AUTOMATED MEASURING AND DISPENSING SYSTEM

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Abstract

In today's fast-paced world where technology has beat almost everything, automation has started to transform each and every industry, including the retail market. This main focus of the project is to develop an Automated Measuring and Dispensing Unit for supermarkets, aimed at allowing customers to independently measure and collect specific quantities of commodities such as wheat, grains and flour without the need for staff assistance.

The system combines mechanical and electronic engineering with a simple, affordable, and efficient design. A plastic barrel stores the product, which is dispensed through an Archimedes screw powered by a gear motor. And the user is able to enter their required inputs which is taken through a 4x3 keypad, and information is displayed on a 16x2 LCD screen with I2C communication for better visibility and user friendliness. The main unit of the project is an Arduino Uno microcontroller which handles as the heart of the system, which integrates user interaction through the keypad, weight measurement via the four 50kg load cells and manages the weight through HX711 amplifier, and the motor controller through an L298N motor driver.

This project aims to minimize human dependency in supermarkets, reduce customer waiting time, and increase the precision and consistency of product measurements. The system also offers a user-friendly interface helping the customers with convenience and real-time process feedback, making it easy for anyone to use without any hesitation. While the current model focuses on commodities such as wheat, grains and flour. The design also leaves some room for future upgrades and improvements to make it well accurate system. Through this work, we the main focus is to make the retail shopping experience more efficient, modern, and self-reliant through shifting manual systems to well automated systems.

Acknowledgements

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Chapter 01 – Introduction

1.1 Introduction to the project

When purchasing grains or other loose products from a supermarket, most of the time they are in need of staff assistance weigh and pack the required quantity. The main reason this system is very worth it is because the manual process not only consumes a lot of time but also reduces overall operational efficiency, especially during busy shopping hours. Moreover, it increases dependency on human labor, which could otherwise be redirected to more critical areas of service.

This Automated Measuring and Dispensing Unit was developed due to the recognition of the above-mentioned issue — a system which is designed to let customers to independently measure through the system and collect products like wheat without any staff involvement. Though the system is complex to build, the idea is very simple: the customer inputs the quantity they want using a keypad and it displays everything for the customers convenience, and the system measures the amount itself and dispenses the exact amount the customer wanted through an Archimedes screw mechanism.

This project lies a balance between mechanical design, well precise electronic measurements, and a well user-friendly interaction. The combination was done as a load cell-based weight measurement, a well stabled dispensing mechanism, which is driven by a gear motor, and an Arduino Uno microcontroller to build a cost-effective solution. And also, the system ensures that the user can monitor entered inputs as well the progress via an LCD display and easily input their requirements through a simple keypad.

This project not only addresses to the current inefficiencies in supermarkets which were mentioned above, but does a huge background work for smarter and automated shopping experience. The main focus is to reduce the employees' workload and improve customer satisfaction. And finally**,** the core reason is to ensure consistency in product measurement**,** which is the most important reason, all while being scalable for future upgrades like required product selection, automated billing and smart packaging.

In short, it is a step towards a more modern and self-reliant retail environment.

1.2 Aim

The aim of this project is to design and develop a fully automated, user-friendly, and accurate measuring and dispensing unit that allows supermarket customers to independently select, measure, and collect specific quantities of dry products like grains, without requiring staff assistance.

The main focus of this system is to minimize human error, reduce customer queues and enhance the overall shopping experience of the customer by integrating mechanical, electronic, and software components into a single, easy-to-use machine.

1.3 Objectives

- The design must incorporate an Archimedes screw and gear motor to develop a dependable storage along with dispensing system which will handle commodities effectively.
- The precise weight measurement can be achieved through the combination of four high-precision 50kg load cells with an HX711 amplifier which reduces weight reading errors.
- The system should feature an easy-to-operate interface which combines a 4x3 keypad for input and a 16x2 LCD display operated through I2C for real-time feedback. This interface design enables all customers to use the system without specific training.
- The Arduino Uno serves as the main controller to integrate all system components (motor, sensors, display and keypad) which results in a unified operational system.
- Users should be able to monitor their system control actions in real time by implementing visual feedback which allows them to pause, resume or reset dispensing operations.
- A durable framework with affordable features should exist within the system design making it practical for supermarkets and capable of expansion for sustainable long-term operations.
- An automatic reset feature should be enabled to prepare the system for the next customer without human interaction, thus enhancing operational efficiency and customer satisfaction.

