

MONITORING LOAD IMBALANCE IN DISTRIBUTION TRANSFORMER PT. PLN ULP TULEHU BASED ON THE INTERNET OF THINGS (IOT)

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ABSTRACT

Distribution transformer maintenance is an important thing to keep the transformer operating optimally, one of which is by monitoring load imbalance and overload on the distribution transformer. Load imbalance is a condition where the electrical loads connected to each phase of the distribution transformer are not the same size. At PT PLN ULP Tulehu, the transformer load measurement activities are still carried out manually, the tool used by officers in measuring the distribution transformer load is ampere pliers and is carried out once every six months. This shows that substation load monitoring is still done manually or not in Real Time so that monitoring results cannot be monitored in a short span of time. As a result, disturbances in the transformer cannot be known early on. The location of transformers that are scattered in various locations can also be an obstacle for officers to be able to measure loads on time, allowing the risk of transformers being damaged more.

This research aims to assist officers in monitoring imbalances and overloads on distribution transformers remotely. The monitoring tool uses the Pzem-016T sensor by measuring electrical parameters such as current, voltage, frequency, load imbalance presentation and used load presentation then the measurement data is monitored in the Blynk application. The test results show that the monitoring equipment is able to work well to read the condition of load imbalance and transformer used load remotely. This monitoring tool has a deviation value (error) of the design measuring instrument against the standard measuring instrument is 0.68% for R-N voltage (volts), 0.76% for S-N voltage (volts), 0.15% for T-N voltage (volts), 0.38% for IR current (amperes), 0.52% for IS current (amperes), 0.81% for IT current (amperes).

Keywords : monitoring, distribution transformer, imbalance, overload, internet of things.

INTRODUCTION

Distribution transformers are electrical equipment that is very important in distributing electrical energy to consumers. Damage to the distribution transformer causes electrical energy to not be distributed. According to Salustiano et al (2013), various things cause damage to distribution transformers in their operation, but load imbalance and overloading account for 45% of the causes of transformer damage. In the PLN distribution transformer management regulations, the maximum distribution transformer loading is 80% of its full load current, and the maximum load imbalance is 25%. Therefore, maintaining the distribution transformer is an important thing to keep the transformer operating optimally. One way is to monitor transformer load measurements regularly and periodically. Measurement of the peak load of the distribution transformer is carried out during the day (office, market and factory loads) and at night (residential loads).

To be able to take maximum load measurements (at peak load times) officers have

difficulty, this is because the number of transformers in PLN ULP Tulehu as many as 65 units is not comparable to the number of inspection officers totaling 2 people, the tools used by officers in measuring distribution transformer loads are ampere pliers and are carried out once every six months. This shows that substation load monitoring is still done manually or not in Real Time so that monitoring results cannot be monitored in a short span of time. As a result, disturbances in the transformer cannot be known early on. The location of transformers that are scattered in various locations can also be an obstacle for officers to be able to measure loads on time, allowing the risk of transformers being damaged more.

Monitoring load imbalance and overload in distribution transformers is important for the continuity of distribution transformer operations. Internet of Things (IOT) technology supports the need for remote monitoring, in addition to this IOT technology can store monitoring data to be displayed and analyzed online.

METHODS

In carrying out a research process it is very important to determine the method as a reference, therefore the research method we use is the research and development method, which is a method used to develop a certain tool model based on the research process. The research method used to obtain data and information is the literature study method, which is the collection of data and information by reading reference books, E-books, and websites.

Field study (Observation) is a data collection technique by going directly to the field to observe problems that occur directly at the scene systematically events, behavior, objects seen and other things needed in supporting ongoing research. The following is the location of the field observation site located in the PLN ULP Tulehu area at the 50 kVA GD TLH027 substation shown in Figure 1.



Figure 1 Manual Transformer Load Measurement

This research will be conducted in the work area of PT PLN (Persero) ULP Tulehu, more precisely at TLHTLH002 substation, Dsn. Bridge 2, Tulehu Village which is 3.4 Km from the Tulehu ULP office with coordinates: -3.615283, 128.32215.

