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MPPT (Maximum Power Point Tracker) System in PLTS And Micro hydro Based on IoT (Internet of Things)

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Abstract - Electrical energy from a generator that utilizes the movement of an object. Over time, innovations in environmentally friendly power plants have emerged. One of them by utilizing the energy of water and the energy of sunlight (solar). Water energy can be used to drive turbines on micro hydro, while solar energy is used to supply solar cells. Micro-hydro and solar cells can be combined into one, creating a more effective solution called hybrid generation. However, the average output power that comes out of the micro-hydro and solar cells cannot be maximized. So, to overcome this we need to create a control system in order to get the maximum output power, this control tool is called the Maximum Power Point Tracker (MPPT). Voltage and current entering and leaving the MPPT can be monitored in real time using an Internet of Things (IoT) based smartphone.

Keywords: Solar Cell, Micro hydro, Maximum Power Point Tracker, Internet of Things

I. INTRODUCTION

Renewable energy is energy obtained from the earth's natural resources which are unlimited and never run out. Renewable energy can be created by utilizing increasingly sophisticated technological developments, so that it can become an alternative energy source. The types of renewable energy are solar energy, wind energy, water energy, wave energy, ocean thermal energy, etc. Photovoltaics converts solar energy directly into electrical energy using the photoelectric effect [1]. However, the level of sunlight at any time can vary.

PLTMH (Micro hydro Power Plant) is one of the plants whose basic principle of work is to utilize the potential energy possessed by the flow of water at a certain height distance from the power plant installation. The amount of water discharge that varies from time to time causes the results of the output power of the MHP to vary and not optimal. Different levels of solar radiation and varying outputs of MHP cause the results of the output power of solar cells to vary and not maximize [2]. From the above problems I tried to design a "MPPT (Maximum Power Point Tracker) System in PLTS and Micro hydro Based on IoT (Internet of Things)". So that the output power that comes out of PLTS and micro-hydro can be maximized, MPPT will be installed. And in this tool, I use the Internet of Things (IoT) which functions as monitoring the parameters of the output current and output voltage on the PV, Micro hydro, and MPPT. So that the output current and output voltage can be adjusted view on the smartphone in real time.

II. LITERATURE REVIEW

Solar panels are components that can convert solar energy (the sun) into electrical energy using a principle called photovoltaic. The way solar panels work is to submit sunlight and store the energy produced in a battery [3]. With this, the system can run even in the afternoon or even in rainy conditions. The solar panel can be seen in Figure 1.

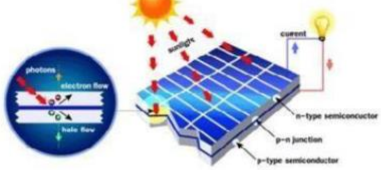

Figure 1. Solar Panel

MHP (Micro hydro Power Plant) is a technology to utilize the water discharge that is around us to be converted into electrical energy. This is done by utilizing the water discharge to drive a turbine which will produce mechanical energy [4]. Furthermore, this mechanical energy drives a generator and generates electricity. Micro hydro can be seen in Figure 2.

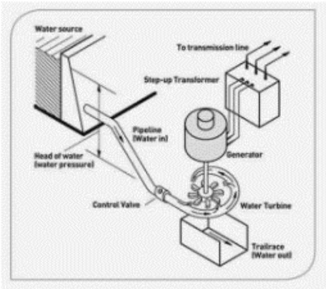

Figure 2. Micro hydro

Buck Converter is a DC voltage converter which is used to lower the DC voltage from PV to a lower level. Buck Converter has the advantage that it does not require a transformer and the ripple at the output voltage is also low. Buck Converter is needed when the desired output voltage remains at a predetermined level even though the input voltage (eg from PV) has risen to a level that is no longer effective for the performance of a converter circuit. Buck Converter is a DC voltage converter used to lower DC voltage from PV to lower levels. Buck Converter has the advantage that it does not require a transformer and the ripple at the output voltage is also low. Buck Converter is needed when the desired output voltage remains at a predetermined level even though the input voltage (eg from PV) has risen to a level that is no longer effective for the performance of a converter circuit.

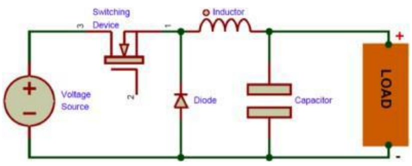

Figure 3. *Buck Converter*

Boost Converter is a DC voltage converter that is used to increase the DC voltage from Micro hydro to a higher level. Boost Converter is needed when the desired output voltage remains at a predetermined level even though the input voltage (e.g., from a micro hydro) has decreased to a level that is no longer effective for the performance of a converter circuit. Boost Converter can be seen in Figure 4.

