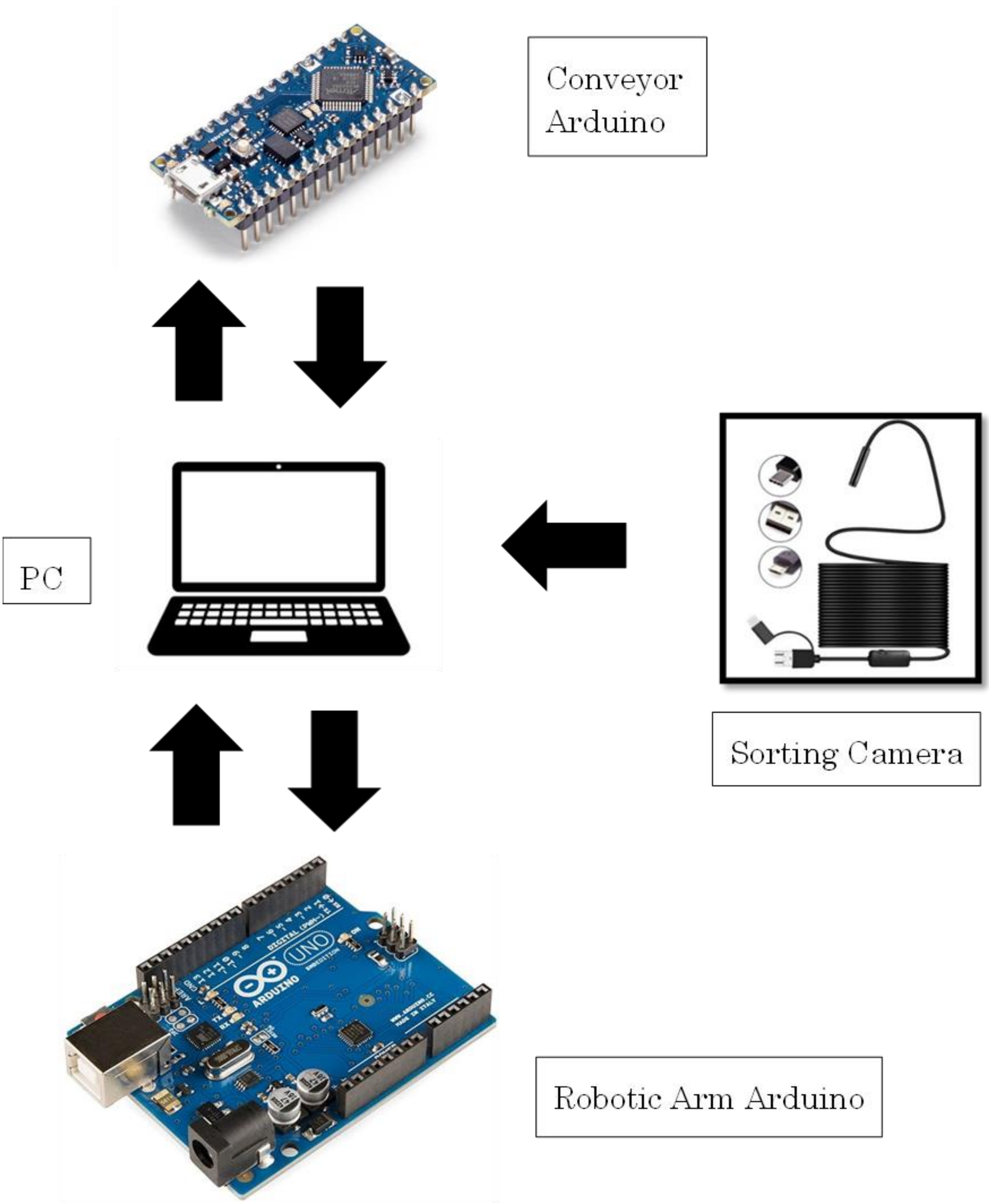


Figure 43

COMMUNICATION

In the project, the communication happens between 4 terminals which are:

- ❖ PC (Central control)
- ❖ (Feeding, Sorting, Conveyor) Arduino → C. Arduino
- ❖ (Robotic Arm, Assembly Station) Arduino → A. Arduino
- ❖ Sorting Camera

The communication used in this project is based on ***Serial Communication.***

COMMUNICATION BETWEEN C. ARDUINO & CAMERA

During the sorting camera's operation, after the part is recognized the camera sends a character (R, r, B, b) where:

- ❖ 'R' for Red Base
- ❖ 'r' for Red Lid
- ❖ 'B' for Blue Base
- ❖ 'b' for Blue Lid

to the PC, the Conveyor Arduino is programed so that at this stage it waits for the one of these characters (R, r, B, b).

When one of the characters is sent, it opens the respective lane for that part and resumes the conveyor's movement.

COMMUNICATION BETWEEN C. ARDUINO & A. ARDUINO

In the sorting station, when the IR Sensors that corresponds to either (The red base and red lid) or (The blue base and blue lid). The C. Arduino is programed that when one of those conditions are true the C. Arduino sends a character (m, n) where:

- ❖ **'m' means that the parts of red product are ready in the sorting station.**
- ❖ **'n' means that the parts of blue product are ready in the sorting station.**

The A. Arduino is programmed that when it receives one of the characters (m, n) it starts its tasks to either handle and assembles the red or blue product depending on the character sent.

ALGORITHM

CONVEYOR ARDUINO ALGORITHM:

1. Upon pressing the start button and detecting the presence of a product in the feeding system through the IR sensor, the feeding system will initiate the movement of the first product, triggering the activation of the conveyor motor.

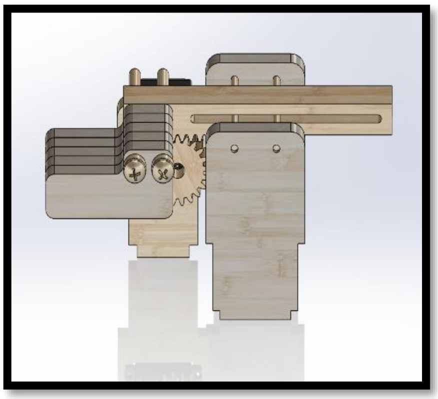


Figure 46

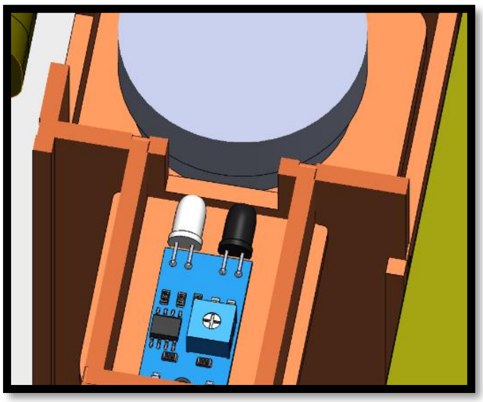


Figure 45

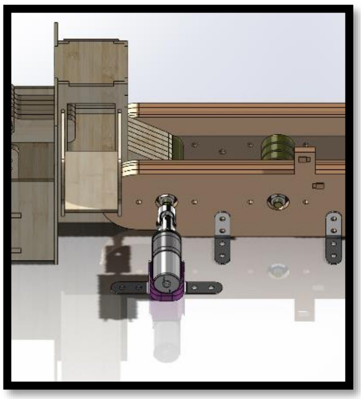


Figure 44

2. Under normal circumstances, the gate located at the camera position remains closed, causing the product to come to a halt beneath the camera when the IR sensor near that station is triggered.

Figure 47

3. The system will wait for a message from the PC, which is connected to the camera, to determine the product type.

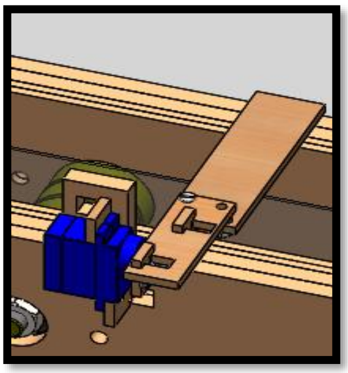


Figure 48

4. Upon receiving the message, the gate at the camera location will open, and based on the identified product type, the appropriate guide gate will close accordingly.

5. The product will then proceed to move along the designated path and be guided towards its respective storage area.

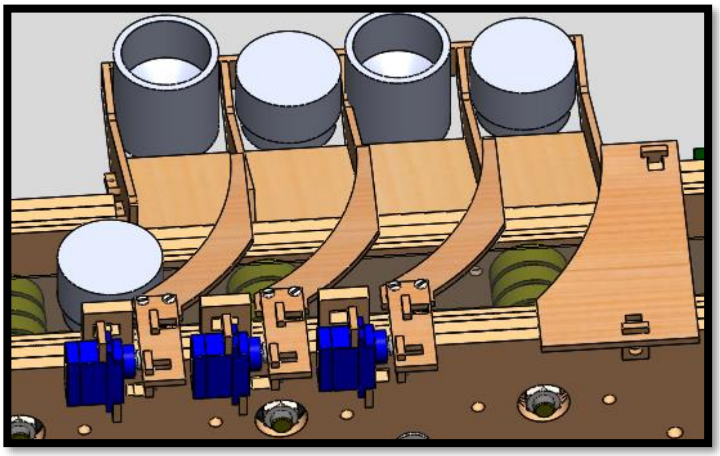


Figure 49

6. Subsequently, the following product will be fed into the system, with the IR sensors providing the necessary information for detection.

