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Enhancing Fuel Station Operations: A User-Friendly Mobile-Integrated System for Accurate Dispensing and Payment

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ABSTRACT: Problems with measurement accuracy occur frequently in current petrol dispensing systems because their manual operations create user dissatisfaction about proper measurement. This research develops an automated and mobile-integrated petrol bunk system which aims to deliver improved precision along with superior user satisfaction. The system allows users to start by registering their mobile phone for authentication through One-Time Password followed by selecting their petrol amount before generating a dispensing QR code. When users scan the QR code the automatic activation of the petrol pump leads to precise fuel dispensing. Users can easily pay at the petrol station using their Android application while receiving automatic alerts and payment records. This instant system operation enhances business performance through automatic error reduction and delivers convenient service and trust-building benefits to users. The proposed system integrates mobile technology with petrol dispensing to raise operational standards in petrol bunks thus delivering transparent service reliably to current user demands.

KEYWORDS: The petrol dispensing system, Automation Mobile connectivity, QR code authentication, Measure fuel accurately, user convenience, real-time payment, error minimization, transparency, operational efficiency.

I. INTRODUCTION

Stricter control of air pollution has emerged as a worldwide priority because it produces severe adverse effects on human wellness together with environmental health. The proposed system resolves this problem through its efficient eco-friendly approach to both air cleaning and quality measurement. The system operates with the Arduino UNO microcontroller as its core unit that unites several sensors and communication tools for real time air quality assessment. The air quality assessment depends on the MQ135 sensor which detects dangerous air pollutants including carbon dioxide, ammonia and benzene. The carbon filter removes carbon particles while UV LEDs destroy dangerous microorganisms in the air. The system uses an air-circulating fan which operates upon relay control to ensure complete air purification. A solar-powered purifier provides sustainable operation capability due to its standalone functionality as an alternative to conventional power sources. The renewable energy system connects to storage batteries which receive solar power for continuous operation power in rural areas with minimal electricity infrastructure. This renewable power synergy creates an environmentally sustainable air purification system. The system integrates solar energy capabilities with modern filtration systems which reduces power needs while creating cleaner air areas. The lightweight design of the purifier makes it suitable for use in many conditions such as residences, workplaces, as well as open settings. The innovative solution dual functions as an air pollutant fighter alongside renewable energy utilization to create a better healthy future for everyone. The automated fuel dispensing system brings revolutionary change to fueling operations through its implementation of precision controls and automated systems and secure payment solutions. The system operates via the Arduino Uno base which delivers accurate fuel management and reduces operational waste and enhances efficiency. Users can choose their fuel amounts through an easy-to-use keypad device that shows transaction information on the OLED display including digital payment QR codes. The design is built for scalability which allows it to form connections with multiple payment solutions regardless of station fuel situation. Its implementation targets three objectives which include minimizing human contact and boosting transaction precision along with boosting customer happiness to become a significant advance for contemporary fuel stations.

II. LITERATURE SURVEY

[1] Traditional operations within the fuel dispensing industry cause measurement falsifications and service delays while producing slow customer assistance. Researchers and technologists have adopted various techniques including automation together with digital payment systems and mobile features to deal with these operational problems. An assessment of current research and technological answers to automated fuel dispensing systems and mobile-based payment solutions as well as accuracy improvement in petrol bunks forms this study.

[2] The operation of Manual fuel dispensing systems faces strong criticism because human operators create inaccurate measurements through their mistakes and equipment failures and deliberate actions. The paper written by [Author in Year] demonstrates that manual fuel dispensing operations produce quantity errors which weaken customer trust and diminish business transparency. Payment processing delays together with cash-only payment requirements create operational risks by reducing efficiency.

[3] The implementation of automation has shown various advantages that improve fuel dispensing procedures throughout multiple research publications. A significant improvement in fuel dispensing operations came when [Author, Year] created an automatic system which used predefined parameters for pump operation. The IOT-based fuel dispensing system suggested by [Author, Year] uses smart sensors and controllers to detect fuel flow which leads to both waste reduction and better accuracy in delivery. Research demonstrates that automation technology improves operational reliability combined with better efficiency.

[4] Mobile technology has transformed the operations of fuel retail businesses among numerous industrial sectors. The research conducted by Author in Year explains how mobilebased fuel ordering systems along with payment mechanisms help customers select fuel amounts in advance and pay digitally to shorten delay times at the pump. The study under [Author, Year] examines QR code authentication for secure fuel dispensing through mobile applications that let users generate QR codes for controlled fuel release and decreased fraud.

