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Inventory System

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❖ **Disclaimer**

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❖ **Dedication**

This work is devoted to our families, who provided the motivation to see our efforts through and inspired us to achieve this milestone. It is also dedicated to all those who supported us, even with a single word of encouragement. Lastly, we dedicate this work to ourselves, as a testament to our perseverance and dedication.

❖ Acknowledgement

We would like to thank our supervisor, Dr. Anas Toma, for all the time and assistance he spent with us in order to complete this work. We would like to thank all who played an important role in courses related to the graduation project.

We want to take advantage of this opportunity and thank our family and friends who supported us financially and morally in completing this project by all means and means.

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❖ **Abstract**

Our project aims to develop an integrated inventory system that streamlines the arrangement and storage of packages on warehouse shelves. The system allows users to classify packages and assign specific cells to different types of packages through a user interface connected to the hardware.

Packages to be added to the system are placed in a designated area, where a robotic arm, moving along the x and y axes, picks up the package and places it on the appropriate shelf based on its type. Retrieval of packages from the shelves can be done by selecting the package barcode or cell number through a mobile application or keypad.

This system enhances the efficiency of storing packages on high shelves, particularly in warehouses, by cataloging and displaying the available items and their storage locations.

❖ **Introduction**

Our project proposes to build an integrated stock control system aimed at making arrangement and storing of packages on warehouse shelves an easier task. Thereafter, a user-friendly interface connected to the hardware enables users to classify packages and assign specific cells for different package types. This kind of innovation enhances the accuracy and efficiency in inventory

management as it becomes easier to handle small packages like those found in very big warehouses.

➤ **Problem**

Nevertheless, manual handling and storage of packages by conventional Warehouse Management Systems (WMSs) are associated with several inefficiencies that result into problems such as errors, misplacements or delays during retrieval among others. As a result, they may not adequately address the high precision and automation necessary for classifying and storing items in the respective purchase orders. Our solution is based on an automated system that minimizes human errors while enhancing operational efficiency.

➤ **Objectives**

This project has the following objectives:

- ❖ To create a user interface that will allow easy sorting and assigning of parcels to particular cells on warehouse racks.
- ❖ Develop and implement a robotic arm that move along the x-axis at one end, while it moves along the y-axis at the other end in order to place packages on their right shelves depending on their types.
- ❖ Able to recover packets via either keypad entry or mobile app by choosing pack barcode or cell number.
- ❖ Increase the efficiency of stocking and picking high-level packages in warehouses.
- ❖ Show available goods and where they are stored instantly.

➤ **Significance of The Work**

The importance of this work stems from its contribution to the warehouse management systems field. This project offers a significant improvement over

traditional approaches by creating an integrated inventory system with automatic storage and retrieval capabilities. The use of a robot arm, simple interface, eliminates human mistakes, increases accuracy and overall improves warehouse operations effectiveness. Furthermore, the dissertation demonstrates how various technical skills like mechanical design, electronics and software development can be applied in order to achieve innovative and practical outcomes while solving a problem.

➤ **Organization of The Report**

Initially, we wrote this report with the first chapter and the introduction, in which we provide a comprehensive background on the research topic, while the second chapter focuses on previous studies and courses and the challenges that were faced during the work, in addition to mentioning the solutions to overcome them and how they were achieved through knowledge of what was studied in previous competitions.

The third chapter revolves around project reviews, understanding the current scene, and examining previous representative projects in order to work on developing them and solving the problems that were identified.

The fourth chapter talks about the action plan to address the problem at hand, the precise and detailed process of building the project, and the subsequent use of programs and tools.

The fifth chapter presents the results, discusses them, summarizes the resulting data, analyzes it, and compares it to understand the project more deeply and interpret the results.

We end in Chapter Six with a set of conclusions and recommendations and a final summary that presents the lessons learned while working on the project, the next steps to improve it, and a proposal for new features from which we or anyone coming can start developing the project.

➤ **Constraints and earlier work**

■ **Constraints**

Weak capabilities of the hardware used: As the Arduino and ESP have a Single Core Single Thread microcontroller, thus this limits the possibility of using the microcontroller for more than one task at the same time.

■ **Earlier Work**

Courses and Practical Experiences:

- ❖ **Micro-controllers Course:** This course is meant to give a full knowledge of the microcontroller systems which are very important when controlling robotic arm and other hardware like in the inventory system. We learned how to use micro-controllers for automation and precision control during this course.

- ❖ **Micro-processor:** With this course, we shall be knowledgeable enough to handle integrated circuits (ICs) and modules that help us understand their behavior with respect to current and voltage. This was important since it ensured our designs of electronic circuits that controlled the movements of the robotic arm were reliable.

