# Design of IoT-Based Smart Charging Power Supply for Pratima Security

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***Abstrak***

*Catu daya sangat diperlukan dalam sistem pengamanan pratima karena berfungsi sebagai sumber energi utama yang memastikan seluruh komponen sistem keamanan Pratima dapat beroperasi secara optimal terutama saat terjadi gangguan listrik. Penelitian ini merancang sistem catu daya dengan fitur smart charging untuk sistem pengamanan Pratima berbasis IoT. Sistem ini menggunakan mikrokontroler ESP8266, sensor arus dan tegangan, serta terhubung dengan aplikasi Telegram untuk memberikan notifikasi saat baterai 18650 penuh. Berbeda dengan penelitian sebelumnya yang memanfaatkan website, sistem ini menawarkan solusi pemantauan yang lebih sederhana dan efisien melalui Telegram. Tujuannya adalah menjaga kualitas baterai 18650, mencegah overcharge, dan menyediakan cadangan daya untuk menjaga sistem pengamanan tetap aktif. Penelitian ini menggunakan metode Software Development Life Cycle (SDLC) dengan model Waterfall yang terdiri dari 5 tahap yaitu tahap analysis, design, implementation, testing, dan maintenance. Hasil dari penelitian ini diharapkan dapat menjadi alternatif catu daya berfitur smart charging dengan harga terjangkau serta dapat diterapkan pada perangkat IoT lainnya yang membutuhkan sistem pengisian daya otomatis dan efisien.*

***Kata kunci:*** *Baterai 18650, Catu daya, ESP8266, Smart Charging, Telegram*

***Abstract***

*A power supply is essential for the Pratima security system because it serves as the primary energy source that ensures all components of the Pratima security system can operate optimally, especially during power outages. This study designs a power supply system with a smart charging feature for the IoT-based Pratima security system. This system uses an ESP8266 microcontroller, current and voltage sensors, and is connected to the Telegram application to provide notifications when the 18650 battery is full. Unlike previous studies that utilize websites, this system offers a simpler and more efficient monitoring solution via Telegram. The goal is to maintain the quality of the 18650 battery, prevent overcharging, and provide a power reserve to keep the security system active. This study uses the Software Development Life Cycle (SDLC) method with a Waterfall model consisting of 5 stages: analysis, design, implementation, testing, and maintenance. The results of this study are expected to be an alternative power supply with a smart charging feature at an affordable price and can be applied to other IoT devices that require an automatic and efficient charging system.*

***Keywords:*** *18650 Battery, Power Supply, ESP8266, Smart Charging, Telegram*

## 1. Introduction

A Temple is a place of worship that holds sacred significance for Hindu communities in Indonesia. Within a temple complex, there are Pratima, which are considered manifestations of gods, goddesses, and ancestors in the form of statues. Pratima possess a high level of sacredness and are made from valuable materials; therefore, their existence must be properly protected. Various news reports in previous years have indicated numerous cases of Pratima theft in several regions of Bali. To prevent such incidents, a Pratima security system is required to safeguard Pratima within temples.

The Pratima security system is designed as an IoT-based system to protect Pratima in a temple. This system utilizes a microcontroller and various sensors, such as sound sensors and others, to monitor the condition of the Pratima. The Pratima security system developed by I Putu Prayoga Diatmika Putra et al. [1] aims to prevent and minimize undesirable events, such as the loss of Pratima. The system requires a power input to operate properly. One of the most important aspects of Pratima security is the availability of a reliable power supply. In general, a power supply is a device that provides electrical energy to one or more electrical loads.

To maximize the efficiency and safety of battery charging, a power supply integrated with a smart charging feature is required. A study conducted by Reko Rivani and Ayong Hiendro [2] discussed the design of an automatic charger capable of disconnecting the charging current when the battery reaches its maximum threshold and resuming charging when the battery voltage drops to a minimum threshold.

The main difference between previous studies and this research is that the proposed smart charging power supply is applied to a Pratima security system as a backup power source using simple equipment at an affordable cost. In previous research, the system was connected to a website for monitoring smart charging power, whereas this study utilizes Telegram for power monitoring and for sending notifications when the battery is fully charged.

The primary objective of this research is to maintain battery power quality, prevent overcharging, and reduce the risk of battery damage. The output of this study is the development of a power supply system with a smart charging feature for a Pratima security system. This system is designed to send text-based battery status notifications via Telegram when the battery reaches full capacity. The proposed technology is expected to be applicable to other devices as well.

