Volume 01, Issue 01, June, 2026 ISSN(Online):
FORGE Journal of Multidisciplinary Research
(A Double Blind Peer-Reviewed Journal)
Publisher- FORGE
www.forgeindia.org

SELF-OPERATED PETROL PUMP: A GSM AND SMART CARD BASED AUTOMATED FUEL DISPENSING SYSTEM

Pooja Dalavi[1*], **Sunaina Golandag**[2], **Snehal Powar**[3]
[1,2,3]Research Scholar, SETI, Panhala, India, poojadalavi86@gmail.com
[*]Corresponding author

Conflict of Interest
The authors declare that there is no conflict of interest.

Funding Statement
The authors declare that no financial support or funding was received for this research.

Acknowledgment
The authors would like to acknowledge that no external assistance was received for this study.

Data Availability Statement
The data used in this study are available from the corresponding author upon reasonable request.

Consent for Publication
"All authors have reviewed and approved the final version of the manuscript for publication."

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Abstract

The rapid advancement of embedded systems and communication technologies has enabled the automation of various industrial and commercial processes. Conventional petrol pumps rely heavily on human operators for fuel dispensing, transaction processing, and customer management. Such dependency often leads to increased operational costs, fuel pilferage, accounting errors, and service delays. This paper presents the design and implementation of a Self-Operated Petrol Pump System based on microcontroller, GSM communication, and smart card technology. The proposed system automates customer authentication, fuel dispensing, transaction recording, and account balance management without requiring continuous human supervision. A smart card-based access mechanism, coupled with password verification, ensures secure operation, while GSM communication provides real-time transaction updates. The developed system offers improved efficiency, enhanced security, reduced labor costs, and transparency in fuel distribution. The proposed design is particularly suitable for remote areas, unattended fuel stations, and modern automated fueling infrastructure.

Keywords

Smart Petrol Pump, GSM Communication, Smart Card Authentication, Embedded Systems, Fuel Dispensing Automation, Microcontroller Applications.

1. Introduction

Automation has become a key requirement in modern industrial and commercial sectors due to the growing demand for efficiency, reliability, and cost optimization. Embedded systems and wireless communication technologies have significantly transformed traditional operational methods by reducing human intervention and improving process control [2], [4]. Automated systems are increasingly adopted in banking, transportation, manufacturing, and energy sectors to enhance productivity and operational accuracy [5].

Petrol stations represent an important component of transportation infrastructure. However, conventional fuel stations depend extensively on manual operation, requiring attendants for fuel dispensing, payment collection, transaction recording, and customer management. Such practices increase operational expenditure and create opportunities for fuel theft, billing inaccuracies, and unauthorized transactions [10], [13]. Furthermore, establishing fuel stations in remote locations becomes economically challenging due to the requirement for continuous staffing and monitoring. Recent advancements in smart card technology, wireless communication, and embedded control systems have enabled the development of automated service platforms capable of operating with minimal human involvement [3], [6]. Smart cards

provide secure storage of user credentials and account information, while GSM networks facilitate real-time communication and transaction monitoring [4], [7]. The integration of these technologies creates opportunities for implementing intelligent fuel dispensing systems capable of enhancing operational efficiency and security. The proposed Self-Operated Petrol Pump System utilizes an AT89S52 microcontroller, GSM communication module, smart card authentication mechanism, relay-controlled dispensing unit, and LCD-based user interface. The system authenticates users through password verification, validates account balances, dispenses fuel according to customer requirements, and updates transaction records automatically. Such automation minimizes manpower requirements while ensuring accurate and secure fuel distribution [8], [12]. The primary objective of this work is to develop a cost-effective and secure fuel dispensing solution capable of operating autonomously. The proposed system aims to eliminate manual intervention, reduce operational costs, improve transaction transparency, and provide a scalable platform for future integration with IoT-based fuel management systems [14], [15].

