DESIGN OF AUTOMATIC CHANGE OVER SWITCH (ACOS) PROTOTYPE USING MICROCONTROLLER BASED ON INTERNET OF THINGS (IOT)

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ABSTRACT
Electricity supply from PLN is not always stable and sometimes experiences interruptions due to problems in the transmission or distribution system of the main power source. To overcome this problem, a backup source such as PLTS is required. The Automatic Change Over Switch (ACOS) system is designed to detect failures and automatically switch to an alternative power source when a disconnection occurs. It allows switching from PLN power supply to solar panel automatically. This ACOS is controlled by Wemos and equipped with a PZEM-004T sensor. The system can be monitored and set up via an Internet of Things (IoT) Smartphone app in manual or automatic mode.

Keywords : *Automatic Change Over Switch (ACOS), Solar Cell, Microcontroller Wemos D1 Mini, Internet of Things (IoT)*

1. INTRODUCTION

Electrical energy is now a crucial element in our lives. Most of the appliances that support our daily activities use electrical energy as their power source. With the increase in population and technological advancements, the demand for energy and fuel continues to rise. However, this is in contrast to the decreasing availability of primary fuels. To meet the growing demand for energy, various alternative energy sources, including renewable energy, are being developed by the government. Solar Power Plant (PLTS) is expected to be one of the mainstay alternative energy sources to meet electricity needs in the future. Indonesia has a huge potential for solar energy, especially since most of its territory has a tropical climate, which is suitable for the development of this alternative energy. Although the production of solar power plants is quite complex and expensive, its environmentally friendly construction makes it increasingly applied in Indonesia.

Some areas in Indonesia still do not get a full and stable electricity supply for 24 hours. In addition, rolling blackouts also often occur as a result of which not a few residents complain. Moreover, if the rotating blackout occurs long enough, it will greatly disrupt the activities of the residents. With a solar power system as a backup power source and PLN as the main power source, automatic switching from the main source to a backup source that does not take a long time is one solution so that residents' activities are not disrupted. ACOS is a device or system capable of automatically and in a short time switching the load from the main power supply to the backup power supply. The microcontroller works based on the program embedded in it. The microcontroller will monitor and determine the source used to back up the load, then ACOS will switch the source of electrical energy, where there is an interlock system as a means to lock between the use of two sources so as not to enter the load simultaneously.

The potential for solar energy in Indonesia is very large, especially since Indonesia has a tropical climate where sunlight is suitable for alternative energy. Although its production is quite complex and expensive, its environmentally friendly construction and operation make this plant widely used in Indonesia. With a solar power system as a backup power source and PLN as the main power source, automatic switching from the main source to a backup source that does not take a long time is one solution so that residents' activities are not disrupted. With the above problems, this final project research will raise the title “DESIGN OF AUTOMATIC CHANGE OVER SWITCH (ACOS) PROTOTYPE USING MICROCONTROLLER BASED ON INTERNET OF THINGS (IOT)”.

1.1 Problem Formulation

Based on the background description above, the author can draw the following problem formulations:

1. How does the ACOS prototype work using an IoT-based microcontroller?2.
2. What are the test results of the ACOS prototype using an IoT-based microcontroller?

1.2 Problem Limitation

To avoid too complex problems that arise, the author may need to limit the discussion of this problem, as follows:

1. This tool only makes a prototype design, not an actual tool design.
2. The electricity generated by this tool design is only used for simulation not the actual tool. So that the resulting voltage is small.
3. The remote monitoring process is only limited to the voltage generated along with the control of turning on and off.

1.3 Research Objectives

The research objectives of the final project, among others:

1. Knowing how the ACOS prototype tool works using an IoT-based microcontroller.
2. Knowing the test results of the ACOS prototype using an IoT-based microcontroller.

2. METHODS

2.1 Research Design

The design of the Automatic Change Over Switch (ACOS) prototype using a microcontroller based on the Internet of Things (IoT) is designed with the hope that it can be implemented according to its main function in terms of helping human activities so that they are not disturbed in the event of a power outage from PLN.

