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Implementation of RFID lock based filling machine using keypad system

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Abstract : Conventional filling apparatuses are susceptible to inaccuracies and unauthorized manipulations, which may result in imprecise dispensing and possible contamination of the product. The innovation of a filling mechanism integrated with an RFID lock capitalizes on RFID technology to ascertain the specific container designated for filling and implements a RFID lock to ensure the container's security throughout the dispensing operation. This advanced machine is equipped with an interactive interface that allows for the selection of the precise volume of liquid required for filling. It incorporates an RFID reader that scrutinizes the tag associated with an authorized operator, thus ensuring that machine access is restricted to duly authorized personnel. Subsequently, the filling apparatus administers the liquid in the exact amount as predetermined. The RFID lock-based filling machine presents multiple prospects for enhancement, including the incorporation of sensors and visual surveillance equipment to oversee the filling activity continuously and identify any discrepancies or deviations from the established procedure, thereby optimizing the filling process for industrial applications.

IndexTerms **- RFID lock,Precise volume selection,Sensor incorporation,Industrial application.**

I. INTRODUCTION

Radio-Frequency Identification (RFID) technology is widely recognized for its pivotal role in enhancing automation and access control systems through its non-contact, swift identification features. This technology is particularly beneficial in the realm of automated filling machines utilized for product packaging. Traditional filling machines typically depend on mechanical locks or password-based entry systems to regulate access, which may inadvertently impede the filling process. The integration of an RFID-based access system promises to refine operational efficiency. This paper delineates the conceptualization of an RFID-enabled lock mechanism tailored for an automated filling apparatus. The envisaged system employs RFID tags coupled with readers to verify user credentials and facilitate access to the apparatus. Access is exclusively reserved for authorized individuals possessing valid RFID tags, enabling them to activate or deactivate production sequences. This system introduces an augmented security layer surpassing conventional mechanical locks or rudimentary password mechanisms. Additionally, the RFID framework possesses the capability to log access details pertinent to quality assurance and auditing processes. The RFID lock mechanism offers a seamless and expeditious authentication process, negating the necessity for manual input of codes or keys during each interaction. This attribute has the potential to curtail operational downtime between successive filling cycles by obviating the delays associated with mechanical lock systems. Enhanced access control translates to increased production efficiency. The proposed RFID lock mechanism harbors significant advantages for sectors engaged in automated filling or packaging operations. The expedited, contactless access control facilitated by RFID technology could substantially elevate production line efficacy. The integration of user activity monitoring further augments quality oversight capabilities.

1.1 Problem Definition

The problems include security vulnerabilities, inefficiencies in access control, lack of user accountability, compatibility concerns, cost-effectiveness, reliability, precision, and scalability. The goal is to leverage RFID technology to enhance security, improve access control efficiency, provide user accountability, ensure compatibility with existing machinery, analyze cost-effectiveness, guarantee system reliability and precision, and design for scalability. Addressing these issues is vital for the RFID lock-based filling machine to surpass current constraints and improve security, efficiency, and accountability in the filling operation.

1.2 Proposed Work

The RFID Lock-Based Filling Machine automates liquid dispensing using RFID technology for precision and security. It's powered by a dedicated supply, regulated for consistent voltage to protect the microcontroller and other devices. The user interface includes an LCD display and keypad. The RFID reader and card authenticate user access. After authentication, the user inputs the required liquid volume, prompting the microcontroller to power the pump via the relay. The flow sensor continuously monitors the volume dispensed, communicating with the microcontroller to stop the pump once the specified volume is reached. Finally, the

LCD display confirms the successful completion of the dispensing process with a verification message, marking the end of a secure and precise operation.

1.3 Objective

The objectives focus on enhancing the security, efficiency, and accountability of filling machines using RFID technology. This includes developing an RFID-based authentication mechanism, integrating it with existing infrastructure, and designing a scalable system. The plan also involves conducting a cost-benefit analysis to ensure a favorable return on investment. The RFID system is engineered for high reliability and precision, and sensors are incorporated to monitor and optimize the filling process. These objectives aim to address challenges and advance automated filling technologies in industrial applications.

