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Design and implementation of IoT-based motorcycle keyless ignition and starter using RFID and Blynk

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Abstract: Motorcycles are one of the most widely used means of transportation in the community. However, this widespread usage has led to an increase in thefts, especially when motorcycles are not equipped with adequate security systems. Statistical data shows that motorcycles have the highest theft rate compared to other vehicles. To address this issue, an enhanced security system is necessary. This study proposes the use of Radio Frequency Identification (RFID) sensor and the Blynk application to provide additional security for motorcycles. The RFID system will only be accessible using the motorcycle owner's e-KTP (electronic Indonesian Identity Card) or other registered cards to start the vehicle. Additionally, the Blynk mobile application allows for vehicle control (ON and OFF) via Wi-Fi and provides real-time monitoring of the vehicle's status. This application enables motorcycle activation remotely via Wi-Fi, with a range of approximately 10 meters. Meanwhile, there is a 4-second delay to start the motor starter using e-KTP. Test results indicate that this IoT-based keyless ignition and starter system is effective in enhancing motorcycle security. With this system, motorcycles have a dual-layer security mechanism to minimize theft attempts.

Keywords: Keyless Ignition, Keyless Starter, IoT, RFID, Motorcycle Security System

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Introduction

Human mobility is dynamic and tends to increase day by day, leading to a higher demand for transportation [1]. Various types of vehicles, from manual to automatic motorcycles, have been developed. This mass production has resulted in a significant increase in the motorcycle population. In Indonesia, the rapid growth in the number of motorcycles has brought about issues such as a rise in motorcycle thefts [2]. Criminals employ various methods, including direct robbery, breaking the ignition with a T-shaped key, using fake keys, or transporting the motorcycles away. According to data from the Central Statistics Agency (BPS), motorcycle thefts have been on the rise, with 18.557 units stolen in 2020 and quite similar to 18.005 units in 2021 [3]. The frequent occurrence of thefts is often due to motorcycle owners' lack of attention to security. For instance, some owners merely turn off the engine and leave the key hanging when parking their vehicles. Many still use padlock keys to secure their motorcycles, typically attaching the padlock to the front disc. This method is inefficient and inconvenient, as owners must carry the padlock everywhere they go [4]. Therefore, there is a need for a security system that is more effective, efficient, and convenient to use.

One solution for enhancing vehicle security systems is the use of Radio Frequency Identification (RFID) [5]. This system can significantly improve vehicle safety and provide owners with a sense of security when leaving their vehicles in public places. Previous studies have typically combined RFID sensors with Arduino Uno controls to create smart key systems [6] [7]. However, this approach has some drawbacks, including the size and visibility of the equipment, making it less effective for discreet use. Additionally, Arduino Uno requires an added Wi-Fi module to connect to the internet, unlike the NodeMCU ESP8266, which has an integrated Wi-Fi module.

Other studies have utilized ATmega and Arduino Nano as control units [8] [9] [10] [11]. The ATmega system can experience fuse bit errors during bootloader processing, and its dimensions are similar to the larger Arduino Uno. The Arduino Nano, on the other hand, consumes higher power, which is a critical concern since the control system relies on the vehicle battery for energy. Therefore, a control system with lower power consumption would be more advantageous [9]. Another study by [12] explored using a Personal Identification Number (PIN) as a motorcycle security system. However, this method has its own limitations, such as the risk of users, especially the elderly, forgetting the PIN. Additionally, there is a possibility that the PIN could be discovered by others.

Based on previous research, we propose a security system that utilizes an RFID sensor integrated with the NodeMCU ESP8266 and the Blynk mobile application for remote control. This system allows the motorcycle to be turned on and off in two ways: using an e-KTP card or another registered card, and via the Blynk application connected through a Wi-Fi network [13]. With real implementation and testing, this dual security approach enhances motorcycle safety by significantly reducing the risk of theft. This system is also designed to be scalable, cost effective, and easy to implement for different types of vehicles or applications. It uses of readily available components and open-source software to reduce overall costs.

Methodology

The keyless starter system is designed to identify input from either the RFID sensor or the Blynk application. This input is processed by the NodeMCU ESP8266 microcontroller, which activates the relays connected to the motorcycle's ignition and starter. Figure 1 illustrates the block diagram of the proposed keyless starter system.

