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Investigation of Source Imbalance Conditions in Hybrid Power Generation

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Abstract: *Electrical energy is essential for life. With the increasing need for clean and sustainable energy, micro-scale power plants based on hybrid systems are present as a solution. The integration of two different sources can pose technical challenges, one of which is the voltage imbalance between phases, especially when there is a disturbance such as the output of one phase from the inverter. This work aims to analyze the characteristics of the voltage and current imbalance that occurs in the hybrid generation system under normal conditions and when one phase of the inverter is disconnected. The experimental method is used to measure the voltage, current and frequency between the micro generator and the inverter from the solar panel. This test was carried out using a linear load in the form of a light bulb with each phase connected to a 100 watt light bulb. The results of the study indicate that the imbalance of one source can affect the proportion of power and generator supply when the load becomes greater.*

Keywords: *Micro Generator, Photovoltaic PV, Source imbalance and Electrical energy*

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I. INTRODUCTION

The demand for reliable electricity will grow in parallel with the expansion of the industrial sector, commercial and domestic has spur effort for look for solution generator efficient and environmentally friendly electricity environment. One of the an increasingly sophisticated approach popular is implementation system generator electricity micro hybrid [1] which integrates energy renewable with source energy conventional. In the context of this, combination between system photovoltaic (PV) which utilizes energy solar and mini synchronous generator as source energy conventional offer potential For create system more generators stable and sustainable.

Energy solar through system photovoltaic has known as one of the source energy renewable friendly environment and can updated. However, the dependence on the conditions changeable weather, as well fluctuation the power generated by solar panels, gives rise to challenge in guard stability supply electricity. Potential energy solar in Indonesia is very big, namely around 4.8 kWh/m² or equivalent with 112,000 GWp, but the new one utilized only around 10 MWp [2]. Intensity radiation the sun received by Solar PV is compared straight with radiation available sun, where the decrease Solar PV voltage accompanied by with improvement current electricity generated. Along with increasing Solar PV output power, Power Factor value also improves, influenced by the interaction between Power active and power reactive generated. In addition, the efficiency of the Grid-Tied Inverter tends to low at the moment radiation sun low, but will increase and become more stable along with increasing intensity radiation sun [2]. On the other hand, mini synchronous generators, although can provide supply more power stable, depending on the material burn fossils that are not can updated, which can increase emission carbon and impact environment other.

Microgrid is system with group burden source micro. For produce quality power high and can reliable. [3]. System generator electricity Hybrid power is fusion between energy based on renewable and also energy conventional. With objective make a more generators efficient, effective and reliable For supply need energy electricity[4].

Study about mini synchronous generator has done by several researcher previously, from journal written Nurjaman D has done study For identify influence current excitation to generator voltage in situation dynamic loading. The data obtained from review direct and experimental show that arrangement current excitation very influence Mini Hydro synchronous generator voltage Curug. Research results show that voltage the generator output is 6.133kV when current excitation is 2.2A, and the voltage highest is 6.479kV when current excitation is 4.6A[5]. Research results show that Not yet Lots written literature about How interaction between second

system This influence quality power electricity. Interaction This can covers things like effect fluctuation load on performance generator and composition supply power, or effect mini harmonic synchronous generator to distortion total harmonics generated by the photovoltaic grid inverter.

Imbalance system power electricity defined as deviation in magnitude voltage or current from one of or two from three phase system three phase. When the voltage system three phase No identical in magnitude and/or difference phase between both of them No exactly 120 degrees, then it happened imbalance voltage [6].

Therefore that, researchthis aiming for investigate various effects and conditions imbalance generation electricity in system generator electricity micro hybrid that integrates photovoltaic (PV) and mini synchronous generators. Research this will focus on analysis dynamics interaction second system generator this in face fluctuations and imbalances power, and the impact to quality power, and proportion power consequence fluctuations. It is expected results study this can give more insight deep about ways for optimize performance system micro hybrid and reduce impact negative imbalance generation electricity in context utilization energy renewable in a way more effective and efficient.

