

Design and Implementation of an Advanced Bus Ticketing System using RFID and GSM Technology

Prof. Yeole Sandip Shankar¹, Wagh Aniket Madhukar², Wagh Ashwini Dnyaneshwar³,
Aher Samadhan Nivrutti⁴, Varpe Radhika Jagannath⁵

^{1,2,3,4,5}Department of Electrical Engineering

S. N. D College of Engineering and Research Center, Yeola

Abstract: *The rapid advancement of smart city technologies has increased the need for efficient and automated public transportation systems. This project focuses on the design and implementation of an advanced bus system with automatic ticketing, student pass facility, balance calculation, and SMS alert using RFID and GSM technologies. The proposed system enables passengers to travel cashless by scanning an RFID card, after which the fare is automatically calculated and deducted based on the destination. Student pass holders can verify pass validity electronically, reducing manual checking and misuse. An LCD displays ticket and balance information, while SMS alerts notify users about fare details, remaining balance, low balance warnings, and pass expiry. This system minimizes human intervention, reduces waiting time, improves transparency, and enhances overall passenger convenience, making it suitable for modern public transportation systems*

Keywords: RFID, Automatic Ticketing System, Student Pass, GSM Module, Cashless Transportation, Smart Bus System, SMS Alert.

I. INTRODUCTION

Public transportation systems form the backbone of urban mobility and play a crucial role in the economic and social development of a nation. In countries like India, buses are the most affordable and widely used means of transportation, serving millions of passengers daily across urban and rural regions. Efficient bus services help reduce traffic congestion, fuel consumption, and environmental pollution while ensuring accessibility for all sections of society, including students and daily wage earners. However, despite their importance, many public bus systems still depend on outdated manual ticketing methods that limit efficiency and user satisfaction [1][2].

The conventional bus ticketing system primarily relies on paper-based tickets and cash transactions handled manually by conductors. This process is time-consuming and often leads to long queues, delays during boarding, and crowd management issues inside buses. Manual fare calculation increases the chances of human error, disputes between passengers and conductors, and revenue leakage for transport authorities. Moreover, the use of paper tickets contributes significantly to environmental pollution and increases recurring operational costs [3][4].

With the rapid growth of urban populations and increasing daily commuters, the limitations of traditional ticketing systems have become more evident. Passengers today expect faster, cashless, and transparent services similar to those provided in other digital platforms. Smart city initiatives introduced by governments emphasize the modernization of public transportation using digital and automated technologies to enhance commuter convenience and system efficiency [5][6].

One of the key challenges in public transportation is handling cash transactions. Carrying cash is inconvenient for passengers and increases the risk of theft and mismanagement. Cash handling also makes accounting complex for transport authorities. To overcome these challenges, cashless payment systems such as smart cards, mobile payments,



and RFID-based solutions have gained popularity worldwide. These systems offer faster transactions, improved transparency, and better data management [7][8].

Radio Frequency Identification (RFID) technology has emerged as a reliable and cost-effective solution for automated ticketing systems. RFID-based ticketing allows passengers to simply tap a smart card on a reader, enabling instant identification and fare deduction without physical contact. RFID systems provide high accuracy, fast response time, durability, and reusability compared to magnetic stripe or paper-based tickets, making them suitable for large-scale public transport applications [9][10].

Another significant issue in bus transportation is the management of student passes. Student concessions are widely provided but are often misused due to lack of proper verification mechanisms. Manual checking of passes is inefficient and prone to fraud. Integrating student pass facilities into an automated RFID-based system allows secure validation of pass authenticity and validity, reducing misuse while ensuring that eligible students receive benefits seamlessly [11][12].

Balance management and fare calculation are critical components of any automated ticketing system. Passengers frequently face uncertainty regarding remaining balance or fare deductions in manual systems. An automated balance calculation mechanism ensures accurate fare deduction based on predefined routes or destinations. Providing real-time balance information enhances passenger trust and eliminates disputes related to overcharging or incorrect billing [13].

To further improve passenger communication, the integration of GSM technology enables real-time SMS alerts. SMS notifications can inform passengers about ticket fare, remaining balance, low-balance warnings, and student pass validity. Such real-time alerts improve transparency, keep passengers informed, and encourage timely recharges, thereby ensuring uninterrupted travel services [14].

