Analysis of Overcurrent Safety in Miniature Circuit Breaker AC (Alternating Current) and DC (Direct Current) in Solar Power Generation Systems

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Abstract. The sun is a source of energy and has advantages over fossil energy sources. This solar energy really needs to be researched and developed further. The use of solar energy is by installing a Photovoltaic Cell (PV) along with the Solar and Battery Control system. In short, it can be referred to as a Solar Power Plant (PLTS). This PLTS will be used in buildings as the Solar Building System (SBS). Completing this system requires a protection system management. The protection system known to the general public is the use of a Miniature Circuit Breaker (MCB). This MCB is intended for direct current and alternating current. To get a good protection system in PV mini-grid, how to use MCB and how to install it must be chosen. So that you will get a conclusion that the characteristics and level of efficiency are better than the two uses of the MCB.

Keywords: Solar Building System (SBS); Magnetic Circuit Breaker (MCB); Solar Power Plant.

1. Introduction

In this modern era, the human need for electrical energy is one of the main needs and this need for electrical energy is one indicator of a country’s progress. To fulfill this, the generation of electrical energy is needed. Where at this time humans still use fossils to meet their energy needs. So that the longer it is getting depleted, the average growth in energy demand is estimated at 4.7% per year during 2011 - 2030 [1].

The Solar Power Plant (PLTS) is one of the developments in the use of renewable energy which has the potential to be applied in Indonesia which has the potential for solar radiation an average of 4.8kWh / m² / day [1]. Besides producing electrical energy from the conversion of solar light energy, solar cells have other advantages, namely high reliability, not polluting the environment (causing no emissions), and not causing noise, although in terms of development efficiency and operation, further research is needed. also at the University of Muhammadiyah Sidoarjo so that this PLTS can be used as an alternative energy source, in addition to the utilization of PLN electricity [2].

The performance of a photovoltaic cell (PV) depends on the sunlight it receives. Climatic conditions (eg clouds and fog) also have a significant effect on the amount of solar energy received by cells so that it will also affect their performance as proven [3] [4].

In this research, the PLTS will be used as an alternative energy source in the Electrical Engineering Laboratory. To complete this system, it is necessary to have adequate and reliable protection management. The protection meant here is the use of a Miniatur Circuit Breaker (MCB). There are several very basic treatments in this MCB, especially in the use of the PLTS system, namely:

The characteristics of using MCB DC or AC are the most reliable for PLTS systems.
1. What is the most reliable MCB installation in the PV mini-grid system. System input output
2. In which part should the MCB be installed in the PV mini-grid system.
This is done as a research tool for the initial steps of implementing the Solar Building System (SBS) as well as a means of reducing the cost of electrical energy supplied by PLN [5][6].

2. Method

2.1. Research Flowchart
The research flow chart in this method is as shown in Figure 1.

Fig. 1. Research flow chart

The research to be carried out has the following stages:

2.2. Research Stages
This research was carried out with the following activity plans, including:
1. Installation of PV at the Electrical Engineering Laboratory campus 2 Muhammadiyah University Sidoarjo. Along with a current storage device (accumulator), control unit filling and load. Simulated the use of PV power interconnected with the Sub Distribution Panel (SDP) in the Electrical Engineering Laboratory. The collection of disconnection current data using MCB AC and DC by changing the polarity of the output voltage.
2. Data analysis of the characteristics of the MCB AC and MCB DC.
3. Perform system applications and try their application on the system installed in the Electrical Power and Energy Conversion Engineering Laboratory, University of Muhammadiyah Sidoarjo.
4. Evaluation and improvement.
5. Reporting.

2.3. Data collection technique
Data collection techniques used by researchers to support research are: Measurement of MCB AC and DC disconnection currents with polarity exchange using an DC system. This measurement is carried out using a DC generator and measured using an ampere meter.

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3. Results
3.1. Block Circuit Diagram

The PV mini-grid block diagram is shown in Figure 2. Figure 2 shows the PLTS system starting from Photovoltaic (PV) - Solar Charge Controller (SCC) - divided by two, the first to the load and the other to the ACCU.

The series used for the implementation of the research is as shown in Figure 3. Measurement of MCB AC and DC disconnection currents with polarity exchange using a DC system. This measurement is carried out using the output from the SCC, namely by using a DC current with an inverted MCB polarity. By measuring the current in its path using an ampere meter. The series can be seen in Figure 3.
The research process uses a schematic diagram as shown in Figure 3, the current measurement is carried out starting from the current 0 to the MCB disconnection current.

3.2. Components and Circuits Used
The components used are as shown in the documentation in Figures 4 to 5.

![Photovoltaic](image1)

Figure 4. Photovoltaic.

Figure 4. shows this *Photovoltaic (PV)* image is used to capture the Sun's energy to be converted into Electric Power.

![Solar Charge Controlled (SCC)](image2)

Figure 5. Solar Charge Controlled (SCC)

Figure 5. shows a picture of the *Solar Charger Controller (SCC)* which is used to regulate the incoming current and voltage from the PV to the battery and load. Besides the two components above, there are other components that are used for testing, namely MCB, which is used MCB AC and MCB DC. The MCB AC image is as shown in Figure 6 and the MCB DC image is as Figure 7.

![MCB AC With Voltage And Current Meters](image3)

Figure 6. *MCB AC* With Voltage And Current Meters
In Figure 6, namely MCB AC using the ABB brand with a capacity of C6, which is a disconnection current of 6 A.

![Image of MCB AC](image)

Figure 7. DC MCB With Voltage And Current Meters

In figure 7, namely MCB DC using the TOMZN brand with a capacity of C3, namely the disconnecting current of 3 A. The photo of the test series as a whole can be seen in Figure 8. This image shows a test circuit using a PV system and an inverter.

