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UPS design using lithium-ion batteries, automatic smart charging, and monitoring with blynk application

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ABSTRACT
This study aims to determine the results of UPS design using Lithium ION batteries, automatic smart charging, and monitoring with the Blynk application. This study uses an experimental research design to test and implement Uninterruptible Power Supply (UPS) that uses Lithium-Ion batteries and Automatic Smart Charging with monitoring through the Blynk application. An Uninterruptible Power Supply (UPS) is an electrical backup device in case of a sudden power outage. A modified Valve Regulated Lead Acid (VRLA) battery replaces it with an 18650 Lithium-ion battery, which is parallelized in series to produce the same 12V voltage. DC because this Lithium battery has a longer life than VRLA batteries. In this final project, the author uses the Blynk application to monitor batteries and automatic smart charging, making it easier and more practical. The results of this study state that the tool can operate optimally without hurting the electronic devices tested.

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INTRODUCTION

The global energy crisis and the increasing need for electrical energy have become serious challenges in managing energy resources sustainably. Countries worldwide, including Indonesia, face pressure to provide an adequate electricity supply to a growing population. At the national level, Indonesia is experiencing the problem of rotating power outages caused by load capacity exceeding the capacity determined by PLN. Sudden power outages can cause damage to electronic equipment and loss of data being processed, resulting in serious repercussions on people's productivity and comfort.

The increasing demand for national electrical energy resulted in PLN having to carry out power cuts in rotation because the load capacity had exceeded the predetermined capacity. A sudden power outage will cause electronic equipment to be damaged quickly, and the work (data) being done will be lost. To anticipate this, you can apply an additional Uninterruptible Power Supply (UPS) as a backup electrical energy provider when the main supply is cut off. The application of modified lithium-ion (Li-ion) batteries presents higher power capabilities and a greater energy density because Li-ion batteries can produce more power with less footprint and lower weight. Li-ion batteries can be three times more compact and six times lighter than batteries (VRLA). In addition, the Li-on battery has a longer life; the charger used on the UPS generally uses the old way, which is using a battery charger, which takes a very long time, 12 hours. The author has an idea to charge the battery on the UPS automatically, namely by using automatic smart charging. Automatic smart charging makes it easier for the UPS to optimize existing power and charge the battery automatically. If the UPS battery runs out of power, the UPS battery will always be ready to use (standby); another advantage of automatic smart charging is that users can find out the battery capacity and in and out of power using digital monitoring via the Blynk application.

Although Uninterruptible Power Supply (UPS) is a common solution to overcome power outages, there is still a need for improved UPS efficiency and reliability. Previous research may not fully integrate new battery technologies like lithium-ion (Li-ion) and intelligent automatic charging systems. This research proposes modifying the UPS by replacing conventional batteries with Lithium-Ion batteries and implementing Automatic Smart Charging. Lithium-ion batteries are expected to increase the capacity, efficiency, and life of the UPS. Meanwhile, using Automatic Smart Charging is expected to increase UPS power availability and provide ease of monitoring through the Blynk application.

The main objective of this research is to improve UPS's efficiency and reliability through battery modification and implementation of Automatic Smart Charging. In addition, this study aims to provide solutions that can overcome the negative impact of power outages on electronic equipment and data. The results of the study are expected to contribute to optimizing the use of UPS with the latest technology, minimizing damage to electronic equipment, and protecting data from loss due to power outages. The implications of this research could stimulate innovation in providing backup electrical energy and developing more efficient battery technologies globally. In addition, implementing Automatic Smart Charging and monitoring via the Blynk application can provide ease of use and monitoring for UPS users.

METHODS

This study uses an experimental research design to test and implement Uninterruptible Power Supply (UPS) that uses Lithium-Ion batteries and Automatic Smart Charging with monitoring through the Blynk application. The population of this study is all UPS devices that will be implemented with Lithium-Ion batteries and Automatic Smart Charging. The sample of this study was selected by purposive sampling method by taking several representative UPS units to be tested and monitored. Instruments used in the study include a modified UPS with Lithium-Ion batteries, Automatic Smart Charging, NodeMCU Esp 8266, and the Blynk app. Data collection is done by observing UPS performance, measuring battery capacity, and monitoring charging automatically through the Blynk application. Data analysis is done by analyzing UPS performance, measuring battery capacity, automatic charging speed, and successful monitoring through the Blynk application. The data will be processed and interpreted to evaluate the effectiveness of the modified UPS. This research is expected to contribute to developing a more efficient and practical UPS by utilizing Lithium-Ion battery technology and Automatic Smart Charging integrated with the Blynk application.

