IOT-BASED THREE PHASE LOAD IMBALANCE MONITORING AND CONTROL SYSTEM USING BLYNK APPLICATION WITH MICRO SD DATA LOGGER

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Abstract

Electricity is needed for daily life such as technology needed for humans to carry out their activities, for example communication technology, transportation, and others. Therefore, electricity is an important thing to support the progress of an area, so that the smooth distribution of electricity is expected to always be optimal and as little as possible to avoid disturbances that can hinder the continuity of electricity distribution. one of the disturbances that commonly occur is load imbalance. Load imbalance is a disturbance that often occurs due to uneven load placement on each phase, this can cause current to flow on the neutral conductor. The requirement to be said to be balanced is when the three current or voltage vectors are equal and the three vectors form an angle of 120º to each other. Based on IEEE 446 - 1995 standardization regarding Power Quality, load imbalance is only allowed to be 5-20% and according to IEC and ANSI that the tolerable load imbalance value is 5%. The results of the research that has been done show the results of the PZEM-004T sensor reading of voltage and current are functioning properly when compared to a multimeter measuring instrument. The data generated from the PZEM-004T sensor readings can be stored in the micro sd data logger in text format. The control system on this tool when tested with an unbalanced load on each phase takes approximately 3 seconds to disconnect the current to the load and takes less than 1 second to reconnect the current to the load. The reading results of current, voltage, and load imbalance can be seen on the LCD installed on the device and can be seen in the Blynk application. With the results of research on this tool is expected to facilitate technicians in monitoring load imbalance anywhere and anytime.

Keywords: Load imbalance, PZEM-004T, Data Logger, ESP32, Blynk Application

INTRODUCTION

Electricity is one of the important components in life so it is expected that the distribution of electricity runs continuously and without obstacles. Airport is one example of electricity consumers who need electricity in a large enough capacity, in this case the Airport uses a lot of loads and various such as air conditioning, lights, refrigerators, printers and many other equipment, usually in the installation of the load is not evenly distributed on each phase which can cause load imbalance. Unbalanced loads in electrical installations always occur and the cause of unbalanced loads is influenced by many factors including the distribution of loads between phases (phase R, phase S, and phase T) which are unbalanced. As a result of unbalanced load sharing in each phase, the current flows in the neutral phase N. As a result of the current flowing in the neutral phase, it causes losses. As power distribution systems continue to grow in size and complexity, reducing losses can result in substantial savings for power providers. Other benefits of reducing losses include the resulting system capacity, and the possible deferral of capital expenditure for improvements and expansion of the system itself (Al-Badi, et all, 2011). In the distribution of electrical energy, it is desirable that the electrical power supplied to the load is almost close to the source value. In other words, the electric power distribution system has high efficiency or little power loss. To get a high-power efficiency value, a 3-phase system requires a load balance between its phases.

As for what is meant by a balanced state when :

1. All three current/voltage vectors are equal.
2. The three vectors form an angle of 120º to each other.

As for the unbalanced state is when:

1. The three vectors are equal but do not form a 120º angle with each other.
2. The three vectors are not equal in size but form a 120º angle with each other.
3. The three vectors are not equal and do not form a 120º angle with each other.

Based on IEEE 446 - 1995 standardization regarding Power Quality, load imbalance is only allowed to be 5-20% and according to IEC (International Electrotechnical Commission) and ANSI (American National Standards Institute) that the tolerable load imbalance value is 5%. Because with the onset of load imbalance can cause current flowing on the neutral side and the current flowing on the grounding (grounding) then if allowed to continue can cause significant losses.

