Design And Construction Of Automatic Transfer Switch (ATS) System With Backup Control System In Hybrid Power Plant (PLN - PLTS - GENSET)

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Abstract.

PLN's electricity supply is not always continuous in the process of distributing power, because under certain conditions there will be blackouts caused by interruptions or maintenance in the distribution system. An alternative to overcome PLN disturbances is to use renewable sources such as solar power plants and generators with an ATS automatic control system controlled using PLC. This study conducted a literature study to collect relevant theories and references about this research. PLC diagram leaders are designed for the process of transferring PLN, PLTS and Generator to load electrical power. Solar power plants operate during disruptions to PLN resources during operational hours (10 a.m. – 3 p.m.) and generators operate when solar power resources cannot supply to the load and at night outside solar power plant operating hours. The ATS system is able to switch the process of switching PLN and PLTS power sources very quickly without any time lag so that the load is directly supplied by PLN and PLTS power sources. The process of switching the generator source takes approximately 2 seconds for the starting process. The process of transferring battery power resources to critical loads without any time lag during the generator starting process and when generator starting failure occurs.

Keywords: *ATS; PLC and Load switching.*

I. INTRODUCTION

The provision of the main electric power supply service from PT PLN (Persero) is not always continuous in the process of power distribution, because under certain conditions there will be blackouts caused by interference or maintenance on the distribution system. The provision of electrical energy or electric power is needed especially in industrial centres because it will disrupt the production process which will make a big loss for the industry. The development of the current control system for industrial needs is increasing, with the main equipment [1]. The main source of electricity generally comes from PLN, where PLN supplies electricity supply needs continuously. However, if an industry is not covered by electricity from PLN, then the electricity supply can come from its generator. Backup power sources are used to back up if the main power source experiences interference. Backup power sources can be in the form of generators, solar power plants, batteries and so on. [2] Electric energy management, especially when there is a power outage at the main source (PLN). PLN as the main source does not always run well or normally, so it takes PLTS and generators as a back up of the main electricity supply (PLN). As a control to facilitate the operation of the generator when it will take over the supply of electricity to the load or vice versa, an automatic control system is often called the Automatic Transfer Switch (ATS) [3]. control circuit to switch from the main supply to the backup supply.

The control on this system uses a Programmable Logic Controller (PLC) because it is easier to program and also easy to change as needed. However, this supply switch takes time to process. [4]. being PLC (Programmable Logic Controller). PLCs can be used as control systems due to their ease of programming (ladder diagram based) [5]. Programmable Logic Controller) as a controller that simultaneously regulates the supply of emergency resources using inverters for lighting needs and other resource needs. One alternative to overcome electricity supply disruptions from PLN is to use renewable energy sources such as solar power plants with diesel plants as backup [6]. That is why an idea emerged to design and implement a PLC-based Automatic Transfer Switch (ATS) which is one solution to solve this problem. This ATS will replace the role of the generator operator who must always be on standby when there is a blackout by PLN [7].

With an automatic control system to manage the transfer of power sources between PLN, solar power plants and generators. The process of transferring the energy source will be controlled by an Automatic Transfer Switch (ATS), this is important to ensure the continuity of electricity supply without any interruption. To overcome these problems, a control system is designed in the PLC program that is able to automatically regulate the transfer of energy sources between PLN, PLTS, and Genset, design electrical diagrams of energy sources, PLC and loads, and build and test the ATS control system. This research aims to design an automatic control system for the transfer of energy sources between PLN, PLTS, and Genset, in order to maintain the continuity of electricity supply, design electrical diagrams of energy sources, PLC and loads, and build and test the ATS control system.The results of this study are expected to increase energy security and energy independence to replace PLN energy when it is not available and increase the efficiency of transferring energy sources between PLN, PLTS and Generator Sets in maintaining the sustainability of electricity supply.

II. METHODS

This research will be carried out at the Workshop of the Department of Electrical Engineering, Ambon State Polytechnic with a planned research time of 1 or 2 months. In this study, data collection only conducts literature studies to collect relevant theories and references about this research.

