PALESTINE POLYTECHNIC UNIVERSITY

College of Information Technology and Computer Engineering

Computer Engineering Department

Computer Systems Engineering

Title Of The Project

Perfume Production Machine

Prepared by :

Arsalan Manasra

Osama Abdallah

Yazan Shalab

Supervisor :

Dr. Mousa Farajallah

This project is submitted to fulfill the requirements for a Bachelor's degree in Computer Systems Engineering

Aug 18, 2025

Documentation and Anti-Plagiarism Declaration

We confirm that the graduation project entitled "Perfume Production Machine" was prepared by the student(s) named below, under the supervision of Dr. Musa Farajallah, in partial fulfillment of the requirements for the Bachelor's degree in Computer Systems Engineering.

We declare that no part of this work will be reproduced illegally or constitute plagiarism, including but not limited to direct copying or unauthorized use of the work of others. All reference materials are properly documented and used solely to support and illustrate the project ideas.

By signing this declaration, we affirm our commitment to maintaining academic integrity and acknowledge that we have not and will not engage in any plagiarism, cheating, or other violations of academic standards. We assume full responsibility and accept any consequences should a violation of this declaration be proven.

Date:

Graduation Project Group:

Arslan Manasra – Signature:

Osama Abdallah– Signature:

Yazan Shalab – Signature:

Abstract

The "Perfume Production Machine" automates and enhances perfume manufacturing, addressing challenges like inconsistencies, inefficiencies, and human error. By incorporating advanced automation, it ensures high-quality production.

The system uses infrared (IR) sensors for precise bottle positioning and ultrasonic sensors to monitor ingredient levels, ensuring accuracy in every batch. Its dispensing mechanism enables precise mixing, even for small quantities. Motors, including DC motors, power the mixing and bottle movement processes, ensuring reliability and efficiency.

Practical challenges, such as varying power requirements, are resolved by adapting power supplies and using uniform-sized faucets. User interaction is simplified with an LCD interface for configuring and monitoring production parameters.

This machine boosts productivity and quality while offering a customizable solution for crafting unique fragrances. Its modular design supports future improvements, making it ideal for small artisans and industrial manufacturers alike.

مشروع "آلة إنتاج العطور" هو خطوة مبتكرة تهدف إلى أتمتة عملية تصنيع العطور وتحسينها. تواجه الطرق التقليدية مشاكل مثل عدم الدقة، الإهدار، وأخطاء البشر أثناء قياس ومزج المكونات. هذه الآلة صُممت لحل هذه التحديات باستخدام تقنيات حديثة.

تستخدم الآلة مستشعرات الأشعة تحت الحمراء لتحديد مكان العلب بدقة ومستشعرات الموجات فوق الصوتية لمراقبة مستويات المكونات، مما يضمن إنتاجًا متسقاً ودقيقاً. كما أن نظامها يتيح مزج الكميات الصغيرة بدقة عالية، وتحريك العلب بسلاسة باستخدام محركات موثوقة و سيضمن أيضا نظام تنبيه و تعبئة آلي.

واجهة الاستخدام تتضمن شاشة LCD لتسهيل التحكم والمتابعة، بينما التصميم القابل للتطوير يتيح إجراء تحسينات مستقبلية. الآلة تلبي احتياجات الحرفيين وصناع العطور على نطاق صناعي، مما يجعلها خيارًا مثالياً لزيادة الكفاءة والإنتاجية بجودة عالية.

باختصار، هذه الآلة تقدم حلاً شاملاً وعصرياً لصناعة العطور بمستوى احترافي ومخصص.

Acknowledgment

In the name of God, the Most Gracious, the Most Merciful, who has blessed us with the strength and knowledge and helped us complete this project. To those who have inspired and supported us to become who we are today: our families, friends, and supervisor.

We would not have achieved this accomplishment without their support, care, and encouragement. We extend our sincere gratitude to all of them, and we are grateful to our graduation project supervisor, Dr. Musa Farajallah, for his guidance, support, and encouragement throughout the project.

We also extend our sincere gratitude to our families, whose constant encouragement and support have been the cornerstone of our journey. Their generosity, both spiritually and practically, has shaped our identity. My mother, my father, and all our family members, your belief in us has been a beacon of light, and we are grateful to you from the bottom of our hearts. Finally, we acknowledge the collective effort that has propelled us forward. Every person who has touched our lives and left a mark of care and encouragement has played a vital role in our story. As we celebrate this occasion, we express our gratitude for the moments shared and the countless individuals who have left an indelible mark on our hearts.

Contents

List of Figures

List of Tables

Abbreviations

DC	District of Columbia. 3,6,15,16,17,21,22,23,35,41
IDE	Integrated Development Environment. 25,36
CMYK	Cyan, Magenta, Yellow, and Key. 7,8
MQTT	Message Queuing Telemetry Transport. 7
UARTs	Universal Asynchronous Receiver / Transmitter. 11
LX6	Linear Executable. 11
PSU	Power Supply Unit. 16,33,41
MQ-3	Metal Oxide. 15,25,27,34,37,38,41

CHAPTER ONE: INTRODUCTION

1.1 Preface

In this project, a perfume production machine will be implemented to automate the mixing and filling processes. The initiative will aim to significantly increase efficiency in perfume production by reducing the time required for manual tasks, minimizing human errors, and optimizing resource utilization through precise automation. Shop managers will streamline their workflows and minimize risks associated with manual mixing like as incorrect ingredient ratios that may lead to product defects or safety hazards. The project will also introduce new capabilities, including customized blending and enhanced inventory management, further contributing to operational efficiency.

1.2 Problem Statement

In the evolving perfume industry, shop administrators face challenges in efficiently mixing perfumes due to manual processes prone to errors and inconsistencies like inaccurate ingredient measurements or scent imbalances that affect product quality. As the range of fragrances expands, tracking inventory levels and ensuring consistent mixing quality becomes overwhelming. Moreover, amateurs venturing into perfumery find the manual mixing intimidating and risky. The outdated methods fail to ensure consistency in scent profiles, leading to unpredictable results and wasted materials. to meet the demands of the modern perfume market, highlighting the urgent need for an automated solution — for example, reducing production time while ensuring consistent fragrance quality across large batches. to enhance efficiency and improve the perfume mixing experience.

The goal of this project is to achieve a streamlined and automated perfume mixing process that ensures high consistency and accuracy while minimizing manual intervention. Currently, manual mixing methods are prone to inconsistencies and errors, making it challenging for perfume shops to meet customer demands and maintain high-quality standards. To address these issues, we propose an automated solution that simplifies the mixing process, reduces errors, and provides a more reliable and efficient production system suited to the needs of the modern market.

1.3 Project Aims and Objectives

To enhance efficiency and reduce manual labor in perfume production, we automate the mixing process and monitor the system levels of perfumes to automate refilling, integrate a control system through LCD display, and include error alert mechanism to ensure continuous production flow.

1.4 Project Requirements

1.4.1 Functional Requirements:

- The system should support automated blending of fragrances according to user specifications.
- Provide an easy-to-use interface for selecting fragrance types, entering ingredient ratios, and monitoring production.
- Enable control capabilities through start/stop operation and settings.
- Sensors should continuously monitor ingredient levels and alert the user when alcohol, water, or fragrance concentrations are running low.
- Notify users of any operational errors.

1.4.2 Non-Functional Requirements:

- The system should maintain consistent and accurate mixing and refilling, ensuring the reliability of output quality.
- Real-time monitoring and immediate response to low ingredient levels and machine malfunctions.
- The system should be adaptable to include additional ingredients or new mixing features.

1.5 System Description

innovative automated system designed to streamline perfume production by automating the mixing and filling processes traditionally performed manually in retail settings. The system is divided into five main sections:

1. **Filling Station**: Ensures precise pouring of the custom-blended fragrance into bottles.

2. **Mixing Station**: Used to mix ingredients to achieve a thorough scent.

3. **Bottle Sealing Station**: Secures each cap tightly, ensuring that perfume bottles are sealed effectively.

4. **Control Unit and I/O Interface:** Provides an intuitive interface that manages the system we designed.

Our project integrates multiple sensors (such as infrared and ultrasonic sensors), as well as servo, DC and stepper motors, to ensure accuracy and reliability at every stage of production. The system design includes a conveyor system that moves bottles through these stations with precision, supported by an Arduino Mega microcontroller for communication. Users interact with the machine through an LCD screen and keypad, allowing control and monitoring of the system in terms of fragrance levels and machine status in real time. The machine also features automated refilling and alert systems to notify users when supply levels are low, ensuring continuous production without manual intervention.

