

# Design of Energy Database Management System (EDBMS) on the unit 2 outgoing transformer at the State Polytechnic of Malang

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**Abstract.** Recently, the efficiency of electrical energy is one of big challenges in the world. The needed energy is very huge; meanwhile the sources of energy are limited. Many researchers have been trying to find solutions for increasing the energy efficiency. One of ways is to monitor the use of the energy easily so we can reduce the energy usage. This paper proposes a system for monitoring energy usage by using Internet of Thing. Such system is called as Energy Internet of Things (IoT) based Database Management System (EDBMS). All buildings are supplied by Unit 2 Outgoing Transformer in the State Polytechnic of Malang which collects data of the used energy by using smart energy meter. It uses router LAN in UPT PP for sending the data from all buildings to the cloud, and displaying the received data on a web page. The collected data will be used for the analysis of power quality. Based on the result of the harmonic monitoring that shown the value are still in the standard range because the limitation of allowable THD current is 15%. And based on IEEE STD 446-1995, the standard for three-phase load imbalance is as much as 5-20% maximum for each phase. Meaning, Unit 2 Outgoing Transformer is out of standard or it does not comply with the standard.

## 1. Introduction

The coming of Fourth Industrial Revolution or 4IR lately has changed many aspects of life including economy, technology, industry, and life style. Intelligent technologies developed in this era can connect many aspects of human life. One sign of the coming of 4IR is the fast development of Internet of Things (IoT) technology along with easiness it offers. Many researchers carry out researches on many any issue related to 4IR, such as energy monitoring based on system database which is known as Energy Database Management System (EDBMS). One of the main objectives of the development of EDBMS is to save the energy. An example case which will be raised in the effort to save such energy is to design a monitoring device for the unit 2 outgoing transformer at the State Polytechnic of Malang. As has been known that the energy supplied to the State Polytechnic of Malang comes from distribution substation 1 Unit Pelayanan Teknis Perawatan Peralatan (UPT PP) which has two transformers with 2 x 500 kVA capacity each. The energy from distribution substation 1 UPT PP supplies various building at the State Polytechnic of Malang, by using two Main Voltage Main Distribution Panel (MVMDP) distribution.

Energy management is any activity which is related to data recording, monitoring, and analyzing, controlling energy usage to get as efficient as possible usage [1]. Some researchers have developed web based monitoring system [1-5]. Some of those include web based monitoring information system for



project development with a case study at Dinas Bina Marga dan Pemantusan [3], and web-based application by [2]. Refer to Ersan Kalbaci [5] in their paper, they design a metering infrastructure based on current, voltage, and power measurement. Their equipment uses ZigBee as communication means between Personal Computer (PC) with transceiver system, and uses current as well as voltage sensors. They found that their metering infrastructure is able to monitor current, voltage, and power magnitude which is used as the basis for basic effort to do efficiency. Some countries have already developed smart meter which is installed at every house and grid [6,7,8]. There are various designs of smart meter offered as well as communication means used to support the smart meter, data recording method which can be selected whether each month, each two month, or depends on the user requirement. Unfortunately, the monitored data is limited to current, voltage, and power.

In this paper, we propose a new design of metering and monitoring system which not only measures current, voltage, and power consumption, but also measures cos phi and THD whether for current and voltage. The energy monitoring system we designed will use Arduino microcontroller, which has been selected because of its easiness and inexpensive application. Data collection and access will be done by applying IoT technology. The collected data will be stored in a web cloud, a database which provides facilities to display the monitored energy data and accumulate the data in daily, monthly, and yearly basis. The data which is acquired hourly will be collected and the energy used will be averaged. The previous recorded data is also stored in the provided database. This data can be used to perform energy efficiency and future load prediction of the unit 2 outgoing transformer.

