Online monitoring and data logging power quality parameters of Low Voltage Distribution Panel (LVDP) on industrial system

B Setiawan, F Ronilaya, D K P Aji, A Setiawan and E S Putra*

Electrical Engineering Department, State Polytechnic of Malang. Jl. Soekarno-Hatta No. 9, Malang 65141, Indonesia

*ekananda_putra@polinema.ac.id

Abstract. Electrical energy is an important component in an industry, that is needed by electrical equipment / machines that exist in the industry. Currently, the majority of electrical energy is produced from fossils, almost 85% of all energy comes from fossil fuels. Therefore, efficiency application of electricity loads in industries need to be logged and analyzed. To make electricity load efficiency possible, it can be done by monitoring and logging real-time electricity loads in the industry. So that, the electrical power consumed can be analyzed. In this paper, a 3-phase electricity monitoring system is builder for Low Voltage Power Distribution (LVDP) that can be monitored anytime and anywhere via internet for the needs of electricity quality analysis. Monitoring parameters are voltage, current, real power, apparent power, power factor, IHD voltage and current, and voltage and current THD for each phase. The system uses sensor ZMPT101B to get voltage value each phase and Current Transormator (CT) to get current value each phase. Then, that sensor value calculates with Arduino and raspberry pi. Arduino to calculate real power, apparent power, and power factor. Raspberry pi to calculate IHD voltage, current and THD voltage and current. That variables send to database and display on the web. Error reading of voltage sensor is found on average error 0.00254% compared to multimeter. For current sensor, the average error is 0.0074%. On the user interface, all functions are running well including the addition of devices, as well as monitoring parameters of each phase, so that, it can be utilized for the needs of electrical analysis, which means the power consumed and the malconsumed can be known.

1. Introduction

Now day, electrical energy has become one of the primary human needs because all environments in the home, workplace, factories, etc. require electrical energy [1,2]. Every year electricity consumption continues to increase, and also the depletion of petroleum reserves which has an impact on the increase in fuel and of course affects the increase in electricity use [2,3]. Therefore, to find out the amount of electrical energy that is being used, it is necessary to measure the use of electrical energy. Measurement of the use of electrical energy is a process of electricity management that is very important, so that, the process of saving and efficiency can easily be obtained [2,4].

In an industry, there is an electrical equipment called LVDP. LVDP panels are electrical equipment consisting of several electrical components, which serve as the main divider of the low voltage distribution channel to each load channel, as a main power barrier and a safety in the main circuit of a
low voltage distribution system [5]. Seeing the important role of LVDP, it is very important to have monitoring to see the electricity condition at any time for the needs of the analysis [6].

By utilizing Internet of Things (IoT) technology, it is expected that information related to electrical energy measurement includes Real Power (Watt), Apparent Power (VA), Power Factor (%), Voltage RMS (V), Current RMS (A), Total Harmonic Distortion (THD), Individual Harmonic Distortion (IHD) can be monitored anywhere and anytime [1]. Making it easier for users to analyze the needs.

2. Literature review

2.1. Low Voltage Distribution Panel (LVDP)
LVDP is a device which is functions to receive electrical power from transformers or generators for further distribution to low voltage distribution panels. This LVDP receives electricity from the transformer. The distribution of electricity distribution to the low voltage distribution panels from outgoing LVDP to the panels is as follows: The Sub Distribution Panel uses a NYY cable type which then distributes to the distribution panel [5].

LVDP works at low voltage. This equipment has a function as the main power divider for the installation of feeders installed on LVDP [5].

2.2. Power quality
Power quality can be defined as the degree of deviation from the nominal value of frequency, current and voltage of magnitude. Deviations can also be in the form of wave forms. Power quality can also be explained as the extent to which the power supplied is compatible with the smooth operation of electrical equipment. In other words, it is a true measure of how well the power system supports the smooth operation of the charge [7,8].

2.3. Harmonics
In electric power systems, the power distributed is at the voltage level with a single frequency (50 Hz or 60 Hz), but due to the rapid and complex development of the electrical load, especially the use of non-linear loads, will cause changes in sinusoidal waveforms [9]. Wave defects caused by interactions between the sinusoidal waveforms of the system and other wave components caused by the use of non-linear loads, better known as harmonics, in other words harmonics are sinusoidal current or voltage components whose frequency is a multiple of integers from their fundamental frequency [10].