The research flow diagram can be seen in the following image:

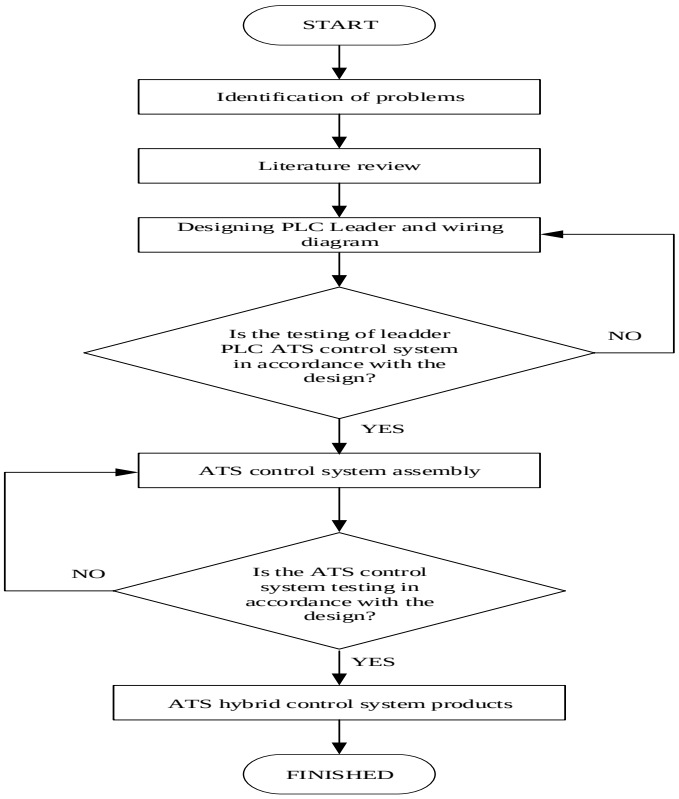

Fig 1. Research Flow Chart

III. RESULTS AND DISCUSSION

ATS Control System Working Description

The Automatic Transfer Switch (ATS) system description works to backup as follows:

1. The main source of electricity supply comes from PLN, if there is a disruption/outage in the electricity supply from PLN during the day, the load will be supplied by the solar energy source.
2. If the condition of the solar energy source during the day is not able or cannot supply the load, the load will be supplied by the generator.
3. When there is a disruption/blackout in the electricity supply from PLN at night, the load will be supplied by the generator.

The operational hours of solar power plants supply to the load at 10 am – 3 pm, outside of that time the solar power plant does not operate.

ATS (Automatic Transfer Switch) system with PLC

Fig 2. ATS control system design results

Figure 2 shows the results of the ATS system assembly. The ATS system has five power contactors to distribute the load, namely K1, K2, K3, K4 and K5. Each contactor distributes the load from the PLN network source, PLTS and Generator to the load. K1 distributes electrical resources from PLN to the load, K2 distributes electrical resources from solar backup resources to the load, K3 distributes electrical resources from generator backup resources to the load and K4 with K5 distributes battery resources to critical loads (lighting, CCTV and so on) during the generator starting process and generator starting failure. ATS (Automatic Transfer Switch) with PLC will control the transfer switch system for the process of transferring the main resources of the PLN network to backup resources of the solar power plant and generator resources.