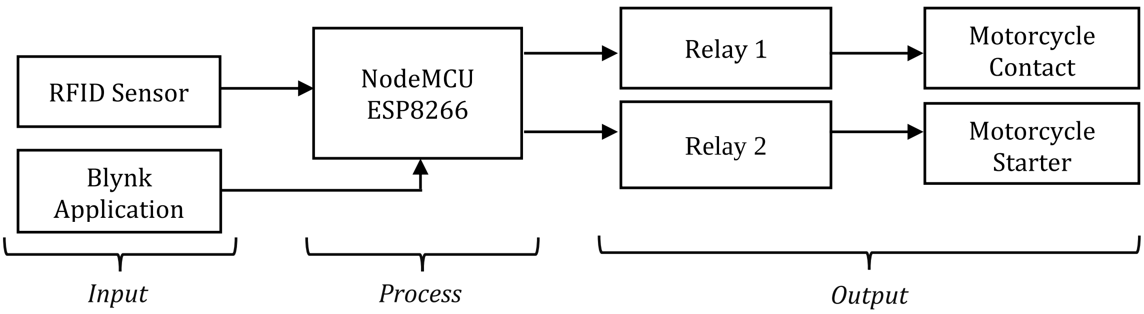
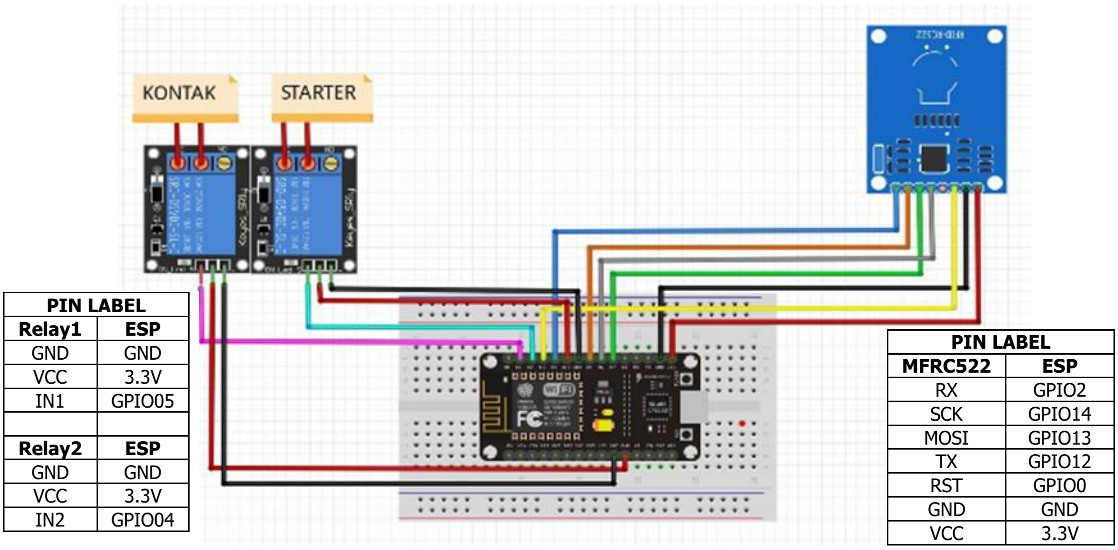


Figure 1. Block Diagram of Keyless Starter

In Figure 1, the block diagram of the system is divided into three main sections: input, process, and output. Each section contains several components:

a. Input Block: This block includes the RFID sensor and the Blynk application. The RFID sensor provides input values to the ESP8266 microcontroller, indicating HIGH (ON) or LOW (OFF) states. Similarly, the Blynk application sends input values from a mobile device to the ESP8266 microcontroller to activate the relay.
b. Process Block: This block features the NodeMCU ESP8266 microcontroller, which serves as the main control unit, processing inputs and managing the system's operations.
c. Output Block: This block comprises dual-channel relays connected to the motorcycle's ignition and starter. The relays execute commands from the microcontroller to turn the motorcycle's ignition and starter ON or OFF, thereby enabling the keyless starter system to control these components.

