
Implementation Of An Internet Of Things-Based Motorcycle Security System Using GPS Tracker And Microcontroller

Ahmad Ferdian Syaputra^{1)*}, Adi Wibowo²⁾

^{1,2)} Sistem dan Teknologi Informasi, Fakultas Teknik dan Ilmu Komputer, Universitas Muhammadiyah Kotabumi

*Corresponding Author

Email : achmadferdian16@gmail.com

Abstract

Motor vehicle theft remains a common problem caused by the weakness of conventional security systems that rely solely on mechanical locks. This study aims to design and implement an Internet of Things (IoT)-based motorcycle security system using ESP32 integrated with RFID RC522, GPS Neo-6M, vibration sensor, starter relay, buzzer, ThingsBoard Cloud, and Telegram Bot. The research employed an experimental method with a prototype approach, including requirement analysis, system design, hardware and software implementation, system integration, and system testing. The developed system performs user authentication using RFID, detects vehicle vibrations, transmits real-time vehicle location coordinates, and provides security notifications through Telegram. Vehicle telemetry data are also transmitted to the ThingsBoard Cloud platform using the MQTT protocol for real-time monitoring. The testing results indicate that all system features functioned properly, including RFID authentication, GPS monitoring, vehicle relay control, vibration detection, MQTT data transmission, and Telegram notifications, with a system success rate of 100%. The developed IoT-based vehicle security system is capable of improving vehicle security more effectively and modernly compared to conventional security systems.

Keywords: *Internet of Things, ESP32, RFID, GPS Tracker, Vehicle Security.*

INTRODUCTION

The rapid development of information and communication technology in the digital era has brought significant changes across various sectors, including motor vehicle security. One of the rapidly growing technologies is the Internet of Things (IoT), which refers to the concept of communication among devices through internet networks in real time (Gautama et al., 2025). IoT technology has been widely implemented in automation and monitoring systems because it improves efficiency and enables remote device control more effectively (Pratama et al., 2023; Munir & Wibisono, 2025).

Motorcycles are one of the most widely used means of transportation in Indonesia due to their practicality and affordability. However, the increasing number of motorcycle users has also led to a rise in motorcycle theft cases. Conventional security systems, such as mechanical locks and simple alarms, still have several limitations because they are relatively easy to bypass and are unable to provide real-time vehicle monitoring for owners.

The implementation of IoT technology can provide an effective solution for improving vehicle security. By integrating microcontrollers, sensors, GPS trackers, and internet networks, users are able to monitor vehicle conditions in real time through smartphones. In addition, the system can automatically provide notifications when suspicious activities occur, such as vehicle vibrations or unauthorized access attempts.

This study implements an Internet of Things-based motorcycle security system using ESP32 as the main controller (Azhar & Nurpulaela, 2024). The system is integrated with RFID RC522 for user authentication, GPS Neo-6M for vehicle tracking, a vibration sensor for security disturbance detection, relays for ignition and starter control, and a buzzer as a warning alarm. Furthermore, the system utilizes the ThingsBoard Cloud platform for telemetry data monitoring and Telegram Bot for real-time security notifications (Gustia et al., 2025).

The use of RFID aims to enhance vehicle access security, ensuring that only registered RFID card users are able to start the vehicle (Fauzan et al., 2026; Muzakir et al., 2023). The GPS tracker is used to assist in vehicle tracking in the event of theft, while the vibration sensor detects suspicious activities and automatically sends notifications to users.

Several previous studies have developed IoT-based vehicle security systems (Andreas & Arijanto, 2024; Fauzan et al., 2026). However, most of these studies still have limitations in terms of real-time monitoring and remote vehicle control features. Therefore, this research integrates multiple security technologies into a single system to provide a more effective and modern vehicle security solution. This research was conducted in Kotabumi Tengah Village based on a pre-research permit issued by the Faculty of Engineering and Computer Science, Universitas Muhammadiyah Kotabumi. The developed system is expected to become an alternative solution for improving motor vehicle security using Internet of Things technology in a more effective, efficient, and user-friendly manner.

