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Design of Automatic Transfer Switch System Solar Power Plant – PLN

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Abstract *– The utilization of solar power for generating energy is increasing in scale. The Solar Power Plant (SPP) operating system comprises On Grid, Off Grid, and Hybrid systems. To successfully execute a power supply transfer operation, it is important to do thorough study. The transfer process is automated by the utilization of voltage sensors. The voltage sensing is derived from the output of both the SPP system and the PLN (Indonesian State Electricity Company) system. This study involved conducting prime SPP (Self-Paced Reading) and prime PLN (Picture Naming) tasks. The stress analysis technique is conducted during transfer in both primes. When converting SPP to PLN and transferring from PLN to SPP, voltage measurements are conducted if the SPP is in its prime state. When the power line network (PLN) is in its optimal state, voltage measurements are conducted during the transition from PLN to the solar power plant (SPP) and vice versa. When the SPP is in its prime state, the average voltage during the transfer from SPP to PLN is at 217.8 V, as indicated by the measurement findings. The average voltage for transferring power from the power grid (PLN) to the power plant (SPP) is at 225.4 V. During the peak power load period, the average voltage transferred from the power grid (PLN) to the power plant (SPP) is at 220.18 V, whereas the average value when moving from SPP to PLN is at 220.12 V. At the prime PLN, there is a minor voltage variance due to the higher stability of the PLN voltage.*

Keywords: *Solar Power Plant (SPP); Indonesian State Electricity Company (PLN); Change Over Switch (COS)*

I. Introduction

The use of solar energy continuously continues to increase on this earth. Especially in Indonesia. Indonesia has a large enough rainfall of solar energy. That is equal to 4.8 kWh/m2/day [1][2].

Currently the use of Solar Power Plants (SPP) is increasing[3]. Some of the SPPs use the ON Grid system with the Indonesian State Electricity Company (PLN) (Fig. 1) and some use the Off Grid system (Fig. 2). The use of the SPP system with On Grid will use a system where the SPP will operate during the day when the sun provides a lot of energy on the face of the earth then it is on grid right with PLN using the KwH Meter export Import[4]. By using this kwH meter export import, the SPP can provide electrical energy to the nets of the PLN system[5].

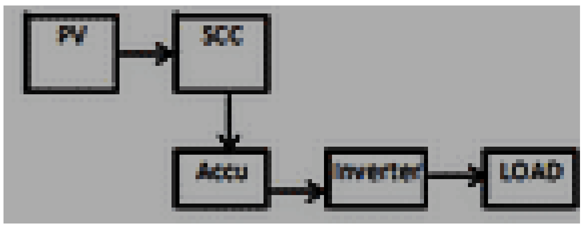

Fig. 1. Off Grid System

Fig. 1 shows an off-grid system. This system is not connected to the grid at all. From PV goes to SCC fills the Baterey then goes to the inverter to produce a new alternating current voltage to the load[6][7]. This system is in great demand from users because it is practical. Whereas in the Off Grid system, the SPP system will stand alone without being connected to PLN[8]. So, this system requires batteries.

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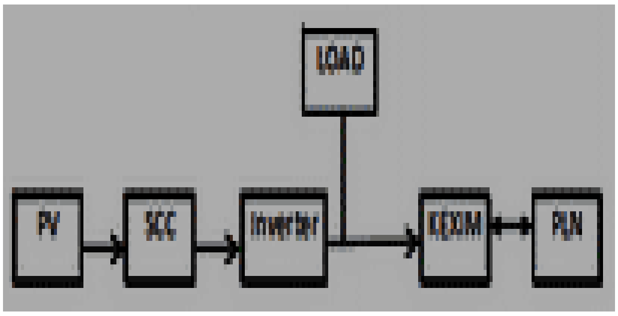

Fig. 2. On Grid System

Fig. 2 shows the ongrid system, where this system involves PLN. This system connects SPP with PLN electricity through KWH Exim (KWH Export Import)[9]. When the sun is hot, the sun will shine on the PV and the PV will generate electricity. It is when the sun is hot that the SPP system will supply the PLN system. Thus, the KWH meter Exim will record the supply of SPP to PLN. When the sun is not hot or natural conditions are late in the evening or night, PLN will provide supplies at the customer's expense[10][11]. So, the customer has to pay PLN. Thus, until a certain period, the use of PLN will be reduced by the supply of SPP to the PLN network. So that PLN bills will decrease. By contributing to PLN's grids, electricity customers will get a refund from the sale of their SPP power. For this on grid system no batteries are required[12].