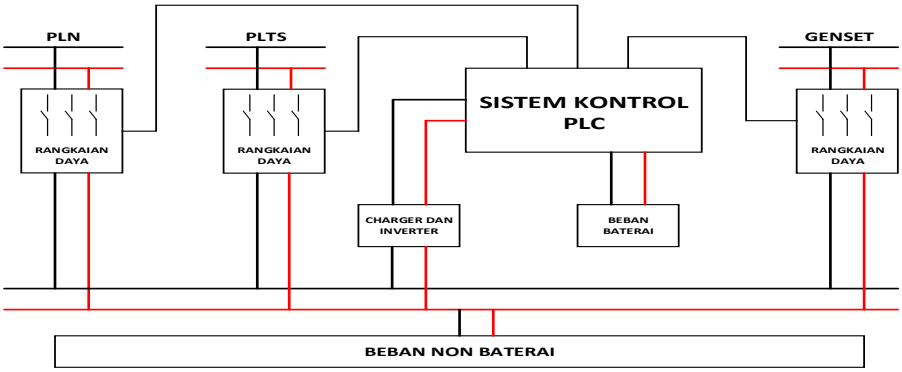

Fig 3. ATS system block diagram

Figure 3 is a block diagram of the PLC-based Hybrid ATS system. Based on the wiring diagram, it can be seen that the PLC as a programmable control device to maintain critical load power (lighting, cctv and others) from battery sources through DC to AC inverters for some lighting loads and power on certain sockets during the process of transferring or igniting PLN network resources to backup sources, in this case using solar power plants and generators. Battery work here is intended so that power outages can last long so that unwanted things do not occur due to power outages for consumers. The work of each power contactor K1, K2, K3, K4 and K5 is controlled by a PLC (Programmable Logic Controller) which has been programmed in advance so that the PLC works according to the desired ATS control description.In addition to controlling the power contactor, the PLC also controls several relays (R4, R5, and R6) to turn on/off the generator and start the generator automatically when there is a power outage at the main PLN source. Relay R4 serves to start the generator, relay R5 is used to start the generator and Relay R6 serves to turn on the buzzer when starting the generator fails.

The PLC will automatically detect the PLN mesh main source whether the status is on or off through relay R1, then make a decision to switch the load to the PLTS load source. The PV voltage sensor will detect whether the voltage remains stable or the voltage drops, when the PLTS voltage sensor detects the PV voltage drops, the relay R2 will be OFF and the PLC will automatically switch the load to the generator load source and start the generator and switch the main load to the generator backup power source. In some time the PLC switches the battery load to the genset backup power source. So the battery load is now supplied by

the generator power source.The presence of Generator voltage is detected by R3 to the PLC so that the PLC can transfer the load to the Generator backup power source. As long as the main PLN power source is off, the load continues to be served by the Generator. However, when the PLN source is turned back on, the PLC detects the PLN voltage through relay R1 and a few moments later activates the power contactor K1 to distribute power from the PLN network to the load and at the same time the Generator contactor K3 opens and disconnects the source from the Generator to the load. Similarly, when the solar power plant can supply the load, the PLC detects the solar power voltage through relay R2 and a few moments later activates the power contactor K2 to distribute the source from the solar power to the load and the generator will automatically shut down.

PLC Diagram Leadder Design

The results of the PLC diagram leader design are shown in the Figure below. This diagram leader is designed according to the description of the ATS control system with PLC and battery as an emergency backup source in the process of generator set starting and generator starting failure.

1. PLN control system

The PLN control system on the PLC leader uses a voltage sensor to detect the PLN ON voltage. The timer is used to start the time when the load will be supplied by PLN's power source.

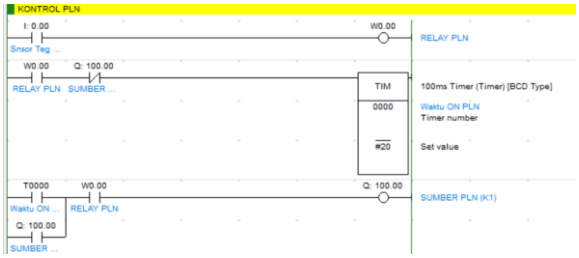

Fig 4. PLN control system

2. Solar PV control system

The solar power control system on the PLC leader uses a voltage sensor to detect the voltage of the solar power plant ON to detect the voltage of the solar power plant can be supplied to the load.

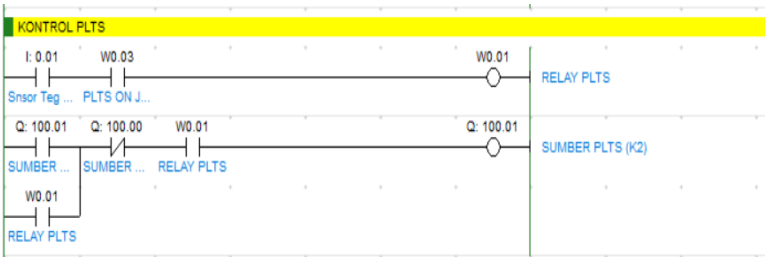

Fig 5. Solar Power Plant Control System

3. Generator set control system

The generator control system on the PLC leader uses a voltage sensor to detect that the generator set can supply to the load. The standby timer is used for the standby generator set for some time when the main source is ON. The starting process lasts for 2 seconds, the counter is used to calculate the starting failure of the Generator 3 times.