1.4 Limitations or Scope

While the Automated Measuring and Dispensing Unit offers significant advantages, there are some limitations and boundaries to its current design, especially in this first version:

- Product Type Restriction:

The optimization of the current system is mainly for dry, free-flowing commodities such as grains (wheat, rice, pulses, etc.). It would not be able to handle liquids, sticky materials, or extremely fine powders due to the current mechanism without design modifications.

- Capacity Constraints:

The maximum weight the system can accurately measure is limited by the combined rating of the load cells (200kg). For heavier loads which are above 200kg, a higher-capacity load cell system would be needed.

- Slight Over-dispensing Possibility:

Due to mechanical inertia (especially at the end of the screw rotation), there might be a very small margin where the dispensed weight exceeds the input slightly. However, this has been minimized as much as possible through smart control logic.

- User Interface Simplicity:

The current version uses a physical keypad and LCD screen. Though it is simple and reliable, it has a major issue which lacks more advanced features such as touchscreen or voice commands, which could be much better and can be considered in future upgrades.

- Manual Refilling Requirement:

Once the grain level in the barrel runs low, staff must manually refill the storage unit. Full automation of the refilling process is not included in this project phase.

- Single Product Handling:

The unit is designed for a single type of product at a time. So handling multiple products would require either multiple units to keep the commodities separately or a more complex storage and dispensing mechanism to store each and every commodity in an effective way.

Despite these limitations, the system achieves its main goal — providing an easy, fast, and reliable way for customers to measure and collect the quantity they need without staff involvement. Future versions can be expanded by analyzing the limitations well and giving a better output based on real-world testing and feedback.

Chapter 02 – Literature Review

The development of an efficient automated measuring and dispensing system requires thorough examination of existing work involving relevant components and technologies. Multiple technical articles served as the basis for understanding how sensors and actuators function in comparable projects. The background research helped us choose the appropriate components which we integrated into our system.

L298N Motor Driver Module with Arduino

The accurate control of gear motor rotational motion stood as a fundamental requirement for our project. The article "Interface L298N DC Motor Driver Module with Arduino" provided step-by-step information about L298N motor driver operation. The article presented information about pin configurations along with basic wiring procedures as well as control logic guidelines and Arduino example codes required for speed and direction control. Our knowledge of these specifications helped us implement the motor driver correctly into our control system to achieve dependable delivery operations.

Using 50kg Load Cells with HX711 and Arduino

The precise measurement of weight served as a fundamental requirement to finish our project tasks. The article "50kg Load Cells with HX711 and Arduino. 4x, 2x, 1x Diagrams" demonstrated useful information about arranging several load cells into 1x, 2x or 4x setups and describing HX711 signal processing for sensors. We used the information provided to design a four-load-cell system that used HX711 for achieving stable weight sensing with high precision during dispensing operations.

Interfacing a 4×3 Matrix Keypad with Arduino

The project utilizes a 4x3 matrix keypad for providing users with convenient input capabilities. The article "Interface 3 & 4×4 Membrane Keypad with Arduino" explained the electronic scanning mechanism of matrix keypads and their operation through rows and columns to identify button presses. Through its sample Arduino codes and Keypad library explanation the article enabled us to establish a quick and effective user input system.

Integrating I2C Liquid Crystal Displays

The I2C-based 16x2 LCD display was selected for providing user feedback while using only a few Arduino I/O pins. The article "I2C Liquid Crystal Displays" provided complete instructions about I2C communication, wiring setup and basic programming for I2C display control. Through this approach the hardware design became simpler and the Arduino achieved better device management with its constrained resources.

Chapter 03 – Methodology

3.1System Overview

The Automated Measuring and Dispensing Unit developed in this project consists of three main functional units and two supportive units, each playing a key role in ensuring the smooth operation of the system.

The first main unit is the Dispersion Unit, which handles the mechanical process of dispersing out the commodities. It consists of a storage barrel, an Archimedes screw, and a gear motor. The Archimedes screw is placed horizontally at the bottom of the barrel and rotates at low RPM to steadily push out the commodities as required. The controlled movement of the screw ensures that the product is dispensed smoothly without clogging or sudden bursts.

The second main unit is the Control Unit, which acts as the brain of the system. The responsibility of the control unit is for executing the operational logic, managing sensors and outputs to meet the user requirements, and interacting with the user. The Control Unit integrates a 4x3 keypad for input collection, a 16x2 LCD display (via an I2C interface) for communicating with the user, an L298N motor driver for controlling the motor, two buck converters for providing 5V and 11V regulated outputs, and an Arduino Uno board that links and coordinates all other parts.