From the perspective of transport authorities, an automated ticketing system offers improved monitoring, data collection, and revenue management. Digital records of passenger travel, fare transactions, and system usage help in route optimization, demand analysis, and policy planning. It also reduces dependency on manual labor and enhances system reliability and scalability [15].

In this context, the proposed project titled “Advanced Bus with Automatic Ticketing, Student Pass Facility, Balance Calculation and SMS Alert” aims to address the shortcomings of traditional bus ticketing systems. By integrating RFID, Arduino-based control, GSM communication, and automated fare processing, the system provides a secure, efficient, and user-friendly solution for modern public transportation. This project represents a significant step toward intelligent, cashless, and sustainable public transport systems aligned with future smart city requirements [16].

II. PROBLEM STATEMENT

The existing bus ticketing system relies heavily on manual operations such as cash handling, paper ticket issuance, and physical verification of student passes, which results in long queues, delays, fare disputes, human errors, and revenue leakage. Passengers often face inconvenience due to the lack of real-time balance information and pass validity updates, while transport authorities struggle with inefficient record keeping and monitoring. Additionally, the use of paper tickets increases operational costs and contributes to environmental pollution. These limitations highlight the need for an automated, cashless, and reliable ticketing system that ensures accurate fare calculation, secure student pass validation, real-time balance management, and instant passenger notification.

Objective

1. The aim of this project is to implement advanced bus with automatic ticketing, student pass facility, balance calculation and SMS alert.
2. The manual use of bus reservation is presently very troubled thing and also consumes a lot of time by having to stay on a long queue.
3. Android Phones can reduce the trouble of the customers to stand in queue and book the tickets.



With the use of RFID smart cards the overhead of waiting for ticket was reduced

4. This development has resulted in transaction through virtual money instead of real ones.

5. This project deals with the development and implementation of smart ticket generator application which is more effective and simple than current ticketing system.

III. LITERATURE SURVEY

Paper 1

Title: RFID-Based Ticketing for Public Transport System: Perspective Megacity Dhaka

Year: 2010

Author(s): Arif Ul Alam

Publication / Journal: IEEE International Conference on RFID Technologies

Summary:

This paper presents an RFID-based automated ticketing system designed to replace conventional paper-based ticketing in public transportation. The author focuses on the challenges faced in megacities such as Dhaka, including overcrowding, ticket fraud, long queues, and inefficient fare collection. The proposed system issues RFID smart cards to passengers, which are scanned during travel to automatically record journeys and deduct fares. The system architecture includes RFID readers, backend databases, and fare management modules to ensure secure and accurate transactions.

The study demonstrates that RFID-based ticketing significantly reduces boarding time and human intervention while improving revenue transparency for transport authorities. The author concludes that RFID technology offers high reliability, fast transaction speed, and scalability for large urban transport systems. However, the paper also highlights challenges such as infrastructure cost and the need for public awareness before large-scale deployment.

Paper 2

Title: Intelligent Agent-Based RFID System for On-Demand Bus Scheduling and Ticketing

Year: 2013

Author(s): Paul Hamilton, Suresh Sankaranarayanan Publication / Journal: International Journal of Future Computer and Communication

Summary:

This research proposes an intelligent agent-based ticketing and scheduling system using RFID technology. The system integrates RFID smart cards with intelligent software agents that dynamically manage ticketing, passenger data, and bus schedules. The authors emphasize automation and decision-making capabilities that allow transport systems to adapt to passenger demand in real time. The system improves operational efficiency by linking ticketing data with scheduling algorithms.

Experimental analysis shows that the intelligent RFID-based system reduces congestion, improves ticket processing speed, and enhances service reliability. The authors note that real-time data collection enables better planning and passenger flow management. Despite the benefits, system complexity and dependency on network communication are identified as potential limitations. The paper concludes that intelligent RFID systems are a strong foundation for smart public transportation.