As for the Hybrid system, it is shown in Fig. 3. In Fig. 3, it is shown the SPP and PLN combining system or what is called the Hybrid system[13][14]. In this system SPP works normally. When the sun is hot, the sun will shine on the PV and the PV will charge the battery[3]. Battery is ready to handle the load through the inverter[15].

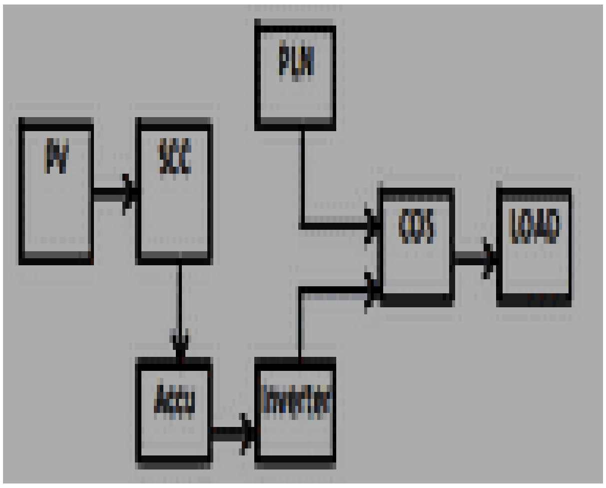

Fig. 3. Hybrid System

If the battery has run out of voltage, the battery will drop and the inverter will die[16]. In this system there are additional components, namely COS (Change Over Switch) which can transfer the load supply source from the SPP system to the PLN system. Currently the battery is not supplying the load and when the sun is hot, the sun will be able to charge the battery again until it is full[17]. If it is felt that the battery is sufficient to turn on the inverter, then COS will transfer the power supply supply which was previously carried out by PLN to be converted into an SPP system which will supply the load[3][18].

In this research, the hybrid SPP system will be explored more deeply. Because this hybrid system is a new system, it is necessary to know several problems related to the operation process, including: The operation of the SPP switching system to PLN or vice versa. At what voltage does the switching process occur? This is necessary to know to understand the characteristics of the system. Both the switching system from SPP to PLN and from PLN to SPP in Primary SPP conditions. Measurement of PLN to SPP and from SPP to PLN on Primary PLN conditions.

For the transfer switch process, SPP uses an inverter to convert DC (Direct current) into AC (Alternating current)[19][7]. Sensing is done on the inverter unit. If the inverter voltage has dropped to its supply limit, the system will switch to PLN[17][20]. After that, the SPP will charge the battery again and the inverter will have a rising voltage again. When the inverter output voltage rises and meets the requirements, the system will experience a transfer switch to PLN again [16][21].

In this study, information will be sought regarding at what inverter output voltage the system will switch to PLN and at what inverter output voltage the system will change back to SPP from PLN. So that with this COS system, the energy supply to the system will not be cut off. The load continues to operate normally.

Installed COS has the facility to select which conditions function as prime and which conditions function as secondary[22]. Selection of PLN as prime or SPP as prime can be carried out. As prime, this is meant as the main source. If the SPP is used as prime, then if the SPP experiences a drop, then the system will move to PLN. If the SPP issues a normal voltage output then the supply will switch to the SPP again[23]. Vice versa if PLN is used as prime, then when PLN experiences a voltage drop, the system will switch to SPP. When PLN returns to normal, the system will return to PLN.

In this research will be done by positioning the primary on the SPP. And to get good results, research on the switching process is carried out.

II. Material and Metods

II.1. Flowchart of Methods

The flowchart of the method can be seen in Fig. 4.