2. Literature Review

The development of automated fuel dispensing systems has attracted significant research attention due to increasing demands for operational efficiency and security in fuel management applications. Chen [1] discussed the role of display technologies in embedded monitoring systems and highlighted the importance of effective human-machine interfaces for automated applications. LCD-based interfaces continue to play a critical role in providing user feedback and transaction information in automation systems. Mazidi et al. [5] and Calcutt et al. [2] extensively investigated microcontroller-based embedded system architectures and demonstrated their suitability for industrial automation applications. Their studies established the foundation for integrating sensing, control, and communication functions within compact embedded platforms. RFID and smart card technologies have emerged as reliable solutions for secure identification and authentication. Finkenzeller [6] presented the fundamentals of contactless identification systems and discussed their widespread adoption in access control and automated transaction environments. Similarly, Miles et al. [3] demonstrated the effectiveness of RFID technologies in secure user authentication and asset tracking applications. Wireless communication technologies have further enhanced the capabilities of embedded automation systems. Eberspächer et al. [4] described GSM architecture and services that enable reliable remote communication and monitoring. Wireless communication systems facilitate real-time transaction reporting and improve operational transparency in automated applications [7]. Embedded hardware-software integration techniques have been explored extensively for industrial control applications. Vahid and Givargis [8] proposed unified approaches for embedded system design, emphasizing the importance of hardware-software co-design in achieving reliable automation performance. Mackay et al. [10] further discussed industrial communication protocols and control architectures suitable for distributed automation systems. Recent studies

have focused specifically on automated fuel management systems. Khan et al. [12] proposed an RFID-based fuel dispensing mechanism utilizing embedded controllers for secure customer identification and automated fuel delivery. Their work demonstrated the potential of embedded systems to improve operational efficiency in fuel stations. Patel and Shah [13] developed a GSM-enabled fuel station management platform that facilitated remote monitoring and transaction reporting. Their findings indicated significant improvements in accountability and operational transparency through wireless communication integration. Dash et al. [14] introduced an Internet of Things (IoT)-based fuel monitoring system capable of real-time fuel level tracking and centralized management. The proposed architecture highlighted the growing importance of cloud-based supervision in fuel distribution networks. Verma and Singh [15] investigated intelligent fuel distribution systems integrating RFID, cloud computing, and remote management technologies. Their research demonstrated enhanced scalability and improved data. Although considerable progress has been achieved in automated fuel dispensing technologies, many existing systems focus on either authentication or monitoring functions independently. The proposed work addresses this limitation by integrating authentication, transaction management, fuel dispensing, GSM communication, and database management into a unified self-operated petrol pump platform.

3. Research Objectives

The major objectives of the proposed study are:

1. To design and develop an automated petrol dispensing system using a microcontroller-based control architecture.
2. To implement secure customer authentication using smart card and password verification mechanisms.
3. To integrate GSM communication for real-time updates and accounting.
4. To automate fuel dispensing operations through relay-controlled actuation systems.
5. To reduce manpower requirements and operational costs associated with conventional fuel stations.
6. To improve transaction transparency, customer convenience, and system security.
7. To provide a scalable platform for future integration with IoT and cloud-based fuel management technologies.

4. System Architecture and Hardware Components

4.1 System Architecture

The proposed system is designed to automate fuel dispensing operations through the integration of embedded control, smart card authentication, and GSM communication technologies. The system consists of a microcontroller unit, smart card reader, keypad, LCD display, relay driver circuit, fuel dispensing mechanism, GSM communication module, and power supply unit [2], [4], [8]. The microcontroller serves as the central processing unit and coordinates all system activities. Customer

authentication is performed through a smart card and password verification process. Upon successful authentication, the user enters the required quantity of fuel through the keypad. The controller verifies the available balance and activates the dispensing mechanism through relay-based control. Simultaneously, transaction details are displayed on the LCD screen and communicated through the GSM network [5], [6]. The architecture ensures secure access control, accurate transaction processing, and automated fuel delivery without continuous supervision.

4.2 AT89S52 Microcontroller

The AT89S52 microcontroller acts as the core controller of the proposed system. It is responsible for processing user inputs, managing database information, controlling relay operations, and coordinating communication between peripheral devices. Due to its reliability, low power consumption, and ease of interfacing, the AT89S52 remains suitable for embedded automation applications [2], [5].

