Design Smart Panel to Support Energy Conservation with Active Approach Methods

F. Yudi Limpraptono, Eko Nurcahyo, and M. Ibrahim Ashari
Department of Electrical Engineering, National Institute of Technology Malang, Indonesia
Email: fyudil@lecturer.itn.ac.id, ekonur@lecturer.itn.ac.id, Ibrahim_ashari@lecturer.itn.ac.id

***Abstract*—Electric energy is a basic human need, various electrical appliances have been used in everyday life, like a lighting system, refrigerator, HVAC (heating ventilation and air conditioning) etc. Currently the price of electric energy is increasingly expensive, which is due to the increasing use of electrical energy and the declining supply of fossil energy. This situation encourages to seek efforts in saving electrical energy. The culture of electricity saving has been promoted by the Indonesian government, by requiring all government agencies to implement electricity-saving programs. From the background that has been described above, it is necessary a system that can support the method of active energy efficiency approach. One system that can support active energy efficiency is an electrical power monitoring system that is connected to an electric load distribution panel system that is able to control load automatically. Modern electrical energy monitoring systems are required to be able to provide some facilities such as the ability to provide reports and data analysis with a very varied communication methods to be able to provide the desired information as part of an active approach. The purpose of this research is to design the prototype of control system and monitoring of electrical power in buildings, which have smart and low cost characteristics to support electrical energy conservation by active method.**

***Index Terms*—embedded system, energy conservation, smart panel**

I. Introduction

Currently electric energy is a basic human need, various electrical appliances have been used in everyday life, like a lighting system, refrigerator, HVAC (heating ventilation and air conditioning), rice cooker, washing machine, etc. Recently the price of electric energy is increasingly expensive, which is due to the increasing use of electrical energy and the declining supply of fossil energy. This situation encourages to seek efforts in saving electrical energy [1]. Data from the results of research indicate that the energy requirement in the building absorbs 40% of the total world energy needs. In Indonesia, this sector requires about 50% of total energy expenditure, and more than 70% of overall electricity consumption [2]. The effect of such energy usage, the building sector in Indonesia contributes to 30% of greenhouse gas emissions [3].

Efforts by the Indonesian government to improve the culture of energy saving and reduce the need for electrical energy, the government issued the Regulation of the Minister of Energy and Mineral Resources (ESDM) number 13 of 2012 on Electricity Energy Saving, states that all office buildings must implement the electricity energy saving program on the air conditioning system, lighting system and other supporting equipment. Some references in the implementation of the policy that is by using energy-efficient appliances, the implementation of a good energy management system and change the behavior of people who live in the building [4].

There are two approaches in energy efficiency efforts, namely passive energy efficiency and active energy efficiency. Passive energy efficiency activities can be done by installing and using energy-saving equipment and efforts to correct power factor. Passive energy efficiency is a fundamental effort for energy conservation, but a passive approach alone is not enough. Energy efficiency requires an active approach such as load control, system automation and monitoring of electrical energy consumption [5].

From the background that has been described above, it is necessary a system that can support energy efficiency with the method of active approach. Electrical power monitoring system is one system that can support the active energy efficiency. The electrical power monitoring system is connected to an electric load distribution panel, capable of recording power consumption and being able to control the electrical load automatically. Modern electrical energy monitoring systems are also required to be able to provide some facilities such as the ability to provide reports and data analysis with a very varied communication methods to be able to provide the desired information as part of an active approach.

Several issues relate to the provision of systems to support the conservation of electrical energy of the active approach method that is the system must be able to connect with a number of separate measuring equipment, the ability to transmit data between devices, the ability to store measurement data and be able to produce the various analyzes required for decision making. On the other hand with the rapidly growing field of information and communication technology, the system is required to use effective communication methods such as IP-based, autodial and connection with mobile devices or smart phones.

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The rest of this paper is organized as follows: Sect. II discusses ENERGY CONSERVATION and Development of Energy Conservation Technology which including four published research results. Sect. III analyzes DESIGN SYSTEM that consists of DESIGN hardware, DESIGN smart panel, controller unit, Input and output unit and Power meter Unit. Finally, detailed and sequential concluding remarks are given in Sect. IV.

II. Energy Conservation

A. Introduction

The number of buildings has a wide impact on the environment, human health, and the economy. According to the United States Department of Energy, buildings in the United States contribute for 40% of the country's major energy consumption and 40% of CO2 emissions [6]. In a crowded urban environment, this figure is much higher, as in New York City, buildings contribute 75% of city energy [7]. In Indonesia, this sector accounts for 50% of total energy expenditure, and over 70% of overall electricity consumption [2]. The effect of such energy usage, the building sector in Indonesia contributes to 30% of greenhouse gas emissions [3].

The dominant energy consumption in commercial buildings is heating/cooling, ventilation (HVAC) and lighting. Recent efforts to switch to alternative energy and renewable energy have resulted in major research and development projects around the world. Recently, many pilot projects have been consolidated in the United States, Europe, China and Japan. J. Varela, exposing large-scale projects in Europe. The scope of the project includes: intelligent customer engagement, integration of distributed energy resources, operations and network planning [8]. In China a great Smart City project is under way. The project aims to build safe, sustainable, comfortable habitable cities and smart cities that develop intelligent services in the areas of health, transportation and safety [9].