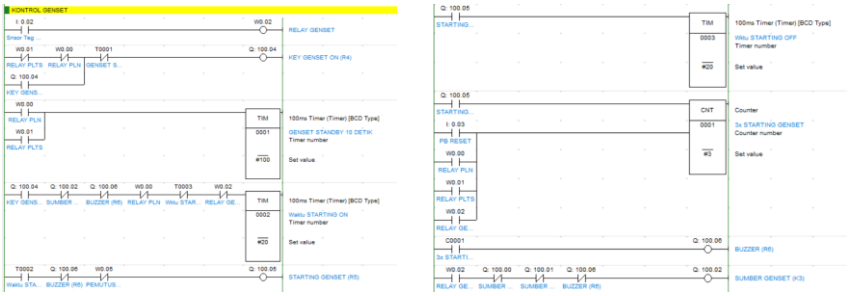

Fig 6. GENSET Control System

4. Battery control system

The battery control system on the PLC leader uses 2 outputs (2 contactors) to supply the load. K4 contactors to distribute battery power sources to critical loads and K5 contactors to distribute non-battery power sources (PLN, PLTS and Gensets) to critical loads.

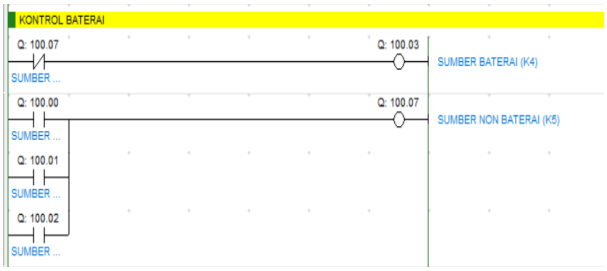

Fig 7. Battery Control System

5. Solar PV operating time control system

The operating hours of the solar power plant on the PLC leader are used to operate the solar power source to the load at 10 am – 3 pm. Outside of that time, solar power plants do not operate.

Fig 8. Solar Power Plant Uptime Control System

The PLC diagram leadder is designed to detect the PLN main source voltage, PLTS source voltage, generator set backup source voltage and PLTS operating time.

ATS (Automatic Transfer Switch) system testing with PLC

Testing of the ATS system with PLN, PLTS and GENSET energy sources is as follows:

Table 1. ATS System Test Results

No.	Testing	Energy Source				Power Output
		PLN	Solar Power Plant	GENERATOR SET	BATTERY	
1	PLN ON (during the day during the operational hours of the solar power plant)	ON	OFF	OFF	OFF	PLN
2	PLN ON (at night outside the operating hours of the solar power plant)	ON	OFF	OFF	OFF	PLN
3	PLN OFF (during the daytime during solar PV operating hours)	OFF	ON	OFF	OFF	Solar Power Plant
4	PLN OFF (at night outside the operating hours of solar PV)	OFF	OFF	ON	ON	Battery and GENERATOR
5	PLN OFF outside the operational hours of the solar power plant and some time later PLN ON and back OFF	0N and OFF	OFF	(when PLN IS OFF, the generator is on standby for 10 seconds)	ON	Battery, GENSET and PLN
6	Failure to start GENSET	OFF	OFF	OFF	ON	BATTERY

1. PLN ON testing (during the day during the operational hours of the solar power plant)

PLN as the main source, when the solar power plant is operating and the PLN source is ON, the load will be supplied by PLN.

Fig 9. PLN ON testing during solar PV operational time

Figure 9 shows the R1 ON relay as a PLN voltage sensor, the 4 ON relay as a connection to a non-battery load source, and the load supplied by the PLN main source through the K1 ON contactor which is marked by the PLN indicator light on.

2. PLN ON testing (at night outside the operational hours of the solar power plant)

When PLN ON at night outside the operational hours of PLTS, the load will still be supplied by PLN sources because PLN is the main source. The way the control system works is the same as PLN ON in the operational time of the solar power plant.

3. PLN OFF testing (during the day during the operational hours of the solar powerplant)

During the daytime or during the operational hours of PLTS and PLN OFF, the load will be supplied by the PLTS source because the PLTS works during its operational hours and when the main source of PLN is OFF.

Fig 10. PLN OFF testing during solar PV operational hours

Figure 10 shows the R1 OFF relay which means that the main source of PLN is OFF, the 4 ON relay as a link to the non-battery load source and the load is supplied by the PLTS source through the K2 contactor which is marked by the on-turn of the PLTS indicator light.

4. PLN OFF testing (at night outside the operating hours of PLTS)

When at night or outside the operating hours of the solar power plant and the main source of PLN OFF, the generator will automatically be turned on for the starting process of the generator ON then the load will be supplied by the backup source of the generator because PLN OFF outside the operating hours of the solar power plant.

