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Design of Additional Safety Locks for Motor Vehicles Using RFID

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Abstract

Indonesia, facing the dual challenges of rapid economic development and rising vehicle theft rates due to economic inequalities, has prompted a need for innovative security solutions in the automotive sector. This research aims to address this growing concern by introducing a sophisticated motor vehicle security system utilizing Radio Frequency Identification (RFID) technology. The proposed system employs RFID keys, which use ID tag cards as unique identifiers to activate motor vehicles. The methodology centers around the integration of RFID technology with a microcontroller, creating a security system that is both advanced and user-friendly. This system includes an alarm feature that is triggered when an ID tag card not registered with the vehicle's RFID is used, providing an additional layer of security against unauthorized access. The results of implementing this system have been promising. Testing revealed that the RFID locks, when combined with the microcontroller, effectively recognized authorized ID tag cards and successfully denied access when unauthorized cards were used. The alarm system also functioned as intended, activating when discrepancies in ID tag data were detected. This integration of RFID with a microcontroller not only enhanced the security of motor vehicles but also contributed to a significant reduction in vehicle thefts in the community, showcasing the potential of RFID technology as a viable solution to the prevalent issue of vehicle security in Indonesia.

Keywords: RFID, Microcontroller, Motor Vehicles, Alarm

1. INTRODUCTION

Indonesia, recognized as a developing nation, is currently witnessing significant strides in its economic landscape. There has been a notable surge in the development across various sectors, evidenced by the substantial influx of motorized vehicles in the market. The number of these vehicles in Indonesia has reached impressive figures, soaring into the millions, indicative of the country's burgeoning automotive industry [1], [2].

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Despite this growth, there is a concerning disparity between the number of vehicles available and the job opportunities that can mitigate poverty and unemployment. This imbalance has inadvertently contributed to an uptick in the crime rate. The increase in motor vehicle theft is particularly alarming, with frequent reports in both print and electronic media highlighting this issue. Such trends underscore the need for more effective crime prevention strategies [3].

In the realm of technology, there have been significant advancements in motor vehicle security systems. From sophisticated alarm systems to basic additional key locks, a variety of options are available to vehicle owners [4], [5]. However, these systems are not without their flaws. For instance, conventional alarm systems can be easily neutralized by cutting the cables that trigger them, rendering the vehicle vulnerable to theft. On the other hand, additional keys, while somewhat effective, can be duplicated or tampered with by skilled thieves, leaving vehicles susceptible to unauthorized access [6].

In response to these challenges, the adoption of Radio Frequency Identification (RFID) as a security measure for motor vehicles has emerged as a promising solution. RFID keys, which utilize an ID tag card for identification and vehicle ignition, offer a sophisticated and secure alternative [4], [6]. The primary advantage of RFID keys lies in their ability to not only secure the vehicle but also simplify the ignition process. These keys are integrated with the vehicle's electrical system, enabling a seamless engine start. Moreover, the incorporation of an alarm system in the RFID key adds another layer of security. If an unauthorized ID tag card is used, the alarm is automatically triggered, providing an immediate alert to potential theft [7]. The combination of RFID technology with microcontrollers creates a robust security tool that effectively minimizes the risk of motor vehicle theft, thereby enhancing community safety and peace of mind [8], [9], [10].

The primary aim of this research is to explore and evaluate the efficacy of Radio Frequency Identification (RFID) technology in enhancing the security of motor vehicles in Indonesia. Amidst the rising concerns of vehicle theft and the inadequacies of traditional security systems, this study seeks to ascertain whether the implementation of RFID-based locks can significantly reduce the incidence of vehicle thefts. By examining the technical aspects of RFID systems, their integration with vehicle electronics, and the real-world impact on theft prevention, the research aims to provide a comprehensive analysis of RFID as a potential solution to a pressing societal issue. The ultimate goal is to contribute to the development of more secure, reliable, and technologically advanced methods of vehicle protection, thereby supporting Indonesia's ongoing efforts to combat crime and improve public safety.