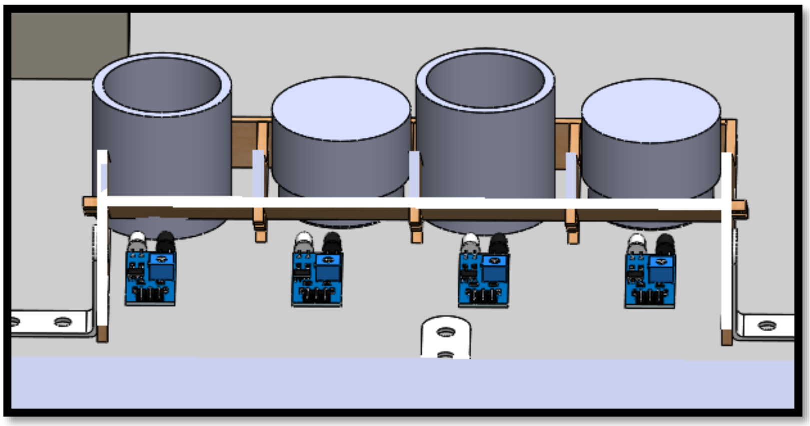


Figure 50

7. Once the IR sensors detect the cover and base of the same color, the conveyor Arduino will send a signal to the Robotic Arm Arduino to initiate the assembly process.

C. ARDUINO CODE FLOWCHART

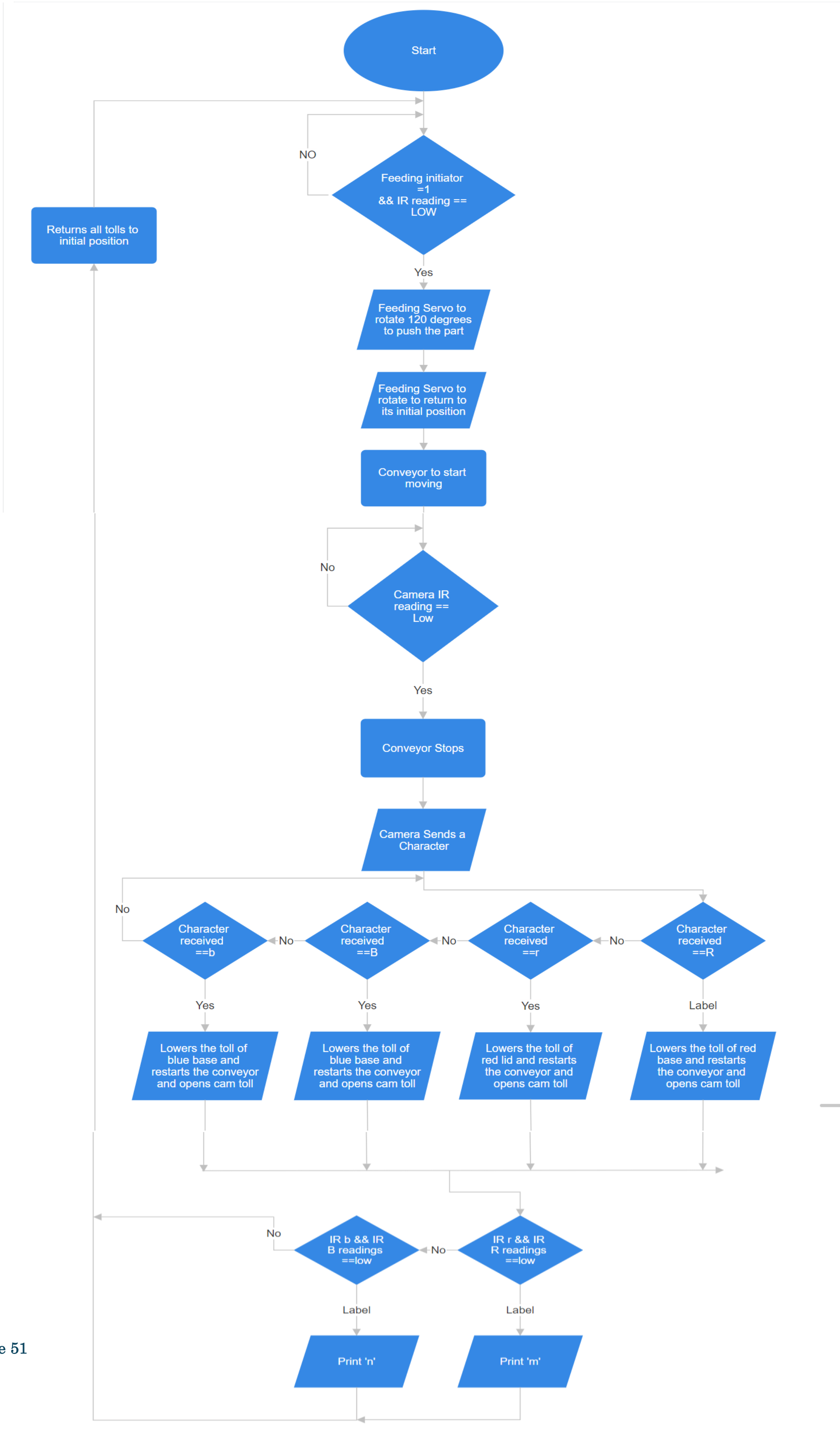

Start
NO
Feeding initiator =1 && IR reading == LOW
Returns all tolls to initial position
Yes
Feeding Servo to rotate 120 degrees to push the part
Feeding Servo to rotate to return to its initial position
Conveyor to start moving
No
Camera IR reading == Low
Yes
Conveyor Stops
Camera Sends a Character
No
Character received ==b
No
Character received ==B
No
Character received ==r
No
Character received ==R
Yes
Yes
Yes
Label
Lowers the toll of blue base and restarts the conveyor and opens cam toll
Lowers the toll of blue base and restarts the conveyor and opens cam toll
Lowers the toll of red lid and restarts the conveyor and opens cam toll
Lowers the toll of red base and restarts the conveyor and opens cam toll
No
IR b && IR B readings ==low
No
IR r && IR R readings ==low
Label
Label
Print 'n'
Print 'm'

Figure 51

ROBOTIC ARM ARDUINIO ALGORITHM EXPLAINATION

The task of this Arduino is to control the robotic arm to assemble the parts and move them to store area.

1. Upon receiving a signal from the conveyor Arduino indicating the presence of a base and cover with the same color, the system initiates the calculation of inverse kinematics. This calculation enables the determination of the arm's required position to reach the base, and the motors are then adjusted accordingly using a PID controller that considers encoder, and potentiometers act as feedback for the stepper motors.

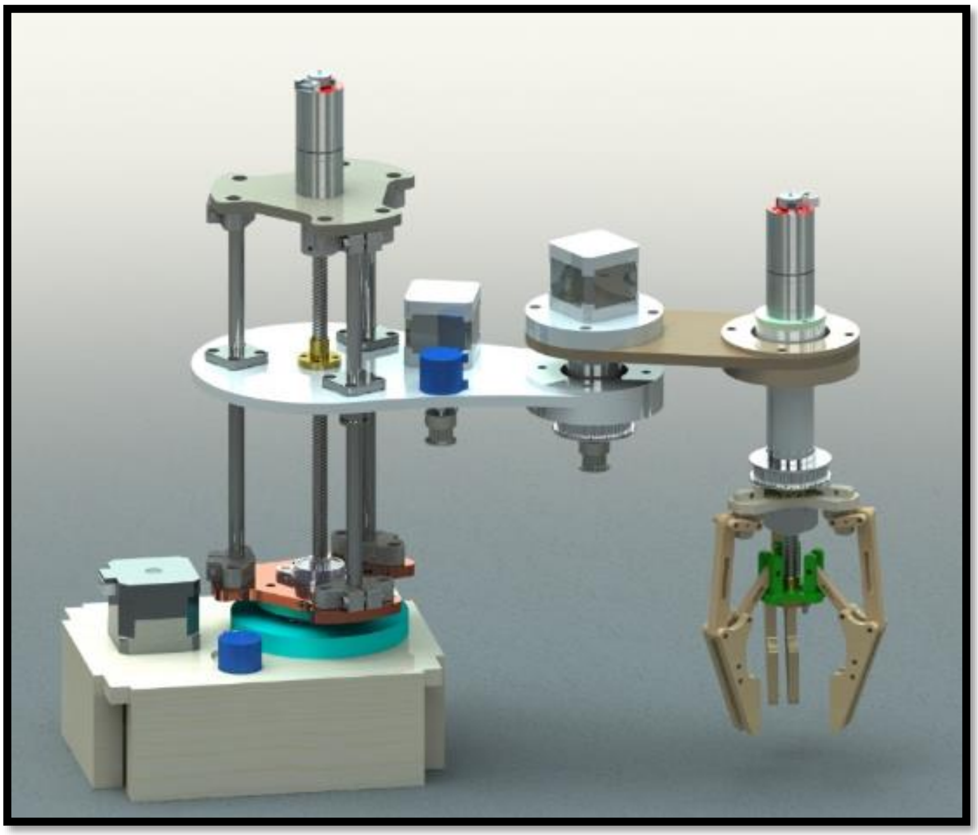


Figure 52

2. The gripper is subsequently closed to securely hold the base in place.

3. The system proceeds to calculate the inverse kinematics once again, this time to determine the position for clamping. The motors are adjusted accordingly to move the arm to this position.