1.6 Project Limitations/Constraints

1- Power Supply Complexity:

The system requires multiple voltage levels (e.g., 5V, 12V, 24V) to operate various components such as sensors, pumps, relays, and motors. Managing these different power needs may pose challenges in stability and integration.

2- Microcontroller Limitations:

Although the Arduino Mega 2560 was chosen for its extensive I/O capabilities, there is a risk that it may not sustain stable performance under full load or high-frequency operations, potentially requiring hardware adjustments or replacements.

3- Sensor Variability:

IR and ultrasonic sensors may provide inconsistent readings due to environmental interference, bottle alignment issues, or reflection angles. These fluctuations could require frequent recalibration to ensure accuracy.

4- Time Constraints:

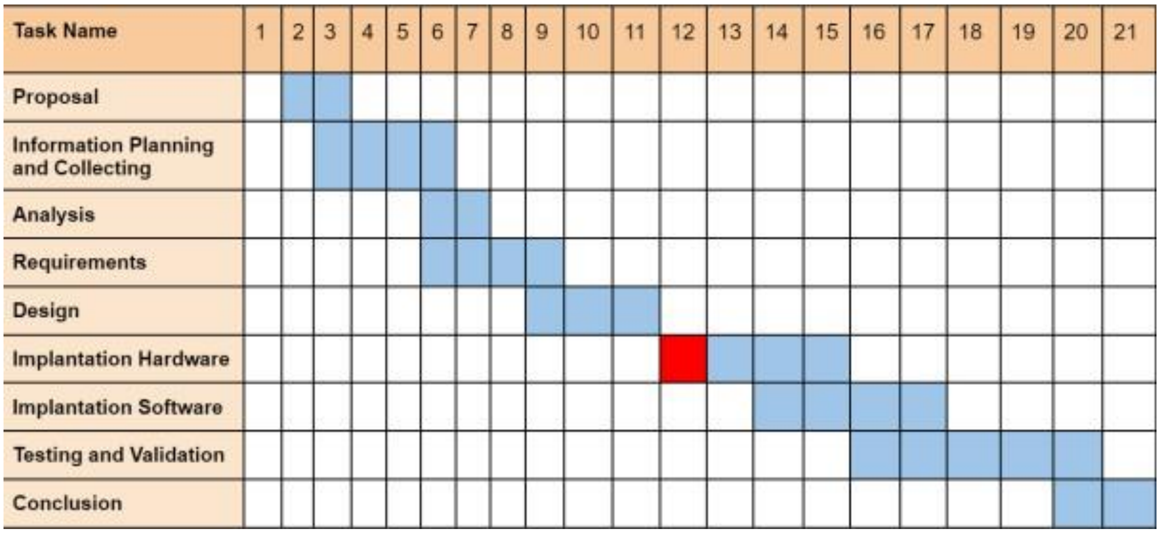
Building and testing a complete production line — from mixing to filling and capping — within limited academic timeframes presents scheduling risks, especially when integrating hardware and software subsystems.

5- Manual Assembly Challenges:

Due to the complexity and custom nature of the design, many components may need to be assembled manually. This introduces potential for human error during wiring, calibration, or component alignment.

1.7 Project Schedule

Table 1.1: Schedule Time



1.8 Report Outline

In this chapter, the general definition of the project and the aim of the problem it is meant to solve are both defined. This chapter also covers the functional and nonfunctional requirements, which describe potential problems and a plan for advancing the work.

CHAPTER TWO: THEORETICAL BACKGROUND

2.1 Preface

In this section, we will discuss the project in terms of the theories we intend to employ, as well as related projects that have been completed in the past. We will also clarify the concept of each project, compare it to ours, highlight the differences, and explain how we can build on previous work by integrating it into our own project.

2.2 Theoretical Background Concepts

2.2.1 General Description:

The inefficiencies and inconsistencies in traditional manual perfume production methods are common challenges in the industry. To address these, the following principles are essential for designing an automated perfume production system:

- **Select the Appropriate Base Framework:** Choose a suitable mechanical and structural design to accommodate all components, ensuring stability and optimal integration.

- **Ultrasonic Sensors:** These sensors measure precise liquid levels within tanks, operating at frequencies between 20 kHz and several gigahertz. They ensure the correct amount of liquid is dispensed for blending.

- **DC Motors:** Typically equipped with two wires (positive and negative), these motors are used for simple, bidirectional control. Reversing the connections alters the rotation direction, making them ideal for driving pumps or conveyors.

- **L298N Motor Driver:** This affordable and versatile driver controls both the speed and direction of two DC motors, enabling precise operation of mixers, conveyors, or other moving components in the production process.

By applying these principles, the automated perfume production system achieves reliability, precision, and efficiency, addressing the growing demands of the modern fragrance industry.

2.3 Literature Review

This section will present a selection of earlier project that are comparable to ours and compare them.

2.3.1 Paint Mixing Dynamics Study

This project focused on automating the paint mixing process to ensure color consistency and quality. An Arduino Mega was used as the core microcontroller, along with a highresolution camera for analyzing the mixed paint's color. The system utilized a custom mixing algorithm to determine the proportions of primary colors (red, green, blue) based on user inputs and commercial paint databases. The paint mixing machine provided realtime monitoring and adjustments to achieve the desired color homogeneity, and its performance was modeled using empirical differential equations to optimize mixing time and quality.

2.3.2 Advanced Color Mixing Machine for Your Desired

This project aimed to develop a device capable of producing a wide variety of colors by mixing CMYK primary colors. The machine incorporated a color sensor to detect the target color and determine its CMYK composition. A mobile application allowed users to select colors manually or via the sensor. The system was built with a focus on precision, usability, and automation. It used a combination of ESP8266 and MQTT protocol for efficient communication between the device and the application, enabling real-time color mixing and adjustment.

While previous projects focused on specific color-mixing applications, our project aims to provide a comprehensive and intelligent solution for perfume production. The following table provides a detailed comparison of the three projects based on their key aspects, highlighting the evolution in objectives, technology, and outputs from the previous projects to our own.

Table 2.1: shows a comparison between previous projects and our project

Aspect	Paint Mixing Process	Color Mixing Machine	Perfume Production Machine
Objective	Automate paint mixing (RGB model)	Precise color mixing (CMYK model)	Automated perfume production with safety
Technology	Arduino, camera, mixing algorithm	Raspberry Pi, color sensor	Arduino Mega, sensors, actuators
Input	User-defined values	Sensor or app input	User input or predefined settings
Output	Homogeneous paint with analysis	Accurate color replication	Custom perfume blends, fully automated process, modular design, enhanced safety
Features	Process modeling, empirical analysis	Mobile control	Modular design, enhanced safety

2.4 Summary

The system allows users to select the perfume composition via an LCD screen. After that, the components are automatically dispensed and mixed. The bottle is then capped and labeled, ensuring a seamless and efficient production process.

CHAPTER THREE: SYSTEM DESIGN

3.1 Preface

Most perfume mixing machines only have a motor that does the mixing, and as a result, they rely heavily on the hands of workers. To provide better service, it was necessary to use more electronic and solid components. These elements that help in the mixing and filling processes are described in this chapter. In fact, there are many different types and sizes of parts, and the range of parts and their types is very wide. The parts were selected for this project taking into account the materials used in each part as well as the. completeness of the production process.

3.2 The system components and design option

This section explains the components of our project and why we picked them.

3.2.1 Hardware components

In order to get the best value at the lowest possible cost, we carefully examined the design and chose the best components and controls for our project

1. Microcontroller

A microcontroller will be required to process the data provided to the machine, making it a critical component of the project. The selection of the processor type will be based on key characteristics, including cost, sufficient memory, suitable size, speed, and the number of I/O pins. After evaluating various options, the Arduino Mega 2560 will be selected due to its balance of affordability, ample memory capacity, compact form factor, high processing speed, and a sufficient number of I/O pins, making it an ideal fit for the project's requirements. Numerous types of microcontrollers exist, each designed for specific applications.

- **Raspberry Pi 4 Model B:** it is the latest product in the popular Raspberry Pi range of computers. It offers ground-breaking processor speed, multimedia performance, memory, and connectivity **.**

Figure 3.1: Raspberry Pi 4 Model B

- **ESP32:** microcontroller integrated with Wi-Fi and Bluetooth, featuring a high-performance dual-core processor, a large number of GPIO pins, and support for multiple communication protocols. It is widely used in Internet of Things (IoT) projects and automation systems thanks to its fast data processing capabilities and low power consumption.