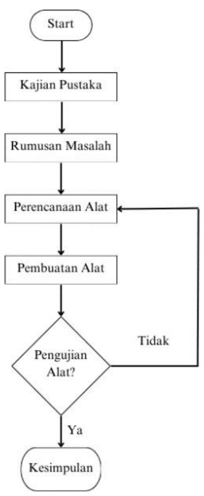

Figure 1 Research Design

In the picture above this research starts from a literature review to find a collection of basic reference theories about Automatic Change Over Switch (ACOS), solar cells, microcontrollers, and the Internet of Things (IoT). Looking for several references so that problems such as how to make, how to work, and how the test results of the Automatic Change Over Switch (ACOS) prototype using an Internet of Things (IoT) based microcontroller and continued with problem formulation, after formulating the problem, the design of the tool is carried out and manufacturing starts from the tool design. Furthermore, testing the Automatic Change Over Switch (ACOS) prototype design tool using an Internet of Things (IoT) based microcontroller is carried out, if it works, data collection is carried out, then the data taken can be analyzed so that we get results and conclusions. If it does not work, it will return to designing the tool. Research completed.

2.2 Tool Design

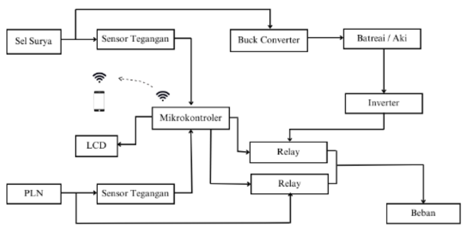

Figure 2 Tool Design

The block diagram above can be seen that there is a voltage sensor that functions to detect whether or not the voltage of the Solar Cell power supply source and PLN. Automatic Change Over Switch (ACOS) consisting of ATS is a system for switching electrical energy sources equipped with a relay as a switch, and a microcontroller that regulates which source must be used so as not to enter the load simultaneously. Then the data obtained will be displayed through the LCD screen. The voltage sensor will detect whether there is voltage coming from PLN. If there is voltage at PLN, it can be monitored through the LCD screen, and if the voltage sensor does not detect any voltage at PLN, the system will read automatically as a temporary diversion of electrical energy sources by Solar Cells. Vice versa, if the source from PLN has returned to normal then the Automatic Transfer Switch (ATS) will work automatically switching the source from Solar Cell to PLN source. The microcontroller will monitor and determine the source used to back up the load. With the PZEM sensor, we can see the results of current, voltage, and which source is used to back up the load.

2.3 Wiring Diagram

The following is a wiring diagram of the Automatic Change Over Switch (ACOS) prototype design using an Internet of Things (IoT) based microcontroller.

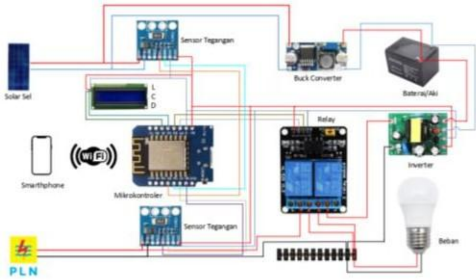

Figure 3 Wiring Diagram of ACOS Prototype using IoT-based microcontroller

2.4 Tool Components

A. Hardware

1. Solar Cell

Figure 4 Solar Cell

Solar cells are active components that convert sunlight into electrical energy. Solar cells are composed of several materials, including protective glass and transparent adhesives that protect the cells from environmental conditions. In addition, there are anti-reflection materials that help absorb more light and reduce light reflection. In this study, a crystalline type of solar cell with a power of 10Wp was used.

2. Buck Converter

Figure 5 Buck Converter

Buck converter is used to regulate the voltage from the solar panel to match the voltage needed in the battery charging process. The output voltage can be varied based on the duty cycle of the control.

3. Battery

Figure 6 Battery

The battery serves to store electrical energy generated by solar panels in the form of direct current. The energy stored in the battery acts as a backup (back up) and is usually used when solar panels do not produce electricity. In this research, a Lithium type battery with a capacity of 5V is used.

4. Inverter

Figure 7 Inverter

An inverter is a device that converts direct current (DC) voltage into alternating current (AC) voltage. The main function of the inverter is to convert the DC input voltage into a symmetrical AC output voltage with the desired magnitude and frequency. The energy stored from solar cells in the battery will be converted from DC to AC current before being applied to the load.

5. INA226 Sensor

Figure 8 INA226 Sensor

The INA226 sensor is a multifunctional sensor module, for example used for measuring DC voltage and current contained in an electric stream. Basically the way INA226 works is the same as INA219. This sensor flows the current to be measured through the IN+ and IN- terminals through a shunt (current resistor). The A/D converter measures the voltage drop across the shunt and the INA226 calculates the current.

6. PZEM-004T Sensor

Figure 9 PZEM-004T Sensor

The PZEM-004T is a sensor that measures various parameters, including voltage, current, active power, and power consumption (Wh). The module comes with a wiring system consisting of two parts: one wire for connecting the voltage and current terminals, and the other wire for serial communication.

