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Utilization of Bluetooth Module As An Additional Security of Arduino-Based Motorized Vehicles

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ABSTRACT

The escalation in motorcycle ownership has paralleled a rise in theft incidents, challenging the efficacy of existing security measures. Despite the integration of standard security systems on motorcycles, the persistence of thefts underscores the need for innovative solutions. This study introduces a novel security device that leverages Bluetooth HC-05 technology and an ATmega328 microcontroller to address this issue. The proposed system transcends conventional security protocols by establishing a dynamic link between the motorcycle and its owner. An alarm is triggered when the distance between the paired Bluetooth devices exceeds a predefined threshold, signaling potential unauthorized movement. Moreover, the system is engineered to deactivate the motorcycle's ignition upon Bluetooth connectivity loss, immobilizing the engine and thwarting theft attempts. This advanced security mechanism enhances the protection of motorcycles by incorporating proximity-based alerts and automated engine shutdown features, offering a formidable deterrent against theft. The article delineates this security system's design, implementation, and potential impact, positioning it as a critical advancement in motorcycle anti-theft technology.

Keywords: Arduino Nano V3, ATmega328 Microcontroller, Bluetooth HC-05

ABSTRAK

Peningkatan kepemilikan sepeda motor telah sejalan dengan meningkatnya insiden pencurian, yang menantang efektivitas langkah-langkah keamanan yang ada. Meskipun sistem keamanan standar telah diintegrasikan pada sepeda motor, ketekunan pencurian menunjukkan perlunya solusi inovatif. Studi ini memperkenalkan perangkat keamanan baru yang memanfaatkan teknologi Bluetooth HC-05 dan mikrokontroler ATmega328 untuk mengatasi tantangan ini. Sistem yang diusulkan melampaui protokol keamanan konvensional dengan menciptakan tautan dinamis antara sepeda motor dan pemiliknya. Alarm akan berbunyi ketika jarak antara perangkat Bluetooth yang dipasangkan melebihi ambang batas yang telah ditentukan, menandakan adanya pergerakan yang tidak sah. Selain itu, sistem ini dirancang untuk menonaktifkan pengapian sepeda motor ketika konektivitas Bluetooth hilang, sehingga mesin tidak dapat dinyalakan dan upaya pencurian dapat dicegah. Mekanisme keamanan canggih ini meningkatkan perlindungan sepeda motor dengan menggabungkan peringatan berbasis jarak dan fitur pematian mesin otomatis, memberikan pencegah yang kuat terhadap pencurian. Artikel ini menguraikan desain, implementasi, dan dampak potensial dari sistem ini, yang memposisikannya sebagai kemajuan penting dalam teknologi anti-pencurian sepeda motor.

Kata kunci: Arduino Nano V3, ATmega328 Mikrokontroller, Bluetooth HC-05

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1. Introduction

Transportation systems are deeply entrenched in modern society, serving as indispensable conduits for the movement of individuals and goods. In the Indonesian context, motorcycles are particularly esteemed for

their affordability relative to other vehicular options [1]. However, the prevalence of motorcycles has been accompanied by a surge in theft incidents, a phenomenon that has been documented both formally and informally [2]. The onus of motorcycle security traditionally falls upon the owner, despite manufacturers' efforts to incorporate various security features, including mechanical and electronic deterrents like ignition covers, steering locks, and alarms [3]. Nevertheless, these measures are often deemed insufficient in curbing the incidence of theft, largely due to the vulnerability of alarm systems to deactivation [4]. Consequently, this leaves owners without reliable indicators to monitor their vehicle's status or to track its location post-theft [5].

Given these challenges, there has been a pivot towards leveraging technological advancements to enhance vehicle security. Artanto's study (2012), "Design and Implementation of Car Key Automation with Bluetooth Control using Android-Based Mobile Application," is a precursor to this endeavor [6]. Drawing inspiration from Aranto's work, the present research proposes a similar application tailored for motorcycles, substituting the password verification process with a microcontroller-based mechanism.