Fig 11. PLN Testing OFF outside the operational hours of solar power plants

Figure 11 shows the generator set ON marked with relay R4 ON, generator voltage sensor ON which is marked with the R3 relay ON and relay 4 ON as a connection to a non-battery load source, then the load is supplied by the generator through the K3 contactor which is marked by the ignition of the generator indicator light.

5. Testing PLN OFF outside the operational hours of solar power plants and some time later PLN ON and back OFF

At night or outside operating hours, PLTS and the main source of PLN OFF and the load is supplied by the generator but some time later PLN ON then the load will be supplied by the main source of PLN and

some time later PLN OFF again then the generator must supply the load. So to anticipate the main source of PLN ON and OFF, the generator must be in standby when the main source of PLN is experiencing interference which results in the main source ON and OFF again. If the main source of PLN OFF again some time later then the generator does not need to restart the process and the load will be supplied by the generator. However, if the time that has been set for standby is complete, the generator will restart to supply the load.

Fig 12. Generator set testing standby when PLN ON

Figure 12 shows the load being supplied by PLN through the K1 contactor which is marked by the PLN indicator light on and the generator is on standby when PLN OFF occurs again which is marked by the ignition of the R3 relay and the R4 relay.

6. Failure to start GENSET

When the generator fails to start 3 times, the buzzer will turn on to notify the operator that the generator is experiencing a disturbance due to failure to start. During the failure of the generator, the load will be supplied by the battery source to the Critical load (lighting, CCTV and so on).

Fig 13. Failure testing starting Generator Set

IV. CONCLUSION

Based on the results of the ATS system design by integrating PLC and concluded as follows:

The Automatic Transfer Switch (ATS) system has been designed using PLC as the control centre to control the PLN, PLTS and Generator power sources. The ATS system is able to switch the battery power source in approximately 0.05 seconds when the generator is starting and when the three power sources (PLN, PLTS and Genset) fail to supply the load. The process of changing the power source takes place very quickly approximately 0.05 seconds so that the load is supplied very quickly by the power source (PLN and PLTS) but for switching the generator power source it takes approximately 2 seconds for the starting process with PLTS operational time from 10 am to 3 pm.

The electrical diagram of the energy source consisting of PLN system, PLTS system, Generator system, battery system, load system and control system using PLC has been tested in accordance with the description of the Automatic Transfer Switch (ATS) control system for transferring PLN, PLTS and Generator energy sources. The ATS system built is able to switch between PLN and PLTS power sources very quickly without any time lag so that the load is directly supplied by PLN and PLTS power sources. Meanwhile, the transfer of PLN's power source to the generator source takes about 2 seconds for the starting process. During the 2-second starting time, critical loads are supplied by the battery to maintain continuity of electrical power and the battery is off when the generator operates. The battery is also a backup in case of generator set starting failure.

REFERENCES

[1]. D. Sucipto, Y. Alim, and A. Yusni, “Electrical simulation of PLC-based automatic transfer switch control on trainers as a learning medium for DIII students of electronic engineering polytechnic of mutual hope,” ***Power Elektronik: Jurnal Orang Elektro***, vol. 6, no. 2, pp. 38–42, Jan. 2019, doi: 10.30591/polektro.v6i2.1196.

[2]. D. Harjono, T. J. Satria, and N. Nurhaidah, "Rancang Bangun Automatic Transfer Switch (ATS) Automatic Main Failure (AMF) Menggunakan PLC LS Master K120s," ***Jurnal ELIT***, vol. 3, no. 2, pp. 40–47, 2022.

[3]. A. Supriyadi, H. Purnama, and S. W. Jadmiko, "Rancang Bangun Automatic Transfer Switch (ATS) Automatic Main Failure (AMF) Menggunakan PLC LS Master K120 sosiding The 12 th Industrial Research Workshop and National Seminar Bandung," 2021.

[4]. Fathurrahman, F., Irawan, A. ., & Fridayanti, sri . (2023). Effectiveness Of Regional Regulation Number 20 Of 2001 Regarding Regulation Of Street Traders And Seasonal Street Traders In Tarakan City. *International Journal of Educational Research &Amp; Social Sciences*, *4*(3), 429–434. https://doi.org/10.51601/ijersc.v4i3.652.