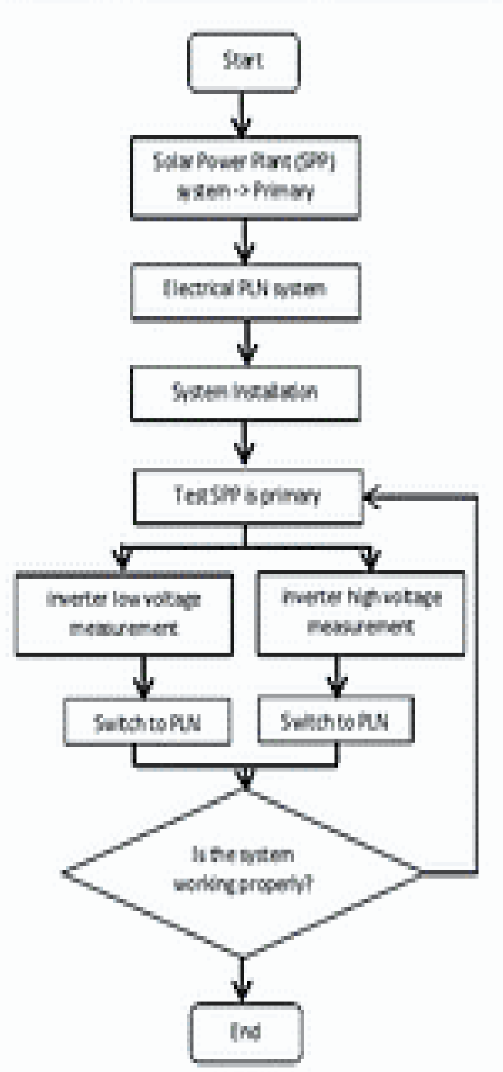

Fig. 4. Methods Research Flow Chart 1 st Step

II.2. Research Stages

This research was carried out with the following activity plans, including Designing the PLN – SPP Automatic Transfer Switch with a security system and measurement system. Testing the SPP system starting from PV, charging the battery to the inverter, and then entering the COS system. Conduct trials of the PLN system until it enters the COS. Conduct trials for the primary position of PLN and SPP. Position switch to SPP. Measure the output voltage of the inverter until it reaches the lowest battery position, then the COS switches to PLN. The system is supplied by PLN. PV will charge the Baterey again and measure the inverter output voltage. Measure the inverter output voltage until the COS switch to SPP returns. Evaluation and improvement. Reporting.

After that, the primary positioning was carried out at PLN and the same method was carried out as the SPP primary. Flowchart with the primary PLN position as shown in Fig. 5.

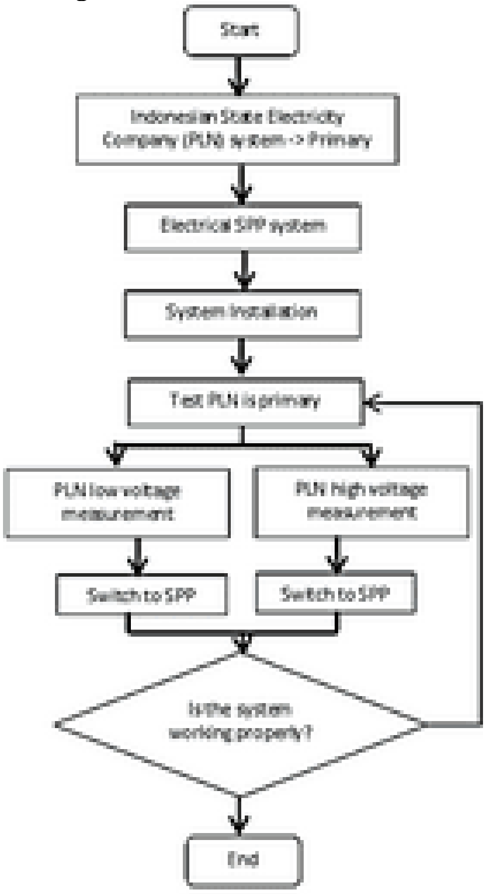

Fig. 5. Methods Research Flow Chart 2nd Step

II.3. Data collection technique

Data collection techniques carried out are as follows:

a) Measurement of the Transfer Switch Process with Prime SPP at the output voltage of the inverter, how much switching occurs to PLN.
b) Measurement of the output voltage of the SPP inverter when charging the battery. What is the highest inverter output voltage so that COS will switch from PLN to SPP.
c) Measurement of the Transfer Switch Process with Prime PLN at the output voltage of the inverter, how much switching to SPP occurs.
d) PLN voltage measurements during the SPP Switch Transfer Process to PLN.