Figure 3.2: ESP32

- **Arduino Mega 2560:** The Arduino Mega 2560 is a microcontroller board based on the ATmega2560. It has 54 digital input/output pins (of which 15 can be used as PWM outputs), 16 analog inputs, 4 UARTs (hardware serial ports), a 16 MHz crystal oscillator, a USB connection, a power jack, an ICSP header, and a reset button.[1]

Figure 3.3: Arduino Mega 2560

The table 3.1 compares the hardware specifications of the Raspberry Pi 4, ESP32, and Arduino Mega 2560.

Table 3.1: Comparison between microcontrollers

Category	Raspberry Pi 4	ESP32	Arduino Mega 2560
CPU	Quad-core ARM Cortex-A72 (64-bit) @ 1.5 GHz	Dual-core Tensilica Xtensa LX6 @ 240 MHz	8-bit AVR ATmega2560 @ 16 MHz
Memory	4 GB	520 KB SRAM	256 KB Flash, 8 KB SRAM
Networking	Gigabit Ethernet / Wi-Fi 802.11ac	Wi-Fi 802.11bgn & Bluetooth 4.2	None
GPIO Pins	40-pin GPIO	34 GPIO pins	54 digital & 16 analog pins
Storage	Micro SD	4-16 MB Flash memory	256 KB Flash memory
Price	$55	$15	$10–$15
USB Ports	2x USB 3.0, 2x USB 2.0	1x Micro USB	1 USB port

The Arduino Mega 2560 was chosen as the project's main microcontroller due to its ability to meet complex requirements. It features a high number of digital and analog input/output (I/O) pins, making it ideal for controlling the various sensors and pumps. Its high processing and communication capabilities ensure effective control over all interconnected units, resulting in a smooth and integrated production process.

2. IR Sensor Module

An infrared sensor (IR sensor) is an optical-electronic component sensitive to radiation within the infrared wavelength range of 780–50 µm. These sensors are widely used in motion detectors for applications like lighting control in building services and detecting unauthorized entry in alarm systems. Within a specific angle range, the sensor elements detect thermal radiation (infrared) that varies due to the movement of object[2].

Figure 3.4: IR Sensor Module

In the context of the project, an IR sensor module can be employed for tasks such as detecting stops, identifying the presence of a perfume bottle, and determining whether the bottle cap is empty or full. To justify its selection, the IR sensor module is compared with the PIR motion sensor, as shown below:

Table 3.2: Comparison of IR Sensor and PIR Sensor

Feature	**IR Sensor**	**PIR Sensor**
Detection	Infrared reflection	Thermal radiation
Range	2–30 cm (short-range)	3–10 m (long-range)
Sensitivity	Precise for small objects	Effective for large movement
Output	Digital/Analog	Digital
Project Suitability	Ideal for bottle and cap detection	Limited to motion detection

It can be used in our project by detecting stops, detecting the presence of a perfume bottle, determining whether the bottle cap is empty or full.

3. HC-SR04 Ultrasonic Sensor:

HC-SR04 as shown in figure 3.5, is ultrasonic ranging sensor used to measure the distance to an object with high accuracy and stable readings. It consists of one ultrasonic transmitter, a receiver and control circuit. The transmitter will emit high frequency sound which bounce off any nearby solid object and the some of the sound will be reflected and detected by the receiver of the sensor. The emit signal and return signal will be proceeding by the control circuit in order to calculate the time different between them. Then using some simple formula, the distance between the sensor and reflected object will be calculated[3].

Figure 3.5: Ultrasonic Sensor

shows some specifications of HC-SR04:

Table 3.3: HC-SR04 Specifications

Operating Voltage	5.0 (V) DC
Working Current	15(mA)
Ultrasonic Frequency	40 kHz
Max Range	4 (m)
Min Range	2 cm

The ultrasonic sensor is used to measure the distance between the sensor and the liquid level in the tank, and the software calculates the distance between the liquid level and the sensor and then determines the required amount of water to be added to obtain the required mixture in the tank.

4. MQ-3 Sensor

This sensor is used to sense the alcohol percentage and then display it on the screen. The user then chooses whether to adjust the alcohol percentage, continue, or drain the components.

Figure 3.6: MQ-3

5. Red Flash Buzzer

A piezoelectric buzzer, shown in Figure 3.7, is an audio signaling device like a beeper. The main function of this is to convert the signal from audio to sound. It is powered through DC voltage [4]. We will use this device as a sound notification in our alert system.

Figure 3.7: Red Flash Buzzer

7. Power Supply: Computer PSU (5V/12V/24v)

A power supply, shown in Figure 3.9, is an electrical apparatus that delivers electric power to electronic devices, such as laptops, servers, or other electronic equipment. Its primary role is to transform electric current from a source into the appropriate voltage, current, and frequency required to operate the device. This conversion may involve changing from AC to DC or DC to DC. Pneumatic valves require 12V DC to operate, so a power supply will satisfy this need [5].

Figure 3.8: Computer PSU (5V/12V/24V)

8. 12V Peristaltic Aquarium Chemical Dosing Pump Tube Head

Due to the small size of the internal rotor, the 12 volt mini water pump requires a small amount of 12 volt DC voltage. It has one water outlet, one outlet, and one inlet.With a voltage of 12 volts, this water pump is referred to as a mini water pump.We will have several of these pumps, each connected to one of the basic components. These pumps are connected to a control unit, which determines the ratios. [6]

Figure 3.9: 12V Peristaltic Aquarium Chemical Dosing Pump Tube Head

9. Relay

A relay is an electronic switch that can be used to control high voltage and current loads using a low voltage and current signal. A 5V relay module is a type of relay that can be controlled by a 5V signal, and is compatible with an Arduino microcontroller. The switch may have any number of contacts in various contact configurations, such as make contacts, break contacts, or combinations of both[7].

Figure 3.10: Relay

In our project, an 8-channel relay module will be integrated to control the operation of the pumps and the alarm buzzer. This module serves as an effective interface between the Arduino board and components that require a voltage higher than 5V, such as pumps and alarms. It enables precise control over turning each pump on and off individually. By using the relay module, we can regulate the flow of different perfume ingredients by activating specific pumps as needed, ensuring a consistent and accurate mixing process while enhancing the system’s efficiency and reliability in advanced operational environments.

11. LCD

An LCD is a common electronic screen utilized in various devices.

For our project, we incorporated a 20x4 LCD to present essential information and directions to the end-user. This approach enhances the user experience, streamlining interactions with our system. Specifically, the LCD displays queries and guidance for user input via the keypad. Once this input is assessed, the relevant outcomes are showcased on the LCD

Figure 3.11: 20*4 LCD

12. Keypad

A keyboard consists of buttons arranged in a grid, where each button is located by row and column. Such keyboards are often integrated into systems that operate using microcontrollers.

In our project, we will use the keyboard as an input device to provide customers with the ability to select the type of perfume they want. This is achieved by displaying clear and concise instructions

on the accompanying LCD screen, which the customer can then enter into the keyboard to confirm their selection

Figure 3.12: keypad

13. Stepper motor with Gear

A stepper motor with gear refers to a type of motor that operates by moving in precise, discrete steps and is equipped with a gear mechanism. The integrated gear system enhances the motor's performance by increasing torque and reducing the rotational speed of the output shaft, enabling more controlled and stable motion. This combination is particularly useful in applications that demand high precision and repeatability, such as automated systems, 3D printers, and robotic arms.
Unlike standard DC motors, stepper motors allow for exact position control without the need for feedback systems, and the addition of a gearbox further amplifies torque while reducing step angle, resulting in smoother and more accurate movements. This makes stepper motors with gears ideal for scenarios requiring a balance of precision, torque, and control[8].

Figure 3.13: Dc Motor With Gear

14. Motor Gear

The gear for the motor is an essential component that helps control the speed and torque of the motor. By using gears, the motor can deliver smoother and more precise movements while handling heavier loads with stability. In our project, we use the gear with the motor to regulate the motion of the conveyor belt, ensuring that perfume bottles are transported accurately from one stage of production to the next.

Figure 3.14: Motor Gear

15. Paddle agitators

In our system, mixing occurs in a separate tank using a DC motor connected to paddle agitators that reach the tank walls. This setup ensures efficient blending of ingredients, ideal for low-viscosity fluids and processes like dissolution and heat transfer. The agitators produce gentle laminar flow, maintaining the mixture's quality without damaging sensitive components.

Figure 3.15: Paddle agitators

16. Conveyor Belt

The bevel belt conveyor is made of lightweight, durable aluminum alloy with a high-quality anti-static PVC belt that is wear-resistant and stable during operation. It features adjustable speed control, strong motor performance, and easy mobility with universal castors. Commonly used in various industries, this conveyor will be utilized in our project to smoothly transport the perfume bottle from one stage of the production process to another.