Afterward, the schematic diagram design is crucial for illustrating the connectivity between different electrical components. It integrates various components into a single, cohesive diagram, ensuring proper functionality and ease of application. Figure 2 presents the schematic diagram of the keyless starter system. The NodeMCU ESP8266 is a module capable of running microcontroller functions with a Wi-Fi connection. It supports three Wi-Fi modes: Station, Access Point, and Both. The module requires a voltage of 3.3V to operate. Figure 3 (a) displays the NodeMCU ESP8266 along with its pinout, which includes 9 GPIOs, 3 PWM pins, 1 ADC channel, and RX and TX pins [14]. RFID, a compact wireless technology, uses radio frequency to scan objects. The RFID sensor automatically identifies tag cards. Figure 3 (b) shows the MFRC522 RFID reader device, which captures radio frequency waves from the RFID tag and transfers data wirelessly. Scanning data is as simple as bringing the card close to the RFID reader. A relay is an electronic component that operates on the principle of electromagnetic induction. When a conductor is energized by an electric current, a magnetic field forms around it. Figure 3 (c) shows the relay module, commonly used as a switch to operate electronic equipment such as lights, electric motors, and other devices with ON/OFF control. The microcontroller processes the sensor output values to determine the commands sent to the relay [4].



PIN LABEL	
Relay1	**ESP**
GND	GND
VCC	3.3V
IN1	GPIO05
Relay2	**ESP**
GND	GND
VCC	3.3V
IN2	GPIO04

PIN LABEL	
MFRC522	**ESP**
RX	GPIO2
SCK	GPIO14
MOSI	GPIO13
TX	GPIO12
RST	GPIO0
GND	GND
VCC	3.3V

Figure 2. Wiring Diagram of the Keyless Starter

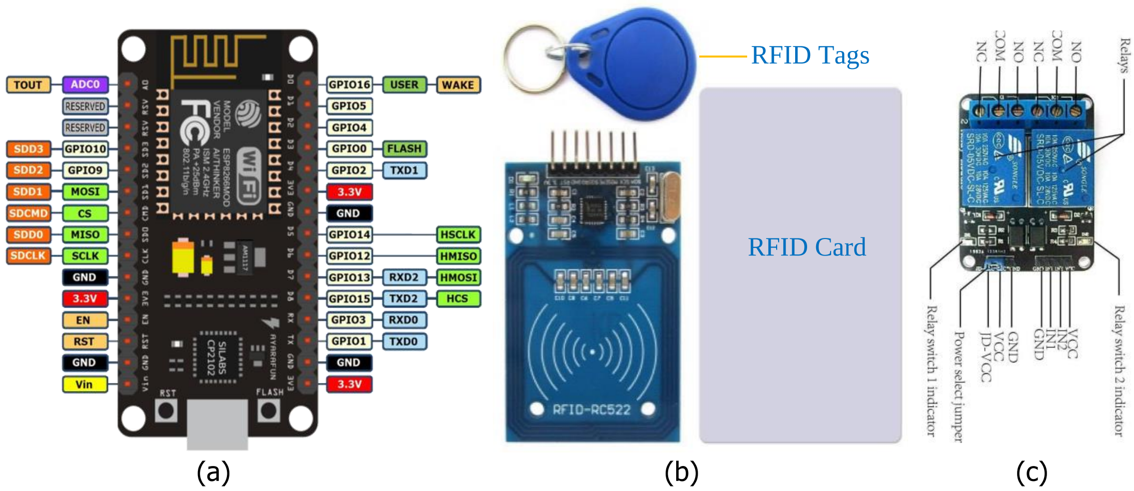


Figure 3. (a) NodeMCU ESP8266 with Pin Out, (b) RFID MFRC522, and (c) Relay 2 Channels

The design of this system utilizes two software tools: Arduino IDE and Blynk. The NodeMCU ESP8266 is programmed using the Arduino IDE software, enabling it to receive input from the sensor and subsequently control the relays. Figure 4 illustrates the flowchart for scanning RFID and activating the relays. Meanwhile, Figure 5 displays the code for the Keyless Starter in Arduino IDE. The code begins by including the necessary libraries and defining and initializing various variables. The void setup() function is used to declare pin modes (INPUT or OUTPUT), initialize libraries, and it runs only once at the start. In contrast, the void loop() function is designed to execute and repeatedly run the program. The motorcycle's engine will turn ON if the RFID is scanned twice, resulting in both relays being set to HIGH.

