RFID-GSM BASED INTELLIGENT CART FOR AUTOMATED RETAIL

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ABSTRACT

The rapid growth of retail industries has increased the demand for efficient and automated billing systems to enhance customer experience and reduce operational delays. This project presents the design and implementation of an RFID-GSM based intelligent cart system that automates the shopping and checkout process in retail environments. The system utilizes Radio Frequency Identification (RFID) technology to identify products through tags attached to items, eliminating the need for manual barcode scanning. A microcontroller-based system continuously reads the RFID tags using an RFID reader and updates the product details and total cost in real-time on an OLED display. The integration of a GSM module enables the transmission of billing information directly to the customer's mobile phone via SMS, ensuring a paperless and secure transaction process. A push button is used to confirm the final purchase, and a buzzer provides immediate feedback during product scanning. The system significantly reduces waiting time at billing counters, minimizes human errors, and enhances transparency in transactions. Furthermore, it supports eco-friendly operations by reducing paper usage and contributes to improved inventory management. The proposed intelligent cart system is cost-effective, user-friendly, and suitable for deployment in supermarkets and shopping malls to streamline retail operations and improve customer satisfaction.

Keywords: RFID, GSM, Intelligent Cart, Automated Billing, Microcontroller, Retail Automation, OLED Display, Embedded System

I INTRODUCTION

The advancement of embedded systems and wireless communication technologies has significantly transformed the retail industry by enabling automation and improving operational efficiency. Traditional shopping systems rely heavily on manual barcode scanning and cashier-based billing, which often leads to long queues, delays, and human errors, especially during peak hours [1]. Customers frequently experience inconvenience due to time-consuming checkout processes, which reduces overall shopping satisfaction [2]. To overcome these limitations, automated systems using technologies such as Radio Frequency Identification (RFID) and Global System for Mobile Communication (GSM) have been introduced [3]. RFID technology enables contactless identification of products without the need for direct line-of-sight scanning, making it more efficient compared to conventional barcode systems [4]. Embedded systems play a crucial role in integrating hardware and software components to perform dedicated functions in real-time applications [5]. These systems are widely used in consumer electronics, industrial automation, and communication systems due to their reliability and efficiency [6]. The integration of RFID with microcontrollers allows automatic detection of

products placed in a shopping cart and updates the billing information instantly [7]. Additionally, GSM technology facilitates wireless communication by sending transaction details directly to the customer's mobile device, enhancing transparency and security [8]. The growing demand for smart retail solutions has encouraged researchers to develop intelligent systems that reduce human intervention and improve accuracy [9].

In this context, the RFID-GSM based intelligent cart system is proposed to automate the billing process and eliminate the need for traditional checkout counters. In this system, each product is equipped with an RFID tag, and the shopping cart is embedded with an RFID reader, microcontroller, display unit, and GSM module [10]. When a product is placed in the cart, its information is automatically detected and displayed along with the price, allowing customers to monitor their expenses in real time [11]. If a product is removed, the system updates the bill accordingly, ensuring flexibility and accuracy [12]. The final bill is generated when the user confirms the purchase, and the details are sent via SMS using the GSM module [13]. This approach not only reduces billing time but also minimizes errors associated with manual operations [14]. Moreover, it enhances the overall shopping experience by providing a seamless and efficient process [15]. The implementation of such intelligent systems contributes to the modernization of retail infrastructure and supports the concept of smart shopping environments.

II LITERATURE SURVEY

Recent advancements in retail automation have led to the development of various smart shopping systems aimed at improving efficiency and customer experience. Several researchers have explored the use of RFID technology for automated billing systems due to its ability to provide fast and accurate identification of products [1]. RFID-based systems eliminate the need for manual barcode scanning and significantly reduce checkout time [2]. Studies have shown that RFID technology improves inventory management by enabling real-time tracking of products within retail stores [3]. In addition, embedded systems have been widely used in automation applications due to their compact size, low power consumption, and high reliability [4]. Researchers have integrated microcontrollers with RFID readers to develop intelligent shopping carts that automatically update billing information as items are added or removed [5]. Wireless communication technologies such as GSM have also been incorporated to send billing details and alerts to customers, enhancing system usability [6]. Some studies have focused on combining RFID with IoT platforms to enable remote monitoring and data analysis for retail management [7]. Furthermore, OLED and LCD displays are commonly used in such systems to provide real-time feedback to users [8]. The use of buzzers and indicators helps in providing immediate confirmation during product scanning [9].