## 2. Research Method

The method used in this research includes the stages carried out in conducting research. These stages are carried out to get the research results as expected. The primary method used is the waterfall method, which includes other methods such as system block diagrams, system overviews, hardware requirements, software requirements, hardware design, software design, and flowcharts.

### 2.1 Research Flow

The research workflow represents a series of processes carried out to obtain information in this study. The research workflow for this study is illustrated as follows.

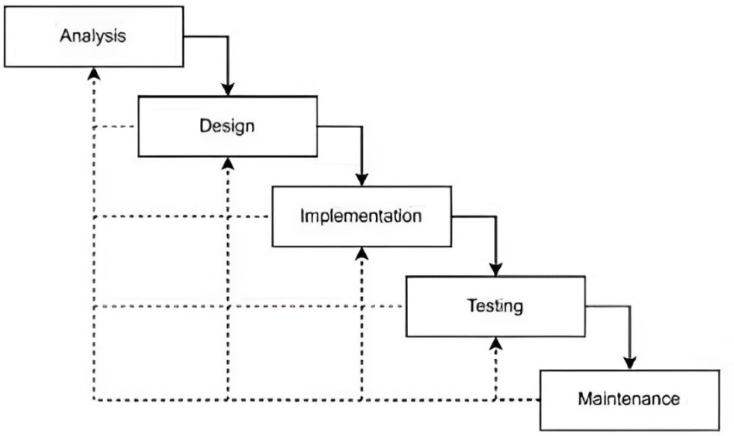


Figure 1. Waterfall Method

The Waterfall model on Figure 1 is a sequential application development model that flows downward in stages, resembling a waterfall, and is part of the Software Development Life Cycle (SDLC) methodology. The Waterfall model is recursive in nature, where each stage can be repeatedly revisited and refined until the stage is fully completed and perfected.

### 2.2 Block Diagram

A block diagram is a visual tool used to simplify complex systems, processes, or workflows. The following block diagram illustrates the research entitled Design of a Power Supply with IoT-Based Smart Charging Features for Pratima Security in the Temple.

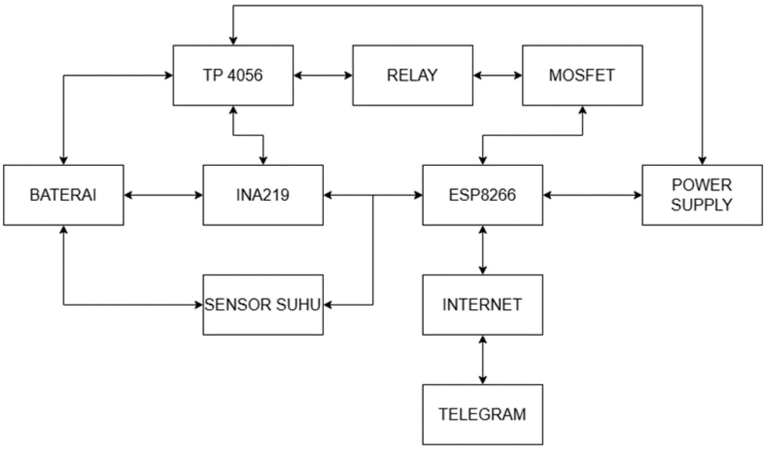


Figure 2. Block Diagram

Figure 2. presents the block diagram of the study entitled Design of an IoT-Based Power Supply with Smart Charging Features for Pratima Security in the Temple. The ESP8266 is used as the main microcontroller of the system. In addition, the system consists of an INA219 module, a TP4056 charging module, a relay, a MOSFET, and a temperature sensor, which together support the implementation of the smart charging feature. The power source used in this system is an 18650 lithium-ion battery. Telegram is integrated into the system to provide notification and monitoring of the smart charging power supply.

### 2.3 System Overview

The general overview of the research object provides a comprehensive description that facilitates the researcher in conducting the study and analyzing the resulting research data. The general overview of the research is presented as follows.