Paper 3

Title: Mobile Enabled Bus Tracking and Ticketing System

Year: 2014

Author(s): Suresh Sankaranarayanan, Paul Hamilton Publication / Journal: IEEE International Conference on Information and Communication Technology (ICoICT) Summary:



This paper introduces a mobile-enabled bus tracking and automated ticketing system that integrates RFID with GSM communication. The proposed system allows passengers to receive ticket confirmations, fare details, and travel updates through mobile notifications. The authors emphasize the importance of real-time communication between transport systems and passengers to improve transparency and trust.

The study concludes that GSM-based SMS alerts significantly enhance passenger awareness and satisfaction. Real-time notifications reduce disputes related to fare deduction and balance availability. The authors also highlight that mobile-enabled systems improve accountability for transport operators. However, network dependency and signal reliability are noted as challenges in rural or low-coverage areas.

Paper 4

Title: Automated Ticket Vending System Using RFID Tags

Year: 2013

Author(s): Sidharth R., V. R. Subramanian, R. Vijayaraghavan

Publication / Journal: International Journal of Engineering Research and Applications

Summary:

This paper presents an automated ticket vending system using RFID tags for public transport applications. The system allows passengers to purchase and validate tickets using RFID cards without manual intervention. The authors focus on reducing paper usage, human errors, and ticket duplication through digital automation. The system architecture includes RFID readers, embedded controllers, and fare calculation modules.

Results show that RFID-based ticket vending systems improve transaction accuracy and reduce operational overhead. The authors also discuss the environmental benefits of eliminating paper tickets. However, the paper highlights issues such as card misplacement and the need for secure data storage. The study concludes that RFID automation is a practical alternative to conventional ticketing systems.

Paper 5

Title: Smart Card-Based Automatic Fare Collection System for Public Transport

Year: 2015

Author(s): Mathew Jos, Ahammed Aslam N., Akhil E. P., Divya Lakshmi G.

Publication / Journal: International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering

Summary:

This research focuses on a smart card-based automatic fare collection system designed to improve efficiency in public transport services. The system uses embedded controllers and smart cards to store passenger details and fare balance. Automatic fare deduction is performed based on travel distance or predefined routes. The authors highlight the role of automation in minimizing fare disputes and improving operational transparency.

The study demonstrates that smart card systems reduce boarding time and enhance passenger convenience. It also provides transport authorities with accurate digital records for monitoring and planning. The authors acknowledge challenges such as initial system deployment cost and maintenance. Overall, the paper supports the adoption of smart card technology for modern transportation infrastructure.

Paper 6

Title: Cashless Fare Collection System for Smart Transportation

Year: 2016

Author(s): R. Karthikeyan, P. Anbarasu

Publication / Journal: International Journal of Computer Applications



Summary:

This paper discusses the importance of cashless fare collection systems in the context of smart cities. The proposed system integrates RFID technology with embedded controllers to enable contactless fare payment. The authors emphasize reduced cash handling, improved transaction security, and enhanced passenger convenience. The system architecture supports scalability and integration with other smart city services.

The results indicate that cashless systems significantly reduce transaction time and operational costs. The authors also highlight the benefits of data analytics enabled by digital fare collection. Challenges such as cybersecurity and user adaptation are discussed. The paper concludes that cashless automated ticketing systems are essential for future intelligent transportation systems.

IV. PROPOSED SYSTEM

A. Overall System Architecture

The proposed system is an automated bus ticketing and passenger management solution designed to replace conventional manual ticketing methods. The architecture integrates RFID technology, embedded control using Arduino, GSM communication, and display interfaces to provide automatic ticket generation, student pass verification, balance calculation, and SMS alert services. The system is designed to operate in real time within a public bus environment and supports cashless transactions, thereby reducing human intervention and operational errors.

The entire system is centralized around the Arduino microcontroller, which acts as the main processing unit. All input devices such as RFID reader and keypad, and output devices such as LCD, buzzer, GSM module, and motor driver are interfaced with the controller. The modular design ensures scalability, reliability, and ease of maintenance, making the system suitable for real-world public transport deployment.

B. Power Supply Unit

The power supply unit is responsible for providing stable and regulated DC voltage to all system components. It consists of an AC supply, step-down transformer, bridge rectifier, and voltage regulator circuit. The transformer reduces the high-voltage AC mains supply to a lower AC voltage suitable for electronic circuits. This reduced AC voltage is then converted into DC using a bridge rectifier.