The ubiquity of mobile phones across societal strata has facilitated the development of Android-based motorcycle security systems that utilize Bluetooth technology [7]. Bluetooth, a short-range wireless communication standard named after 10th-century Scandinavian ruler Harald Blatand, employs frequency hopping to mitigate interference within the ISM band, spanning 2.4 to 2.48 GHz [8]. Within the Android ecosystem, Bluetooth is an interface for transmitting commands to an Arduino microcontroller, which processes signals and actuates relays for load management [9]. Among the Bluetooth modules employed, the HC-05 stands out for its ease of use and compliance with the Serial Port Protocol (SPP), supporting Bluetooth V2.0+EDR at a data rate of 3Mbps, thus facilitating seamless serial communication with various controllers and personal computers [10].

2. Method

2.1. Block Diagram of the System

The block diagram describes a motorcycle security system designed to enhance protection against theft. A power source at the system's core is represented by a battery, which supplies the necessary voltage to various components. Initially, the battery is connected to a setting button, allowing users to configure the system according to their preferences. The setting button is then linked to a microcontroller, which serves as the system's central processing unit. This microcontroller processes input from the setting button and controls a display indicator, providing the user with real-time status updates and feedback. Positioned alongside the microcontroller is a Bluetooth module, connected to another Bluetooth module via a dotted line, signifying a wireless communication link. This enables remote communication and control between the two modules.

The second Bluetooth module is connected to another microcontroller, allowing extended functionality and control capabilities. The battery directly powers this microcontroller, ensuring it has a reliable power source. Additionally, the battery is connected to a relay controlling the CDI motor, which is an integral part of the motorcycle's ignition system. The relay, governed by the microcontroller's commands, can switch the CDI motor on or off, enhancing the security system by preventing unauthorized ignition. Through this intricate setup, the system ensures a robust security mechanism for motorcycles, utilizing both wired and wireless components to provide comprehensive protection and ease of use for the vehicle owner. A block diagram of the system design is shown in Figure 1.

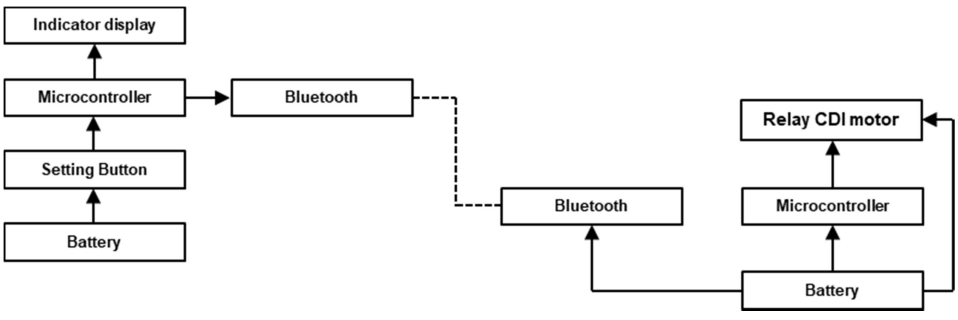

Figure 1. Block diagram of the system.

The system design stage is a crucial initial step for planning the structure of the device to be created and formed. This is done to ensure that the device's manufacturing process is structured, systematic, and

efficient. Eagle software will be used for this research because it is easier for beginners and has comprehensive features. It is also compatible with all 32-bit and 64-bit Windows and Linux systems. The circuit schematic of the research to be conducted consists of several stages.

2.2. Bluetooth Motor Relay Design

The circuit design for this system is meticulously arranged to ensure functionality and reliability. The motorcycle battery is at the core of the system, which supplies power to the Arduino. The Arduino is the central processing unit that controls various components and manages system operations. A capacitor is connected to the Arduino to stabilize the power supply. This capacitor helps filter out any noise or fluctuations in the voltage, ensuring that the Arduino receives a steady and clean power supply. A FET transistor is used to control the motor relay. The transistor connects the motor relay and the Arduino, functioning as an electronic switch. This allows the Arduino to control the motor relay, which in turn can control the motorcycle's ignition system. The use of a FET transistor ensures efficient and reliable switching with minimal power loss. A voltage regulator is also connected to the Arduino. The regulator ensures that the voltage supplied to the Arduino remains consistent, protecting the microcontroller from potential damage caused by voltage spikes or drops.

This is crucial for maintaining the stability and longevity of the system. Additionally, a buzzer is integrated into the circuit, which is connected to the Arduino. The buzzer serves as an audible alert mechanism, providing real-time notifications or alarms to the user. This can be useful for indicating system status, errors, or security breaches. Finally, a Bluetooth module is connected to the Arduino, enabling wireless communication. This allows the system to interface with external devices, facilitating remote control and monitoring. The Bluetooth connection enhances the flexibility and usability of the system, allowing for convenient and efficient operation. Through this carefully planned circuit design, the system ensures robust security and control for the motorcycle, leveraging both wired and wireless components to deliver a comprehensive and user-friendly solution. Figure 2 depicts the research circuit scheme carried out on the motor Bluetooth relay.