7. LCD (*Liquid Crystal Display*)

Figure 10 LCD (Liquid Crystal Display)

LCD (Liquid Crystal Display) is a type of display that uses liquid crystal as the main media. One of the LCD variants is the 20x4 LCD, which can display up to 80 characters in 4 lines, with each line displaying 20 characters. On Arduino, the 20x4 LCD is used to display information in a structured manner, a default library called LiquidCrystal.h is available. LCDs are available in various sizes such as 8x1, 16x1, 16x2, 16x4, and 20x4. To control these LCD sizes, you can follow this tutorial, with the only difference being the initialization of the number of columns and rows.

8. Relay

Figure 11 Relay

Relay is an electronic component that functions as an electrically controlled electrical switch, consisting of two main parts: electromagnetic (coil) and mechanical (switch contacts). This switch is operated based on electromagnetic principles, allowing high-voltage electricity to be controlled by low-power electric current.

9. Wemos D1 Mini

Figure 12 Wemos D1 Mini

The Wemos D1 mini is a small WiFi board that uses the ESP8266 chip, known for its affordable price and reliable performance. This ESP8266 allows microcontrollers like Arduino to connect to the internet via a Wi-Fi network. The Wemos D1 mini can be used to create small projects without the need for an Arduino as a microcontroller, as this module can work independently or stand-alone in processing every line of code or program entered.

B. Software

1. Arduino IDE

Figure 13 Arduino IDE

The Arduino IDE, or Arduino Integrated Development Environment, is software designed to write code for the Arduino. Arduino utilizes a modified version of the C programming language. Programs created in the Arduino IDE are called sketches and are saved in text format with the extension .ino. The Arduino IDE serves as a text editor for writing, editing, and validating code, as well as for uploading it to the Arduino board. At the bottom of the Arduino IDE is a black window that displays the status of various activities, including error messages, compilation, and upload processes.

2. Thingspeak

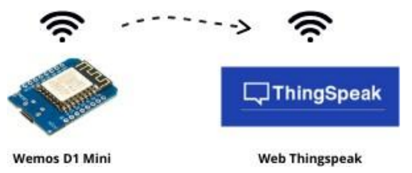

Figure 14 Thingspeak

On this platform, users can upload sensor data from various development boards or websites. Data uploaded to Thingspeak can be set as private or public. The data is presented in the form of channels that contain visualizations. This application is useful for storing sensor data. Users who want to utilize this web must first register. Data from the Wemos D1 mini microcontroller will be sent wirelessly to the Thingspeak web, which can be accessed via laptop or smartphone.

2.5 Tool Testing Techniques

This testing technique is carried out to determine the work of the tools that have been made and determine whether the tool works according to the procedure, therefore it is necessary to test the tools that have been designed. In this testing process the author performs the process of switching from the main power supply (PLN) to the backup power supply (Solar Cell). Which relay will energize when the solar cell start and stop process. Can the ACOS process be controlled manually via a smartphone. In addition, the author compares the voltage that can be monitored through the smartphone display with the voltage displayed on the LCD.

3. RESULTS AND DISCUSSION

3.1 Research Result

A. ACOS Testing Results Manually

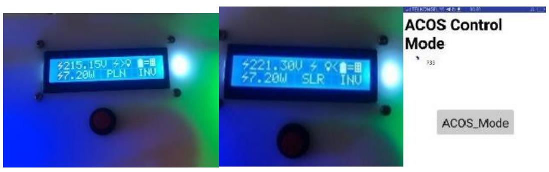

Figure 15 Manual ACOS testing

Manual testing of the Automatic Change Over Switch (ACOS) system is done by manually switching the power source via a button on the device or via a smartphone. With this method, the system will switch to the backup power supply, and the switch can be monitored via the LCD or smartphone screen.

Table 1 ACOS circuit testing conditions manually

	R1	R2	Kondisi Beban
PLN ON SOLAR SEL OFF	ON	OFF	ON
PLN OFF SOLAR SEL ON	OFF	ON	ON

When the main source (PLN) is deliberately moved, the backup power supply source (Solar Cell) will automatically back up and if the main source (PLN) is moved back, it switches back to the main source (PLN).