4. The gripper is opened, allowing the arm to retrieve the cover.

5. The base is then clamped securely to the assembly.

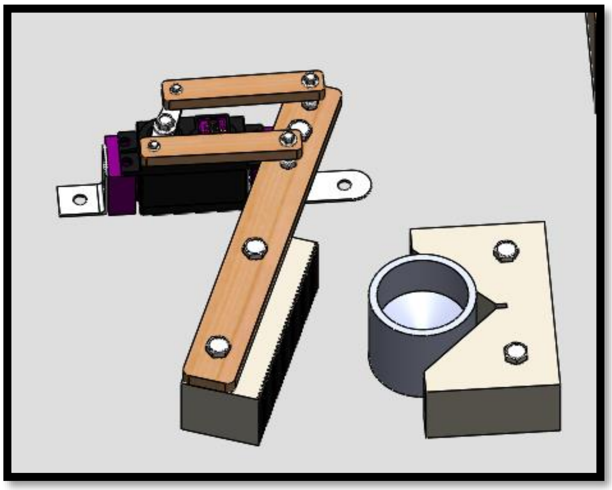


Figure 53

6. During the assembly process, the gripper rotates around its axis, facilitating the proper threading of the components.

7. Once the assembly is complete, the base is unclamped, and the arm moves the final product to its designated storage area.

