Control of the load supply on hybrid generating system

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Abstract. Solar Power Plants are strongly influenced by the intensity of solar radiation received by the system. For the availability of sustainable use of electrical energy from solar power, hybridization is needed with Perusahaan Listrik Negara (PLN) sources if Black Out occurs, the combination of the two electrical energy sources is known as the Hybrid Generator. Power plant hybridization is combining two or more power plants with different energy sources, to obtain synergies that provide economic and technical benefits (reliability of the supply system). Hybrid plants will have maximum use if accompanied by load control. Load control aims to efficiently regulate the use of electrical energy so that the generated electrical energy is balanced with the use of the load released so that the Hybrid Generator will not occur Black Out. Based on tests that have been carried out the intensity of sunlight affects the power produced by solar cells. The highest sunlight intensity when testing is during the day at 567 Lux with a voltage value of 21.22 V and current of 0.30 A, while the lowest sunlight intensity is at 17.00 with the intensity of sunlight 56 Lux with a voltage value of 5.5 V and current 0.15 A.

1. Introduction
Renewable energy such as solar, wind, ocean waves, geothermal energy, and others have not been utilized optimally. Solar energy is an alternative energy that has good prospects because it is always available in nature, and is a clean and renewable source of energy [1–4]. Indonesia is one of the countries that gets more sunlight than other countries, with an estimated around 4.8 kW / m² / day. Based on this phenomenon renewable energy such as solar power is one of the promising alternative energies for Indonesia. In terms of its supply, energy can be grouped into energy (non-renewable) which is used up and renewable energy (renewable). For the availability and utilization of electrical energy from hybrid solar power with PLN sources if the blackout occurs. The combination of the two electrical energy sources is known as the Hybrid Generator [5–8]. The main purpose of a hybrid system is basically to try to combine two or more energy sources (generating systems) so that they can cover each other's weaknesses and supply reliability and economic efficiency can be achieved on certain load types [9–14]. A hybrid generator will have maximum use if accompanied by load control. The use of uncontrolled loads in the Electrical Engineering Building at the State University of Malang is a problem, the use of excessive loads will affect the hybrid plant, load control aims to regulate the use of electrical energy efficiently so that the use of physical energy can be controlled and its use is not excessive.
The Building of the Electrical Engineering at the State University of Malang has three places for load use, namely, load in the building (indoor load), outside buildings (outdoor load) and illegal load, illegal loads can be inside or outside the building, this burden is known when using loads inside or outside the building its use exceeds the predetermined limit. Then the load control will be divided into three parts: (1) Load Control (Indoor Load), (2) load control (Outdoor Load), (3) load control (Illegal Load), each load will be determined capacity and limited use.

2. Methods

2.1. Block Diagram

Regarding Figure 1, the working process block diagram is as follows:

1. Solar panels serve as a means of converting energy used to charge batteries. Solar panels are mounted on the battery to get maximum sunlight, for a 500-watt panel capacity.
2. PLN is the source of a combination of hybrid plants, as a backup energy source, for PLN capacity 900 Watt 50 Hz.
3. Voltage and current sensors convert analog values to measuring units and read power when PV power is less than the specified load, the voltage and current sensors send signals to the microcontroller. The LDR sensor functions to measure the intensity of sunlight.
4. Relay On / Off functions the circuit breaker when there is more load and as a switch between sources from PV with PLN and generator on a hybrid system. LCD as monitoring power from PV and PLN and power at load.

![Figure 1. Block Diagram](image)

2.2. Flowchart

Technically, the operating condition is very important, and it should be monitored since the first condition [15–17]. In these works, the first time the device is run or initial start is the voltage sensor initialization, current sensor, LDR and rotation sensor, after initializing the sensors - the process of converting the analog value of the voltage sensor, current sensor, LDR to a unit of measurement so that the value is read and displayed in LCD, then if the energy produced by the solar cell (PV) is less than the total load, if Yes then the PLN relay automatically closes then the energy of the solar cell (PV) is replaced by the PLN, otherwise, the PLN relay is open. solar (PV), then the measuring value will be displayed on the LCD.
2.3. Mechanic Design

The explanation of the mechanical design of the Hybrid Generating System in Figure 4 is as follows: Panel Box, Panel box measuring 60x40 cm which is an electric laying place such as a microcontroller, indicator lights, and Push Button. LCD serves to display the power of solar cells and PLN as well as the power of the load, besides that it displays the measuring value of the intensity of sunlight that is on the source of the generator and load. Push-button, like the right, left, up, and down direction buttons on the LCD.
3. Results and Discussion

3.1. Tool Testing

Block diagram is very helpful for the testing model which used in the implementation [18–20]. Testing tools are done when all the components in the device have been connected following the system block diagram that has been designed and mechanically for supporting the system that has been made, the tests carried out using solar energy sources, and PLN. Stages of testing methods include: Tests for each circuit block include ACS172 current sensor input block, ZMPT101B voltage sensor, light sensor, rotation sensor then controller block on Arduino Mega 2560, and output blocks in the form of relay contacts at load. Testing is done with the whole system.