![Image of Test Circuit](image)

Figure 8. Test circuit using DC MCB and AC MCB with Voltage and Current Meters

In Figure 8, you can see the full circuit of DC and AC MCB testing systems and setting the current through them using DC or AC currents. The DC current uses the output from the SCC, while the AC current test uses the output current from the inverter. For load testing using a series of lamps and other loads available.

3.3. Measurements Taken
Measurements taken to carry out this research are: DC Current Measurement on AC MCB AC and DC MCB. This measurement is carried out using a DC ampere meter at the point after the SCC to the load on the PLTS system by providing an initial load of 0 to the break of the MCB. Measurement was carried out with 2 different treatments, namely by reversing the polarity of the DC current source.
3.4. Measurement results

DC Current Measurement on AC MCB and DC MCB This measurement is carried out using a DC ampere meter at the point after the SCC to the load on the PLTS system by providing an initial load of 0 to the break of the MCB. Measurement was carried out with 2 different treatments, namely by reversing the polarity of the DC current source.

Table 1. Measurement of AC-DC MCB load Input Position Below and Output Above

| NO | TRY INTO          | BREAK CURRENT |
|----|-------------------|----------------|
| A  | MCB AC LOAD DC    |                |
| 1  | 1st Treatmen (Input Position Lower Output Top) |                |
|    | 1. 1st Trial      | 4,740          |
|    | 1.2. 2nd Trial    | 3,020          |
|    | 1.3. 3rd Trial    | 2,700          |
|    | 1.4. 4th Trial    | 2,670          |
|    | 1.5. 5th Trial    | 2,820          |
|    | AVERAGE BREAK VALUE | 3,190         |

In table 1. You can see the measurement of the cut-out current on the AC MCB with a DC load. The input polarity is below the MCB and the output is above, with a MCB capacity of 6 A, so the results of the study show that the current termination at an average current is 3.190 A.

Table 2. Measurement of AC-DC MCB load Input Position Above and Output Below

| NO | TRY INTO          | BREAK CURRENT |
|----|-------------------|----------------|
| B  | MCB AC LOAD DC    |                |
| 2  | 2nd Treatmen (Input Position Upper Output Lower) |                |
|    | 2.1. 1st Trial    | 2,420          |
|    | 2.2. 2nd Trial    | 3,850          |
|    | 2.3. 3rd Trial    | 3,900          |
|    | 2.4. 4th Trial    | 3,760          |
|    | 2.5. 5th Trial    | 3,910          |
|    | AVERAGE BREAK VALUE | 3,568         |

In table 2. You can see the measurement of the cut-out current on the AC MCB with a DC load. The input polarity is above the MCB and the output is below, with a MCB capacity of 6 A, so the results of the study show that the current termination at an average current is 3.568 A. on if the input polarity is up.

For more details can be seen in the figure. 9. In Figure 9 it can be seen that the input position below and the output above has a more precise security result than the input position above and the output below.
Figure. 9. Comparison of input output AC MCB with DC Load

Table 3. Measurement of DC load DC MCB Input Position Below And Output Above

| NO TRY INTO | BREAK CURRENT |
|-------------|--------------|
| C MCB DC LOAD DC |                |
| 3 1st Treatmen (Input Position Lower Output Top) |                |
| 3.1. 1 st Trial | 5,180         |
| 3.2. 2 nd Trial | 5,190         |
| 3.3. 3 rd Trial | 5,200         |
| 3.4. 4 th Trial | 5,220         |
| 3.5. 5 th Trial | 5,210         |
| AVERAGE BREAK VALUE | 5,200         |

In table 3. You can see the measurement of the cut-out current on the DC MCB with the DC load. The input polarity is below the MCB and the output is above, with a MCB capacity of 6 A, so the results of the study show that the current termination is at an average current of 5,200 A.

Table 4. Measuring DC load DC MCB Input Position Above and Output Below

| NO TRY INTO | BREAK CURRENT |
|-------------|--------------|
| D MCB DC LOAD DC |                |
| 4 2 nd Treatmen (Input Position Upper Output Lower) |                |
| 4.1. 1 st Trial | 4,300         |
| 4.2. 2 nd Trial | 4,310         |
| 4.3. 3 rd Trial | 4,320         |
| 4.4. 4 th Trial | 4,330         |
| 4.5. 5 th Trial | 4,350         |
| AVERAGE BREAK VALUE | 4,322         |

In table 4. You can see the measurement of the cut-out current on the DC MCB with the DC load. The polarity of the input is above the MCB and the output is below, with a capacity of 6 A MCB, the results show that the current termination at an average current of 4.322 A. on if the input polarity is down.
Meanwhile, to compare the same MCB capacity with different loads, the results are as shown in the graph in Figure 10.

![Comparison of input output DC MCB with DC Load](image)

**Figure. 10. Comparison of input output DC MCB with DC Load**

In Figure 10 it can be seen that the input position below and the output above has a more precise security result than the input position above and the output below.

### 4. Conclusions and Suggestions

#### 4.1. Conclusion

The value of the cut-out current when using an AC MCB with a DC load with a polarity ratio, it is found that: By using the input polarity on the bottom of the AC MCB, it has a more precise value than if the input is placed on the top of the AC MCB. The value of the cut-out current if you use an AC MCB with AC load and with a DC load, it is found that: The termination current value if using a DC MCB with a DC load with a polarity ratio, it is found that: By using the input polarity on the top of the DC MCB, it has a more precise value than if the input is placed on the bottom of the DC MCB.

#### 4.2. Suggestion.

In future research, it is better to involve the element of calculating the time when the MCB is in the cut-out current position.

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