International Journal of Electrical, Energy and Power System Engineering (IJEEPSE)
e-ISSN: 2654-4644
Vol. 5, No. 1, pp. 19-23, February 2022
Accredited by KEMENRISTEKBRIN, No. 200/M/KPT/2020
http://www.ijeepse.ejournal.unri.ac.id

Health Monitoring System for Transformer by using Internet of Things (IoT)

Dirman Hanafi*
Faculty of Electrical and Electronic Engineering
Universiti Tun Hussein Onn Malaysia
Johor, Malaysia
dirman@uthm.edu.my

Zarkhoni Aziz
Faculty of Electrical and Electronic Engineering,
Universiti Tun Hussein Onn Malaysia
Johor, Malaysia
ahmadzarkhoni98@gmail.com

**Corresponding author: Dirman Hanafi, dirman@uthm.edu.m*

***Abstract*— Transformer is an important device in electrical field that used to transfer electricity from one circuit to another with changing the voltage level. The transformer will be having a problem such as increasing in temperature and make a lot of noise. Typical transformer measurement system will take time for testing and less accurate. The aim of this project is to design the IoT system for monitoring and evaluate the performance of the transformer current, sound and temperature. The monitoring system using three types of sensors to sense the current, sound and temperature. ESP32 is being used to keep and process the data before sending to the Blynk application to show the value by using internet. Two different conditions are being tested to the transformer which are transformer without load and with load. Ammeter and ACS712 current sensor are used to get the current value. Besides, for temperature value used two equipment which are using thermometer and MLX90614 temperature sensor. The transformer sound obtained from the sound sensor. The data will be display in Blynk application. The result obtained show the health monitoring system for transformer by using Internet of Things is acceptable because has low error and save time to measure the parameters.**

Keywords—Blynk, Arduino IDE, Internet of Things (IoT), Transformer.

I. INTRODUCTION

In power system, a distribution transformer is an electrical device that provides the final voltage transition in the electrical power distribution side that stepping down the voltage used in distribution lines to the voltage that will use by the consumers. A distribution transformer is a complex piece of equipment with a complex electromagnetic circuit inside of it. The selection of specific transformer auxiliaries, as well as the proper design of a magnetic circuit, structure and insulation system makes transformer more reliable equipment [1].

The key causes of a transformer's health degradation are problems such as overburdening and insufficient heating. Gathering data from transformer is very important to monitor and control the entire of the transformer in efficiently and reliably [2]. The health and safe operation of transformer in electrical distribution is important due to unexpected fault that will occur [3]. Therefore, transformer health monitoring and accurate fault diagnosis are beneficial in reducing equipment harm economic loss and impacts on the reliability of electric power systems [4]. The transformer monitoring for problem before may help avoid expensive repairs and a reduction in service life [5]. This method allows to track the transformer's health on a regular basis and take the appropriate steps to ensure that it is properly maintained [6].

Wireless monitoring system by using Internet of Things (IoT) has been around for a while and mostly used in industry to track key performance from remote locations [7,8,9]. It provides useful information about the health of the distribution transformer and will facilitate the services of the transformer and increase the lifetime of a transformer [10]. The output data is stored in a database after processing so that the report can be viewed using mobile applications [11]. As a result, an online measurement device is used to collect and analyze various types of data from sensors over time [12].

II. METHODOLOGY

A. Circuit of Monitoring System

A circuit diagram for monitoring system needs to be developed by using Fritzing software. The microcontroller which is ESP32 need to be connected to all the three sensors that related to this project. The sensors are current sensor, sound sensor and temperature sensor. ESP32 require a supply to turn it on so that the ESP32 is connected to the 5.5V power supply. The power supply from the plug is connected with Vin pin for positive and GND pin for negative that has been stated at the ESP32. The circuit diagram can be show in Figure 1 as below:

Received: Jan 27, 2022 | Revised: Feb 20, 2022 | Accepted: Feb 28, 2022

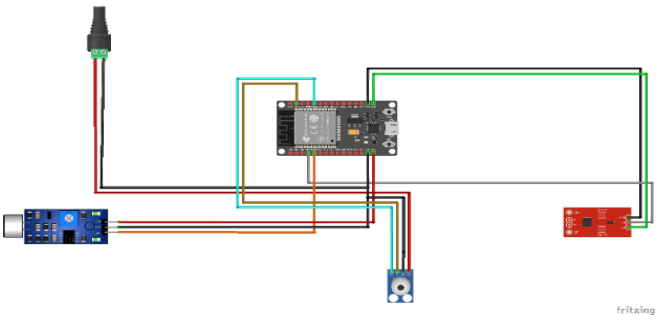

Fig.1. Circuit of Monitoring System

Table I below shows the components pin connection in monitoring system circuit. All the connection is from ESP32 and connected with each of the sensors to make sure the sensor can be functioning well.