The rectified DC voltage contains ripples, which are filtered and regulated using voltage regulator ICs to obtain constant output voltages such as 5V and 12V. These regulated voltages are essential for safe operation of the Arduino, RFID module, GSM module, LCD, and other peripherals. A stable power supply ensures reliable system performance and prevents malfunction due to voltage fluctuations.

C. Arduino-Based Control Unit

The Arduino microcontroller acts as the heart of the proposed system and controls all operations. It continuously monitors inputs from the RFID reader and keypad, processes fare calculation logic, updates passenger balance data, and controls output devices. The embedded program written in Arduino IDE governs the sequence of operations and decision-making processes.

The controller authenticates RFID cards by matching unique tag IDs with stored data. Based on the passenger type (regular or student) and selected destination, the Arduino calculates the appropriate fare and deducts it from the stored balance. It also triggers display updates, SMS notifications, buzzer alerts, and motor control actions, ensuring synchronized system operation.

D. RFID-Based Passenger Identification and Student Pass Validation

The RFID module is used for contactless passenger identification and ticket authorization. Each passenger is issued an RFID card that contains a unique identification number linked to their account details, balance, and pass information.



When the passenger taps the RFID card near the reader, the system reads the card ID and sends it to the Arduino for verification.

For regular passengers, the system checks the available balance before allowing travel. For students, the system verifies pass validity based on stored expiry dates. If the student pass is valid, the system permits travel without fare deduction. If the card is invalid or the balance is insufficient, appropriate alerts are generated. This mechanism ensures secure access, prevents misuse of student passes, and eliminates manual verification.

E. Fare Selection and Balance Calculation Using Keypad

A 4×4 keypad matrix is interfaced with the Arduino to allow passengers or conductors to input destination codes or route selections. Each key corresponds to a predefined fare value stored in the system memory. Once a destination is selected, the Arduino calculates the fare automatically.

The calculated fare is deducted from the passenger’s stored balance in real time. The updated balance is immediately displayed on the LCD screen. If the remaining balance falls below a predefined threshold, the system generates a low-balance alert. This automated balance calculation ensures accuracy, eliminates fare disputes, and enhances passenger trust in the system.

F. Information Display and Alert Mechanism

An LCD display is used to provide real-time information to passengers, such as card validation status, ticket fare, remaining balance, and student pass validity. Visual messages guide the user through the ticketing process, improving usability and system transparency.

A buzzer is included as an alert mechanism to provide audible feedback for events such as successful card scanning, invalid card detection, low balance warning, or transaction failure. These alerts ensure immediate user awareness and help in smooth operation within crowded bus environments.

G. GSM Communication and Motor Control

The GSM module enables real-time SMS communication between the system and passengers. After each transaction, an SMS is sent to the registered mobile number containing details such as fare deducted, remaining balance, and pass validity information. In case of low balance or pass expiry, warning messages are also sent. This feature enhances transparency and keeps passengers informed at all times.

A motor driver IC and DC motor are included to demonstrate physical actuation, such as automated door control or gate simulation. The Arduino controls the motor through the driver IC based on system authorization signals. This feature represents the system’s capability to integrate access control and automation, making it extensible for future smart transportation applications.

V. SYSTEM DESIGN

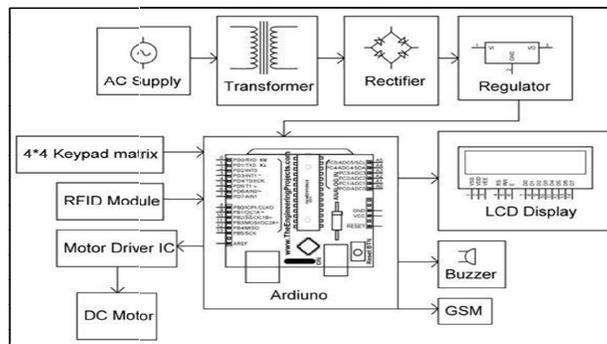


Fig 1: System Architecture

DOI: 10.48175/568



The working of the system begins with the power supply unit, which is used to provide the required electrical power to all electronic components. The system is powered using an AC mains supply. Since electronic components cannot operate directly on high-voltage AC, a transformer is used to step down the input AC voltage to a lower level. The transformer changes the voltage and current levels without altering the frequency or total power transferred, ensuring safe operation of the circuit.

