ELKOMIKA: Jurnal Teknik Energi Elektrik, Teknik Telekomunikasi, & Teknik Elektronika

ISSN(p): 2338-8323 | ISSN(e): 2459-9638 | Vol. 11 | No. 2 | Halaman 510 - 521
DOI : http://dx.doi.org/10.26760/elkomika.v11i2.510 April 2023

Safety Design using ATS by Identifying Voltage Interference based on Fuzzy Logic

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Received 28 Februari 2023 **|** *Revised* 29 Maret 2023 **|** *Accepted* 2 April 2023

ABSTRAK

Sumber energi listrik PLN merupakan sumber utama bagi masyarakat. Namun kenyataan saat ini PLN masih belum maksimal dalam menyalurkan energi seperti dapat terjadi pemadaman, dan fluktuasi tegangan yang merupakan gangguan tegangan AC. Gangguan tegangan sendiri dapat menyebabkan kerusakan pada beban rumah tangga. Oleh karena itu, dalam jurnal ini membuat suatu inovasi dengan memanfaatkan sumber dari Baterai yang berfungsi untuk membackup ketika sumber PLN mengalami pemadaman dan gangguan. Dengan mengembangkan sistem yaitu automatic transfer switch (ATS) yang dapat membuat beban dalam kondisi aman dan mendapatkan aliran energi dari sumber cadangan. Sistem ini bekerja dengan mendeteksi 6 gangguan tegangan AC dengan metode fuzzy logic. Gangguan tersebut antara lain Interruption, Sag, Swell, Sustained Interruption, Undervoltage, dan Overvoltage. Dan sistem ATS bekerja saat jenis gangguan Durasi Panjang yaitu Sustained Interruption, Undervoltage, dan Overvoltage. Sistem automatic transfer switch ini mampu melakukan perpindahan sumber dalam waktu 5ms.

Kata kunci*: Automatic Transfer switch, Fuzzy Logic, Gangguan AC, PLN*

ABSTRACT

The primary source of electricity is PLN. However, the current situation shows that PLN is still not doing its best to distribute energy, as seen by blackouts and voltage fluctuations, which are disturbances of the AC voltage. Household loads can damaged by voltage disruptions. As a result, an innovation is made in this journal by utilizing the battery source, which serves as a backup when the PLN source encounters a blackout and other disruption. By developing a system, namely an automated transfer switch (ATS), that can maintain loads in a safe condition and allow energy to flow from backup sources The fuzzy logic method is used to identify six AC voltage disturbances in this system. There are six of AC voltage disturbances: interruption, sag, swell, sustained interruption, undervoltage, and overvoltage. The ATS system functions when there is a long duration disturbance, such as a sustained interruption, undervoltage, or overvoltage. This automatic transfer switch system has a switching time of 5 milliseconds.

Keywords*: Automatic Transfer switch, Fuzzy Logic, Voltage Disruption, PLN*

1. INTRODUCTION

At this time, electrical energy is a highly significant and advantageous source for human life. Specifically, it can be used as a source of power, lighting, motion, and other things.The existence of PLN significantly improves the effectiveness and efficiency of people's lives. The development of numerous electronic devices is also prompted by the presence of electricity. If PLN sources are able to constantly deliver energy with good power quality, they can be termed to have high electric power. If PLN sources are able to constantly deliver energy with good power quality, they can be termed as having high electric power **(Wijaya et al., 2019).** We must accept this and cannot stop it. Interference is what results in a complete blackout, and the disruption in question may stem from issues on the generating, transmission, or distribution sides. Several factors, including excessive speed, abrupt load changes, and others, can lead to disturbances in the AC voltage **(Arif et al., 2018).** All communal activities will come to an end when PLN passes away. Of course, not everyone wants this because it will make a work harder. Losses will occur from the negative impact of AC voltage disturbances (power quality) on both the customer side and the power plant (PLN). Additionally, the frequency of AC disturbances may contribute to the deterioration of electronic equipment. The neighborhood, where energy is now a source of life, most definitely does not want this. So that the Automatic Transfer switch (ATS), which is a switch that activates automatically to switch from the primary source to the backup source, is described in this journal. Transfer happens when the primary source (PLN) goes completely dark and a disturbance is found. The various AC disturbance kinds are separated into two categories: short duration and long-duration. The difference between a disturbance with a short duration and one with a long-duration is that the former lasts for less than a minute, while the latter lasts longer than that. Additionally, this system will pick up on 6 disruptions that fall into 2 categories. However, if there is a disruption that long duration than 60 seconds, a transfer switch or the ATS system will function. When there is a sustained interruption, undervoltage or overvoltage disturbances, for example **(Ginting et al., 2014).**