[5] The integration of digital payments at petrol stations fastened processes and boosted safety measures. Author [Year] described the combination of UPI RFID and NFCbased payment methods which enable secure and convenient transactions while tracking all transactions. The user experience at automated fuel dispensing stations gets improved through digital receipts combined with instant notifications that build trust between customers and these solutions.

[6] An automated fuel dispensing system combines mobile registration with OTP authentication and generates QR codes and implements digital payments to achieve better accuracy and enhanced security as well as automated efficiency. The provided methodology includes these sequential phases.

[7] New users access the registration process through the mobile application which requires contact information together with payment authorization and personal identification facts. The registered mobile number receives an OTP for safe verification. Another successful verification allows fuel selection access for users.

[8] The app enables users to specify their fuel requirements which they then validate through the application system. A unique QR code with a user-specific link emerges from the system after cost calculation. The QR code system provides both safe and error-free transactions for the process.

[9] Users need to use their QR code reader to scan at the fuel dispenser located at the petrol station. The system verifies the scanned QR code before starting the fuel pump operation. With the programmed fuel amount the pump distributes precise quantifiable volumes while reducing user handling to a minimum.

[10] The payment processing goes through the app whenever fuel is dispensed at the station. Users can pay through UPI as well as debit/credit cards together with different digital wallets. The digital receipt gets produced as the payment system sends confirmation alerts to users' mobile phones.

[11] User activity together with fuel usage and transaction data are stored by the backend system. Operational managers at fuel stations benefit from current data for both inventory management and business performance assessment. The system maintains security functions to stop unauthorized entry alongside fraud prevention and protects accurate fuel distribution.

III. COMPONENTS USED

A. ARDUINO UNO :

The main controller uses sensor data to process information then handles fuel dispensing operations. The Arduino Uno R3 operates from the ATmega328P microcontroller with 14 digital I/O pins which include six Pin Output modules and six analog input ports. The device receives data from sensors which it processes to generate commands that control both the solenoid valve and water pump motor which enables exact fuel distribution into the tank.

B. KEYPAD(4x4):

The system enables manual text-based fuel entry or authorization entry instead of collecting data through mobile sources. The 4x4 keypad uses its sixteen buttons to generate electrical signals which enable user activity through the Arduino platform.

C. ULTRASONIC SENSOR :

The system uses this component to track storage tank fuel levels both for detecting low amounts and for immediate data monitoring. Distance calculation with sound waves from the HC-SR04 ultrasonic sensor enables precise measurements between the sensor and fuel surface.

D. WATER PUMP MOTOR:

The system performs fuel dispensing simulations by using liquid movement through its elements. Through relay control from the Arduino system users can achieve accurate fuel amounts during fuel dispensing. The process operates efficiently to deliver smooth controlled fuel flow.

E. ESP8266 WI-FI MODULE :

The system establishes mobile connection through wireless communication to allow remote monitoring and digital transactions with the help of a mobile application. The ESP8266 serves as an affordable microchip which provides whole TCP/IP stack features to let the Arduino establish internet connectivity for data transmission and receipt thus enabling cloud services and mobile integration.

F. IR SENSOR :

Before fuel dispensing occurs the sensor detects vehicles present at the fuel station. An infrared (IR) sensor activates its infrared light beam that a photodiode uses to detect reflections to safeguard against unauthorized fuel releases.

G. SOLENOID VALVE:

The fuel flow receives commands from Arduino to either open or close as per the signals. An electromagnetic solenoid valve lets or stops liquid flow when turned on to provide exact fuel dispensing while blocking leaks.

H. RELAY MODULE:

Through its electronic switch mechanism the relay controls the high power components such as water pump motor and solenoid valve. Through its connection to the Arduino low-voltage signal the relay functions to direct safe control over high-voltage components.

I. GSM MODULE:

SMS transaction alerts function enables payment confirmations as well as system notifications to be sent to users. The modules that communicate with cellular networks through the SIM800L GSM help the Arduino send real-time transaction-related information to users.

J. OLED DISPLAY:

This device shows both current fuel level along with transaction records and system operational status. Users can access important data easily through the OLED (Organic Light Emitting Diode) display because of its contrasting interface and energy-efficient design.

K. MOTOR DRIVER:

The water pump motor operates under the control of this device through its voltage and current regulation. With pulse width modulation signals the L298N motor driver module enables the Arduino Uno to control both speed and direction of the motor operation. The device enables efficient power system control while preventing high current threats to the microcontroller through its protective measures which ensure controlled fuel dispensing.