Figure 3.16: Conveyor Belt

17. Stepper Motor Driver

This upgraded stepper motor driver supports up to 32 microstepping segments for high-precision control. It works with 42, 57, and 86 type stepper motors (2-phase/4-phase) and operates on 9V–42V DC with up to 4.0A output. Features include high-speed optical isolation, selectable current and subdivision modes, offline hold, semi-enclosed design for harsh environments, and built-in temperature and overcurrent protection. [9]

Figure 3.17: Stepper Motor Driver

18. 43A Motor Driver Module

This driver, based on Infineon BTS7960 high-power full H-bridge chips, features built-in thermal and over-current protection. It utilizes a dual BTS7960 H-bridge circuit, providing strong driving and braking capabilities while effectively isolating the microcontroller from the motor driver. With a high current capacity of up to 43A, this module will be used in our project to operate the Linear Actuator Motor efficiently and reliably

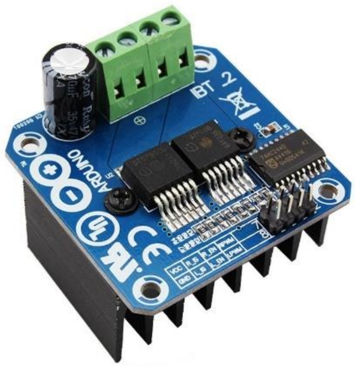


Figure 3.18: 43A Motor Driver Module

19. Linear Actuator Motor

This high-quality, heavy-duty linear actuator offers reliable performance and stable operation, with equal push and pull capabilities and excellent environmental adaptability. It features a no-load current of less than 1A, a maximum load current of 3A, and a built-in high-quality limit switch for precise control. Constructed from durable aluminum alloy with a low-noise design (below 65 dB) and IP54 rating for outdoor use, it is commonly applied in automotive, medical, and engineering fields. In our project, this actuator will be used to close the perfume bottle securely and efficiently.

Figure 3.19: Linear Actuator Motor

20. On/Off switch

We used an on/off switch to control the power supply and serve as a safety feature, allowing the system to be quickly turned off in case of emergencies or maintenance.

Figure 3.20: On/Off switch

3.2.2 Software components

This section will provide some information about the main programs and software technologies used in my project.

3.2.2.1 Arduino (IDE)

The Arduino Integrated Development Environment or Arduino Software (IDE) is an open source, contains a text editor for writing code, a message area, a text console, a toolbar with buttons for common functions and a series of menus. It runs on various operating systems.

3.2.2.2 Conceptual System Design

The conceptual system design for our project represents a prototype of an automated perfume production machine that integrates multiple sensors, control modules, and actuators to perform the mixing and filling process with minimal human intervention. At the heart of this system is an Arduino Mega microcontroller, which serves as the central processing unit, receiving data from various sensors such as ultrasonic sensors for liquid level detection, an IR sensor for bottle presence, and an MQ-3 sensor for alcohol concentration measurement.

The process begins with the interface unit, where the keypad and LCD display allow the user to select the type of perfume and set the desired quantity. The system then checks the liquid levels in the ingredient tanks using ultrasonic sensors to ensure sufficient materials are available for production. During the processing stage, the MQ-3 sensor continuously monitors the alcohol content, while the relay module controls the pumps to dispense precise amounts of each ingredient into the mixing tank.

Once the mixing is complete, the output unit, equipped with an IR sensor, ensures that the bottle is correctly positioned before filling. The piezoelectric buzzer provides alerts for completion or errors during operation. The integration of these components, as shown in the system block diagram in Figure 3.17 and the conceptual diagram in Figure 3.16, ensures synchronized operation, accurate measurements, and efficient production flow.

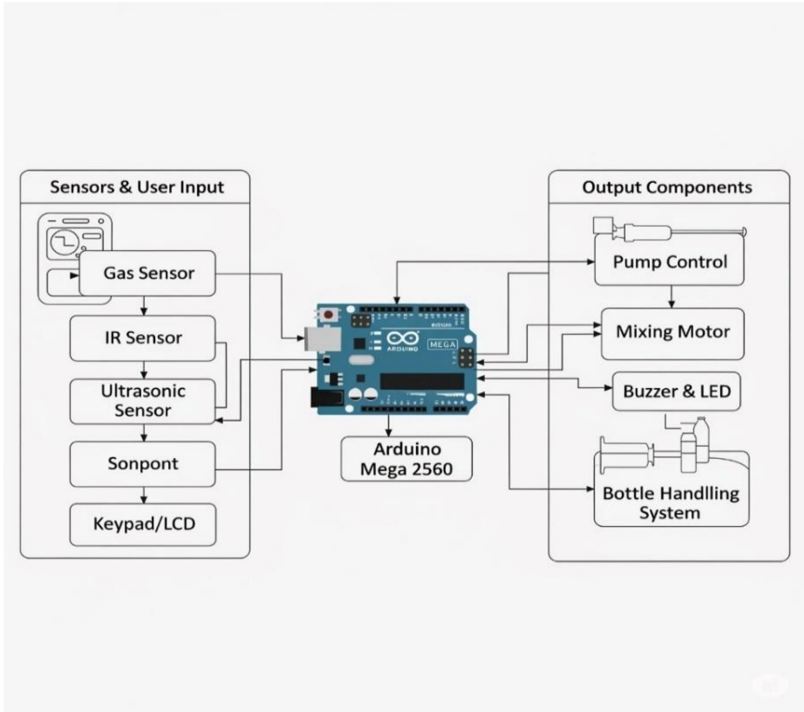


Figure 3.21: System conceptual diagram

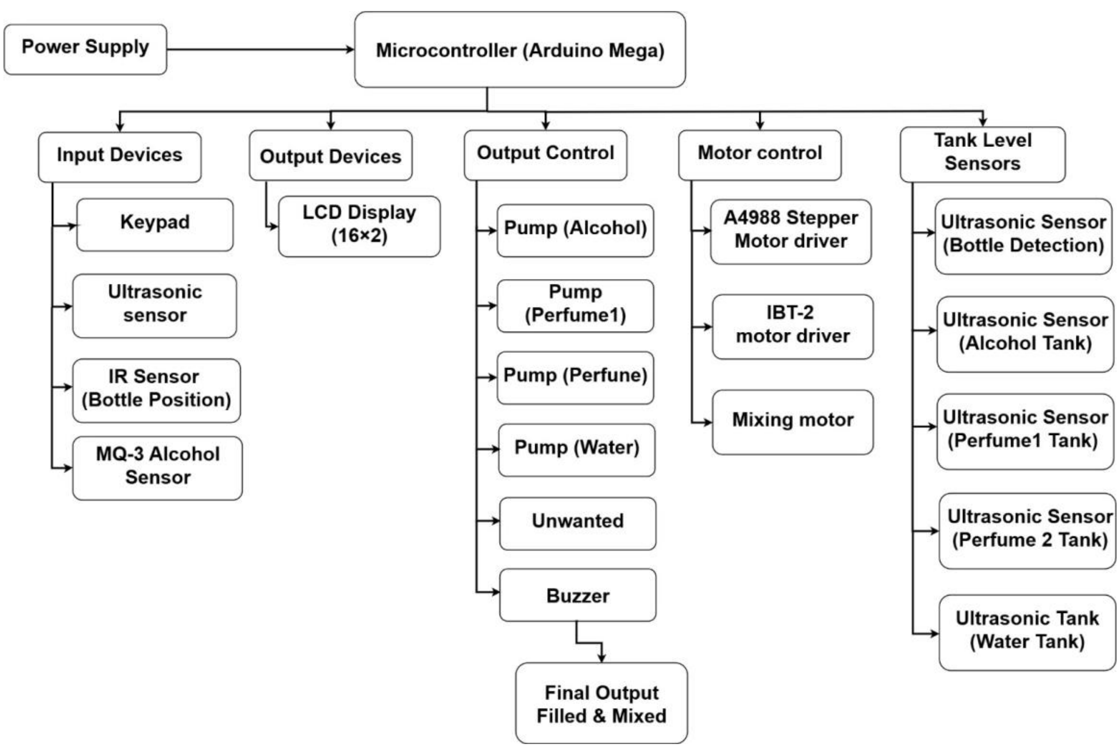


Figure 3.22: Block Digram

3.4 Algorithms and methodologies

3.4.1 Algorithms

3.4.1.1 Mixing process

The mixing algorithm ensures that the fragrance components are accurately distributed in the mixing chamber based on pre-defined or user-specified ratios.