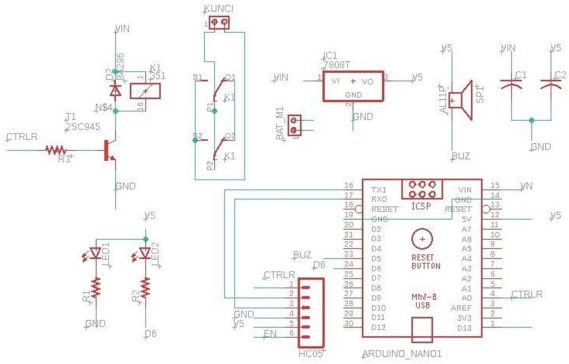

Figure 2. Motor bluetooth relay circuit.

2.3. Owner's Bluetooth Relay Design

The circuit design for this system is carefully arranged to ensure functionality and reliability. The battery is at the core of the system, which provides power to the Arduino. The Arduino is the central processing unit that controls various components and manages system operations. A capacitor is connected to the Arduino to stabilize the power supply. This capacitor helps filter out any noise or fluctuations in the voltage, ensuring that the Arduino receives a steady and clean power supply. A voltage regulator is also connected to the Arduino. The regulator ensures that the voltage supplied to the Arduino remains consistent, protecting the microcontroller from potential damage caused by voltage spikes or drops. This is crucial for maintaining the stability and longevity of the system. Additionally, a buzzer is integrated into the circuit, which is connected to the Arduino.

The buzzer serves as an audible alarm mechanism, providing real-time notifications or alerts to the user. This can be useful for indicating system status, errors, or security breaches. An L.E.D. is also connected to the Arduino, providing visual indications of the system status. The L.E.D. can be used for various purposes, such as showing whether the system is active, indicating errors, or providing visual feedback to the user. Finally, a Bluetooth module is connected to the Arduino, enabling wireless communication. This allows the system to interface with external devices, such as smartphones or other microcontrollers, facilitating remote

control and monitoring. The Bluetooth connection enhances the flexibility and usability of the system, allowing for convenient and efficient operation. This carefully planned circuit design ensures robust security and control, leveraging both wired and wireless components to deliver a comprehensive and user-friendly solution. Figure 3 illustrates the research circuit scheme carried out on the owner of the Bluetooth relay.

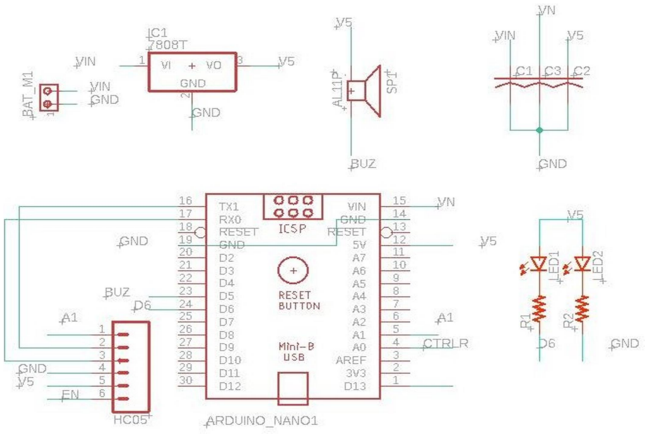

Figure 3. Owner's bluetooth relay circuit.

2.4. Software Program Design

Software design requires writing code or programs. This process uses software such as the Arduino IDE to facilitate users and is connected to a microcontroller and Bluetooth HC-05 for remote control. Creation of AT commands for the Bluetooth HC-05 module:

1. Once the cables are connected and an empty code has been uploaded to the Arduino, the button on the Bluetooth HC-05 module should be pressed and held for 3 seconds. After release, the LED on the Bluetooth module will begin to blink slowly.
2. The serial monitor in the Arduino IDE should then be opened to send commands and view responses from the HC-05. The baud rate must be set to 9600. The Tools menu can be selected to access the serial monitor, followed by choosing "Serial Monitor," or the shortcut Ctrl+Shift+M can be used.
3. It is essential to adjust the baud rate of the COM port to 9600. This can be done by navigating to: <This PC> <Manage> <Device Manager> <Ports> <USB Serial 340> <Properties> <Port Settings> <Bits per Second> <Select 9600> <OK>. Ensure the baud rate is set to 9600 and the line ending is configured to "Both NL & CR."
4. Lastly, the AT command should be entered and the send button pressed to test communication with the Bluetooth HC-05 module. If the message "OK" is received, it indicates that the Bluetooth module is functioning correctly with the AT commands [11].