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Uninterruptible Power Supply (UPS)

In electrical terms, the definition of UPS is a device whose function is to back up electrical power in the event of a sudden power outage to prevent damage to the electronic device it records. The UPS uses energy from a dry battery to carry out its function, which is then converted to an alternative current (AC) voltage using an inverter circuit.

UPS Components

- Transformer
- Rectifier (Coordinator)
- Smoothing Filter
- Battery
- Inverter

Types of Uninterruptible Power Supply (UPS)

- Standby UPS
- Line Interactive UPS
- Standby-Ferro UPS
- Double Conversion On-Line UPS
- Delta Conversion On-Line UPS

Lithium-ion Battery

Lithium-ion batteries are one type of secondary battery (rechargeable battery) that can be recharged and are not harmful to the battery ecosystem because they do not contain harmful materials

Various Lithium-Ion Batteries

- Lithium Cobalt Oxide
- Lithium Manganese Oxide
- Lithium Feed Phosphate
- Lithium Nickel Mangan Cobalt Oxide
- Lithium Nickel Cobalt Aluminium Oksida
- Lithium Titanate

Lithium-Ion Battery Components

a. A negative electrode (anode) is a stain that functions as a collector of lithium ions and is an active material.
b. Positive Electrode (Cathode), an electrode whose capacity is equivalent to the anode, which is the authority of dynamic particles and materials. However, the important thing is that the cathode is the positive terminal.
c. Electrolyte: The electrolyte is the part that guides lithium particles from the anode to the cathode or vice versa.
d. Separator: A separator is a material between the anode and cathode, preventing a short circuit from contact between the cathode and anode.

IoT

The Internet of Things is an idea that aims to develop the advantages of endlessly connected web networks. The Internet of Things refers to objects that can be recognized as virtual depictions in Internet-based constructions.

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Blynk App

Blynk is an iOS and Android OS application to control Arduino, NodeMCU, Raspberry Pi, and so on via the Internet. Blynk will be created on the web and prepared for the Internet of Things.

NodeMCU ESP8266

NodeMCU is an Internet of Things (IoT) product development board based on eLua Firmware and System on a Chip (SoC) ESP8266-12E. ESP8266 is a WiFi chip with a complete TCP/IP protocol stack. The author chose NodeMCU ESP8266 because it is easy to program, has an adequate I/O pin, and can access the Internet to send or retrieve data via a WiFi connection. The specifications of NodeMCU are as follows.

Table 1. NodeMCU Specifications

10 port pin GPIO
PWM functionality
I2C and SPI interfaces
1 Wire interface
ADC

Sumber: www.eprints.akakom.ac.id 2015

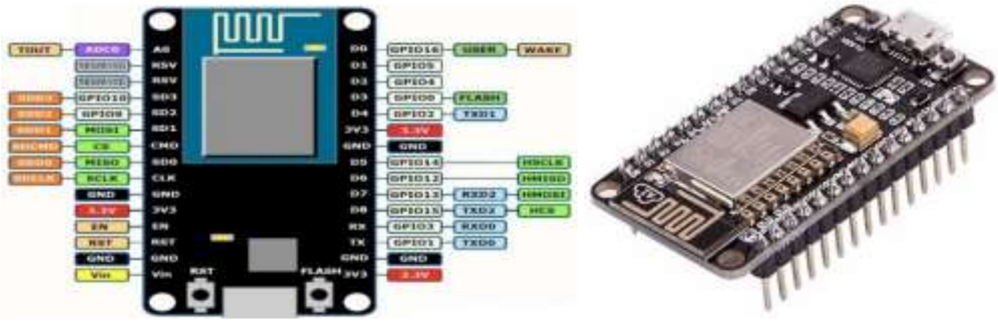

Figure 1. NodeMCU ESP826 and Pin Scheme
Sumber: www.eprints.akakom.ac.id 2015

The picture above is the footpin on NodeMCU.