Table I. Components pin connection

From pin	To pin		
ESP32	**Current Sensor**	**Temperature Sensor**	**Sound Sensor**
GND	GND	GND	GND
Vin		Vin	VCC
3V3	5V		
D35			OUT
D34	Vo		
D22		SCL	
D21		SDA	

B. *Prototype*

The prototype in Figure 2 below is consisted of three sensors which are ACS712 act as current sensor, MLX90614 act as temperature sensor and sound sensor. All the sensors are connected with the microcontroller that has been programmed with C++ language or coding by using Arduino software. The microcontroller used is ESP32 that have been built in WI – fi module in it. So, it can be connected to the device to monitor the health of the transformer by using Internet.

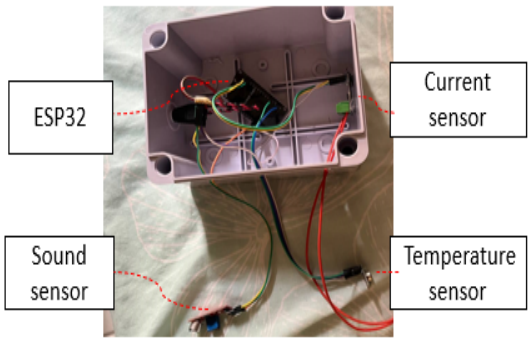

Fig.2. Prototype for the monitoring system of the transformer

III. RESULT AND DISCUSSION

All the result obtained through the testing on hardware had shown in this part. Besides, this part had analyzed and discussed the findings from the measurement instruments and measurement by using Internet of Things (IoT).

A. *Transformer without Load Testing*

Figure 4 shows the connection of the monitoring system to the transformer without load while Figure 5 shows the result obtained from the testing in Blynk application.

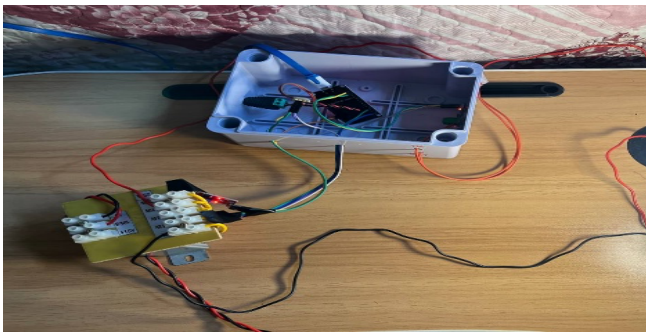

Fig.4. Prototype connection without load

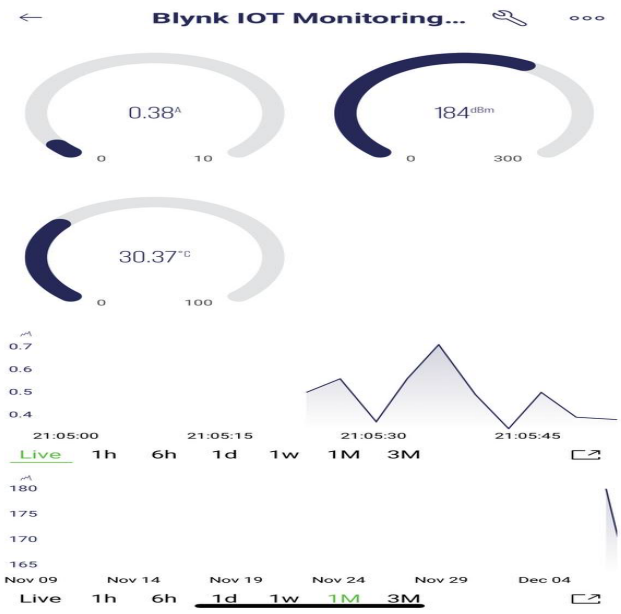

Fig.5. Result obtained from Blynk application

Table II, Table III and Table IV shows 10 samples testing on each of the parameters that has been test on the transformer without load to see the performance of the transformer. The result in Table II obtained from current sensor and ammeter. It is to make a comparison between the value of the current when tested with ammeter and current sensor. The highest current value obtained from ammeter is 0.36A and for tested with current sensor is 0.38A. The value of current is small because no load connected to the transformer. Electromagnetic force will limit the current flow to maintain enough magnetic field to produce the required back of electromagnetic force. The average error is below 10% which is 7.10%. It is because of the instrumental error due to operation of the device used.