INFORMASI GARDU NOMOR : TLHTLH002

PENYULANG : TULEHU
 ALAMAT : GARDU TELKOMSEL JEMBATAN 2
 LOKASI : GARDU TELKOMSEL JEMBATAN 2
 DAYA : 50 KVA
 I-NOM : 72 A
 MERK TRAFO : UND
 PHASE : 3 PHASE
 MILIK : PLN
 SECTION :
 JUMLAH PLG : 0 PLG
 KOORDINAT : -3.615283,128.32215



NO	TGLUKUR	KVA		PROSEN DEARATING	CREST FACTOR	I-Rms (A)				I-PEAK(A)			THD		
		TRAFO	BARU			R	S	T	N	R	S	T	R	S	T
1	06/01/2022 - 19:21:23	50	47	6	1.478	17.11	3.016	4.776	13.04	24.2	5.4	7.21	4.88	29.81	6.59
2	02/08/2021 - 19:01:54	50	51	-2	1.427	13.42	4.567	5.776	7.89	18.5	7.18	8.23	4.79	25.46	24.8
3	15/02/2021 - 19:03:09	50	51	-2	1.456	12.43	5.436	5.145	6.74	17.4	8.63	7.47	4.23	8.08	4.6
4	07/08/2020 - 19:06:17	50	45	10	1.489	10.4	4.957	7.01	4.501	14.8	7.9	10.6	4.84	8.49	5.81
5	28/02/2020 - 18:38:41	50	44	12	1.555	17.6	9.9	2.423	12.68	27.3	15.4	3.84	0.963	5.56	17.13
6	07/08/2019 - 20:31	50	46	2	1.529	10.33	15.59	6.51	6.18	15.3	23.9	10.4	4.7	5.71	15.92
7	12/02/2019 - 18:56	50	44	12	1.63	34.02	4.878	25.7	19.58	53.6	8.08	43.6	15.19	8.87	18.44



Figure 2. TLHTLH002 substation

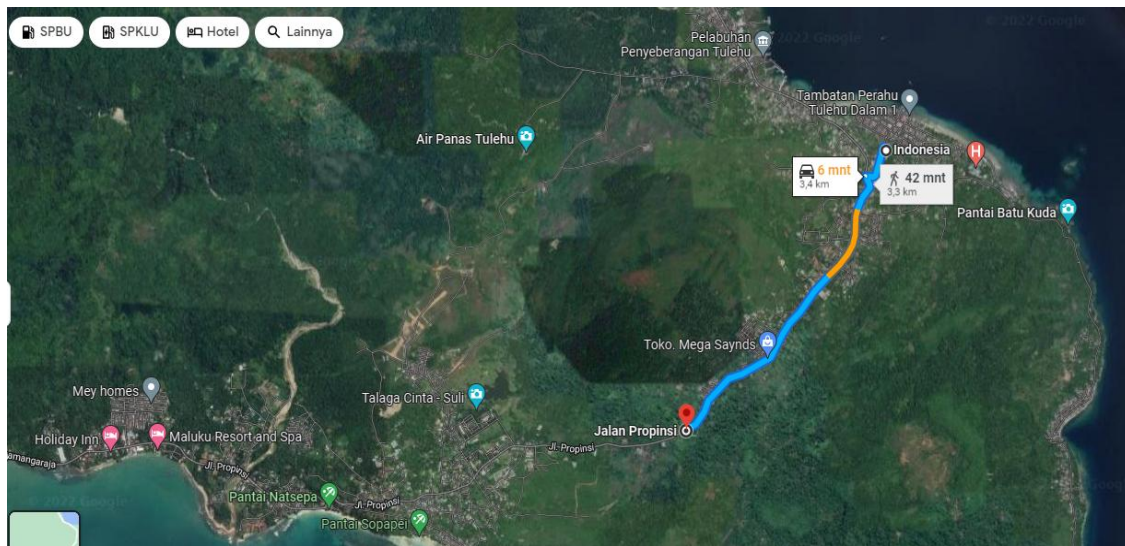


Figure 3. TLHTLH002 substation location

Below is a picture of the design of the circuit system of the Unbalance and Overload Monitoring Tool on the Internet Of Things (IOT) Based Distribution Transformer which uses three Pzem-016 sensors, one Simcom7600CE Arduino Modem Modbus LTE module, one 4-channel Relay module, one 220V-12V Power supply, one IC 7805. The system design picture can be seen in Figure 4.