The output of the transformer is fed to a bridge rectifier circuit. The bridge rectifier converts the low-voltage AC signal into a pulsating DC signal. Most electronic circuits require DC power for operation, and hence rectification is essential. The rectified output still contains ripples, which are then regulated using a voltage regulator circuit. The voltage regulator provides a constant and stable DC voltage regardless of variations in input voltage or load conditions. This regulated DC output is supplied to the Arduino controller and other modules such as RFID reader, GSM module, LCD display, keypad, and buzzer.

The Arduino microcontroller acts as the central control unit of the entire system. It receives power from the regulated DC supply and continuously monitors all connected peripherals. The complete system logic is implemented using a program written in the Arduino programming language, which is based on embedded C. The Arduino coordinates all operations such as RFID card validation, fare calculation, balance deduction, display updates, buzzer alerts, and SMS transmission.

When the system is powered ON, the LCD initially displays a message such as “Kindly Swipe Your Card”. The passenger then brings the RFID card near the RFID reader. The RFID module reads the unique ID of the card and sends it to the Arduino for verification. In this project, four RFID cards are used, each representing a different user. Initially, each RFID card is recharged with a balance of ₹1000, which is stored in the system memory.

After successful card detection, the Arduino prompts the user to enter the destination using the 4×4 keypad. Each keypad number corresponds to a predefined travel destination and fare. For example, destination 1 is assigned a fare of ₹50, destination 2 costs ₹100, destination 3 costs

₹150, and destination 4 costs ₹200. When the user selects destination 2, the system automatically calculates the fare as ₹100 and deducts it from the card balance.

Once the fare is deducted, the updated balance is calculated and displayed on the LCD. For instance, if ₹100 is deducted from the initial balance of ₹1000, the remaining balance shown on the display is ₹900. Simultaneously, the Arduino activates the GSM module to send an SMS notification to the registered mobile number of the cardholder. The SMS contains details such as card ID, fare amount, and remaining balance, for example: “ID 1: Fare ₹100 deducted. Remaining balance ₹900.” The same process is repeated for other RFID cards.

The fourth RFID card is configured as a student pass. When the student card is scanned, the system does not deduct any balance. Instead, it verifies the validity of the student pass stored in memory. If the pass is valid, the LCD displays a message such as “Student Pass Valid till JUN-30- 2019”, and an SMS containing the pass validity details is sent to the registered mobile number. This eliminates the need for manual checking of student passes and prevents misuse.

If the balance in any RFID card falls below a predefined minimum threshold, the system automatically triggers a low-balance warning. The buzzer is activated to provide an audible alert, and the GSM module sends an SMS notification stating “Low Balance – Please Recharge Your Card”. This ensures that passengers are informed in advance and can recharge their cards without inconvenience.

Thus, the proposed system ensures fully automated ticketing, accurate fare calculation, real-time balance updates, student pass validation, and instant SMS alerts, resulting in a reliable, efficient, and user-friendly smart bus ticketing solution.



Hardware component

1. Transformer



Fig 2: Transformer

The transformer is a key component of the power supply unit and is used to step down the high-voltage AC mains supply to a lower AC voltage suitable for electronic circuits. In the proposed system, the transformer reduces the input AC voltage (230 V) to a safer low-voltage level required for rectification and regulation. This voltage transformation is achieved without changing the frequency of the supply, ensuring efficient power transfer through electromagnetic induction.

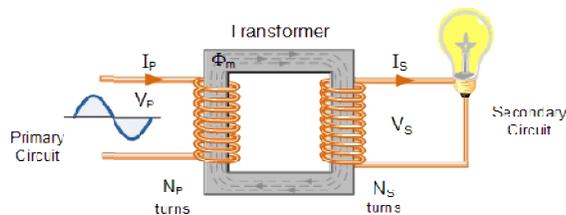


Fig 3: Single Phase Voltage Transformer

In the advanced bus ticketing system, the transformer ensures electrical isolation between the high-voltage mains and low-voltage control circuitry. This isolation protects sensitive components such as the Arduino controller, RFID module, GSM module, and LCD display from damage due to voltage surges or fluctuations, thereby improving system reliability and safety.

