Automatic Transfer Switch (ATS) Using Omron CP1L PLC and Human Machine Interface

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Abstract
Airports in aviation services are required to use facilities with the latest technology. This requires a stable and uninterrupted electricity supply to operate correctly. The Automatic Transfer Switch design based on the CX-Designer Human Machine Interface moves the electrical power supply source from PLN to the Generator Set or vice versa. There are two operating modes, namely manual mode and auto mode. In operation, it is also equipped with an interlock function between the PLN contactor and the generator and a PLN phase loss sensor for the R, S and T phases. For auto mode, it uses a timer with a setting for PLN of 12 seconds and for the generator of 15 seconds. The control system uses an Omron CP1L-L20DR-D PLC with CX-Programmer programming for Human Machine Interface with CX-Designer. The Automatic Transfer Switch test was successful in system testing, starting from manual and auto mode, PLN phase loss testing, and timer testing; 100% of the entire hardware and software system ran well.

Keywords: automatic transfer switch, PLC, HMI.

INTRODUCTION

Airports today are adopting advanced technologies such as automation systems, facial recognition, data analysis and others to increase efficiency and safety. This technology often requires a steady, uninterrupted power supply to operate correctly.

Power supply failures at airports not only disrupt daily operations but can also have a significant economic impact. Flight delays and other disruptions can cause passenger dissatisfaction, disrupt global flight schedules, and harm the image of airports and airlines' image.

In emergencies, such as natural disasters or other unforeseen circumstances, airports often serve as evacuation points or aid centres. A reliable electricity supply is essential in ensuring that airports can function as coordination points and assistance centres in such situations [1].

Therefore, the reliability of the electrical power supply at the airport is a critical aspect that must be managed very well. Backup systems, regular maintenance, automatic monitoring technology, and emergency plans are some of the essential components that must be considered to ensure a stable and guaranteed power supply at the airport.

To increase the reliability of the electricity system, there are usually two backups that guarantee the continuity of the system; one of the most widely used backup energy sources is a generator. Generators usually use a diesel engine as a power source because diesel is the motor fuel with the highest energy content (around 10 kWh per litre). The autonomous time of a diesel engine is determined only by the fuel tank's volume.

A well-designed spare diesel engine can run at full load for several days. The most important thing is to consider the order in which they are charged when turned on so as not to overcharge them. Often, overmastering is done to trigger a full load when the generator is just turned on. Oversizing results in very low generator efficiency and shortens the life of the diesel engine.

As technology advances, PLN's main electricity supply will significantly impact consumers' electricity supply [2]. However, PLN electricity does not last forever because total blackouts often occur at certain times due to various disturbances in the distribution system. Automatic Transfer Switch (ATS) is an electrical power system equipment that controls the electrical energy supply from the primary source PLN to the generator set (genset) as a backup electricity source. ATS works automatically as a position transfer switch when there is a disturbance or outage at the PLN primary power source by controlling the time settings [3]. ATS is implementing a practical solution when you are in an emergency in a work environment requiring electric power to continue running [4].

METHODS

In the research, 3 (three) steps must be carried out; the first step is to create a series of Automatic Transfer Switches consisting of 1) a control circuit from PLC Omron CP1L-L20DR-D, 2) an automatic switch transfer circuit with 2 (two) 220VAC 4P contactors as a simulation of PLN source power supply contacts and generator set, 3) voltage sensor simulation from 3 (three) PLN sources) phase, namely phases R, S, and T, 3) independent power supply for the ATS control system, namely using a 24VDC battery according to the Omron PLC voltage used, 4) push button to turn on and turn off the PLN contactor and generator set in manual mode.

The second step is to create a ladder diagram using CX-Programmer software from Omron; apart from programming functions, this software can also function such as setting up and operating the PLC, debugging programs, displaying addresses and values, setting and monitoring, and remote programming over the network [5].

The third step is to create an Automatic Transfer Switch display design with a CX-Designer-based HMI integrated with the Omron CP1L-L20DR-D PLC. HMI functions to visualize work processes, events or processes that occur in real life by creating a simulation first. HMI is also useful for operators to identify program errors before running the program on natural systems in the industry.

The block diagram below shows the design of the Automatic Transfer Switch (ATS) using the Omron CP1L PLC and Human Machine Interface.