3.1.1. Testing Each Block

Testing the ACS 712 current sensor and the ZMPT 101B voltage sensor that can be seen that the indicator lights on both sensors are on, and the measurement results displayed on the LCD by reading the current and voltage values using a 5 Watt lamp load can be measured. Reading of value current and voltage values can be seen in Figure 4.

![Figure 4. Testing of current sensor ACS 712 and Voltage Sensor ZMPT 101b](image)

In Figure 4 of the ACS 712 current sensor and the ZMPT 101B voltage sensor above it can be seen the measurement on the PLN voltage with a voltage value of 204.75 V and a current value of 0.03 A and a load value of 5 Watts displayed on the LCD at load 1. Testing Current and voltage sensors using PLN as a source of testing. Testing of current and voltage sensors also takes measurement samples every one minute. The measurement sample every one minute can be seen in Table 1 measurement every one minute.

| No | PLN Voltage (V) | Current (A) | Power (W) | Load 1 Voltage (V) | Current (A) | Power (W) |
|----|----------------|-------------|-----------|-------------------|-------------|-----------|
| 1  | 204.75         | 0.03        | 6.14      | 204.75            | 0.03        | 6.14      |
| 2  | 202.31         | 0.03        | 6.07      | 202.31            | 0.03        | 6.07      |
| 3  | 201.09         | 0.03        | 6.03      | 201.09            | 0.03        | 6.03      |
| 4  | 202.31         | 0.03        | 6.07      | 202.31            | 0.03        | 6.07      |
| 5  | 201.09         | 0.03        | 6.03      | 201.09            | 0.03        | 6.03      |
| 6  | 202.31         | 0.03        | 6.07      | 202.31            | 0.03        | 6.07      |
| 7  | 201.09         | 0.03        | 6.03      | 201.09            | 0.03        | 6.03      |
| 8  | 202.31         | 0.03        | 6.07      | 202.31            | 0.03        | 6.07      |
| 9  | 199.86         | 0.03        | 6.00      | 199.86            | 0.03        | 6.00      |

Testing the measurement using the ZMPT 101B voltage sensor and ACS 712 current sensor in the above tool shown in the LCD in Figure 1 shows a measured voltage value of 204.75 V while the current with a measurement value of 0.03 A then the test will be compared with measuring using AVO meter. The value of reading the voltage value by using the AVO meter can be seen in Figure 2.
3.1.2. Testing Is Done With The System as A Whole

In Figure 5, the microcontroller is supplied with a power supply as a power supply with a voltage of 5V. Relay, current sensor, and voltage sensor are connected to the Arduino Mega microcontroller and can be seen in the picture above indicator lights of the microcontroller, current sensor, voltage sensor and relay lights up to indicate that the component is functioning properly. The next test is to test the whole system block and the LCD will display the value of the voltage, current, and intensity of sunlight from solar energy sources and PLN then the voltage and current of the three loads namely indoor loads, outdoor loads and illegal loads. Test carried out on a Solar Power Plan with a capacity of 300 Wp, a maximum voltage of 21.8 V, a maximum current of 6.05 A by using a 5-watt lamp load for making samples.

Figure 5. Reading the Voltage Value by using the AVO Meter

Figure 6. Test Result For Current, Voltage, Sunlight Measurements On 26/01/2019
Measurement of voltage and current in solar panels using AVO meter and tang ampere can be seen in Figure 7.

Figure 7. Voltage Value and Current using Avo Meters, Pliers Amperage, and LCD.

Based on the testing of measurements in the solar cell in figure 6 on day 1 on 26/1/2019 between 07.00 WIB and 17.00 WIB, it can be seen that the highest voltage is 20.68 V at 07.00 WIB with the intensity of sunlight amounting to 565 Lux, while the lowest voltage is 17.13 V at 17.00 WIB with a light intensity of 415 Lux.

Figure 8. Test Result For Current, Voltage, Sunlight Measurements On 27/01/2019

Based figure 8 on the testing of measurements on the solar cell above, on the 2nd day on 27/1/2019 between 07.00 WIB and 17.00 WIB, it can be seen that the highest voltage is 20.79 V at 07.00 WIB with the intensity of sunlight amounting to 565 Lux, while the lowest voltage is 16.01 V at 17.00 WIB with a light intensity of 395 Lux.
Figure 9. Test Result For Current, Voltage, Sunlight Measurements 28/01/2019

Based figure 9 on the testing of measurements in the solar cell above, on the 3rd day on 28/1/2019 between 07.00 WIB and 17.00 WIB, it can be seen that the highest voltage is 21.22 V at 07.00 WIB with the sunlight intensity of 557 Lux, while the lowest voltage is 5.5 V at 17.00 WIB with a light intensity of 56 Lux.

