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Design and Construction of an IoT-Based Motor Vehicle Security Control and Monitoring System with Google Assistant and GPS

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vehicle security,
Google Assistant,
GPS,
ESP32

ABSTRACT

The development of Internet of Things (IoT) technology is driving the development of smarter and more integrated motor vehicle security systems. This research designs an IoT-based vehicle control and monitoring system connected to GPS and Google Assistant. The system allows users to track location in real time, control the engine via voice commands, and receive notifications when the vehicle exits a designated zone. Test results show that the response time for Google Assistant and Telegram notifications averages 1–2 seconds, geofencing accuracy reaches ±1–4 meters, and GPS is capable of pinpointing the location based on actual conditions. Furthermore, the vibration sensor proved sensitive, outputting a value of 4095 when detecting vibrations. These findings demonstrate that the system performs reliably in tracking, controlling, and providing alerts, while improving user safety and comfort when accessing the vehicle.

Introduction

The development of the Internet of Things (IoT) is driving the emergence of smarter and more integrated vehicle monitoring and control systems. In Indonesia and several Southeast Asian countries, motorized vehicles remain the primary mode of transportation, making the application of IoT to vehicle security crucial for improving user comfort and safety (Samsugi & Wajiran, 2020; Edo Irawan & Muzakir, 2022).

Previous research has generally focused on location tracking using GPS (Segara & Subari, 2017). However, most of these systems lack practical remote control and integration with voice control platforms like Google Assistant or fast notifications via Telegram. These limitations prevent existing systems from fully supporting responsive and interactive vehicle security.

This research aims to develop an IoT-based vehicle security system that integrates GPS, Google Assistant, and Telegram. The system enables real-time location tracking, engine control via voice commands, and automatic notifications when the vehicle exits a geofenced area. Therefore, this research is expected to address the shortcomings of previous studies by providing a more efficient, interactive, and accessible vehicle security solution.

Research methods

This research uses a quantitative and experimental approach, as it is suitable for both system development (experiments) and performance evaluation in real-world conditions. The research design used is a systems engineering experiment, focusing on the design, implementation, and testing of an IoT-based vehicle security system.

The system was developed through the design, construction, and integration stages of hardware and software. The components used include an ESP32 microcontroller, a GPS module, a vibration sensor, a relay, and integration with Google Assistant and Telegram as control and notification platforms (Karthickeyan S et al., 2020). The microcontroller is programmed to process location data from the GPS and signals from the vibration sensor, then send the results to a connected server and application.

Programmed microcontroller processes data collected from GPS and vibration sensors to determine the location and condition of the motor vehicle at the beginning of the research procedure. To assess the efficacy and accuracy of the system's response under various conditions, the system underwent several tests. Response accuracy, notification, and user feedback were evaluated by analyzing the data collected from each test (Himawan et al., 2023).

The system evaluation uses three main metrics:

GPS Accuracy and Geofencing

Accuracy is calculated by comparing the GPS coordinates received by the system with the actual coordinates on Google Maps. The distance difference is calculated using the haversine formula, then the average deviation (in meters) is recorded.

Response Time

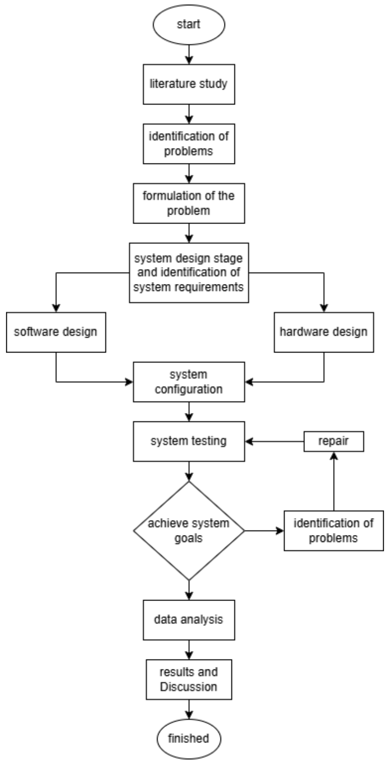
Response time is calculated from the difference between when a command or stimulus is given (for example, a voice command to Google Assistant or a vibration to a sensor) and when the system responds (the engine is turned on/off or a notification is received on Telegram). The value is measured in seconds over several trials, then the average is calculated.