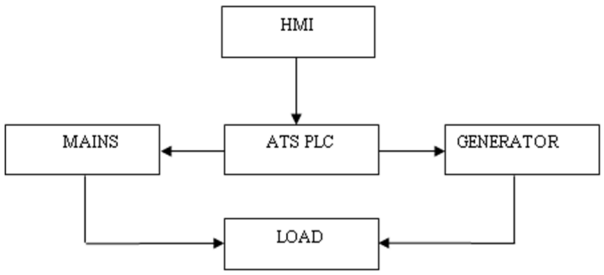

Figure 1 Blok Diagram Plan

The block diagram above consists of the PLN and Genset power supply sources, ATS with Omron PLC as the controller for switching switches from PLN to Genset or vice versa, and the Human Machine Interface as the control system interface.

RESULT

The results of this research carried out testing of Automatic Transfer Switches, PLC Programming, and Human Machine Interface (HMI) Display Design.

Automatic Transfer Switch (ATS)

ATS functions to regulate or control the change of electrical energy supply from the primary source, namely PLN, to a backup power source or generator set (genset), which works automatically as a position transfer switch when there is a disturbance or blackout at the primary power source (PLN) by controlling the time settings [6].

This circuit has two power supplies: a power supply from a 24DC battery, which functions as an independent power supply for the PLC control system, and a PLN 220 VAC power supply, which is used for the control output from the PLN contactor and generator. In the circuit, two 220VAC/4P contactors function as switches to control the PLN electric power supply and generator. As a control system, an Omron CP1L-L20DR-D PLC has 20 inputs and outputs with a 24VDC power supply with information from a push button and a PLN phase loss sensor [7].

The series has four push buttons: 2 push buttons for PLN (ON and OFF push buttons) and two generator push buttons (ON and OFF push buttons). Three relays are used as PLN voltage sensors representing 3 phases, namely R, S, and T, which simulate phase loss at the PLN source.

PLC Programming

Ladder programming in this research uses CX-Programmer software, fully integrated into all Omron PLCs. The addressing table is a table that contains input-output functions and the address of each part. The addressing table helps programmers identify input and output so that it will shorten programming time. The PLC input and output addresses are shown in the figure below.

Name	Data Type	Address / Value	Usage	Comment
K_genset	BOOL	100.02	Out	Kontaktor Genset
K_pln	BOOL	100.00	Out	Kontaktor PLN
m_auto_gen	BOOL	W10.12	Work	Memori untuk Kontak Genset Auto
m_auto_pln	BOOL	W10.00	Work	Memori untuk Kontak PLN Auto
m_man_gen	BOOL	W10.13	Work	Memori untuk Kontak Genset Manual
m_man_pln	BOOL	W10.11	Work	Memori untuk Kontak PLN Manual
pb_genOff	BOOL	0.03	In	Push Button Genset OFF
pb_genOn	BOOL	0.02	In	Push Button Genset ON
pb_plnOff	BOOL	0.01	In	Push Button PLN OFF
pb_plnOn	BOOL	0.00	In	Push Button PLN ON
sel_autoManual	BOOL	W0.00	Work	Selector Switch Model Auto / Manual
TegPLN_R	BOOL	0.11	In	True = Ada Tegangan PLN
TegPLN_S	BOOL	0.10	In	True = Ada Tegangan PLN
TegPLN_T	BOOL	0.09	In	True = Ada Tegangan PLN
sim_R	BOOL	W0.01	Work	Simulasi Gangguan PLN Fasa R terbuka
sim_S	BOOL	W0.02	Work	Simulasi Gangguan PLN Fasa S terbuka
sim_T	BOOL	W0.03	Work	Simulasi Gangguan PLN Fasa T terbuka
RST	BOOL	W0.04	Work	Simulasi Gangguan PLN Fasa RST

Figure 2 PLC Input and Output Address

Ladder 0 makes Auto and Manual sets equipped with PLN ON and OFF push buttons and GEN ON and OFF with memory output for PLN contacts and manual Genset positions.

Figure 3 Ladder Set Manual

Ladder 1 is an auto timer set on PLN and generators. In this study, the time setting for PLN was 12 seconds (TIM 000), and GEN was 15 seconds (TIM 0001). There are three relay coils for the phase loss sensor, namely phase R 0.11, phase S 0.10, and phase T 0.09; if the three relays are energized, then the PLN contactor is ON, and vice versa if one of the relays is OFF, then the PLN contactor will be OFF.