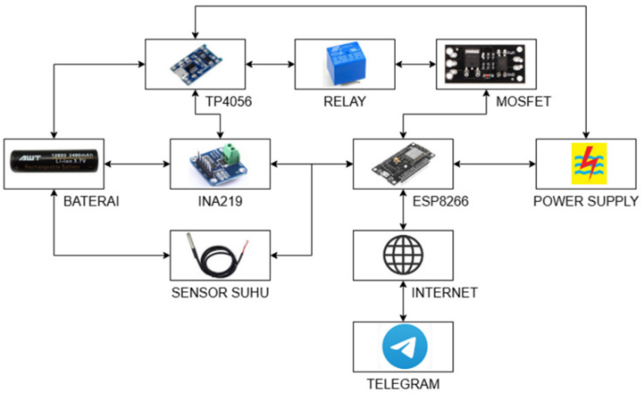


Figure 3. System Overview

Figure 3. illustrates the general overview of the Design of an IoT-Based Power Supply with Smart Charging Features for Pratima Security in the Temple. The main component of the proposed power supply system is the ESP8266 microcontroller, which is responsible for sending notifications via Telegram when the battery reaches full capacity. An 18650 lithium-ion battery is used as the primary power source. The INA219 sensor is utilized to measure the battery voltage and power consumption. Under certain operating conditions, the electrical current is disconnected using a relay, which is integrated with the TP4056 battery charging module. In addition, a temperature sensor is implemented to monitor the battery temperature and overall battery condition.

### 2.4 Hardware

Hardware refers to components that have a physical form and can be seen and physically touched. Hardware functions to perform processing, input, and output operations. The hardware requirements used in this research are described as follows.

Table 1. Hardware Requirements

| Hardware | Description |
|---|---|
| NodeMCU ESP8266 | Microcontroller used for IoT devices |
| TP4056 | Module used to charge 18650 batteries |
| INA219 | Sensor module capable of monitoring voltage and current |
| DS18B20 Temperature Sensor | Module used to measure battery temperature |
| Relay | Module used as a switching device |
| Mosfet | Breakout board module for the D4184 transistor |
| Battery | Lithium battery with a cylindrical shape, 18 mm in diameter and 65 mm in length |

Table 1. presents the hardware components used in this study. The hardware utilized in the Design of an IoT-Based Power Supply with Smart Charging Features for Pratima Security in the Temple includes the NodeMCU ESP8266 microcontroller, TP4056 module, INA219 sensor, DS18B20 temperature sensor, relay module, MOSFET module, and a 18650 battery.

### 2.5 Software

Software refers to applications or programs designed to support research activities, enabling the implementation of the research in an efficient and effective manner. The software required for this study is described as follows.

Table 2. Software Requirements

| Software | Description |
|---|---|
| Arduino IDE | Arduino IDE is used to create, edit, verify, and upload program code to the microcontroller. |
| Telegram | Telegram is used to monitor the smart charging system through notification messages. |
| Fritzing | Fritzing is used to design and visualize the hardware layout. |
| Diagram.net | Diagram.net is used to create diagrams, flowcharts, and system overviews. |

Table 2. lists the software requirements used to support the research on the Design of an IoT-Based Power Supply with Smart Charging Features for Pratima Security in the Temple. The software used includes Arduino IDE, Telegram, Fritzing, and Diagram.net.

### 2.6 Hardware Design

The overall system design involves the integration of previously designed module circuits. The complete system circuit of this research is explained in the following figure.

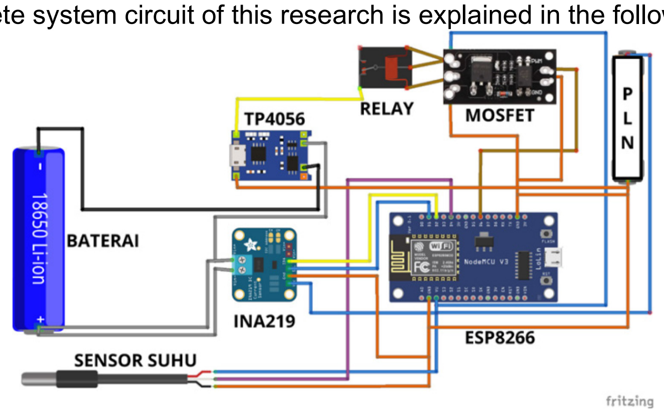


Figure 4. Hardware Design

Figure 4. presents the complete system circuit of the Design of an IoT-Based Power Supply with Smart Charging Features for Pratima Security in the Temple. This overall circuit integrates all modules and components into a smart charging power supply system. The components used include the ESP8266 as the main microcontroller and as an internet connectivity module for sending notifications via Telegram, the INA219 as a current and voltage monitoring sensor, the TP4056 as a battery charging module, the DS18B20 temperature sensor for monitoring battery temperature, a relay for controlling electrical current, and a Mosfet board based on the D4184 transistor. The power source used in this system is a Li-ion 18650 battery.