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2. METHODS

2.1. Types of research

The anticipated outcome of this research is the development of a prototype tool, designed as an auxiliary safety lock specifically for motorized vehicles [1]. This innovative product is expected to blend both hardware and software components seamlessly. The hardware aspect of the device will comprise various components, each meticulously chosen to ensure optimal performance and durability. These components are essential for the physical operation of the lock, providing the necessary security mechanism directly interfacing with the vehicle. Complementing the hardware, the software plays a crucial role in this ecosystem. It will be engineered to facilitate the effective functioning of the hardware components, ensuring that they operate harmoniously within the device's system. The software will also provide user-friendly interfaces and possibly include features such as real-time monitoring or remote-control capabilities. Together, the synergy between the hardware and software components of this prototype aims to establish a new standard in motor vehicle security, offering an advanced layer of protection against theft and unauthorized access.

2.2. Tools and materials

To create a sophisticated motor vehicle safety lock using RFID technology, a comprehensive set of tools and materials is essential. This section outlines the necessary equipment and resources required for the design and development of this innovative security system.

1) Hardware Components:
The assembly and functionality of the RFID-based motor vehicle safety lock system are reliant on a carefully curated selection of hardware tools, each serving a specific and crucial role.

a) AT89S52 Microcontroller: A crucial component for controlling the system's operations.
b) RFID Reader and RFID Tags: Key elements for the identification and authentication process.
c) Relay: An electrical switch that controls the locking mechanism.
d) Liquid Crystal Display (LCD): For visual feedback and system status display.
e) Computer: For programming and interfacing with the hardware.
f) Screwdriver: For assembling and disassembling components.
g) USB Downloader: To transfer software to the microcontroller.
h) Multimeter: For measuring electrical properties and troubleshooting.
i) Soldering Iron: To join electronic components.

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j) Connecting Cables: For establishing connections between different components.
k) Cutting Pliers: For cutting and manipulating wires.

2) Software Tools:
Bascom-8051: A programming environment for developing microcontroller code.
Windows Seven Operating System: The platform for running the necessary software.
a) Microsoft Visio: For designing circuit diagrams and system layouts.
b) Microsoft Office 2007: For documentation and reporting.
c) Microsoft PowerPoint: For presenting the project findings and designs.

2.3. System Design

The design includes several stages of tool design, namely making a block diagram, selecting components that suit the characteristics, according to needs and in accordance with the data book so that the component selection is in accordance with the specifications of the tool to be made. This design stage starts from creating a circuit block diagram, selecting components, arranging the component layout (layout creation), installing components and the finishing process. The design of this tool aims to get good final results as expected and can make it easier to find and repair if there is damage to the tool series. This design stage starts from creating a series of block diagrams [1], selecting components, arranging the component layout (layout creation), installing components and the finishing process. The design process as shown in Figure 1.

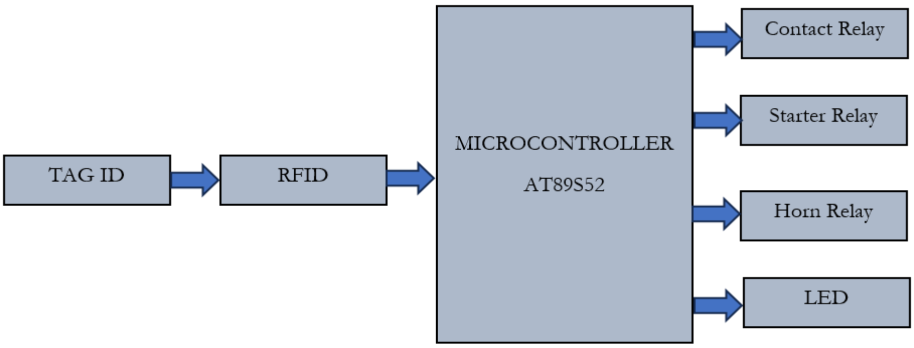

Figure 1. Block Diagram

The description of the block diagram in Figure 1:
1) Power
2) Functions as a voltage source. Where this tool uses a 12-volt Accu as the input source for the circuit.

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3) Tag ID Tag Card dan RFID
4) Functions as input data to the microcontroller. If the ID on the ID tag card has been detected, it will be forwarded to the microcontroller for further output, namely motor ignition, and alarm.
5) Alarm
6) It is a sound indicator that notifies you if your motorbike is in an unsafe condition or there are signs that it will be stolen.
7) Microcontroller
8) It is an IC that functions as a controller for the entire circuit [1].