4.3 GSM Communication Module

The GSM module enables wireless communication between the fuel station and the customer. It provides real-time notifications regarding transaction status, account balance, and fuel dispensing information. GSM technology offers reliable communication coverage and supports remote monitoring applications [4], [7].

4.4 Smart Card Reader

The smart card reader is employed for customer identification and account verification. Each card contains unique user credentials and account information. The authentication process enhances transaction security and prevents unauthorized fuel dispensing [3], [6].

4.5 LCD Display Unit

The LCD module serves as the primary human-machine interface of the system. It displays operational instructions, authentication status, fuel quantity information, transaction details, and remaining account balance. Effective display systems improve user interaction and operational transparency [1].

4.6 Relay Driver Circuit

The relay driver circuit functions as an interface between the microcontroller and the fuel dispensing mechanism. The relay receives control signals from the microcontroller and activates the dispensing motor accordingly. Electrical isolation provided by the relay enhances system safety and reliability [10].

4.7 Keypad Interface

The keypad allows users to enter authentication passwords and specify fuel requirements. It provides a simple and cost-effective method for user interaction with the system.

5. Software Design and Flowchart

The software architecture is developed using embedded programming techniques to manage authentication, transaction verification, communication, and fuel dispensing functions. The software continuously monitors user inputs and system status to ensure reliable operation [8]. The operational sequence begins when a customer inserts a smart card into the reader. The microcontroller retrieves card information and prompts the user to enter a password. Upon successful authentication, the user enters the desired fuel quantity. The controller then verifies the account balance and calculates the corresponding transaction amount. If sufficient balance exists, the fuel dispensing relay is activated. After fuel delivery, the account balance is updated automatically and the transaction information is stored. The GSM module transmits transaction details to the customer. In case of authentication failure or insufficient balance, the transaction is terminated and an error message is displayed [4], [12]. The flowchart of the system can be represented by the Figure 1.

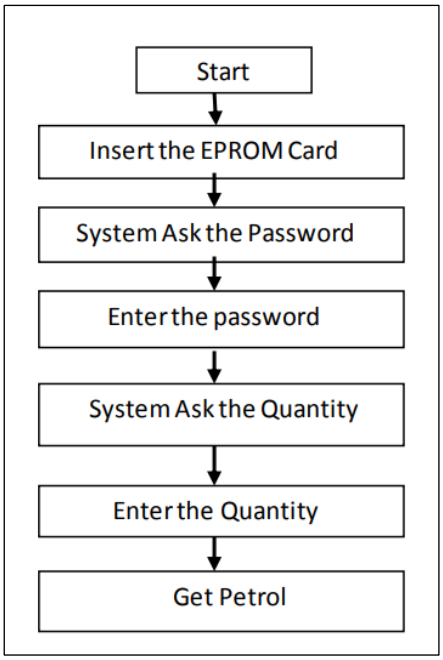

Figure 1 - Operational sequence adopted for automated fuel dispensing.

6. Working Methodology

The operation of the proposed self-operated petrol pump follows a structured sequence designed to ensure security and reliability. Initially, the user inserts a registered smart card into the card reader. The controller accesses customer information stored within the centralized database and requests password authentication. This two-level verification mechanism significantly enhances security and minimizes unauthorized access [3], [6]. Once authentication is successful, the customer specifies the desired quantity of fuel using the keypad. The microcontroller calculates the transaction amount based on the fuel quantity requested and verifies

the available account balance. If the balance is sufficient, the relay driver activates the dispensing unit. The dispensing mechanism delivers fuel corresponding to the selected quantity. Upon completion of fuel delivery, the deducted amount is updated in the customer account database. The remaining balance and transaction details are displayed on the LCD and communicated through the GSM network [4], [13]. This methodology ensures accurate fuel dispensing, secure financial transactions, and complete automation of fuel station operations.