Figure 54

A. ARDUINO CODE FLOWCHART

Figure 55

SORTING CAMERA OPERATION

BLUE BASE DETECTION

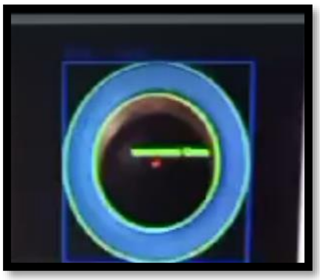


Figure 57

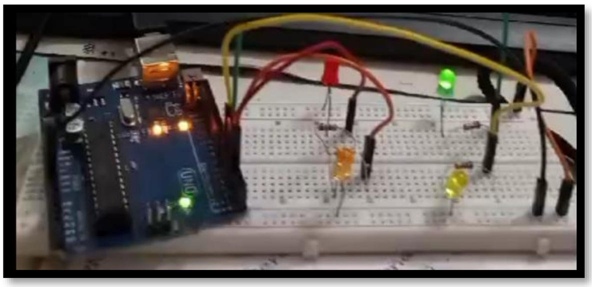


Figure 56

BLUE LID DETECTION

Figure 60

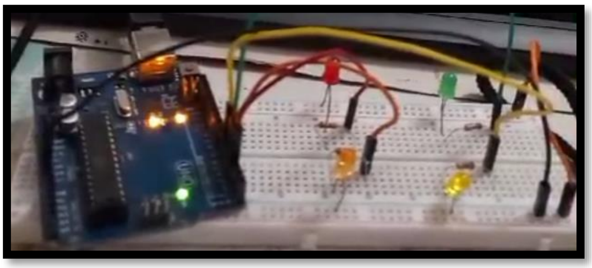


Figure 59

RED BASE DETECTION

Figure 62

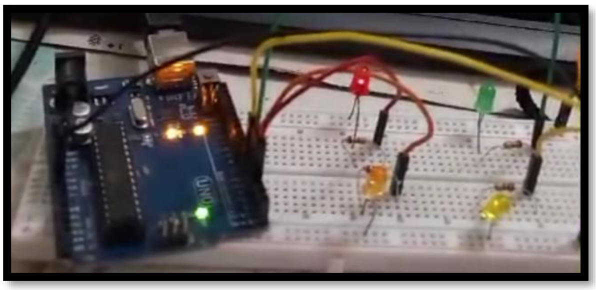


Figure 61

RED LID DETECTION

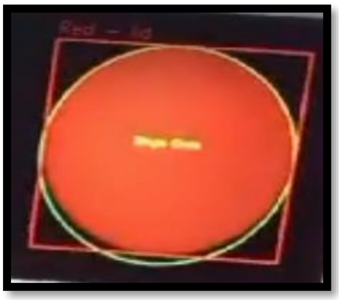


Figure 64

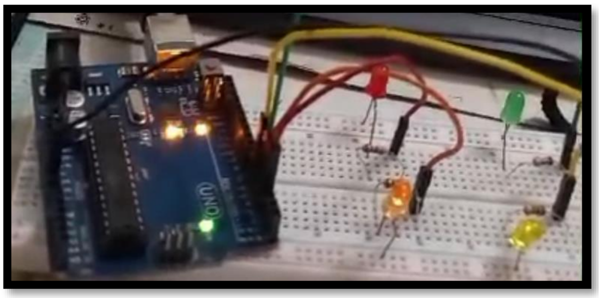


Figure 63

SORTING CAMERA CODE FLOWCHART

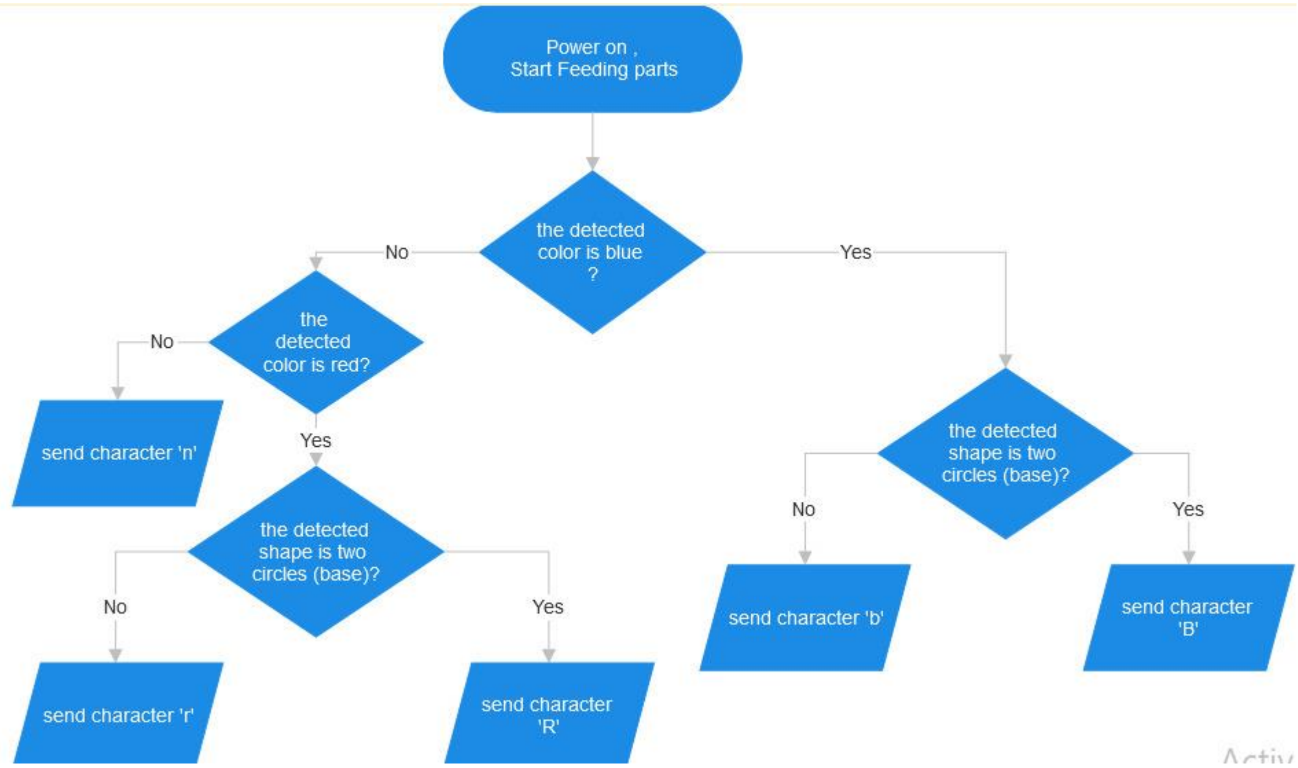


Figure 65

PID CONTROL

CIRCUITRY

CIRCUIT SCEHMATICS

POWER PCB SCHEMATIC

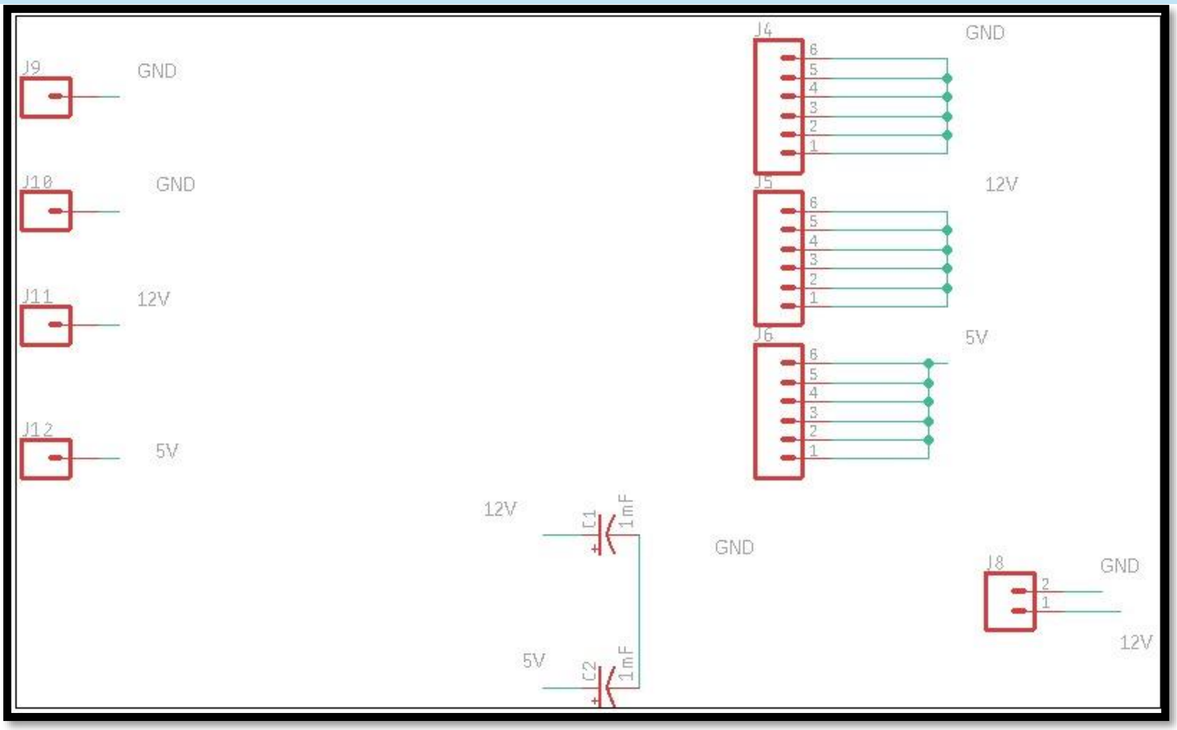


Figure 66

- ❖ **Components: Terminals, 2x 1000 µF, Buck Converter**
- ❖ Used for:

  Giving required voltage to all electrical components which include:

  - ✓ Motors: 3x DC Motors, 3x NEMA 17 Stepper Motors, 2x MG955 Servo motors, 4 SG90 Servo Motors.
  - ✓ Sensors: 2x Potentiometers, 6 IR Sensors.
  - ✓ Drivers: 3x Stepper Motor Driver(A4988), 2x DC Motor Driver(L298N)

This PCB is connected to the power source and provides the common ground for all the electrical components used too.

CONVEYOR ARDUINO PCB SCHEMATIC

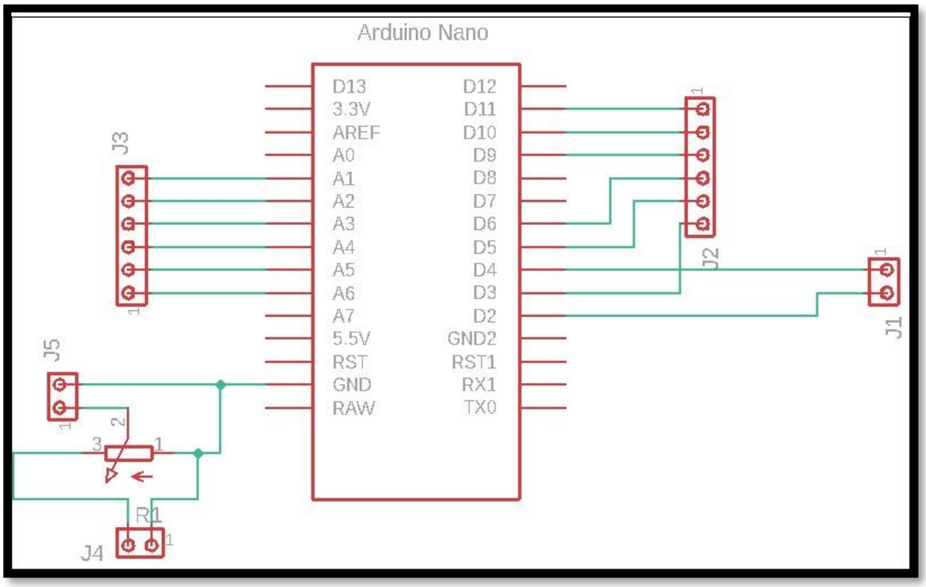


Figure 67

- ❖ **Components: Terminals, 1x Potentiometer, 1x Arduino Nano**
- ❖ Used for:

  Controlling the Actuators and Receiving input signals from the sensors

  - ✓ Motors Controlled: 1x DC Motor1, 1x MG955 Servo motor, 4 SG90 Servo Motors.
  - ✓ Sensors: 6 IR Sensors.

ROBOTIC ARM PCB SCHEMATIC

- ❖ **Components: Terminals, 3x Stepper Motor Driver(A4988), 1x Arduino UNO**
- ❖ Used for:

  Controlling the Actuators and Receiving input signals from the sensors
  Used for controlling the robotic arm and the assembly station.

  - ✓ Motors Controlled: 2x DC Motor1, 1x MG955 Servo motor, 3x NEMA 17 Stepper Motors
  - ✓ Sensors: Encoder, 2x Precision Potentiometer