RESEARCH METHODS

This study employed an experimental method using an Internet of Things (IoT)-based prototype approach (Saptadi et al., 2025). The experimental method was chosen because the research focused on the design, implementation, and testing of a microcontroller-based motorcycle security system. The prototype approach was selected as it provides a systematic development process, starting from requirement analysis, initial system design, hardware and software implementation, to comprehensive system performance evaluation.

The purpose of this research was to develop a vehicle security system capable of user authentication, real-time vehicle monitoring, remote starter control, vehicle location tracking using a GPS tracker, and automatic notification delivery through Telegram.

The prototype method in this study consisted of several stages: system requirement analysis, system design, hardware implementation, software implementation, IoT system integration, system testing, and analysis of testing results. This approach was chosen because IoT-based vehicle security systems require gradual development and testing processes to ensure that all components work properly in an integrated manner.

Research Location and Object

The research was conducted in Kotabumi Tengah Village, North Lampung Regency. The object of this study was an Internet of Things-based motorcycle security system implemented using the ESP32 microcontroller. The system was designed to improve vehicle security through RFID authentication, vehicle location monitoring, vibration detection, security alarms, starter motor control, cloud-based monitoring, and real-time Telegram notifications.

Research Flowchart

The research stages were carried out systematically, starting from problem identification to conclusion drawing. The research flowchart was used to describe the research process in a structured manner, facilitating the design, implementation, and testing of the Internet of Things (IoT)-based vehicle security system. The study began with the identification of problems related to the increasing number of motorcycle theft cases and the limitations of conventional security systems. The next stage involved system requirement analysis, including hardware, software, monitoring systems, RFID authentication, GPS tracker, vibration sensor, and Telegram notification requirements.

The subsequent stage involved hardware and software design, including system architecture design, wiring diagrams, and system workflow design. After the design process was completed, the IoT system was implemented using ESP32 integrated with RFID RC522, GPS Neo-6M, relays, vibration sensors, buzzers, and the ThingsBoard Cloud platform. The developed system was then integrated with internet networks and Telegram Bot for real-time monitoring and notification processes. The next stage involved system testing to evaluate system performance and determine the success rate of the vehicle security functions. The testing results were analyzed as the basis for system evaluation before drawing the research conclusions. The research flowchart is shown in Figure 1.

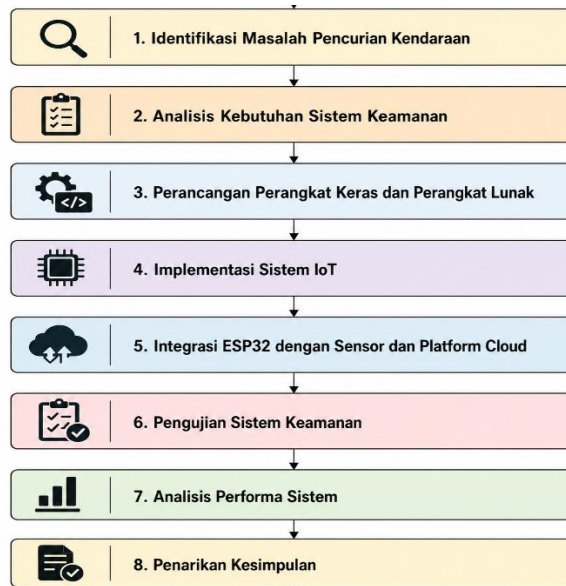


Figure 1. Flowchart Tahapan Penelitian
 Source: Prepared by the Author, 2026

System Architecture

The system architecture was designed to illustrate the communication flow among components in the Internet of Things (IoT)-based vehicle security system. The system uses ESP32 as the main controller connected to RFID RC522, GPS Neo-6M, vibration sensor, relays, and buzzer. Sensor data are processed by ESP32 to determine the vehicle security status and control output devices in real time. In addition to local control, ESP32 also transmits monitoring data to the ThingsBoard Cloud platform using the MQTT protocol through a WiFi connection (Gitakarma et al., 2024). The system is also integrated with Telegram Bot to send security notifications to users whenever suspicious activities are detected on the vehicle.