The third main unit is the Scaling Unit, which enables precise measurement of the dispensed product. This unit includes four 50kg load cells arranged in a Wheatstone bridge formation and an HX711 amplifier module. The load cells detect the weight changes in real-time, while the HX711 provides stable and accurate readings to the Arduino.

In addition to these three main units, there are two Supportive Units:

The Power Control Unit is used to adjust and reduce the voltage to match the operational needs of the system's electronics so that it won't get unnecessary power.

The Power Supply Unit is used to ensure that the system has a stable and continuous AC power source during operation.

By combining these units, the system achieves the goal of automatically dispensing measured quantities of commodities such as grains based on user inputs.

3.2 Important Components and their Functions

A summary of system components with their designated functions appears in the following

Component	Purpose/Function
Plastic Barrel	Store the commodities as bulk, such as wheat, grains and flour.
Archimedes Screw	Mechanically moves the product out of the barrel when rotated using the motor.
Gear Motor (100 RPM)	Powers the rotation of the Archimedes screw to ensure controlled dispensing according to the customer requirements.
L298N Motor Driver	Regulates the direction and speed of the motor according to system commands so that it meets the customer requirements.
Load Cells (4 x 50kg)	Measures the weight of the dispensed product by having the in the four corners resulting in high accuracy.
HX711 Module	The load cells transmit minimal signals to this amplifier which produces readable digital data for Arduino processing.
Arduino Uno	This controller functions as the central processing unit and output controller which integrates all system components.
4x3 Keypad	Allow users to input the required quantity of the commodities for dispensing.
16x2 LCD Display with I2C Module	The system delivers immediate feedback and guidance to users during their operations.
Down Buck Converters (LM2596)	The system needs voltage reduction together with voltage regulation for its various sections.

The reason to specifically use these components is to provide a system that offers cost efficiency and simplified maintenance alongside scalability for upcoming improvements.

3.3 Circuit Implementation

The system's electrical connections received thorough planning to fulfill safety requirements and operational reliability and basic troubleshooting options. The L298N motor driver receives its power from the primary supply before it distributes this power through two buck converters in parallel fashion. The system contains one converter that generates 5V for the HX711 load cell amplifier and LCD display and another converter that produces approximately 11V for the Arduino Uno.

The Control Unit wiring includes:

- The gear motor receives its power through the L298N motor driver that operates under signal instructions from the Arduino.
- The 4x3 keypad uses connections to Arduino digital input pins to recognize user input without difficulty.
- A connection using the I2C interface allows the 16x2 LCD display to have fewer wires thus simplifying the circuit design.

The Wheatstone bridge configuration drives the operation of the Scaling Unit through four load cells. The HX711 amplifier module receives signals from the load cells before transferring data through data and clock pins to the Arduino Uno. Real-time weight readings produced by this setup remain stable for accurate dispensing operations.

The Dispersion Unit features the Archimedes screw that directly connects to the gear motor shaft. The rotating motor shifts the screw which releases the product through a specified outlet.

The overall system includes dedicated ports for:

- 14V power input,
- 12V motor power output,
- 5V sensor power output,
- Load cell data input and clock input.

The Arduino code includes detailed documentation of wiring and pin configurations to maintain clear and simple system operations.

3.4 Libraries Used

The Arduino program incorporates various libraries that reduce complex operations while enhancing system reliability.

- **HX711_ADC.h—**
  The library enabled the HX711 load cell amplifier to produce stable and trustworthy readings which produced precise weight measurements.
- **LiquidCrystal_I2C.h—**
  The implementation of I2C communication protocol enabled simplified control over the 16x2 LCD display which reduced wiring complexity.
- **Wire.h—**
  It serves as a fundamental requirement for the Arduino to communicate through I2C with the LCD display module.
- **Keypad.h—**
  This hardware component enables efficient error-free collection of data from the 4x3 matrix keypad through keypress interpretation and scanning.

The libraries proved fundamental for creating software modules that enhanced project reliability.

3.5 Algorithm and Logic Flow

The system follows a step-by-step approach which arranges its operational principles to create a logical workflow and smooth user interaction.

Step 1: User Input

The user starts their operation by using the keypad to enter the desired weight measurement. The system displays each keypress to the LCD screen instantly for user verification. Users who need to fix a typing error can use the * button to return to an empty input field. The user completes the transaction by pressing the # button after the correct weight entry.