System Reliability

Reliability is calculated based on the percentage of successful system executions out of the total number of trials performed. The formula used is:

$$\text{Reliability (\%)} = \text{Number of Successes}/\text{Number of Trials} \times 100\%$$
$$= 10/10 \times 100\% = 100\%$$

The following is the Research Methodology Diagram used in this study:



Picture 1. 1 Research methode

To integrate an Internet of Things (IoT)-based system for vehicle control and monitoring, the title and background of this research were first developed by analyzing the widespread problem of motor vehicle theft. To facilitate remote control and system automation, this concept emerged from the need to effectively enhance motor vehicle security systems using popular platforms such as Telegram, Blynk, and Google Assistant.

2.1 Literature Study

This step includes a review of relevant literature, including books, scientific journals, and previous studies on the integration of Blynk, Google Assistant, and Telegram; car component control; and the use of motor vehicle security systems within an IoT framework. The goal is to strengthen the theoretical foundation and determine the best approach for system development.

2.2 Identification of Problems

At this point, a more focused research orientation was ensured by defining and clarifying the parameters and scope of the subject matter to be studied. The main problem identified was that the current motor vehicle security and control system was insufficiently flexible, necessitating an automated and integrated approach.

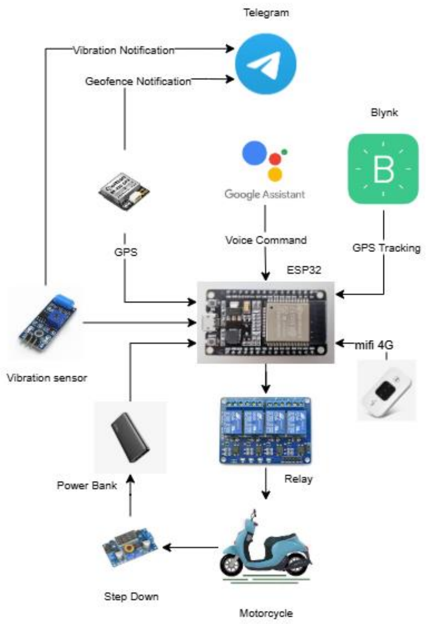
2.3 Formulation of the Problem

"How can a motor vehicle security, monitoring, and control system be built to function through Telegram and Google Assistant?" is one example of a specific research topic developed to address the identified problem(Nur Faqih et al., 2022).

2.4 System Design Stage And Identification Of System Requirements

A block diagram is created during the system design phase to show the main architecture, which includes a microcontroller, sensor modules, power supply, and Telegram interface. The system specifications and technical requirements necessary to support the design are defined. These specifications include software and hardware elements, such as vibration detection and GPS location modules, as well as a microprocessor capable of executing voice instructions for vehicle automation and control.

A block diagram illustrating the entire system, including the interconnection between the main components, is presented in the following figure.



Picture 1. 2 System Block Diagram

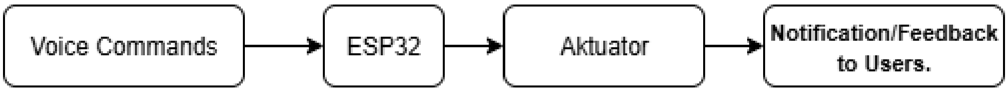
a. software design

A crucial stage in creating an Internet of Things-based monitoring and control system is the software design phase. The Arduino IDE, chosen for its flexibility in software development and its ability to effectively handle dependencies and development environments, was used to program the microcontroller early in the process.

The software development process involved writing scripts to manage device control and data exchange over the network, as well as integrating with Blynk, Google Assistant, and Telegram Bot using relevant libraries. This integration allows users to monitor and manage the system directly from their mobile phones (Edo Irawan & Muzakir, 2022).

The microcontroller processes sensor data so the system can react adaptively to changing environmental conditions. Users can more easily control and monitor the system remotely with this configuration because the software can connect and be managed in real time using the Blynk platform and Google Assistant.