- ❖ **CPU Lab:** The hands-on experience we obtained from this lab was extremely helpful in developing practical skills such as wiring, soldering, debugging of hardware parts etc. The building process as well as finalizing adjustments on the inventory system required effective troubleshooting methods especially when it came to problems related to hardware items.

- ❖ **Critical Thinking and Scientific Research Component:** We have really grown in terms of our research skills and even writing professional papers through this component. It helped us with tools and

techniques needed for conducting an extensive research, presentation of findings in a structured way.

Previous Projects and Research:

- ❖ **Automated Storage and Retrieval Systems (AS/RS):** Our research on AS/RS provided a basic understanding of automated stock systems and the challenges involved in their implementation. To our project, we researched several models of AS/RS to identify best practices and innovative solutions.
- ❖ **Robotics and Automation:** For instance, previous projects that involved robotics and automation like robot arms for manufacturing or assembly lines have revealed how mechanics design should be handled as well as how control algorithms work for exact moves. These engagements underscored the significance of harmonizing hardware with software for maximum efficiency.

❖ **Literature review**

Numerous solutions are available for existing problems of inventory management systems and robotic automation which entail countless documented fields that aim at enhancement of accuracy and efficiency. Our project will be unique because it will incorporate a robotic arm to handle the packages with precision and provide an intuitive interface where one can easily classify and retrieve the parcels. The goals of this combination of hardware and software innovations is to redefine the way warehouses are managed in terms of efficiency.

❖ Methodology

➤ Overview

We first design the mechanism of the mechanical part of the machine to move the gripper along the x, y and z axes. Then we design the states of the machine and identify the components required to control it such as inputs, microcontrollers, motors, etc. We will explain each part later. After building the machine and assembling the mechanical parts, we assemble and test the system.

➤ Mechanical Components

- Stainless steel shaft rods, 60cm long and 8mm in diameter

The use of 8mm stainless steel column bars in mechanical applications offers several advantages. Stainless steel is known for its excellent resistance to corrosion, making it suitable for environments where exposure to moisture or chemicals is a concern. The 8mm diameter provides sufficient strength and stability for many applications while remaining relatively lightweight.

Stainless steel shaft bars are commonly used in many industries, including robotics, automation, manufacturing, and machinery. They are often used as linear motion guides, axles, support columns, or rotational components.



Figure 1 stainless steel shaft rods

- **Timing Belt**

The timing belt is a flexible belt with teeth on its inner surface, also known as the toothed belt or synchronous belt. It is used in machines and engines to transmit rotational motion and ensure precise synchronization between components. We have used it in the input and output line for products in order to bring the products to the delivery point and remove them from the receiving point and deliver them.