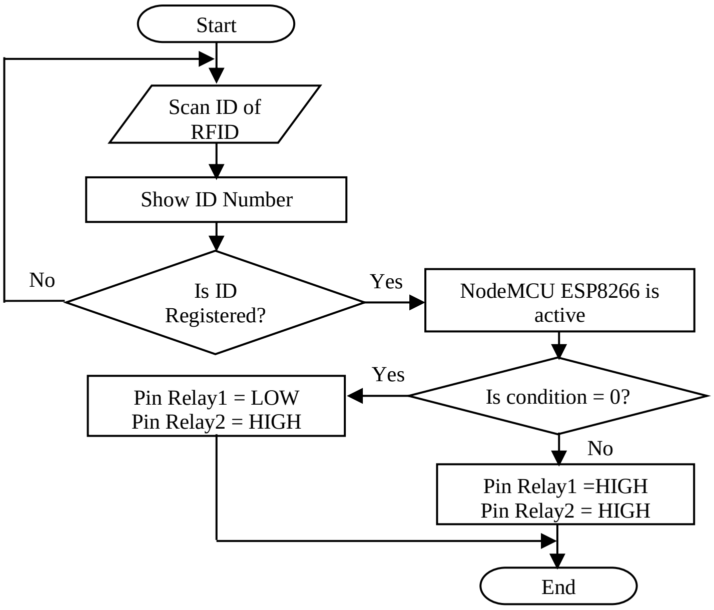


Figure 4. Flowchart for scanning RFID and activating the relays

```
#include <SPI.h>
#include <MFRC522.h>
#include <BlynkSimpleEsp8266.h>

#define SS_PIN 2
#define RST_PIN 0
MFRC522 mfrc522(SS_PIN, RST_PIN);
int pinRelay1 = 5;
int pinRelay2 = 4;

char auth[] =
"JBhMO75yOmBrbX5VU9ZxUD2hE5E29b1l";
char ssid[] = "JERO GEDE";
char pass[] = "yuaka207567";
int kondisi;

void setup()
{
 Serial.begin(9600);
 Blynk.begin(auth, ssid, pass);
 SPI.begin();
 mfrc522.PCD_Init();

 pinMode(pinRelay1, OUTPUT);
 pinMode(pinRelay2, OUTPUT);
 digitalWrite(pinRelay1, HIGH);
 digitalWrite(pinRelay2, HIGH);
 condition = 0;
}

void loop(){
 Blynk.run();

 // cek the new RFID card
 if ( ! mfrc522.PICC_IsNewCardPresent()){
  return;
 }

 // Select RFID card
 if ( ! mfrc522.PICC_ReadCardSerial()){
  return;
 }

 // Showing ID of RFID card on Serial
Monitor
 Serial.print("UID:");
 String content = "";
 byte letter;
 for (byte i = 0; i < mfrc522.uid.size; i++){
  Serial.print(mfrc522.uid.uidByte[i] <
  0x10 ? " 0" : " ");
  Serial.print(mfrc522.uid.uidByte[i], HEX);

  content.concat(String(mfrc522.uid.uidByte
  [i] < 0x10 ? " 0" : " "));

  content.concat(String(mfrc522.uid.uidByte
  [i], HEX));  }

 Serial.println("");
 content.toUpperCase();

 if (content.substring(1) == "04 6F 85 2A 18
  5B 80"){
  if (condition == 0){
   digitalWrite(pinRelay1, LOW);
   delay(4000);
   digitalWrite(pinRelay2, LOW);
   delay(3000);
   digitalWrite(pinRelay2, HIGH);
   condition = 1;  }
  else if (condition == 1){
   digitalWrite(pinRelay1, HIGH);
   digitalWrite(pinRelay2, HIGH);
   delay(1000);
   condition = 0;
  } } }
```

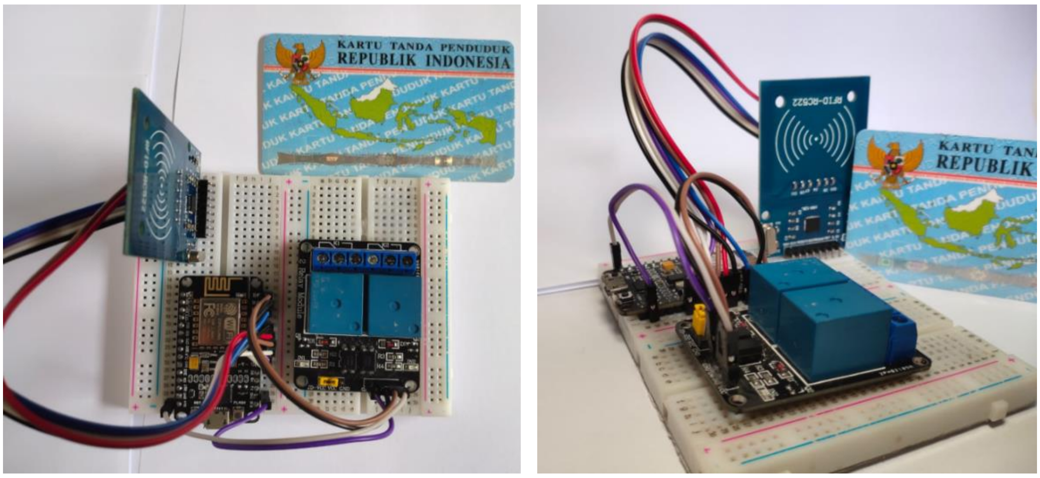
Figure 5. The code of the Keyless Starter in Arduino IDE