2. Rectifier

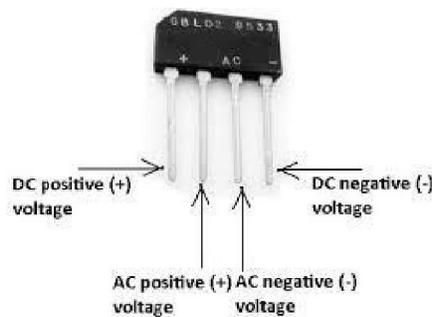


Fig 4: Rectifier

The rectifier converts the low-voltage AC output of the transformer into DC voltage, which is essential for operating electronic components. In this project, a bridge rectifier circuit is used because it provides full-wave rectification, utilizing both halves of the AC signal to generate a pulsating DC output with improved efficiency.



The rectified DC output still contains ripples, but it serves as the base input for the voltage regulation stage. In the proposed system, rectification ensures that a unidirectional current is supplied to the regulator, enabling stable and continuous operation of the embedded control system used for ticket processing and passenger management.

3. Voltage Regulator

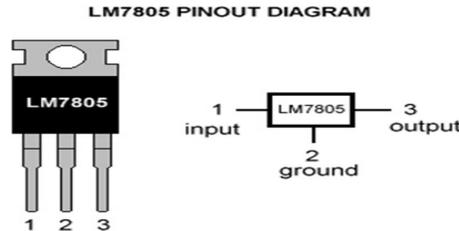


Fig 5: Pinout diagram

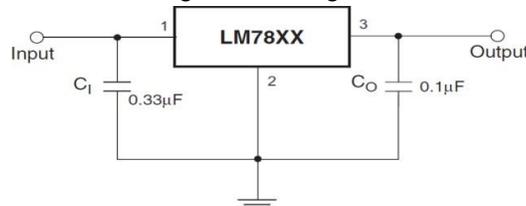


Fig 6: Voltage regulator

The voltage regulator is responsible for maintaining a constant DC output voltage regardless of variations in input voltage or load conditions. In this project, regulator ICs such as 7805 and 7812 are used to provide regulated 5 V and 12 V DC supplies required by different components.

The Arduino controller, RFID module, keypad, and LCD require a stable 5 V supply, while components like the GSM module and motor driver may require higher voltage levels. The regulator ensures uninterrupted and noise-free power, which is essential for accurate fare calculation, reliable RFID detection, and stable GSM communication.

4. Arduino

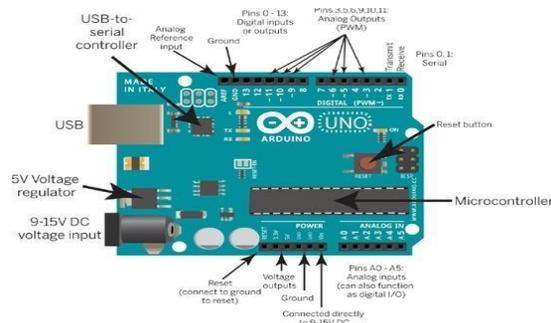


Fig 7: Arduino

Arduino is the central processing unit of the proposed system and controls all system operations. It receives input signals from the RFID reader and keypad, processes ticketing logic, calculates fare, updates balance, and controls output devices such as LCD, buzzer, GSM module, and motor driver IC. The control program is written in Arduino language based on embedded C.



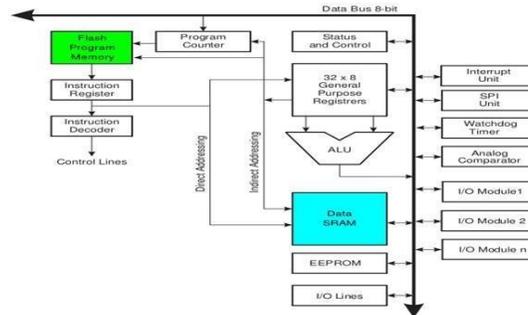


Fig 8: Arduino architecture

In this project, Arduino acts as an intelligent controller that ensures synchronization between hardware modules. It validates RFID cards, differentiates between regular passengers and students, manages transaction data, and generates control signals for SMS alerts and motor actuation. Its flexibility and ease of programming make it ideal for implementing smart transportation solutions.