B. Automatic ACOS Testing Results

Table 2 ACOS Testing Results Automatic

Testing of the Automatic Change Over Switch (ACOS) circuit is carried out automatically to switch the source of electrical energy from the main power supply or PLN to the backup power supply or solar panel during a blackout. This switching process can be monitored through the LCD and smartphone screen

Table 3 Testing condition of ACOS circuit automatically

	R1	R2	Kondisi Beban
PLN ON SOLAR SEL OFF	ON	OFF	ON
PLN OFF SOLAR SEL ON	OFF	ON	ON

When the system receives electricity supply from PLN or solar panel, the user can monitor the system through LCD and smartphone. If there is a failure in the electricity supply, the system will shut down and the load will not function. The system is equipped with a relay that functions as a switch to switch between different power sources.

C. Solar Cell Testing

- measurement day 1

Table 4 Solar cell measurement day 1

Waktu Pengukuran (WIB)	Tegangan (Volt)
08.00	12,91
09.00	13,10
10.00	13,23
11.00	13,29
12.00	13,22
13.00	13,28
14.00	13,09
15.00	12,95
16.00	12,91

- measurement day 2

Table 5 Solar cell measurement day 2

Waktu Pengukuran (WIB)	Tegangan (Volt)
08.00	12,58
09.00	12,81
10.00	12,90
11.00	13,10
12.00	13,17
13.00	13,20
14.00	13,24
15.00	13,19
16.00	12,80

- measurement day 3

Table 6 Solar cell measurement day 3

Waktu Pengukuran (WIB)	Tegangan (Volt)
08.00	12,57
09.00	13,82
10.00	13,28
11.00	13,21
12.00	13,31
13.00	13,30
14.00	13,41
15.00	13,06
16.00	12,97

From the table data obtained, it can be concluded that the voltage and current measurements on Solar Cells carried out for several days produce different voltage values. In the test results of the table above, it can be seen that the voltage obtained changes from the smallest with a voltage of 12.57 V at 08.00 WIB, which then rises continuously until the highest voltage value is at 14.00 WIB of 13.41 V. Then it drops again with the final voltage at 17.00 WIB of 12.97 V. Then it dropped again with the final voltage at 17.00 WIB of 12.97 V.

D. Buck Converter Testing

Table 7 Buck converter value measurement

Percobaan ke	Tegangan Input	Tegangan Output
1	12.80 VDC	5.19 VDC
2	12.83 VDC	5.16 VDC

The above test is carried out to find out whether the buck converter can work properly or not when reducing the voltage from 12V to 5V. Measurements are made on the input and output sides of the Buck Converter to determine the voltage value, the results of the above test which initially had a voltage of 12.80VDC dropped to 5.19 VDC. This proves that the buck converter works well as a voltage reducer.

E. Battery Testing

Table 8 Battery value measurement

Waktu Pengukuran (WIB)	Tegangan (Volt)
08.00	12,84
09.00	12,90
10.00	12,87
11.00	12,89
12.00	12,92
13.00	12,90
14.00	13,13
15.00	12,87
16.00	12,80

The battery charging test results show that the highest voltage was recorded at 2:00 pm, with a value of 13.13 V, while the lowest voltage was recorded at 5:00 pm, with a value of 12.80 V.

F. Inverter Testing

Table 9 Inverter value measurement

Percobaan ke	Tegangan V out Ideal	Pengukuran menggunakan Multimeter
1	220 VAC	230 VAC
2	220 VAC	237 VAC

The above test aims to convert DC mains voltage into AC mains voltage. The inverter receives a DC voltage source as input, which can come from a battery. From the test results, it can be concluded that there is a voltage difference between the ideal output voltage and the measurement with a multimeter. However, this difference is still within the tolerance limits so that it does not affect the performance of the tool circuit.

G. INA2226 Sensor Testing

Table 10 INA226 Sensor value measurement

Percobaan ke	Daya pada LCD	Daya pada smarthphone
1	3,13 Watt	3,15 Watt
2	3,50 Watt	3,45 Watt
3	3,20 Watt	3,20 Watt

Based on the test results, it can be concluded that the INA226 sensor has functioned properly as expected.

H. PZEM-004T Sensor Testing

Table 11 PZEM-004T Sensor value measurement

Percobaan ke	Tegangan pada LCD	Tegangan pada smarthphone
1	223 VAC	215 VAC
2	218 VAC	214 VAC
3	222 VAC	228 VAC

From the test circuit data above, it can be concluded that the PZEM-004T sensor has worked well as desired. The results of the above tests can be concluded that there is a voltage difference between the output voltage results through the LCD screen and through the smartphone screen. But the difference in the test results is still within the tolerance value so that it does not affect the device circuit.