3. Results

3.1. Work Procedure

a. Working procedure of Bluetooth motor circuit, as follows:

- The testing procedure for the motorcycle security system is meticulously designed to ensure that the circuit's functionality aligns with the design specifications. The process begins with connecting the power supply, where the 12-volt motorcycle battery powers the Bluetooth module attached to the Arduino, ensuring the activation of the Bluetooth circuit in the motorcycle. Simultaneously, the Bluetooth module connected to the owner's Arduino is powered on using a separate battery, ensuring both Bluetooth modules are operational.
- Next, the Bluetooth modules are initialized. The Bluetooth module on the motorcycle is set up to receive and transmit signals powered by the motorcycle's battery, while the owner's Bluetooth module is configured and initialized to establish a connection with the motorcycle's Bluetooth module.
- The circuit functionality is then tested, starting with a power stability check to verify that the power supplied from the motorcycle battery to the Bluetooth module is stable, aided by a capacitor that filters out any noise or fluctuations. Additionally, the voltage regulator connected to the Arduino is checked to ensure it maintains a consistent voltage level, protecting the Arduino from potential voltage spikes or drops.

- Functional verification is then conducted, testing the control of the motorcycle ignition system via the Bluetooth modules. The owner's Arduino sends a signal to the motorcycle's Bluetooth module, which activates the ignition system through the Arduino and the relay connected to the CDI motor. The buzzer and LED indicators connected to the Arduino are checked to ensure they provide audible and visual feedback based on the system's status.
- The final validation step ensures that the system provides accurate and timely feedback through the buzzer and LED indicators, confirming that all components respond appropriately to commands and that the overall system operates as intended.

b. Working procedure of the Owner's Bluetooth circuit, as follows:

- The circuit design begins with supplying power from the battery to the Arduino, which serves as the central processing unit. The battery delivers the required voltage to power and operate the Arduino and all connected components. To stabilize the power supply and ensure the Arduino receives clean and consistent power, a capacitor is integrated into the circuit and connected to the Arduino. This capacitor functions to filter out any fluctuations or noise that may occur from the power source.
- A voltage regulator is also incorporated into the circuit and connected to the Arduino. This regulator maintains a stable and consistent voltage input to the Arduino, safeguarding it against potential damage from voltage spikes or drops. This step is essential to ensure the stability and longevity of the system.
- In addition, a buzzer is integrated into the circuit and connected to the Arduino. This buzzer functions as an audible alarm mechanism that can notify of connection.
- An LED is also connected to the Arduino to indicate the system status visually. This LED can notify the owner of connection occurrences and disconnections.
- The Bluetooth module is connected to the Arduino as the owner's Bluetooth, allowing the system to communicate wirelessly.

A comprehensive security and reliability communication system is conducted between the owner's Bluetooth and the motorcycle's Bluetooth to verify that all connections are secure and components are operating within specified parameters. Through this test procedure, the motorcycle's functionality and the reliability of its security system can be carefully evaluated, ensuring this system meets the design specifications and provides strong protection against motorcycle snatching. When the owner is out of range of the motorcycle Bluetooth, the connection between the two Bluetooths will be lost, and the motorcycle Bluetooth will automatically command the engine to shut down. The overall device circuit is given in Figure 4.

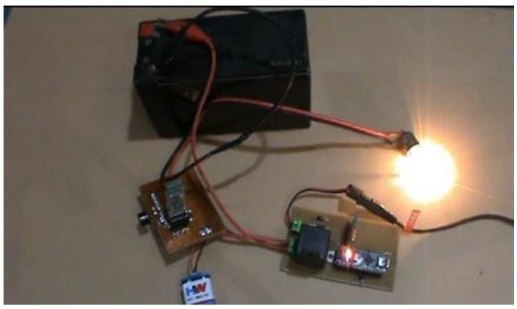

Figure 4. Device circuit.