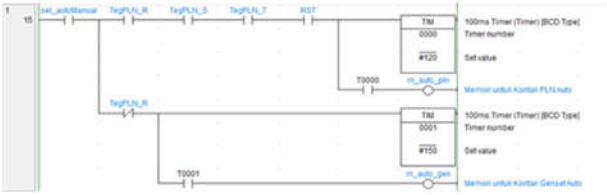

Figure 4 Auto Mode Ladder Timer

Human Machine Interface

CX-Designer is an HMI software made by Omron. It functions to visualize events, occurrences or processes happening in the plant in real life, making it easier for operators to do their work with HMI. Usually, HMI is also used to indicate machine error machine status, make it easier for operators to start and stop operations, and monitor several parts on production machines [8].

The image below shows the points in CX-Designer, boolean and integer types, I/O addresses on the Omron CP1L-D20DR-D PLC and the address ladder.

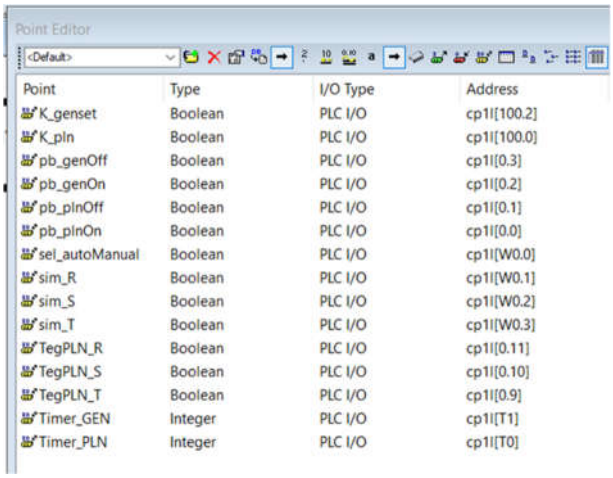

Figure 5 CX-Designer Point Editor and I/O Address

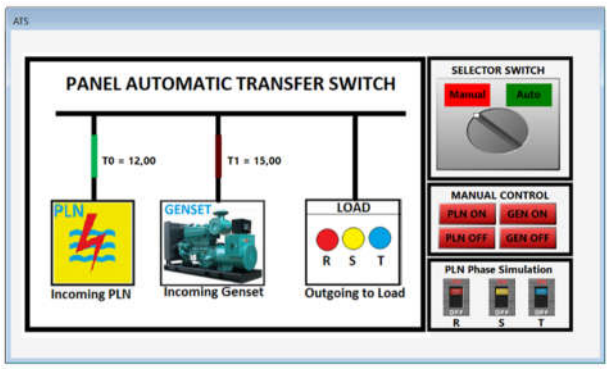

Figure 6 ATS display with CX-Designer HMI

The overall design of the Human Machine Interface Automatic Transfer Switch during testing is shown in the image below.

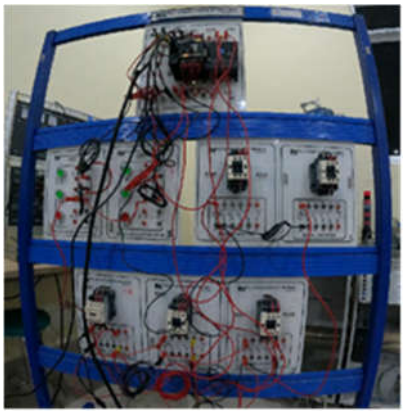

Figure 7 ATS Plan Testing

Manual Mode Testing

This test aims to test the ON and OFF push buttons on PLN and GENSET. After that, the interlock box test is also carried out, namely when the PLN push button is ON; if the GEN ON push button is pressed, the GEN contactor will not energize. The manual mode test table is shown in the table below.

Table 1. Manual Mode Push Button Testing

No	Push Button	PLN	Genset	KET
1	PLN ON	ON	OFF	Normal
2	PLN OFF	OFF	OFF	Normal
3	GEN ON	OFF	ON	Normal
4	GEN OFF	OFF	OFF	Normal
5	PLN ON GEN ON	ON ON	OFF OFF	Interlock Interlock
6	GEN ON PLN ON	OFF OFF	ON ON	Interlock Interlock

Auto Mode Testing

This auto mode test aims to test whether the system can work if it moves the switch automatically if the electrical power supply source goes dead. Tests were also carried out to test the timer settings on the PLN and Genset, according to the tool design for setting the PLN timer for 12 seconds and the Genset timer for 15 seconds. The auto mode test table is shown in the table below.