Flowchart communication :



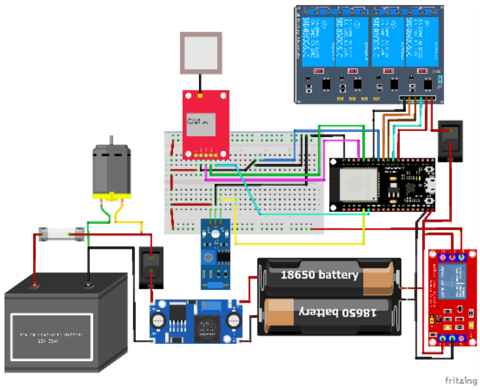
Before moving on to hardware integration, extensive testing was performed to ensure all components were operating as intended after the completion of the programming phase.

b. Hardware design

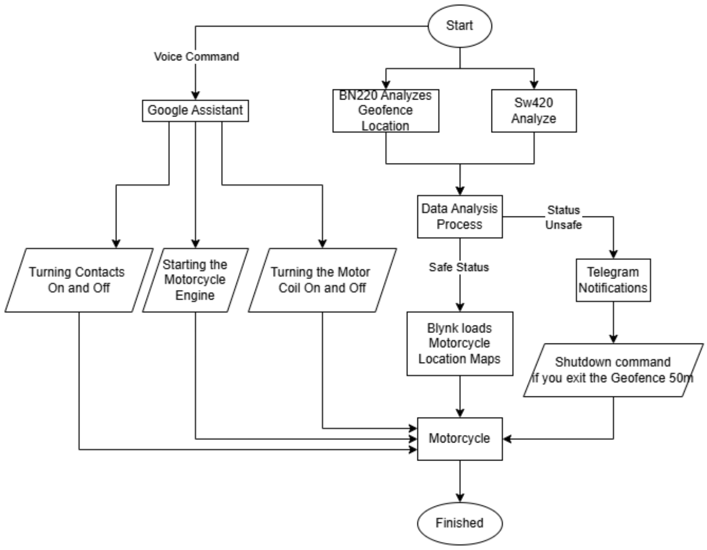
The primary objective of the hardware design phase is to create a GPS- and Google Assistant-based motorized vehicle monitoring and control system. To monitor vehicle condition, this system uses a microcontroller connected to several sensors, such as vibration sensors and GPS sensors. Vehicle location and geofence radius are determined using GPS sensors (Sofyan et al., 2022).

Additionally, the system includes a communication protocol that connects the hardware to the Blynk and Telegram apps, allowing users to monitor vehicle conditions and receive real-time alerts. After processing data from the GPS and vibration sensors, the microcontroller automatically adjusts the system's behavior based on the vehicle's position and condition.

Users can choose between automatic and manual operation thanks to the system's manual control feature, in addition to automatic control. Users can monitor vehicle conditions and locations in real time, providing a high level of security and system management flexibility.



Picture 1. 3 component circuit



Picture 1. 4 module mechanisme

2.6 System Configuration

Once the hardware and software design is complete, the next step is to configure the device. This setup involves configuring and adjusting the components to ensure proper functionality.

2.7 System Testing

The purpose of this system testing procedure is to ensure the device operates as intended and meets all design requirements. Data collected so far includes Google Assistant responses, vibration sensor responses, and GPS tracking and Geofence notification accuracy (Luthfiansyah et al., 2019). To determine how well the system responds, testing is conducted in various scenarios. Test data will be examined to determine whether the system can adapt to changing weather and environmental conditions. The test results will determine the system's readiness for use or the need for additional improvements (Marcos, 2021).

2.8 Data Analysis

This study aims to evaluate the performance of an IoT-based motor vehicle monitoring and operation system using Blynk, Telegram, and Google Assistant. Data collected includes the accuracy of GPS Geofence tracking and notifications, Vibration Sensor responses, and Google Assistant responses under various conditions (Arizal et al., 2023). The system's ability to adapt to environments and situations in crowded public areas, its response to voice requests using Google Assistant, and its GPS accuracy are all compared in this study. The analysis results will show how well the system performs and its reliability in modifying the response and accuracy of the motor vehicle security system through remote control and monitoring (Segara & Subari, 2017).