## 2. Theoretical background

### 2.1. Energy Database Management System (EDBMS)

Energy management is defined as a technical and management function to collect data, check thoroughly, analyses, monitor, replace, and control the energy stream within the energy system so the energy can be used in efficient way which can meet the requirements from technical and economy considerations. Technically, the use of such energy is feasible and high efficient, while operationalize of the energy economically gives possibility to the company to maintain its product competitiveness power. The effective energy management will give a chain effect which benefits the company. The success energy management succeed to reduce the energy cost to operationalize the facilities and equipment, reduce the production cost, and reduce the maintenance cost as well. Besides that, the decrement of energy consumption means reducing the impact to the environment and CO<sub>2</sub> emission. The energy management which is well integrated within the company activities will deliver a significant contribution in increasing the company performance [1]. The implementation of the energy management system is related with measurement benchmarks namely, Voltage (v), Electrical Current (I), Power (P), Frequency (f), Cos phi, THD, i IHD, v IHD, and kWh.

### 2.2. Web Cloud (Cloud Computing)

Cloud computing is computation service delivery whether for server, storage, database, network, software, analysis, and other else through the internet. Many companies have already considered or even implemented the cloud computing to increase their performance. Cloud users need client devices such as laptop, desktop computer, pad, smart phone, or other computation power with web browser or agreed other access routes, to access the cloud system via World Wide Web (WWW). Commonly, the cloud user will log-in to cloud managed a service provider or private company. Cloud computing works as client-server using web browser protocol. Cloud provides application-based server and all services data to the users, with the output displayed on the client devices. Suppose a client wants to create a document using word processor, cloud provides the application which fits with the client's need which runs on the server and displays the works done by the user on the client's web browser display.

The memory allocated for the client's web browser system is used to create the application data displayed on the client's system, but all computation and changing will be recorded by the server, and the final result including the created or permanently changed file is saved in the cloud server. The

performance of the cloud application depends on the network access speed, and the reliability as well as the processing speed of the client's device. The cloud system works by using the internet as the link to the server in processing the data. This system enables the user to log-in to the server through the internet and connect to the computer program which runs the required application without installing it in the client's computer. The infrastructure such as data storage media and also the instructions or commands from the client are stored virtually via the internet where such instructions are proceeded to the application server.

### 3. Experiment and design methodology

#### 3.1. EDBMS work description

The EDBMS or energy monitoring system can be accessed through the created web cloud where the measurement data of Unit 2 Outgoing Transformer collected by Power Meter 2120 is delivered to the cloud by Arduino. The measured data includes data of the use of Current (R, S, T), Voltage (R, S, T), Real Power (P), Reactive Power (Q), Pseudo Power (S), kWh, Frequency, %ITHD, %V THD, and Power Factor.

#### 3.2. Design of EDBMS

In our research, the plan for the energy monitoring system is the plan on Unit 2 Outgoing Transformer where transformer 2 is connected to several buildings at the State Polytechnic of Malang. The use of web cloud gives the advantage of the easiness to access the data anytime and anywhere, where the data displayed in the web cloud is real-time data. The block diagram of the designed EDBMS is depicted in Figure 1.