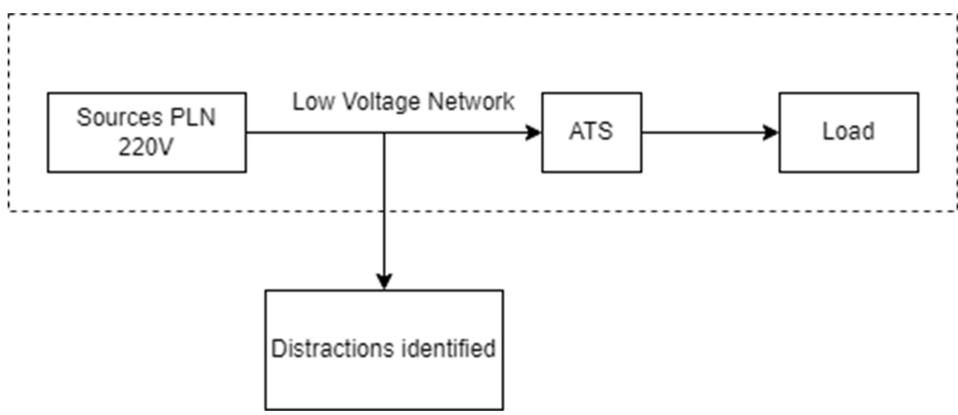

Figure 1. Block for Voltage Interference Identification

An identifier placement block schematic is shown in Figure 1 above. A single-phase low-voltage network with a nominal voltage of 220V **(Ratnasari, 2015).** Between the source and the ATS system, which will be connected to the load, is where this tool will be. So this system is used to detect disturbances in the 220V low-voltage network. And the location of this system is after the source, so that when a disturbance is detected, the system will automatically switch to a backup source.

2. METHODS

Figure 2 depicts the block design of the Automatic Transfer Switch (ATS) system that uses fuzzy logic to detect voltage abnormalities.