Module Relay

A relay module is an electrically operated switch that turns a circuit on or off using a much higher voltage or current than the NodeMCU can handle. There is no connection between the low-voltage circuit operated by the NodeMCU and the high-power circuit. Relays protect each circuit from each other. Each channel in this module has three connections named NC, COM, and NO. The NC and NO relay sections connect the power source (phase cable) with the SPO terminal. The type of contact used in this device is Normally Closed (NC) so that the source connection to the SPO is closed under normal conditions. The contact will be automatically disconnected (open) when the current is over.

The transistor switch connects the relay's winding part (coil) to the NodeMCU control pin. The selected relay network, the 2-channel 5 V relay module, is shown in Figure 2.

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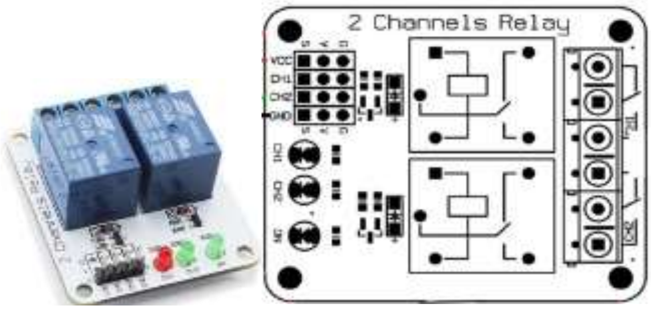

Figure 2. Relay Module and Schematic
Sumber: www.eprints.akakom.ac.id 2015

DC's Tegang Sensor

DC voltage sensors work based on field effects. This current sensor can be used to measure AC or DC. This sensor module has an operational amplifier circuit, so the current measurement sensitivity increases and can measure small changes. These sensors are used in industrial, commercial, and communication applications. Examples of applications include motor control sensors, power usage detection and management, sensors for switched power supplies, overcurrent protection sensors, and so on. ACS712 Current Sensor Specifications:

Table 2. ACS712 current sensor specifications

ACS712-based features: The time of increase in external changes = 5 μs. Frequency width up to 80 kHz. The total output error is 1.5 at working temperature TA= 25°C. Internal conductor resistance 1.2 mΩ. Minimum insulation voltage of 2.1 kVRMS between pins 1-4 and 5-8. Output sensitivity 185 mVA. Able to measure AC or DC up to 5 A. The output voltage is proportional to the input of AC or DC. Working voltage 5 VDC.

Sumber: www.eprints.akakom.ac.id 2015

This sensor works because the current read flows through the copper wires, generating a magnetic field captured by the integrated field IC and converted into proportional voltage. Accuracy in sensor readings is optimized by installing the components contained in it between the conductor that generates the magnetic field and the field transducer nearby.

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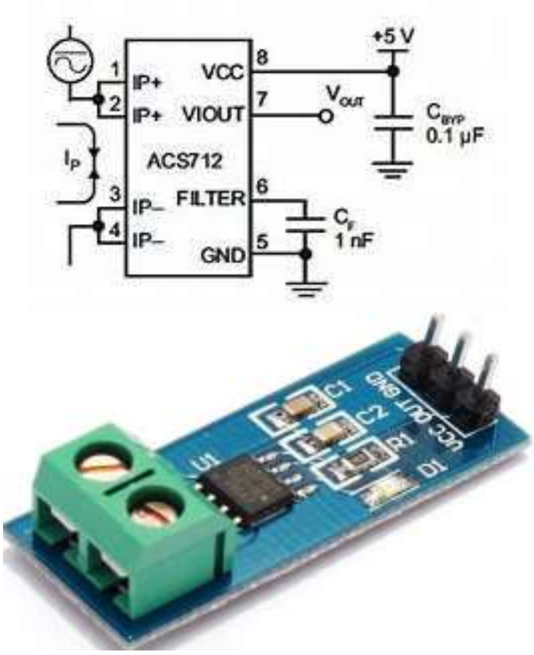

Figure 3. ACS712 Voltage sensor module and scheme
Sumber: www.eprints.akakom.ac.id 2015

Tool Planning

Types of Planning

Design (UPS) using Li-ion batteries and automatic smart charging is done by modifying or changing VRLA batteries with lithium-ion batteries. This battery replacement is used to find efficiency to provide sufficient power sources in equipment, generally for backup power in case of a PLN power outage. By doing the series-parallel installation of this type of battery, it gets the same capacity, voltage, and amperes as the capacity of VRLA batteries. The design of automatic smart charging is carried out to supply voltage and amperes according to what the lithium-ion battery needs to work properly.