I. Wemos D1 Mini Testing

Figure 16 Wemos D1 Mini Testing

Based on the tests carried out in the picture above, when the Wemos D1 Mini is functioning properly, the value is approximately 5V and the blue light will be on.

J. Relay Testing

Figure 17 Relay Testing

Based on the tests shown in the figure above, the relays function properly when tested using an avometer, indicating that the relay contacts are working optimally.

K. Arduino IDE Testing

The initialization process uses the Arduino IDE application. Can be done with several steps, among others:

1. The first step is to click the icon . After that the program will load with the display below

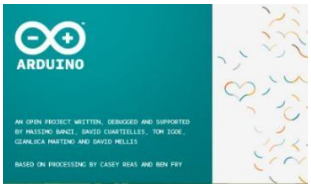

Figure 18 Arduiono IDE Initial Loading View

Figure 19 Arduino IDE Sketch View

2. Next, the program that has been made is entered into the Arduino software and compiled. Testing is done by checking the function of each existing port.

Figure 20 Arduino IDE program

3. If the program runs well, a done compiling notification will appear.

L. Internet of Things (IoT) Testing

Testing on the Internet of Things (IoT) which aims to facilitate the Automatic Change Over Switch (ACOS) monitoring control system in my tool using a smartphone as the main interface equipped with a control and monitoring display. In this tool using a website server as an interface for monitoring and applications for control, equipped with a user and password before the login display so that some people can access it as technicians.

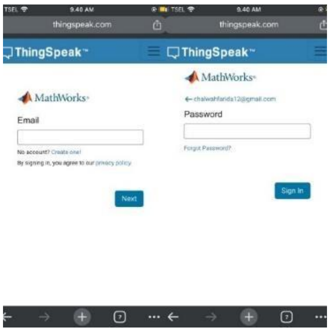

Figure 21 Display before Login

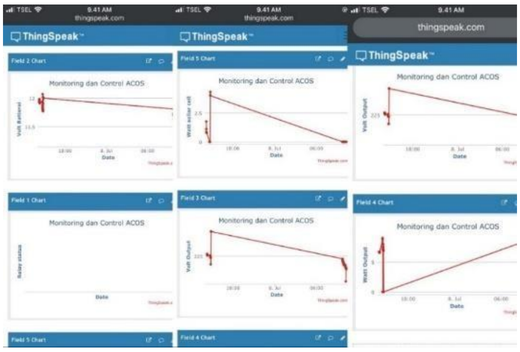

Figure 22 Display After Login

3.2 Hardware and Application Synchronization

In this test, synchronization is carried out between the hardware and the application used. The purpose of synchronization on this tool is to find out whether it can work harmoniously at the same time between the hardware and the application used.

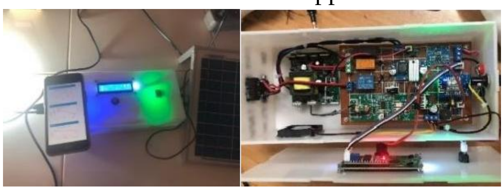

Figure 23 Hardware and Application Synchronization

Hardware and application synchronization experiments located on a website with the address thinspeak.com, obtained results in accordance with the desired design workings. Where when the hardware and applications start running, they can work in harmony and can be monitored and controlled through the smartphone screen interface.

4. CONCLUSIONS AND SUGGESTIONS

Conclusion

1) After designing the Automatic Chnage Over Switch (ACOS) system using an Internet of Things (IoT) Based Microcontroller, conclusions can be drawn, among others: In the design of this prototype tool there are two sources of electrical power supply used, namely the main power supply source (PLN) and the backup power supply source (Solar Cell) which works alternately. Automatic Change Over Switch (ACOS) which is a system for switching electrical energy sources equipped with a relay as a switch, and a microcontroller that regulates which source must be used so as not to enter the load simultaneously. Then the data obtained will be displayed through the LCD screen.
2) After testing this tool that the Automatic Change Over Switch (ACOS) circuit system can work properly where when the main power supply source experiences interference / disconnection then ACOS will automatically move / switch to a backup power supply source with a predetermined delay, and vice versa if the main power supply has returned to normal it will move the load back to the main power supply source.

Suggestions

1) Prototype design and monitoring using microcontrollers can be further developed by adding various additional power supply sources to create new innovations in renewable energy.
2) In the Automatic Change Over Switch (ACOS) Prototype Design with an Internet of Things (IoT) based microcontroller by adding varied controls and monitoring so that more complete data is obtained.

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