Results and Discussions

Implementing this keyless starter tool involves three main stages: hardware development, application integration, and system installation. Each stage—hardware realization, application implementation, and system installation—has been meticulously executed to ensure seamless functionality.

Hardware Setup

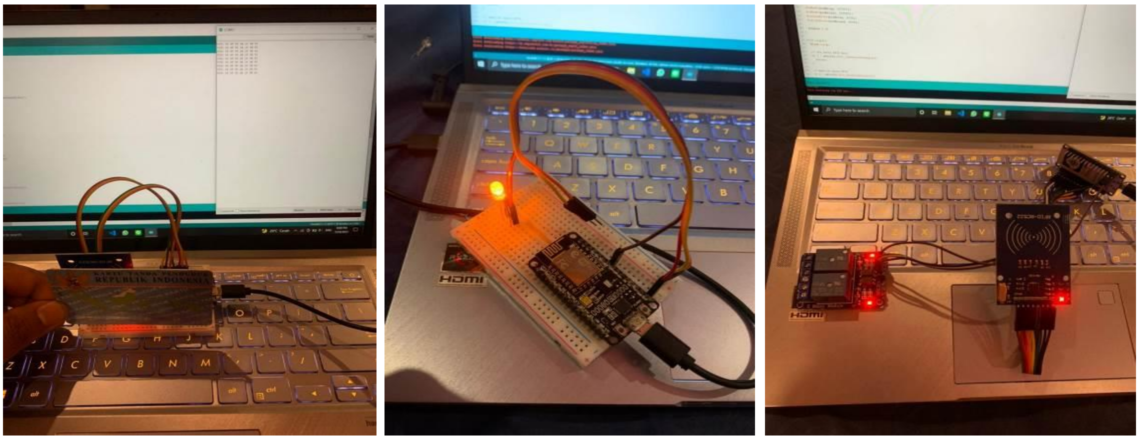
The components utilized in this keyless starter prototype adhere to the designed wiring diagram. Figure 6 shows the hardware implementation of the keyless starter in breadboard mode. In this setup, an electronic Indonesian Identity Card (e-KTP) serves as the RFID tag.



(a) (b)

Figure 6. Hardware realization, (a) top view, and (b) side view

Preliminary component testing is essential to verify proper functionality. Therefore, several tests were conducted, including an RFID sensor test. The RFID reader and cards serve as replacements for traditional keys to start the motorcycle engine. This involved testing with two RFID cards, each card tested twice to ensure reliability.



(a) (b) (c)

Figure 7. Preliminary test for (a) RFID, (b) NodeMCU ESP8266, and (c) Relay

Figure 7 (a) shows the testing of the RFID sensor. When the sensor reads a card, the card ID is displayed in the program's serial monitor, and the LED on the NodeMCU ESP8266 flashes to indicate successful reading. The results confirm that the RFID sensor functions correctly. Table 1 presents the RFID test data, showing consistent and accurate readings from the serial monitor across three tests.

