iJRASET
International Journal For Research in Applied Science and Engineering Technology

INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY

Volume: 13 **Issue:** I **Month of publication:** January 2025

DOI: https://doi.org/10.22214/ijraset.2025.66735

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International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.538
Volume 13 Issue I Jan 2025- Available at www.ijraset.com

Smart Trolley with Automatic Billing System using RFID

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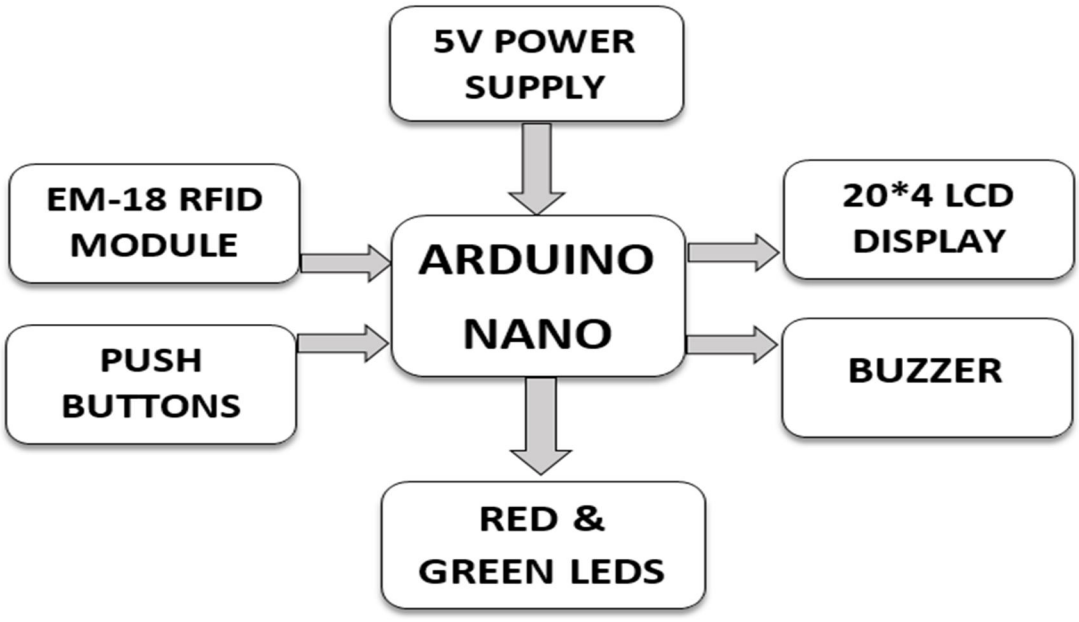
Abstract: ***The integration of RFID technology into retail environments is transforming the shopping experience, making it more efficient, streamlined, and error-free. The Smart Billing Trolley with RFID is a step forward in this evolution, utilizing RFID-enabled trolleys to automate the checkout process, minimize human interaction, and enhance both operational efficiency and customer satisfaction. This paper explores the design, working mechanism, hardware components, applications, and future potential of RFID-based smart billing trolleys in retail settings. By integrating RFID, these trolleys can automatically detect, track, and bill products, drastically reducing the time spent at checkout counters and minimizing human errors.***
Keywords: Automatic Billing System, RFID technology, smart billing trolley, efficient shopping, RFID tags

I. INTRODUCTION

Retail shopping has undergone numerous advancements in technology over the years. One of the most recent innovations in retail automation is the use of RFID (Radio Frequency Identification) technology to facilitate the shopping process. RFID technology has been deployed in various sectors for inventory management, product tracking, and loss prevention, but its full potential in customer-facing scenarios like shopping trolleys has not yet been fully realized. Traditional shopping involves a manual scanning process at the checkout counter, which can be tedious, time-consuming, and prone to human error.

A Smart Billing Trolley, embedded with RFID technology, presents a solution that automates much of this process. This system provides a seamless, automated, and contactless shopping experience by eliminating the need for manual item scanning and reducing the overall time spent at the checkout. Additionally, it integrates a set of hardware components that facilitate automatic billing, product tracking, and real-time updates, improving both customer experience and store efficiency.

Block Diagram



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II. LITERATURE SURVEY

The application of RFID technology to retail and shopping carts has been studied extensively in academic and industry research. Several papers focus on the benefits and challenges of implementing RFID for automated billing.

1) RFID in Retail Operations: RFID technology has been adopted widely for inventory management and supply chain operations. Fink and Sharma (2016) highlight the role of RFID in enabling efficient tracking and management of products, thereby optimizing the store's inventory levels and reducing losses due to misplaced items. In addition, RFID tags on products can be scanned automatically, which reduces manual errors in stock levels.

2) Smart Trolley Systems: Various studies have proposed RFID-based smart trolleys to automate the checkout process. Rao and Anjaneyulu (2017) developed a Bluetooth and RFID-based shopping cart that automatically scans products and calculates the total bill. Their system integrates an RFID reader in the cart, which scans the products as they are placed inside, and the total is displayed on the cart's digital screen.