Received: Jan 27, 2022 | Revised: Feb 20, 2022 | Accepted: Feb 28, 2022

Table II. 10 samples testing on current of the transformer without load

No. of testing	Current by Ammeter (A)	Current by IoT (A)	Error (%)
1.	0.19	0.21	5.00
2.	0.23	0.25	8.70
3.	0.36	0.38	5.56
4.	0.26	0.27	3.85
5.	0.23	0.25	8.70
6.	0.28	0.29	3.57
7.	0.23	0.24	4.35
8.	0.32	0.35	9.38
9.	0.29	0.32	10.34
10.	0.26	0.29	11.54
Average Error			7.10

Table III. 10 samples testing on temperature of the transformer without load

No. of testing	Temperature by Thermometer (°C)	Temperature by IoT (°C)	Error (%)
1.	29.50	30.30	2.71
2.	29.99	30.35	1.20
3.	30.00	30.37	1.23
4.	30.10	30.42	1.06
5.	30.30	30.71	1.32
6.	30.40	30.79	1.28
7.	30.60	31.11	1.67
8.	30.70	31.24	1.76
9.	31.10	31.25	0.48
10.	31.20	31.25	0.16
Average Error			1.29

The result in Table III shows the highest temperature that obtained from temperature sensor is 31.25°C and by using thermometer is 31.20°C. It shows the monitoring system by using Internet of Things (IoT) can sense the temperature of the transformer better than thermometer. The average error shows below 2% which is 1.29%. It can be assumed the small value of error and temperature of the transformer still in a good condition.

Table IV. 10 samples testing on sound of the transformer without load

No. of testing	Sound (dBm)
1.	130
2.	133
3.	184
4.	140
5.	140
6.	152
7.	146
8.	150
9.	141
10.	144

The highest sound obtained is 184dBm due to the vibration that occur between the windings of the core material. The sound that occurs during this testing is because the transformer has an inherent sound level with the size and style of the coil assembly. It gives a small value of noise because the transformer is not connected with any load.

B. Transformer with Load Testing

Figure 6 shows the connection of the monitoring system to the transformer with load while Figure 7 shows the result obtained from the testing in Blynk application.

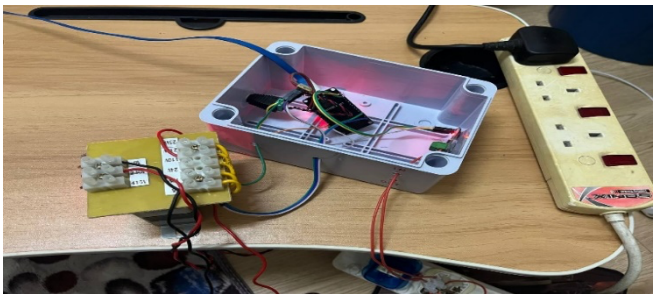

Fig.6. Prototype connection with load

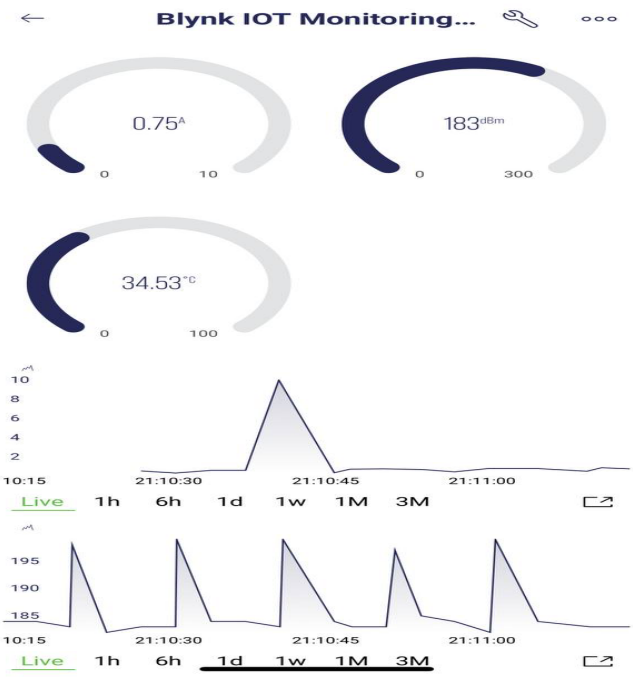

Fig.7. Result obtained from Blynk application

Table V, Table VI and Table VII shows 10 samples testing on each of the parameters that has been test on the transformer without load to see the performance of the transformer.

