Keyless Start: Advancing Vehicle Security and Convenience with RFID Technology

[1][a]Balaji A, [2][a]Karthikeyan K, [3][a]Yukeshwaran A, [4][a*]Sree Sankar J

[a]Karunya Institute of Technology and Sciences, Coimbatore, India

[1] balajia@karunya.edu.in, [2] karthikeyank@karunya.edu.in, [3] yukeshwarana@karunya.edu.in,

[4] sreesankar@karunya.edu

***Abstract*— In this paper, we introduce an exciting innovation—a cutting-edge RFID-based car ignition system designed to elevate both vehicle security and user convenience. We all know that traditional key-based ignition systems come with their fair share of vulnerabilities, including the risk of unauthorized access and car theft. To address these concerns, we've harnessed the power of Radio-Frequency Identification (RFID) technology to completely transform the way we start and stop our cars. Our system relies on RFID tags and readers to authenticate users, making the process of starting and stopping your car incredibly easy. Each authorized user is issued a unique RFID tag linked to their identity. As you approach your vehicle, our RFID reader detects the tag's presence and cross-checks it against a pre-registered database. If the tag is authorized, the ignition system activates, granting you seamless access to your car. However, if the RFID tag isn't recognized, the car remains securely immobilized, significantly enhancing anti-theft protection. This project not only improves the security of your vehicle but also simplifies your life by removing the need for physical keys, making the whole experience of driving your car smoother and more user-friendly. This project serves as an exceptional example of how RFID technology can be successfully integrated into automotive systems, setting a new standard for security and convenience for car owners. Moreover, it highlights the potential for RFID-based solutions to address security concerns across a wide range of applications, from home security to access control and asset management.**

Index Terms — Anti-theft protection, Automotive systems, Integration of RFID technology, RFID-based car ignition system, Keyless vehicle start.

I. INTRODUCTION

Car ignition systems have come a long way since the inception of the automobile. The earliest automobiles featured a hand-crank system to start the engine, which was not only physically demanding but also posed various safety risks [1]. Over time, advancements in technology led to the development of the key-based ignition system. This system became the standard for decades, providing a relatively secure and straightforward means of starting and stopping a vehicle.

However, key-based ignition systems have their limitations. One of the most significant drawbacks is their susceptibility to unauthorized access and theft. Traditional car keys can be easily duplicated, lost, or stolen, making it relatively easy for malicious individuals to gain access to a vehicle and even drive it away. The rise of car theft and unauthorized use has driven the need for more secure and advanced alternatives [2].

In today's rapidly evolving world of automotive technology, our top priorities include ensuring safety and making the driving experience as user-friendly as possible. The automotive industry finds itself at the forefront of a profound transformation in this era of relentless technological advancements. The industry focuses intently on optimizing vehicle security and user convenience. One area of notable evolution is the traditional ignition system. The automotive sector is undergoing a noticeable shift, seeking out more sophisticated and secure solutions to replace key-based ignition systems to ensure security and user convenience. Among these innovative approaches, one stands out—the Radio-Frequency Identification (RFID)-based car ignition system. This technology is hailed as ground-breaking, with the potential to completely transform how we start and stop our vehicles.

The RFID Revolution

Radio-frequency identification (RFID) technology has emerged as a revolutionary solution to the security and convenience issues associated with traditional key-based ignition systems [3]. RFID is not a new technology; it has been used for various applications for many years, such as

inventory tracking in retail and access control in corporate environments [4]. However, its application in the automotive industry has the potential to change the way we interact with our vehicles.

RFID technology operates on the principle of wireless communication using radio waves. It consists of two main components: RFID tags and RFID readers. RFID tags are small, electronic devices that store unique identification data and transmit this data to RFID readers when within range. RFID readers, on the other hand, are devices that send out radio waves to power and communicate with RFID tags. When an RFID tag comes into proximity with an RFID reader, it responds by transmitting its data, allowing for quick and secure identification [5].

The RFID-based Car Ignition System

The RFID-based car ignition system involves replacing traditional keys with RFID tags and readers, offering several advantages that make it a compelling alternative to conventional ignition systems.

1. ***Enhanced Security:***

One of the most significant advantages of RFID-based ignition systems is their enhanced security [6]. Unlike traditional keys, RFID tags are not easily duplicated or lost. Each RFID tag is unique, and its data is securely stored within the tag, making it extremely difficult for unauthorized individuals to gain access to a vehicle. This eliminates the risk of car theft and unauthorized use.