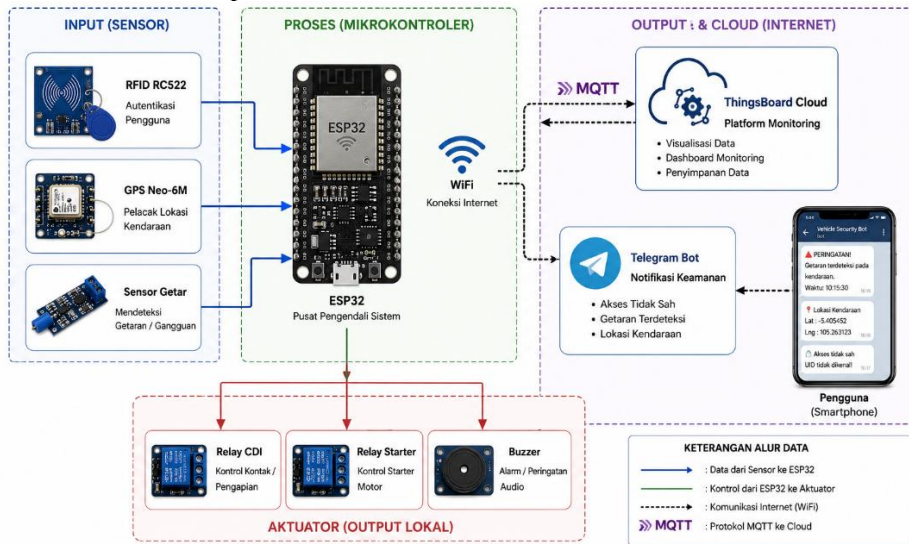


Figure 2. IoT-Based Vehicle Security System Architecture
 Source: Prepared by the Author, 2026

Based on Figure 2, sensors as input devices transmit data to ESP32 for processing and controlling relays and buzzers. Furthermore, telemetry data are transmitted to ThingsBoard Cloud, while security notifications are sent to users through Telegram Bot in real time.

System Wiring Diagram

The wiring diagram was designed to describe the connection among hardware components in the Internet of Things (IoT)-based vehicle security system. The diagram illustrates the configuration between the ESP32 microcontroller and the input, output, sensor, and actuator devices used in this study. The wiring configuration was designed to ensure all components could communicate and operate properly. In this system, the RFID RC522 module uses SPI communication for user authentication. GPS Neo-6M utilizes UART serial communication to obtain real-time vehicle coordinates. The vibration sensor is used to detect security

disturbances, while the CDI relay and starter relay control the ignition and starter systems. Additionally, a buzzer functions as a warning alarm when suspicious activity is detected.

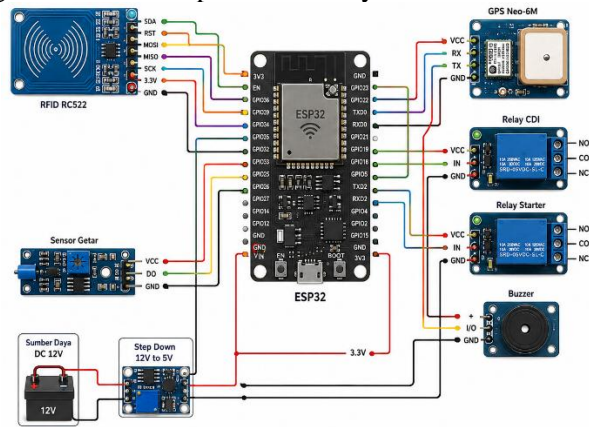


Figure 3. Wiring Diagram of the IoT-Based Vehicle Security System

Source: Prepared by the Author, 2026

Based on Figure 3, ESP32 functions as the main controller connecting all system components. The primary power source uses a 12V battery converted to 5V through a step-down converter to supply ESP32 and other components. Sensor data are processed by ESP32 to control relays, buzzers, and send monitoring data and security notifications via the internet network.