Table 1. Initial testing of RFID

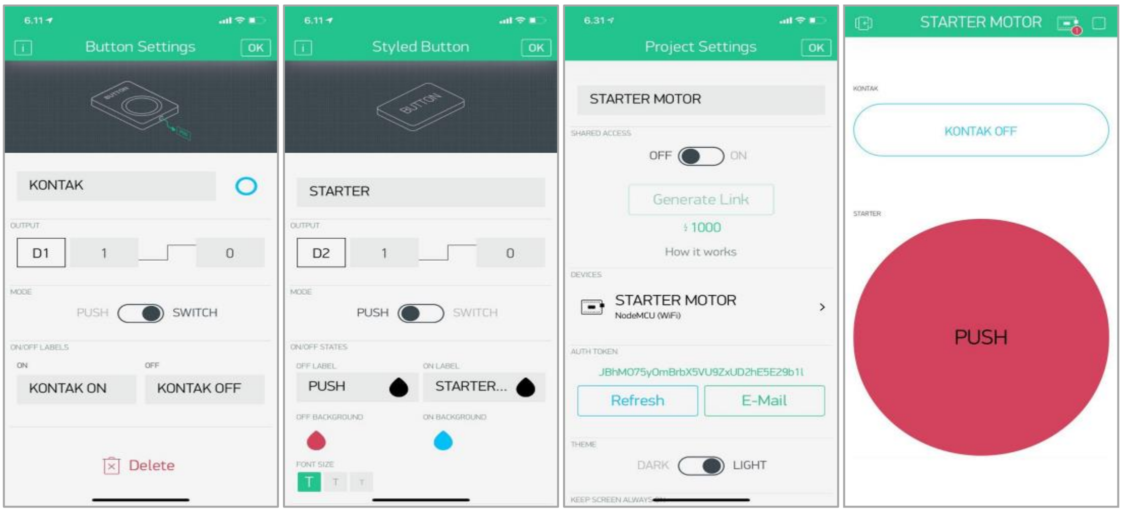
No	RFID	Serial monitor	Result (twice)
1	27 22 60 62	Read	Correct
2	27 22 60 62	Read	Correct
3	87 99 5A 62	Read	Correct
4	87 99 5A 62	Read	Correct

5	35 64 01 79	Read	Correct
6	35 64 01 79	Read	Correct

The NodeMCU ESP8266 is a control module tested by connecting its USB port to a laptop, as shown in Figure 7 (b). The testing involves using the Arduino IDE to upload a basic program designed to turn on an LED light. If the LED lights up successfully, it confirms that the ESP8266 module is functioning correctly. A relay is an electronic component that operates on the principle of electromagnetic induction and is commonly used for control in various devices. Figure 9 (c) depicts the relay testing process. During this test, the relay functioned correctly, as evidenced by the light of the LEDs on inputs 1 and 2, along with an audible clicking sound from both relays.

Application Setup

The application integrated into this tool utilizes the Blynk platform, compatible with both Android and iOS. Designed as an alternative to key cards, this application enables motorcycle activation remotely via Wi-Fi, with a range of approximately 10 meters. Figures 8 (a-c) display the Blynk application's setup and interface, featuring indicators for ON/OFF status and a starter button depicted in Figure 8 (d).

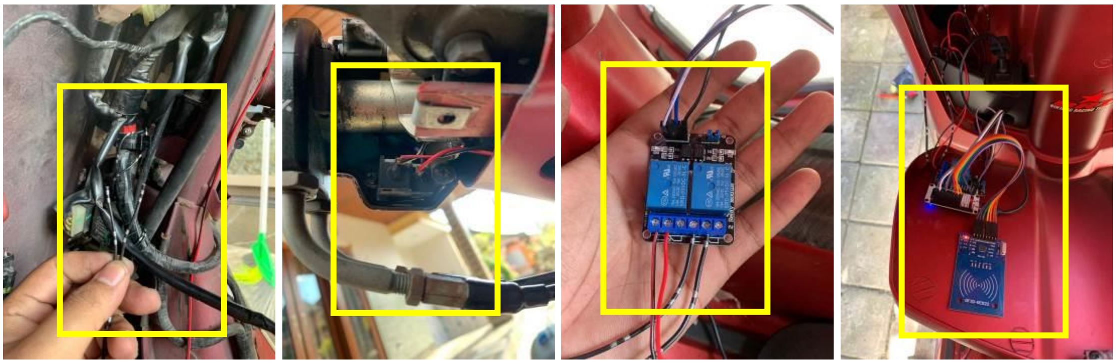


(a) (b) (c) (d)

Figure 8. a) Button Setting, (b) Styled Button, (c) Project Setting, and (d) The Starter App

System Installation and Testing

The installation of the tool on the motorcycle involves four steps: (1) connecting the cable to the ignition socket, (2) connecting the cable to the motor starter, (3) connecting the cable to the relay, and (4) installing the tool in the front trunk of the motorcycle. When accessing the ignition socket, identify the two wires and connect them to the cable already linked to input 1 on the relay. Similarly, for the motorcycle's starter, connect its two wires to the starter motor cable and then to input 2 on the relay. Figures 9 (a) and (b) illustrate the wiring on the ignition socket and the starter, respectively.