Energy efficiency efforts can be achieved by optimizing lighting systems, not wasting energy in unoccupied rooms, and most importantly the operation of heating/cooling systems and ventilation according to actual needs [10]. All these problems can be overcome with a good electrical energy management system.

There are two approaches in energy efficiency efforts, namely passive energy efficiency and active energy efficiency. Passive energy efficiency activities can be done by installing and using energy-saving equipment and efforts to correct power factor. Passive energy efficiency is a fundamental effort for energy conservation, but a passive approach alone is not enough. Energy efficiency efforts require active approaches such as load control, system automation and monitor the use of electrical energy.

Effective power metering and monitoring systems will provide important information to building owners and operators about how their buildings are performing, so substantial improvements can be implemented immediately. For example, an effective metering and monitoring system has the ability to involve tenants, property managers, and owners in measuring energy efficiency. The ability to identify and measure energy use is often enough to produce energy-efficient changes in practices and behaviors, such as reducing waste of electrical power and avoiding peak utility rates. An effective measurement and monitoring system brings 10% direct energy savings and can also help reduce the operational costs of the building [5].

B. Development of Energy Conservation Technology

Automatic metering systems are a basic requirement for energy efficiency. Automatic metering systems typically use dynamic energy dashboards to display information about the operation of a building and energy consumption. Features like graphs, tables, and widgets are used to describe data in meaningful ways, such as searching and tracking load usage. One step ahead, modern automation and control systems, offer a more effective long-term contribution to building overall energy efficiency. When coupled with effective automatic metering, the system is like a variable motor speed for ventilation, indoor and outdoor lighting controls, smart thermostats, and programmed HVAC systems [5].

The following will discuss some published research results relating to the technology of conservation and monitoring of electric power:

1) First is Andrew Morrison and Adam Wright, designing and implementing a device for measuring and storing the use of electrical power at home. The system design provides an interface for viewing the power usage in graphical form that the user wants and the system connected wirelessly to the computer [11].

2) Second is David Delek, et al., developing a system that can be used by the user to control all home appliances such as light bulbs, and various loads connected to the home electrical installation, and can monitor the power required. The system sends power consumption information to a PC, which can be analyzed and can be uploaded to a server, if the user is connected to the internet [12].

3) The third is Rajeev Piyare, presenting a flexible and inexpensive home monitoring and control system based on micro web server. Users accessing the system remotely can use Android smart phone. Home-controlled appliances such as light switches, power plugs, temperature sensors and current sensors [13].

4) Fourth is Kant Suwansit, et al., designing a power monitoring system based on the android operating system for monitoring power consumption. The system has a facility so that users can view the data of electrical power consumption in the past and present in the form of statistical data [1].

III. Design System

A. Design Hardware

In accordance with the purpose of research that design prototype system to support the conservation of electrical energy. The designed system has smart and low cost characteristics. The designed system consists of several smart panel units, local computer network (LAN), database server as data storage, web server containing application of system controller and a power monitoring display. Block diagram of the system shown in Fig. 1.

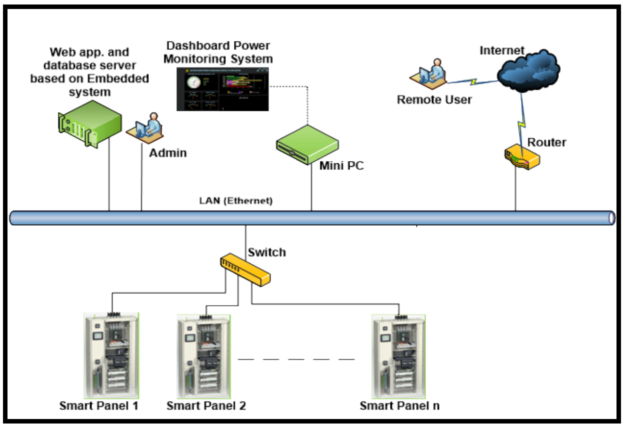

Figure 1. Smart panel and power monitoring system.

The design of the server based system is embedded system Raspberry PI 3, which has low power, low price, small size, and high performance. This is a characteristic of green computing. The system also implements an open source operating system so cost of the system is very cheap.

The monitoring system is responsible for recording all electrical energy consumption in a building, and recording electrical quantities such as voltage, current, power factor, and electrical power. In addition, the system performs and executes automatic control of electrical loads that have been set by the operator. The system can also provide reports in the form of data monitoring results in the period of daily, weekly or monthly. Real time reports are displayed on the Dashboard power monitoring system, which is mounted on a strategic location that can be seen by building users as part of an active approach methods of energy conservation.