Figure 2 Timing Belt

- **Custom 3D Printed Parts**

For assembling the mechanical parts

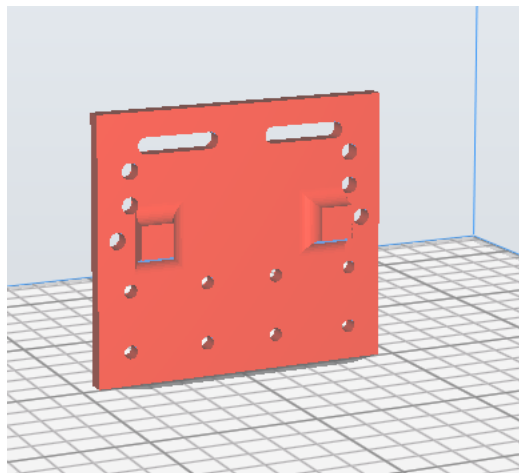


Figure 3 bottom y axis holder

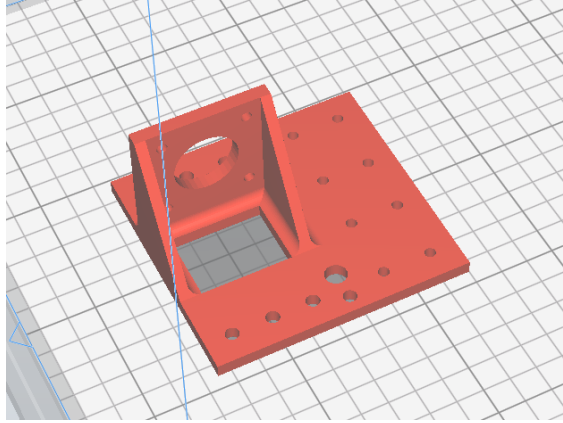


Figure 4 top y axis holder

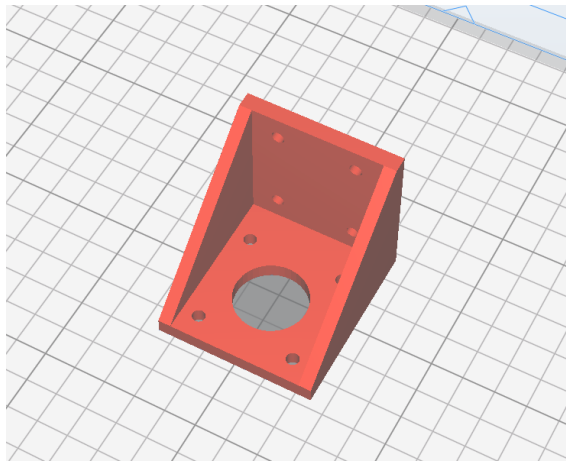


Figure 5 nema17 holder

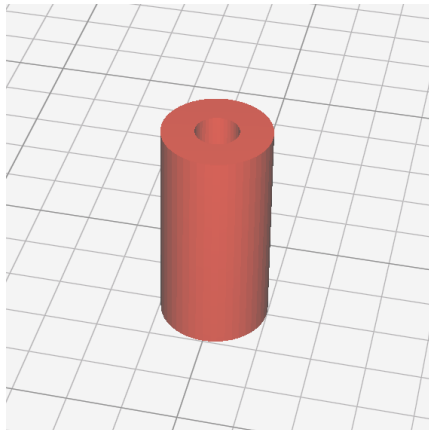


Figure 6 coupler 5mm * 8 mm

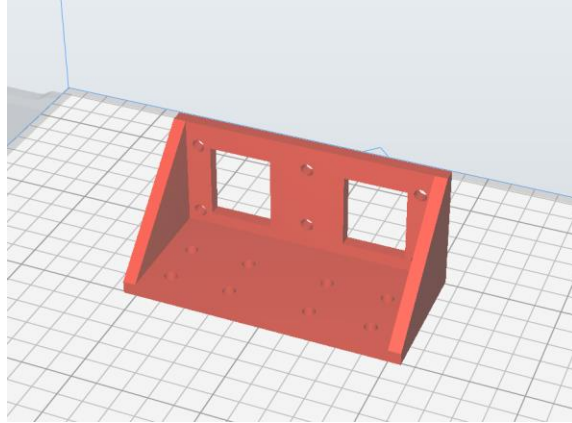


Figure 7 arm top base

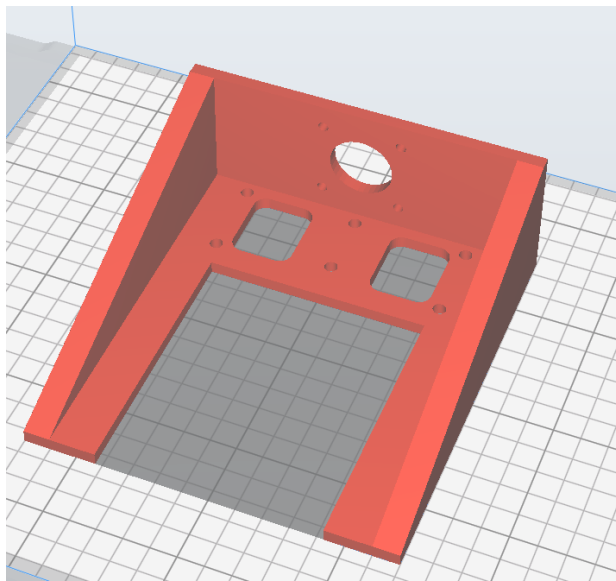


Figure 8 arm bottom base

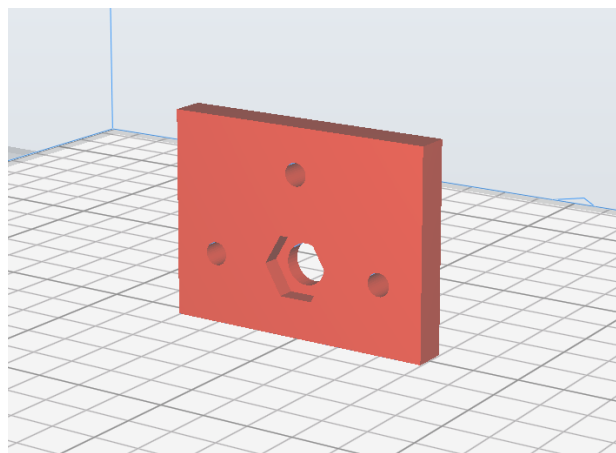


Figure 9 arm Screw nut

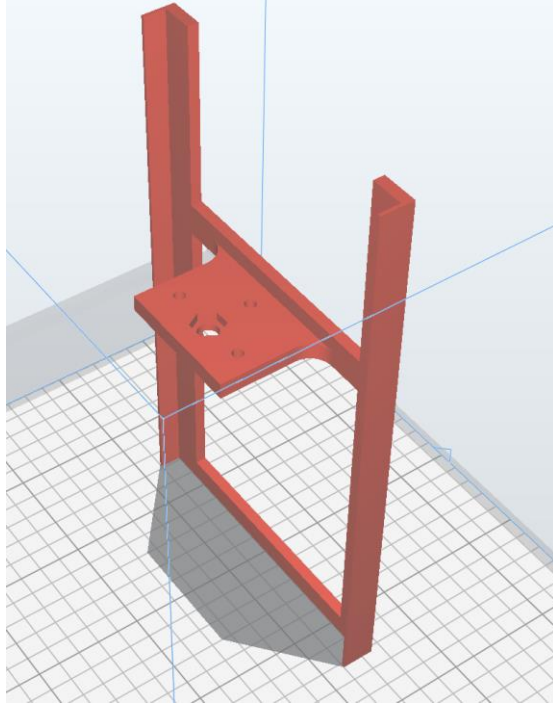


Figure 10 moving arm part

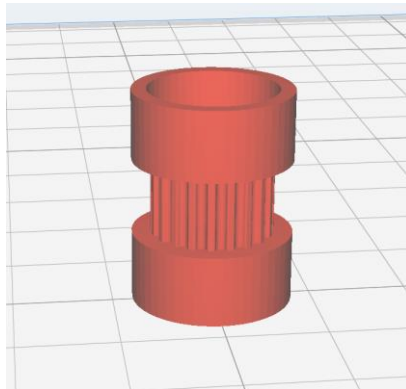


Figure 11 GT2 Timing Pulley in6 out13

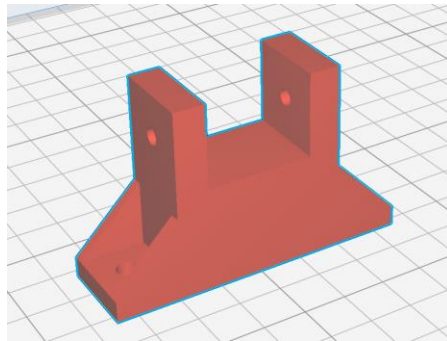


Figure 12 timing pulley holder h35mm

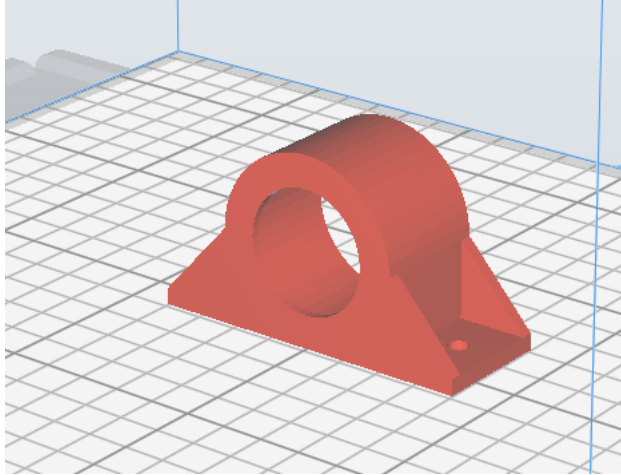


Figure 13 dc motor holder

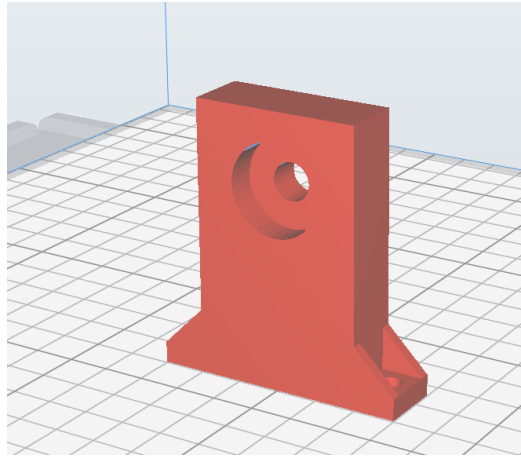


Figure 14 Bearing holder

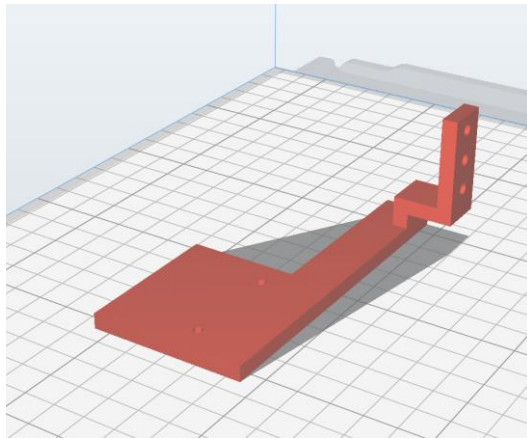


Figure 15 barcode reader holder

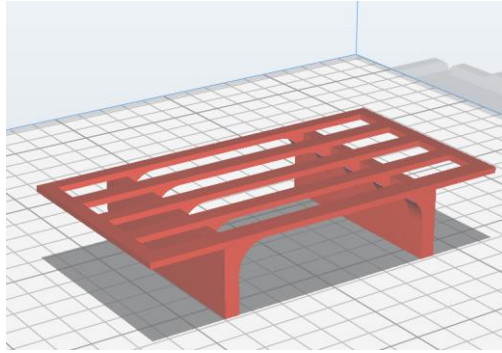


Figure 16 box plate holder

➤ **Hardware Components**

■ **Arduino Mega 2560**

- Overview The Arduino Mega 2560 is a microcontroller board based on the ATmega2560. Having fifty four digital I/O ports (15 of them with PWM outputs) it is great for hooking up and controlling tons of different sensors and devices. Additionally, it has 16 analogue inputs for accurate analogue measurements. The Mega 2560 also has 4 hardware serial ports (UARTs) so they can talk to other devices via these serial port and we used them to connect Arduino with ESP and Arduino wit barcode reader.
- The Mega 2560 is a reliable, feature-rich platform for exploring and developing electronics projects with extensive I/O requirements.
- We used it as the main control unit in order to control the drivers Relays, taking input from sensors, Serial communication with ESP and Barcode reader, taking inputs from IR sensors.



Figure 17 Arduino Mega

■ ESP 8266