2.9 Results and Discussion

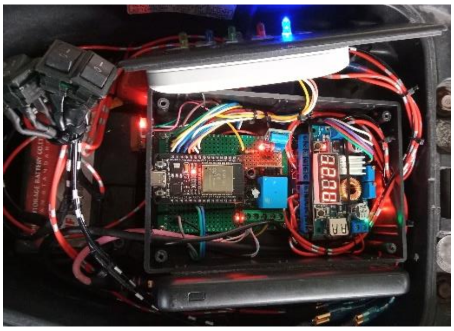
In the final stage of this study, after each part of the IoT-based motor vehicle security monitoring and control system was operating as intended, the test results showed that the system could provide notifications, control motor vehicles, and monitor motor vehicle positions accurately and quickly. The data showed that the system successfully produced fast and accurate responses as expected within reasonable tolerances, indicating significant room for improvement.

2.10 Finished

All stages of development and testing of the accuracy and notification, as well as monitoring and management of the Internet of Things (IoT)-based motor vehicle security system utilizing GPS and Google Assistant, have been successfully completed in this final stage. From problem identification and system design to field testing and data analysis, all project objectives have been achieved. Based on the test results, this system can effectively automate motor vehicles using Google Assistant and provide notifications to consumers in the event of theft. The ease of monitoring and control of this system is a sign of its successful implementation(Dwiyatno et al., 2020).

RESULTS AND DISCUSSION

3.1 GPS Geofence System Testing



Picture 1. 5 System Module

Performance testing of a GPS- and Google Assistant-based motor vehicle security monitoring and control system was conducted for this project. Six key areas were addressed during the testing phase:

1. Google Assistant features
2. Geofence accuracy
3. Map tracking accuracy
4. Vibration sensor response
5. Telegram notification performance
6. Power bank performance

This testing was designed to determine whether the system is a reliable security and control tool for cars and whether it achieves its objectives.

1.3 Google Assistant Performance Testing

Using voice commands accessible anytime and from any location with an internet connection, this test attempts to assess how well Google Assistant performs in controlling relays, specifically in sending commands to motor vehicle systems, such as turning the ignition on and off, starting the engine, and controlling the motor coil. Responses were recorded and documented during ten tests conducted on the system. The time it takes for the relay to activate after receiving a voice command is used to measure Google Assistant's performance.

Measurements taken during the Google Assistant performance testing are shown in Table 3.1, which also presents the test results.

Table 3. 1 Google Assistant Testing

No.	Trial Time (Hours:Minutes)	Execution Status (Success/Failure)	Response Time (seconds)	Timer Documentation
1	10.33	Succeed	02.2 s	00:02.2
2	10.34	Succeed	02.3 s	00:02.3
3	10.35	Succeed	02.8 s	00:02.8
4	10.42	Succeed	02.3 s	00:02.3
5	10.45	Succeed	02.6 s	00:02.6

No.	Trial Time (Hours:Minutes)	Execution Status (Success/Failure)	Response Time (seconds)	Timer Documentation
6	10.47	Succeed	02.5 s	00:02.5
7	07.44	Succeed	02.8 s	00:02.8
8	07.45	Succeed	02.7 s	00:02.7
9	07.46	Succeed	02.1 s	00:02.1
10	07.47	Succeed	01.9	00:01.9

A response time of 1–2 seconds indicates that voice commands can be translated and transmitted to the system quickly. This indicates that the integration between Google Assistant, the server, and the microcontroller runs smoothly without significant delay. With a response time of under 3 seconds, the system is still considered responsive for household IoT applications and real-time device control.

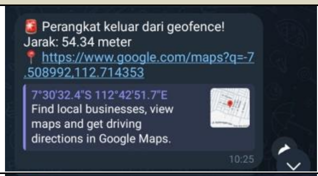
2.3 Geofencing Accuracy Testing

By programming a relay to automatically turn off a motor vehicle's engine when it leaves a geofence, this test aimed to assess the precision and functionality of the Geofence system within a predetermined 50-meter radius. Restarting the engine required the motor vehicle to re-enter the geofence area. The system underwent ten tests, with real-time recording and documentation of its behavior during each test. The accuracy of the geofence in triggering the relay in response to the motor vehicle's location data was used to evaluate its performance (Prima Dwiyana Nugraha et al., 2020).