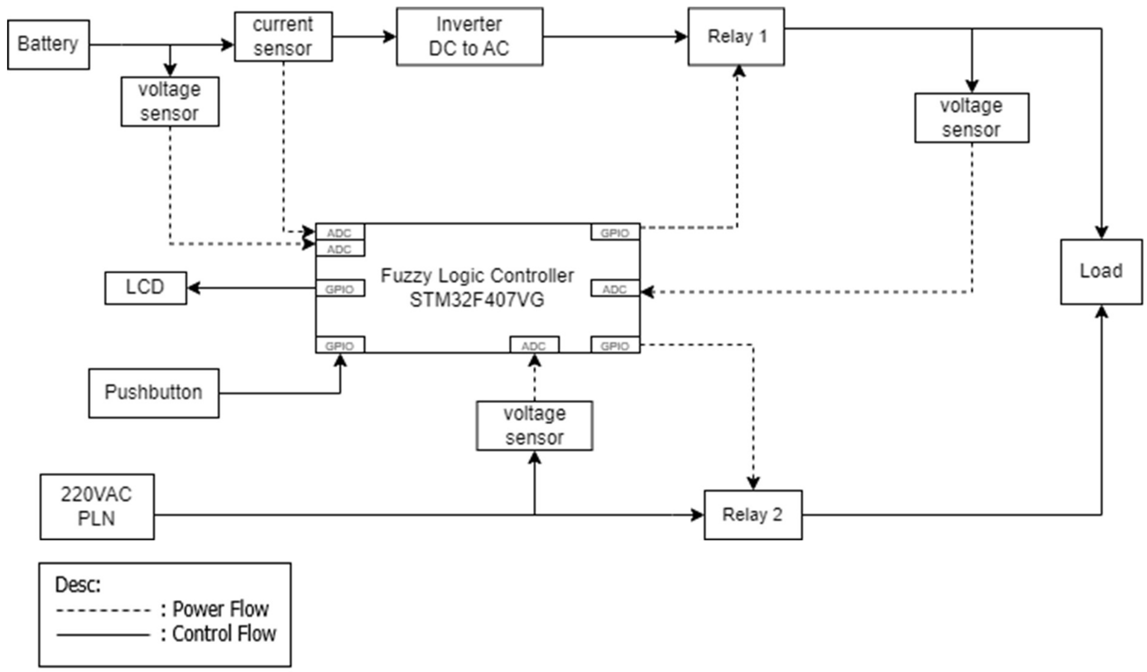

Figure 2. Block Diagram System

In this research, switching works by identifying interruptions in the main source (PLN). This study uses two sources, with the backup supply being a battery connected to an inverter that converts DC to AC. The battery being utilized is a lead acid battery with a capacity 12V and 35Ah **(Rakhmawati et al., 2020).** When choosing batteries, the necessities have been taken into account. The fuzzy logic approach is used to carry out the identification procedure, with the input parameters being voltage and a timer, and the fuzzy output being a declaration of voltage condition. The user can then choose the source to be used manually by pushing a button that serves as a feature. This system functions both automatically and manually. A microcontroller is used to control all systems in this tool because it has all the components needed to implement a program, and the STM32F4 Discovery Microcontroller has features that make it possible to construct applications quickly and effectively **(Rakhmawati et al., 2019).** And then a block diagram of fuzzy logic is shown in Figure 3.

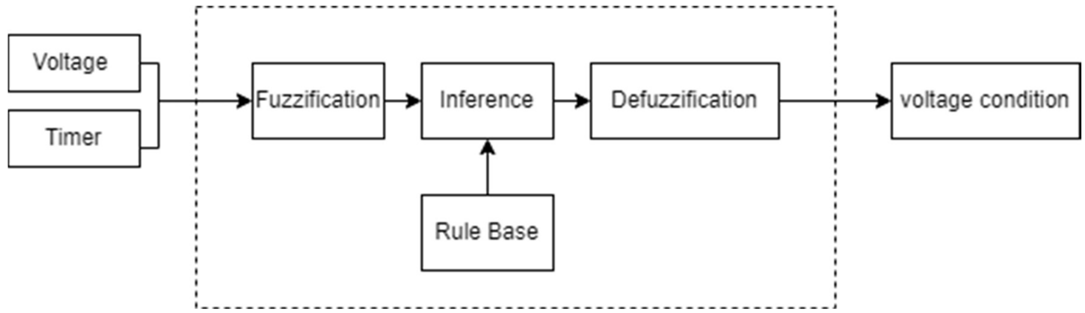

Figure 3. Block Diagram Fuzzy Logic

2.1 Automatic Transfer switch

ATS is a switch that set up to switch from the primary source to the backup source automatically and vice versa. Making ATS essentially involves using relays, timers, contactors, and MCBs to assemble mathematical logic reasoning. These devices serve as breakers or switches **(Supriyadi et al., 2021).** The ATS operates similarly to a switch that can switch sources, with the exception that, depending on the ATS system's architecture, it may be operated manually or automatically **(Majid, 2017).** The ATS system has undergone numerous changes over the years, including the ability to operate automatically based on the amount of load that will be applied. When the system detects a long-duration disturbance, the source moves or shifts to another source. This tool will measure the voltage value in real-time, and if the voltage value exceeds the tolerance limit for a predetermined period of time, an identification process will be carried out to determine the voltage disturbance using fuzzy logic, and if the disturbance has been detected, the ATS system will carry out control and transition **(Syahrin et al., 2020).** The automatic transfer switch is a part of the Omron Relay of the L2Y type. The relay serves as a switching mechanism that can switch the backup power source from the primary power source. Because the load to be employed is an AC load, this tool's design includes two relays. A relay driver circuit uses an interlock circuit to activate the relay so that it does not fire simultaneously when it is turned on **(Sodiq et al., 2021)**. A relay driver circuit uses an interlock circuit to activate the relay so that it does not operate at the same time as the automated relay when it is turned on **(Utomo et al., 2014).**

2.2 Power quality

When there is a divergence in the voltage, current, or frequency of the electric current, it is referred to as a power quality issue and it can lead to failure or issues with consumer electronics. A waveform with good power quality will match the AC voltage **(Hasanah et al., 2018).** For the example in Indonesia, the frequency and voltage are 220 volts AC at 50 Hz. The power quality is evaluated in order to make load operation safer and more effective. The purpose of the power quality audit activity is to investigate and confirm that the electrical energy entering the system or equipment enables the system to perform properly, effectively, and with the least amount of long-term risk to the equipment **(Mahela et al., 2015).** Power quality, according to the IEEE, is "the idea of supplying electric power and earthing (grounding) sensitive equipment to comply with the operational principles of the equipment." And according to the International Electrotechnical Commission (IEC), "power quality is a set of parameters that determine the nature of the power supply delivered to the user under normal operating conditions in terms of supply continuity and voltage characteristics (quantity, frequency, and waveform)" **(Yudha, 2017)** The power quality is then used to evaluate the system's capacity to provide dependable load operation. Unreliable power can cause equipment to break down or be damaged. The efficiency, continuity, and safety of the electrical infrastructure can all be impacted by low power quality. Low power quality can also impact the electrical infrastructure's effectiveness, continuity, and safety **(Nugroho et al., 2021).**