3.2. Testing The ATCommand Program In Master

The AT Command testing aims to configure the owner's Bluetooth as the master. Below is the program and owner Bluetooth circuit:

```
Bluetooth Owner Program
#include<SoftwareSerial.h>
SoftwareSerial BTserial(2,3);//RX|TX

voidsetup(){
  BTserial.begin(9600);
```

```
}

voidloop(){BTserial.println('a');
  delay(250);
}
```

3.3. Testing The ATCommand Program in Slave

AT Command testing aims to configure the Bluetooth motor as an enslaved person. Below is the program and figure for the motorcycle Bluetooth circuit:

```
Bluetooth program on the motor
#include<SoftwareSerial h>
SoftwareSerial BTSerial(2, 3) // RX | TX int
mesin = A0;
char c = ' ';int
cnt
void setup() {
BTSerial.begin(9600);
pinMode(mesin, OUTPUT);cnt
= 0;
}
void loop() {
c=BTSerial.read() cnt++;
if(c=='a') {digitalWrite(mesin,
HIGH) delay(125);
cnt = 0;
}
delay(50);
if (cnt > 150) {
digitalWrite(mesin, LOW);
delay(100);
cnt = 999;
}
}
```

3.4. Test Results Connection Distance Between The Two Bluetooth

This test involved manipulating the RSSI signal values to a lower level during the Bluetooth connection setup using AT commands. Table 1 presents the maximum achievable range of Bluetooth connections.

Table 1. Measurement data of connection distance between bluetooth.

No.	Signal	Distance (m)	Status
1	+INQM:1,1,48	0.1	connected
2	+INQM:1,1,45	1.1	connected
3	+INQM:1,1,40	3.0	connected
4	+INQM:1,1,39	3.9	connected
5	+INQM:1,1,33	4.6	connected
6	+INQM:1,1,27	5.6	connected
7	+INQM:1,1,24	7.1	connected
8	+INQM:1,1,19	7.5	connected
9	+INQM:1,1,17	8.0	connected
10	+INQM:1,1,14	8.2	connected
11	+INQM:1,1,11	8.5	connected
12	+INQM:1,1,9	9.1	connected
13	+INQM:1,1,8	9.5	connected
14	+INQM:1,1,5	9.9	connected
15	+INQM:1,1,3	10.8	connected
16	+INQM:1,1,0	12.0	not connected
17	+INQM:1,1,0	13.0	not connected

Based on Table 1, +INQM: 1,1,48 signifies that in standard mode, there is 1 device that can remain connected for 48 seconds within a range of 0.1 meters, etc. Subsequently, with the signal +INQM: 1,1,0, Bluetooth in standard mode has 1 device that remains unconnected for 0 seconds within a range of 13 meters.

Based on the available data, network connection quality is generally good, with a relatively low percentage of dropped connections. However, some instances of low +INQM values and dropped connections need attention and improvement.

Subsequently, an explanation will be provided in the form of a graph. Figure 5 depicts the signal measurement graph obtained from various distances.

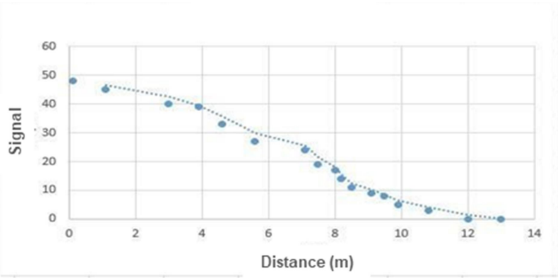

Figure 5. Distance measurement graph of acquired signal.

4. Conclusion

Based on the findings and discussions obtained, the testing of this system on the Bluetooth circuitry between the owner and the motorcycle demonstrates its effectiveness in remotely controlling the motorcycle engine using the HC-05 Bluetooth connection. The system enables users to safely and efficiently control the motorcycle engine across measured distances ranging from 0.1 meters to 13 meters before disconnection. The use of a buzzer and a lamp as connection indicators provides clear feedback to users, ensuring that the engine automatically shuts off when the motorcycle is out of the owner's range. Despite some need for improvement in signal quality and Bluetooth connection stability, the overall test results indicate that the system aligns with planning and is reliable for further implementation.

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