Table 2. Test Result Power PLN on 26/1/2019

| No | Date & Time       | Voltage (V) | Current (A) | Power (W) | Condition |
|----|-------------------|-------------|-------------|-----------|-----------|
| 1  | 1/26/2019 7:00    | 0           | 0           | 0         | 0         |
| 2  | 1/26/2019 8:00    | 0           | 0           | 0         | 0         |
| 3  | 1/26/2019 9:00    | 0           | 0           | 0         | 0         |
| 4  | 1/26/2019 10:00   | 0           | 0           | 0         | 0         |
| 5  | 1/26/2019 11:00   | 0           | 0           | 0         | 0         |
| 6  | 1/26/2019 12:00   | 0           | 0           | 0         | 0         |
| 7  | 1/26/2019 13:00   | 0           | 0           | 0         | 0         |
| 8  | 1/26/2019 14:00   | 0           | 0           | 0         | 0         |
| 9  | 1/26/2019 15:00   | 0           | 0           | 0         | 0         |
| 10 | 1/26/2019 16:00   | 0           | 0           | 0         | 0         |
| 11 | 1/26/2019 17:00   | 0           | 0           | 0         | 0         |
| 12 | 1/26/2019 18:00   | 202.07      | 0.02        | 4.041     | 1         |
| 13 | 1/26/2019 19:00   | 198.73      | 0.02        | 3.974     | 1         |
| 14 | 1/26/2019 20:00   | 203.01      | 0.018       | 3.654     | 1         |

The results of voltage and current measurements at PLN are worth 0 at 07.00 until 17.00 because the source of PLN at that time is deactivated or in condition 0, while the source of PLN at 18.00 until 20.00 there is voltage and current values listed in Table 4 and Table 4 because the PLN source is activated or in condition 1.
Table 3. Test Result Power PLN on 27/1/2019

| No | Date & Time   | Voltage (V) | Current (A) | Power (W) | Condition |
|----|---------------|-------------|-------------|-----------|-----------|
| 1  | 1/27/2019 7:00| 0           | 0           | 0         | 0         |
| 2  | 1/27/2019 8:00| 0           | 0           | 0         | 0         |
| 3  | 1/27/2019 9:00| 0           | 0           | 0         | 0         |
| 4  | 1/27/2019 10:00| 0       | 0           | 0         | 0         |
| 5  | 1/27/2019 11:00| 0       | 0           | 0         | 0         |
| 6  | 1/27/2019 12:00| 0       | 0           | 0         | 0         |
| 7  | 1/27/2019 13:00| 0       | 0           | 0         | 0         |
| 8  | 1/27/2019 14:00| 0       | 0           | 0         | 0         |
| 9  | 1/27/2019 15:00| 0       | 0           | 0         | 0         |
| 10 | 1/27/2019 16:00| 0       | 0           | 0         | 0         |
| 11 | 1/27/2019 17:00| 0       | 0           | 0         | 0         |
| 12 | 1/27/2019 18:00| 199.73 | 0.02        | 3.994     | 1         |
| 13 | 1/27/2019 19:00| 215.43 | 0.02        | 4.308     | 1         |
| 14 | 1/27/2019 20:00| 202.07 | 0.02        | 4.041     | 1         |

Earth's atmosphere or weather conditions are cloudy, cloudy, the types of airborne dust particles, fumes, air vapor, fog, and pollution determine the maximum results of electric current from a row of solar cells that will affect the conversion of solar thermal energy into electricity or the power produced by these solar cells. [5] In addition to atmospheric conditions the position of the sun on the panel also affects the power that will be produced by the panel, but in general, testing carried out above is testing concerning the effect of sunlight intensity on the voltage and current produced by solar cells, the power produced can be seen from the intensity of sunlight during the morning, afternoon and evening.

The measurement results of the above solar cell test measurements showed the highest light intensity during the test, which occurred on the 3rd day of the 12.00 test with the intensity of the sunlight of 567 Lux and with a voltage value of 21.22V and a current of 0.30 A, while the lowest intensity of the sunlight on the 3rd day 17.00 with 56 Lux light intensity has a voltage value of 5.5 V and a current of 0.15. From the test data, it can be concluded that the intensity of sunlight affects the power produced by solar cells.