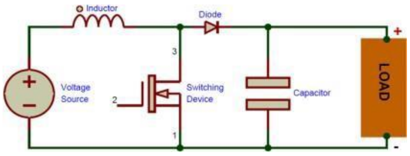

Figure 4. *Boost Converter*

Arduino Uno is a microcontroller development kit based on the ATmega28. Arduino Uno is a board of the Arduino family. The Arduino Uno board has 14 digital input/output pins, 6 analog inputs, a 16MHz ceramic resonator, a USB connection, a power input jack, an ICSP header, and a reset button. Arduino Uno can be seen in Figure 5

Figure 5. Arduino Uno

Battery (Accu/Battery) is an electrochemical component that produces voltage and can be supplied to an electrical circuit. Batteries are the main source of electrical energy used in vehicles and electronic devices [5]. Batteries do not store electricity, but instead contain chemicals that can produce electrical energy. The battery can be seen in figure 6.

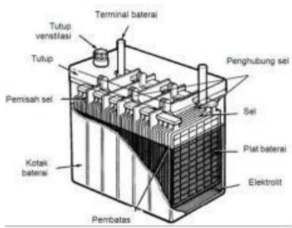

Figure 6. Battery

The DC voltage sensor serves as a tool used to measure or determine the DC voltage parameters that are at the output voltage of the PV and the output voltage of the MPPT. To measure the DC voltage, the DC voltage sensor is controlled by Arduino Uno. The DC voltage sensor can be seen in Figure 7.

Figure 7. DC Voltage Sensor

Current Sensor ACS712 is a current sensor that works based on field effects. This current sensor can be used to measure AC and DC currents. This sensor module is equipped with an operational amplifier circuit, so that the current measurement sensitivity is increased and can measure very small current changes. The ACS712 current sensor can be seen in Figure 8.

ESP32 is a microcontroller introduced by Expressive System which is the successor of the ESP8266 microcontroller. In this microcontroller, there is already a Wi-Fi module in the chip, so it is very supportive for creating Internet of Things application systems. seen in the picture above is the pin out of the ESP32[6].

Figure 8. ACS712 Current Sensor

These pins can be used as inputs or outputs to turn on the LCD, lights, and even to drive a DC motor. ESP32 can be seen in Figure 9.

Figure 9. ESP32

MIT App Inventor is a platform to facilitate the process of creating simple applications without having to learn or use too many programming languages [7]. We can design android applications as we wish by using a variety of layouts and components available. The MIT APP Inventor data application is shown in Figure 10.

Figure 10. MIT APP Inventor App

III. METHODS

The design stage for this tool starts with a literature study, then continues with component requirements analysis, followed by tool design and tool testing.

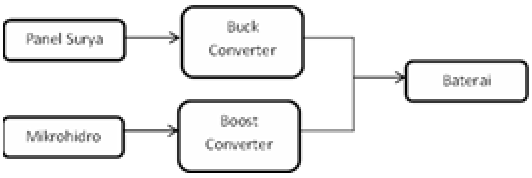

Figure 11. MPPT System Work Diagram on PLTS and Micro hydro [10]

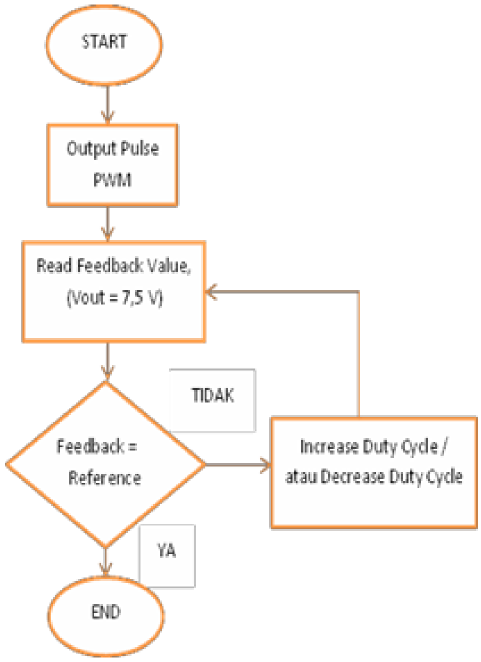

Figure 12. *Flowchart* Program *Buck Converter*

1. Based on the flowchart above, the PWM pin will set how much PWM value is used to produce an output voltage value of 7.5V.
2. Reading the feedback voltage that enters the circuit, is the feedback voltage the same as the reference voltage or not? Using the desired reference voltage of 7.5V.
3. If the feedback voltage = reference voltage, the process can end immediately.
4. However, if the feedback voltage is < reference voltage, it will enter the process of decreasing duty cycle according to the predetermined set point.
5. If the feedback voltage > reference voltage, it will enter into the process of increasing duty cycle (addition of duty cycle) according to the set point that has been determined.
6. The process will continue to repeat until it produces an error = 0 which means the value of the feedback voltage = reference.