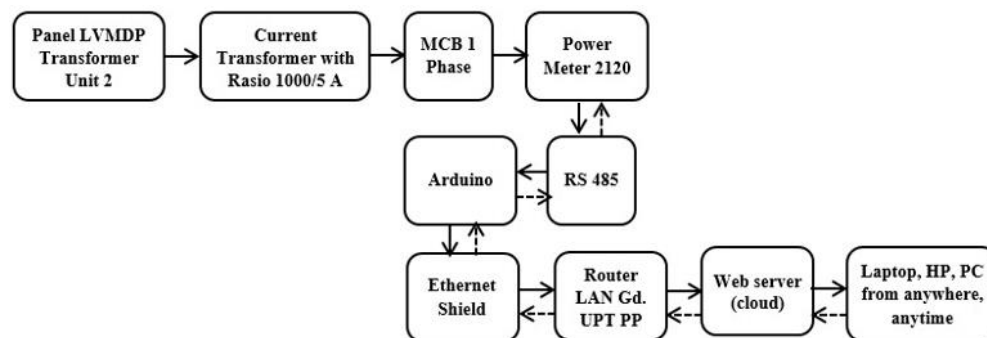
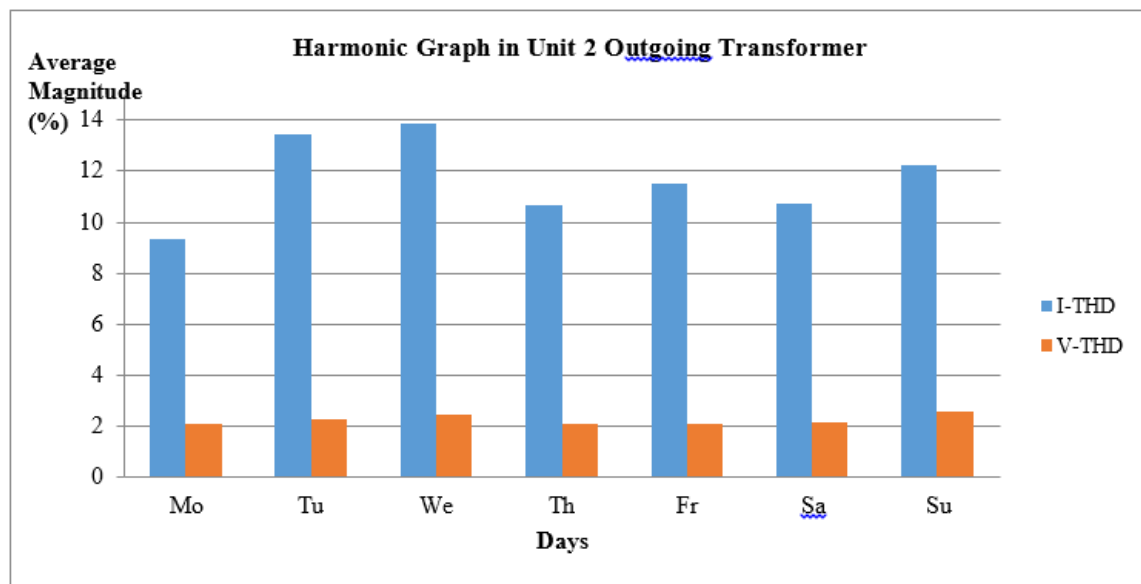


Figure 1. EDBMS block diagram.

### 4. Results and analysis

#### 4.1. Results harmonic of power meter measurement

Harmonics data taking was done to have knowledge regarding the harmonics development in one week, that is, on Friday, May 24, 2019 until Thursday, May 30, 2019. From the data, the harmonics change graphic at Unit 2 Outgoing Transformer is depicted in Figure 2. From the figure we can have knowledge that the highest V-THD value was occurred on Thursday as much as 2.1%, while its lowest one was occurred on Monday as much as 2.09%. For I-THD, the highest value was achieved on Monday as much as 12.19% and the lowest one was achieved on Friday as much as 9.33%. These values are still in the standard range (IEEE Std 446-1995) [9] because the limitation of allowable THD current is 15%.



**Figure 2.** V-THD and I-THD graphics.

#### 4.2. Load imbalance

Unit 2 Outgoing Transformer is the energy supplier to several buildings at the State Polytechnic of Malang namely, building AJ, AE, AF (PUSKOM), AH (1 and 2), AO, AQ, AG, AL dan AUPER. With various load usages at each building, then load imbalance is a certainty. Load imbalance is defined as load which experiences difference in one of the phase or all phases. Load imbalance was calculated on working day that is, on May 27, 2019 and on holiday that is, June 2, 2019 in order to compare how much the load imbalance on working day and holiday. The load imbalance calculation on the transformer is as follows.