METHODS

Research Design

In the process of designing an IoT-based three-phase load imbalance control and monitoring system using the Blynk application with a micro sd data logger, using the Research and Development (R&D) research method to produce certain products and test the effectiveness of these products. In this research using R & D method because the final result of this research will produce a prototype of control and monitoring system of load imbalance using Blynk application based on IoT. The following is a block diagram in planning the tool design:

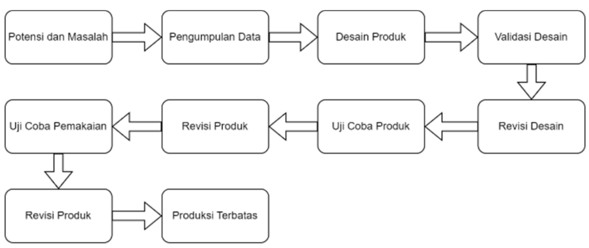

Figure 1 Research design

Tool Design

In accordance with the tool design block, this tool uses ESP32 as a microcontroller that has been programmed as a control and monitoring system. There is an input to the ESP32, namely the PZEM-004T sensor which is useful for measuring current and voltage values. This tool also uses a data logger module as a means of storing data on the calculation results stored on the installed micro sd. The 3-phase MCB is also used to distinguish the electricity supply from the R, S, and T phases. There are also 3 contactors that are used to cut off electricity to the load and a relay that functions to give commands to the contactor to cut off electricity to the load if it gets a command from ESP32. For load installation using 1 socket on phases R, S, and T. Do not forget that ESP32 requires a fairly small source of 3.3V-5V so that an adapter is needed to provide a source to ESP32 to work. The output of the ESP32 can be displayed on a 16x2 LCD and Blynk application, the LCD is used to display current readings, voltage, percentage of load imbalance, and load imbalance status, this LCD is attached to the device. While the Blynk application is used to display the value of current, voltage, percentage of load imbalance and load imbalance status, in this tool there is also a reset button to give a command to connect the contactor when previously disconnected due to load imbalance.

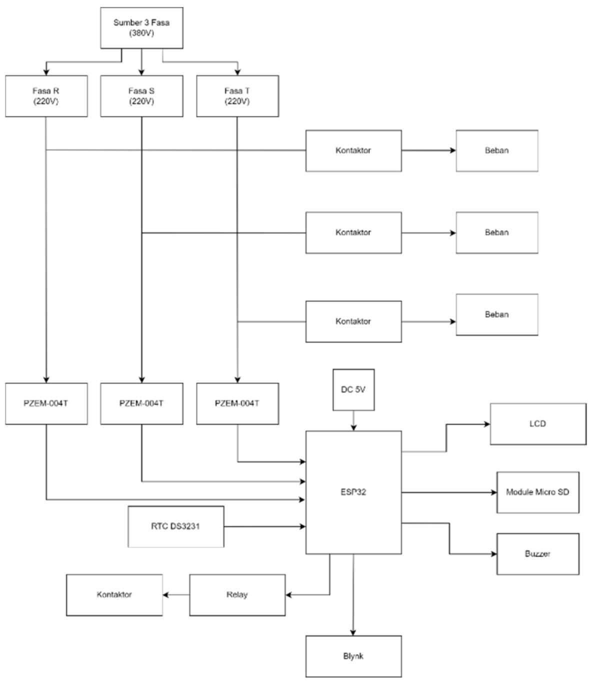

Figure 2 Tool design

Testing Technique

The testing technique is carried out to determine the performance of this tool has worked well in accordance with its function. This test is carried out in two stages, namely the testing stage of each component and testing by all modules that are appropriate and have run well using the library from the Arduino IDE software.

Data Collection Technique

Data collection techniques are carried out when / after the testing technique is carried out, this is done to analyze the data generated from the test with the expectations or analysis that has been carried out which later the results of data collection can be displayed as supporting data in the report.

RESULT AND DISCUSSION

Testing the PZEM-004T Sensor

PZEM-004T sensor testing is carried out to find out the sensor works properly to measure voltage and current. in this test the PZEM-004T sensor is connected to the source and supplied to different loads then data will be taken on the PZEM-004T sensor readings and will be compared with measurements using a Multimeter.

The first test carried out is checking the voltage using a Multimeter and PZEM-004T Sensor which then the results will be matched, and the results obtained from the comparison of voltage readings using a Multimeter and PZEM-004T are appropriate.