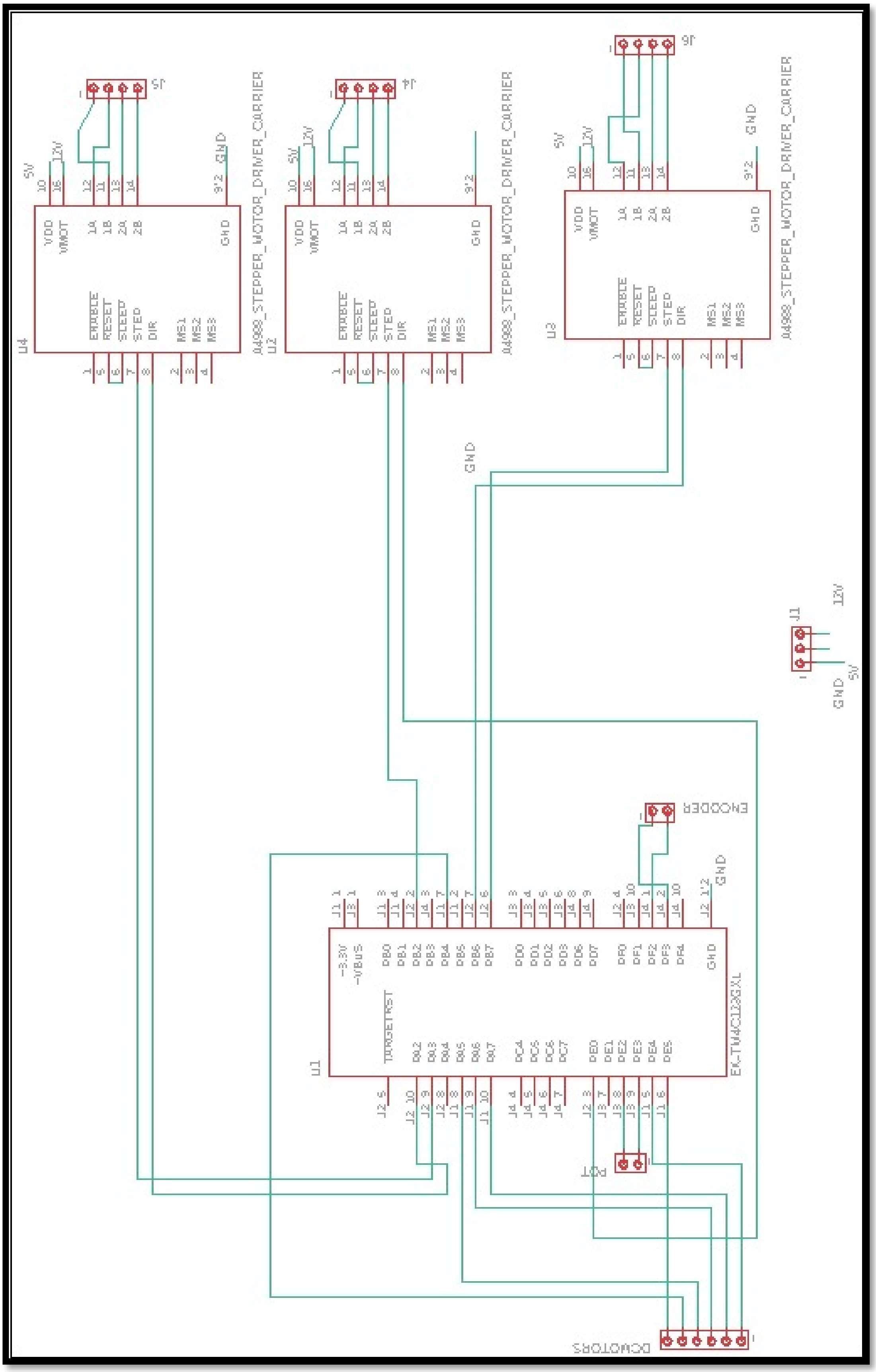

A4988_STEPPER_MOTOR_DRIVER_CARRIER
U2
U3
U4
J4
J5
J6
J1
EK-TM4C123GXL
U1
ENCODER
POT
DCMOTORS
GND
5V
12V

Figure 68

START | STOP CIRCUIT

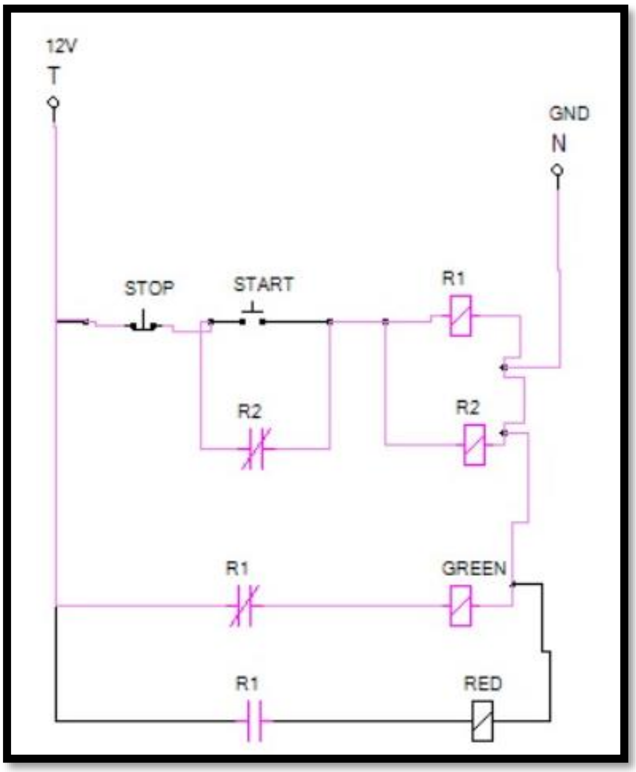


Figure 70

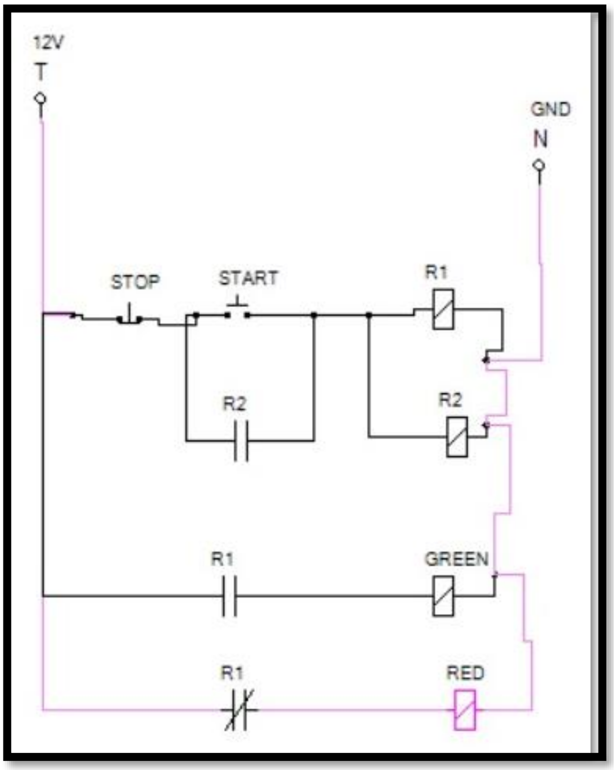


Figure 69

PRINTED CIRCUIT BOARDS

CONVEYOR ARDUINO PCB

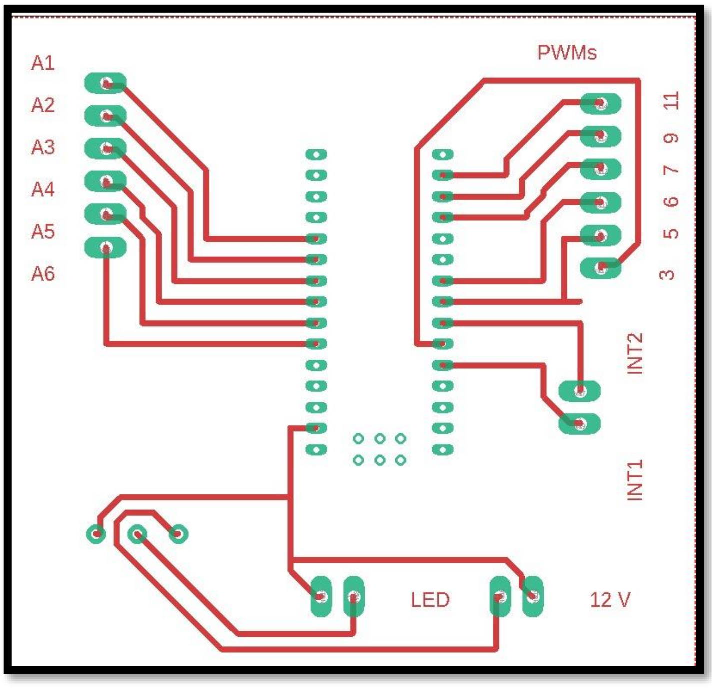


Figure 71

ROBOTIC ARM ARDUINO PCB

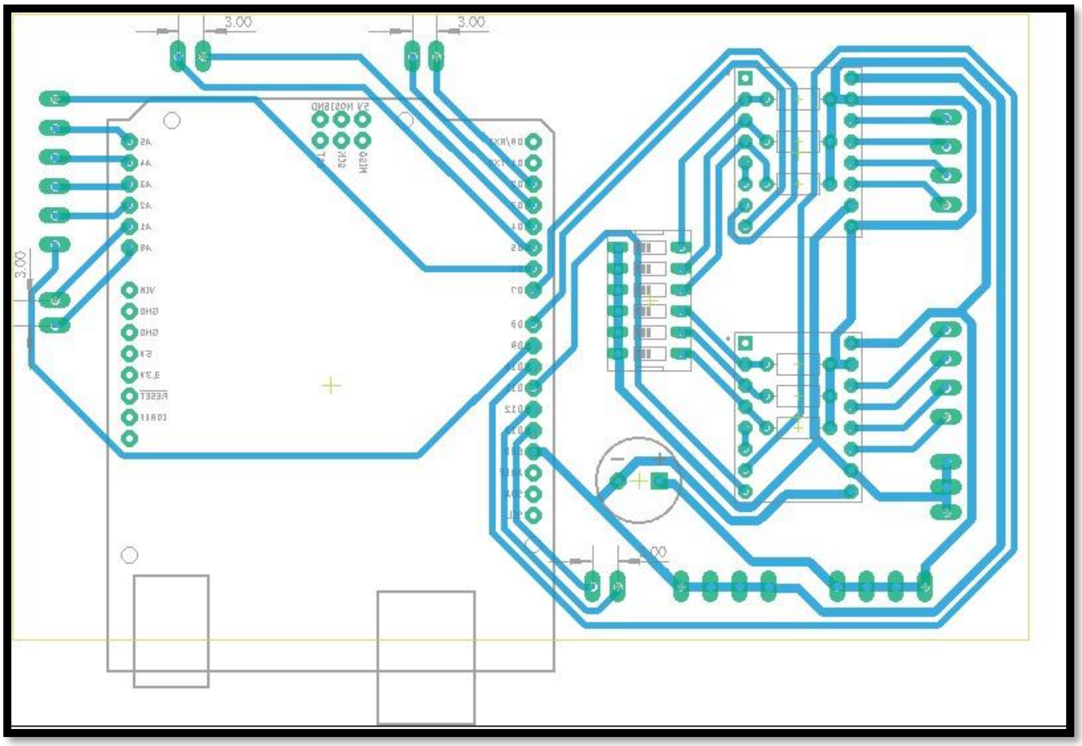


Figure 72

POWER PCB

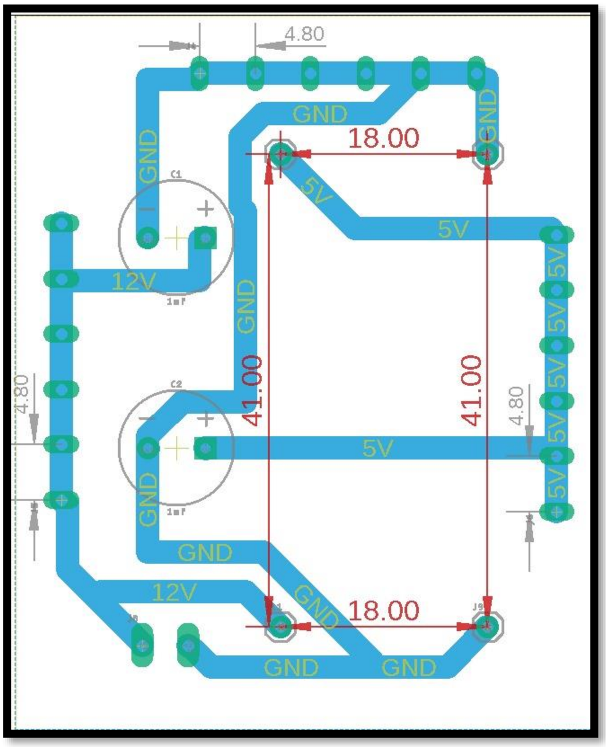


Figure 73

VERFICATION & VALIDATION

FEEDING VERIFICATION

Figure 74 is the old design for the feeding system.