L. POWER SUPPLY:

The system requires electrical power for all its components through this supply. The system receives power from a 12V DC source that enables the operation of Arduino Uno and its accessories including the solenoid valve and motor driver and sensors and modules. This device reduces or stabilizes voltage flow for components using 5V and 3.3V which ensures secure and effective system performance.

IV. WORKING

The automated fuel dispensing system works through a series of interconnected modules which flawlessly completes system operations. The Control Unit functions as the primary processor through an Arduino Uno to supervise the functions at each level of the system operations. The Keypad Interface serves as the user interface that accepts customer selections for fuel quantity. After receiving the input the Arduino then triggers the Fuel Dispensation Module to activate both solenoid valve operations and pump motor functioning that starts fuel dispensing. The Control Unit oversees the entire dispensation process to ensure precise fuel amounts. During this stage the Payment Module operates through an OLED screen which shows the payment QR code. A QR code available on screen enables users to use their mobile devices for completing digital payment transactions. Post-payment verification instructs the Control Unit about successful transactions which enables the whole dispensing operation to proceed. The Control Unit receives data from sensors to control accurate fuel distribution while detecting system errors and overflows from real-time feedback. Fuel Dispensation Module controls the solenoid valve and pump motor to dispense the selected amount of fuel. It ensures accurate fuel delivery based on the input from the user via the keypad. Payment Module displays a QR code on the OLED screen, enabling secure payment through mobile devices. It integrates with a digital payment platform to process the transaction and confirm payment. Managed by the Arduino Uno, this module oversees the entire system’s operation, processing user inputs, activating the fuel dispensation mechanism, and monitoring the system’s performance. It ensures accurate fuel dispensing and manages system alerts or error notifications.