Despite these advancements, several challenges remain in the implementation of smart retail systems. Some existing systems are expensive and require complex infrastructure, making them less suitable for small-scale retail stores [10]. Others face issues related to tag collision and limited reading range in RFID systems, which can affect accuracy [11]. Researchers have proposed solutions such as anti-collision algorithms and improved reader designs to address these limitations [12]. Additionally, security and privacy concerns related to RFID data transmission have been highlighted in various studies [13]. The integration of GSM modules helps in improving communication reliability but may introduce latency in message delivery [14]. Recent research efforts focus on

developing cost-effective and scalable solutions that can be easily deployed in real-world environments [15]. The proposed RFID-GSM based intelligent cart system addresses many of these challenges by providing a simple, efficient, and user-friendly solution for automated retail billing, thereby contributing to the advancement of smart shopping technologies.

III PROPOSED SYSTEM

The proposed system is an RFID-GSM based intelligent cart designed to automate the retail shopping and billing process, thereby eliminating the need for traditional checkout counters. In this system, each product is embedded with a unique RFID tag containing its identification details. The shopping cart is equipped with an RFID reader, microcontroller (such as Raspberry Pi Pico or Arduino), OLED display, GSM module, buzzer, and control buttons. When a customer places a product into the cart, the RFID reader scans the tag and sends the data to the microcontroller, which retrieves the product information such as name and price from the stored database. The OLED display shows the item details along with the updated total cost in real-time. If the customer decides to remove an item, rescanning the same tag deducts the corresponding price from the total amount, ensuring flexibility and accuracy in billing. The buzzer provides an audible indication for successful scanning, enhancing user interaction and system feedback.

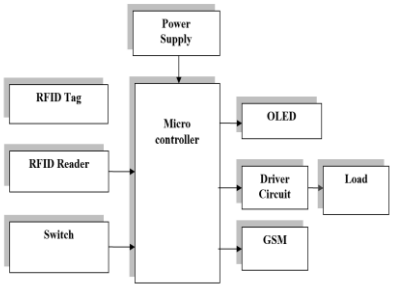

Fig.1 Block Diagram

At the end of the shopping process, the customer can finalize the purchase using a push button integrated into the cart. Once confirmed, the system calculates the final bill and sends the transaction details to the customer's registered mobile number via the GSM module in the form of an SMS. This ensures a paperless billing system and enhances transparency in transactions. The system can also be integrated with a prepaid membership card or digital payment system to enable automatic deduction of the bill amount. By reducing dependency on manual billing, the proposed system minimizes human errors, decreases waiting time, and improves overall shopping efficiency. Additionally, it supports better inventory management and provides a scalable solution for modern retail environments, making it suitable for supermarkets, malls, and smart retail stores.

IV SYSTEM WORKING

The proposed RFID-GSM based Intelligent Cart for Automated Retail integrates RFID technology, a microcontroller, display unit, and GSM communication to automate the shopping and billing process efficiently. This system eliminates long queues and manual billing by allowing customers to scan products directly while placing them into the cart. Each product is attached with an RFID tag that contains unique identification data. When a customer adds an item, the RFID reader scans the tag and sends the information to the microcontroller, such as a Raspberry Pi Pico. The microcontroller processes the data and retrieves the corresponding product details, including item name and price, from its database. These details are displayed on an OLED screen, and the total bill amount is updated in real time. A buzzer provides audible feedback to confirm successful scanning, ensuring that the customer is aware of each registered item. If a product is removed, rescanning the same RFID tag deducts its

cost from the total, making the system flexible and user-friendly.