- A popular and inexpensive Wi-Fi module that can function as a standalone microcontroller, the ESP8266. With a 1GHz Cortex-A8 CPU, it communicates over Wi-Fi and with GPIO pins, and is programmable using the Arduino IDE.
- We used it to receive commands from server (to control the device) and sent them to Mega, and controlling the lcd and keypad, in order to integrating between smart device application and the project giving high advantage by controlling the project from his device also from internet.



Figure 18 ESP 8266

■ Stepper Motor Nema 17

- The NEMA 17 stepper motor is a motor widely used in robotics, 3D printers, and automation systems. With its standard step angle of 1.8 degrees, it provides precise positioning and control. These motors come in different configurations, including different torque ratings and wiring options. NEMA 17 motors are known for their compatibility, reliability and versatility, making them a popular choice for many applications.
- We used it for movements along the axes in order to reach the product cell designated for the storage or extraction process and to access it accurately, in addition to controlling the process of loading and unloading the product itself.



Figure 7 Stepper Motor Nema 17

■ DIV268N Stepper Driver

- The DIV268N is a commonly used stepper motor driver module. It is a bipolar stepper motor capable of driving stepper motors with a maximum current of up to 5 amps. The module supports different microstep modes (full step, half step, etc.) and provides step and direction control inputs for motor control.
- We used it to drive stepper motors to determine the direction of rotation and the required angle in order to assist in the process of delivering products to the designated place or receiving them from the designated place.



Figure 19 DIV268N Stepper Driver

■ DC motor

- A DC motor is an electric motor that uses direct current (DC) to produce mechanical force. The most common types are based on the magnetic forces produced by currents in the coils. Almost all types of DC motors have some internal mechanism, either electromechanical or electronic, to periodically change the direction of current in a part of the motor.