2.4. Mechanical Part Design

Mechanical part planning consists of determining the type of material used for designing the toolbox and planning the installation on the motorbike. All these steps are carried out regularly, so that maximum results are obtained and can run as desired and in accordance with the block diagram.

2.4.1. Component Layout

Figure 2 is a diagram of the layout of the motor vehicle safety lock circuit components using RFID and the configuration of the microcontroller pins in the circuit.

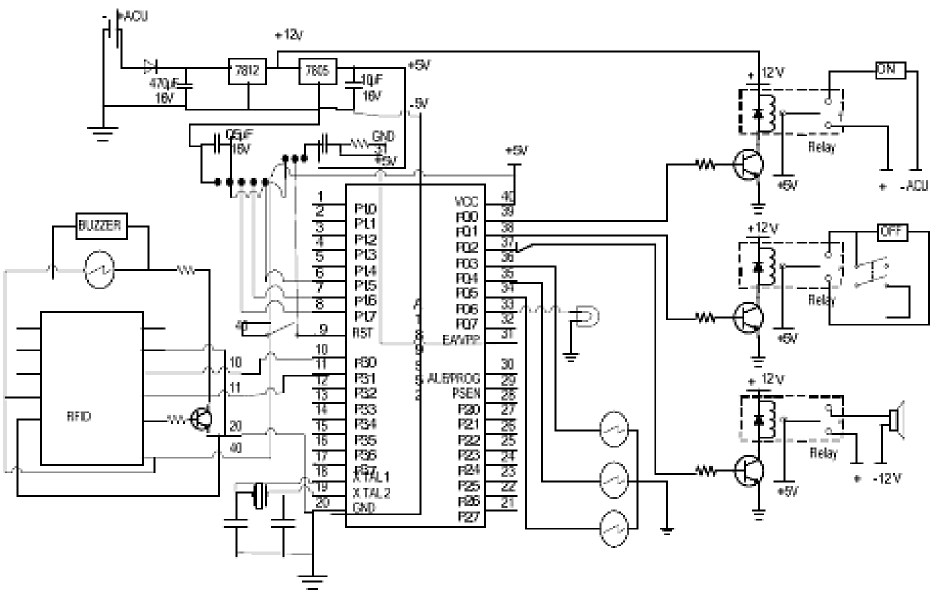

Figure 2. Mechanical Part Design

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2.4.2. Layout Design

PCB is a place where components are placed such as resistors, capacitors, transistors and other components. PCBs must be processed into paths that can connect components to form the desired circuit [2]. The layout design image can be seen in Figure 3.

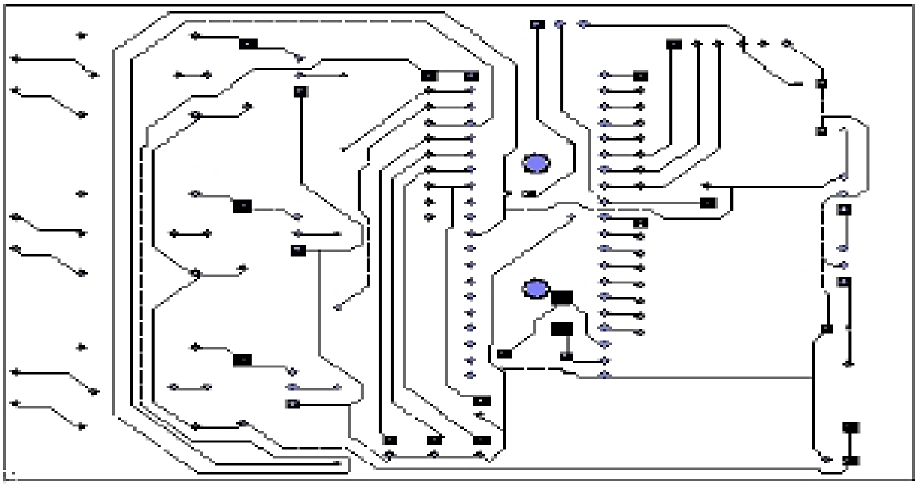

Figure 3. Layout Design

2.4.3. Making Paths on PCB (Printed Circuit Board)

The way to make a path on a PCB is by writing directly with a permanent marker, screen printing (Rugos or screen-printing paint) [2]. However, now many people have done it using the iron method, especially now that designing PCB paths is very easy to do with a computer. The following materials and equipment must be prepared:

1) Laser Jet Printer (Toner Ink).
2) Paper (used) Wall calendar that doesn't crease.
3) PCB Board.
4) Abrasive paper.
5) Electric Iron.
6) Ferri Cloride ($FeCl3$).
7) PCB Drill.
8) Cutter.
9) Stainless steel.
10) Permanent marke.
11) Computer + one of Software (TraxMaker, Protel, Eagle, DipTrace, ExpressPCB)

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2.5. Making Tool Designs

Mechanical design is carried out to determine the size and the right materials to use. The material for this tool is acrylic because this material is light, strong but easy to model. The dimensions of the tool are:

a. Length : 11 cm
b. Width : 13 cm
c. Height : 8.5 cm

3. RESULTS AND DISCUSSION

The resulting product is a motorbike security device resulting from one application of the use of a microcontroller, which was built with attention to quality, practicality, and safety aspects so that the device will provide benefits for the user according to their needs.

3.1 Implementation of tools on motorbikes

To implement a safety device box, a motorbike is used which is placed under the seat so that it is not exposed to rain while driving and is relatively safer because there is a safety lock. The supply can also be installed closer to the motorbike battery, so it is not a hassle to install long cables. The placement of the tools can be seen in Figure 4.

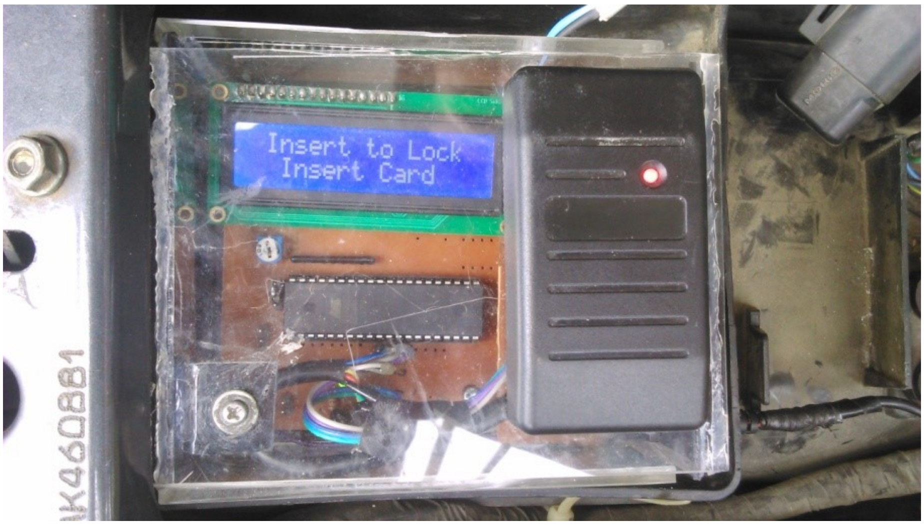

Figure 4. Installing Tools in Motorcycle Seats

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3.2 Tool Activation

When the tool is activated the display on the LCD will show Insert to Lock Insert Card, at this time the motorbike will not be able to be started either using the starter or using the kick starter. To start the motorbike, we have to bring the ID Tag closer until the display on the LCD changes to Insert to Unlock Motor Unlocked as in Figure 5.