II. Literature Review

The advent of Arduino-based automation systems has significantly impacted various industrial processes. Bodhale's work on an automatic bottle filling system [1] demonstrates how smallscale industries can leverage Arduino microcontrollers to enhance efficiency and reduce costs. Similarly, Rosdi's smart infusion pump system [2] offers a solution for remote management and monitoring of IV drips, a critical advancement in healthcare technology.In the realm of agriculture, Lita's automation module for precision irrigation systems [3] and Singh's Arduino-based smart irrigation system [9] represent significant strides towards optimizing water usage and crop growth through intelligent control systems. These innovations are particularly relevant in light of global water scarcity challenges, which Premi and Malakar address with their automatic water tank level and pump control system [4].The manufacturing sector also benefits from Arduino's versatility, as seen in Pannu's automated multiple liquid bottle filling system [6], which introduces the capability to fill bottles based on color, and Thiyagarajan's vision-based bottle classification and filling system [7], which emphasizes precision and user-defined volume selection.Marque's research on developing the control system of a syringe infusion pump [8] further illustrates the adaptability of Arduino-based systems to meet specific medical requirements. Collectively, these studies underscore the transformative potential of Arduino technology in automating and enhancing the efficiency of diverse industrial operations.

III. Methadology

The methodologies involved in this Arduino code for an RFID-based fuel filling system are as follows:-

- RFID Reading :- The RFID reader is continuously monitored for any available data. If data is available, it is read and stored in the input array. This represents the RFID tag that is being read.
- Tag Comparison ;- The read RFID tag (input) is compared with the authorized tag (tag). If they match, access is granted; otherwise, access is denied. This is a simple form of authentication.
- Access Control :- If access is granted, the relays are activated (which could be used to start the fuel pump), and a message is displayed on the LCD. After a delay, the relays are deactivated. If access is denied, a message is printed to the LCD.
- User Feedback :- Throughout the process, feedback is provided to the user through the LCD display. Messages are displayed asking the user to swipe their card, indicating when fuel filling has started and ended, and so on
- Flow Measurement :- A flow sensor measures the volume of liquid dispensed, providing accurate control over the dispensing process.

3.1 Hardware Components

The RFID lock-based filling machine is composed of various satellite components each serving a specific function within the system :-

- Power Supply (12v/Amp 5mps) :- Provides the electrical energy required to power the entire machine, ensuring that all components receive a stable supply of electricity for optimal operation.
- Voltage Regulator (FC7805) :- Maintains a constant voltage level to the microcontroller and other sensitive electronic devices, protecting them from potential damage due to voltage fluctuations.
- Microcontroller (Arduino Nano Board) :- Acts as the central processing unit of the machine, controlling the operational logic, processing user inputs, and managing the workflow of the filling process.
- LCD Display (16x2 Alphanumeric) :- Offers a user-friendly interface that displays system statuses, instructions, and confirmation messages, facilitating interaction between the machine and the operator.
- Keypad (Matrix Keypad 3x3) :- Allows the user to input commands or personal identification numbers for authentication and to specify the desired volume of liquid for dispensing.
- RFID Reader (E18) :- Reads the data from the RFID card to authenticate user access, ensuring that only authorized personnel can operate the machine.
- RFID Card (E18 Card) :- Contains unique identification information used by the RFID reader to verify the credentials of the user attempting to access the machine.
- Relay (5v / SPDT) :- Functions as an electronic switch that is activated by the microcontroller to control the power circuit of the pump, initiating the liquid transfer process.
- Buck Convertor :- The buck converter is a voltage regulator that steps down the input voltage to a lower, stable output voltage. It ensures that the connected components receive the appropriate voltage level.
- Diaphragm Pump (12v Pump) :- Transfers the liquid from the storage reservoir to the dispensing aperture once activated by the relay.
- Solenoid Valve :- The solenoid valve regulates the flow of fluid (usually water) in response to control signals. It can open or close to allow or stop the flow.
- Register :-The register stores necessary data for processing and operational control.

- Water Tank :- The water tank stores the water supply. It feeds the diaphragm pump, maintaining a constant water source.
- Printed Circuit Board (PCB) :- The PCB provides structural integrity and electrical connectivity for all electronic components.