Step 2: System Taring

The Arduino sends instructions to the scaling unit which activates taring of the system after confirmation. The system taring procedure eliminates the weights of both barrel components and stored wheat to measure only the newly dispensed amount.

Step 3: Dispensing Process

The motor operates the Archimedes screw by making it move the grain toward the outside. The system required special precision logic to function correctly. The motor receives instructions to decrease its pulse delay to 20ms when the system reaches the last 200g of the target weight which is 600g or less.

The system employs the same slow-down procedure when the weight exceeds 600g and the remaining amount reaches 200g.

Step 4: Real-time Monitoring

During dispensing the Arduino system constantly retrieves weight data from the connected load cells. The system stops the motor operation the instant the measured weight reaches or surpasses the input target value.

Step 5: Completion and Reset The system shows the measured weight after completion of the dispensing process and then displays a "Thank you" message. The system waits for five seconds before resetting its operation and getting ready to handle new user inputs.

Block Diagram

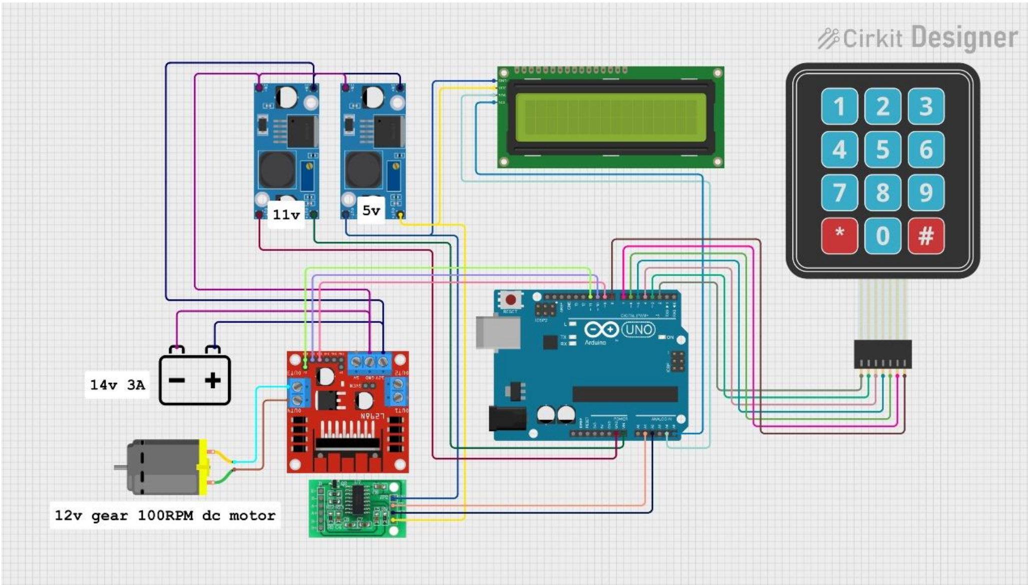

Figure 1: Circuit Diagram

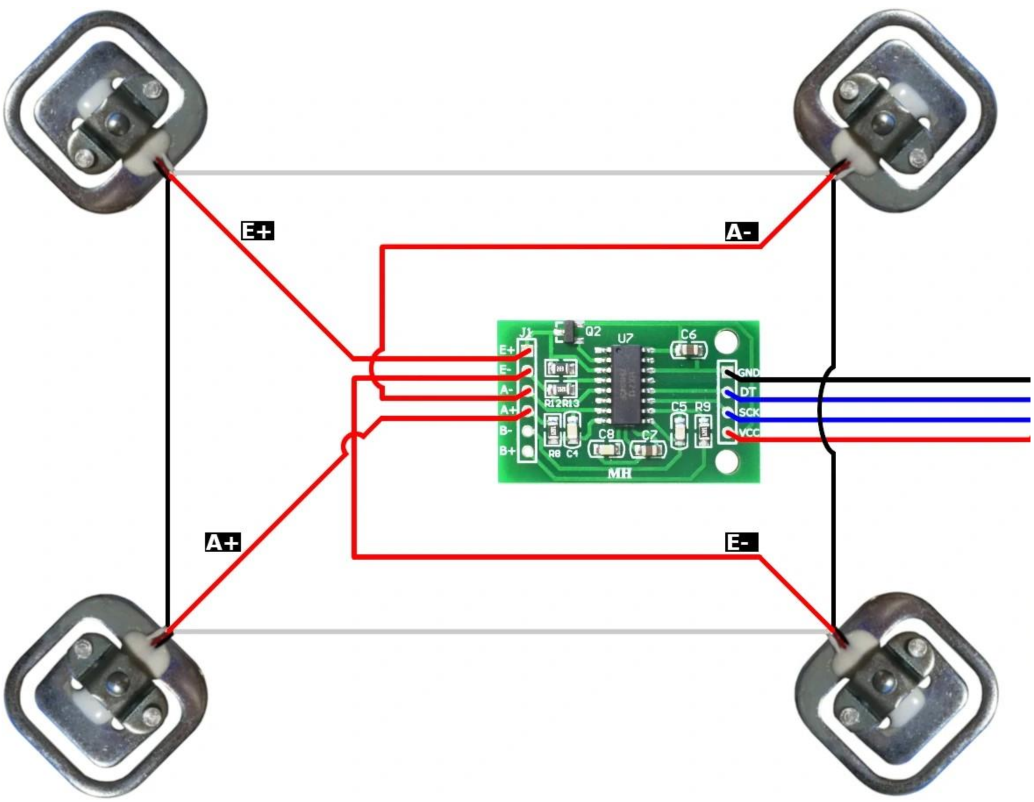

Figure 2: Scaler Diagram

Chapter 04 – Discussion

4.1 Problems Faced During the Project

A number of developmental difficulties arose during this phase which demanded well-considered modifications and solutions.

Selecting an Effective Dispensing Mechanism:

The selection of an appropriate horizontal grain movement method proved to be essential because several options existed. Our design requirement focused on achieving reliability with accuracy alongside maintainability simplicity.

Screw Blockage Issues:

As the Archimedes screw rotated within its casing friction occurred because it made minimal contact with the walls. The blockages formed by this action disrupted the dispensing system operation.

High Friction at Axle Connection Points:

Mechanical resistance and motor strain developed because of excessive friction at the screw's axle connection points to the casing.

Motor Power Insufficiency: The motor initially failed to produce sufficient torque needed to properly rotate the screw thus causing improper dispensing results.

Motor Instability: When the motor operated it showed slight movement away from its storage barrel mounting position which disrupted both alignment and operational efficiency.

Unstable Load Cell Readings:

Testing of the weighing system (scaler) produced irregular measurement outputs that made measurement results unreliable.

Multiple Voltage Requirements:

Power distribution became complicated because the system components needed different voltages (5V for sensors and display, 11V for Arduino, 14V for the motor).

Wiring Defects:

The system displayed unexpected keypad errors that led to damaged jumper wires causing faulty connections as well as unreliable input readings.

4.2 Solutions Implemented

We applied practical solutions to system stability and performance improvement through the resolution of each problem.

Choosing the Right Dispensing Method:

We chose the Archimedes screw mechanism after conducting a thorough evaluation process. The chosen Archimedes screw provided accurate flow control and simple maintenance procedures as well as future serviceability.

Reducing Screw Friction:

We treated all screw edges for polishing until the edges stopped touching the casing. The smooth rotation became possible because all unnecessary friction was eliminated.

Minimizing Friction at Connection Points:

The axle ends required ball bearings to reduce friction. The bearings allowed for smooth rotation at low resistance which decreased motor strain.

We replaced our motor with a newer generation model of equivalent 12V, 100RPM, 3A power to achieve better performance. The machine received a new high-torque DC gear motor with specifications of 12V power supply and 100RPM speed and 3A current rating. The new motor provided sufficient power to rotate the screw load while maintaining a stable operation without motor stall.

Motor Mount Reinforcement:

The motor received security through the use of 4x4 inch bolts and nuts. The added reinforcement kept the motor locked in position to the screw when the system was in operation.

Stabilizing Load Cell Readings:

The weighing discrepancies stemmed from the fact that Arduino and load cells operated on different grounding systems. Connecting the scaler ground to Arduino ground pin established a common ground that remarkably improved measurement stability.

Optimizing Power Distribution:

The system implements two buck converters with one generating a steady 5V for sensors and display while the other produces 11V for the Arduino. A single main power source provided a parallel wiring arrangement to power the motor controller directly with 14V and all other units.

Fixing Wiring Problems:

A multimeter examined all jumper wires before connecting them into the system. The system received new, functional wires as a replacement for broken or defective wires to achieve reliable power distribution across the entire network.

4.3 Future Implementations

The existing system meets fundamental requirements yet future developments will create a more efficient and intelligent solution that enhances user experience in automated supermarket procedures.