Research Subjects and Testing Techniques

The research subject was an IoT-based vehicle security system implemented on a motorcycle. Testing was conducted using the purposive testing method on the main system functions under several operational conditions. The testing parameters included WiFi connection, RFID, GPS tracker, relay, vibration sensor, MQTT, ThingsBoard Cloud, and Telegram notifications. System success criteria were determined based on the system’s ability to read RFID data, transmit real-time data, detect security disturbances, display vehicle locations, send Telegram notifications, and control vehicle relays properly.

Hardware Components

The hardware components used in this study are presented in Table 1.

Table 1. Hardware Components

No	Component	Function
1	ESP32	Main microcontroller
2	RFID RC522	User authentication
3	GPS Neo-6M	Vehicle location tracking
4	2-Channel Relay	Ignition and starter control
5	SW-420 Vibration Sensor	Vehicle vibration detection
6	Buzzer	Security alarm
7	RFID Card	User access
8	Smartphone	System monitoring

Source: Prepared by the Author, 2026

Software Components

The software used in this study is presented in Table 2.

Table 2. Software Components

No	Software	Function
1	Arduino IDE 2.3.2	ESP32 programming
2	ThingsBoard Cloud	Telemetry monitoring
3	Telegram Bot API	User notification
4	MQTT Protocol	IoT data communication

Source: Prepared by the Author, 2026

The programming language used in this research was Arduino-based C++ with the following libraries:

- WiFi.h
- PubSubClient.h
- MFRC522.h
- TinyGPS++.h
- HTTPClient.h

Requirement Analysis

The initial stage of the research involved identifying the requirements of the IoT-based vehicle security system. The analysis focused on vehicle monitoring, user authentication, notification delivery, and real-time vehicle location tracking requirements.

System Design

At this stage, the system architecture, hardware wiring, data communication flow, system flowchart, and monitoring dashboard design were developed. ESP32 was designed as the central controller for all sensors and actuators.

Hardware Implementation

The hardware implementation stage was carried out by assembling all electronic components according to the system wiring diagram. RFID, GPS, relays, vibration sensors, and buzzers were connected to ESP32 using predefined pin configurations.

Software Implementation

The software implementation stage was conducted using Arduino IDE. The program was developed to:

- Read RFID UID
- Control the CDI relay
- Control the starter motor
- Read GPS data
- Read vibration sensor data
- Send MQTT telemetry data
- Send Telegram notifications

Data Analysis Technique

The data analysis technique used in this study was descriptive quantitative analysis. The testing data were analyzed based on the success rate of the system in performing Internet of Things (IoT)-based vehicle security functions.

The analysis parameters included:

- RFID reading success rate
- MQTT data transmission success rate
- GPS accuracy
- Vibration sensor response
- Telegram notification success rate
- Relay control success rate

The system success percentage was calculated using the following formula:

$$\text{Success Percentage} = \frac{\text{Number of Successful Tests}}{\text{Total Number of Tests}} \times 100\% \dots \dots \dots (1)$$

The testing results were then analyzed to evaluate the performance of the vehicle security system in improving real-time motor vehicle security.

RESULTS AND DISCUSSION

The research results indicate that the Internet of Things (IoT)-based vehicle security system was successfully implemented using ESP32 as the main controller. The system was integrated with RFID RC522, GPS Neo-6M, vibration sensors, relays, buzzers, ThingsBoard Cloud, and Telegram Bot for real-time monitoring and security notifications. The implementation was carried out by connecting all hardware components according to the designed wiring diagram, enabling all components to function properly.

System Implementation Results

The system was capable of performing user authentication using RFID, detecting vehicle vibrations, transmitting vehicle locations through a GPS tracker, controlling the starter motor, and sending security notifications via Telegram. In the hardware implementation, RFID was used as the vehicle security access system, GPS Neo-6M was utilized for vehicle location tracking, while the vibration sensor functioned to detect suspicious activities. The CDI relay and starter relay were used to control the ignition and starter systems in real time through IoT technology.