III. Result and Discussion

III.1. Block Circuit Diagram

The block diagram of this study is shown in Fig. 3. In Fig. 3, you can see the process chart starting with sunlight being captured by the PV and entering the Solar Charge Controller (SCC). From the SCC the electric current goes to the battery. From the battery into the inverter as a module to convert direct current (DC) into alternating current (AC). After changing the DC current to AC current, the system enters the Change Over Switch (COS). In this first stage, measurements of the inverter output voltage that enters the COS are carried out to find out the lowest voltage until switching from SPP to PLN occurs. In this system, the primary position is SPP.

The second measurement is the inverter output voltage when the COS position is on the PLN. When the PV fills the battery, the battery voltage will rise. As the battery voltage increases, the output voltage of the inverter will also increase. At this stage, it will be measured up to the inverter output voltage, how much COS will switch from PLN to SPP. After carrying out the research steps and repeated 5 times, the results of the Over Switch implementation during charging (Switching PLN to SPP) were obtained as shown in Table 1.

Table 1. Charge (Switching PLN to SPP)

TRIAL TO	Voltage		STATUS
	DC INV	AC INV	
1	13,05	227,00	SO
2	12,92	224,70	SO
3	12,95	225,00	SO
4	12,90	224,50	SO
5	13,10	228,00	SO
TOTAL	64,92	1.129,20	
AVERAGE	12,98	225,84	

SO = Switch Over

Table 1 shows that after 5 repetitions with the same load, the switch replacement process from PLN to SPP has an average inverter input voltage of 12.98 Vdc and 225.84 V. This process is the process of charging Baterey as the source of the inverter. At a certain voltage as above and fulfilling the requirements, COS will switch over.

In this research, SPP is used as prime. If the battery's charging capacity increases to the point where an SO occurs from PLN to SPP. The SO process occurs at a higher position than the SPP working voltage so that the SPP system can handle loads for a longer time.

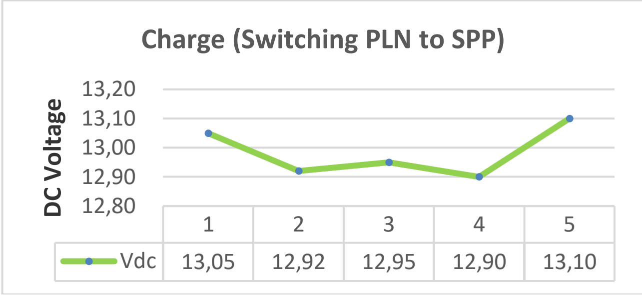

Fig. 6. Charging dc Voltage Position (PLN-SPP)

Fig. 6 shows the movement of the dc voltage in the process of switching PLN to SPP. It appears that there is a difference in the switch replacement process, this is due to the precision of the inverter in switching.

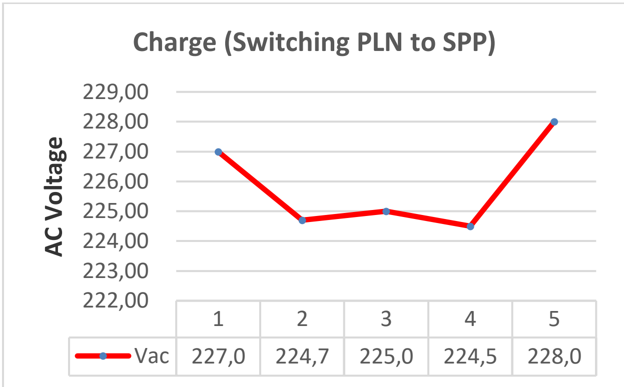

Fig. 7. Charging Voltage Position (PLN-SPP)

Fig. 7 shows the value of the ac voltage when switching from PLN to SPP, the value of the ac voltage referred to is the value of the output voltage from the inverter with the input dc voltage as shown in Fig. 6. The value of the DC voltage that enters the inverter has the same ratio as the output AC voltage from the inverter in units of time. This can be seen in Fig.s 6 and 7 which have the same chart movement.