3.2 Software Components

It consists mainly of two parts that are :-

- Arduino IDE **:-** The Arduino Integrated Development Environment (IDE) serves as a multifunctional tool tailored for the creation, modification, and uploading of code onto Arduino boards. This software, also referred to as the Arduino Software, offers a unified platform wherein developers can seamlessly compose, arrange, and oversee their code. Its key features encompass a text editor for coding tasks, a message area for exhibiting feedback and status updates, and a text console designated for debugging and communication purposes. Additionally, it incorporates a toolbar housing essential functions, alongside a series of menus facilitating access to diverse features.
- Code :- The code starts by declaring variables and constants for the RFID system, including the relay pump, buzzer, and keypad layout. It includes the Keypad.h, SoftwareSerial.h, and LiquidCrystal.h libraries and creates an LCD and a SoftwareSerial object for the RFID reader.In the setup() function, it initializes the serial communication, sets the relay pump and solenoid as output and turns them off initially, and displays a welcome message on the LCD.The loop() function prompts the user to swipe their RFID card and grants or denies access based on the card's data. If access is granted, the user is prompted to enter the desired fuel amount via the keypad, which is used to calculate the operation time for the pump and solenoid valve.If the entered amount is greater than 0, the pump and solenoid valve operate for the calculated time, otherwise, they remain off. After the operation, the system resets to its initial state, ready for the next RFID card swipe.

IV. WORKING

The "Implementation of RFID Lock based filling machine with Keypad System" project aims to automate liquid filling using RFID card and matrix keypad controls. Powered by a regulated power supply, the system is centered around an Arduino Nano microcontroller. An LCD display provides real-time feedback, while a matrix keypad enables user interaction for entering filling commands. Upon swiping an authorized RFID card, relays activate to control a diaphragm pump and solenoid valve for liquid dispensing. Unauthorized cards trigger an "Access Denied" message. This system enhances security and efficiency in applications like fuel and beverage dispensing. Components like voltage regulators, buck converters, resistors, and capacitors ensure smooth operation and protect against damage. The diaphragm pump and solenoid valve work together based on user input, facilitated by the Arduino Nano board. Overall, the system showcases effective integration of components for a user-friendly automated solution.