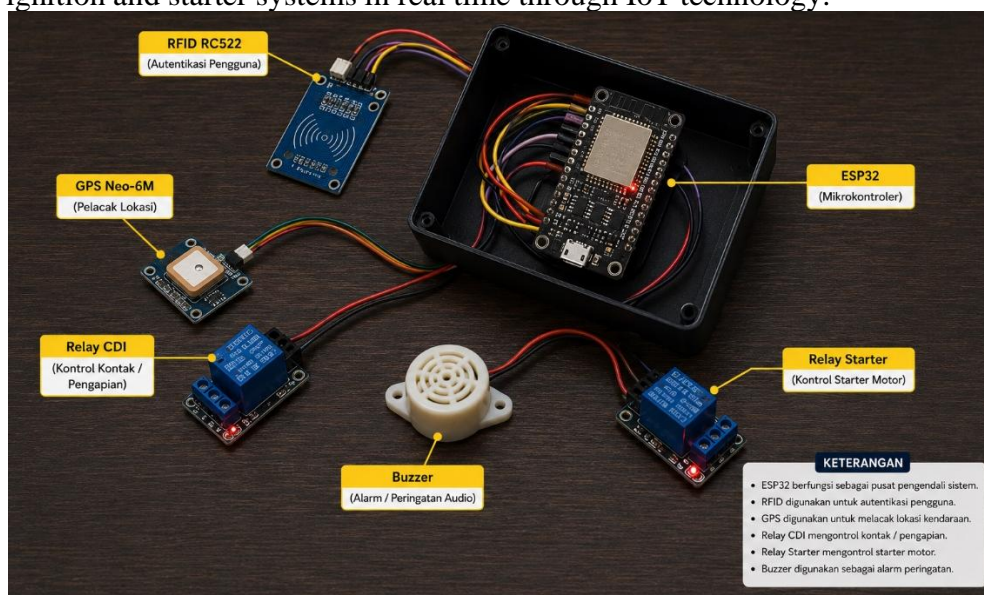


Figure 4. Hardware Implementation of the Vehicle Security System

Source: Prepared by the Author, 2026

In addition to hardware implementation, software implementation was also carried out using Arduino IDE. The ESP32 program was developed to control RFID reading, monitor vibration sensors, transmit GPS data, send MQTT data to ThingsBoard, and deliver Telegram notifications.

```

START
Inisialisasi WiFi,MQTT,RFID,GPS,Relay,Buzzer,Sensor Getar
Koneksi WiFi
Koneksi ThingsBoard
Kirim Notifikasi Telegram Sistem Aktif
LOOP
Jika MQTT Tidak Terhubung
Reconnect MQTT
EndIf
Baca RFID
Jika RFID Valid
Toggle Relay CDI
Bunyi Buzzer
Kirim Telegram Motor ON/OFF
ElseIf RFID Tidak Valid
Alarm Buzzer
Kirim Telegram RFID Tidak Dikenal
EndIf
Baca Sensor Getar
Jika Getaran Terdeteksi
Status = BAHAYA
Alarm Buzzer
Kirim Telegram Bahaya
Else
Status = AMAN
EndIf
Baca GPS
Jika GPS Valid
Ambil Latitude dan Longitude
EndIf
Kirim Data MQTT:
Latitude
Longitude
Status Motor
Status Keamanan
Jika Perintah MQTT = ON
Relay CDI ON
EndIf
Jika Perintah MQTT = OFF
Relay CDI OFF
EndIf
Jika Perintah MQTT = START dan Motor Aktif
Relay Starter ON 2 Detik
Relay Starter OFF
EndIf
Delay 50 ms
END LOOP
    
```

Figure 5. Arduino IDE Pseudocode Implementation

Source: Prepared by the Author, 2026

RFID RC522 Testing Results

RFID testing was conducted to evaluate the system’s ability to read RFID card UID data used for vehicle user authentication. Based on the testing results, the RFID RC522 module successfully read the card UID and transmitted the data to ESP32 for the verification process. When the RFID card UID matched the data stored in the program, the CDI relay was activated, allowing the vehicle to be started. Conversely, if the UID was not recognized, the system activated the buzzer and sent a warning notification through Telegram.