(a) (b) (c) (d)

Figure 9. The Instalation of Keyless Ignition and Starter on the Motorcycle

Connect the red wire from the starter motor to relay input 2 and the black wire from the ignition key to relay input 1. Figures 9 (c) and (d) show the wiring on the relay module and the installation of the tool in the front trunk of the motorcycle. To prevent water splashes, the RFID sensor, NodeMCU ESP8266, and relay are installed in the front trunk, positioned close together for more accessible wiring. Finally, connect the NodeMCU ESP8266 to the motorcycle's built-in USB port using a USB type-A cable.

After installing the tools on the motorcycle, an overall test was conducted. The test focused on starting the motorcycle using either the tag card (e-KTP) or the Blynk application. The system operates as follows: when the e-KTP card is tagged to the front trunk of the motorcycle, as shown in Figure 10 (a), the RFID sensor reads the registered card. Relay 1 then automatically activates the motor contacts. There is a 4-second delay before Relay 2 engages to start the motor starter. After this delay, the motor starts automatically, as depicted in Figure 10 (b). In this case, the RFID sensor and ESP8266 might need a brief moment to process the next command after the first relay activation. The delay ensures smooth and error-free processing. This delay can also prevent multiple actions from occurring too quickly, which might confuse or inconvenience the user. It can also serve as a brief period for the system to provide feedback (e.g., via an LED indicator or a sound) to the user that the first action has been completed, enhancing the overall user experience.

(a) (b) (c) (d)

Figure 10. Overall Final Test using eKTP (a & b) and Blynk Application (c & d)

The ON/OFF test was conducted three times. Table 2 presents the test results using the e-KTP, while Table 3 displays the results using the Blynk application. To turn off the motor, simply tap the card in the same location as when turning it on. Table 4 presents range testing using Blynk to ON/OFF the engine.

Table 2. ON/OFF testing result using eKTP

No	e-KTP	Engine	Result
1	Read	ON	Correct
2	Read	OFF	Correct
3	Read	ON	Correct
4	Read	OFF	Correct
5	Read	ON	Correct
6	Read	OFF	Correct

Table 3. ON/OFF testing result using Blynk

No	Contact	Starter	Engine	Result
1	ON	ON	ON	Correct
2	ON	ON	ON	Correct
3	ON	ON	ON	Correct
4	OFF	-	OFF	Correct
5	OFF	-	OFF	Correct
6	OFF	-	OFF	Correct

Table 4. Range testing result using Blynk

No	Range	Contact	Starter	Engine
1	1 Mtr	ON	ON	ON
2	3 Mtr	ON	ON	ON
3	5 Mtr	ON	ON	ON
4	10 Mtr	ON	ON	ON
5	11 Mtr	ON	ON	OFF
6	12 Mtr	ON	ON	OFF

The next test involved the Blynk application, which is configured with two controllers: the Contact Button and the Starter Button. The Contact Button is used to turn the ignition on and off, while the Starter Button starts the motor. To operate, press the ON ignition button to activate the motor ignition, then press the Starter Button to start the motor. To turn off the motor, press the OFF button. Figures 10 (c) and (d) show the motor's ON and OFF conditions, along with the Blynk application's interface.

After comprehensive testing, the tool proved to operate correctly. This proposed system provides enhanced security for the motorcycle, reducing theft attempts. Future improvements include adding a GPS module to capture the motorcycle's geolocation for further analysis [15].

Conclusion

This study proposes a motorcycle keyless starter using the NodeMCU ESP8266 as a microcontroller. The NodeMCU controls dual-channel relays that connect to the motorcycle's ignition and starter. The motorcycle can be started by either tapping a registered e-KTP card to the RFID reader or using the Blynk application on a smartphone via Wi-Fi. The application enables motorcycle activation remotely via Wi-Fi, with a range of approximately 10 meters. Meanwhile, there is a 4-second delay to start the motor starter using e-KTP. The test results indicate that this system effectively enhances motorcycle security and reduces theft attempts. Future improvements include adding a GPS module to capture the motorcycle's geolocation, allowing for analysis of human mobility dynamics and patterns.

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