II. EXPERIMENTAL PROCEDURE

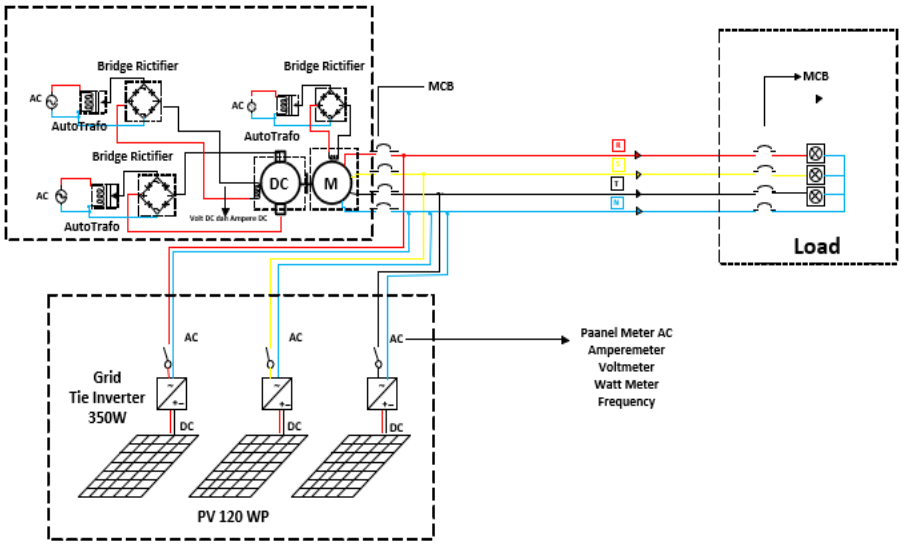
2.1. Literature Study

This research begins with a literature study to explore relevant references regarding stability parameters in hybrid power systems. This stage also includes the overall experimental design of a micro hybrid system, including determining the technical specifications and optimal configuration between energy sources in the form of a mini hybrid generator and an inverter from a solar power plant (photovoltaic).

2.2. Circuit Design

Design includes the construction of a micro hybrid power plant, mini generator installation, photovoltaic inverter design, and the implementation of a circuit protection system to ensure the safety and reliability aspects of the system. At this stage, load testing was also carried out on each phase of the mini hybrid generator using a linear load of 100 watts.

Figure 1 Circuit Design



2.3. Data Retrieval

The next process is data collection, which includes monitoring the power conditions on each phase in normal operating conditions and when there is a system imbalance. Analysis is carried out on the proportion of power distribution under these conditions. The imbalance scheme is realized by disconnecting the photovoltaic inverter source alternately on the R, S, and T phases. Measurements are made on important parameters such as voltage, current, frequency, and rotation speed of the hybrid mini generator.

This analysis is used as a reference to evaluate the quality of electrical power produced by the system that has been designed and operated.

III. RESULTS AND DISCUSSIONS

3.1. Current and Voltage Measurement Results

Current and voltage measurements were carried out on each phase (R, S, and T) both on the generator and photovoltaic inverter sides to determine the characteristics of power distribution under normal conditions and when an imbalance occurs. The study was conducted at 09:00 a.m to 15:00 p.m.

The first experiment is about current and voltage measurement result of the Mini Hybrid Generator with Photovoltaic Inverter under normal condition. The result are show in figure 2 and figure 3.