Table 2. Discharge (Switching SPP to PLN)

TRIAL TO	Voltage		STATUS
	DC INV	AC INV	
1	11,65	219,00	SO
2	11,65	219,00	SO
3	11,60	218,00	SO
4	11,50	216,00	SO
5	11,60	217,00	SO
TOTAL	58,00	1.089,00	
AVERAGE	11,60	217,80	

SO = Switch Over

Table 2 shows that after 5 repetitions with the same load, the switch replacement process from PLN to SPP has an average inverter input voltage of 11.62 Vdc and 217.80 V. This happens because there must be an Baterey charging process as an inverter source. Thus, the inverter output will have a normal voltage.

In the research above, the SPP is used as prime. If the battery's ability to charge is reduced to the point where an SO occurs from SPP to PLN. The SO process occurs at the lowest battery voltage position so that the inverter output also drops. In the position as in table 2 there is SO SPP to PLN.

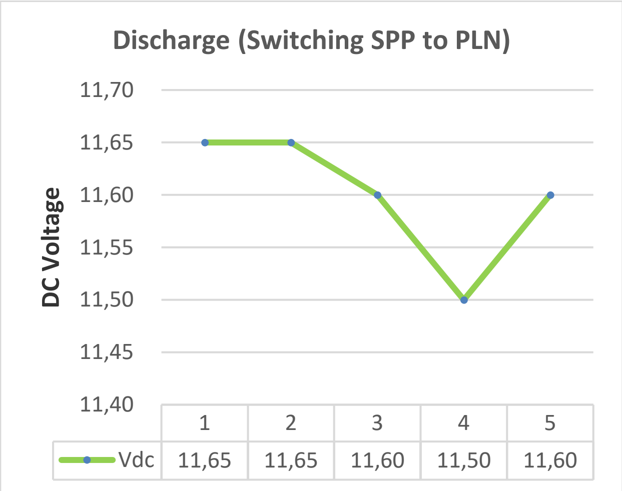

Fig. 8. Position of dc Charging Voltage (PLN-SPP)

Fig. 8 shows the movement of the dc voltage in the process of switching PLN to SPP. It appears that there is a difference in the switch replacement process, this is due to the precision of the inverter in switching.

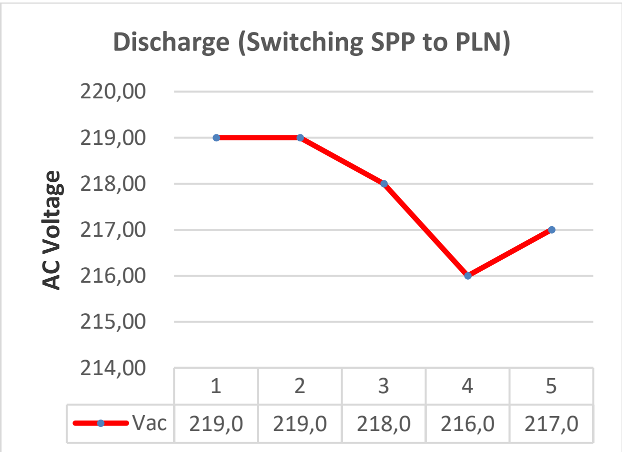

Fig. 9. Voltage Discharge (SPP-PLN)

Fig. 9 shows the value of the ac voltage when switching from PLN to SPP. The value of the ac voltage referred to is the output voltage value of the inverter with the input dc voltage as shown in Fig. 8. The value of the DC voltage that enters the inverter has the same ratio as the output AC voltage from inverter in unit time. This can be seen in Fig.s 8 and 9 which have the same chart movement.

In this second stage, a change in the primary position was carried out, which previously was SPP changed to PLN. The PLN output voltage that enters this COS is measured to find out the lowest voltage until a switching occurs from PLN to SPP.

The second measurement is the PLN voltage when the COS position is on the SPP. When PLN experiences interference and PLN voltage drops, COS will switch to SPP. After that the PLN voltage does not increase because the disturbance has been completed, then PLN will be normal, and COS will switch SPP to PLN. At this stage it will be measured up to the PLN voltage, how much COS will switch from SPP to PLN.

After carrying out the research steps and repeated 5 times, the results of the Over Switch implementation (Switching PLN to SPP) were obtained as shown in Table 3.

Table 3. Switching PLN to SPP

TRIAL TO	Voltage AC PLN	STATUS
1	220,40	SO
2	220,00	SO
3	220,30	SO
4	220,20	SO
5	220,00	SO
TOTAL	1.100,90	
AVERAGE	220,18	

SO = Switch Over

Table 3 shows that after 5 repetitions with the same load, the switch replacement process from PLN to SPP has an average voltage of 220.18 Vac.