3) Checkout Automation: The research by Kotlarsky et al. (2019) focused on fully automated checkout systems, such as Amazon Go. These systems combine RFID with other technologies like computer vision and sensor networks to create an entirely cashier-less retail experience. This paper emphasizes the importance of RFID in reducing transaction times and enhancing the convenience of shopping.

4) RFID-based Loss Prevention: Sivakumar (2015) explored the use of RFID in minimizing retail theft. Integrating RFID with smart trolleys can help store management keep track of items in the cart, preventing customers from inadvertently leaving the store with unscanned items.

These studies show a consistent trend toward the implementation of RFID for automating the shopping and checkout processes, reducing human error, improving inventory accuracy, and enhancing customer satisfaction.

III. PROBLEM STATEMENT

In traditional retail environments, the checkout process is often time-consuming and inefficient, leading to long queues and customer dissatisfaction. Customers must wait for their items to be manually scanned by cashiers, which can result in delays, human errors, and lost sales opportunities. Additionally, inventory management remains a challenge for retailers, as manual tracking of products can lead to inaccuracies and stock discrepancies.

The existing checkout systems are not optimized for speed and accuracy, and there is a need for an innovative solution to streamline the shopping experience. The RFID-based Smart Billing Trolley, powered by Arduino, aims to address these issues by automating the product identification and checkout process. This system can reduce checkout times, minimize human error, and improve inventory management through real-time product tracking.

IV. PROPOSED METHODOLOGY

The proposed system operates as follows:

1) Requirement Analysis and Design

- Define system objectives: automate product identification and billing using RFID technology.
- Select components: RFID tags for products, RFID reader, Arduino microcontroller, display screen, and power supply.

2) System Architecture

- Integrate the RFID reader with Arduino for real-time scanning and data processing.
- Display product info (name, price) and total bill on an LCD/LED screen.
- Optionally, implement inventory tracking for real-time stock management.

3) Software Development

- Program Arduino to interface with the RFID reader and process scanned data.
- Develop an algorithm for calculating the total bill and displaying information.
- Add alert feedback (e.g., buzzer) on successful scans.

4) Hardware Assembly

- Mount components on the trolley, ensuring ease of use and reliable power supply.

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5) Testing and Debugging
- Test components individually and perform system integration testing to ensure functionality.
- Conduct user testing to simulate real-world shopping scenarios.

6) Optimization and Refinement
- Optimize code for speed and efficiency.
- Improve the display interface for user-friendliness and add error handling for scanning issues.

7) Deployment and Evaluation
- Deploy in a real retail environment for testing, collecting feedback from customers and staff.
- Measure the system's effectiveness in reducing checkout times and improving customer satisfaction.

V. SYSTEM OPERATION

1) Item Scanning: As the customer picks up items from the shelves, the RFID reader on the shopping trolley automatically scans the tags on these products. This process happens without the need for manual scanning of individual barcodes.
2) Product Identification: The RFID reader transmits the scanned data (product ID, price, description) to the microcontroller. The microcontroller then processes the data and displays it on the trolley's screen.
3) Real-Time Bill Calculation: Each time an item is added to the trolley, the system calculates the total cost of the items in real-time. The total bill is updated on the display screen, providing immediate feedback to the customer.
4) Checkout Process: When the customer is ready to check out, they can proceed to a designated self-checkout station. The trolley communicates with the store's server, and the customer's payment can be processed either through a mobile app, credit/debit card, or other methods.

VI. COMPONENTS USED

1) Arduino Nano - Central processing unit.
2) I2C LCD (20x4) - Display for output.
3) EM-18 RFID Reader - For scanning RFID tags.
4) LED Indicators (Red and Green) - Indicating status (Red for Item Remove / Green for Add Item)
5) Buzzer - Audible alert.
6) Push Button - Input trigger (Item Remove)
7) Power Supply - For powering the components.

VII. FUTURE SCOPE

1) Personalized Shopping Experience: Future versions of smart trolleys could integrate AI to provide personalized recommendations, discounts, and offers based on customer preferences and past shopping behavior. The system could suggest products, provide recipe ideas, or notify users about sales related to their shopping habits.
2) Augmented Reality (AR) Integration: With the advent of AR, smart trolleys could use the display or a connected mobile app to overlay product information, reviews, or recommendations as the shopper moves through the store.
3) Complete Store Automation: Smart trolleys could eventually be part of a larger ecosystem of IoT devices, contributing to fully automated stores. These trolleys would automatically guide themselves to checkout points or even leave the store once the shopping process is completed.
4) Advanced Inventory Management: The continuous tracking of products within the trolleys could provide real-time data about product demand, stock levels, and shopping trends. Retailers could use this data to optimize inventory management and improve restocking schedules.