Design Method

First, the voltage from the PLN AC source enters the automatic charger. There are several components, such as the CT travo, to reduce the voltage of 220V to 12-15VDC, and there is also an automatic kit that functions as a breaker and connector of current flowing to the travo from PLN.

Furthermore, the output of the automatic charger then enters the lithium-ion battery by paralleling 12 batteries and serializing the three groups of batteries that have been paralleled to get the desired capacity and voltage after the DC voltage from the battery and then converted with the inverter so that it makes the AC voltage 220V with a frequency of 50Hz or 60Hz.

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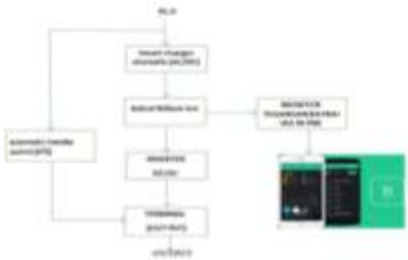

Figure 4. UPS planning scheme
Source: personal design

The output from the inverter is directly connected to the terminal point so that it can easily be used for the load. As for monitoring the voltage on the battery here is also used the blynk application that has been programmed to monitor the status of the battery using an Android smartphone.

Planning Instruments

Design of lithium nickel manganese cobalt oxide battery with type 18650, voltage 3.7 volts DC 9.25 WH, capacity 2,500 mAH to be 12 volts DC 26,400 mAH,

Lithium-ion Battery Series Range

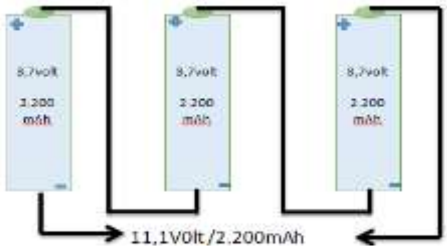

Figure 5. Serial Range Battery
Source: personal design

This series is used to increase or increase the voltage of the battery. Specified in the Formula and calculation as follows:

Vtot = Vbat1 +Vbat2 + Vbat3
Vtot = 3.7V + 3.7V + 3.7V
Vtot = 11.1 V

Parallel Circuit Lithium-ion Battery

This circuit is used to increase or increase the capacity of the battery.

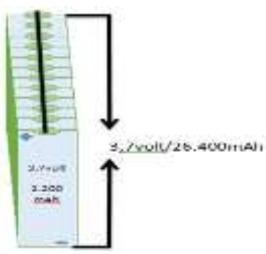

Figure 6. Parallel circuit battery
Source: personal design

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Specified in the Formula and calculation as follows:

Itot = Ibat1 +Ibat2 + Ibat3

Itot = 2.000mAH + 2.200mAH + 2.200mAH

Itot = 26,400mAH

Seri-Parallel Network and Connection to BMS

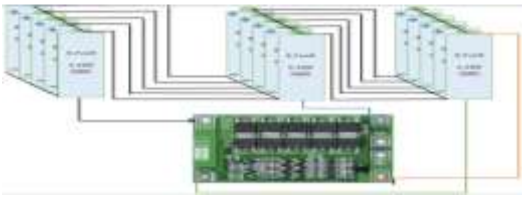

Figure 7. Battery circuit after connecting with BMS
Source: personal design

The connection of the batteries already on the parallel series raft and the BMS installation. The BMS above uses BMS 3S, which means three series where at the terminal holes, there are 0V negative, 4, 2V, 8, 4V, AND 12.6V

Battery Management systems (BMS)

BMS is a technology that functions to maximize pack battery life. The goal is to ensure the battery stays within its ideal working parameters.