##### 4.2.1. Working day

$$\% I_{UBL} = \left| \frac{I_r}{I_{avr}} - 1 \right| + \left| \frac{I_s}{I_{avr}} - 1 \right| + \left| \frac{I_t}{I_{avr}} - 1 \right| \times 100\%$$

$$I_{avr} = \frac{I_r}{3} + \frac{I_s}{3} + \frac{I_t}{3}$$

$$= \frac{92,38}{3} + \frac{84,14}{3} + \frac{70,68}{3}$$

$$= 82,4$$

$$\% I_{UBL} = \left| \frac{I_r}{I_{avr}} - 1 \right| + \left| \frac{I_s}{I_{avr}} - 1 \right| + \left| \frac{I_t}{I_{avr}} - 1 \right| \times 100\%$$

$$= \left| \frac{92,38}{82,4} - 1 \right| + \left| \frac{84,14}{82,4} - 1 \right| + \left| \frac{70,68}{82,4} - 1 \right| \times 100\%$$

$$= (0,121 + 0,021 + 0,142) \times 100\%$$

$$= 9,482 \%$$

#### 4.2.2. Holiday

$$\% I_{UBL} = \left| \frac{I_r}{I_{avr}} - 1 \right| + \left| \frac{I_s}{I_{avr}} - 1 \right| + \left| \frac{I_t}{I_{avr}} - 1 \right| \times 100\%$$

$$\begin{aligned} I_{avr} &= \frac{I_r}{3} + \frac{I_s}{3} + \frac{I_t}{3} \\ &= \frac{71,92}{3} + \frac{59,29}{3} + \frac{49,51}{3} \\ &= 60,24 \end{aligned}$$

$$\begin{aligned} \% I_{UBL} &= \left| \frac{I_r}{I_{avr}} - 1 \right| + \left| \frac{I_s}{I_{avr}} - 1 \right| + \left| \frac{I_t}{I_{avr}} - 1 \right| \times 100\% \\ &= \left| \frac{71,92}{60,24} - 1 \right| + \left| \frac{59,29}{60,24} - 1 \right| + \left| \frac{49,51}{60,24} - 1 \right| \times 100\% \\ &= (0,193 + 0,015 + 0,178) \times 100\% \\ &= 12,926 \% \end{aligned}$$

Where:

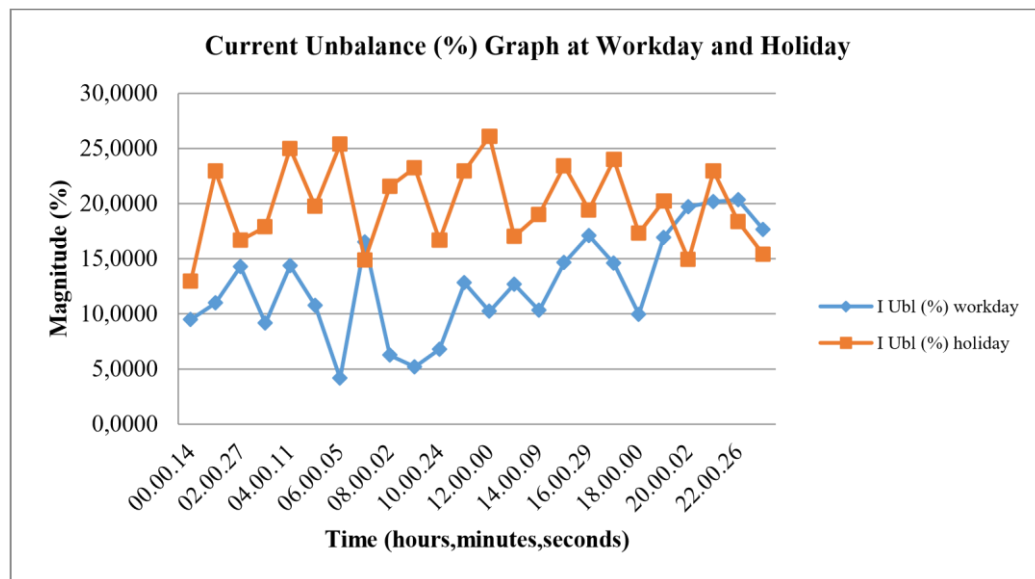
% I<sub>UBL</sub> : Percentage current unbalance