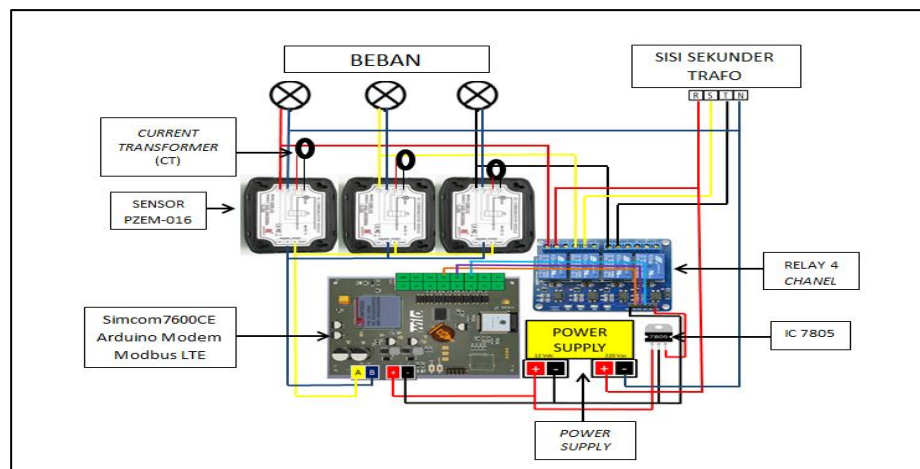


Figure 4. System Design

Description:

- A. Electric Load is an equipment connected to the power system that consumes electrical energy.
- B. The Secondary Side of the Distribution Transformer is part of the distribution transformer that distributes electrical energy to 220V/380V low voltage customers.
- C. Current Transformer (CT) serves to reduce the current value so that it can be read by the Pzem-016 sensor.
- D. Sensor Pzem-016 serves to read the value of current, voltage, and frequency.

- E. Simcom7600CE Arduino Modbus LTE Modem functions to process monitoring data and send data to the Blynk application using the internet network.
- F. Relay serves to disconnect and connect the electrical circuit when needed.
- G. Power Supply 220-12V serves to convert 220VAC voltage to 12VDC voltage.
- H. IC 7805 Serves to reduce 12VDC voltage to 5VDC voltage.

DISCUSSION

VAC Voltage Measurement

Measurements are made using an ampere pliers measuring instrument and are carried out without load. This voltage measurement serves to ensure that the voltage used is in accordance with the Nominal Voltage Service standard (SPLN T6. 001 2013, the service voltage tolerance limit is +5% and -10% of the nominal voltage).

Table 1. VAC Voltage Measurement

Measure Time	Input			Output		
	R-N	S-N	T-N	R-N	S-N	T-N
09.26 Wit	225.5	225.3	225.8	225.4	225.3	225.6

Power Supply Testing

The power supply used in this tool is a type of power supply adapter that is widely used in the market with an output voltage of 12 Vdc and a current of 2A. But for some components such as relay modules using an operational voltage of 5 Vdc, for that the voltage from the 12Vdc power supply must be reduced to 5Vdx by using the IC 7805 component. The following is a table of testing and use of the power supply shown in Table 2

Table 2 VDC Voltage Measurement

No	Voltage		Load Supplied
	Input	Output	
1	12 Vdc	12 Vdc	Simcom 7600ce Arduino Modem Modbus Lte
			Sensor Pzem 016
2	5 Vdc	5 Vdc	Relay Modul

