Multi-Area Smart Monitoring of Electrical Quantities Based on Mini Single Board Computer BCM 2835

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***Abstract*- Multi-Area Smart Monitoring Systems are application and devices that can monitor the amount of electricity at various locations in the distribution panel with two or more different locations. The Single Board Computer BCM2835 SoC, ARM11767JZF-S 700 MHz processor (Raspberry Pi model B) is utilized to serve as interfaces for obtaining data of electrical quantities and save the data into the database system. All data utilized in this study are obtained from two different locations namely LAB-JTE building and ICT-UNILA building, and these data have been recorded and sent through the Local Area Network connection to a computer server and monitored in real time.**

From the results of monitoring conducted from May 30th until June 1st 2016 shown that the voltage, current and load connected to the monitored phase relatively has an asimetric trends. The monitoring results also demonstrate that at noon, the electrical energy consumption trends in UNILA is in accordance with the working hours in UNILA. Finally, by comparing the results of monitoring the electrical quantities trend at LAB-JTE and ICT-UNILA building shown that the conditions of electrical quantities in ICT-UNILA building has a better measurement result.

Keywords— Multi-area panel distribution, real time monitoring, Electrical Quantities, BCM2835, UNILA.

I. INTRODUCTION

University of Lampung (UNILA) has always been implementing some of its developmental plans by working tirelessly to increase the quality and service in various ways such as the development of information technology, improvement of infrastructure as well as laboratory equipment which have an influenced in increasing the number of electrical energy consumption. The electrical equipment should be able to work normally within the limits the standard values. But in reality, abnormal conditions may occur in the electrical quantities for long duration. If these conditions are not monitored, this can result in electrical outages and even damage to the equipment.

To alleviate the above mentioned problems, UNILA built a system that can provide real-time information in cases of both normal and abnormal events. With such a system, it is expected that if an abnormal condition is monitored, the operator can take a proper action early, so that a sudden blackout conditions and the risk of equipment damage can be avoided.

This study is a continuation of the results of electrical quantities monitoring in UNILA [1]. However, the previous research is still focused on one of the panel that exist in Integrated Laboratory of Electrical Engineering Departement (LAB-JTE). For LAB-JTE, datas are only stored on a Rasberry Pi and then some off-line analysis are carried out. In fact, UNILA has many buildings and need to be monitored in order to take preventive action or protection in case of abnormal conditions. Hence, this research is developed for multi-area system, in an effort to monitor the electrical quantities at multiple locations panel of three phase power distribution network, located in different buildings at the same time.

Mini Single Board Computer BCM 2835, ARM11767JZF-S 700 MHz processor (Raspberry Pi model B) are main components used in this study. Raspberry Pi serves as an interface for getting the data of electrical quantities and save the data to the database system [2]. Electrical quantities of data on two distribution panel measured by the sensor is sent through the Internet and stored on a computer server that can be accessed by the manager. Finally, the trend information of electrical quantities in real time considering the two different locations can be monitored simultaneously. Furthermore, the expected results of such monitoring may be used as a reference for stakeholders with respect to maintenance and planning for the future models.

II. RELATED WORKS

A. Previous Research

Some researchers have carried out related works in regards to real-time monitoring of electrical quantities and stability of power systems [1] - [4]. In addition, previous studies which is consider as a significant referenced in this research considered the use of Microcontroller, Raspberry Pi, Arduino and WEB application for the measurement and monitoring system [5]-[12]. References [1] and [4] which are mainly associated with the design and prototype of monitoring electrical quantities such as voltage, current, power, cos ¢ and energy consumption application using BCM2835 are also considered the primary references of this work. In [1] and [4] measured data are stored in real-time on a database server based Linux and MySQL server. Data obtained are further processed by the web server so that it appears in the form of historical statistical chart that can be accessed online through the Internet. However, [1] and [4] are still only applied to one panel of three phase distribution system in UNILA. The works of the above mentioned references however had some limitations with respect to developing a multi-area system that can be monitored in real time. Therefore, other researches are still required for a more desirable results and this is the objective of this paper.