The results of the Geofence accuracy test are summarized in Table 3.2 below.

Table 3. 2 Geofencing Accuracy Testing

No.	Trial Time (Hours:Minutes)	Geofence Radius (m)	50m Accuracy Status (As Per/Difference)	Documentation
1	10.16	50.05	In accordance	

No.	Trial Time (Hours:Minutes)	Geofence Radius (m)	50m Accuracy Status (As Per/Difference)	Documentation
2	10.25	54.34	difference 4m	
3	10.26	53.56	difference 4m	
4	14.41	51.58	difference 1m	
5	15.42	51.06	difference 1m	
6	15.43	50.82	difference 1m	
7	14.56	51.42	difference 1m	
8	15.45	53.72	difference 3m	
9	20.12	52.06	difference 2m	
10	20.23	54.49	difference 4m	

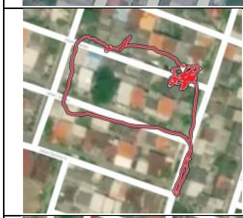
With a geofence radius of 50 m, a positional error of ±1–4 m is still relatively small and insignificant. This indicates that the GPS module is capable of detecting object positions with sufficient accuracy to ensure entry or exit from the geofence area. Variations of 1–4 m can be caused by satellite signal conditions, environmental obstacles such as buildings or trees, and atmospheric factors, but do not reduce the system's reliability in this geofencing application.

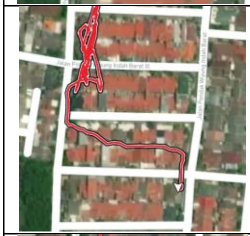
3.3 GPS Tracking Accuracy Testing

To enable users to track the movement and direction of their motor vehicles, crucial in the event of theft or unauthorized use, this test was conducted to assess the accuracy and performance of the GPS tracking system in displaying the location of motor vehicles on the Blynk app map in real time. Ten tests were conducted on the system, and during each test, each attempt was recorded and documented immediately. The response time of movement updates and the accuracy of the position displayed on the map were used to measure GPS accuracy.

The results of the GPS Tracking Accuracy Test are presented in Table 3.3 below.

Table 3. 3 GPS Tracking Accuracy Testing

No.	Trial Time (Hours:Minutes)	Accuracy Status (Compliant/Inconsistent)	Documentation
1	10.16	in accordance	
2	10.25	in accordance	
3	14.41	in accordance	
4	20.12	in accordance	

No.	Trial Time (Hours:Minutes)	Accuracy Status (Compliant/Inconsistent)	Documentation
5	20.23	in accordance	
6	13.02	in accordance	
7	13.03	in accordance	
8	13.05	in accordance	
9	13.05	in accordance	
10	13.06	in accordance	

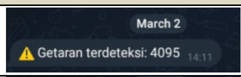
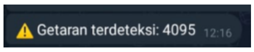
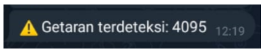
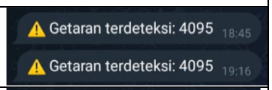
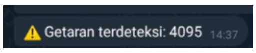
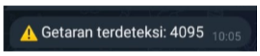
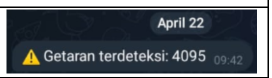
Test results show that the position recorded by the GPS module has an average deviation of 3–5 meters from the actual position. This level of accuracy is sufficient for vehicle or moving object tracking applications within a 50 m geofence radius, as the position error is much smaller than the specified area radius. Factors affecting accuracy include satellite signal quality, weather conditions, and physical obstacles around the location. With this accuracy, the system can be relied upon to monitor object movement in real time.

4.3 Vibration Sensor Response Testing

The purpose of this test was to measure how quickly the vibration sensor responds to notifications sent via Telegram. A key part of the system is the vibration sensor, which is responsible for detecting any physical disturbance that typically produces vibrations, such as attempted theft of a motor vehicle. When the sensor detects these vibrations, it immediately notifies the vehicle owner. Ten system tests were conducted, each recorded on video and in real time. Based on how quickly the system detected the vibration and sent the Telegram notification, the vibration sensor's performance was assessed.