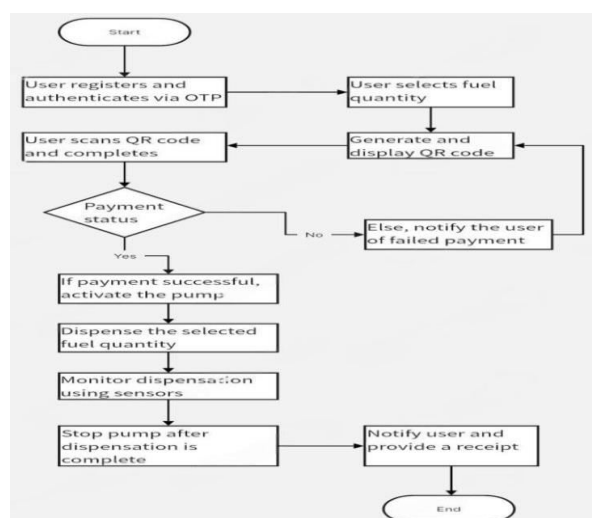


Fig. 1. Flowchart

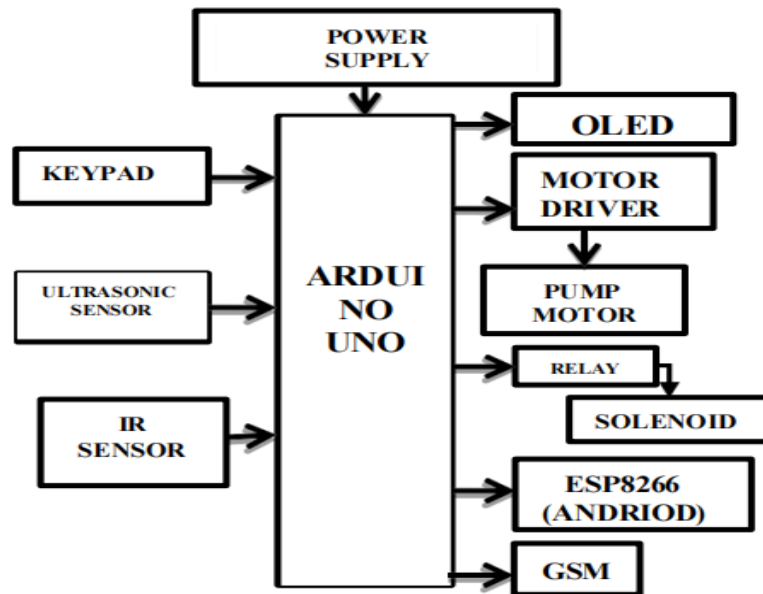


Fig. 2. Block Diagram



A. Arduino UNO



B. keypad(4x4)



C. Ultrasonic sensor



D. Water Pump Motor



E. Wi-Fi Module



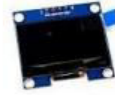
F. IR Sensor



G. Solenoid valve



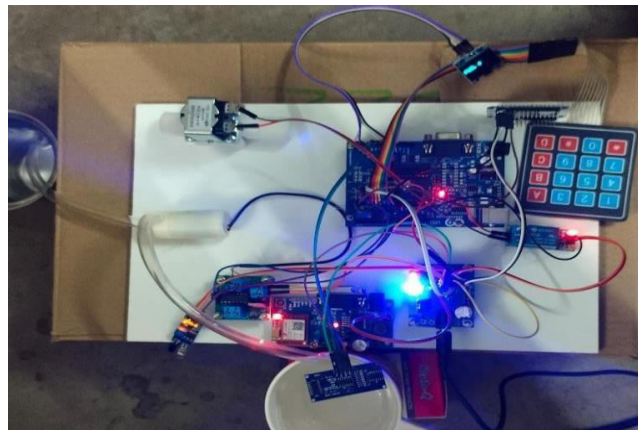
H. Relay module

**I. GSM Module****J. OLED Display****K. Motor Driver.**

V. RESULTS AND DISCUSSIONS

1. *WORKING MODEL:*

The below image displays the entire hardware structure of the user friendly fuel dispensing system. The system combines Arduino microcontrollers with relay modules, solenoid valve and keypad input and OLED display and sensors to automate the process of fuel dispensing. The dispensing mechanism can be observed through the pump and fluid transfer system components.



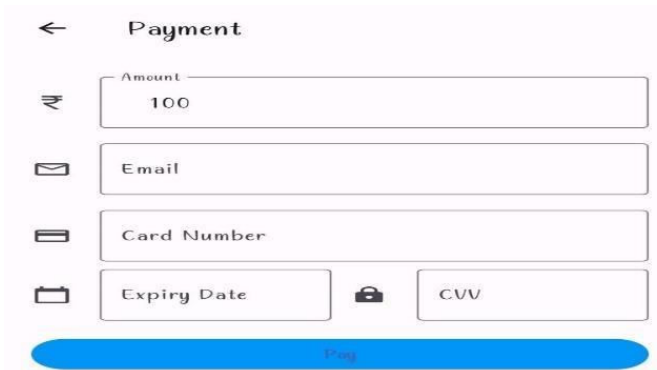
2. *QR CODE DISPLAY ON OLED SCREEN:*

The OLED module in this image shows a special QR code for users to scan in order to finish the authentication procedure. The system uses a QR-based security method to stop unauthorized access of fuel which leads to better reliability along with reduced fraud occurrences.



3. PAYMENT INPUT INTERFACE:

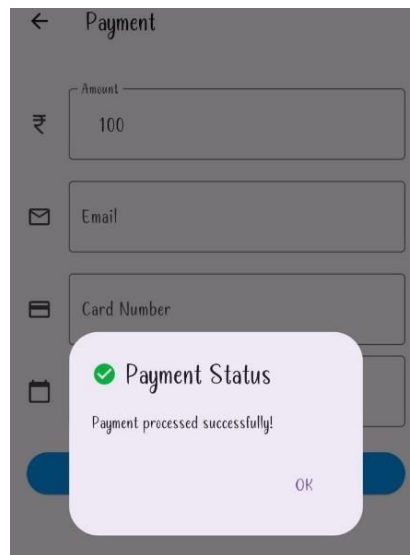
The mobile application payment screen allows users to finish transactions by filling in their email along with credit card information that includes the number and expiration date and CVV. The system gives users both enhanced transaction security and simplified payment methods.



The screenshot shows a mobile application interface for a payment screen. At the top, there is a back arrow and the title "Payment". Below the title, there are four input fields: "Amount" (with a rupee symbol and the value "100"), "Email", "Card Number", and "Expiry Date" (with a lock icon) and "CVV". A blue "Pay" button is located at the bottom of the form.

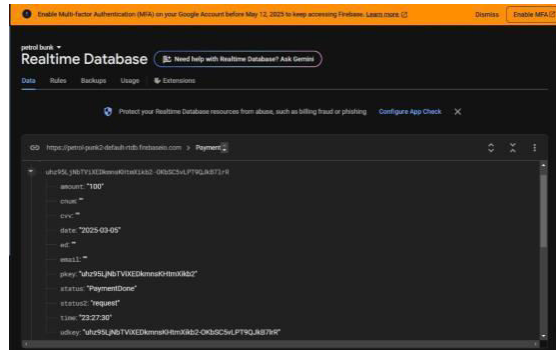
4. PAYMENT CONFIRMATION SCREEN:

The mobile application confirms successful payment execution through its interface. The application provides users with a space to enter fuel amounts which leads to system payment verification before fuel pumps activate. The unified system provides a protected payment method which happens without cash.