It was changed for several factors:

1. The Fixation of the slider and the servo motor was very hard to implement which led to troubles while operating.
2. The Slide used for the part to slide through to the conveyor was not inclined enough and the parts usually would stop midway before reaching the conveyor.
3. The IR compartment was too small to operate with.
4. The Magazine Slide caused the parts to fall over in the feeding compartment.

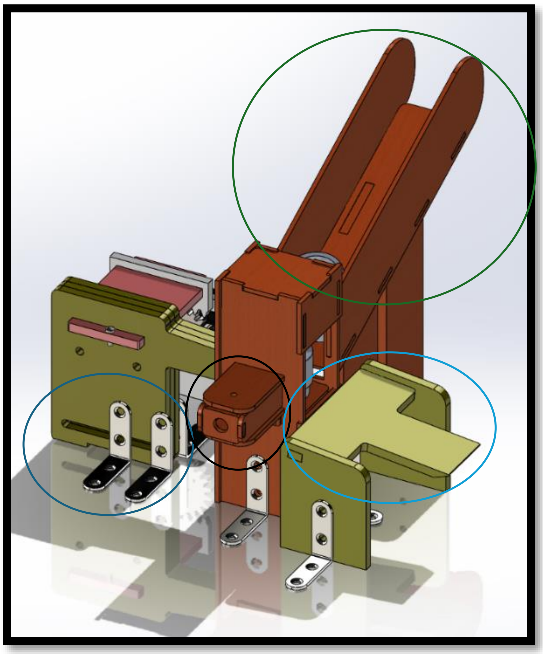


Figure 74

Figure 75 is the successor design for the feeding system.

It solved all the problems in the previous design but a problem with the conveyor slide emerged which was that the part would get stuck between the slide and the conveyor.

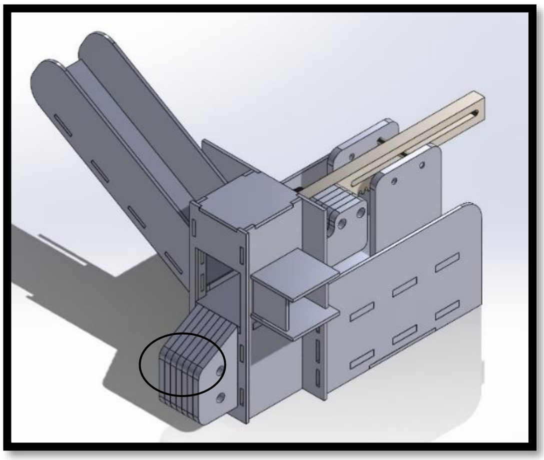


Figure 75

Figure 76 is the Final design for the feeding system.

It solved the problems in the previous design and now that system works as intended.

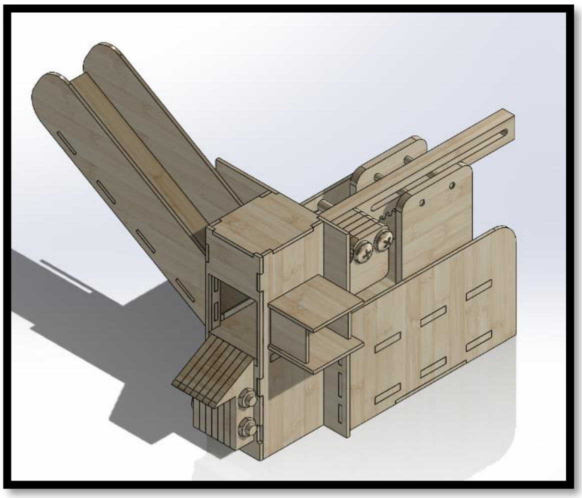


Figure 76

SORTING VERIFICATION

In figure 77, during testing, it was found that the part would get stuck in the highlighted area.

The solution was to add a small pusher on the conveyor belt that pushes the part.

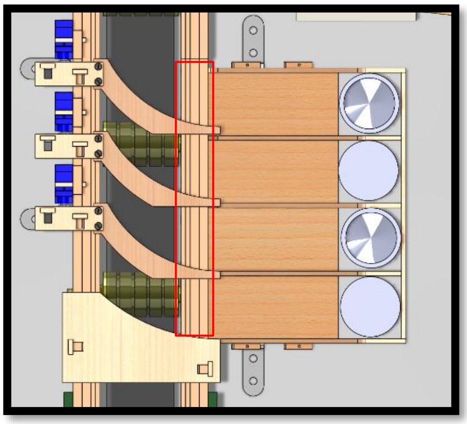


Figure 77

CONVEYOR VERIFICATION

In figure 78, after several trials, several modifications needed to be applied on the conveyor.

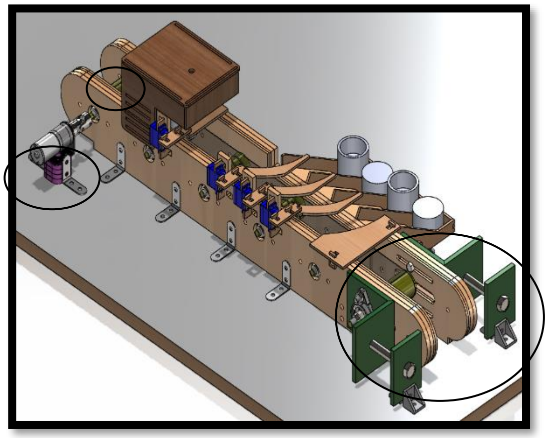


Figure 78

1. The material of the power shaft is to change to Iron for as it is subject to large torque and tension force.
2. The Tensioner mechanism material to be made of Sheet metal rather than wood for stability and rigidity.
3. The DC motor is to be fixed on a sheet metal for stability and rigidity.

ROBOTIC ARM VERIFICATION

The Gripper

- In figure 80, the gripper was made from laser cut wood, during operation, some links got broken.
- Also, the part would sometimes slip from the gripper's links.
- There was an additional degree of freedom in this design that would cause incorrect gripping action.
- The gripper was somewhat tight for the part and during operation it sometime couldn't fully grip the part due to this tightness.
- This was all fixed in the Final design which is demonstrated in figure 79.
- The new gripper is made of laser cut sheet metal which is sturdy and reliable.

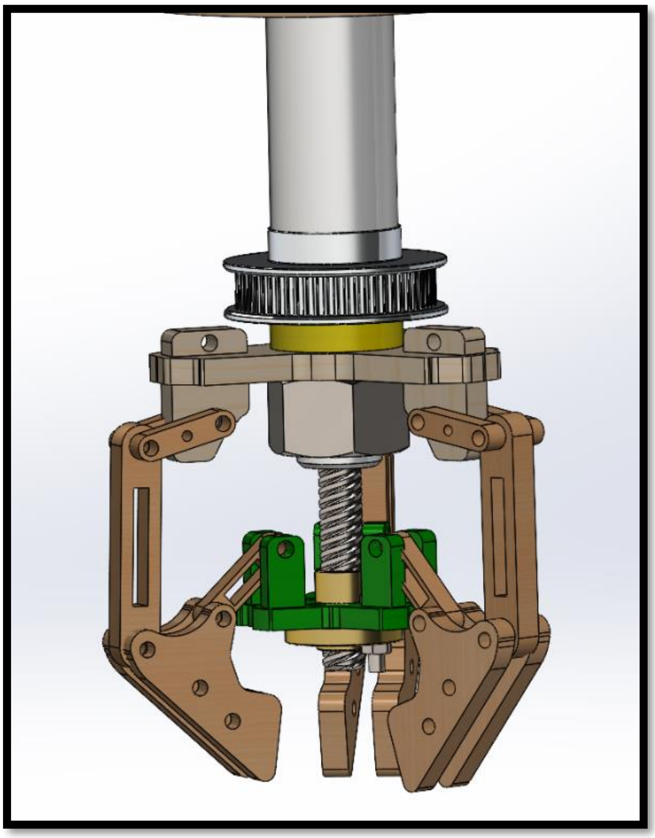


Figure 80

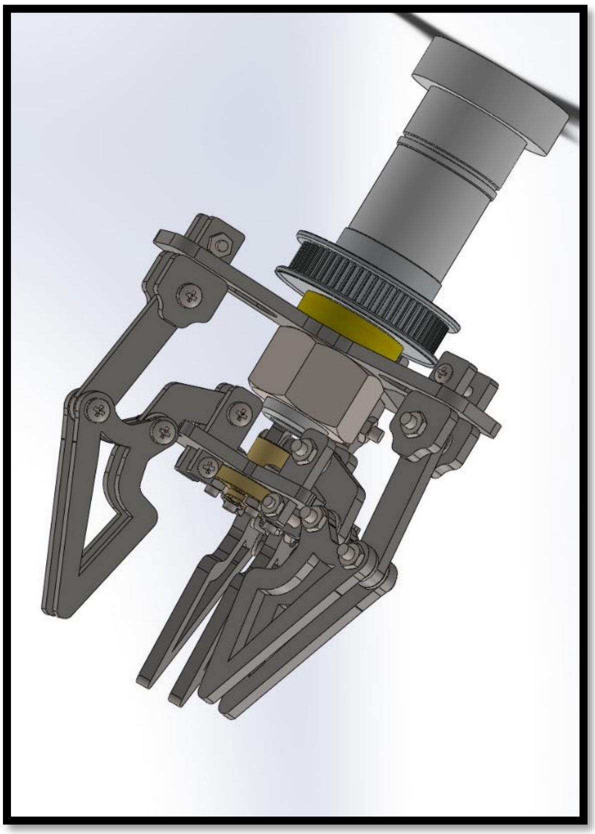


Figure 79

ASSEMBLY VERIFICATION

Figure 81 demonstrates the assembly station.