Blynk Monitoring Testing and Discussion

The location of the tool test is located at the THLTLH 002 Tulehu substation with a substation capacity of 50 KVA. This test is carried out by connecting CT (current transformer) and jumper cables R, S, T, N to the low voltage side of the distribution transformer (PHB-TR). This tool works by detecting the current flowing into the load. The amount of current flowing will be used as a reference to determine the amount of power that becomes the load on the transformer. In general, the working system of this tool starts from reading the current data from the current sensor, namely CT (current transformer) which is installed in series on each phase. Furthermore, the results of the current sensor readings are processed in the microcontroller. The monitoring data will be directly monitored through the Blynk application using the internet network. The parameters measured are IR current, IS current, IT current, total current, VR-N voltage, VS-N voltage, VT-N voltage, Frequency (Hz), percentage of load imbalance, and percentage of used load. If the unbalanced load is above 25% and the used load is above 80% then a notification from Blynk will appear as a warning sign.

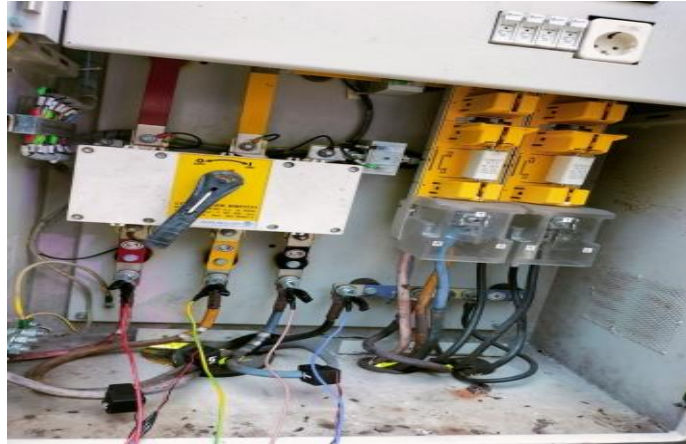


Figure 3. Set up circuit on PHB-TR

Data was collected 10 times from 16.30 WIT to 21.00 WIT. Blynk monitoring data can be seen in Table 3.

Table 3. Monitoring Result Data Using Blynk

Hasil Monitoring Menggunakan Blynk														
No	Time	Voltage (V)			Current (I)				Frek (Hz)	Usedload (%)	Unbalance (%)	Status Relay	Notifikasi	
		R-N	S-N	T-N	R	S	T	Total					Unbalance > 25%	Usedload > 80%
1	16.30	230.5	230.5	232.2	10.81	6.46	4.95	22.22	50	10.29	30.63	On	Y	N
2	17.00	230.6	230.4	232.1	10.56	5.92	4.89	21.37	50	9.894	32.16	On	Y	N
3	17.30	229.8	229.7	231.8	11.18	6.47	5.1	22.75	50	10.53	31.62	On	Y	N
4	18.00	229.3	229.5	230.7	11.01	6.29	4.94	22.24	50	10.3	32.34	On	Y	N
5	18.30	228.9	229.2	231.4	12.03	6.93	5.9	24.86	50	11.51	30.12	On	Y	N
6	19.00	228.6	229.7	229.4	12.41	6.99	6.62	26.02	50	12.05	28.72	On	Y	N
7	19.30	227.7	228.9	229.7	15.7	7.05	7.34	30.09	50	13.93	37.69	On	Y	N
8	20.00	227.6	228.6	229	15.92	7.11	8.06	31.09	50	14.39	35.75	On	Y	N
9	20.30	226.3	228.5	229.8	16.14	7.17	8.78	32.09	50	14.86	33.93	On	Y	N
10	21.00	226.3	228.3	228.6	16.36	7.23	9.5	33.09	50	15.32	32.22	On	Y	N

In this test, the Blynk application can receive measurement data well in accordance with the parameters and electrical quantities used, in 10 trials there was an imbalance of load between phases so that a notification from Blynk appeared as a warning sign.

Calculation of Deviation Value (Error) of Measuring Instrument

In the test, the measuring instrument used as a comparison is a type of digital measuring instrument of ampere pliers with the Hioki brand. This comparison is important to see the percentage error of the design measuring instrument against the standard measuring instrument. After taking measurement data of voltage VR-N, VS-N, VT-N and currents IR, IS, IT using

standard measuring instruments and design measuring instruments, a calculation table is obtained for the deviation (error) of the design measuring instrument compared to the standard measuring instrument.