B. Hardware Topology Design

Fig. 1 illustrates a design of the hardware topology for smart monitoring devices connected to arduino and BCM 2835 (Raspberry Pi) through GPIO pin. Obtained data such as current, voltage, power, cos ¢ an energy consumption will be recorded in real-time on a database server based on Linux and MySQL server and will be processed further by a WEB server and appear in the form of historical statistical chart that can be accessed online through the Internet.

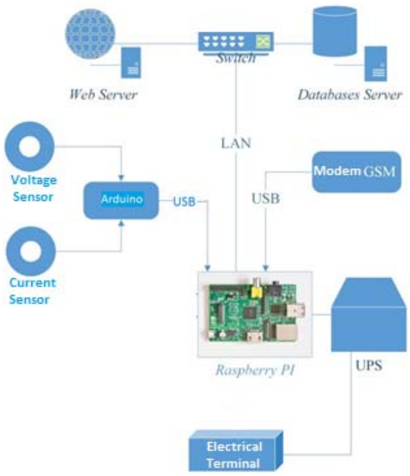


Fig. 1 Hardware Topology Design for Smart Monitoring System

III. RESEARCH METHODOLOGY

A. Block Diagram System

In order to understand the system easier, the block diagram is described as shown in Fig. 2:

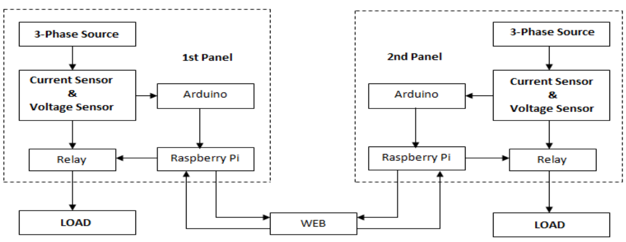


Fig. 2 Block Diagram System

B. Hardware Design

In this study, two hardware prototypes with the same design are made and positioned in the two of three-phase distribution panels with different locations. The design of the hardware is structured by electronic components as described in Fig. 3 below:

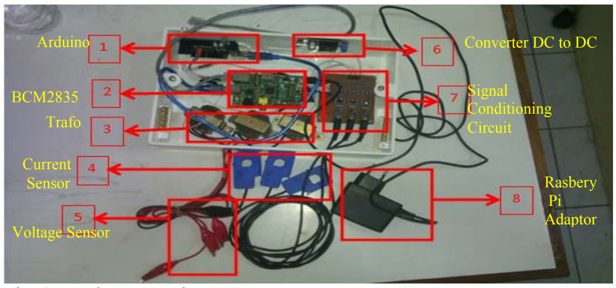


Fig. 3 Hardware Design

C. Program Design

Python programming [13] is used to create several function and routine that run on Rasberry Pi, such as: Sensor's data program reader, calculation program to obtain the electrical quantity, record the electrical quantity data, data base system receiver program and WEB interface display.

Current and voltage values will be measured directly, while for other electrical quantities can be determined using equations [14]

$$E = P.t \, (Wh)$$
$$E = (P.t) / 1000 \, (kWh)$$
$$P = E / t$$
$$P = V . I \cos ¢$$
$$Pf = P / (V . I)$$

Where:

P = Power (Watts) ; E= Energy consumption (KWh)
t = time (hours) ; V = Voltage (Volt)
I = Current (Amper) ; Pf = Power Factor (cos ¢)

IV. RESULTS AND DISCUSSION

A. Prototype Testing

Prototype designed has been tested with variations of load. Table 1 shows a data for prototype result compared to measurement device (multi-meter)

TABEL.1
TEST RESULTS

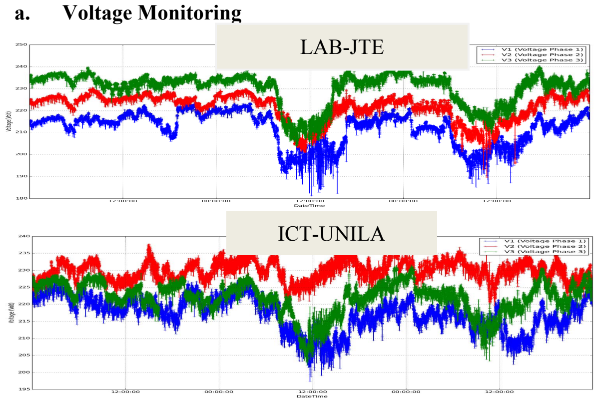
No	Various of Load	Test Results					
		Volt (v)		Current (I)		Pf (cos ¢)	
		Proto type	Volt meter	Proto type	Ampere Meter	Proto type	Cos ¢ meter
1	Load 1	221,10	220	2,2	2,2	0,99	0,99
2	Load 2	221,95	222	5,28	5,27	0,99	0,99
3	Load 3	220,75	221	0,44	0,59	0,99	0,99