After some trials, it was found that the height of the V-Block and the clamper needed to be reduced to allow the gripper of the robotic arm to properly handle and pick up the part.

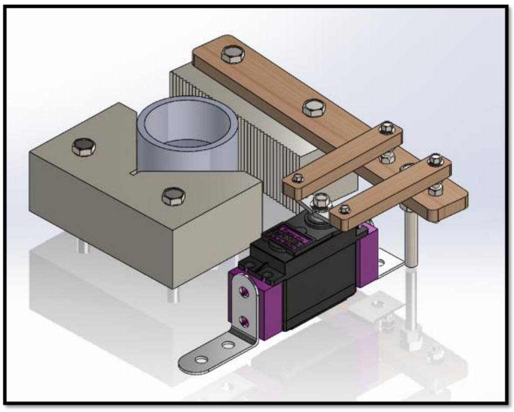


Figure 81

STORAGE VERIFICATION

The storage demonstrated in figure 82 illustrates the storage station.

The design is satisfactory and therefore verified.

Figure 82

VALIDATION

PCB VALIDATION

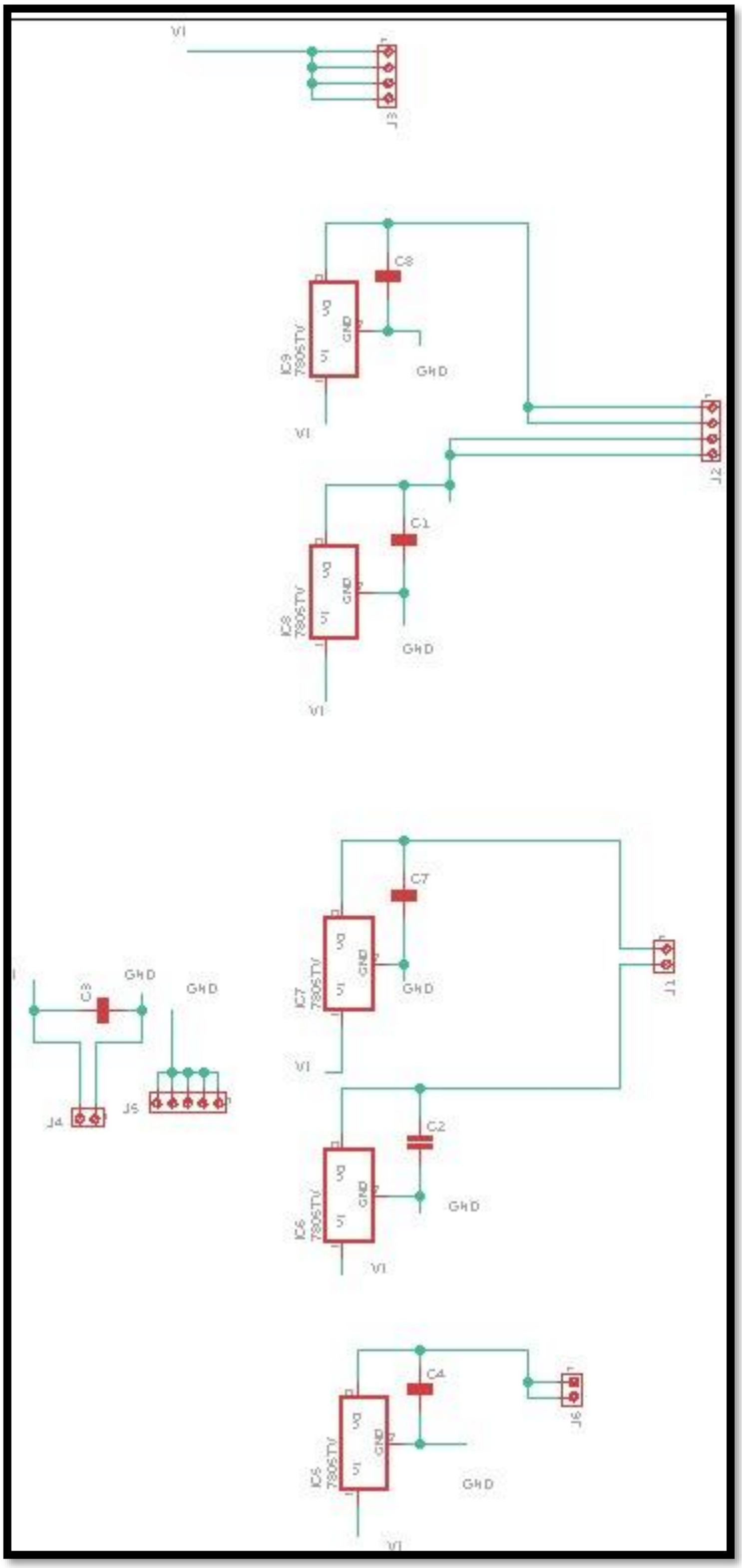


Figure 83

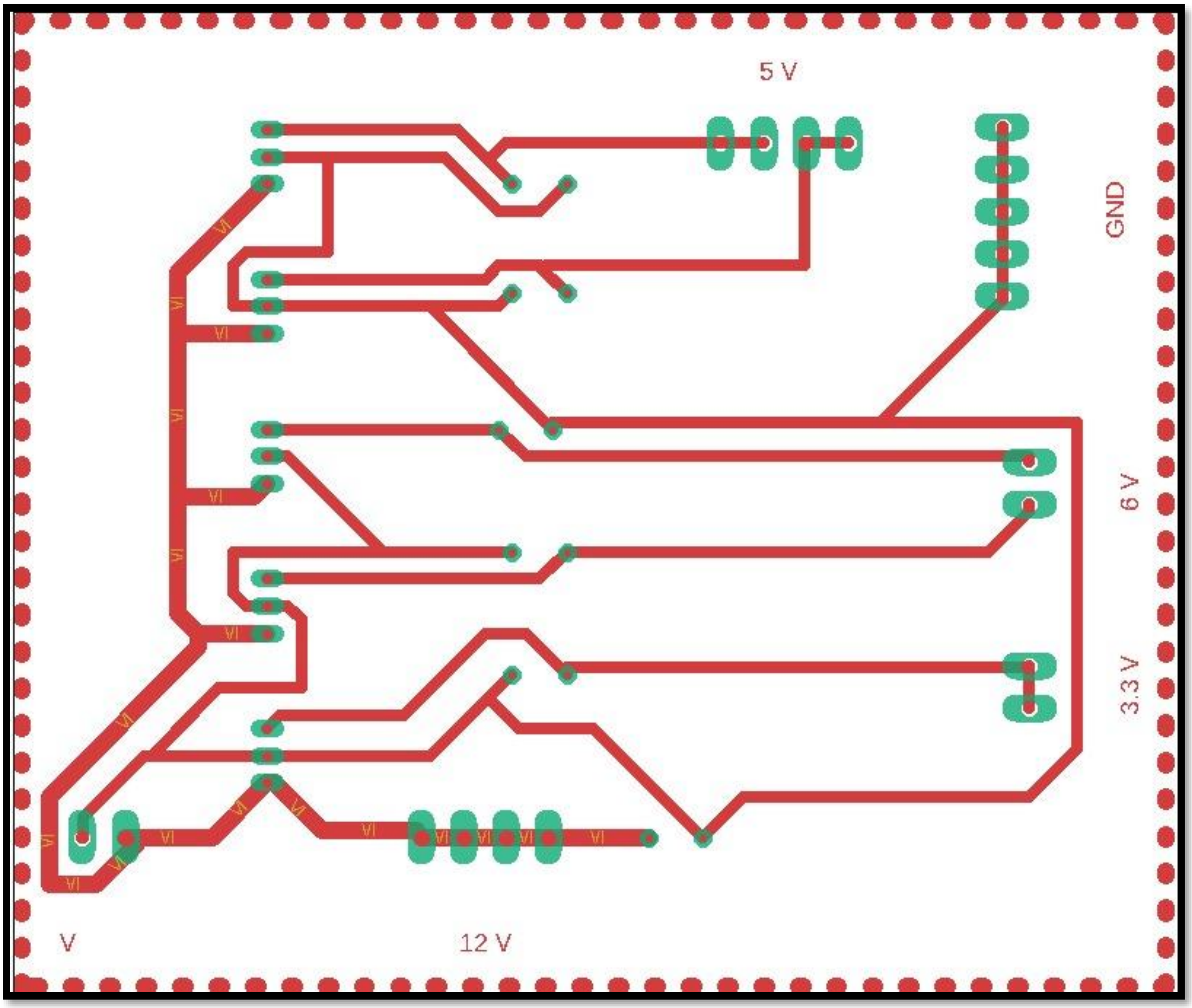


Figure 84

- The schematic in fig. 83 and the PCB layout in fig. 84 were of an old design of the power PCB.

- They were totally functional, but they presented some limitations in the power input to the electrical components used.

- Voltage regulators were used in this design. The regulators tended to get heated after some time even after equipping each with a heat sink.
- This design & PCB were scrapped and the PCB in fig. 73.