Table V shows the result when the transformer is connected to the load, the current is exceeded 0.40A compared to without load which is below 0.40A. The highest current value obtained from ammeter is 0.69A and from current sensor is 0.75A. It shows the current value is starting to increase when connected to the load. When electrical load is connected to the transformer, a current will flow in the secondary winding and out to the load, The average percentage error is 9.54% which is below 10%.

Received: Jan 27, 2022 | Revised: Feb 20, 2022 | Accepted: Feb 28, 2022

Table V. 10 samples testing on current of the transformer with load

No. of testing	Current by Ammeter (A)	Current by IoT (A)	Error (%)
1.	0.42	0.46	9.52
2.	0.55	0.50	9.10
3.	0.63	0.69	9.52
4.	0.68	0.72	5.88
5.	0.57	0.50	12.28
6.	0.56	0.62	10.71
7.	0.48	0.52	8.33
8.	0.69	0.75	8.70
9.	0.62	0.68	9.68
10.	0.43	0.48	11.63
Average Error			9.54

Table VI. 10 samples testing on temperature of the transformer with load

No. of testing	Temperature by Thermometer (°C)	Temperature by IoT (°C)	Error (%)
1.	30.90	31.77	2.81
2.	31.10	31.83	2.35
3.	31.50	31.99	1.56
4.	32.90	33.19	0.88
5.	33.10	33.41	0.93
6.	33.50	33.83	0.99
7.	33.80	34.53	2.15
8.	30.10	31.35	4.15
9.	35.10	35.58	1.37
10.	35.90	36.13	0.64
Average Error			1.78

Table VI shows the temperature of the transformer getting warmer time by time when it connected to the load. The highest temperature that obtained from this testing is 36.13°C. It is sense by the temperature sensor in the monitoring system. By using thermometer, the highest temperature is 35.90°C. The value is not same because of the equipment used could give precise value or because of the place that the thermometer and the MLX90614 was located. The average error of the temperature is below 2% which is 1.78%. It can be assumed that the monitoring system can sense the temperature of the transformer approximately with the thermometer.

Table VII. 10 samples testing on sound of the transformer with load

No. of testing	Sound (dBm)
1.	160
2.	166
3.	169
4.	170
5.	170
6.	174
7.	183
8.	183
9.	177
10.	184

Table VII shows the sound of the transformer starts to increase which is 160dBm until 184dBm when the transformer is connected with the load. A transformer is magnetically excited by an alternating current so that it becomes extended and contracted twice during a full cycle of magnetization. The load noise is different cause the vibrations in the transformer tank walls and magnetic shields due to the electromagnetic force produces by the load currents. The presence of harmonic in load current can produce vibrations and increase the sound level of the transformer.

IV. Conclusion

For the conclusion, the health of the transformer is important to develop the good electricity in our country in order to keep the electrical supply in a good condition without having any disturbance because of the destruction happened to the transformer. The monitoring system consisting of ESP32 as a microcontroller and other three sensors which are current sensor, sound sensor and temperature sensor. The health of the transformer can be monitor by using Internet of Things (IoT) after make a testing on the transformer that connected with the load and without connected to the load. The performance of the transformer which are the current, sound and temperature was shown in the Blynk application. The highest value of current obtained from ammeter is 0.69A and the highest value of current obtained from ACS712 is 0.75A which the average error for all the samples of testing is 8.32%. Furthermore, the highest value of temperature for both conditions obtained from thermometer is 35.90°C while MLX90614 temperature sensor is 36.13°C which average error for all the samples of testing is 1.54%. Lastly, the sound of the transformer obtained is 184dBm and it is the highest humming sound of the transformer obtained from the testing for both conditions.

V. Acknowledgment

The authors would like to thank the Faculty of Electrical and Electronic Engineering, Universiti Tun Hussein Onn Malaysia for the facilities that has been provided and for its support. Title of the project “Health Monitoring System for Transformer by using Internet of Things (IoT)”.

References

[1] Jaiswal, G. C., Ballal, M. S., Tutakne, D. R., & Vishnu, P, “Intelligent condition monitoring system for distibution transformer and health status diagnosis”, International Conference on Power, Instrumentation, Control and Computing (PICC), pp. 1-6, IEEE, 2018.

[2] Hayati, M. A. E. A. E., & Babiker, S. F, “Design and implementation of low-cost SMS based monitoring system of distribution transformers”, Conference of Basic Sciences and Engineering Studies (SGCAC), pp. 152-157, IEEE, 2016.

[3] Pawar, R. R., & Deosarkar, S. B, “Health condition monitoring system for distribution transformer using Internet of Things (IoT)”, International Conference on Computing Methodologies and Communication (ICCMC), pp. 117-122, IEEE, 2017.