[5]. Sulaiman, S., Halim Soebahar, A. ., & Mundir, M. (2023). Madrassa Diniyah Curriculum Transformation In Pesantren: A Study Of Wali Songo Mimbaan And Salafiyah Syafi'iyah Sukorejo Pesantren In Situbondo. *International Journal of Educational Research &Amp; Social Sciences*, *4*(3), 444–453. https://doi.org/10.51601/ijersc.v4i3.659.

[6]. Mutiara Cipta, D. ., & Alvin, S. (2023). Safeguarding Personal Information: Communication Privacy Management By Gen-Z Influencers. *International Journal of Educational Research &Amp; Social Sciences*, *4*(3), 465–471. https://doi.org/10.51601/ijersc.v4i3.653.

[7]. Sharia Financing Banks In Indonesia 2016-2020 Period. *International Journal of Science, Technology & Management*, *3*(5), 1268-1275. https://doi.org/10.46729/ijstm.v3i5.626

[8]. Butarbutar, M., Kurnia Lubis, A., Tua Siregar, R., & Supitriyani, S. (2022). Implementation Of Work Stress In Moderating Work-Life Balance And Flexible Work Arrangements For Job Satisfaction During The Covid-19 Pandemic. *International Journal of Science, Technology & Management*, *3*(5), 1357-1364. https://doi.org/10.46729/ijstm.v3i5.615

[9]. Evanthi, A., & Mukti Azhar, R. (2023). Planning and Implementation of Event Marketing in Sociopreneurship . *International Journal of Science, Technology & Management*, *4*(6), 1451-1459. https://doi.org/10.46729/ijstm.v4i6.1003.

[10]. Nugraha, B., Sianturi, I., & Aini Rakhman, R. (2023). The Effect Of Supply Chain Management And Corporate Communication Skills On Production Performance At PT. Berlian Manyar Sejahtera. *International Journal of Science, Technology & Management*, *4*(6), 1477-1485. https://doi.org/10.46729/ijstm.v4i6.966.

[11]. Parulian Simanjuntak, G., & Sensi W, L. (2023). Evaluation Of The Implementation Of The Internal Audit Capability Model (IACM) Level 3 In The Supervision System Of The Inspectorate General Of The Ministry Of Agriculture. *International Journal of Science, Technology & Management*, *4*(6), 1581-1602. https://doi.org/10.46729/ijstm.v4i6.1011

[12]. Hanif Triyana, M., & Indah Fianty, M. (2023). Optimizing Educational Institutions: Web-Based Document Management . *International Journal of Science, Technology & Management*, *4*(6), 1653-1659. https://doi.org/10.46729/ijstm.v4i6.976

[13]. Muryanto, F., Sukristyanto, A., & Juliswara, V. (2022). Examining The Policy Narrative and The Role of the Media in the Policy Response to the Covid-19 Crisis in Indonesia. *International Journal of Science, Technology & Management*, *3*(5), 1295-1306. https://doi.org/10.46729/ijstm.v3i5.599

[14]. Setia Pratama, A., Sudarmiatin, S., & Wishnu Wardhana, L. (2023). The Influence Of Product Perceived Quality, Service, Environment And Assortment On Customer Loyalty With Customer Satisfaction As An Intervening Variable In Angkringan UMKM In Mojokerto Regency. *International Journal of Science, Technology & Management*, *4*(6), 1420-1432. https://doi.org/10.46729/ijstm.v4i6.978.

[15]. S. Apripurnomo and H. Purnama, "Design and Build PLC-Based Automatic Transfer Switch Simulator for the Use of Generator Sets in Residential Installations."

[16]. S. Sadi and S. Mulyati, "ATS (Automatic Transfer Switch) berbasis programmablle logic controller CPM1A Automatic Transfer Switch (ATS) based on programmablle logic controller CPM1A," ***Jurnal Teknik***, vol. 8, no. 1, Mar. 2019, doi: 10.31000/jt.v8i1.1579.

[17]. M. A. F. Haurissa and M. Jamlaay, "***Multiscience*** design of ATS (Automatic Transfer Switch) system by integrating PLC (Programmable Logic Controller) and inverter."

[18]. H. Utomo, A. Sadnowo, and S. R. Sulistiyanti, "Implementation of PLC-Based Automatic Transfer Switch in the Electronics Engineering Laboratory, Department of Electrical Engineering, University of Lampung," ***Jurnal Informatika dan Teknik Elektro Terapan*****,** vol. 2, no. 2, 2014.