Tabel.1 is a measurement test results using hardware prototype compared to the results of standard measuring devices owned (multi-meter). It shows that a prototype and multi-meter have a very small difference in results, so it can be concluded that this tool is reliable enough to operate.

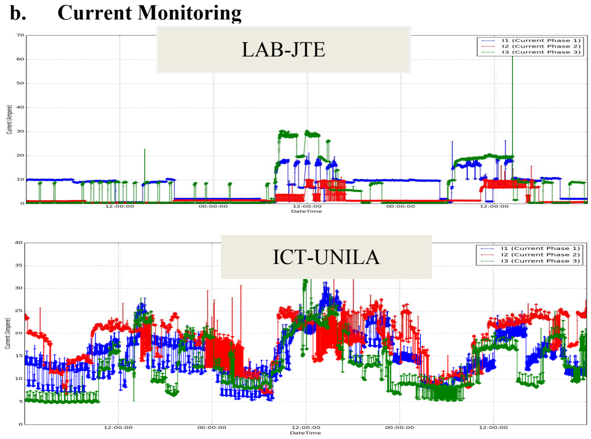
B. Results of System Testing

The testing of the system was done at two different locations; 3-Phase distribution panel of LAB-JTE building and ICT-UNILA building. The results of the monitoring system in both buildings are stored in a data base system MySQL server, and the final step is displaying the data from the existing database into a WEB interface. In this test, the database was split into five tables that are; voltage, current, power, cos ¢ and energy consumption. The trend of measurement results are displayed in WEB interface statistics chart. Monitoring charts results for each measurements describe are in Fig. 4 (a, b, c, d, and e). The graphs show the result of data measurement on multi area monitoring system during May 30th until June 1st 2016.