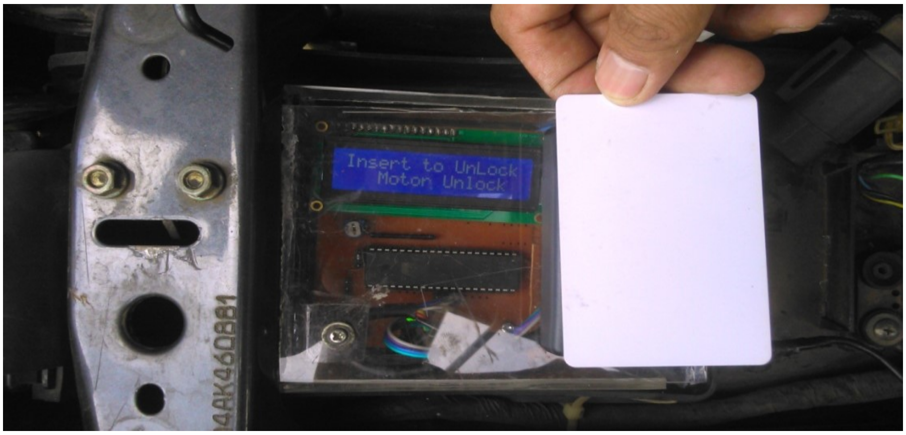

Figure 5. How to Start a Motorcycle Using an ID Tag

3.3 Circuit Measurement

After the tool design process is complete, the next step is to carry out work measurements on the tool that has been designed. Measurements are carried out in order to obtain data from the tool system, so that with this data we can find out the specifications of the tool that has been designed. The measurement results can be a source in circuit analysis. The measurement method at each test point is carried out in order to determine the characteristics of the output and obtain suitability between one block and another block. This measurement aims to determine the output of all circuit blocks, both the power supply circuit and the RFID and Buzzer circuit.

In the power supply circuit, several test points are carried out to carry out measurements. The test points for testing are the output voltage from the battery voltage source, the voltage at the microcontroller input, the voltage at the RFID, and the voltage at the buzzer. In the process of taking test points, how many times have you tried taking test points before? If the collection affects the system, then the test point cannot be taken as a test point because it could endanger the detection system. The equipment that will be used to take measurements is as follows: (1) power supply circuit, (2) digital Multimete, and (3) sufficient cables.

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3.3.1 Power Supply Circuit Measurements

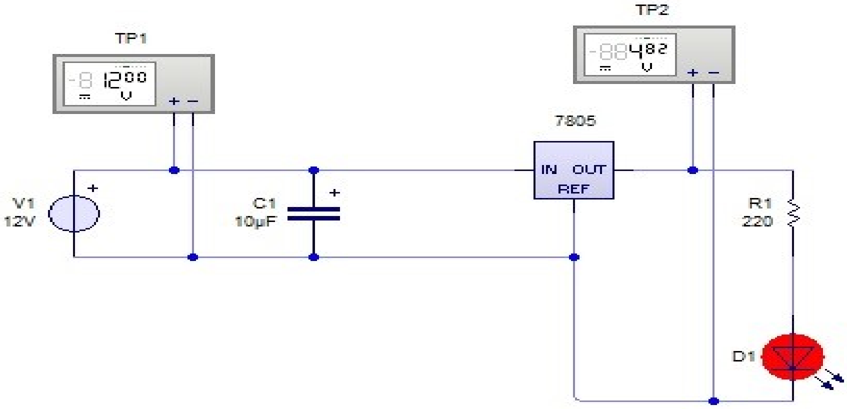

Figure 6. Power Supply Circuit Measurements

3.3.2 AT89S52 Microcontroller Measurements

The microcontroller circuit measurement (Figure 7) is an input data processing circuit in designing motor vehicle safety locks using RFID. The input data is obtained from the ID tag. The microcontroller circuit consists of several components that support the work of the microcontroller. Before testing the circuit, connect the microcontroller circuit to the power supply circuit.

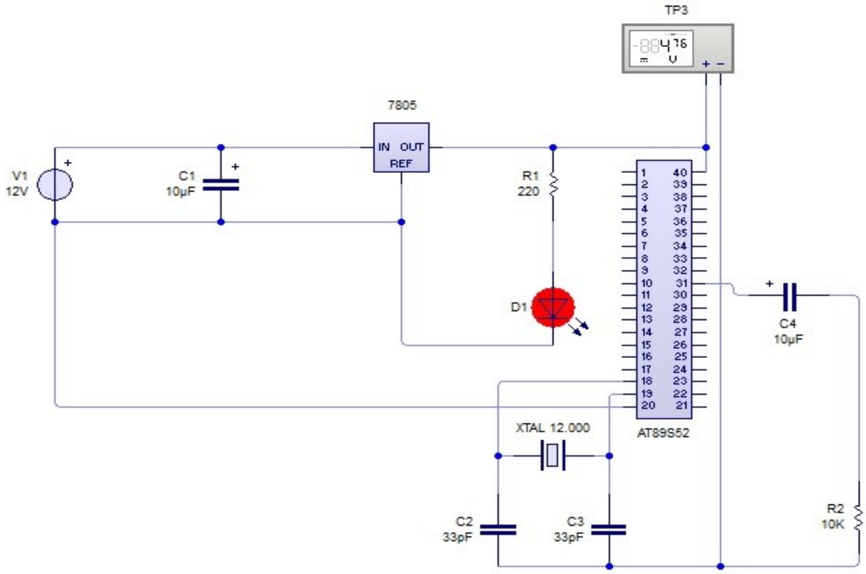

Figure 7. AT89S52 Microcontroller Measurements

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3.3.3 Circuit Measurements RFID (Radio Frequency Identifier)