4.1 Block Diagram

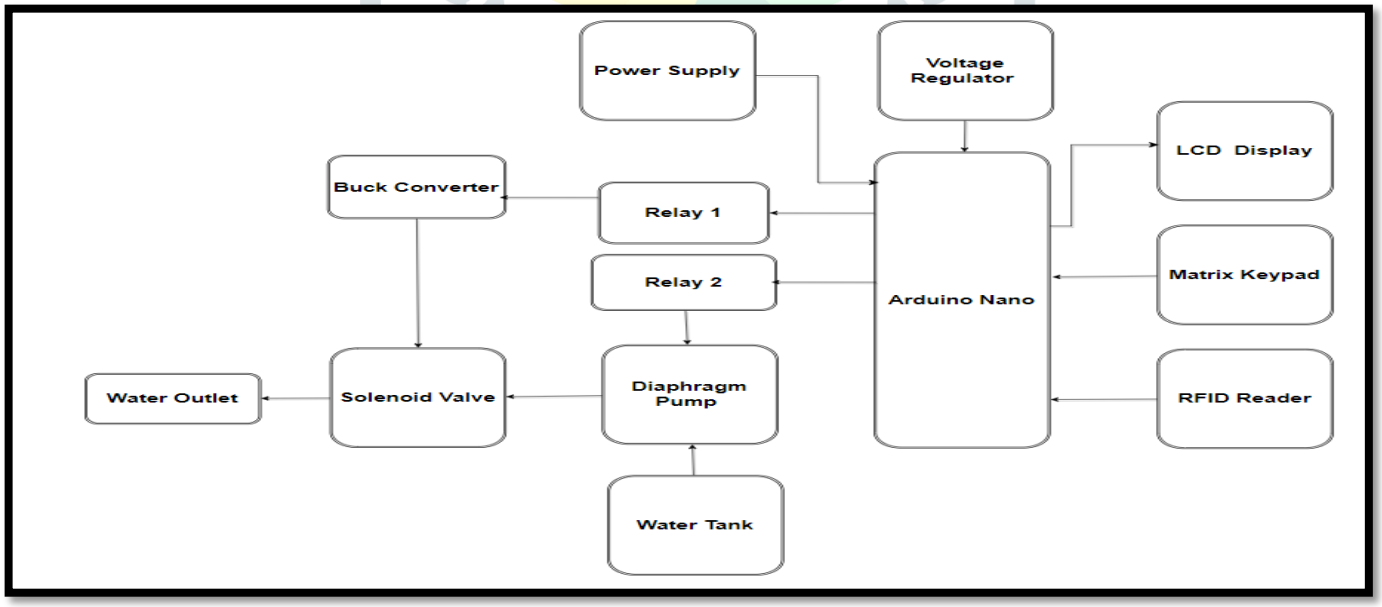

Fig. 4.1 Hardware Block Diagram

Figure 4.1 depicts the layout of our project implementation. The schematic diagram illustrates the interconnections between various components. This well-organized arrangement ensures effective communication and coordination among the components, contributing to the successful implementation of our project.

4.2 Project View

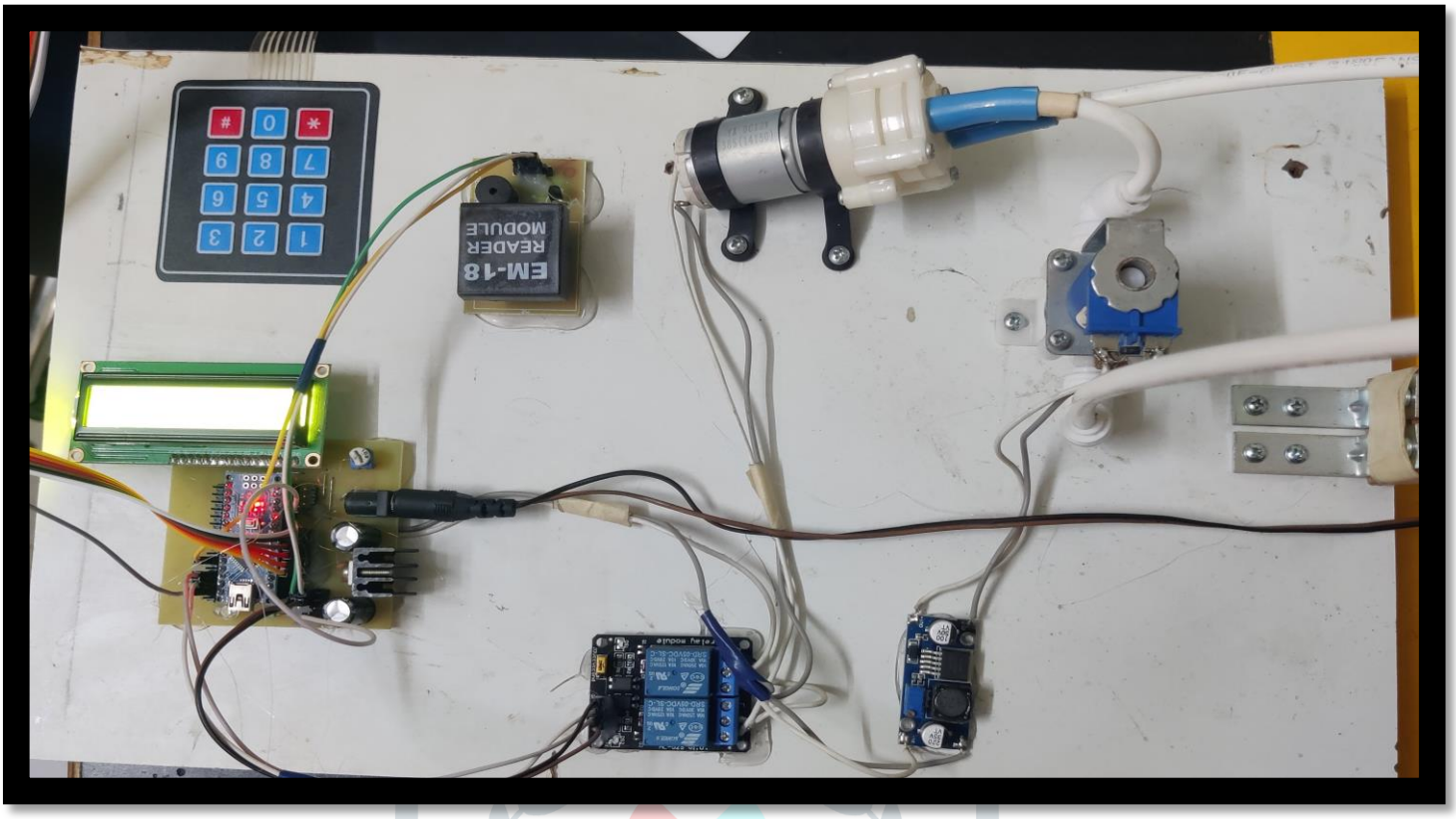

Fig. 4.2 Project Top View

Figure 4.2 depicts our project "Implementation of RFID lock based filling machine using keypad system" in a working condition from top zoomed in view .