The algorithm starts by checking that the component ratios provided by the user add up to 100%. It also checks whether the component levels in the tanks are sufficient for the required volume. For each component, the required volume is calculated.

The mixing process is completed after ensuring that the components are at the correct levels using ultrasonic sensors. By measuring the distance between the sensor and the height of the materials, the alcohol sensor detects the alcohol content and allows the option of either mixing, which operates the mixing motor, or adjusting or discharging the components.

3.4.1.2 Fault Detection process

This algorithm constantly monitors the system for faults, such as missing components, sensor malfunctions, or complete sensor failure.

Sensor Monitoring: The system regularly reads data from all sensors, including ultrasonic sensors (for liquid levels), infrared sensors (for bottle presence), and the MQ-3 sensor (for detecting the concentration of volatile gases during the mixing phase). Sensor failure can occur when a sensor stops sending data, provides constant readings regardless of real conditions, or outputs values outside its normal operating range.

Fault Detection: The data from each sensor is compared to pre-set thresholds. If any value is out of range — such as an empty tank, hazardous gas concentration, or abnormal/unresponsive sensor readings — the algorithm identifies it as a fault, ensuring operational safety and reliability.

Operation Alerts: When a fault is detected, the system sends real-time notifications to the user via an LED and a piezoelectric buzzer.

.

3.4.1.3 Refill process

The refill algorithm monitors the ingredient tanks to ensure uninterrupted production flow.

Level Monitoring: Ultrasonic sensors continuously measure the liquid levels in each ingredient tank and send real-time data to the system.

Refill Alert: If the level of any tank drops below a predefined threshold, the system immediately notifies the user via an LED indicator and a piezoelectric buzzer, prompting them to manually refill the tank.

Production Continuity: By alerting the user before a tank is completely empty, the system minimizes downtime and ensures a smooth production process.

3.4.1.4 Production Flow Control process

This algorithm manages the movement of bottles through the various production stages, ensuring synchronization and efficiency.

Bottle Detection: IR sensors at each station detect the presence of bottles. The algorithm uses this data to confirm when a bottle is correctly positioned.

Movement Coordination: The conveyor system and actuators move bottles to the next station only after confirming that the current process (e.g., filling, capping) is complete.

Process Synchronization: The algorithm ensures that each station operates in sequence. For example, the mixing stage must finish before the bottle is capped.

Error Handling: If a sensor detects a missing bottle or a misalignment, the algorithm pauses the production line and alerts the user to correct the issue.