GPS Tracker Monitoring Results

The GPS Neo-6M module was used to obtain real-time vehicle location coordinates. Based on the testing results, the GPS module was able to accurately read latitude and longitude data when the vehicle was located in an open area. The vehicle location data were then transmitted to the

ThingsBoard Cloud platform, enabling users to monitor the vehicle position directly using smartphones or computers.

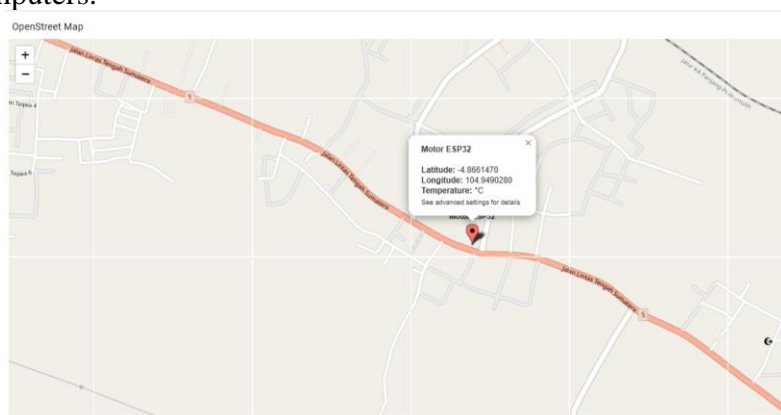


Figure 6. Vehicle Location Monitoring Using GPS

Source: Prepared by the Author, 2026

ThingsBoard Cloud Monitoring Results

The ThingsBoard Cloud platform was used for real-time vehicle telemetry monitoring through the MQTT protocol. The system successfully transmitted several important data, including:

- Vehicle latitude
- Vehicle longitude
- Vehicle status
- Vehicle security status

The monitoring dashboard successfully displayed telemetry data in real time, making it easier for users to monitor vehicle conditions.

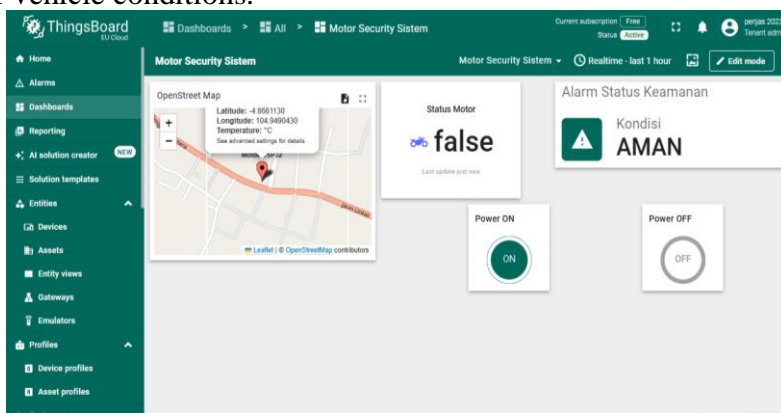


Figure 7. ThingsBoard Cloud Monitoring Dashboard

Source: Prepared by the Author, 2026

Telegram Notification Testing Results

Telegram Bot was used as the vehicle security notification platform. Based on the testing results, the system successfully sent automatic notifications during several conditions, including:

- Motor ON
- Motor OFF
- Unauthorized RFID detected
- Vehicle vibration detected
- Starter motor activated
- Vehicle location information

The notifications were successfully received by users in real time through smartphones using the Telegram application (Rizki et al., 2025; Gustia et al., 2025).