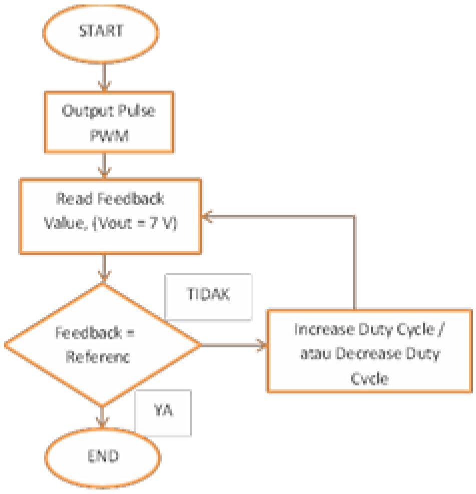

Figure 13. *Flowchart* Program *Boost Converter*

1. Based on the flowchart above, the PWM pin will set how much PWM value is used to produce an output voltage value of 7V.
2. Reading the feedback voltage that enters the circuit, is the feedback voltage the same as the reference voltage or not? Using the desired reference voltage of 7V.
3. If the feedback voltage = reference voltage, the process can end immediately.
4. However, if the feedback voltage > reference voltage, it will enter into the process of decreasing duty cycle (reduction of duty cycle) according to the predetermined set point.
5. If the feedback voltage is < reference voltage, it will enter the process of increasing duty cycle
   (addition of duty cycle) according to the
   predetermined set point.
6. The process will continue to repeat until it produces an error = 0 which means the value of the feedback voltage = reference.

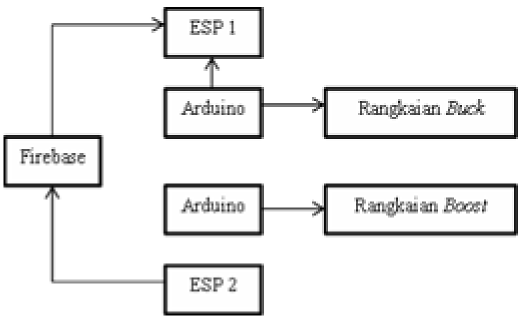

Figure 14. IoT Monitoring [9]

The following is an explanation of the IoT-based monitoring diagram, the boost converter circuit with a micro-hydro source is given an ACS712 current sensor and a voltage sensor, then the sensor will detect the current, the voltage coming out of the micro-hydro and the duty cycle controlled by the Arduino UNO [8]. After that the output current and output voltage of the micro hydro, boost converter output voltage and duty cycle are detected, then the sensor data is sent via serial communication (RX TX) to ESP32 1 and 2. ESP32 1 and 2 will send sensor data it goes to firebase. All data stored in firebase will be read by ESP32 1, from that reading will be displayed by the smartphone.

IV. RESULT AND DISCUSSION

The results and discussion of making the MPPT System PLTS and Micro hydro (Internet of Things) Based on IoT presents the following data:

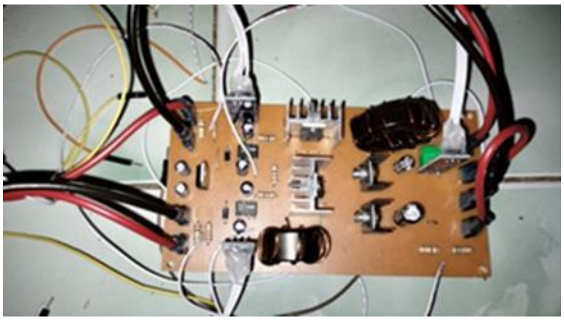

Figure 15. MPPT Circuit

The MPPT system in PLTS and micro hydro is assembled based on the simulation design that has been made. After completing the assembly, testing is carried out.

The MPPT system in PLTS and micro hydro was carried out several tests in order to obtain the appropriate data desired and to determine whether the equipment was feasible or not to be used.