5. LCD Display



Fig 9: LCD display

The LCD display is used as a visual interface between the system and passengers. It displays important information such as card detection status, fare amount, remaining balance, student pass validity, and system prompts like “Swipe Your Card” or “Enter Destination.”

In the advanced bus ticketing system, the LCD improves user interaction and transparency by providing real-time feedback. Displaying transaction details reduces confusion, minimizes disputes, and ensures that passengers are fully informed about ticketing and balance status during travel.

6. Buzzer



Fig 10: Buzzer



The buzzer is an audio alert device used to provide immediate feedback to the user. It generates sound signals to indicate events such as successful card scanning, invalid card detection, low balance warning, or system error. In this project, the buzzer enhances system usability in crowded bus environments where visual alerts alone may not be sufficient. Audible alerts ensure quick passenger awareness and help conductors or drivers identify transaction status instantly, improving operational efficiency.

7. GSM Module

The GSM module enables wireless communication between the ticketing system and passengers through SMS services. It sends real-time messages containing ticket fare details, remaining balance, low balance alerts, and student pass validity information to the registered mobile number.

In the proposed system, GSM communication enhances transparency and trust by keeping passengers informed beyond the physical bus environment. It also supports record confirmation and acts as a notification system for recharge reminders, ensuring uninterrupted cashless travel.



Fig 11: GSM Module

8. Keypad Matrix

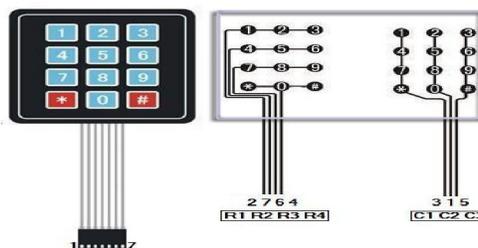


Fig 12: Keypad Matrix

The keypad matrix serves as an input device for selecting destinations or travel options. Each key corresponds to a predefined route or fare value stored in the system memory. The keypad allows user interaction without requiring complex interfaces.

In this project, the keypad enables accurate fare selection and calculation. It eliminates manual fare entry errors and ensures standardized ticket pricing. The keypad matrix also simplifies system design while providing reliable and quick input for the controller.



9. RFID Module

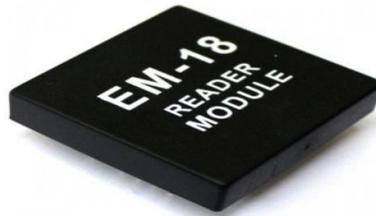


Fig 13: RFID Module

The RFID module is used for contactless identification of passengers. Each passenger is provided with an RFID card containing a unique identification number. When the card is scanned, the RFID reader transmits the card ID to the Arduino for authentication.

In the advanced bus system, RFID technology enables fast, secure, and cashless ticketing. It also supports student pass validation by checking stored validity data, reducing misuse and eliminating the need for manual ticket or pass verification.

10. Motor Driver IC

The motor driver IC acts as an interface between the Arduino controller and the DC motor. Since the Arduino cannot supply sufficient current to drive a motor directly, the motor driver amplifies the control signals to provide the required current and voltage.

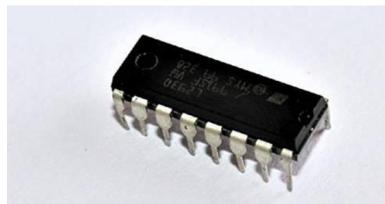


Fig 13: Motor Driver

In this project, the motor driver IC is used to demonstrate automated control such as door operation or gate simulation. It reflects the system's ability to integrate physical actuation with ticket authorization, making the design extensible for smart access control applications.

11. DC Motor



Fig 14: DC Motor

The DC motor represents mechanical actuation within the system. It converts electrical energy into mechanical motion when driven through the motor driver IC. The motor operates based on control signals generated by the Arduino.

In the proposed system, the DC motor is used to simulate automated actions such as opening or closing of bus doors after successful ticket validation. This demonstrates the system's potential for future expansion into fully automated and intelligent transportation systems.