Then for the measurement data and comparison of subsequent deviation (error) values can be seen in Table 4.

N O	WAKTU	BLYNK						TANG AMPERE						ERROR (%)					
		TEGANGAN (V)			ARUS (I)			TEGANGAN (V)			ARUS (I)			TEGANGAN (V)			ARUS (I)		
		R-N	S-N	T-N	R	S	T	R-N	S-N	T-N	R	S	T	R-N	S-N	T-N	R	S	T
1	16.30	230.5	230.5	232.2	10.81	6.46	4.95	230.8	230.9	232.5	10.72	6.35	4.98	0.13	0.17	0.13	0.84	1.73	0.6
2	17.00	230.6	230.4	232.1	10.56	5.92	4.89	230.5	230.8	232.3	10.49	5.95	4.86	0.04	0.17	0.09	0.67	0.5	0.62
3	17.30	229.8	229.7	231.8	11.18	6.47	5.1	229.7	230.1	231.9	11.09	6.48	5.13	0.04	0.17	0.04	0.81	0.15	0.58
4	18.00	229.3	229.5	230.7	11.01	6.29	4.94	230.4	230.2	230.8	11.05	6.29	4.96	0.48	0.3	0.04	0.36	0	0.4
5	18.30	228.9	229.2	231.4	12.03	6.93	5.9	228.8	229.8	231.5	12.03	6.95	5.84	0.04	0.26	0.04	0	0.29	1.03
6	19.00	228.6	229.7	229.4	12.41	6.99	6.62	229.5	230.1	229.6	12.39	6.93	6.68	0.39	0.17	0.09	0.16	0.87	0.9
7	19.30	227.7	228.9	229.7	15.7	7.05	7.34	228.6	229.2	229.8	15.74	7.07	7.42	0.39	0.13	0.04	0.25	0.28	1.08
8	20.00	227.6	228.6	229	15.92	7.11	8.06	227.7	228.9	230	15.88	7.16	8.14	0.04	0.13	0.43	0.25	0.7	0.98
9	20.30	226.3	228.5	229.8	16.14	7.17	8.78	226.4	228.8	229.7	16.17	7.21	8.7	0.04	0.13	0.04	0.19	0.55	0.92
10	21.00	226.3	228.3	228.6	16.36	7.23	9.5	226.3	228.4	229.4	16.32	7.24	9.59	0	0.04	0.35	0.25	0.14	0.94
RATA-RATA		228.6	229.3	230.5	13.21	6.762	6.61	228.87	229.72	230.75	13.19	6.76	6.63	0.16	0.17	0.13	0.38	0.52	0.81

In the first measurement at 16:30 WIT, the value on the Blynk serial monitor for VR-N voltage is 230.5V, VS-N voltage is 230.5V, VT-N voltage is 232.2V, IR current is 10.81A, IS current is 6.46A, IT current is 4.95A. The value at the ampere pliers for VR-N voltage is 230.8 V, VS-N voltage is 230.9 V, VT-N voltage is 232.5V, IR current is, 10.72A IS current at is 6.32A, IT current is 4.98A. Then the error values are obtained:VR-N Voltage is 0.13%, VS-N Voltage is 0.17%, VT-N Voltage is 0.13%, IR Current is 1.04%, IS Current is 1.73%, IT Current is 0.6%.