3. Method
Figure 1 below show flowchart how the device work.

Figure 1. Flowchart.
First microcontroller reads voltage and current sensor of Line R, S, T. In this paper using a microcontroller Arduino and an Embedded System, Raspberry Pi. The Raspberry Pi uses Analog to Digital Converter (ADC), MCP30008 for reading the value of each sensor. After microcontroller reads sensors, the microcontroller calculates to get parameters of power quality. Arduino calculates real power, apparent power, and power factor while Raspberry pi calculate IHD and THD. Parameters of power quality send to MySQL database and display to website in graphs and tables for electrical quality analysis needs.

Figure 2 below shows how the system works. In LVMDP paired with voltage sensors and current sensors on each line R, S, and T.

Figure 3 below shows the schematic of the system and Figure 3.4 show the electronic diagram at each phase.

To get R, S, T current value, the system uses Current Transformer (CT). The CT changes a larger current become smaller current, so, it can be read by the microcontroller. The research uses CT with ratio 100A:1A, so, the CT changes current flow 100A become 1A current sensing. The microcontroller just can read voltage (0 – 5Volt), therefore, signal conditioning is needed. Signal conditioning described in the figure 3.5.
Signal Conditioning is to convert current to voltage from the output CT. Value of R3 can be calculated with the formula below.

- \( I_{pp} = \text{Max Output CT} \times \sqrt{2} \times 2 \)
- \( 5V = R3 \times I_{pp} \)
- \( R3 = \frac{5}{2.8} = 1.7857 \text{ Ohm} \approx 1.8 \text{ Ohm} \)

So from the formula above, the value of R3 is 1.8 Ohm.

4. Results

4.1. Voltage sensor

| No | Multimeter | Sensor | Calibrated | Error |
|----|------------|--------|------------|-------|
| 1  | 220V       | 210 V  | 220.02 V   | 0.0009%|
| 2  | 212 V      | 208 V  | 215.696 V  | 0.0141%|
| 3  | 182 V      | 194 V  | 185.428 V  | 0.0023%|
| 4  | 140 V      | 173 V  | 140.026 V  | 0.0018%|
| 5  | 95 V       | 135 V  | 95 V       | 0%     |
| 6  | 55 V       | 86 V   | 60.945 V   | 0.0106%|
| 7  | 20 V       | 27 V   | 19.94 V    | 0.0016%|

Average Error: 0.0025%

From Table 1 above shows the results of the calibration of the voltage sensor by conducting 7 experiments with different voltage values. From these results, the average sensor reading error was 0.0025%. The error is very small which indicates an accurate sensor reading.

4.2. Current sensor

| No | Multimeter | Sensor | Calibrated | Error |
|----|------------|--------|------------|-------|
| 1  | 1.38A      | 1.1A   | 1.1002A    | 0.00018%|
| 2  | 1.51A      | 1.2A   | 1.2159A    | 0.0135%|
| 3  | 1.50A      | 1.2A   | 1.2070A    | 0.0058%|
| 4  | 1.74A      | 1.4A   | 1.4206A    | 0.0147%|
| 5  | 1.62A      | 1.3A   | 1.3138A    | 0.0106%|
| 6  | 2.84A      | 2.4A   | 2.3996A    | 0.00016%|

Average Error: 0.0074%
Table 2 show the results of the calibrated current sensor by conducting 6 experiments with different current values. From these results, the average sensor reading error was 0.0074%. The error is very small which indicates an accurate sensor reading.

4.3. System testing
The results of system are show in the figure 5. System has been tried on a LVDP in Graha Polinema building in State Polytechnic of Malang.

Data that has been read by the microcontroller can be sent to the database in server via Internet using wireless shown on figure 6 and figure 7.
Then the result of experiments of system are display on the website in the form of graphs and tables shown on figure below.

![Image of Interface website](image)

**Figure 8.** Interface website.

5. Conclusion

System of On-line Data Monitoring and Data Logging Power Quality Parameters of Low Voltage Main Distribution Panel (LVMDP) on Industrial Systems can be implemented properly. This is evidenced by the error of the voltage sensor reading and the current sensor reading error of. That value is fairly small and shows that the sensor is accurate, on voltage sensor error is 0.0025%, and current sensor error is 0.0074%. In testing the delivery of data to the server, all data can be transmitted successfully and can be displayed on the website in the form of graphs and tables that can help for the analysis of the quality of the electricity network in buildings - buildings in the industry.

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