RFID testing is carried out by applying a supply voltage of 12VDC to the circuit as shown in Figure 8. After that, the output voltage is measured when it detects whether there is an ID tag near the RFID or not and the difference in voltage will be seen when an ID tag is detected or not.

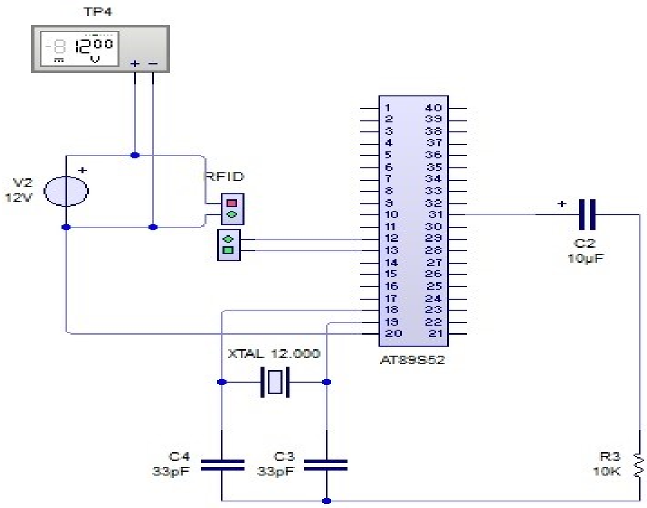

Figure 8. Circuit Measurements RFID

3.3.4 Buzzer Circuit Measurement

Buzzer testing (Figure 9) is carried out by first applying a supply voltage of 12VDC to the circuit. After that, measure the buzzer voltage when it is active (sounds) and you will see the difference in voltage when the buzzer is active or not.

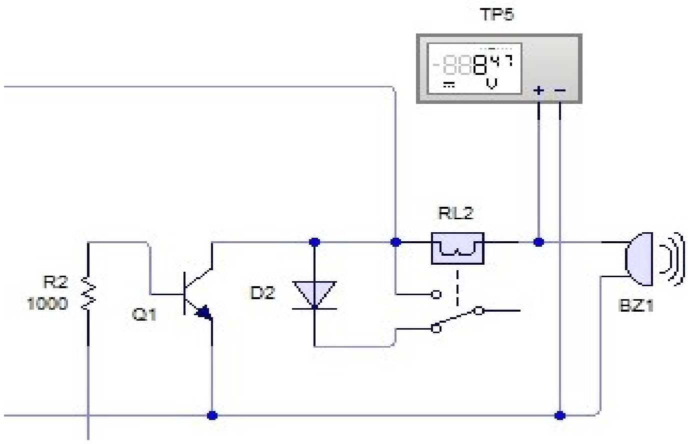

Figure 9. Buzzer Circuit Measurement

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3.4 Measurement Results

3.4.1 Power Supply Circuit Measurement Results

The circuit measurement results (Table 1) were obtained from the battery voltage output at Test Point 1 (TP 1) and the output from the IC 7805 at Test Point 2 (TP2).

Table 1. Power Supply Circuit Measurement Results at Test Points 1 and 2

TP 1 (Pengukuran Output Battery)	TP 2 (Pengukuran Output IC 7805)
12.00 VDC	5.00 VDC
11.80 VDC	4.82 VDC
11.49 VDC	4.79DC

3.4.2 Mikrokontroler AT89S52 Circuit Measurement Results

The circuit measurement results (Table 2) were obtained from the battery voltage output and the output from the IC 7805 regulator at Test Point 3 (TP 3).

Table 2. Microcontroller Circuit Measurement Results at Test Point 3

TP 3 (Microcontroller Input Measurement)
05.00 VDC
04.80 VDC
04.76 DC

3.4.3 RFID Circuit Measurement Results

This RFID circuit measurement is useful for knowing the characteristics and comparing the output voltage when an ID tag is detected or not. Measurements as shown in Table 3 were carried out by bringing the ID tag closer to the RFID Reader, then measuring the output voltage from the gas sensor circuit. Measurements were carried out at Test Point 4 (TP 4).