Functions and How BMS Battery Works

Some of the functions and workings of the battery management system include:

1) Charge balancing,
2) Active balancing,
3) Temperature monitoring is used to avoid damage due to overheating.
4) Low tensile cut-off (low-voltage cut-off),
5) Pemantauan state of charge (SOC)

Automatic Smart Charging Design

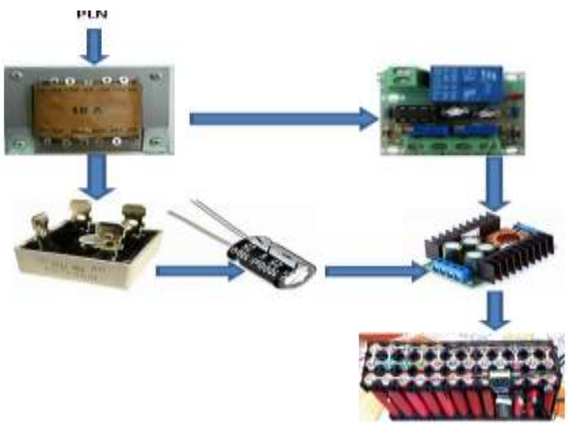

Figure 8. Network Smart Charger Automatic
Source: personal design

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Using the electrical voltage from PLN entered into the automatic kit (ACH SP) at the IN 220 terminal, this terminal is phase and neutral connected. The 220V output terminal is connected to the CT 5Amper travo input as a step down, terminal 0 and connected because there are 2 keyholes at the terminal. This automatic kit to regulate the voltage that enters this automatic kit is set at 11.9 V on and 12.6 V off.

Battery Monitoring by using the Blynk application on Android

Figure 9. Battery monitoring design scheme
Source: personal design

A VCC and GND, pin voltage sensor, connected to a battery will be monitored on the NodeMCU that has been programmed using the Arduino program. Before that, the MCU Node is given a 5-volt DC power supply for operation and a connected relay to control DC and AC output. NodeMCU's Wi-Fi is connected to the Blynk application to Android to monitor battery voltage via smartphone.

Arduino programming for Blynk applications

Float programming for two resistors of 30K ohms and 7500Ω. Chad auth is an activation code from blynk Chad id = Pass token = password. Starting my string to complete the message and select resistors and Chatr sensor data where to receive characters. To move the program from Arduino to the Blynk app.

Figure 10. Arduino programming to NodeMCU
Source: personal design

Application project startup blynk connect to NodeMCU

The Blynk application has 3 main components: the application, Server, and Libraries. Blynk Server functions to handle all communication between smartphones and hardware. Widgets available on Blynk include buttons, value display, history graph, Twitter, and email. How to manufacture a user interface on Blynk as follows:

a. Open the Blynk app and create an account to get an auth token sent via email.

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Figure 11. The beginning of the Blynk application project
Source: Personal documents

b. After the auth token is obtained, you can start adding widgets to support the End Project view, such as buttons

Figure 12. Use of Button
Source: Personal documents

BATTERY TEST RESULTS

Battery Charging Process One by One

Battery testing: the battery charging module is TP4056 1A USB type micro to determine each battery's voltage. (Fig. 13)

Figure 13. Lithium-ion battery charger
Source: Personal documents

Battery Draining/Discharging Process

The process of draining the battery to find out the capacity of each battery.

Figure 14. degradation of battery by sculpting
module HW-586/Zhiyu battery capacity meter
Source: Personal documents

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Preparation

Using 2 3x5 holders and 2 1x3 holders, the total battery is 36 pieces. Battery soldering uses a 0.1x8mm nickel plate to connect one battery to the next.

Figure 15. Installation of holders and soldering nickel plates on batteries and installation of BMS
Source: Personal documents

Automatic Smartcharger Testing

In this automatic charger test,

Table 3. Battery charging testing (charger)

NO	BATTERY VOLTAGE	CHARGER VOLTAGE	TIME	EFFICIENCY
1	12.0V	13.5V	5 HOURS	GOOD
2	11.1V	13.5V	6 HOURS	GOOD
3	12.5V	17.8V	2 HOURS	NOT GOOD (HOT)

Table 3 shows that the battery voltage of 11V with a charger voltage of 15.8V takes up to 6 hours to charge the battery to a voltage of 12.3V fully. Then, if the battery voltage is at 11.5V, it will shorten the charging time, which is 4 hours, while if the battery voltage is higher, it will shorten the battery charging time by only 2 hours.