2.3 AC Voltage

Normal voltage conditions, which have a value ranging from above 0.9 to below 1.1, are among the two conditions that AC voltage typically possesses based on its RMS value. In this state, it is still generally safe. About abnormal voltage conditions, which are voltage conditions that are higher than the value of normal voltage conditions, if these conditions arise and are permitted to do so, the equipment will be harmed **(Situmorang, 2019).** The table that follows describes the state of the ac voltage based on the RMS value and duration.

Table 1. Condition of Voltage Category (Committee of the IEEE Power & Society, 2009)

Categori	Time Duration	Voltage Magnitude
Normal	-	>0,9 pu & 1,1 pu
Short Duration RMS Variation		
Interruption	0,01- 60s	<0,1 pu
Sag	0,01- 60s	0,1-0,9 pu
Swell	0,01- 60s	1,1-1,2 pu
Long Duration RMS Variation		
Sustained-interuption	>60s	<0,1 pu
Undervoltage	>60s	0,1-0,9 pu
Overvoltage	>60s	1,1- 1,2 pu

Each sort of disruption that occurs has a different voltage magnitude and duration, as shown in Table 1 **(Valtierra-Rodriguez et al., 2016).** Due to the fact that the source being used is a single-phase source, the voltage magnitude of 1 Pu, which has a value of 220v, is per unit. It is possible to identify the sort of disturbance that was present at that time by looking at the table above, which includes the time duration of the disturbance. In situations of AC voltage disturbances, the voltage is frequently unstable or can occur up/down. A disturbance with a brief duration is one that has a disturbance state or an interruption that lasts less than one minute. Regarding some of these issues, specifically interruption, voltage sag, and voltage swell **(Tan & Ramachandaramurthy, 2012).** Long duration a disturbance that have than one minute. Regarding a few of **(Firmansyah et al., 2016) t**hese types of disturbances, specifically: Sustained Interrupt, Undervoltage, and Overvoltage**.** Additionally, this system can detect both short-duration disturbances even though switching only works with long-duration disturbances.

2.4 Fuzzy Logic Controller

Fuzzy logic is a type of reasoning that can be used to resolve issues containing ambiguity, inaccuracy, and vagueness. Fuzzy logic is a subfield of artificial intelligence, which is the study of how to make computers mimic human intellect **(Suhariningsih et al., 2020).** As a result, computers are predicted to be able to perform tasks that need intelligence that humans perform **(Ardiansyah et al., 2020).**There are three primary procedures for applying fuzzy logic to a device, including A technique called "fuzzification" converts an input from a hard form (crisp) to a fuzzy one. Most presented as fuzzy sets, each with a membership function. An example that clarifies the relationship between input and output variables when the variables that are processed and those that are created are fuzzier is the interface system (Evaluation Rule). In order to clarify the connection between input and output, it is typically presented as a "IF-THEN" statement. Defuzzification is the process of converting variables that are provided to control equipment as fuzzy (vague) data into definite data (crisp) (Thamrin et al., 2012)**.** In this journal, fuzzy logic uses input and output parameter data based on Table 1, namely is conditions of voltage category.

3. RESULT AND DISCUSSION

The outcomes of system testing where the manufactured hardware system measures 20 cm by 10 cm. This gear, which includes an automatic transfer switch and a tool for defect detection, makes up the entire system. This tool aids in determining whether a disturbance occurs at the primary source in accordance with the plans (PLN).

Figure 4. Hardware System

An overview of the completed tool is shown in the figure 4. There are upper and lower boards in this tool. And the top board and bottom board are shown in more detail in the image below:

(a) (b)

Figure 5. (a) Display Top Board; and (b) Display Bottom Board

This tool used two sources: batteries as a backup source and a variac as a failure simulator. Variac functioned as the main source of PLN. And because an AC source is the intended output, an inverter is added after that on the side of the backup source (battery). The inverter converts a DC supply into an AC source. And as for how this tool functions, the source will switch to a backup source if a voltage disruption is detected on the side of the main source for more than one minute. As previously stated, the Sugeno fuzzy-type approach is used to identify voltage disturbances. Additionally, the source will automatically switch to a backup source if the primary source blackout. And then this tool has a pushbutton that may be used to manually activate it by selecting the desired source.