Furthermore, RFID technology can be integrated with advanced encryption and authentication protocols to further bolster security. Access to the vehicle can be restricted to authorized users only, reducing the chances of theft or misuse. In the event of a lost or stolen RFID tag, it can be quickly deactivated and replaced, ensuring that the vehicle remains secure.

2. Convenience and Ease of Use:

RFID-based ignition systems offer unparalleled convenience to vehicle owners. Users no longer need to fumble with traditional keys, making it easier and quicker to start and stop the vehicle. RFID tags can be discreetly attached to keychains or other personal items, ensuring that they are always within reach. This means no more digging through pockets or bags to find the car key.

Moreover, the process of entering and starting the vehicle can be further streamlined by using proximity sensors. When the authorized user is in close proximity to the vehicle, the system can automatically unlock the doors and prepare the vehicle for ignition. This hands-free approach enhances the overall user experience and reduces the time spent on mundane tasks like searching for keys.

3. Customization and User Profiles:

RFID-based ignition systems offer the flexibility to create user profiles and customize vehicle settings. Each RFID tag can be associated with specific user preferences, such as seat and mirror positions, climate control settings, and entertainment options. When an authorized user approaches the vehicle, the system can recognize their RFID tag and automatically adjust the vehicle settings to match their preferences. This level of personalization enhances the driving experience and makes the vehicle feel like a tailored extension of the user.

4. Remote Access and Control:

With the integration of modern technology, RFID-based ignition systems can be linked to smartphone apps and connected car platforms [7] . This connectivity allows users to remotely access and control various vehicle functions. For instance, users can lock and unlock the vehicle, start the engine, and even set the climate control from their mobile devices. This level of control adds another layer of convenience and security, especially in situations where remote operation is necessary.

5. Reduced Maintenance and Wear:

Traditional key-based ignition systems involve physical contact between the key and the ignition switch, leading to wear and tear over time. Keys can become worn and may require replacement or maintenance. In contrast, RFID-based systems do not involve any physical contact. RFID tags are passive devices with no moving parts, which means they have a longer lifespan and require minimal maintenance. This reduces the cost and hassle of replacing worn-out keys.

6. Compatibility and Integration:

RFID-based ignition systems are highly adaptable and can be integrated into both new and existing vehicles [6]. For manufacturers, it offers a streamlined and modern approach to vehicle security and user experience. For owners of older vehicles, retrofitting an RFID system is a feasible option, ensuring that the benefits of this technology are not limited to new car purchases.

By swapping out traditional keys for RFID tags and readers, we aren't just reimagining vehicle ignition; we're also making the everyday experience of using your car safer and more user-friendly.

In this paper, we present an innovative RFID-based ignition system that has the potential to significantly improve both convenience and security.

II. METHODS

The first thing to do is to learn how a car normally starts and then add the new way starting the car.

A traditional car ignition system typically works as follows:

1. ***Key Insertion***: The driver inserts a physical key into the ignition switch, usually located on the steering column or dashboard.

2. ***Ignition Switch:*** Turning the key in the ignition switch sends an electrical signal to the car's electrical system. This signal indicates that the driver intends to start the engine.

3. ***Starter Motor:*** The electrical signal activates the starter motor. The starter motor engages with the engine's flywheel, which is connected to the crankshaft.

4. ***Engine Cranking:*** The starter motor turns the engine over by rotating the crankshaft. This initiates the engine's internal combustion process.

5. ***Fuel and Air Mixture:*** During cranking, the engine draws in a mixture of fuel and air, which is then compressed and ignited by the spark plugs.

6. ***Engine Start:*** The ignition of the fuel and air mixture starts the engine. It runs on its own and continues to operate until manually turned off.

7. ***Key Release:*** Once the engine is running, the driver can release the key from the ignition switch. The engine remains running until the driver turns it off.

This is a simplified explanation of how a traditional car ignition system works. Keep in mind that modern vehicles often have more advanced ignition systems, including electronic ignition systems, but the basic principle of starting the engine with a key is similar.

In this research, we have substituted the conventional ignition switch with an RFID sensor. The RFID-based car ignition system is designed to enhance the security and convenience of starting and stopping a vehicle. It relies on Radio-Frequency Identification (RFID) technology to authenticate authorized users and provide keyless access to the vehicle.

Components used:

1. *Stepper Motor:*

A stepper motor is an electromechanical device that converts digital input pulses into precise and controlled rotational movements, making it suitable for applications requiring accurate positioning [8].

Fig 1. Stepper Motor

2. *RFID Sensor:*

An RFID sensor is a device that uses radio-frequency identification technology to read and communicate information stored on RFID tags or cards, enabling contactless data exchange and identification.