- We used this motor to control the input and output production lines



Figure 20 DC motor

■ LCD 16*2

- The 16 x 2 LCD is a very basic module commonly used in DIY and circuit projects. 16x2 translates a width of 16 characters per line into two such lines. In this LCD screen, each character is displayed in a 5 x 7 pixel matrix.
- They are used to display the status of the system and set the barcode for the item that the user enters through the control keyboard.



*Figure 10 LCD 16*2*

■ IR sensor

- The infrared sensor (IR sensor) is a radiation-sensitive optoelectronic component with spectral sensitivity in the infrared wavelength range 780 nm... 50 μ m. Infrared sensors are now widely used in motion detectors, which are used in building services to turn on lights or in alarm systems to detect unwelcome guests.
- They used this sensor in order to sense the arrival of the product after it is inserted through the conveyor part to the place where it will be carried and place it on the shelf.



Figure 21 IR sensor

■ Keypad 4*4

- A keyboard is an input device consisting of a set of buttons arranged in a grid or matrix. Each button typically represents a specific letter, number, or command. Keyboards are commonly used to enter data or make selections in various electronic devices and systems.
- They used it to order the product by barcode and send it to the production line, in addition to specifying the location of the product that will be stored on the shelf.

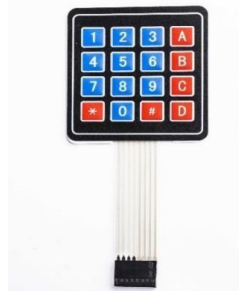


Figure 22 Keypad 4*4

■ Breadboard

- A breadboard (sometimes called a protoboard) is the basis for building and prototyping electronics. A breadboard allows you to easily and quickly create temporary electronic circuits or conduct experiments on circuit design.
- They used it to facilitate the connection process and connect the wires with the rest of the parts used in order to facilitate the maintenance process and also provide voltage source lines.