The final result is shown below. The source will continue to use the primary source, or there won't be a switch to a backup source, when normal conditions or no interference is detected at the main source.

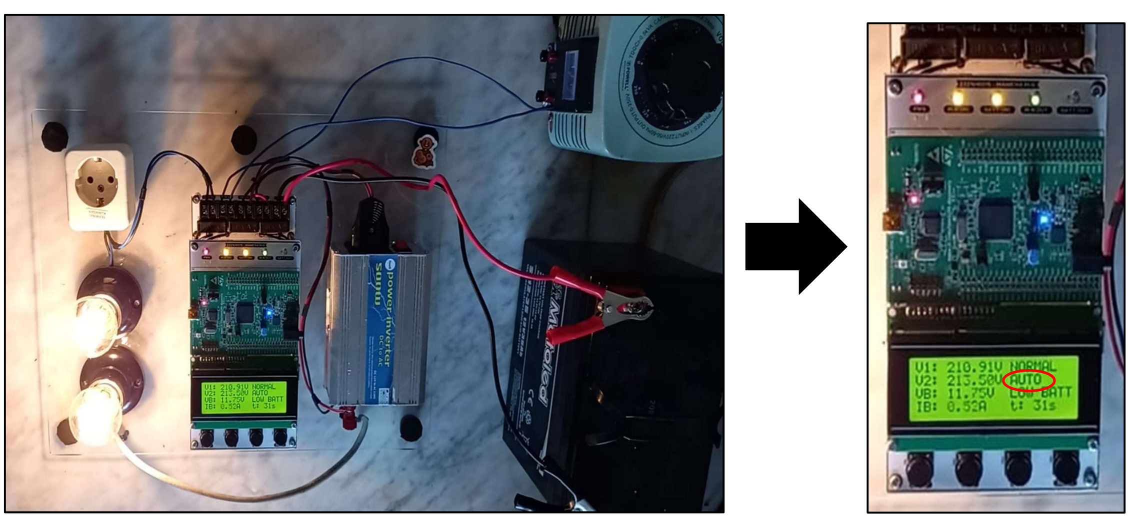

Figure 6. When Normal Condition

From Figure 6, it is explained from the LCD display that V1 is the voltage value that is read from the primary source side and V2 is the voltage from the secondary source side. Following that, VB is the battery's voltage value, and IB is its current value. Additionally, it is visible that "AUTO" is displayed on the LCD, indicating that the system being utilized right now is an automatic system. Figure 6 shows how the supply is used from the primary source (PLN) when there is no disruption detected (a normal condition) within 30 seconds in this system and the voltage (V1) reads 210.91 volts. And as seen in Figure 7 below, the system also includes an LED light that adjusts its "on" based on the state of the power source being used. The PLN output source lights up, as it does in normal conditions.

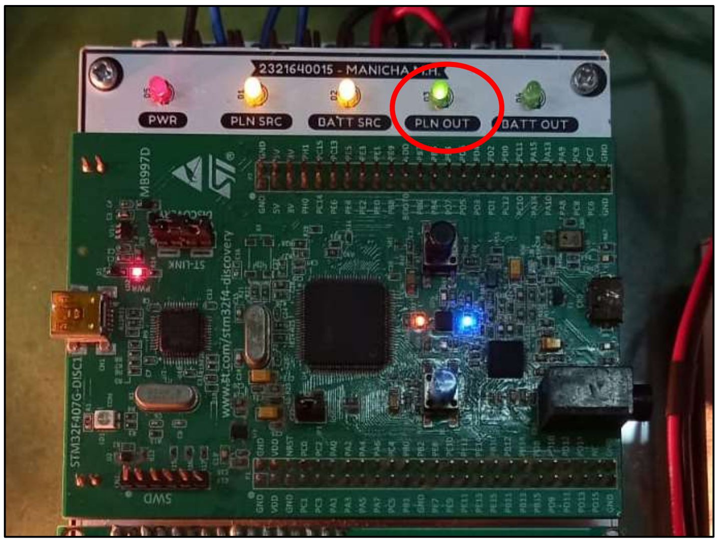

Figure 7. LED Condition

After that, when the system will immediately switch to a backup source when a voltage disruption is detected and lasts for longer than one minute, as shown in the figure below:

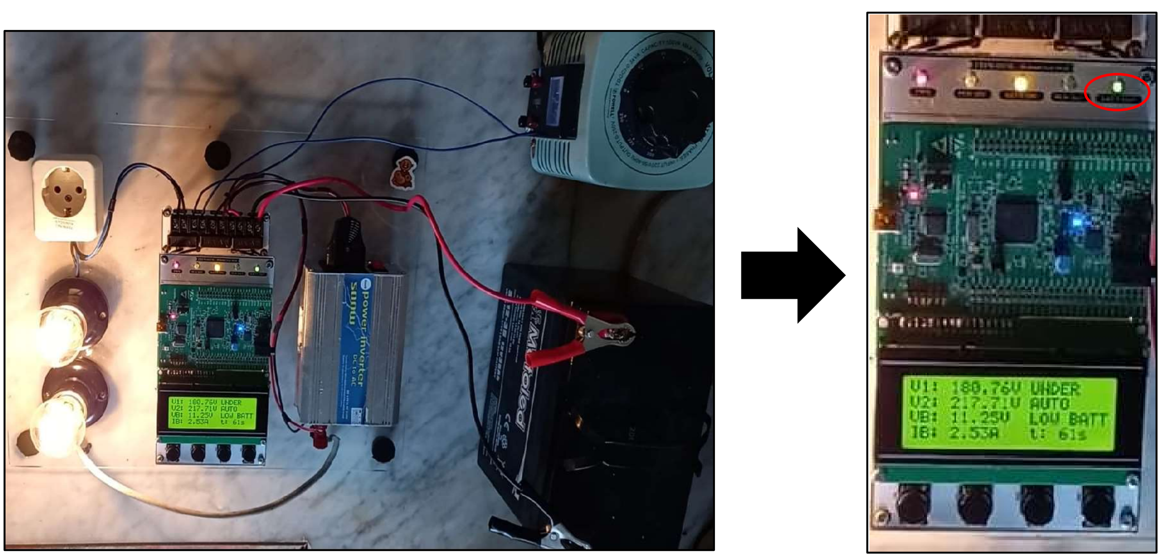

Figure 7. When Undervoltage Condition

Figure 8 shows an undervoltage condition if the voltage (V1) is read at 180.76 volts. In this system, if a long-duration disturbance is detected within 61 seconds (longer than one minute), the supply will switch to a backup supply (battery). And then in the next test, when the condition is manually set (using a pushbutton):

Figure 8. When Feature Manual by Inverter

On the LCD screen, the display changes from "AUTO" to "Inveter/PLN" when the feature is manually selected by pressing the pushbutton. According to the source the user has chosen. An all-identification test and automatic switching are shown in Table 2 below.

Table 2. Results of the Integration Test

Vrms (volts)	Timer (Second)	Output Disturbance	Supply Condition
220	30	Normal	PLN
6.24	60	Interruption	PLN
17.39	60	Interruption	PLN
20	61	Sus-Interruption	Battery
17.98	61	Sus-Interruption	Battery
228	30	Normal	PLN
179.35	60	Sag	PLN
179.13	60	Sag	PLN
186.80	60	Sag	PLN
179.86	61	Under	Battery
180.76	61	Under	Battery
188.25	61	Under	Battery
210.91	30	Normal	PLN
243.27	60	Swell	PLN
248.38	60	Swell	PLN
244.12	61	Over	Battery
252.10	61	Over	Battery

And then this system has been proven to switch from the primary source to the backup within 5 milliseconds.

Figure 10. Time Respect Driver Relay

Figure 10 explains that when relay 1 switches to relay 2, there is no intersection between the two, which means that the switching is running safely. And Table 3 is a table of the time transition test results.

Table 3. Testing the Transition Time of the Relay Driver

	Relay Condition		**Time respect (ms)**
Relay 1	ON	OFF	5
Relay 2	OFF	ON	5

From Table 3 is transition test result where it is stated that checking for time switching is done by each relay. And the findings were as expected, with the transfer process taking less than a second and the test results coming in at 5 milliseconds for each functional relay.

4. CONCLUSION

The results are that the system can identify voltage disturbances at the main source (PLN). One state is normal, and there is six types of disturbances: interruption, sustained interruption, sag, undervoltage, swell, and overvoltage. With switching parameters of 5 milliseconds, the automatic transfer switch system has been successfully used for long-duration disturbances like sustained interruption, undervoltage, and overvoltage in secure circumstances where there is no leakage voltage between the two PLN sources and the battery.

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