7. Results and Discussion

The developed prototype successfully demonstrated automated fuel dispensing functionality using smart card authentication and GSM communication. Experimental testing confirmed reliable operation of all integrated hardware modules under various operating conditions. The authentication mechanism effectively restricted unauthorized access and ensured that only registered users could initiate transactions. The relay-controlled dispensing system accurately delivered the specified fuel quantity, while the LCD interface provided clear operational guidance to users [1], [12]. The GSM module successfully transmitted transaction information and balance updates in real time. Automated balance deduction eliminated manual accounting errors and improved transaction transparency [13]. The centralized database architecture simplified account management and reduced administrative overhead. Compared with conventional fuel stations, the proposed system offers significant advantages in terms of manpower reduction, transaction security, operational efficiency, and service availability [14], [15]. The results demonstrate that the proposed system can serve as an effective solution for unattended fuel stations, remote fuel distribution centers, and modern automated fueling infrastructure.

8. Advantages

The proposed Self-Operated Petrol Pump System offers several advantages:

- Reduction in manpower requirements and operational costs.
- Improved transaction security through smart card authentication.
- Elimination of manual billing and accounting errors.
- Real-time transaction monitoring using GSM communication.
- Enhanced transparency and accountability in fuel dispensing.
- Prevention of unauthorized fuel distribution.
- Improved service availability in remote and unattended locations.
- Simple system architecture with low implementation cost.
- Easy scalability for future upgrades and integration.
- Reliable operation with minimal human intervention [12]–[15].

9. Future Scope

Several enhancements can be incorporated to further improve the proposed system. RFID-based smart cards may replace conventional card mechanisms to increase

operational speed and reliability [6]. Biometric authentication techniques such as fingerprint recognition can provide additional security layers.

Cloud-based databases and Internet of Things (IoT) technologies can enable centralized monitoring and management of multiple fuel stations from a remote control center [14], [15]. Mobile payment integration can further simplify customer transactions and improve user convenience.

Advanced analytics and predictive maintenance techniques may also be implemented to monitor equipment performance and optimize fuel inventory management. These developments would significantly enhance the efficiency and scalability of automated fuel dispensing systems. Figure 2 shows the future proposed system.

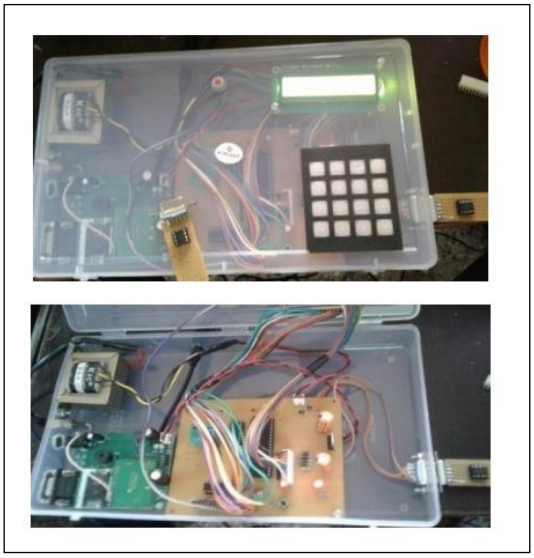

Figure 2 – Future proposed system

10. Conclusion

This study presented the design and implementation of a Self-Operated Petrol Pump System based on microcontroller, GSM communication, and smart card technologies. The proposed system automates customer authentication, fuel dispensing, transaction processing, and account management without requiring continuous human supervision.

The integration of embedded control systems and wireless communication technologies resulted in a secure, reliable, and cost-effective fuel distribution platform. Experimental evaluation demonstrated effective operation of authentication, dispensing, communication, and transaction management functions. The proposed system reduces operational costs, enhances transaction transparency, and improves service accessibility.

The developed system has considerable potential for deployment in remote fuel stations, unattended fueling facilities, educational demonstrations, and future smart fuel management applications. The integration of emerging technologies such as IoT,

cloud computing, and biometric authentication can further enhance system performance and operational capabilities.

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