VI. RESULT

The proposed advanced bus ticketing system was successfully designed, implemented, and tested under various operating conditions. All hardware components including the Arduino controller, RFID module, keypad matrix, LCD display, GSM module, buzzer, motor driver IC, and DC motor worked as expected. The power supply unit provided stable and regulated voltage, ensuring reliable operation of the entire system without interruptions.

During testing, RFID card detection was found to be fast and accurate. When a valid RFID card was scanned, the system correctly identified the passenger and displayed appropriate messages on the LCD screen. The response time between card scanning and system acknowledgment was observed to be less than one second, which is suitable for real-time bus ticketing applications. Invalid or unauthorized cards were immediately rejected, and alert messages were generated.

The fare calculation and balance deduction mechanism performed accurately for all predefined destinations. When a passenger selected a destination using the keypad, the corresponding fare was correctly deducted from the stored balance. The updated balance was instantly displayed on the LCD, eliminating fare ambiguity. Multiple transactions were tested consecutively, and no calculation errors were observed during operation.

The student pass functionality also produced correct results. When the student RFID card was scanned, the system verified pass validity without deducting any balance. The LCD displayed the pass expiry date, and an SMS confirmation was successfully sent to the registered mobile number. This confirmed that the system can effectively differentiate between regular passengers and student pass holders.

The GSM module successfully transmitted SMS notifications after each transaction. Messages included fare details, remaining balance, student pass validity, and low-balance warnings. SMS delivery was reliable and timely, providing transparency and real-time communication with passengers. The low-balance alert feature functioned correctly when the balance dropped below the predefined threshold.

Audible alerts generated by the buzzer were clearly noticeable and correctly synchronized with system events such as successful card scanning, low balance detection, and invalid card usage. The motor driver IC and DC motor responded accurately to Arduino control signals, demonstrating the feasibility of integrating automated mechanical actions such as door control or access authorization.

Overall, the experimental results confirm that the proposed system is efficient, reliable, and user-friendly. It successfully automates ticket generation, fare calculation, student pass validation, and passenger notification. The system reduces manual effort, minimizes errors, and supports cashless transactions, making it suitable for implementation in modern public transportation systems.

VII. CONCLUSION

The proposed Advanced Bus with Automatic Ticketing, Student Pass Facility, Balance Calculation and SMS Alert system has been successfully designed, developed, and tested to overcome the shortcomings of traditional manual bus ticketing systems. The integration of RFID technology with an Arduino-based control unit enables automated passenger identification, accurate fare calculation, and secure validation of student passes without human intervention. The system effectively replaces cash-based and paper-based ticketing with a digital, contactless solution, reducing boarding time, operational errors, and fare-related disputes. Real-time information display through the LCD and audible alerts using a buzzer further enhance system usability and transparency during operation.

In addition, the inclusion of GSM-based SMS alert functionality significantly improves passenger communication by providing instant notifications regarding ticket fare, remaining balance, low-balance warnings, and student pass validity. The experimental results confirm the reliability and efficiency of the system under various operating conditions. The modular and scalable design allows easy expansion for future enhancements such as GPS integration, online recharge facilities, and centralized data monitoring. Overall, the proposed system provides a practical, efficient, and smart solution for modern public transportation and supports the vision of intelligent and cashless mobility systems.



FUTURE SCOPE

The proposed advanced bus ticketing system can be further enhanced by integrating GPS technology to enable real-time bus tracking and route monitoring, allowing passengers to receive location-based updates and estimated arrival times. An online or mobile-based recharge facility can be added to allow passengers to recharge RFID cards using UPI, debit/credit cards, or mobile wallets, eliminating the need for physical recharge points. The system can also be connected to a centralized cloud database to store passenger travel history, fare transactions, and operational data for better analysis and decision-making by transport authorities.

In future implementations, the system can be expanded to support QR code and mobile-based ticketing alongside RFID for greater flexibility. Biometric or facial recognition authentication may be incorporated to enhance security and prevent card misuse. Advanced data analytics and AI-based algorithms can be used for demand forecasting, route optimization, and dynamic fare management. With these enhancements, the system can be adapted for use in railways, metro systems, school buses, and intercity transport, making it a comprehensive smart transportation solution aligned with smart city initiatives.

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