The results of the Vibration Sensor Response Test are presented in Table 3.4 below.

Table 3. 4 Vibration Sensor Response Testing

No.	**Trial Time (Hours:Minutes)**	**Response Status with a Max Value of 4092 (Compliant/Inappropriate)**	**Documentation**
1	14.11	4095 (in accordance)	
2	14.51	4095 (in accordance)	
3	12.16	4095 (in accordance)	
4	12.19	4095 (in accordance)	
5	18.45 & 19.16	4095 (in accordance)	
6	20.09	4095 (in accordance)	
7	14.37	4095 (in accordance)	
8	10.05	4095 (in accordance)	
9	09.42	4095 (in accordance)	
10	14.18	4095 (in accordance)	

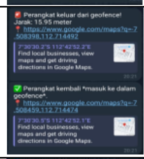
A value of 4095 indicates that the vibration sensor detected maximum vibration quickly, consistent with the characteristics of the module used. This indicates the sensor has a highly sensitive response, capable of detecting small mechanical changes within a short time. This capability allows the sensor to reliably trigger alerts or actuator controls in real time when vibrations occur in the device or its surrounding environment.

5.3 Telegram Notification Response Testing

The purpose of this test was to assess how quickly the Telegram app responds to notifications sent and received via pre-programmed sensor data. Users' ability to quickly receive alerts from Telegram is crucial, especially in situations involving real-time security and surveillance. Immediate response times were collected and documented for each of the ten tests conducted on the system. The time between the sensor's occurrence and the user's receipt of the notification was used to calculate the response speed.

The results of the Telegram Notification Response Test are presented in Table 3.5 below.

Table 3. 5 Telegram Notification Response Testing

No.	Trial Time (Hours:Minutes)	Notification Response Time (seconds)±	Notification Status (Sent/Failed)	Documentation
1	14.45	±2.0 s	Sent	
2	20.21	±2.0 s	Sent	
3	11.27	±2.0 s	Sent	
4	10.45	±2.0 s	Sent	
5	11.12	±2.0 s	Sent	
6	14.18	±2.0 s	Sent	

No.	Trial Time (Hours:Minutes)	Notification Response Time (seconds)±	Notification Status (Sent/Failed)	Documentation
7	14.22	±2.0 s	Sent	
8	14.28	±2.0 s	Sent	
9	14.36	±2.0 s	Sent	
10	14.37	±2.0 s	Sent	

A response time of ±1–2 seconds indicates the system's ability to deliver notifications quickly and reliably via Telegram. This small time lag indicates a smooth integration between the microcontroller, server, and Telegram API, allowing users to receive information in near real-time. This speed is sufficient for IoT-based monitoring and security systems, as it ensures every critical event is detected and communicated promptly.

6.3 Power bank testing

The purpose of this data collection is to assess the charging efficiency and durability of the power bank during system operation. The goal is to determine whether the power bank and the vehicle battery are properly charged while the vehicle is running. This test also shows whether a buck converter (step-down voltage regulator) is an effective way to charge the device. In this configuration, the buck converter reduces the initial voltage of the 12V vehicle battery to 9V with a current of 1.5A. The input power must be at least 10 watts for the power bank to charge efficiently and quickly.

The power is calculated using the formula:P = V x I

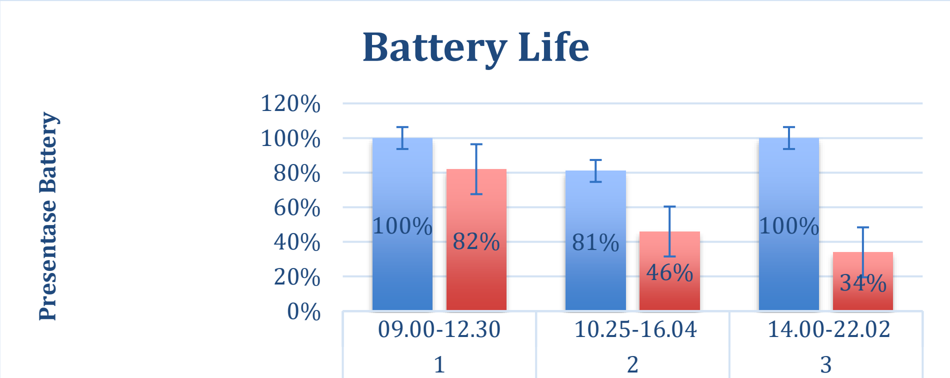
$$P = V \times I$$

Where:
P = Power (in watts)
V = Voltage (in volts)
I = Current (in amperes)