In this study PLTS operates at 06.00 to 17.00 WIB can be seen in tables 2,3 and 4 while the PLTS source will be automatically replaced by PLN starting from 18.00 until 20.00 WIB shown in tables 5 and 6.

4. Conclusion

By considering Control Loads on Hybrid Generating Systems, the system needs to control regularly. Renewable energy such as solar energy and wind energy become alternative energy in the future if its use can be used properly. The use of excessive loads can affect the generation process of solar energy and wind energy, so load control is needed so that the load generated is balanced with the load used test data on load supply control on hybrid generating systems shows that the intensity of sunlight affects the power produced by solar energy. In the future, this research important can be developed by adding an Internet of Thing (IoT) system to monitor and retrieve data easily.

References

[1] Boute A and Zhikharev A 2019 Vested interests as driver of the clean energy transition: Evidence from Russia’s solar energy policy Energy Policy 133 110910
[2] Ishaq H and Dincer I 2020 A comparative evaluation of OTEC, solar and wind energy based systems for clean hydrogen production Journal of Cleaner Production 246 118736
[3] Lai X, Yu M, Long R, Liu Z and Liu W 2019 Clean and stable utilization of solar energy by integrating dish solar Stirling engine and salinity gradient technology Energy 182 802–13
[4] Wang X, He Y and Liu X 2018 Synchronous steam generation and photodegradation for clean water generation based on localized solar energy harvesting Energy Conversion and Management 173 158–66
[5] Chandrasekhar A, Vivekananthan V and Kim S-J 2020 A fully packed spheroidal hybrid generator for water wave energy harvesting and self-powered position tracking Nano Energy 69 104439

[6] Riahi A, Ben Haj Ali A, Fadhel A, Guizani A and Balghouthi M 2020 Performance investigation of a concentrating photovoltaic thermal hybrid solar system combined with thermoelectric generators Energy Conversion and Management 205 112377

[7] Agbemuko A J, Dominguez-Garcia J L and Gomis-Bellmunt O 2020 Impedance-Based Modelling of Hybrid AC/DC Grids With Synchronous Generator for Interaction Study and Dynamic Improvement Electric Power Systems Research 179 106086

[8] Peffley T B and Pearce J M 2020 The potential for grid defection of small and medium sized enterprises using solar photovoltaics, battery and generator hybrid systems Renewable Energy 148 193–204

[9] Heylen E, Ovaere M, Proost S, Deconinck G and Van Hertem D 2019 Fairness and inequality in power system reliability: Summarizing indices Electric Power Systems Research 168 313–23

[10] Min D, Ryu J and Choi D G 2020 Effects of the move towards renewables on the power system reliability and flexibility in South Korea Energy Reports 6 406–17

[11] Cai J, Xu Q, Cao M and Yang B 2019 A novel importance sampling method of power system reliability assessment considering multi-state units and correlation between wind speed and load International Journal of Electrical Power & Energy Systems 109 217–26

[12] Sajadi A, Preece R and Milanović J 2020 Identification of transient stability boundaries for power systems with multidimensional uncertainties using index-specific parametric space International Journal of Electrical Power & Energy Systems 123 106152

[13] Halder A, Pal N and Mondal D 2020 Higher order sliding mode STATCOM control for power system stability improvement Mathematics and Computers in Simulation 177 244–62

[14] Peddakapu K, Mohamed M R, Sulaiman M H, Srinivasarao P and Reddy S R 2020 Design and simulation of resistive type SFCL in multi-area power system for enhancing the transient stability Physica C: Superconductivity and its Applications 573 1353643

[15] Mishra M K and Lal V N 2020 An improved methodology for reactive power management in grid integrated solar PV system with maximum power point condition Solar Energy 199 230–45

[16] Naderipour A, Abdul-Malek Z, Nowdeh S A, Ramachandaramurthy V K, Kalam A and Guerrero J M 2020 Optimal allocation for combined heat and power system with respect to maximum allowable capacity for reduced losses and improved voltage profile and reliability of microgrids considering loading condition Energy 196 117124

[17] Mousa H H, Youssef A-R and Mohamed E E M 2019 Variable step size P&O MPPT algorithm for optimal power extraction of multi-phase PMSG based wind generation system International Journal of Electrical Power & Energy Systems 108 218–31

[18] Bai L and Xue D 2018 Universal block diagram based modeling and simulation schemes for fractional-order control systems ISA Transactions 82 153–62

[19] Saidy M and Hughes F M 1996 An extended block diagram transfer function model of a synchronous machine International Journal of Electrical Power & Energy Systems 18 139–42

[20] Lobontiu N 2018 Block Diagrams and Feedback Control System Modeling System Dynamics for Engineering Students (Elsevier) pp 541–92