Figure 8. Vibration Sensor Testing
 Source: Prepared by the Author, 2026

Vibration Sensor Testing Results

The vibration sensor was used to detect vehicle security disturbances such as vibrations caused by attempted theft. Based on the testing results, the sensor successfully detected vehicle vibrations and automatically activated the buzzer alarm.

When the sensor detected vibrations, the system also sent warning notifications through Telegram, enabling users to immediately identify suspicious activities occurring on the vehicle.

System Testing Results

System testing was conducted on all main functions of the IoT-based vehicle security system. The testing results showed that all system features operated properly according to the system design.

Table 3. System Testing Results

No	Testing Parameter	Result
1	WiFi Connection	Successful
2	Valid RFID	Successful
3	Invalid RFID	Successful
4	GPS Tracker	Successful
5	Vibration Sensor	Successful
6	CDI Relay	Successful
7	Starter Relay	Successful
8	Telegram Notification	Successful
9	ThingsBoard Monitoring	Successful

Source: Prepared by the Author, 2026

Based on the testing results presented in Table 3, all features of the vehicle security system successfully operated according to the designed specifications.

System Success Percentage Analysis

The system success percentage was calculated based on the number of successful tests compared to the total number of system tests conducted. From the nine tests performed, all tests were successfully executed, resulting in the following calculation:

$$Success\ Percentage = \frac{9}{9} \times 100\% = 100\%$$

These results indicate that the developed Internet of Things-based vehicle security system performed effectively and met the objectives of the research.

Discussion

Based on the implementation and testing results, the integration of ESP32 with RFID RC522, GPS Neo-6M, vibration sensors, relays, and Telegram Bot significantly improved vehicle security

compared to conventional security systems. The system was capable of providing real-time vehicle monitoring and automatic notifications when suspicious activities occurred (Rahayu & Sari, 2025). The implementation of the ThingsBoard Cloud platform also facilitated users in monitoring vehicle conditions through an internet-based dashboard (Kiswantono & Saifullah, 2024).

The main advantages of this system include real-time monitoring, RFID authentication, vehicle location tracking, and automatic notification delivery to users. In addition, the system was capable of remotely controlling the vehicle starter motor through internet connectivity.

However, the system still has several limitations, including dependency on internet connectivity and GPS signal availability. In areas with unstable internet connections, delays may occur during data transmission and notification delivery. Furthermore, GPS readings are influenced by environmental conditions and satellite signal strength.

CONCLUSION

Based on the research results, the Internet of Things (IoT)-based motorcycle security system using ESP32 was successfully designed, implemented, and tested. The developed system integrated several important components, including RFID RC522, GPS Neo-6M, vibration sensors, CDI relays, starter relays, buzzers, ThingsBoard Cloud, and Telegram Bot into a unified vehicle security system connected through internet networks. The integration of these components enabled the system to perform monitoring and security control functions in real time.

The testing results demonstrated that the system was capable of performing user authentication using RFID technology, controlling the ignition and starter motor remotely, detecting vehicle vibrations caused by suspicious activities, transmitting real-time vehicle location data through a GPS tracker, and delivering automatic security notifications through Telegram. In addition, the system successfully transmitted telemetry data to the ThingsBoard Cloud platform using the MQTT communication protocol, allowing users to monitor vehicle conditions through an internet-based dashboard.

Based on the testing of all system features, the developed system achieved a success rate of 100%, indicating that all components and functions operated according to the research objectives and system design. The implementation of IoT technology in vehicle security systems provides a more modern, effective, and efficient solution compared to conventional security systems that only rely on mechanical locks and simple alarms.

However, the developed system still has several limitations, particularly its dependency on stable internet connectivity and GPS signal quality. In areas with poor network coverage, delays in data transmission and notifications may occur. Therefore, future development can include backup power systems, ESP32-CAM integration, and mobile application development to improve system reliability, functionality, and user convenience.