Fig 2. RFID Sensor

3. *Drift gear Motor:*

A drift gear motor is a type of electric motor commonly used in automotive applications to control the movement of power windows, sunroofs, and other mechanisms with incremental rotational motion.

Fig 3. Drift gear motor

4. *Lever Switch:*

A lever switch is a mechanical switch that is activated by the movement of a lever, typically used in various electronic and industrial applications to control circuits or devices when the lever is toggled.

Fig 4. Lever Switch

Figure 6 displays the circuit diagram of the RFID-based ignition system, while Figure 5 showcases the model car we constructed with the RFID-based ignition system.

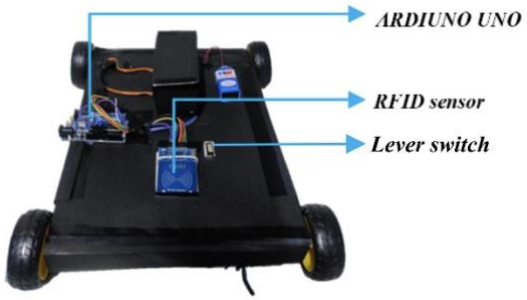

Fig. 5. Model car with RFID-based ignition

Below is the working procedure for our RFID-based car ignition system:

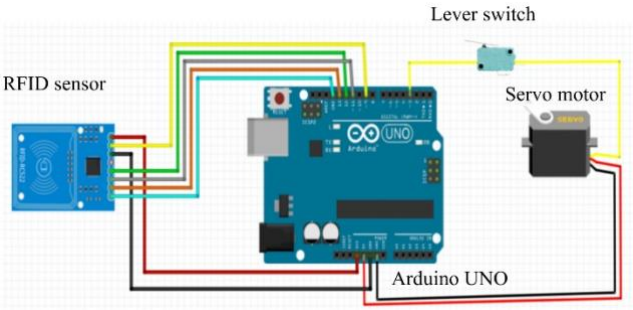

Fig 6. Circuit diagram

When a valid RFID tag is brought in close proximity to the RFID sensor, the sensor transmits an electrical signal, initiating the starter motor, which, in turn, starts the engine. Conversely, while the vehicle is in motion, if an authorized RFID tag is presented near the RFID sensor, the sensor emits an electrical signal to shut down the engine.

***Software and Programming*:**

The Arduino IDE was employed for programming the Arduino UNO board. The following steps were followed while programming:

1. Include necessary libraries: SPI, MFRC522, and Servo.

2. Define the Arduino pins for the MFRC522 RFID module (SS_PIN and RST_PIN) and the Servo motor (SERVO_PIN).
3. Create a Servo object named myservo.
4. Define constants:
    - ACCESS_DELAY: Time delay for authorized access (in milliseconds).
    - DENIED_DELAY: Time delay for access denied (in milliseconds).
5. Initialize the MFRC522 module and set the initial state of the door to closed (isOpen = false).
6. In the setup() function:
    - Begin serial communication at a baud rate of 9600.
    - Initialize the SPI bus.
    - Initialize the MFRC522 module using PCD_Init().
    - Attach the Servo motor to the specified pin (SERVO_PIN) and set it to the initial closed position (70 degrees).
    - Print a message indicating that the system is ready to read RFID cards.
7. In the loop() function:
    - Check if a new RFID card is present using PICC_IsNewCardPresent(). If not, continue to the next iteration of the loop.
    - Read the serial number (UID) of the RFID card using PICC_ReadCardSerial().
8. Extract and format the UID:
    - Convert the UID bytes to hexadecimal strings.
    - Concatenate the hexadecimal values into a single content string.
9. Compare the content string (UID) to an authorized UID (e.g., "14 AA 12 BB").
    - If the UID matches the authorized UID:
    - Print "Authorized access."
    - Toggle the state of the door:
    - If the door is open (isOpen = true), close it by setting the servo angle to 70 degrees.
    - If the door is closed (isOpen = false), open it by setting the servo angle to 0 degrees.
    - Delay for the specified ACCESS_DELAY milliseconds.
    - If the UID does not match the authorized UID:
    - Print "Access denied."
    - Delay for the specified DENIED_DELAY milliseconds.
10. Repeat the loop, continuously checking for new RFID cards and processing access requests based on the card UID.
11. The program continuously monitors the RFID reader for card presence, reads the card's UID, and grants access if the UID matches the authorized UID. It controls the servo motor to open and close the door accordingly and introduces delays for access and access-denied scenarios.