### 2.7 Software Design

The software design involves the development of a user interface focused on the Telegram application in the Design of an IoT-Based Power Supply with Smart Charging Features for Pratima Security in the Temple, with the objective of monitoring the battery condition.


Figure 5. Software Design

Figure 5. shows the software design using the Telegram application, specifically a Telegram Bot, as a tool for monitoring and providing notifications regarding the battery condition in the implementation of the IoT-Based Power Supply with Smart Charging Features for Pratima Security in the Temple.

### 2.8 Flowchart Design

A flowchart or process flow diagram represents the workflow of the system implemented in this research. The flowchart design of the study is explained in the following figure.

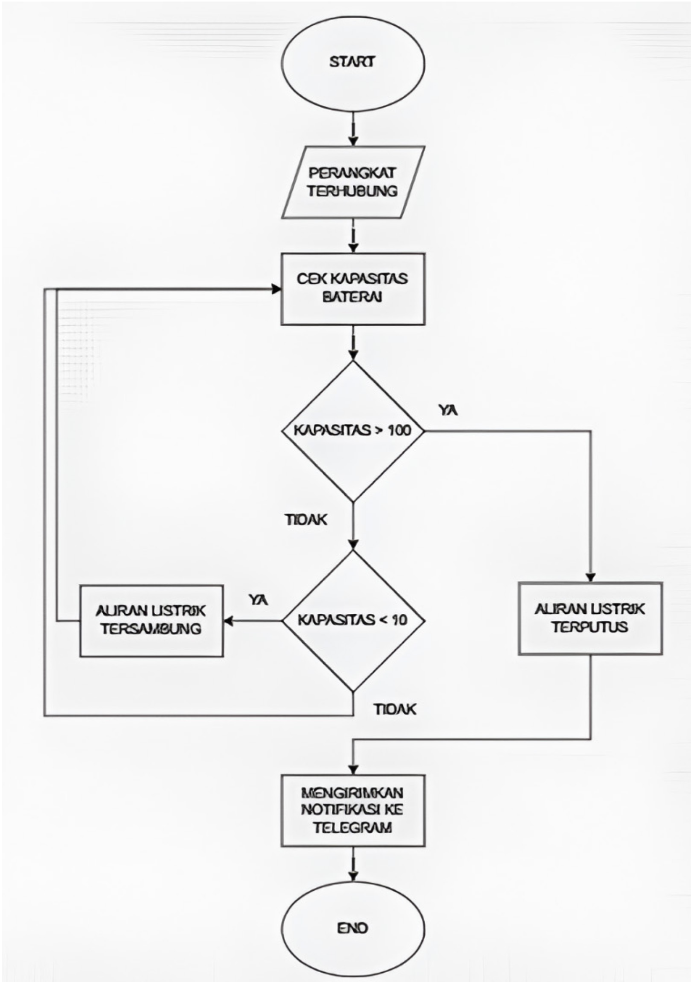

Figure 6. Flowchart Design

Figure 6. illustrates the flowchart of the IoT-Based Power Supply System with Smart Charging Features for Pratima Security in the Temple. The purpose of this system is to prevent battery damage or degradation in battery quality and to address battery overcharging by implementing smart charging features. When the battery reaches full capacity, the system automatically stops the charging process, and when the battery reaches its minimum threshold, the charging process is resumed automatically.

## 3. Literature Study

The literature study refers to general concepts used to broaden the researcher's understanding and to serve as a guideline in the research entitled Design a Power Supply with IoT-Based Smart Charging Features for Pratima Security in Temple. The following section presents the explanation of the literature review that will be discussed.