Programming results

Figure 16. Arduindo Program for Blynk Application
Source: personal documents

This program is an address to connect the Arduino program to the Blynk application by registering an account first on the Blynk application. After registration, the user will get a verification sent to email, then connect the account to the smartphone with a coding chart and variables to set up the relay.

Figure 17. Inputs and Outputs
Source: personal documents

This program connects with the Blynk application, where the author can write the wifi address connected to the smartphone and can give commands through variables and integers to give sensor addresses or pins on the MCU NODe.

Figure 18. Void Setup and Void Loop
Source: personal documents

Void setup is a mandatory component in the Arduino program; this command only works once the tool starts running. Meanwhile, the void loop will continue to work, continuously reading commands from beginning to end until the tool is turned off.

Gambar 19. Blynk write
Source: personal documents

This programming is made to monitor the UPS through the Blynk application, where we can find out the voltage on the battery that is ON and the voltage on the battery that is

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OFF. So, the IoT system in the UPS that we make functions to find charger control and battery monitoring.

Figure 20. Serial Monitor
Source: personal documents

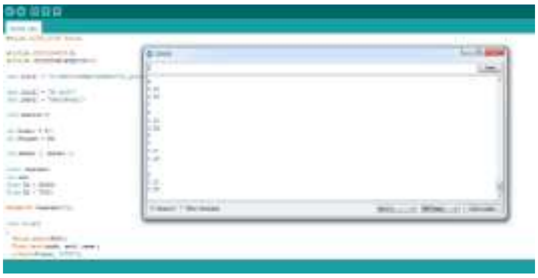

Figure 21. Serial Monitor
Source: personal documents

This serial monitor is in the output state of 0 or off. If the output is 1 or ON, then the battery voltage will be read on the serial monitor, and the Blynk application will show the value of the battery voltage; in the output state of 0, then the relay does not work if the output is ON or 1 then really will be active.

Figure 22. Blynk app
Source: personal documents

The image above is 3 examples where the first image from the left shows the application is off. The middle picture shows the output in the ON or 1 state, where the voltage sensor reads at 12.3 volts, and the input in the OFF or 0 state, where the voltage from PLN does not enter because the input controls the voltage from PLN. The third picture

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shows where the input and output are ON so that the battery voltage value is read and the voltage from PLN enters. This is the process of caring.

Program Testing

Program testing is used to minimize workflow errors, making it easier to find errors in the workings of each component used in program testing divided into several parts. Among them are voltage sensor program testing and relay program testing.

Relay

Figure 23. Relay
Source: personal documents

Relays with light-up indicators are both in the input state and the output in the ON state. The relay on 1 is in the input state of PLN On.

Battery

Figure 24. Battery Indicator
Source: personal documents

This battery display shows a battery voltage of 12.6V. This will turn on when the voltage from PLN is connected, and when charging, the volt amper meter will show the voltage value and current flowing in the battery.

Trial Results

In this sub-chapter, the author will describe the results of testing tools that have been made. The tool that has been made, Uninterruptible Power Supply (UPS) with a voltage of 12.6VDC, is tested on two fan units with 45 watts of power each and one lamp unit with 10 watts. In testing the two electronic devices, the UPS that has been made can last up to 1.5 hours (90 minutes). Then, the author retested the three electronic devices to ensure the UPS's accuracy. After repeated trials, the results obtained remained the same, which lasted 1.5 hours (90 minutes). From a voltage of 12.6VDC, the power will automatically stop delivering voltage at 10.7VDC, and then smart charging will automatically turn on (Cut On). To ensure that the testing of the tool is successful and safe, the author conducts testing again using a multitester to check that all components are not damaged and normal as before

CONCLUSION

After observing and researching for almost 4 months on the Uninterruptible Power Supply (UPS) using Lithium-Ion batteries and Smart Charger, the author concluded that the device can operate optimally without hurting the electronic devices tested. In tests on two fan units with a power of 45 watts each, the author found no damage or weakness in the components, especially the capacitors, which are a vital part of the fan. Similarly, on testing one unit of a 10-watt lamp, the authors did not observe significant changes in the light produced, indicating that the power supply transition from PLN to UPS did not affect the lamp's performance. Overall, the results of this study indicate that UPS with lithium-ion batteries and Smart Charger can be relied on to maintain smooth power on electronic devices without causing negative impacts on the components tested.

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