Figure 2 Current Diagram

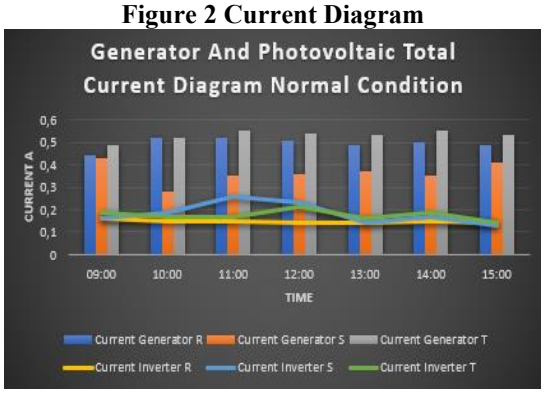
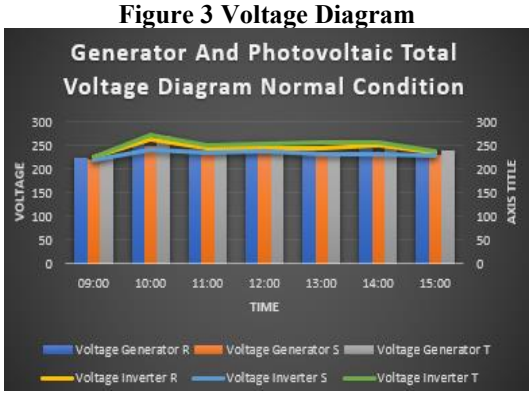


Figure 3 Voltage Diagram



In this experiment, current and voltage measurements were carried out with a hybrid Mini Generator source and Photovoltaic Inverter to supply the load. Each phase supplies a load in the form of a 100w light bulb. The measurement results under normal conditions, the current and voltage in each phase are in a relatively balanced range.

The second experiment is a current and voltage measurement results the Mini Hybrid Generator with Photovoltaic Inverter with phase R = 0. The results are shown in graph as in figure 4 and figure 5.

Figure 4 Current Diagram

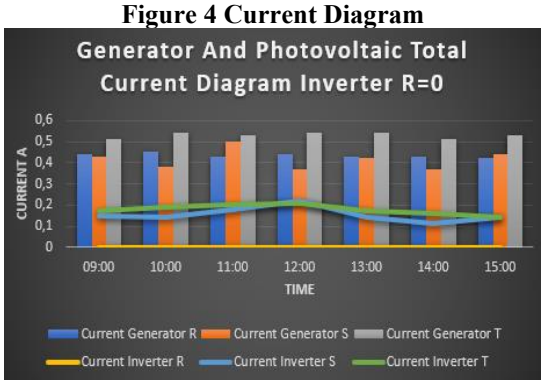
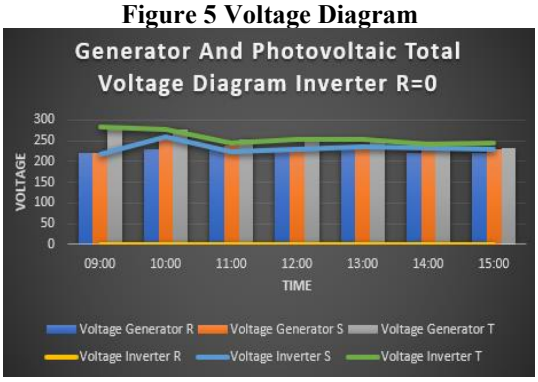


Figure 5 Voltage Diagram



In the second experiment, current and voltage measurements were carried out on the Mini hybrid generator circuit with Photovoltaic Inverter with unbalanced conditions. The condition in question is by removing the PV Inverter source connected to the R phase. This condition affects the voltage and current on the R phase of the generator which of course affects the power.

The third experiment is a current and voltage measurement results the Mini Hybrid Generator with Photovoltaic Inverter with phase S = 0. The results are shown in graph as in figure 6 and figure 7.

Figure 6 Current Diagram

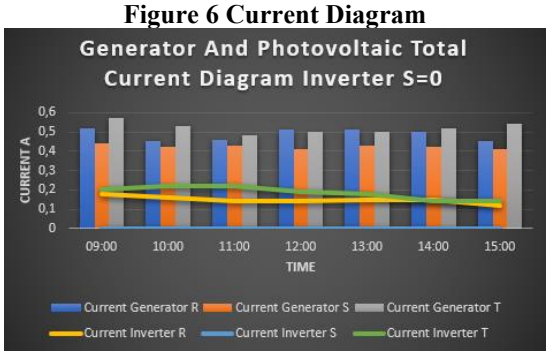
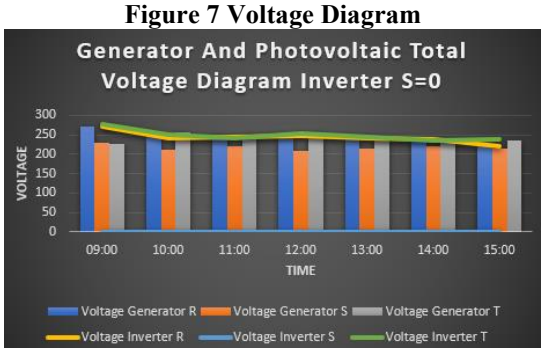