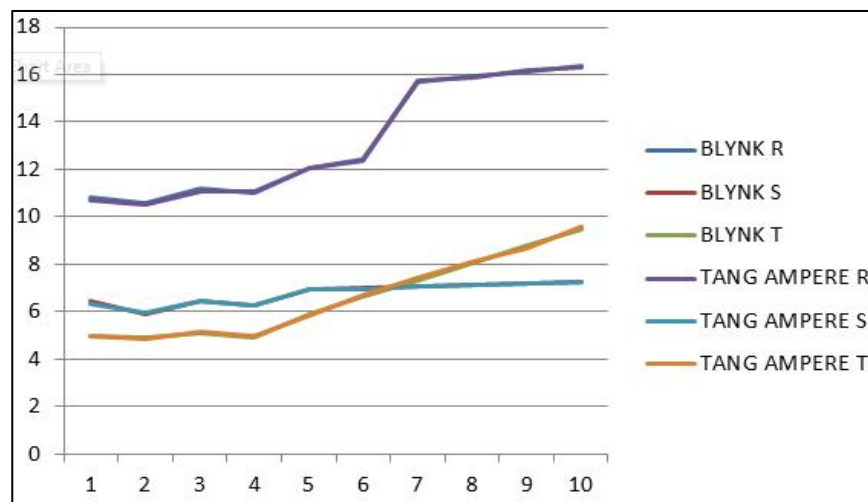


Figure 4. Comparison Chart of Measuring Instruments (Current)

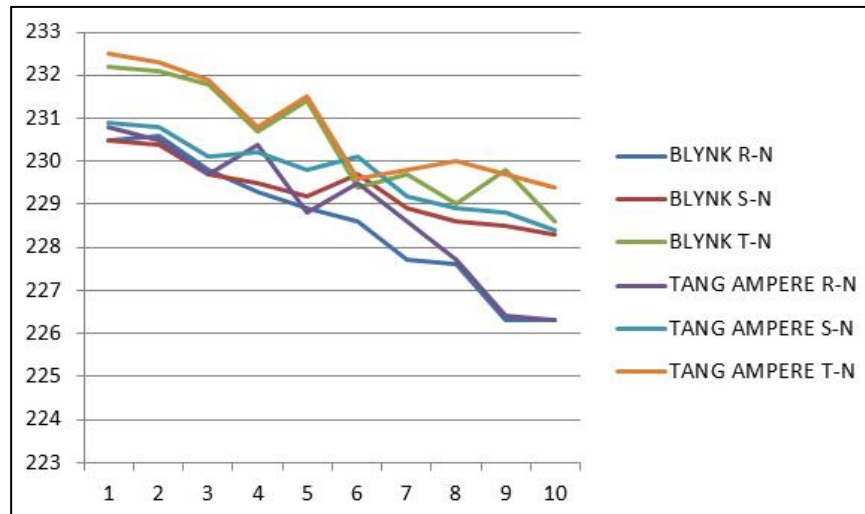


Figure 5. Comparison Chart of Measuring Instruments (Voltage)

After being calculated as a whole and averaged, the deviation (error) value of the design measuring instrument against the standard measuring instrument is 0.16% for R-N voltage (volts), 0.17% for S-N voltage (volts), 0.13% for T-N voltage (volts), 0.38% for IR current (amperes), 0.52% for IS current (amperes), 0.81% for IT current (amperes) and from Figures 6 and 7, the comparison value of standard measuring instruments and design measuring instruments is not too far away.

CONCLUSION

Based on the design stage, testing and discussion of the overall test results, the following conclusions can be drawn: (1) The monitoring tool can read electrical parameters properly such as, IR current, IS current, IT current, total current, VR-N voltage, VS-N voltage, VT-N voltage, Frequency (Hz), percentage of load imbalance, and percentage of used load. If the unbalanced load is above 25% and the used load is above 80%, a notification from Blynk will appear as a warning sign, (2) The deviation value (error) of the design measuring instrument against the standard measuring instrument is 0.68% for R-N voltage (volt), 0.76% for S-N voltage (volt), 0.15% for T-N voltage (volt), 0.38% for IR current (ampere), 0.52% for IS current (ampere), 0.81% for IT current (ampere).

Future suggestions for the development of load imbalance monitoring tools and overloads on distribution transformers based on the internet of things to improve the quality of monitoring, as follows: (1) Increasing the CT (Current Transformer) value so that it can be used for larger transformers. (2) Adding transformer oil capacity and temperature parameters to the transformer. Upgrading the Blynk display so that monitoring can be more detailed and detailed.

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