### 3.1 Internet of Things

The Internet of Things (IoT) is one of the innovations developed due to its advantages in terms of functionality and its ability to support operations without dependence on cables or through network-based systems. IoT, which stands for Internet of Things, refers to a concept or program in which objects have the capability to send or transmit data through a network without the need for computer devices or human intervention.[3]

### 3.2 Arduino IDE

Arduino IDE (Integrated Development Environment) is a software application that plays a crucial role in the development of Arduino projects, in addition to the Arduino board itself. IDE stands for Integrated Development Environment, which can be defined as an integrated environment used for software development.[4]

### 3.3 Smart Charging

Smart charging is a term used to describe a charging control method aimed at minimizing electricity usage costs. Smart charging refers to an intelligent charging process that is useful for maintaining battery quality and power efficiency. The charging process will resume automatically under certain conditions, such as when the battery level is low. This automatic recharging mechanism is referred to as smart charging.[5]

### 3.4 18650 Battery

The 18650 battery, also known as the 18650 cell, is a cylindrical lithium-ion battery commonly used in electronic devices. The battery has a diameter of 18 mm and a length of 65 mm, which is the origin of the name 18650. The nominal operating voltage of an 18650 battery is 3.7 volts.[6]

### 3.5 INA219

INA219 is a current and voltage sensor developed by Texas Instruments. This sensor is designed to measure electrical current and voltage in electronic systems with a high level of accuracy. INA219 uses the I2C communication protocol and can be applied in various applications such as power monitoring, current measurement in solar panels, and power conversion efficiency measurement.[7]

### 3.6 NodeMCU ESP8266

NodeMCU is an open-source IoT platform and development kit that uses the Lua programming language to support the prototyping of IoT products or can be programmed using sketches through the Arduino IDE. With dimensions of 4.83 cm in length, 2.54 cm in width, and a weight of 7 grams, NodeMCU is equipped with built-in WiFi features and open-source firmware.[8]

### 3.7 TP4056

TP4056 is a rechargeable battery charging module specifically designed for lithium-ion (Li-ion) batteries. This module is equipped with two indicator LEDs that provide information regarding the battery charging status.[9]

### 3.8 Temperature Sensor DS18B20

The DS18B20 temperature sensor is a probe-shaped sensor capable of measuring temperature in water. This sensor is waterproof, making it highly suitable for measuring the temperature of liquids being monitored.[10]

### 3.9 Mosfet

The MOSFET module is a breakout board designed for the D4184 MOSFET transistor, which can be used to control high-power DC loads using only a single digital pin from a microcontroller or Arduino. This driver features a fast switching time, making it suitable for Pulse Width Modulation (PWM) control from a microcontroller.[11]

### 3.10 Relay

The relay module is an electronic device that operates based on electromagnetic principles to control electrical contacts or contactors, with the purpose of switching states from ON to OFF or vice versa. The relay module enables effective control of electrical current or other electronic devices, facilitating automatic power regulation and switching.[12]

### 3.11 Telegram

Before smartphones became popular, Telegram was known as a postal service that enabled the rapid delivery of written messages over long distances. The name Telegram was later adopted by a startup that transformed it into a modern application. Telegram is now a cloud-based instant messaging application that emphasizes speed and security. It is designed to transmit various types of messages, including text, voice, video, images, and stickers.[13]

## 4. Result and Discussion

This section presents the results of the developed device, including the realization of the hardware and the implementation of the system design proposed in this study. The following subsections describe the results and discussion of the research.

### 4.1 Hardware Design Implementation

The results of the Internet of Things (IoT) device development that was previously designed are implemented in a physical form and utilized in this research. The following describes the results of the hardware development used in this study.

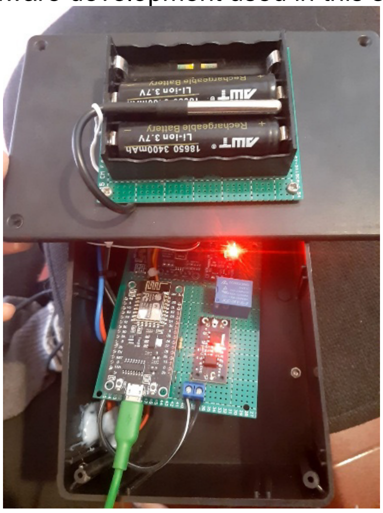

Figure 7. Hardware Design Implementation

Figure 7. shows the result of the hardware implementation in the study entitled Design of an IoT-Based Power Supply with Smart Charging Features for Pratima Security in the Temple, which utilizes an ESP8266 microcontroller, DS18B20 temperature sensor, INA219 module, relay, Mosfet, and battery.

### 4.2 Smart Charging Notification Testing

The smart charging notification test was conducted to verify the proper operation of the system developed in this research. The following program code is used to send notifications to Telegram.