REFERENCES

- Azhar, M. F., & Nurpulaela, L. (2024). Implementasi penggunaan ESP32 sebagai IoT pada project smart charger di PT. Pasifik Satelit Nusantara Bekasi. *JATI (Jurnal Mahasiswa Teknik Informatika)*, 8(4), 7248–7253. <https://doi.org/10.36040/jati.v8i4.10201>
- Andreas, A. N. M., & Arijanto, R. (2024). Rancang bangun smart home IoT dengan integrasi kunci RFID dan otomasi elektronik. *bit-Tech*, 7(2), 235–243. <https://doi.org/10.32877/bt.v7i2.1729>
- Fauzan, A., Reswen, R. A., Muchtar, I. Z., & Niska, D. Y. (2026). Implementasi sistem kunci pintu otomatis berbasis RFID dan Arduino Uno dengan tampilan status akses. *Journal of Computer Engineering, System and Science*, 11(1), 76–85. <https://doi.org/10.24114/cess.v11i1.70455>
- Gautama, N., Yunita, Y., & Hidayat, A. (2025). Internet of Things (IoT): Masa depan kehidupan serba terkoneksi. *Primary Journal of Multidisciplinary Research*, 1(5), 173–177. <https://doi.org/10.70716/pjmr.v1i4.294>

- Gitakarma, M. S., Tjahyanti, L. P. A. S., & Korespondensi, P. (2024). Perbandingan kinerja sistem monitoring dan kontrol IoT berbasis fuzzy logic dengan kontrol manual dalam model skala kecil. *Jurnal Komputer dan Teknologi Sains (KOMTEKS)*, 3(1), 23–28. <https://doi.org/10.37637/komteks.v2i1.1563>
- Gustia, R., Febriani, W., Hasanah, M., & Fradana, A. (2025). Perancangan smart home berbasis IoT menggunakan ESP32, Telegram dan spreadsheet. *Jurnal Pustaka AI (Pusat Akses Kajian Teknologi Artificial Intelligence)*, 5(3), 695–700. <https://doi.org/10.55382/jurnalpustakaai.v5i3.1482>
- Kiswantono, A., & Saifullah, M. I. (2024). Kendali beban pintar: Mengoptimalkan efisiensi energi dengan IoT. *INTER TECH*, 2(1), 10–17. <https://doi.org/10.54732/i.v2i1.1057>
- Munir, M., & Wibisono, I. S. (2025). Pemantauan daya listrik real-time menggunakan IoT untuk efisiensi energi rumah tangga. *Jurnal Algoritma*, 22(2). <https://doi.org/10.33364/algoritma/v.22-2.2391>
- Muzakir, U., Ginting, R., & Munadi, R. (2023). Sistem identifikasi menggunakan RFID dan sensor infrared berbasis IoT terhadap pengembangan kampus pintar. *Jurnal Pendidikan Teknologi Informasi*, 7(2).
- Pratama, S. P., Energi, K. K., Cerdas, B., & Kontrol, S. (2023). Optimisasi efisiensi energi dalam bangunan cerdas melalui sistem kontrol berbasis IoT. *Journal of Technology and Engineering*, 1(1), 1–5. <https://doi.org/10.59613/journaloftechnologyandengineering.v1i1.16>
- Rahayu, P., & Sari, U. (2025). Perancangan sistem smart home berbasis IoT menggunakan ESP32 dan aplikasi Blynk untuk otomatisasi perangkat rumah tangga. *JISKA: Jurnal Sistem Informasi dan Informatika*, 3(2). <https://doi.org/10.47233/jiska.v3i2.2137>
- Rizki, C. A., Khairuniza, N., & Habibah, M. (2025). Implementasi sistem pemantauan daya listrik real-time berbasis ESP32 untuk optimasi energi. *Journal of Electrical Engineering Research*, 1(2), 71–77. <https://doi.org/10.64803/joeer.v1i2.11>
- Saptadi, N. T. S., et al. (2025). *Integrasi Internet of Things IoT dan embedded system dalam era digital* (1st ed.). Sada Kurnia Pustaka.