3.4.2 Flow Chart

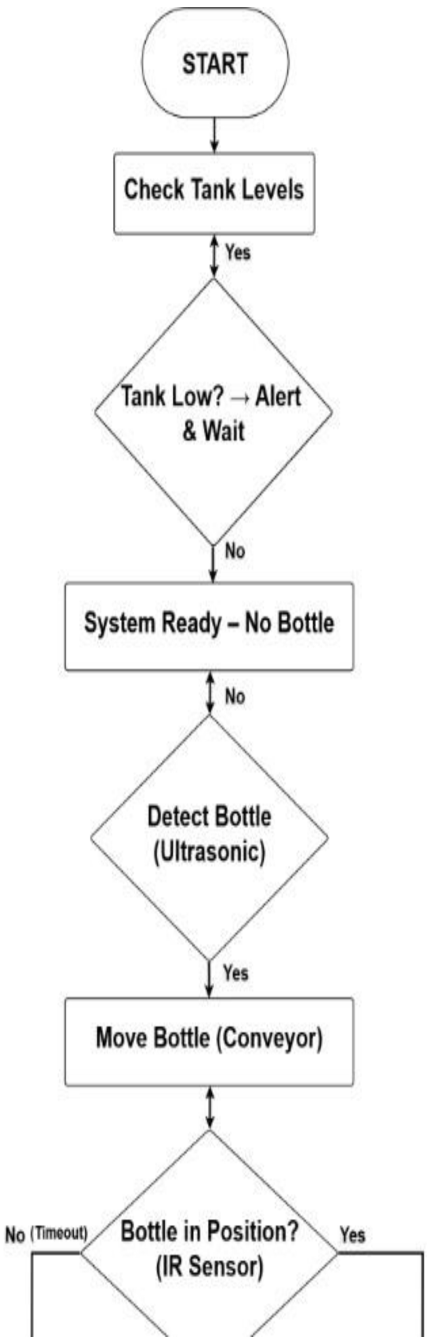


Figure 3.23: Bottle Detection and Positioning Flowchart

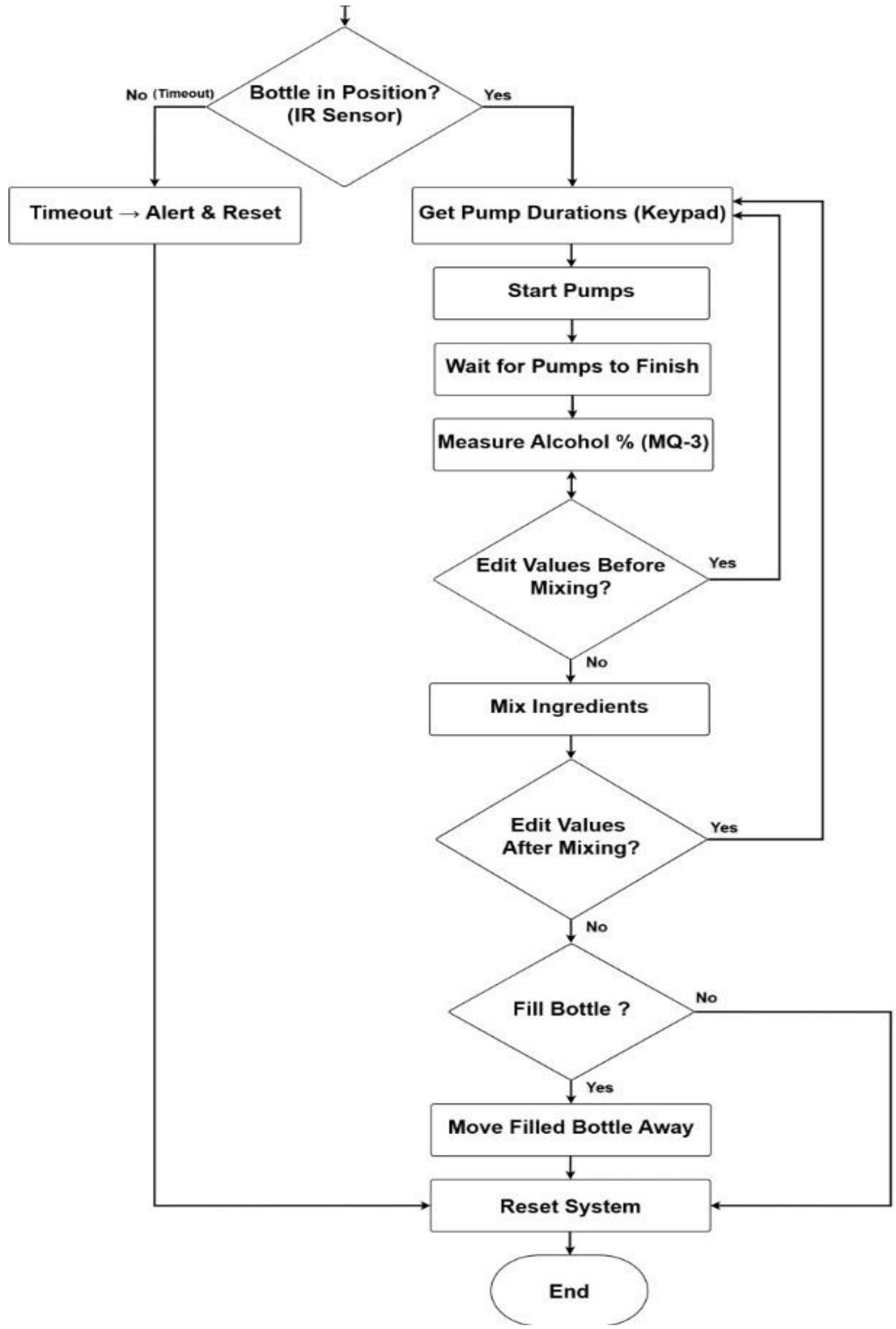


Figure 3.24: Perfume Mixing and Filling Flowchart

3.5 Schematic Diagram

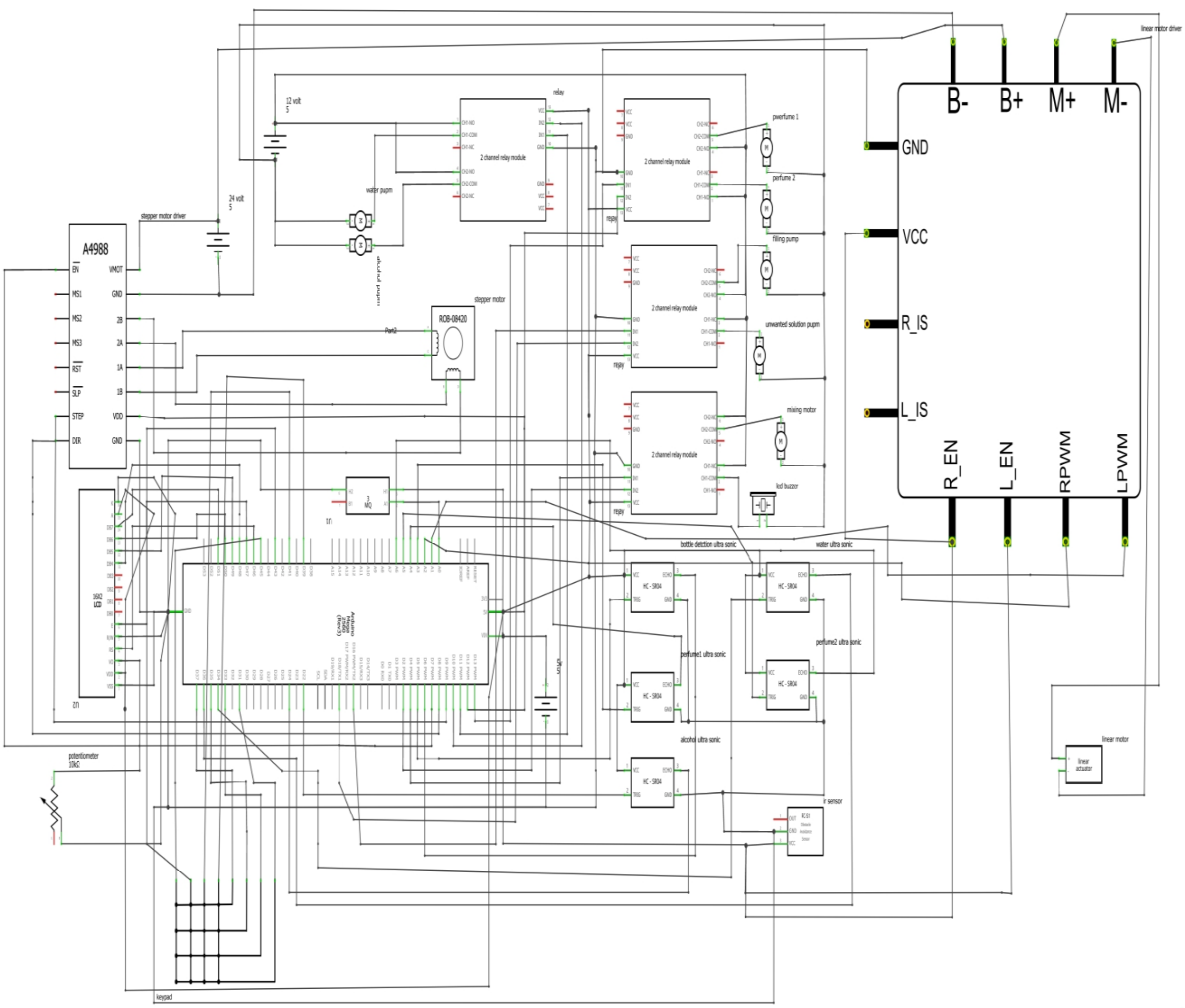


Figure 3.25: Schematic Diagram

Summary

In this chapter, we have discussed the system hardware and software components with their alternatives. The conceptual description of the system and the general flow of the system with all necessary diagrams are presented, too**.**

CHAPTER FOUR: IMPLEMENTATION

4.1 Preface

This chapter explains the implementation part for the hardware components and the software. It dives into more details about the project's overall different hardware components and software modules.

4.2 Hardware Implementation

In this section, we will describe the hardware components used in our project and how they are connected.

4.2.1 Prototype

We designed a custom frame that could support all parts of the machine, including tanks, pumps, motors, sensors, and the user interface. The structure was built using durable materials to ensure stability and proper arrangement of components. Each component was placed in a specific position based on the system design, and we paid attention to ease of access and safety. We used cable organizers to arrange the wiring neatly and avoid electrical hazards. After completing the assembly, we performed physical tests to confirm that the frame could support all operations smoothly.

Figure 4.1: Front view

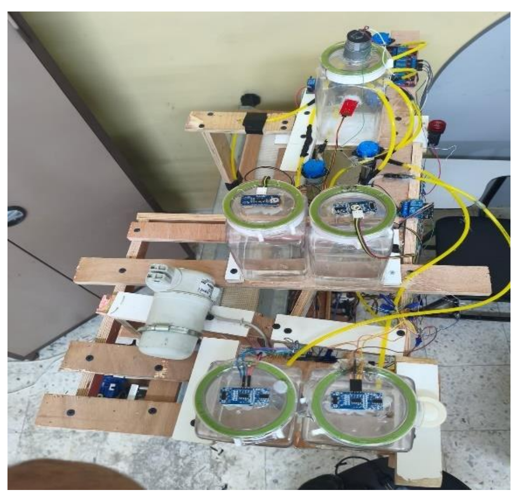


Figure 4.2: Top view

4.2.2 Microcontroller and Power Setup

For system control, we installed the Arduino Mega 2560 at the center of the prototype. It served as the brain of the system, controlling all input and output devices. We used a computer PSU to supply stable 5V and 12V power to components such as pumps, sensors, and motors.

We connected an 8-channel relay module to safely manage the switching of higher voltage components. We also verified that all power connections were stable and correctly grounded.

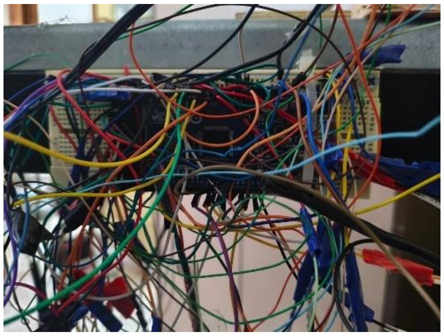


Figure 4.3: Arduino Mega 2560

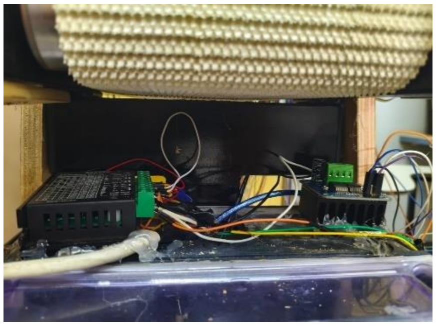


Figure 4.4: Motor Driver Modules

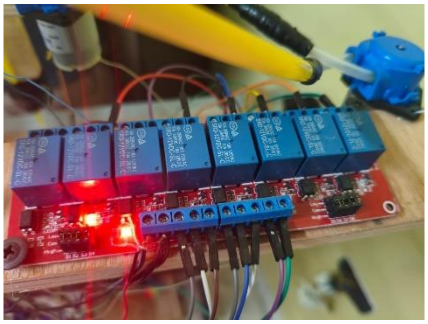


Figure 4.5: 8-Channel Relay Module

4.2.3 Sensor Installation

We installed and tested various sensors throughout the machine:

- IR sensors were mounted on the conveyor to detect the arrival and presence of bottles at each station.
- Ultrasonic sensors were placed above the tanks to monitor the liquid levels and activate the refill mechanism when needed.
- We positioned the MQ-3 alcohol sensor near the mixing tank to check the alcohol concentration during production.

After mounting the sensors, we calibrated them and made sure they responded correctly to different conditions.

Figure 4.6: IR sensor installed on the conveyor for bottle detection

Figure 4.7: Ultrasonic sensor mounted above the ingredient tanks

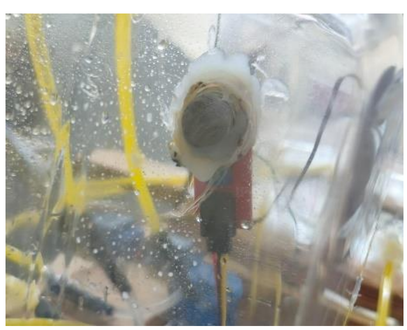


Figure 4.8: MQ-3 alcohol sensor positioned near the mixing tank

4.2.4 Pumping and Mixing Mechanism

To automate the liquid dispensing process, we installed several 12V peristaltic pumps**,** each one connected to a different perfume ingredient. These pumps were controlled through the relay module and activated based on the mixing ratios entered by the user. Inside the mixing tank, we placed a DC motor connected to paddle agitators. This ensured proper mixing of the ingredients without damaging their properties.