Figure 7 Voltage Diagram



The fourth experiment is a current and voltage measurement results the Mini Hybrid Generator with Photovoltaic Inverter with phase T = 0. The results are shown in graph as in figure 8 and figure 9.

Figure 8 Current Diagram

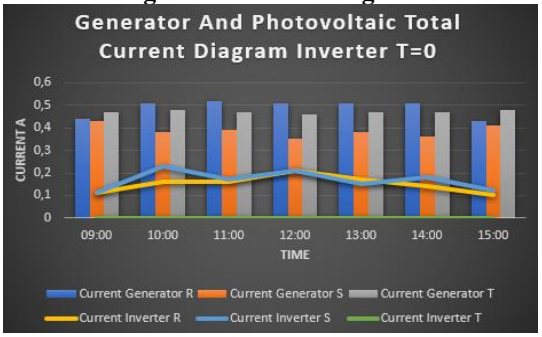
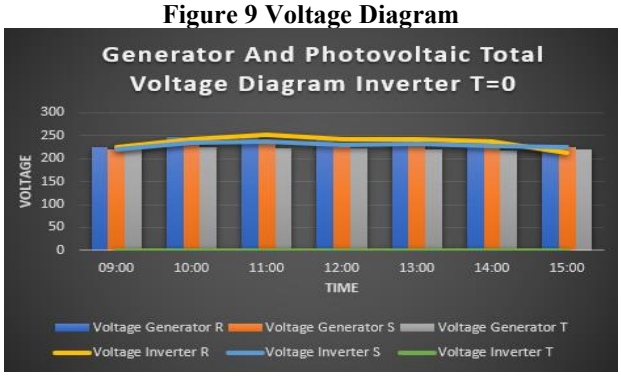


Figure 9 Voltage Diagram



In the 3rd and 4th experiments using the same scheme as the 2nd experiment. Measurements were made with unbalanced inverter source conditions by turning off the S source and the T source alternately. The results of the investigation of the unbalanced scheme carried out affected the current and voltage on both the Mini generator and the photovoltaic Inverter.

3.2. Total Power Proportion

The results of the study were calculated using total power from each experiment so that a comparison of the power proportions could be made during normal conditions or when there was an imbalance in the R, S and T phases. The following is the equation for calculating the power proportions:

Equation 1 : Calculating the power proportions.

$$Power\ Proportion\ Phase = \frac{Pphase}{Ptotal} \times 100\%$$

Information :

P phase = Active power (Watts) in R, S, or T phase

P total = Total active power of all phases

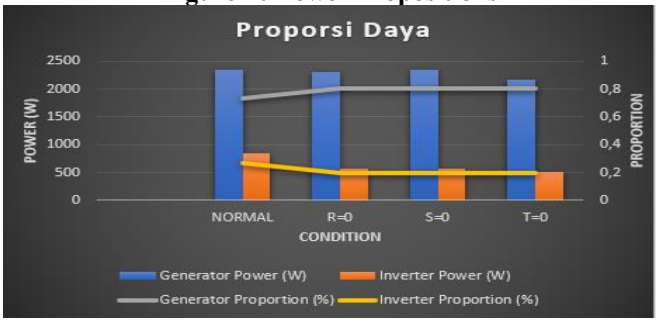
Equation 2 :If power is calculated from measurements.