Table 2. Auto Mode Testing

No	Catu Daya	Timer	PLN	GEN	KET
1	PLN ON	12 sec	ON	OFF	Normal
2	PLN OFF GEN ON	15 sec	OFF	ON	Normal
3	GEN ON PLN ON	12 sec	ON	OFF	Normal

Phase Loss Mode Testing

This test aims to test phase loss in the input voltage of the PLN power supply source in a simulated circuit using three relays representing each PLN phase. The auto mode test table is shown in the table below.

Table 3. Auto Mode Testing

No	R	S	T	PLN	GEN	KET
1	ON	ON	ON	ON	OFF	Normal
2	OFF	ON	ON	OFF	OFF	Normal
3	OFF	OFF	ON	OFF	OFF	Normal
4	OFF	OFF	OFF	OFF	OFF	Normal
5	ON	OFF	OFF	OFF	OFF	Normal
6	ON	OFF	OFF	OFF	OFF	Normal

The results of the test above show that if one of the PLN voltage phases is off, the PLN contactor is off. If the PLN contactor is off, the power supply source is cut off to the load. This functions to protect the three-phase load from unbalanced loads.

CONCLUSION

The Automatic Transfer Switch design based on the CX-Designer Human Machine Interface moves the electrical power supply source from PLN to the Generator Set or vice versa. There are two operating modes, namely manual mode and auto mode. In operation, it is also equipped with an interlock function between the PLN contactor and the generator and a PLN phase loss sensor for the R, S and T phases. For auto mode, it uses a timer with a setting for PLN of 12 seconds and for the generator of 15 seconds.

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REFERENCES

[1] Suhanto, S. (2019). Simulasi Automatic Transfer Switch dan Automatic Mains Failure dengan PLC Omron Sysmac Cp1e. Jurnal Teknik Mesin dan Mekatronika (Journal of Mechanical Engineering and Mechatronics), 4(1), 27-33.

[2] Ananto, M. F. D., Wijayanto, K., & Supriyanto, S. (2021, September). Rancang Bangun Sistem SCADA Panel Automatic Transfer Switch (ATS) Berbasis PLC dan Interface WinCC. In Prosiding Industrial Research Workshop and National Seminar (Vol. 12, pp. 117-123).

[3] Saputro, S. (2015). Rancangan bangun pembuatan alat panel listrik ATS (automatic transfer switch)–AMF (automatic main falure) (Doctoral dissertation, UNIVERSITAS NEGERI JAKARTA).

[4] Rahman, F., & Natsir, A. (2015). RANCANG BANGUN ATS/AMF SEBAGAI PENGALIH CATU DAYA OTOMATIS BERBASIS PROGRAMMABLE LOGIC CONTROL: Design Of ATS/AMF As Automatic Power Supply Transfer Based Programmable Logic Control. DIELEKTRIKA, 2(2), 164-172.

[5] Septian, A. (2018). Penerapan Trainer Human Machine Interface (HMI) Berbasis CX-Designer Sebagai Media Pembelajaran Programmable Logic Controller (PLC). J. Inform. Univ. Pamulang, 3(4).6

[6] Suhanto, S. (2018). RANCANG BANGUN SISTEM AUTOMATIC TRANSFER SWITCH DAN AUTOMATIC MAINS FAILURE PADA GENERATOR SET 80 KVA DENGAN DEEP SEA ELECTRONIC 4420. Prosiding SENIATI, 4(1), 211-217.

[7] ESupriyadi, A., Purnama, H., & Jadmiko, S. W. (2021, September). Rancang Bangun Automatic Close-Transition Transfer Switch (Acts) Dengan

Sistem Back-Up Catu Daya Ups. In Prosiding Industrial Research Workshop and National Seminar (Vol. 12, pp. 504-509).

[8] Prastowo, I., Murti, M. A., & Sunarya, U. (2015). Human Machine Interface (Hmi) Berbasis Android Untuk Monitoring Dan Kendali Sistem Catu Daya. eProceedings of Engineering, 2(2).