An Advanced Automated Chemical Dispensing System
(AutoChemDispense)

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1. Product Description

Liquid handling is a fundamental process in most scientific laboratories and often requires the manual transfer of chemicals from one container to another. However, many chemical containers are bulky and heavy, making the transfer process cumbersome, unsafe, and impractical, particularly for persons with disabilities (PWD). In response to these challenges, this study presents an advanced automated chemical dispensing system. The system is designed with a user-defined volume selection menu that enables precise control over the volume of liquid to be dispensed. Users interact with a graphical user interface (GUI) to select the desired volume and initiate dispensing, after which the input is processed by the dispensing unit to activate the pump. The dispensing process operates on a time-based mechanism, maintaining pump activity for the preset duration. By integrating automation, AutoChemDispense eliminates the need to lift or pour from bulky containers, significantly reducing the risks of spills, injuries, and material waste. Beyond addressing safety concerns, AutoChemDispense demonstrates the potential of open-source technologies for the development of customised, cost-effective, and functional laboratory devices. By merging automation with inclusive design principles, the system enhances accessibility, promotes safer laboratory practices, and supports broader participation in scientific research. In line with this, the project supports Sustainable Development Goal (SDG) 9, which emphasises the advancement of industry, innovation, and infrastructure. This innovative AutoChemDispense system offers a practical and scalable alternative to conventional commercial dispensers, thereby contributing to safer, more efficient, and more inclusive laboratory environments. It also indirectly supports SDG 10 (Reduced Inequalities) as this product is designed in compliance with the needs of PWD in the laboratory.

2. Innovation Objectives

•   To develop an affordable, automated chemical liquid dispenser using Arduino-based control for safe and efficient chemical transfer.

•   To enhance laboratory safety and inclusivity by providing a user-friendly solution that supports all users, particularly persons with disabilities (PWDs).

3. Problem Statement

Disabled students face underrepresentation in STEM fields due to the inaccessibility of laboratory equipment, which commonly overlooks the requirements of their physical conditions. The traditional manual of transferring liquid chemicals from large storage bottles into smaller containers is time-consuming, unsafe, and unsuitable, particularly for people with disabilities, increasing the risk of chemical spills, potential injuries, and inefficiency in lab operations. Although chemical dispensers exist, they are expensive and often require complex handling, making them less accessible to lab users, particularly those with physical impairments. Therefore, there is a critical need for more user-friendly modern equipment, particularly automatic-based equipment for liquid handling in laboratories or the field of science, to improve accessibility and safety.

4. Authenticity / Novelty

This project is an inclusive design specifically for PWD, offering automated handling rather than manually complex handling, addressing the often-overlooked needs of PWD in laboratory settings. It enables safe and independent chemical handling, removing physical barriers in scientific workspaces. Besides that, it is also an alternative that uses affordable, open-source hardware (Arduino Uno, DC pump, relay) and free software (processing), making automation more accessible for educational institutions and resource-limited labs.

5. Implementation Level

   a) Identifying and addressing the challenges in the liquid transferring process within laboratories

   b) Designing schematic diagram (Figure 1)

   c) Develop liquid dispensing circuit system

   d) Test the effectiveness of the circuit system
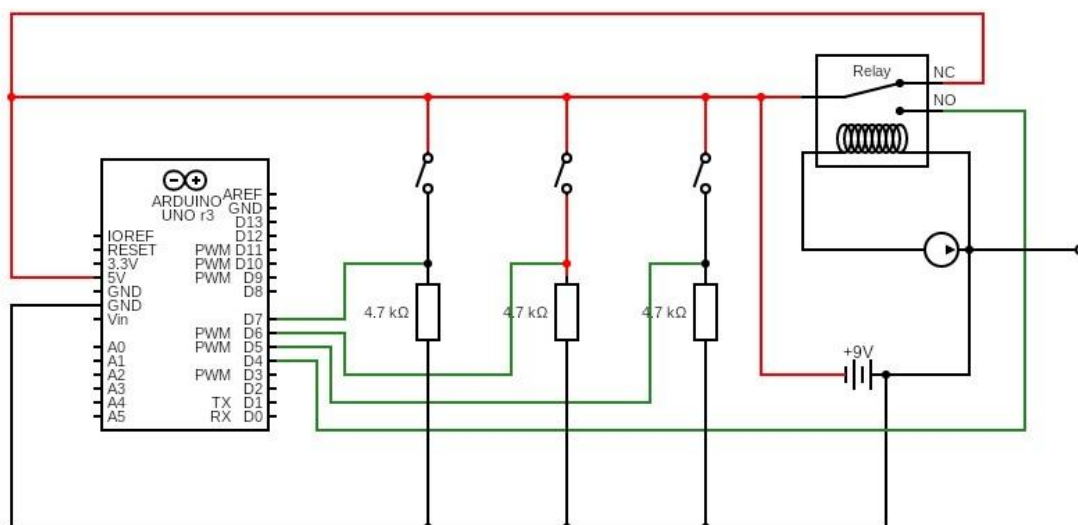
   e) System execution