Table 3. RFID Circuit Measurement Results at TP 4

Saat Tag ID Tidak Terdeteksi	Saat Tag ID Terdeteksi
0.00 VDC	11.97 VDC
0.79 VDC	12.00 VDC
0.58 VDC	11.83 DC

3.4.4 Buzzer Circuit Measurement Results

Buzzer circuit testing (Table 4) is used to compare the output voltage to see when the buzzer is active or not. The test is carried out by spraying the ID Tag close to

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the RFID Reader, then measuring the output voltage from the Buzzer circuit. Measurements were carried out at Test Point 5 (TP 5).

Table 4. Buzzer Circuit Measurement Results at TP 5

Buzzer Inactive	Buzzer Active
0.00 VDC	8.21 VDC
0.79 VDC	8.47 VDC
0.58 VDC	8.0 DC

3.5 Analysis of Measurement Results

The analysis of the RFID-based motor vehicle safety lock system encompasses a detailed examination, incorporating measurements, tool testing, and data collection, all of which are divided into two primary testing phases: ID tag card testing and overall system testing. This comprehensive analysis is designed to rigorously evaluate the system's performance, ensuring it meets the high standards required for vehicle security.

In the first phase, the focus is on ID tag card testing. This involves bringing the RFID card close to the RFID reader. The reader scans the ID, and if the data matches the pre-stored information in the microcontroller, the system acknowledges the authenticity of the ID tag. This verification process is critical for ensuring that only authorized access is granted, enhancing the security of the vehicle. It's a pivotal step in determining the system's ability to effectively differentiate between authorized and unauthorized users, directly impacting its effectiveness in theft prevention.

The second phase involves overall system testing. Here, the functionality of the system is assessed under various conditions to ensure reliability and accuracy. If the scanned ID tag corresponds correctly with the system's data, the system activates ('On' state). Conversely, if the ID tag does not match, the system remains locked ('Off' state), thereby preventing unauthorized access. This phase is essential in evaluating the system's operational integrity and its ability to function reliably in real-world scenarios.

A notable feature of the RFID card system is its operational ease. The card needs to be held close to the reader, but it doesn't require physical attachment. This design offers convenience, especially when the vehicle engine is running, as the card can be easily and quickly presented without needing to be attached to any part of the vehicle. The user-friendly aspect of this system is particularly important in ensuring that the security measures do not impede the practical use of the vehicle.

Overall, these testing stages are crucial in evaluating the efficiency and reliability

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of the RFID-based security system. They ensure that the system operates as intended, providing a secure and user-friendly solution for motor vehicle safety. The combination of precise ID verification and ease of use makes this system an innovative approach to enhancing vehicle security. Through these tests, the system's robustness against potential security breaches can be thoroughly assessed, ensuring that it delivers not only high security but also a seamless user experience.

4. CONCLUSION

In conclusion, the design of an additional safety lock for motor vehicles, which incorporates RFID technology and is controlled by the AT89S52 Microcontroller, represents a significant advancement in vehicle security. The employment of BASCOM-AVR programming facilitates a more efficient control system. This programming environment is particularly advantageous due to its comprehensive features, including simulators for LEDs and LCDs. These features allow for thorough pre-implementation testing and visualization of the program, ensuring that any issues can be identified and resolved before the software is downloaded into the microcontroller. However, during the testing phase, it was observed that the RFID device could only effectively read ID tags within a range of 9 to 9.8 cm. This range is somewhat short of the expected 12 cm as specified in the RFID Reader's data sheet, indicating a need for further refinement to achieve optimal performance.

Despite this limitation, the integration of a microcontroller with RFID technology to create a supplementary security tool has proven to be a promising approach. This system not only enhances the security of motor vehicles but also contributes significantly to reducing the incidence of vehicle theft in the community. It represents a meaningful step towards leveraging advanced technology for community safety and demonstrates the potential of RFID technology in creating more secure environments. This innovative security solution, with further development and optimization, has the potential to significantly mitigate the risk of motor vehicle theft, thereby providing a safer and more secure community.

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