In this section, PLN is used as prime. This will happen if PLN experiences a disruption, either a decrease or a trip. At the time of the trial, PLN was tested by tripping the system.

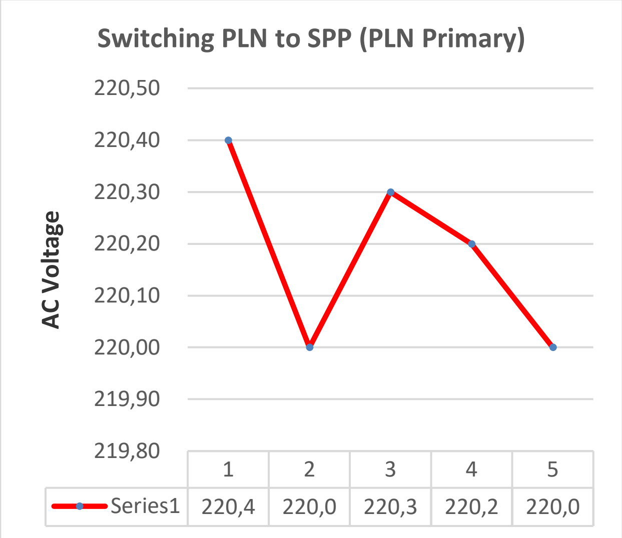

Fig. 10. Switching (PLN-SPP)

Fig. 10 shows the voltage of the PLN to SPP switching process. PLN has been turned off. It appears that there is a difference in voltage during the switching process. This difference is not too big because the PLN voltage is relatively more stable than the SPP voltage.

Table 4. Switching SPP to PLN

TRIAL TO	Voltage AC PLN	STATUS
1	220,00	SO
2	220,10	SO
3	220,10	SO
4	220,00	SO
5	220,40	SO
TOTAL	1.100,60	
AVERAGE	220,12	

SO = Switch Over

Table 4 shows that after 5 repetitions with the same load, the switch replacement process from SPP to PLN has an average voltage of 220.12 Vac. In this section, PLN is used as prime. The Switch Over process occurs when the PLN voltage is ON.

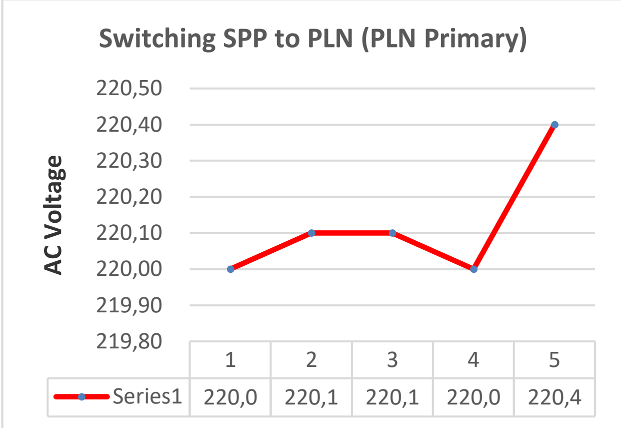

Fig. 11. Charging dc Voltage Position (PLN-SPP)

Fig. 11 shows the movement of the voltage during the switching process from SPP to PLN. The process of switching from PSS to PLN occurs by turning on PLN. It seems that the difference in voltage when switching is not large. This is because the PLN voltage is relatively more stable.

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Conclusion

From the analysis above, the primary position of SPP for the SPP to PLN switching process is at an inverter output voltage of 217.80 V. The PLN to SPP switching process is at a voltage of 225.84 V. This shows the working characteristics of the installed inverter. Whereas in the primary position of PLN, the switching voltage of PLN to SPP does not fall linearly but drastically. It is meant that when PLN experiences disturbances and trips, switching occurs from PLN to SPP. Measurements of PLN's trip voltage several times have an average of 220.18 V. When PLN is on again with normal voltage, a switching process occurs from SPP to PLN. Several times the PLN voltage measurement during switching has an average value of 220.12 V. In the process of switching PLN to SPP and from SPP to PLN again there is a slight difference in voltage but it is in decimal numbers. This happens because the PLN voltage is more stable than the SPP voltage.

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