1. Testing the MPPT (Maximum Power Point Tracker) Buck Converter System with 12V DC Fan Load and PCB Drill

In the table of results of testing the MPPT (Maximum Power Point Tracker) buck converter system using a 12V DC fan load and PCB drill, data is taken from 7.90V to 21.06V input. In this test, it can be seen that the average input power is 4.9W and the output voltage value is stable at approximately 7.5V as desired. While the average value of the output power is 1.7W. The average efficiency value from the test results is 29.1%. At an input voltage of 8V-10V produces an output value of 0, this is because the IR 2103 can only work at an input voltage of more than 10V and if the IR 2103 does not work, the circuit will also not work. With test results as below:

Table 1. MPPT Testing Buck Converter System with 12V DC Fan Load and PCB Drill

No.	Vin *Buck*	Iin *Buck*	Pin *Buck*	Vout *Buck*	Iout *Buck*	Pout *Buck*	Efisiensi
1.	7,90V	0,14A	1,1W	0,01V	0A	0W	0%
2.	9,00V	0,17A	1,5W	0,007V	0A	0W	0%
3.	10,00V	0,22A	2,2W	0,02V	0A	0W	0%
4.	11,00V	0,66A	7,3W	7,25V	0,38A	2,7W	37%
5.	11,90V	0,79A	9,4W	7,60V	0,39A	2,9W	38%
6.	13,00V	0,55A	7,1W	7,20V	0,33A	2,4W	34%
7.	14,01V	0,37A	5,2W	7,49V	0,088A	0,66W	13%
8.	15,15V	0,30A	4,5W	7,60V	0,174A	1,32W	29%
9.	16,01V	0,29A	4,6W	7,59V	0,206A	1,56W	34%
10.	17,02V	0,27A	4,6W	7,47V	0,209A	1,56W	34%
11.	18,14V	0,27A	4,9W	7,58V	0,339A	2,6W	53%
12.	19,05V	0,31A	5,9W	7,55V	0,349A	2,6W	44%
13.	20,02V	0,28A	5,6W	7,57V	0,346A	2,6W	46%
14.	21,06V	0,27A	5,7W	7,47V	0,353A	2,6W	46%
Rata-Rata Efisiensi							29,1%

2. MPPT Circuit Test (Maximum Power Point Tracker) Boost Converter System with 12V DC Fan Load and PCB Drill

In the table of results of testing the MPPT (Maximum Power Point Tracker) boost converter system using a 12V DC fan load and PCB drill, data is taken from 1.00V to 6.10V input. In this test, it can be seen that the average input power is 3.2W and the output voltage value is stable at approximately 7.03V as desired. While the average value of the output power is 1.2W. The average efficiency value of the circuit test is 21%. At the input voltage of 1V-2V produces an output value of 0, this is because the boost converter module cannot work and supplies voltage to the IR 2103 so that the circuit also cannot work. With test results like the table below:

Table 2. MPPT Testing Boost Converter System with 12V DC Fan Load and PCB Drill

No.	Vin *Boost*	Iin *Boost*	Pin *Boost*	Vout *Boost*	Iout *Boost*	Pout *Boost*	Efisiensi
1.	1,00V	0A	0W	0V	0A	0W	0%
2.	2,20V	0A	0W	0V	0A	0W	0%
3.	3,20V	1,03A	3,3W	2,6V	0,22A	0,6W	0,2%
4.	4,1V	1,49A	6,1W	7,03V	0,322A	2,3W	38%
5.	5,1V	0,96A	4,9W	7,04V	0,293A	2,1W	43%
6.	6,10V	0,84A	5,1W	7,06V	0,338A	2,3W	45%
Rat-Rata Efisiensi							21%

3. Results of MPPT (Maximum Power Point Tracking) Testing with PV and Micro hydro Source

Table 3. Results of MPPT (Maximum Power Point Tracking) Testing with PV and Micro hydro Sources

No.	Vin PV	Iin PV	Vin MH	Iin MH	Vout MPPT	Iout MPPT	Daya PV + MH	Daya MPPT	Effisiensi
1.	20,3V	0,14A	6,2V	0,56A	12,32V	0,19A	2,8W + 3,5W	2,3W	37%

4. Monitoring Tests on MIT APP Inventor on IoT-Based Smartphones

Figure 15. Duty Cycle Display

Figure 16. Output PV Display

Figure 17. Output Micro hydro Display

Figure 18. Output MPPT Display

Figure 19. Output Hasil Seri Display

The data above is data from the MPPT (Maximum Power Point Tracker) test of the buck and boost converter system which is read and can be displayed on the MIT APP Inverter application. The magnitude of the solar panel voltage that is read in the application is 21.1V and the current is 0.2A. while for the micro hydro voltage that is read in the application is 4.9V and the current is 0.4A. The duty cycle in the buck circuit is 7% and boost is 1%. The output of MPPT is 14.6V and current is 0.1A.

V. CONCLUSION

1. The MPPT system in PLTS and Micro hydro is made to maximize the voltage coming out of the two generators in order to get maximum power.
2. The working range of the converter needs to be determined based on the input voltage source that will be used to get the optimal duty cycle in the circuit.
3. The use of a large power load will increase the current consumption at the output so that a capacitor with a large capacity is needed to maintain the circuit so that it can work in a stable
4. condition.
5. The value of input and output voltage and current can be monitored in real time using the MIT APP Inventor application on a smartphone.

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