The Automatic Refill Detection System represents one of the future system enhancements. The storage barrel installation of sensors provides the system with real-time measurement of product volume. Staff members receive automatic alerts through the system whenever product levels reach the predefined threshold point thus enabling timely refills that prevent service disruption.

The handling capabilities of the machine will be expanded through Multi-Product Handling improvements. The machine operates best with one specific grain or commodity at present. Users will benefit from system expansion when selecting multiple products through a single centralized management system which boosts both convenience and flexibility.

The upcoming versions of the interface will include a Touchscreen Interface. A touch screen interface replacement of the physical keypad would provide users with a modern and natural user experience. The system would enable dynamic menus together with product images and improved navigation when users switched from buttons to a touchscreen interface.

The implementation of IoT Connectivity stands as a major proposed improvement. The integration of Wi-Fi or Bluetooth modules enables automatic report generation and maintenance alert delivery and refill notification transmission to supermarket management software or mobile applications thus improving operational performance.

The system can reach its maximum mechanical potential through better motor management systems. A precision stepper motor replacement of the existing gear motor would enable better screw rotation control which leads to superior dispensing accuracy for small quantity needs.

The project will transition to Eco-Friendly Design as its final step. Introducing sustainable and recycled material containers for storage barrels would both minimize environmental impact and bring the project into alignment with current sustainability objectives.

Upgraded versions of the automated measuring unit would transform it into an intelligent environmentally friendly tool suitable for advanced retail spaces of the future.

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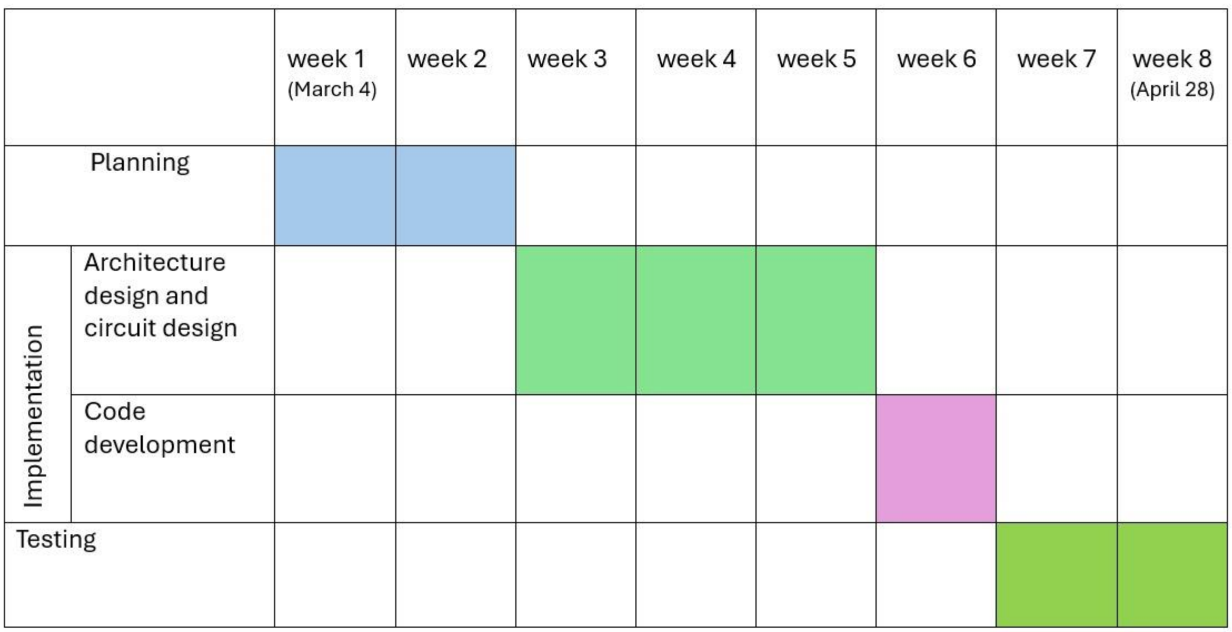
Gantt Chart



Appendix

Budget:

https://docs.google.com/document/d/1DaOAFT8bQvEzSwUqmQyisoYYA060ICEjH8NpNxVbs-0/edit?usp=sharing

circuit diagram:

https://app.cirkitdesigner.com/project/1ef32f10-1c7f-408f-af8e-330d7ac19076

code:

https://github.com/amriHaneef/Robotic_Arduino