Figure 3 Measurement of voltage using a Multimeter

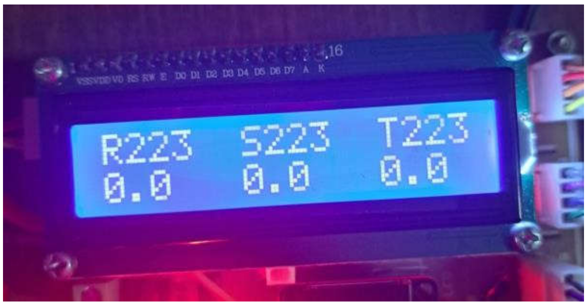

Figure 4 Measurement of Voltage using PZEM-004T

Table 1 Voltage measurements

FASA	Tegangan pada Multimeter	Tegangan PZEM-004T
R	223,4 V	223 V
S	223,4 V	223 V
T	223,3 V	223 V

The next test aims to check the measured current readings using the PZEM-004T sensor and Ampere Pliers that have been used are irons, and 2 cellphone chargers are also appropriate when compared.

Figure 5 Measurement of Current using a Multimeter

Figure 6 Measurement of Current using PZEM-004T

Table 2 Current measurements

FASA	Arus pada Tang Ampere	Arus pada PZEM-004T
R	0,18 A	0,2 A
S	1,52 A	1,5 A
T	0,14 A	0,1 A

Based on the above tests, the PZEM-004T sensor is working properly because the current measurement results displayed on the sensor and Ampere Pliers are correct. It can be concluded from this test that the PZEM-004T sensor can work properly and is ready for use.

Testing the Control System

This test will test several components in this tool that function as a control system, namely contactors and solid state relays that work properly when there is a load imbalance. at this stage the tool will be connected to the load.

This test was carried out 3 times and used different loads in each experiment. In the first test using 3 bulbs of 1 watt and for the second test using 1 watt led, 8 watt led, and 20 watt bulb and for the third test using 2 1-phase motors and fans.

Figure 7 First Experiment

Figure 8 Second Experiment

Figure 9 Third Experiment

Table 3 Testing the Control system

Arus			Kondisi kontaktor dan SSR	Ketidakseimbangan (%)	Kontaktor ON-OFF	Kontaktor OFF-ON
R (A)	S (A)	T (A)				
Pengujian ke-1						
0,05	0,04	0,04	Tersambung (on)	10%	-	-
Pengujian ke-2						
0,03	0,02	0,12	Terputus (off)	73,3%	3,0 detik	0,6 detik
0,12	0,02	0,03	Terputus (off)	73,3%	3,2 detik	0,6 detik
0,02	0,12	0,03	Terputus (off)	73,3%	3,2 detik	0,7 detik
Pengujian ke-3						
2,36	2,42	1,35	Terputus (off)	45,3%	3,5 detik	0,6 detik
2,42	2,35	1,35	Terputus (off)	45,3%	3,2 detik	0,6 detik
1,35	2,35	2,42	Terputus (off)	45,3%	3,1 detik	0,7 detik

From the table data above, it can be concluded that the control system from the SSR and contactor is working properly, when the imbalance is still below 20%, electricity will continue to flow and if the load imbalance is ⩾ 20%, the system will cut off electricity to the load and it takes approximately 3 seconds to cut off electricity, while from OFF-ON conditions it takes less than 1 second. Based on these tests, the control system is working properly.

Testing the Data Logger

This test aims to check whether the data has been processed by ESP32 can be stored on the sd card through the data logger module correctly. This test uses a laptop charger on phase R, a cellphone charger on phase S, an iron on phase T. According to the picture above, it can be concluded that the voltage and current readings in each phase have been stored in the data logger correctly, for the loggger data format, namely date, time, voltage per phase and current in each phase.