V. ADVANTAGES

The advantages of our project are ;-

- Automation :- The system automates the filling process, reducing manual labor and improving efficiency.
- Precision :- By integrating solenoid valves and pumps, the system ensures precise control over the filling process.
- Energy Efficiency :- The buck converter helps optimize energy usage.
- User Interface :- The LCD display and matrix keypad provide an interactive interface .
- Security :- By integrating RFID technology, we ensure that only authorized personnel can use the filling machine. This prevents misuse, reduces waste, and enhances overall security.
- Efficiency :- The user-friendly interface, real-time and automated control mechanisms streamline the filling process. Whether in industrial settings, laboratories, or home applications, our system optimizes efficiency.
- Scalability :- Our design can be adapted for various container sizes, substances, and industries. From small-scale operations to large production lines, the RFID lock-based filling machine offers flexibility and scalability.

VI. DISADVANTAGES

After the succesfull complition and running of our project we found few disadvantages ;-

- Dependence on RFID Cards: The system becomes inaccessible if the RFID card is lost or damaged.
- No Backup Access Method: There's no alternative access method if the RFID mechanism fails, potentially leading to a complete system lockout.
- Hardware Failure: The system lacks redundancies for potential failures of components like the diaphragm pump, solenoid valve, or Arduino Nano board.
- Power Supply Dependency: The system requires a continuous power supply and can stop functioning during power disruptions.
- Environmental Conditions: The system's performance can be affected by environmental conditions, such as weather affecting the RFID reader, or water quality affecting the diaphragm pump and solenoid valve.

VII. APPLICATION

The application for our project to be applied in the real world which are :-

- Agriculture :- Facilitate the precise delivery of water and nutrients to plants, contributing to enhanced growth and vitality.
- Beverage Industries :- The system can be used for automated bottle filling in beverage production.
- Chemical Industries :- It's applicable where precision and safety are critical during filling processes.

- Cosmetic Industry :- Employed for transferring creams, lotions, and perfumes into containers, guaranteeing uniformity and sanitation.
- Automotive Industry :- Assist in the precise allocation of various fluids necessary for vehicle maintenance.

VIII. Future Scope

The future scope for our project are ;-

- Cloud Server :- Businesses combine cloud capabilities with edge computing to analyze data at its source.
- Enhanced User Interface :- Upgrading from a 16x2 alphanumeric LCD display to a more interactive touchscreen interface.
- Energy Efficiency :- Focusing on improving energy efficiency, possibly through solar power supply or system power usage optimization.
- Scalability :- Designing the system to be scalable to handle larger operations, such as controlling multiple filling machines with a single Arduino Nano board.
- Error Handling and Troubleshooting :- Enhancing the Arduino code to include comprehensive error handling and troubleshooting capabilities.
- Integration with Other Systems :- Integrating with other systems like inventory management or billing systems for automated inventory tracking and billing.

IX. Conclusion

The RFID log-based filling machine with a keypad system streamlines filling operations, ensuring accuracy and efficiency. However, addressing complexity, power requirements, and initial costs will be essential for broader adoption. The RFID lock-equipped filling apparatus presents a sophisticated mechanism for the automation and fortification of container filling operations. Leveraging RFID technology for the purposes of identification and authentication, in conjunction with sensors and control mechanisms for oversight of the process, this machinery guarantees precision in the allotment of specified liquid volumes. The incorporation of an RFID lock augments the security measures by impeding unauthorized alterations during the filling phase. In summation, the RFID lock-equipped filling apparatus furnishes a dependable and efficacious solution for industry sectors necessitating meticulous filling applications, encompassing foodstuffs, pharmaceuticals, chemicals, and beyond.

X. Acknowledgment

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