[4] Zhang, C., He, Y., Du, B., Yuan, L., Li, B., & Jiang, S, “Transformer fault diagnosis method using IoT based monitoring system and ensemble machine learning”, Future Generation Computer Systems, 108, 533-545, 2020.

[5] Zanzad, P. R. T., Umare, N., & Patle, P. G, "ZIGBEE Wireless Transformer Monitoring, Protection and Control System", International Journal of Innovative Research in Computer and Communication Engineering (An ISO 3297: 2007 Certified Organization), 4(2), 2395-4396, 2016.

[6] Navamanikumar, P. G., Agnesha, S., Gowsalya, P., Indhu, K., & Sivasakthi, N, " IOT Based Real Time Transformer Health Monitoring System and Phase Preventor", International Journal of Emerging Technologies in Engineering Research (IJETER), 6(4), 119-124, 2018.

[7] Acakpovi, A., Odazie, C., Majeed, I. B., Eduful, G., & Asabere, N. Y, "Transformer Wireless Monitoring System Using Arduino/XBEE", American Journal of Electrical Power and Energy Systems, 8(1), 1-10, 2019.

[8] Ery, S., Linna, O. S., Fitri, W., & Feranita, "IoT Applications in Fermented Tempe Production. International Journal of Electrical", Energy and Power System Engineering (IJEEPSE), 5(1), 1-5, 2022.

[9] Eko, P., Trisianto, N., Ani, S. S., & Delta, M, "PLTD Engine Tank Oil Volume Monitoring System using HC-SR04 Ultrasonic Sensor Based on Internet of Things (IoT)", International Journal of Electrical, Energy and Power System Engineering (IJEEPSE), 4(1), 134-138, 2021.

[10] Srivastava, D., & Tripathi, M. M, "Transformer Health Monitoring System Using Internet of Things", 2nd IEEE International Conference on Power Electronics, Intelligent Control and Energy Systems (ICPEICES), pp. 903-908, IEEE, 2018.

[11] Dhanraj, J. A., Krishnamurthy, B., Ramanathan, K. C., Saravanan, A. K., & Raman, J. K. G, "Design on IoT Based Real Time Transformer Performance Monitoring System for Enhancing the Safety Measures", In IOP Conference Series: Materials Science and Engineering, Vol. 988, No. 1, p. 012076, IOP Publishing, 2020.

[12] Dhanraj, J. A., Krishnamurthy, B., Ramanathan, K. C., Saravanan, A. K., & Raman, J. K. G, "Design on IoT Based Real Time Transformer Performance Monitoring System for Enhancing the Safety Measures", In IOP Conference Series: Materials Science and Engineering, Vol. 988, No. 1, p. 012076, IOP Publishing, 2020.

BIOGRAPHIES OF AUTHORS

DIRMAN HANAFI was born in Agam, Indonesia, in 1967. He received the B.Eng. degree in electrical engineering from the University of Bung Hatta, Padang, Indonesia, in 1994, and the M. Eng. Degree in Control and Instrumentation Program sandwich program between Bandung Institute of Technology (ITB) Indonesia and FH Karlsruhe, Germany, in 1998 and Ph.D. degree in Mechatronic Engineering (specialized in Control and Instrumentation Engineering) from the Department of Control and Robotic Engineering, Faculty of Electrical Engineering, University Teknologi Malaysia (UTM), Malaysia in 2006. In 1998, he joined the Department of Electrical Engineering, University of Bung Hatta, as a lecturer. Since May 2008, he has been with the Department of Mechatronic and Robotic Engineering, University Tun Hussein Onn Malaysia, an Assistant Professor, become an Associate Professor in 2015. July 2019, he has been with the Department of Electrical Engineering, University Tun Hussein Onn Malaysia an Associate Professor. His current research interests include in the field of system identification and Intelligent Control for applications in vehicle suspension systems, robotics and electrical power plants.

ZARKHONI AZIZ was born in Kelantan, Malaysia, in 1998. He went to Sekolah Menengah Sains Alam Shah at Kuala Lumpur, Malaysia for his secondary school and received the Diploma of Electrical Engineering from University Tun Hussein Onn Malaysia (UTHM), Malaysia, in 2018. He makes a system about Lecturer's Whereabout for his Final Year Project in diploma. In 2022, he received the Bachelor of Electrical Engineering with Honors from University Tun Hussein Onn Malaysia (UTHM), Malaysia.

Received: Jan 27, 2022 | Revised: Feb 20, 2022 | Accepted: Feb 28, 2022