Figure 4.9: pump setup

4.2.5 User Interface and Output Devices

We integrated an interactive interface to allow users to control the system easily:

- A 20x4 LCD screen was used to display instructions, system status, and alerts.
- A keypad allowed the user to enter mixing commands or choose perfume types.
- A piezoelectric buzzer was added to give sound notifications for errors or low levels.
- An on/off switch was connected to control the main power of the machine safely.
- A perfume bottle capping mechanism was included to press and seal the cap securely after placing it on the bottle.

Figure 4.10: switch

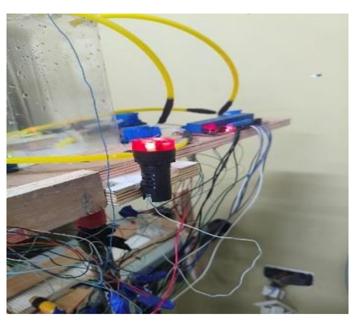


Figure 4.11: Buzzer

Figure 4.12: Press the cover

4.3 Software Implementation

This section explains how the software for the Perfume Production Machine was developed and implemented. The code was written in the Arduino IDE and uploaded to the Arduino Mega 2560 microcontroller. The program was designed in a modular approach, where each part of the system—such as sensor monitoring, pump control, motor movement, error handling, and user interaction—was separated into dedicated functions. This structure improved readability, debugging, and system scalability.

4.3.1 Development Environment

We used the **Arduino IDE** [1] as the main development tool to write, compile, and upload our code to the Arduino Mega. It provided us with a user-friendly environment and access to all necessary libraries for handling sensors, LCD displays, keypads, and relays.

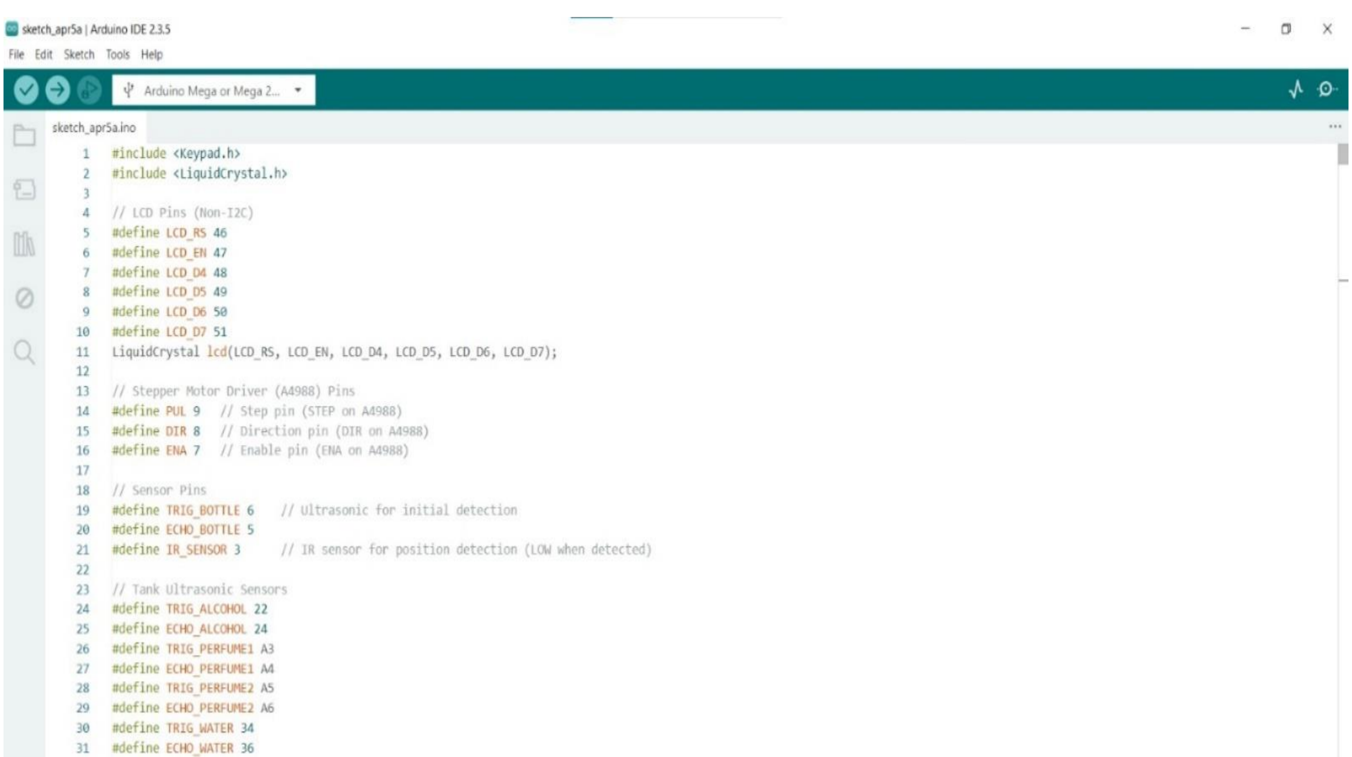


Figure 4.13: Arduino IDE interface showing part of the code

4.3.2 Code Structure

The code was organized into the following key sections:

- **setup() function** – Initializes all pins, sensors, relays, LCD display, buzzer, and keypad. It also checks the initial levels in all tanks before starting normal operation.
- **`loop()` function** – Implements the main control logic, including bottle detection, ingredient dispensing, mixing, and error monitoring..

We also created custom functions for tasks like:

- **handle Bottle Detection()** – Detects bottle presence using ultrasonic and IR sensors and moves it into position.
- **Handle Bottle Processing()** – Executes the full mixing and filling sequence based on user inputs.
- **Get Pump Durations From Keypad()** – Reads user-defined pump times via the keypad.
- **Check Tank Levels()** – Uses ultrasonic sensors to measure tank levels and alerts if refilling is needed.
- **Display Alcohol Percentage()** – Reads and calculates alcohol concentration from the MQ-3 sensor.
- **Activate New Motor() and rotate Motor**() – Control conveyor movement for bottle handling.
- **Ask To Activate Unwanted()** – Optional step to remove unwanted liquid before mixing.

4.3.3 Sensor Integration

We programmed the sensors to work together with the control logic:

- **IR sensors** were used to detect bottles at specific points. If a bottle is missing, the system pauses and displays a warning.
- **Ultrasonic sensors** continuously read tank levels and help the system decide when to refill.
- The **MQ-3 alcohol sensor** measures alcohol concentration and alerts the user if the reading is outside the acceptable range.

All readings were calibrated in code using thresholds we determined through testing.

```
void displayAlcoholPercentage() {
  int sensorValue = analogRead(MQ3_SENSOR); // Read MQ-3 analog value
  float voltage = sensorValue * (5.0 / 1023.0); // Convert to voltage
  float alcoholPercentage = map(sensorValue, 0, 1023, 0, 100); // Simulated percentage

  lcd.clear();
  lcd.setCursor(0, 0);
  lcd.print("Alcohol Sensor:");
  lcd.setCursor(0, 1);
  lcd.print("Level: ");
  lcd.print(alcoholPercentage);
  lcd.print("%");
  delay(3000);
}
```

Figure 4.14: screenshot of MQ3 sensor section in the code

```
bool checkTankLevels(float alcoholLevel, float perfume1Level, float perfume2Level, float waterLevel) {
  while (true) {  // Loop indefinitely until user ignores or tanks OK
    // Check Alcohol tank
    if (alcoholLevel < MIN_ALCOHOL_LEVEL) {
      lcd.clear();
      lcd.setCursor(0, 0);
      lcd.print(F("Refill Alcohol"));
      lcd.setCursor(0, 1);
      lcd.print(F("*:Ignore #:check"));
      digitalWrite(RELAY_BUZZER, HIGH);  // Buzzer ON
      char key = waitForChoice();

      if (key == '#') {
        // Wait pressed: stop buzzer but don't delay
        digitalWrite(RELAY_BUZZER, LOW);
        // Just update the level and continue checking
        alcoholLevel = getAlcoholLevel();
        continue;
      }
      else if (key == '*') {
        digitalWrite(RELAY_BUZZER, LOW);
        break; // User ignores; exit loop, treat as OK
      }
    }
```

Figure 4.15: screenshot of ultrasonic sensor section in the code

4.3.4 User Interaction Logic

We implemented a menu system using the **LCD** and **keypad**. The user can:

- Select a perfume type from preset options.
- Enter custom mixing ratios.
- Start or stop the production process.