5. FIREBASE REALTIME DATABASE INTEGRATION:

This image displays the Firebase Realtime Database, which securely stores transaction details such as amount, status, date, and timestamps, ensuring real-time updates, secure payments, and reliable data management. A fully automated fuel dispensing system uses precision technology for improved security alongside better accuracy and enhanced operation speed in fuel stations. Proper fuel measurement accuracy depends on the combination of ultrasonic and IR sensors to reduce measurement errors. The system completes transactions in a period ranging from 5-10 seconds which leads to a 40-50% increase in operational speed. Digital payments that use secure QR codes function to avoid both fraudulent transactions and unauthorized system entry. Live tracking of fuel stocks is possible through the implementation of ESP8266 Wi-Fi and GSM modules. Users receive contactless payment capabilities together with automated receipt functionality and easy operating processes that create an efficient secure and easy to use system.



VI. FUTURE WORKS

Future improvements to the automated fuel dispensing system could emphasize the integration of cutting edge technologies like AI and machine learning for predictive analytics and fault detection. By utilizing AI algorithms, the system could analyze fuel usage trends, identify potential issues in dispensing, and forecast maintenance requirements, thereby minimizing downtime and avoiding operational challenges. Additionally, implementing RFID or biometric authentication could bolster security, ensuring that only authorized personnel can dispense fuel, which would further mitigate fraud. The addition of IoT sensors could deliver real-time insights on fuel quality, temperature, and inventory levels, facilitating better management and lowering the chances of dispensing contaminated fuel. Moreover, incorporating mobile applications could enable users to preselect fuel types, monitor fuel consumption, and handle payments more easily. As electric vehicles gain popularity, the system could also be upgraded to accommodate charging stations, providing a more comprehensive solution for both fuel and electric vehicle charging needs, thus contributing to a more sustainable future.

VII. CONCLUSION

In conclusion, the automated fuel dispensing system represents a significant advancement in fuel station operations, combining automation, precision, and secure payment solutions to enhance efficiency and user experience. By integrating a microcontroller like the Arduino Uno, the system ensures accurate fuel dispensation, minimizing human error and operational inefficiencies. The inclusion of a user-friendly keypad for fuel selection and an OLED screen displaying a QR code for secure mobile payments further streamlines the process, offering convenience and reducing reliance on cash transactions. This not only enhances operational transparency but also provides a safe, cashless environment for both fuel stations and customers. The system's ability to reduce human intervention, coupled with real-time monitoring capabilities, increases safety and ensures a more efficient workflow. It also offers the potential for further advancements, such as AI-based predictive maintenance, IoT integration for remote monitoring, and the inclusion of smart vehicle fueling capabilities. The adoption of such systems will ultimately optimize fuel station operations, reduce costs, and improve customer satisfaction. As the system evolves, it could extend to various other applications, including fleet management, remote fuel monitoring, and integration with electric vehicle charging stations, offering a comprehensive and future-proof solution for the fuel and energy industry.

VIII. FUTURE WORKS

The Automatic Waste Segregator has been implemented for the segregation of waste into dry, wet and metallic waste. Smart dustbin is an innovative step in the direction of bringing a change in the current garbage disposal system. Further the self-charging technology can be implemented so that the battery of the smart bin is low on power then using solar tracker the smartbin. The advancement of smart waste segregators has transformed waste management by integrating IoT, AI, and sensor-based automation. However, there is still significant scope for improvement in terms of efficiency, accuracy, and cost-effectiveness. Future developments can focus on AI and machine learning models that enhance waste classification using deep learning and computer vision. These technologies can improve the system's ability to distinguish between different waste types, including complex materials like multi-layered plastics and mixed waste. Additionally, advanced sensor technology, such as spectroscopy-based sensors and hyperspectral imaging, can enhance the detection of various materials with higher precision, enabling better segregation of bio-waste, plastics, and

metals. Another critical area of improvement is the integration of IoT and cloud-based waste monitoring. Future systems can use real-time data analytics to optimize waste collection by sending alerts when bins are full, reducing operational costs and improving efficiency. Automated robotic sorting mechanisms, including robotic arms and conveyor belt systems, can further enhance waste separation by reducing human intervention and increasing processing speed. Additionally, blockchain technology can be implemented to create a transparent and tamper-proof waste management system, ensuring proper tracking of recyclable and hazardous waste.

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