PROJECT OVERVIEW

FINAL PROJECT LAYOUT

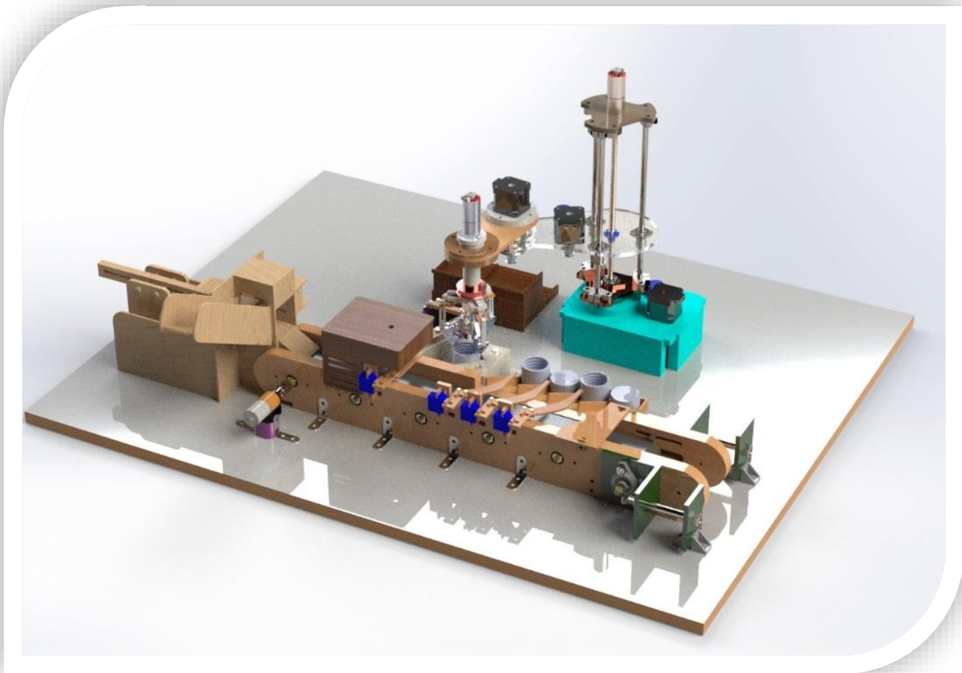


Figure 85

OVERALL SECIFICATIONS OF THE ENTIRE SYSTEM

- ✓ Production Rate: **1 Product/min.**
- ✓ Control wirings are done on **PCB**.
- ✓ Assembles **2 types** of Products.
- ✓ **Multifunctional Robotic Arm**.
- ✓ Equipped with a Control Box.
- ✓ Equipped with **Machine Vision** capabilities.
- ✓ Equipped with Conveyor Tensioner Mechanism.

FINAL SPECIFICATION OF EACH SUB-SYSTEM

FEEDING SUB-SYSTEM

- ✓ Capacity: 6 parts.
- ✓ Feeding Rate: 1 part/ 10 sec.
- ✓ Made from: Laser Cut wood of 3mm & 6mm.
- ✓ Sensors used: 1x IR Sensor.
- ✓ Actuators used: 1x MG955 Servo Motor.

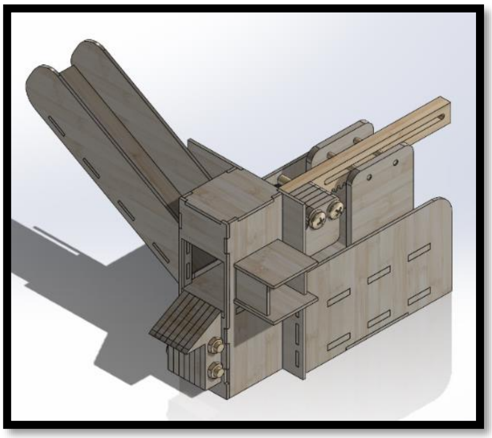
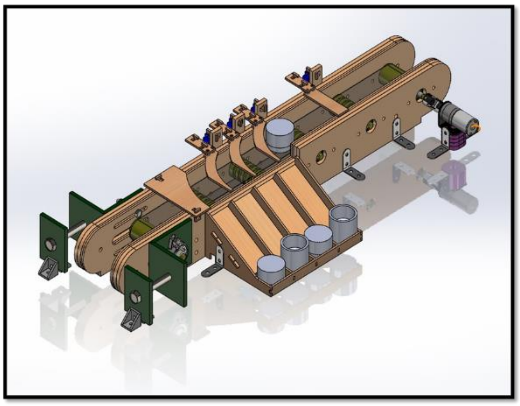


Figure 86

SORTING SUB-SYSTEM

- ✓ Camera Detection time: ≈0.7 sec.
- ✓ No. of sorting lanes: 4 lanes.
- ✓ Made from: Laser Cut wood of 3mm.
- ✓ Sensors used: 5x IR Sensor.
- ✓ Actuators used: 4x SG90 Servo Motor.

Figure 87



CONVEYOR SUB-SYSTEM

- ✓ Length: ≈50cm.
- ✓ Speed: ≈0.25 m/s.
- ✓ No. of idler rolls: 4
- ✓ Power Shaft Material: Iron
- ✓ End Shaft Material: Artelon
- ✓ Rolls Material: Artelon
- ✓ Body material: Laser cut wood 6mm.
- ✓ Power Transmission used: Flexible Coupler
- ✓ Equipped with Tensioner Mechanism.

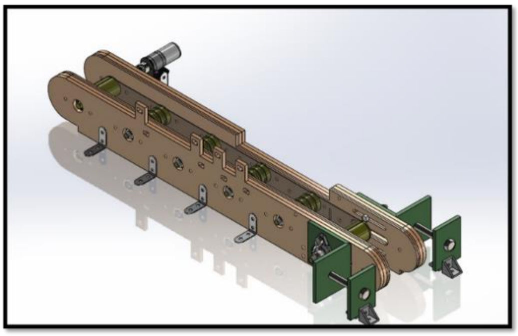


Figure 88

SCARA ROBOTIC ARM

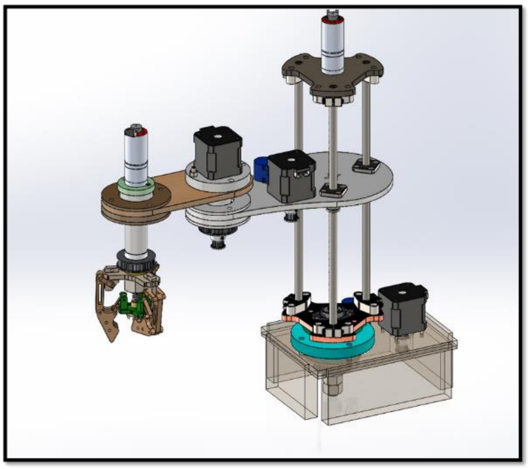


Figure 89

- ✓ Functions: Handling, Assembly, Storing
- ✓ Made from: Laser Cut wood of 3mm.
- ✓ Sensors used: 2x Precision potentiometer, 1x Encoder.
- ✓ Actuators used: 3x NEMA 17 Stepper Motor, 2x DC Motors.
- ✓ Comes with Metallic gripper for handling and assembly; can rotate.
- ✓ Main Components: Bearings, Lead Screw, Iron Shafts, Gripper, Base Pulleys, Flexible Couplers, Timing Belts.
- ✓ Materials used: Steel, Acrylic, Laser Cut Wood, Wood, Artelon.

ASSEMBLY STATION

- ✓ Simple design
- ✓ Actuators used: 1x MG955 Servo Motor
- ✓ Materials used: Artelon, Wood
- ✓ Mechanism Name: Clamping

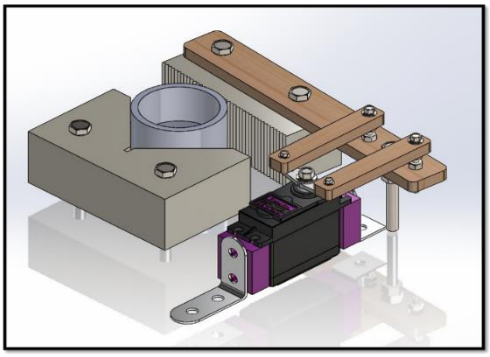


Figure 90

STORAGE

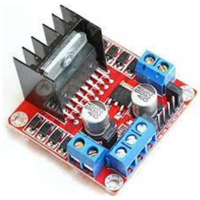
- ✓ Simple design.
- ✓ 2 Level storage for easier storage.
- ✓ Materials used: Laser Cut wood 3mm.
- ✓ Capacity: 4 Finished Products.

Figure 91

PROBLEMS FACED

BILL OF MATERIALS

Name	No.	Image
Arduini UNO R3	1x	
Arduino Nano	1x	
Wires	N/A	
IR Sensor	6x	
Potentiometer	2x	
Servo (SG90)	4x	
Servo (MG995)	2x	

DC Motor	2x	
DC Motor w/Encoder	1x	
Stepper Motor (NEMA 17)	3x	
Stepper Motor Driver(A4988)	3x	
Motor Driver (L298N)	2x	
Limit Switch	1x	
Camera	1x	
Power Supply	1x	

Relay Module	2x	
Buck Converter	2x	
Red Button	1x	
Green Led	1x	
Red Led	1x	

REFERENCES