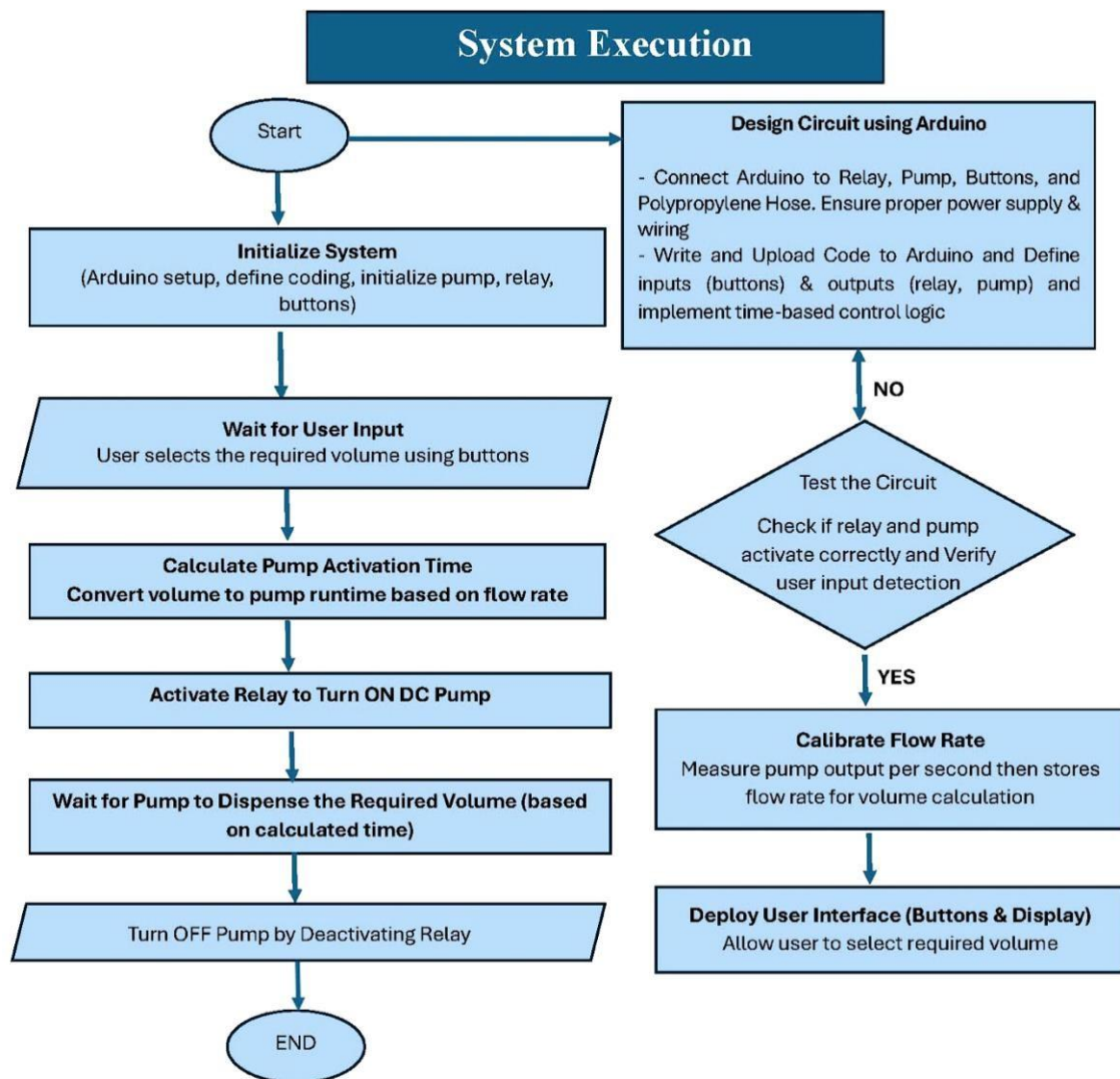Figure 1: Wiring configuration of AutoChemDispense

Figure 2: System execution flowchart

6. Uses and Applications

This project aims to assist all laboratory users, especially those with disabilities, in safely, efficiently, and independently transferring liquid chemicals. The system integrates a straightforward push-button interface that allows users to select from three predefined dispensing volumes (250 mL, 400 mL, and 500 mL), which are released from a polypropylene pump tube, eliminating the need for manual measurement and reducing the risk of handling errors. User-friendly operation is also supported by the graphical user interface (GUI) implemented in Processing software. A time-based mechanism is applied to the device where the pump remains active for the preset duration. Each button press activates the pump for a set of periods to deliver a precise predetermined volume. AutoChemDispense provides a more

accessible platform for people with disabilities (PWD), enabling independent operation without relying on others for assistance.

In addition, the system can be applied in educational laboratories, research and development laboratories, and industrial laboratories, as well as healthcare and pharmaceutical settings.

7. Innovation Product/Project Impact

The innovation of the automated chemical dispenser, AutoChemDispense aligns with SDG 9, "Industry, Innovation, and Infrastructure," by utilizing open-source technology (Arduino Uno, DC pump, and relay) and automation that is accessible to all users, particularly those with physical disabilities, and enhances safety, efficiency, and inclusiveness. In addition, it offers an affordable and practical alternative to conventional methods, improving laboratory practices, addressing challenges in chemical handling, and promoting universal accessibility. On the other hand, it also supports SDGs 10 "Reduced Inequalities," as it is designed with an automation operation system that includes button-activated features. These user-friendly designs allow users to benefit from the system by providing equal access to laboratory equipment, resulting in promoting equal opportunities in education and research environments, especially for PWDs.

8. Achievements

Successfully developed a system of AutoChemDispense, which underwent initial laboratory testing to validate core features and ensure operational reliability. The results indicate that AutoChemDispense can significantly improve workplace safety by reducing risks associated with chemicals and hazardous materials, while streamlining procedures to increase efficiency.