$$P\ phase = V\ phase \times Iphase \times 100\%$$

Condition	Generator Power (W)	Inverter Power (W)	Generator Proportion (%)	Inverter Proportion (%)
Normal	2349.81	851.49	73.40%	26.60%
R=0	2307.44	569.68	80.20%	19.80%
S=0	2355.99	570.33	80.51%	19.49%
T=0	2167.4	519.71	80.66%	19.34%

Table 1 Total Power Proportion

Figure 10 Power Propositions

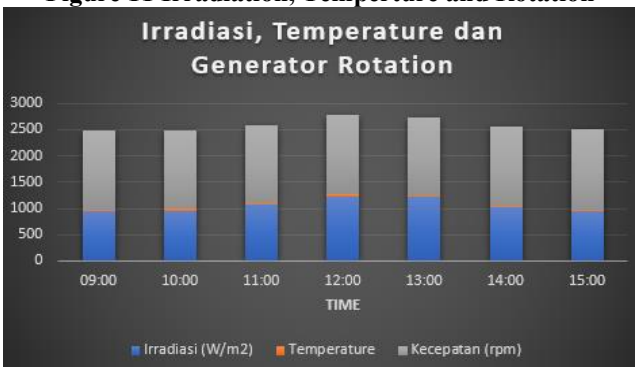


The data in table 1 and Figure 10 show the power proportion between the generator and the PV Inverter when supplying a linear load, namely a 100 watt bulb on each phase. At normal conditions, it shows that the proportion of the mini generator is 73.40% and the proportion of the Photvoltaic Inverter is 26.60% when supplying the load. When the source condition of the inverter is unbalanced R = 0, the proportion of the mini generator power is 80.20% and the proportion of the Photvoltaic Inverter is 19.80%. At S = 0, the proportion of the mini generator power is 80.51% and the proportion of the Photvoltaic Inverter is 19.49% and at T = 0, the proportion of the mini generator power is 80.66% and the proportion of the Photvoltaic Inverter is 19.34%.

3.3. Temperature Exposure Results and Generator Rotation

During data collection, measurements were also taken of irradiation, temperature and generator rotation speed. Measurements were taken at 09.00 a.m to 15.00 WIB pm which is shown in Figure 11.

Figure 11 Irradiation, Temperture and Rotation



Based on the data above at 09.00 a.m. the measured irradiance was 951 (W/m2) and the temperature was 35°C. at 10.00 a.m. the measured irradiance was 961 (W/m2) and the temperature was 38°C. at 11.00 a.m. the measured irradiance was 1069 (W/m2) and the temperature was 40°C. at 12.00 p.m. the measured irradiance was 1232 (W/m2) and the temperature was 42°C. at 13.00 p.m. the measured irradiance was 1212 (W/m2) and the temperature was 39°C. at 14.00 p.m. the measured irradiance was 1023 (W/m2) and the temperature was 38°C. and at 15.00 a.m. the measured irradiance was 950 (W/m2) and the temperature was 38°C. The data shows that the highest irradiation is at 12.00 p.m. and the lowest irradiation is at 15.00 p.m. and the high level of irradiation is directly proportional to the measured temperature.

IV. CONCLUSION

Based on results research that has been done, can concluded that analysis performance synchronous micro generator connected with grid inverter from system photovoltaic show existence change proportion Power when happen imbalance source. Experiment done with method cut off one phase from the inverter take turns, then analyzed distribution power generated by each source to linear load of 100 watts on each phase. Under normal conditions, the proportion the power supplied by the micro generator is 73.40%, while the photovoltaic inverter supply by 26.60%. When it happened termination inverter phase (R = 0), proportion Power from micro generator increased to 80.20%, and the inverter goes down to 19.80 %. Likewise when phase S = 0 and T = 0, the proportion power micro generators rose to 80.51% and 80.66% respectively, while the inverter supplied by 19.49% and 19.34%. Findings this show that system micro hybrid has ability adaptive to imbalance source, with the increasing role of generators dominant when one of them inverter phase is disconnected.This research is expected to contribute to understanding the characteristics between hybrid mini generators and grid photovoltaic inverters, to optimize the efficiency and reliability of hybrid electricity.

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