Figure 23 Breadboard

- jump wire
 - A jump wire (also known as a jumper, patch wire, DuPont wire) is an electrical wire, or a group of them in a cable, with a conductor or pin at each end (or sometimes without them – simply "tinned"), which is typically used to connect components A breadboard or other prototype or test circuit, internally or with other equipment or components, without soldering.
 - We have used various types of them for connection, especially with the Arduino and the rest of the components, in addition to connecting them with other parts and wires from the barcode reader and sensors.



Figure 24 jump wire

- Barcodes reader
 - A barcode reader or barcode scanner is a scanner that can read printed barcodes and send the data they contain serially to a control

unit. Like a flatbed scanner, it consists of a light source, a lens, and a light sensor to translate light pulses into electrical signals. In addition, almost all barcode readers have decoder circuits that can analyze the barcode image data provided by the sensor and send the barcode content to the scanner's output port.

- We used the barcode reader to read the product barcode and send it to the server to receive the correct allowed place for the product to be stored.



Figure 25 Barcodes reader

■ Power Supply

- A power supply is an electrical device that supplies electrical energy to an electrical load. The main purpose of a power supply is to convert electrical current from the source into the correct voltage, current and frequency to power the load. As a result, power supplies are sometimes referred to as electrical power converters.



Figure 26 Power Supply

➤ Process Of Work

■ State management

1. The ESP starts operating and connected to internet then send "ok" to the Arduino
2. The Arduino receive the ok and store it as the current Arduino state,
3. If the Arduino state is "ok", it will check for the IR sensor flag value, if there is product on the input line, it will send "stop" to the ESP and the ESP will store it as its state
4. The Arduino will start moving the arm to the input and grapping the product and reading its barcode, after receiving the barcode from the barcode reader, the Arduino will send "processing: barcode" to ESP, which will send it to the server and the server get the allowed cell for this product to be stored, if theres no allowed cells or the inventory is full or the barcode is wrong, the ESP will send "notFount" to Arduino to return the product to the output, else, it will send "coordinates: x, y" to the Arduino, the Arduino will map these coordinates to the real steps from the current position to the cell position and call the functions for putting the product on the correct cell.
5. After the arm finish, it sends "ok" to the ESP.
6. ESP keep listening to the server for output request, when a request arrives, Arduino will save it in a Queue, waiting for its state to be "ok", if the current ESP state is "ok" and the Queue not empty, the ESP will send "get: x,y" to the Arduino and change its state.
7. When Arduino receive "get" it will change its state to "get" and sends to ESP "getting: x, y" and call the function for outputting item from the cell to the output line.
8. After finishing it will send "ok" again to ESP and change its state to "ok"
9. IR sensor connected to interrupt pin, that allows it to change the flag any time theres a product on the input line
10. LCD will allow to printing the states on the first line and the entered barcode on the second line
11. Keypad will allow to receive barcode input from the user and when user press "#", it will send a request to the server to get the product (like the application)
12. Mobile Application provides easy interface to interact with the system like: adding new products, show products, set allowed products to be stored in each cell, show inventory products, and order any product from the inventory in a specific time.

■ Controller Design

- Based on the previous steps we decide to choose the components shown in the figure below:

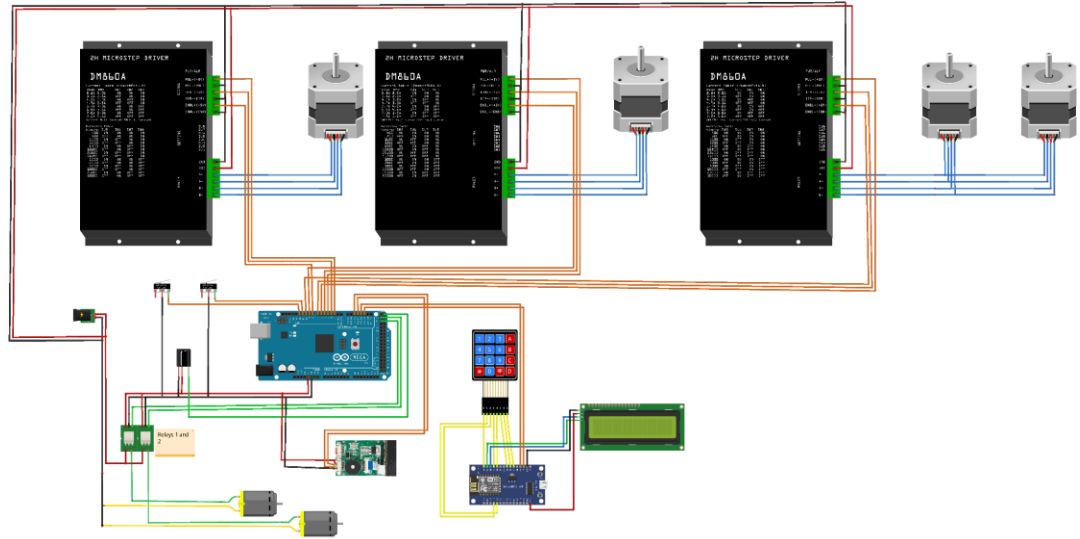


Figure 27 Controller Circuit

- Mobile application

The flutter application was designed to facilitate the process of communicating with hardware for the user and controlling and managing products through a group of pages, the most important of which are:

- Product display interface

After the user adds the product, scans it, and adds the rest of the information, this page provides comprehensive information about the products available in the store and displays the available products as a catalogue.