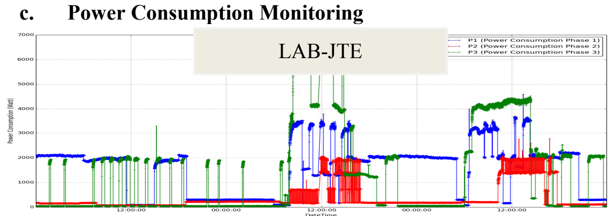
a. Voltage Monitoring

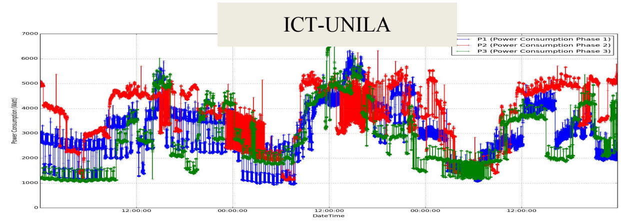


b. Current Monitoring

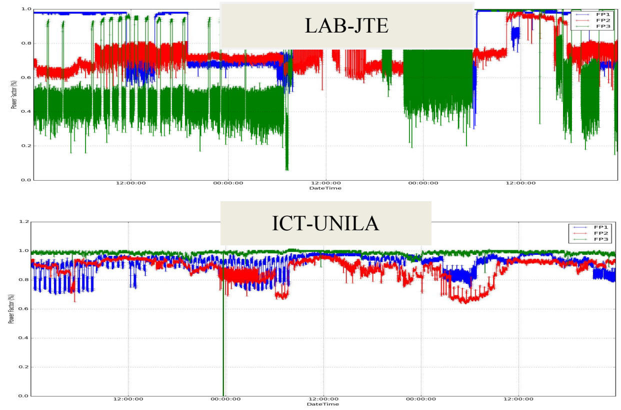


c. Power Consumption Monitoring





d. Power Factor (cos ¢) Monitoring



e. Energy Consumption Monitoring

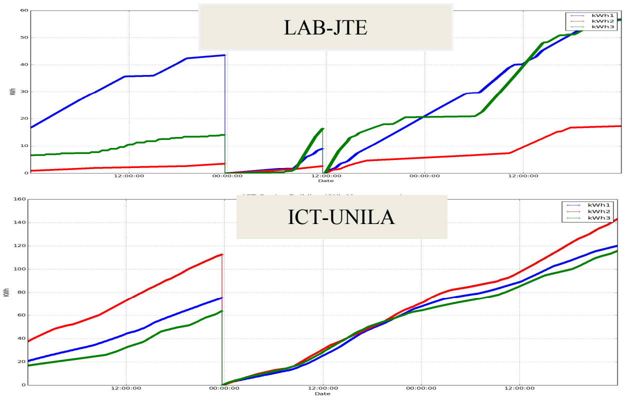


Fig. 4 Results of Monitoring Graphs during May 30th until June 1st, 2016

From the graph of electrical quantities, monitoring results are shown in Fig. 4 (a-e) for LAB-JTE and ICT-UNILA, the trend is as follows:

a. Voltage Monitoring

Voltage rating is about 200 V to 240 V. It can be seen from the graph for each phase shown in Fig.4 (a), the voltage value at two locations are not balance. Voltage drop occurs during the day (working hours) with lowest value for three phase system both in LAB -JTE and ICT UNILA. This illustrates the imbalance load mounted on each phase and electric energy consumption patterns are not evenly distributed, are still focused on the time of day.

b. Current Monitoring

The data shows that monitored current in each phases at two locations are not in balance condition. From the graph of Fig. 4 (b), it shows that the current will increase during working hours (8:00 to 16:00) with 35 A highest value at ICT-UNILA building. This case can be happened because more activities in UNILA are doing during the working hours, while at the night were only used for lighting and air conditioning.

c. *Power Monitoring*
From the graph in Fig. 4 (c), it can be seen that the power consumption tends to be greater in working hours. If we note the power at each phase, then the electrical energy consumption in ICT-UNILA building is larger than LAB-JTE. This is understandable because of the many activities carried on during the day ICT-UNILA.

d. *Power factor Monitoring*
The power factor monitoring charts shows where the value of the power factor was obtained from the calculation using voltage and current measurement data. This is illustrated in Fig. 4 (d), where the power factor at ICT ranged from 0.7 to 0.99 while in LAB-JTE it is around 0.3 to 1. This means that the power factor in ICT-UNILA is better compared to LAB-JTE. One of the Factors that can influence the value of the power factor is reactive load. Hence, if the value of the power factor is unstable, probably it is the caused by the changes of reactive power in the load.

e. *Energy Consumption Monitoring*
In general, since the load connected to each phase is not balence, the energy consumption of each phase will behave in the same manner. The total energy consumption in ICT-UNILA is greater than the LAB-JTE. This is illustrated in Fig. 4 (d), that the activity involving the use of electrical appliances in ICT-UNILA more out of Lab-JTE.

V. CONCLUSION AND FUTURE WORKS

A. *Conclusions*

The paper carried out monitoring of the electrical quantities trend at LAB-JTE to that of ICT-UNILA. The results of the monitoring may be utilized as a reference for stakeholders with respect to maintenance and planning for the future models. The monitoring results show that electrical quantities at two difference locations that have been monitored tends to create unbalance condition. However, electrical quantities monitored in ICT-UNILA is better compared to LAB-JTE.

On the other hand, the electrical quantities for each phase that have been monitored in UNILA are not in balance condition. This condition indicates that the load distribution for each phase is un-balance and need to be fixed. Electrical energy Consumption in UNILA is greater during the day (during working hours) compared to the evening. Electrical quantities condition in ICT-UNILA is better compared to LAB-JTE.

B. *Future Works*

In order to make the utilized system become better, this application should be integrated with a notification system, and extend the project for several places. It is highly recommended to develop mobile application for this project. Besides, the data results from this research should be used as reference for planning an estimation and better electrical system of UNILA in the future.

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