I<sub>r</sub> : The current in R Phase

I<sub>s</sub> : The current in S Phase

I<sub>t</sub> : The current in T Phase

I<sub>avr</sub> : The average current



**Figure 3.** Current imbalance.

Current imbalance is tightly related with load imbalance. The load imbalance on an electrical power distribution system always occurs and this is caused by one phase loads. The impact of such load imbalance is the emergence of current at transformer neutral. This current causes losses that is, losses caused by neutral current on the transformer neutral conductor and losses caused by neutral current flows to the ground. From Figure 3 it can be known that the load imbalance occurred on working day and holiday. The highest load imbalance as much as 20.319% was occurred on working day at 22.00 LT, while the highest load imbalance as much as 26.085% was occurred on holiday at 12.00 LT. These imbalances were caused by unequal load distribution, and unsimultaneously use and load turn-on at the buildings which are supplied by Unit 2 Outgoing Transformer. Based on IEEE Std 4461995 [9], the

standard for three-phase load imbalance is as much as 5-20% maximum for each phase. Meaning, Unit 2 Outgoing Transformer is out of standard or it does not comply with the standard. The analytics calculation of the neutral current at 10.00 LT is as follows.

- Calculating the per phase angle

$$\cos \theta_R = 0.34$$

$$\theta_R = \text{Arc cos } (0.34)$$

$$\theta_R = 70.12^\circ$$

$$\cos \theta_S = 0.56$$

$$\theta_S = \text{Arc cos } (0.56)$$

$$\theta_S = 55.94^\circ + 120^\circ = 175.94^\circ$$

$$\cos \theta_T = 0.98$$

$$\theta_T = \text{Arc cos } (0.98)$$

$$\theta_T = 11.47^\circ + 240^\circ = 251.48^\circ$$

- Calculating  $I_N$

$$\vec{I}_R = I_{Rx} + jI_{Ry}$$

$$\vec{I}_R = (I_R(\cos \theta_R)) + j(I_R(\sin \theta_R))$$

$$\vec{I}_R = (72,86 \cos(70,12^\circ)) + j(72,86 \sin(70,12^\circ))$$

$$\vec{I}_R = 24,77 + 68,52j \text{ A}$$

$$\vec{I}_S = I_{Sx} + jI_{Sy}$$

$$\vec{I}_S = (I_S(\cos \theta_S)) + j(I_S(\sin \theta_S))$$

$$\vec{I}_S = (48,73 \times (\cos 175,94^\circ)) + j(48,73 \times (\sin 175,94^\circ))$$

$$\vec{I}_S = (-48,61) + 3,45j \text{ A}$$

$$\vec{I}_T = I_{Tx} + jI_{Ty}$$

$$\vec{I}_T = (I_T(\cos \theta_T)) + j(I_T(\sin \theta_T))$$

$$\vec{I}_T = (48,73 \times (\cos 251,48^\circ)) + j(48,73 \times (\sin 251,48^\circ))$$

$$\vec{I}_T = (-15,48) + (-46,21)j \text{ A}$$

$$I_N = I_R + I_S + I_T$$

$$I_N = (24,77 + 68,52j) + (-48,61 + 3,45j) + (-15,48 + (-46,21j))$$

$$I_N = -39,32 + 25,76j$$

$$I_N = 47,006 \angle 146,76^\circ$$

Where :

$\cos \theta_R$  : Power factor in R Phase

$\cos \theta_S$  : Power factor in S Phase

$\cos \theta_T$  : Power factor in T Phase

$\vec{I}_R$  : The current in R Phase

$\vec{I}_S$  : The current in S Phase

$\vec{I}_T$  : The current in T Phase

$\vec{I}_N$  : The current in Netral

## 5. Conclusion

Conclusions that can be withdrawn from the calculations and analyses above are as follows:

- EDBMS which has been designed is an energy monitoring system that can be used to optimize and facilitate the data collection of the energy usage at Unit 2 Outgoing Transformer. The collected data is stored in the web cloud which facilitates data accessing in online manner anywhere and anytime.
- The data collection was done through LVMDP 2 via Current Transformer (CT) with 1000/5A ratio and the measured data by PM 2120 was read by Arduino microcontroller with the assistance of RS485. The measured data was then delivered to the web cloud through the Ethernet Shield with the help of LAN cable connected to the web.

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