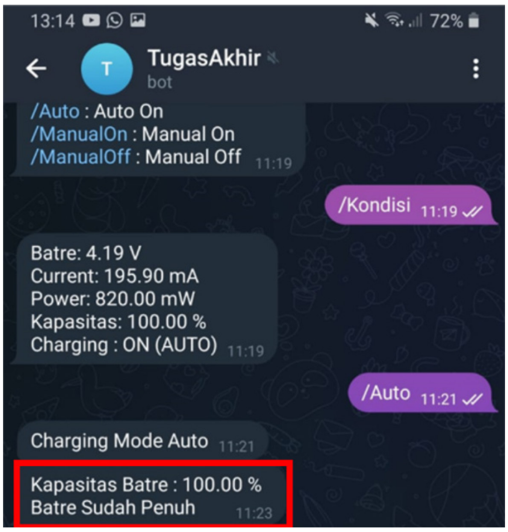


Figure 8. Software Design Implementation

Figure 8. presents the results of the notification testing on the smart charging power supply. When the battery reaches its maximum capacity, the system automatically sends a

notification to Telegram in the form of a full battery message along with the battery capacity information.

### 4.3 Battery Charging Test

Battery monitoring testing was performed using the INA219 module. This test was conducted to ensure the proper operation of the system developed in this research. The following program code is used to monitor the battery status displayed in the Telegram menu.

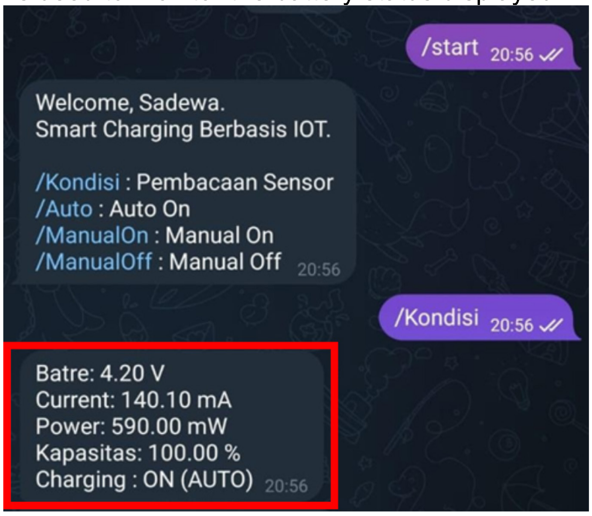


Figure 9. Battery Charging Test

Figure 9. shows the results of battery monitoring testing on the smart charging power supply. The Telegram application provides a sensor reading menu that utilizes the INA219 sensor. In the condition section, which represents the INA219 sensor readings, the system provides information regarding the battery condition. The following presents the results of the battery charging test conducted in this research.

Table 3. Battery Charging Test Results

| Experiment | Current (mA) | Power (mW) | Time (Minutes) |
|---|---|---|---|
| 1 AWT Battery | 195.90 | 820.00 | 38 |
| 1 AWT Battery | 151.00 | 632.00 | 37 |
| 1 AWT Battery | 140.10 | 590.00 | 37 |
| 1 AWT Battery | 139.70 | 584.00 | 38 |
| 2 AWT Batteries | 374.40 | 1560.00 | 68 |
| 2 AWT Batteries | 405.60 | 1688.00 | 74 |
| 2 AWT Batteries | 421.50 | 1746.00 | 77 |

Table 3. presents the results of battery charging tests conducted in this study. The tests were performed using one battery and two batteries of the same brand. Charging with one battery required approximately 37 to 38 minutes, while charging with two batteries of the same brand required approximately 60 to 70 minutes.

### 4.4 Battery Temperature Measurement Testing

Battery temperature measurement testing was conducted using the DS18B20 temperature sensor module, which is used to determine the battery temperature in this study. The following program code is used to send notifications to Telegram.

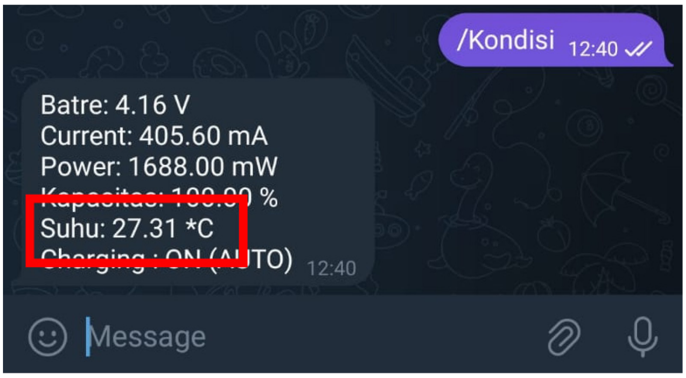

Figure 10. Battery Temperature Testing

Figure 10. shows the results of battery temperature measurements on the smart charging power supply system. The DS18B20 temperature sensor is attached directly to the battery, allowing it to measure the battery temperature. The temperature data is then transmitted to the ESP8266 microcontroller and displayed together with the battery condition data obtained from the INA219 module.