Calculation:
$P = 9V \times 1.5A = 13.5W$

Based on these findings, the power bank received 13.5 watts of power during charging, thus qualifying for fast charging. The power bank will not be able to charge properly and the charging process will take longer if the power received is less than 10 watts. The test was conducted five times, and each time the results were recorded. Graphs 3.6 and 3.7 below show statistics and documentation of the power bank's usage and charging performance.

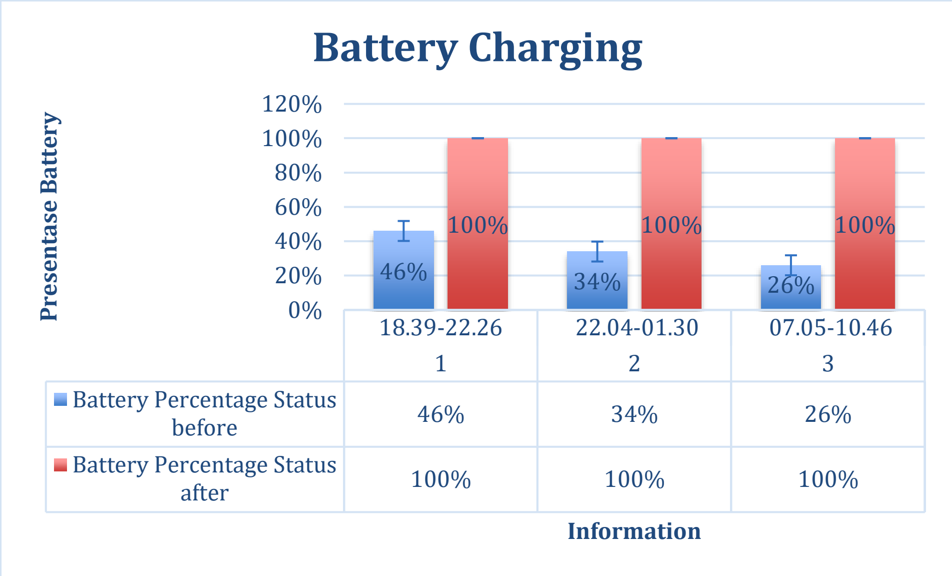
Grafik 3. 1 Battery Life



	09.00-12.30 1	10.25-16.04 2	14.00-22.02 3
Battery Percentage Status before	100%	81%	100%
Battery Percentage Status after	82%	46%	34%

A battery life of over 8 hours indicates sufficient battery capacity to support all-day system operation without recharging. This demonstrates the efficient power consumption of the modules, including the microcontroller, sensors, and GSM communication. With stable power, the system is reliable for continuous device monitoring or control applications, even when used in locations with limited power supply.

Grafik 3. 2 Battery Charging



A 3-hour charging time indicates that the power supply module and battery charging system are operating efficiently. This timeframe is fast enough to ensure the system is ready for use without a long wait, thus supporting the device's continuous operation. Furthermore, the charging process is stable without significant voltage spikes, indicating the battery's safety and reliability during regular use.

Conclusion

An IoT based motor vehicle security system integrating Google Assistant, GPS, geofencing, vibration sensors, and Telegram was successfully implemented based on design and testing results. The Blynk application enables monitoring of the GPS system, demonstrating excellent accuracy and location data consistent with Google Maps displays. Effective wireless control is enabled by Google Assistant, which reacts to voice commands in less than two seconds at a perfect distance of two meters. Vehicle movement is precisely identified by the geofencing feature, and Telegram messages are delivered within 1–5 seconds. With a delivered status and response time of ±1–2 seconds, the Telegram notification system demonstrates reliable performance overall, indicating that this system can be a cutting-edge alternative to traditional security.

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