	A	B	C	D	E	F	G	H
1	TANGGAL	JAM	VR	VS	VT	IR	IS	IT
2	04/07/23	22:40:19	224.40	224.60	224.40	0.00	0.00	0.00
3	04/07/23	22:40:26	224.50	224.70	224.50	0.00	0.00	0.00
4	04/07/23	22:40:34	224.50	224.80	224.50	0.00	0.00	0.00
5	04/07/23	22:40:42	224.70	224.90	224.70	0.00	0.00	0.00
6	04/07/23	22:40:49	224.30	224.60	224.30	0.00	0.00	0.00
7	04/07/23	22:40:56	224.40	224.70	224.40	0.00	0.00	0.00
8	04/07/23	22:41:03	224.30	224.60	224.30	0.00	0.00	0.00
9	04/07/23	22:41:10	224.20	224.50	224.30	0.00	0.00	0.00
10	04/07/23	22:41:17	224.20	224.50	224.30	0.00	0.00	0.00
11	04/07/23	22:41:24	224.10	224.50	224.20	0.00	0.00	0.03
12	04/07/23	22:41:31	224.10	224.40	224.10	0.00	0.00	0.00
13	04/07/23	22:41:38	224.30	224.60	224.30	0.00	0.00	0.00
14	04/07/23	22:41:45	224.50	224.80	224.50	0.00	0.00	0.00
15	04/07/23	22:41:52	224.90	225.20	224.90	0.00	0.00	0.00
16	04/07/23	22:41:59	224.90	225.20	225.00	0.00	0.00	0.00
17	04/07/23	22:42:07	224.80	225.10	224.90	0.00	0.00	0.00
18	04/07/23	22:42:14	224.80	225.10	224.90	0.00	0.00	0.00
19	04/07/23	22:42:21	224.70	225.00	224.80	0.00	0.00	0.00
20	04/07/23	22:42:28	224.40	224.70	224.50	0.00	0.00	0.00
21	04/07/23	22:42:35	224.50	224.80	224.60	0.00	0.00	0.00
22	04/07/23	22:42:42	224.20	224.50	224.20	0.00	0.00	0.00
23	04/07/23	22:42:49	223.80	223.90	223.70	0.10	0.04	0.50
24	04/07/23	22:42:56	222.50	222.70	222.30	0.03	0.13	1.51
25	04/07/23	22:43:03	222.60	222.80	222.40	0.03	0.13	1.51
26	04/07/23	22:43:10	222.80	223.00	222.70	0.03	0.06	1.51
27	04/07/23	22:43:17	222.90	223.10	222.80	0.03	0.06	1.52

230704 Sheet1

Figure 10 Testing the Data Logger

Testing the Blynk App

This test aims to see if the device can be connected and synchronized with the Blynk application. The data displayed on the Blynk application is the voltage of each phase and the current of each phase and the percentage of load imbalance, at the bottom there is a reset button if you want to reset or reconnect electricity to the load.

Figure 11 Readings on the Blynk app

Table 4 Measurements on Multimeter and PZEM-004T

FASA	Tegangan pada Multimeter	Tegangan pada PZEM-004T	Arus pada Tang Ampere	Arus pada PZEM-004T
R	225 V	225 V	2,357 A	2,36 A
S	225 V	225 V	2,421 A	2,42 A
T	225 V	225 V	1,346 A	1,35 A

From the above experiments, it can be seen that the results displayed in the Blynk application are in accordance with the measurements using a Multimeter and those displayed on the LCD. The "RESET" button on the device has also functioned properly. It can be concluded that the Blynk application has functioned properly.

CONCLUSION

Based on several tests that have been carried out on the tool, it can be concluded that:

1. In the prototype of the load imbalance control and monitoring system using several components such as MCB, Contactor, SSR, PZEM-004T, data logger module, LCD, ESP32 and several other supporting components that are connected and programmed so that they can work as expected.

2. Measurement of voltage and current using the PZEM-004T sensor can work by connecting one cable to the source and another cable to the CT with the cable leading to the load. And the readings displayed for a voltage of 223 Volts are the same as measurements using a multimeter and currents of 0.18 A, 1.52 A, 0.14 A are the same as measurements using ampere pliers.

3. Storage of measurement data on the data logger module can be done by connecting the legs of the data logger module with ESP32 in accordance with the circuit that has been made and through the program that has been entered into ESP32.

Suggestions

Based on the tests that have been carried out, the authors realize that there are still shortcomings in this tool so that the authors provide suggestions for future tool development, namely:

1. Adding a reset button to the tool to avoid unwanted things when there is no signal.
2. Adding a notification of a bad or missing signal if this happens in the application.

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