Table 4. Battery Temperature Test Results

| Experiment | Battery | Temperature (C) |
|---|---|---|
| First experiment | 1 AWT Brand Battery | 27.19 |
| Second experiment | 1 AWT Brand Battery | 27.19 |
| Third experiment | 1 AWT Brand Battery | 26.31 |
| Fourth experiment | 1 AWT Brand Battery | 26.75 |
| Fifth experiment | 2 AWT Brand Batteries | 27.31 |
| Sixth experiment | 2 AWT Brand Batteries | 27.44 |
| Seventh experiment | 2 AWT Brand Batteries | 26.38 |
| Eighth experiment | 2 AWT Brand Batteries | 26.31 |
| Ninth experiment | 2 AWT Brand Batteries | 26.25 |
| Tenth experiment | 2 AWT Brand Batteries | 26.19 |

Table 4. presents the results of battery temperature testing. The tests were conducted ten times, where four tests used one battery and six tests used two batteries, performed at different times and durations. The average battery temperature during the testing ranged between 26°C and 27°C.

### 4.5 Simulation of Pratima Security

The Pratima security system designed by Putu Prayoga Diatmika is used in this study as a simulation load for the smart charging power supply as a backup power source. The devices or modules used in the Pratima security system design consist of a NodeMCU ESP8266 microcontroller, motion sensor, buzzer, keypad, and TM1637 seven-segment display. Each module requires a different amount of power consumption. To determine how long the smart charging power supply can back up the Pratima security system, it is necessary to calculate the power requirements of each component used in the security system.

Table 5. The Power Required by Each Component

| Component | Power Required |
|---|---|
| ESP8266 Microcontroller | 70mA |
| PIR Motion Sensor | 32mA |
| Buzzer | 20mA |
| 4x4 Keypad | 10mA |
| Seven-Segment TM1637 | 80mA |

The Pratima security system used in the simulation consists of five components, each with different power consumption levels. The total power consumption required by the Pratima security system is approximately 212 mA when operating in active mode.

### 4.6 Power Supply Calculations

The Pratima security system requires a continuous power supply to ensure proper operation during power outages; therefore, a backup power source in the form of a smart charging power supply is required. The Pratima security system consumes approximately 212 mA when the system is active.

$$\text{Time (hours)} = \frac{\text{Battery Capacity (mAh)}}{\text{Load Current (mA)}}$$

$$\text{Time (hours)} = \frac{405{,}60}{212}$$

$$\text{Time (hours)} = 1.91 \text{ hours or } 1 \text{ hour } 54 \text{ minutes}$$

Figure 11. Power Supply Calculations

Figure 11. shows the smart charging power supply system using two batteries with a total battery capacity of approximately 405.60 mAh is able to back up the Pratima security system for 1 hour and 54 minutes. This duration represents the operating time of the security system while running in active mode.

## 5. Conclusion

The results of this study indicate that the smart charging power supply system is capable of sending notifications via Telegram when the battery is fully charged. The battery condition can also be monitored through the condition menu, which displays a battery voltage of 4.18 V, a capacity of 405.60 mAh, a power measurement of 1688.00 mW, a battery capacity of 100%, and a battery temperature of 27.31°C. The charging test results show that charging a single battery requires approximately 37 to 38 minutes, while charging two batteries requires approximately 60 to 70 minutes. The temperature measurement test during the charging process indicates that the battery temperature ranges from 26 to 27°C.

The simulation of this study on the Pratima security system begins with calculating the total power consumption of the system. The Pratima security system consists of several components, including the NodeMCU ESP8266 microcontroller, motion sensor, buzzer, keypad, and TM1637 seven-segment display. The total current consumption of the system, after accumulation, is 212 mA. The smart charging power supply, which utilizes two batteries with a total capacity of 405.60 mAh, is capable of providing backup power to the Pratima security system for 1 hour and 54 minutes when the system operates in active mode.

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