Throughout the shopping process, the OLED display continuously shows the number of items and the total cost, enabling customers to monitor their spending conveniently. Once the shopping is completed, the customer can finalize the purchase by pressing a checkout button or rescanning a membership card. The microcontroller then calculates the final bill amount and processes the payment, either through a stored balance or integrated payment system. After successful transaction completion, the GSM module, such as SIM900A, sends an SMS containing the purchase details and total bill to the customer's registered mobile number, ensuring a paperless and transparent billing system. The entire system operates on a regulated power supply that converts AC to stable DC voltage. Overall, the microcontroller coordinates all components to ensure smooth, accurate, and efficient operation.

a) Hardware Components

- Raspberry Pi Pico (Microcontroller)
- RFID Reader (EM18)
- RFID Tags
- GSM Module (SIM900A)
- OLED Display (I2C)
- Buzzer
- Push Button / Switch
- Power Supply Unit

b) Software Components

- Arduino IDE
- Embedded C / Arduino Programming
- Microcontroller Firmware
- GSM AT Commands
- RFID Library
- I2C Communication Library

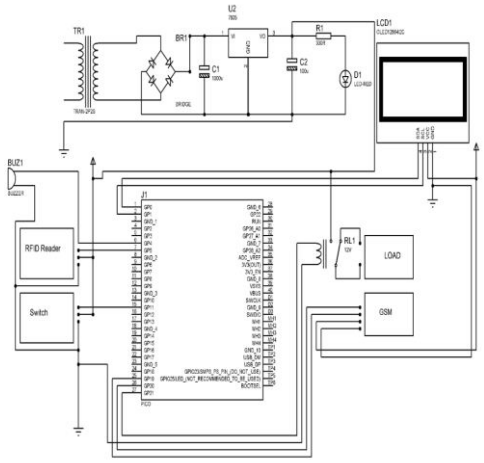

Fig.2 Schematic Diagram

V RESULTS & ANALYSIS

The implementation of the RFID-GSM based Intelligent Cart system demonstrated effective automation of the retail billing process with improved accuracy and efficiency. The RFID reader successfully detected product tags within the specified range, and the microcontroller processed the data in real time to update item details and total cost on the OLED display. The system showed reliable performance in adding and removing items, with accurate price calculation and immediate feedback through the buzzer. The GSM module effectively transmitted billing information to the customer's mobile number via SMS, ensuring a paperless transaction process. Compared to traditional billing systems, the proposed system significantly reduced checkout time and eliminated long queues. It also minimized human errors associated with manual scanning and billing. Overall, the system proved to be cost-effective, user-friendly, and suitable for real-time retail applications, enhancing customer convenience and operational efficiency.

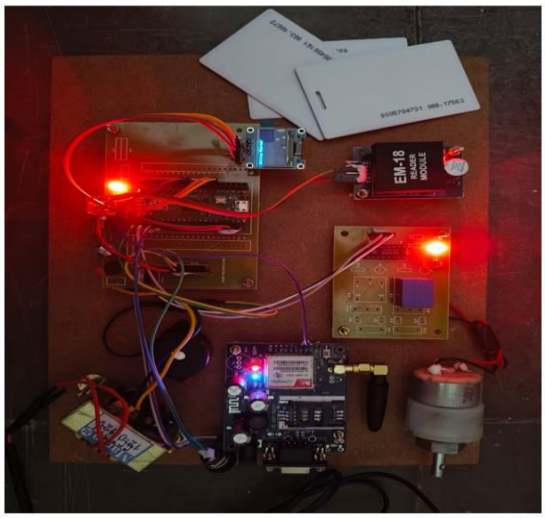

Fig.3 Output

VI CONCLUSION

The progression in science & technology development is an unstoppable process. Now & then evolution changing technologies are being invented. We can't imagine the upcoming future in which technology may occupy each & every place . This innovative project idea can be used is places like shopping complexes, supermarkets & malls to purchase the products. Here RFID card is used to securely access every product in shopping places. If a product is scanned & put into the cart, all the required details of the product will be displayed on the LCD screen. Therefore, an RFID tag/card is used for accessing the products. hence this project will help in improving the security & also the shopping time can be reduced. It also provides an enjoyable & user friendly shopping experience to the customers.

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