Impact of using RFID based ignition system:

A. Enhanced Vehicle Security:

The project enhances vehicle security by significantly reducing the risk of unauthorized access and car theft, leading to decreased insurance claims and
improved safety.

B. Convenient Access Control:

RFID technology offers a more convenient and user-friendly way to start and stop vehicles, simplifying the driver experience and reducing the reliance on physical keys.

C. Improved Fleet Management:

For businesses with vehicle fleets, this system provides better control over vehicle access, reducing unauthorized use, and enhancing fleet security and efficiency.

D. Reduced Key Management Hassles:

The elimination of traditional keys reduces the chances

of key loss or duplication, resulting in cost savings and a streamlined access control process.

E. Future Mobility Integration:

RFID-based car ignition systems can serve as a foundation for future mobility solutions, including car-sharing, autonomous vehicles, and smart city transportation, contributing to the evolution of the automotive industry.

Security Concerns and Solutions:

While RFID-based car ignition systems offer substantial advantages in terms of security and convenience, it is essential to address potential security concerns associated with this technology.

1. Unauthorized Cloning:

One concern is the potential for unauthorized individuals to clone RFID tags and gain access to a vehicle. To mitigate this risk, RFID systems can incorporate advanced encryption and authentication measures. These security protocols make it significantly more challenging for malicious actors to clone RFID tags or intercept communication between tags and readers. Additionally, regularly updating and rotating encryption keys further strengthens the security of the system [9].

2. Data Privacy:

Another concern relates to the storage and transmission of user data within RFID tags. To protect user data and privacy, RFID systems should employ robust encryption and secure data storage practices [9]. User data should be stored securely within the RFID tag, and any communication with the vehicle's system should be encrypted to prevent eavesdropping and data theft.

3. Physical Security:

Physical security measures are essential to safeguard RFID tags from tampering or removal.

III. CONCLUSION

In conclusion, the project utilizes RFID technology to start and stop a car which represents a groundbreaking innovation in the field of automotive access and ignition control. This system offers a secure and convenient alternative to traditional key-based ignition methods, addressing various critical concerns that have long plagued the automotive industry. This RFID-based car ignition system represents a significant step forward in redefining how we access and control our vehicles. It combines enhanced security, user-friendliness, and adaptability into a single, innovative solution. As the automotive industry continues to evolve, solutions like this one play a vital role in shaping the future of transportation, offering a glimpse into a safer, more efficient, and user-friendly driving experience for all vehicle owners. The potential applications of this technology across diverse industries further highlight its transformative impact and the possibilities it brings for a more connected and secure future.

REFERENCES

[1] Vinsel L. Moving violations: automobiles, experts, and regulations in the United States. JHU Press; 2019 Jul 16.

[2] Elkhail AA, Refat RU, Habre R, Hafeez A, Bacha A, Malik H. Vehicle security: A survey of security issues and vulnerabilities, malware attacks and defenses. IEEE Access. 2021 Nov 23;9:162401-37.

[3] Lopez A, Malawade AV, Al Faruque MA, Boddupalli S, Ray S. Security of emergent automotive systems: A tutorial introduction and perspectives on practice. IEEE Design & Test. 2019 Sep 27;36(6):10-38.

[4] Zhu X, Mukhopadhyay SK, Kurata H. A review of RFID technology and its managerial applications in different industries. Journal of Engineering and Technology Management. 2012 Jan 1;29(1):152-67.

[5] Weis SA. RFID (radio frequency identification): Principles and applications. System. 2007;2(3):1-23.

[6] Saparkhojayev N, Kurymbayev A, Akhmetov A. Implementation of RFID-Based Car Ignition System (CIS) in Kazakhstan. InMechatronics and Robotics Engineering for Advanced and Intelligent Manufacturing 2017 (pp. 387-394). Springer International Publishing.

[7] Uddin MS, Ahmed MM, Alam JB, Islam M. Smart anti-theft vehicle tracking system for Bangladesh based on Internet of Things. In2017 4th International Conference on Advances in Electrical Engineering (ICAEE) 2017 Sep 28 (pp. 624-628). IEEE.

[8] Khawari AS. Speed and Direction Control of Stepper Motor (Doctoral dissertation, Department of Technical and Vocational Education (TVE), Islamic University of Technology (IUT), Board Bazar, Gazipur-1704, Bangladesh).

[9] Tu YJ, Zhou W, Piramuthu S. Critical risk considerations in auto-ID security: Barcode vs. RFID. Decision Support Systems. 2021 Mar 1;142:113471.