The LCD guides the user through each step and displays real-time status updates.

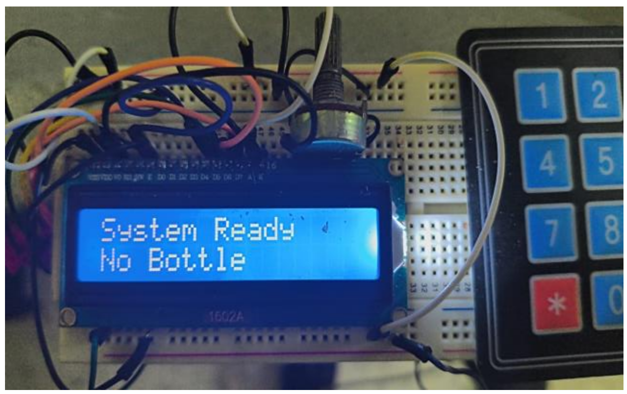


Figure 4.16: LCD

4.3.5 Error Detection and Alerts

We added a section in the code that monitors for any errors or abnormal situations:

- If any tank is empty → show message and activate buzzer.
- If the alcohol level is too high or low → alert the user.
- If a bottle is missing or misaligned → pause system until corrected.

This logic helped us make the system more reliable and user-friendly.

4.4 Implementation Issues

During the implementation of our project, we faced several issues that required adjustments in both hardware and software. Below is a summary of the main problems and how we handled them:

- **Hardware Integration Issues:** Some sensors (like IR and ultrasonic) required careful calibration, and occasional false readings caused delays in bottle detection or inaccurate liquid level measurements.

- **Software Debugging:** The code was complex, with multiple modules (pumps, sensors, motors, keypad, LCD). Synchronizing them sometimes led to unexpected bugs or system freezes.

- **Power Management:** Running multiple relays and motors together occasionally caused voltage drops, requiring careful wiring and stable power supply.

- **Mechanical Alignment:** Proper alignment of the conveyor and bottle position was crucial, as even small misalignments caused errors in filling.

CHAPTER FIVE: RESULTS AND TESTING

5.1 Preface

This chapter presents the testing procedures and the outcomes of the Perfume Production Machine. The goal of testing was to verify the system's functionality, stability, and accuracy in both hardware and software operations. The tests were conducted after full assembly and coding were completed.

5.2 Hardware Testing

Sensor Testing
Each sensor was tested individually. The IR sensors successfully detected the presence of bottles with high accuracy when properly aligned. The ultrasonic sensors measured the levels of liquids inside the tanks and gave consistent readings. The MQ-3 alcohol sensor responded properly to changes in alcohol concentration.

Pump Calibration
We tested each peristaltic pump by activating it for specific time intervals and measuring the volume of liquid dispensed. The results showed that each pump produced a stable output, with slight acceptable variations.

Mixing System
The DC motor connected to paddle agitators worked smoothly during each cycle. The mixing process resulted in uniform blending of the ingredients after approximately 5–10 seconds of operation.

Power and Relay Function
The PSU delivered stable 5V and 12V outputs to the components. The 8-channel relay module accurately controlled all high-power devices, including the pumps and the buzzer, without delays or overheating.

User Interface Devices
The LCD screen displayed all necessary messages clearly, and the keypad allowed for easy input. Some initial delays were fixed by adding debouncing and small delays in the code.

5.3 Software Testing

Dispensing Logic
We tested the system using both preset and custom mixing ratios. The software logic activated the correct pumps for the right duration, and the total volume dispensed matched the input ratios entered by the user.

User Interaction
The system's interface allowed smooth interaction. The user could easily select a perfume type, enter mixing values, and start the process. If incorrect inputs were entered, the system responded with suitable error messages.

Refill Function
We tested the automatic refill process by lowering the liquid level in the tanks. The ultrasonic sensors detected the low level, and the refill pumps were triggered to bring the level back up.

Error Detection
We intentionally removed bottles or disconnected sensors to observe the system's reaction. The machine correctly identified faults and stopped the process, alerting the user via the LCD and buzzer.

Full Cycle Testing
We ran complete production cycles several times. The system remained stable and repeated the full process without crashes or unintended behavior.

CHAPTER SIX: CONCLUSION AND FUTURE WORK

6.1 Conclusion

This project successfully achieved its primary objective of designing and implementing an automated perfume production machine. We were able to build a functional prototype that receives user inputs, dispenses ingredients in accurate ratios, blends them efficiently, and provides real-time feedback and error detection.

Through the integration of various hardware components—such as sensors, pumps, relays, and a mixing system—along with a carefully designed control algorithm, we developed a system that can produce consistent and customized perfume mixtures. The testing results confirmed that the system operated reliably, responded correctly to different scenarios, and handled faults effectively.

This project enhanced our understanding of embedded systems, automation, and real-world implementation challenges. It also demonstrated the value of teamwork, planning, and continuous testing throughout the development process.

6.2 Future Work

While the current version of the system is functional, there are several opportunities for future improvements:

- **Mobile App Integration:** Develop a smartphone application that allows users to control the machine remotely and monitor progress.
- **Wireless Communication:** Add Wi-Fi or Bluetooth modules to allow wireless updates and monitoring without a physical connection.
- **Improved Dispensing Accuracy:** Replace peristaltic pumps with flow-controlled pumps or integrate flow sensors for precise measurement.
- **Automatic Bottle Positioning:** Add a motorized conveyor to automate the bottle placement and removal process.
- **User Profiles and Recipes:** Allow users to save and reuse custom perfume formulas stored in internal memory or an external database.

These improvements would make the machine more user-friendly, scalable, and suitable for commercial use.

6.3 Limitations

Despite the project's success, we encountered some limitations:

- **Pump Precision**: The use of time-based dispensing caused slight variations in the amount of liquid dispensed.
- **Manual Bottle Handling**: The current design depends on manual placement and removal of perfume bottles, which limits automation.
- **Sensor Sensitivity**: Some sensors required careful positioning and calibration to ensure reliable performance.
- **No Real-Time Data Logging**: The system does not store production data or logs, which could be useful for future analysis or quality control.

These limitations were considered during testing and will be addressed in future versions.

6.4 Final Remarks

The Perfume Production Machine represents a successful integration of hardware and software to solve a real-world problem. It provides a solid foundation for future enhancements and commercial development. Through this project, we gained valuable experience in system design, teamwork, and problem-solving, and we believe that the knowledge and skills acquired will support us in future academic and professional endeavors.

References :

[1] "Getting Started with Arduino MEGA2560," [Online]. Available: https://www.arduino.cc/en/Guide/ArduinoMega2560. [Accessed: Oct. 1, 2024].

[2] "An infrared sensor (IR sensor)," Infratec, [Online]. Available: https://www.infratec.eu/sensor-division/service-support/glossary/infrared-sensor/. [Accessed: Oct. 5, 2024].

[3] "Ultrasonic Sensor," TutorialsPoint, [Online]. Available: https://www.tutorialspoint.com/arduino/arduino_ultrasonic_sensor.htm. [Accessed: Oct. 7, 2024].

[4] "What is a buzzer: Working & its applications," ElProCus, [Online]. Available: https://www.elprocus.com/buzzer-working-applications/. [Accessed: Oct. 12, 2024].

[5] "What is power supply? Basic introduction of power supply," Cincon Electronics, [Online]. Available: https://www.cincon.com/newsdetail_en.php?id=7659. [Accessed: Oct. 18, 2024].

[6]12" V Peristaltic Pump," SparkFun Electronics, [Online]. Available : https://www.sparkfun.com/products/10408[Accessed: Aug. 13, 2025].

[7] "Relay," GEYA, [Online]. Available: https://www.geya.net/5v-relay-module-how-it-works-and-application/. [Accessed: Nov. 30, 2024].

[8] "DC Motor With Gear," Power Motor, [Online]. Available: https://www.power-motor.com/. [Accessed: Nov. 12, 2024].

[9] "Stepper Motor Drivers," Texas Instruments, [Online]. Available: https://www.ti.com/product-category/motor-drivers/stepper/overview.html. [Accessed: Nov.10, 2024].

[10] Arduino IDE. [Online]. Available: https://www.arduino.org/. [Accessed: Sep. 20, 2024].