VIII. CONCLUSION

The Smart Billing Trolley with RFID is a promising technological advancement in the retail sector. It not only enhances the customer experience by automating the checkout process but also offers retailers greater efficiency in managing inventory and reducing loss. As RFID technology continues to evolve, and as integration with AI and AR grows, the potential for smarter and more seamless shopping experiences is vast. The future of retail automation is bright, and smart trolleys are just the beginning of a new era in customer-centric innovation.

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IX. ACKNOWLEDGEMENT

I take this opportunity to express my sincere appreciation for the cooperation given by Prof. S.G. GIRAM, Principal of AISSMS'S POLYTECHNIC, Pune and need a special mention for all the help extended by him, constant inspiration and encouragement to make my project a memorable experience. I am thankful to our H. O. D. of E&TC Department, Prof. V.S.Gaikwad for her time to time support and valuable guidance. I am deeply indebted to my internal guide Mrs. M.T. Dangat, for completion of this project for which she has guided and helped me going out of the way. I am thankful to all teachers and professors of our department for sharing with me, valuable knowledge on their respective fields. I would also thank my fellow classmates and friends for their support and timely suggestions. I would also like to thank library staff and laboratory staff for providing me cordial support and necessary facilities, which were of great help for preparing the project report. Thanks to all!

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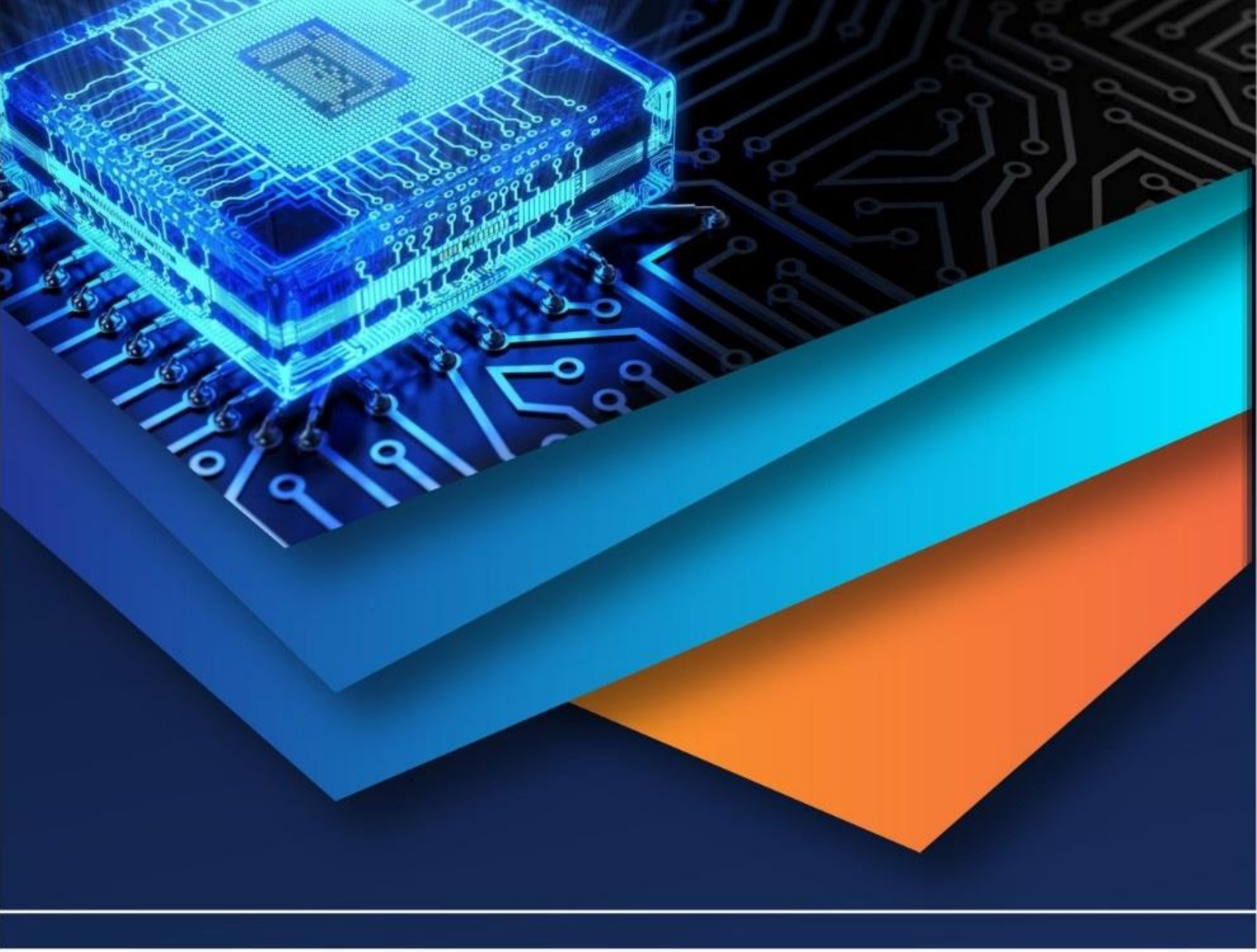

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