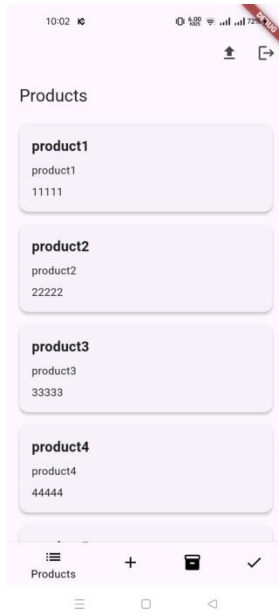


Figure 28 Product display interface

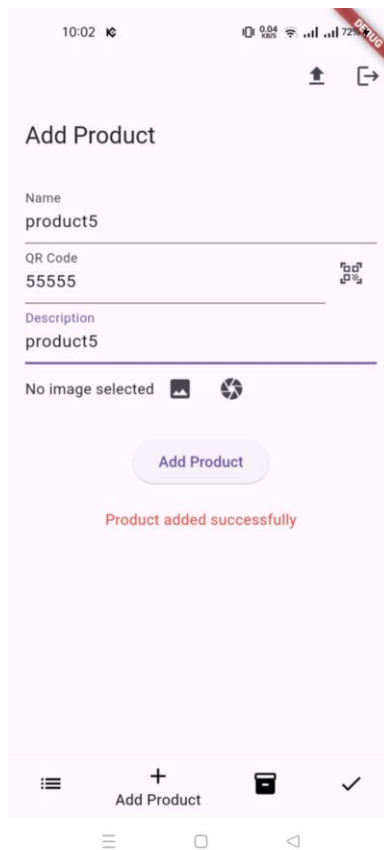


Figure 29 add product

- Allowed products interface

For selecting what product can be stored in a specific cell

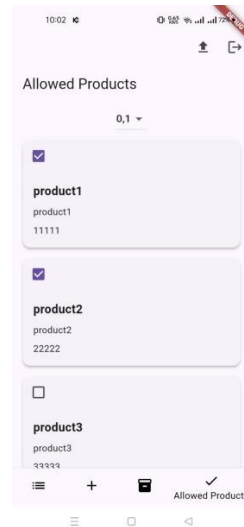


Figure 30 allowed products

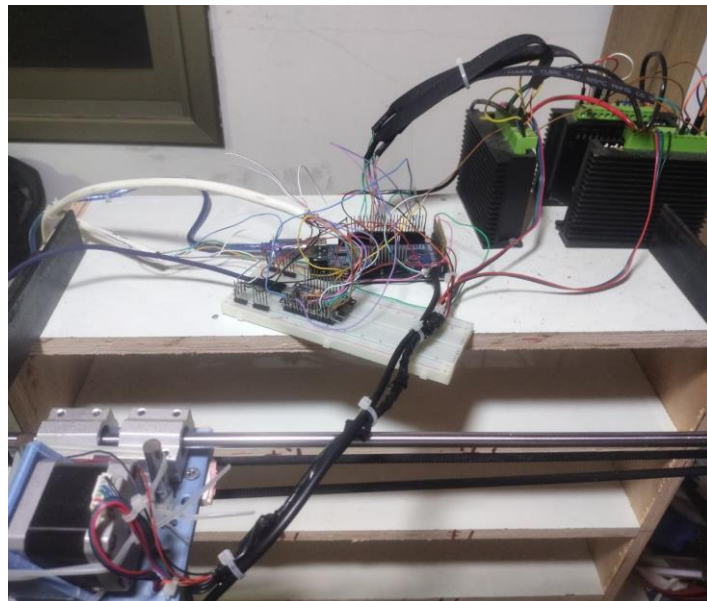
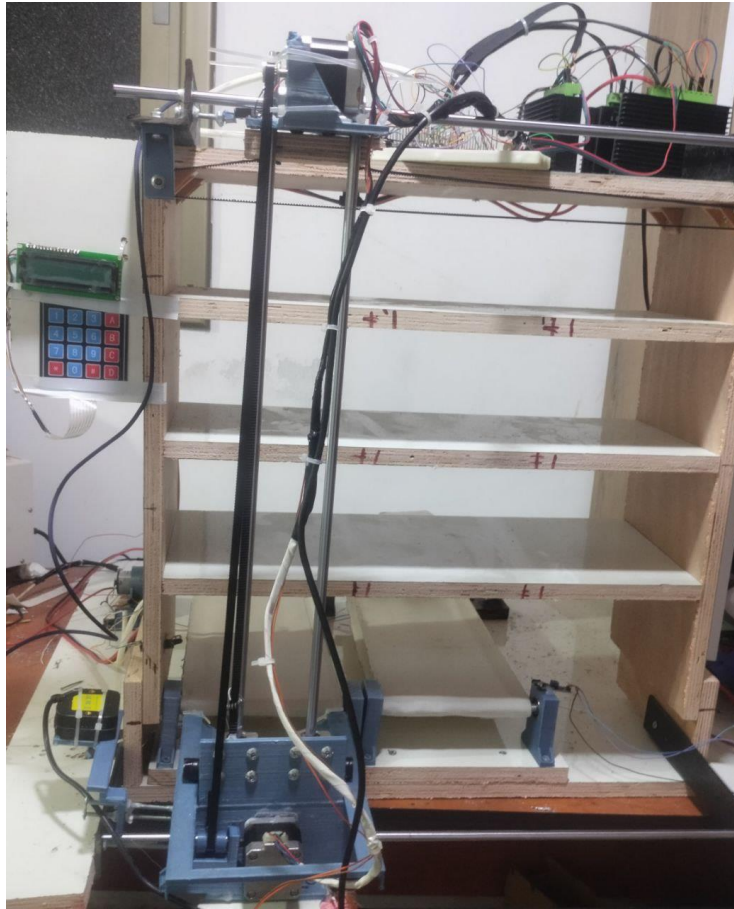
- inventory interface

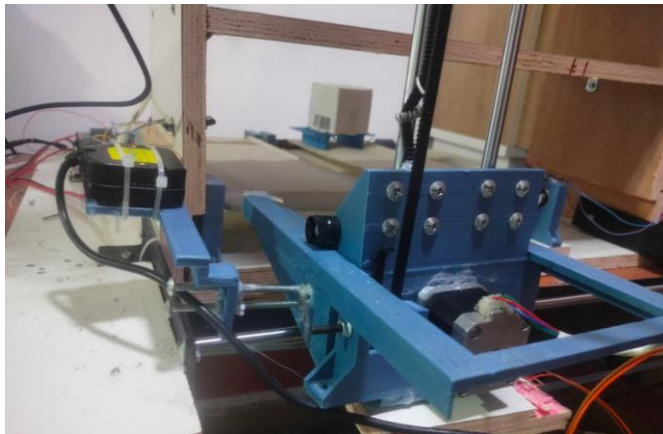
An interface that displays the products present on the store shelf with the ability to click on the product and send it to the output at a specific time



Figure 31 inventory

■ System images





❖ **Future Work**

- 1- Increasing the number of input and output lines and organize them more correctly like adding feedback line for returned products.
- 2- Increase the number of cells to fit more products.
- 3- Expanding the scope of the project to work on real life application, such as preparing orders and assembling them into one package.

❖ **Conclusions and Recommendation**

➤ **Conclusion**

In conclusion, this project aimed to enhance the process of storing products in warehouses and managing them effectively by integrating modern technology and creating an integrated system between the software systems and hardware parts available to us, and this was the main goal of the research in this project. The distinction was in the technology of the project and its integration, such that it is considered a real miniature model of what can be applied in warehouses or various factories. The distinction also came in the multiple ways of controlling the product management process, whether from existing parts, control panels, and the keyboard panel for input or access to integration with the mobile application, so that it is easy for users. And presenting it in an attractive, modern, scalable and sustainable way

➤ **Recommendation**

Before delving into our project, we spent a great deal of time on mastering the Arduino language. Besides that, we have also done much work to find all electronic components and understand what they are used for. This early experience turned out to be very useful and hence, we emphasize that in every hardware projects. To this end, fellow students need to prioritize such understanding before their individual projects begin. Additionally, most of the success that our project has achieved is as a result of identifying our idea earlier enough prior to the scheduled semester for graduation project. Consequently, this focus on advanced planning enhanced our efficiency considerably and enabled us achieve set objectives within the shortest time possible. As such, meticulous planning is recommended for students if they want to reach their project goals at any cost.

❖ References

- <https://docs.arduino.cc/hardware/mega-2560>
- <https://arduino-esp8266.readthedocs.io/en/latest/>