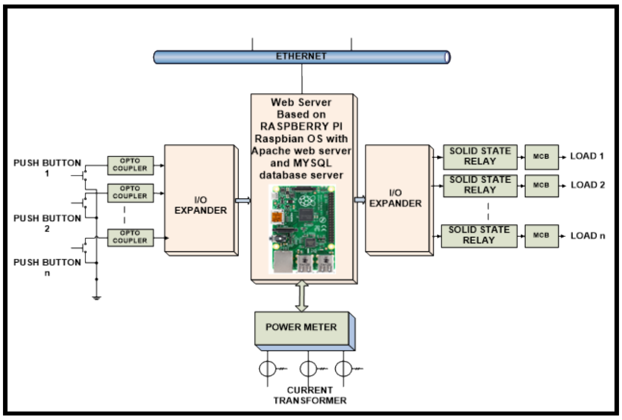

Figure 2. Block diagram of the smart panel.

B. Design Smart Panel

Smart panels are part of the system design that serves as a power distribution panel. Block Diagram of the Smart Panel shown in Fig. 2. The panel is controlled by a programmed Raspberry Pi embedded system so that it is capable of controlling the electrical load as set by the user. Smart panels are also capable of communicating with the server over a computer network, so it can send or receive commands from the server. Smart panel contains an embedded system that will be in charge of reading input from all push buttons and activating switch contactor that will turn on or off load directly. Also in the smart panel has a measuring instrument of electrical quantities that continuously record the consumption of electric power.

C. Controller Unit

Smart panels are controlled by an embedded system Raspberry Pi 3, which has a Broadcom BCM2837B0, Cortex-A53 (ARMv8) 64-bit 1.4GHz processor. Storage capacity of 1GB LPDDR2 SDRAM. It has 2.4GHz wireless LAN and 5GHz IEEE 802.11 b/g/n/ac, Bluetooth 4.2, besides having Gigabit Ethernet, 40-pin GPIO, 4 USB 2.0 ports and HDMI. Fig. 3 shows Raspberry Pi 3.

Figure 3. Raspberry Pi 3.

Raspberry Pi uses the Raspbian linux-based operating system, which comes with several applications such as Apache web server and MySQL database. Raspberry Pi is expanded with I/O port expander MCP23017, so it can add 16 bits I/O port. interface of MCP23017 chip with Raspberry pi using I2C line.

D. Input and Output Unit

The design of the prototype smart panel has 16 inputs and 16 outputs. The input unit is used to read push button status that serves to turn on and off the electrical load. The output unit is used to connect or disconnect the electrical current flowing to the load. The switch circuit on the output unit uses a G3MB-202P solid state relay. Fig. 4 shows 8 solid state relay module. Both the input and output unit circuits are protected by optical isolation to avoid the inclusion of undesired electrical voltage.

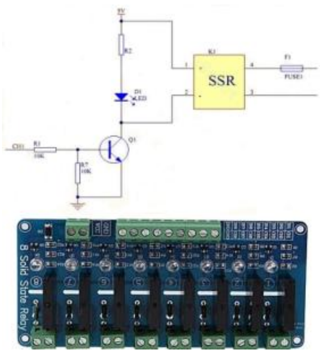

Figure 4. Solid state relay unit.

E. Power Meter Unit

Smart panel design implements PZEM-004t power energy meter for electric power measurement. This module can measure voltage, current, active power and electrical energy. PZEM-004 can store data when power off and able to communicate with controller unit through serial port. Fig. 5 shows power meter module PZEM-004.

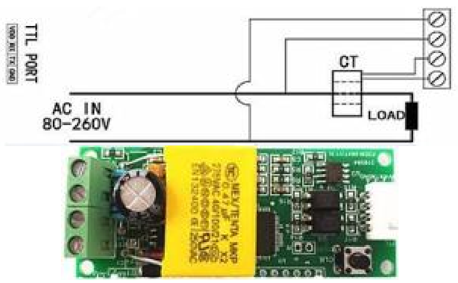

Figure 5. Power meter unit.

IV. CONCLUSION

This paper presents a smart panel design to support electrical energy conservation of active approach method. Smart panels are part of an energy monitoring system project funded by the Indonesian government's research and higher education ministry. Project is implemented within 2 years. The first year is the process of design and realization of smart panel and second year is design and realization of power monitoring system. At the time of writing this paper the process of smart panel realization is in progress. It is expected that smart panel system can be integrated with energy monitoring system and can support energy conservation.

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F. Yudi Limpraptono received the Bachelor's degree in Electronics from Brawijaya University, Malang, in 1994. His Master degree in Embedded System and Ph.D. degree in Computer Engineering both from the University of Indonesia obtained in 2000 and 2015 respectively. Currently, he is a Dean of Industrial Technology Faculty, National Institute of Technology, Malang. His area of research interest includes Embedded System and Green Computing Technology, and member of IEEE since 2010.

Eko Nurcahyo received the Bachelor's and Master degree in Electrical Engineering from National Institute of Technology Malang, obtained in 1987 and 2012 respectively. Currently, he is a head of Diploma of Electrical Engineering, National Institute of Technology Malang. His area of research interest includes power electronic and power management.

M. Ibrahim Ashari received the Bachelor's degree in Electronics from Electrical Engineering, National Institute of Technology Malang, in 1997. His Master degree in Electronics from Brawijaya University obtained in 2008. Currently, he is a Head of Analog Laboratory, Electrical Engineering, National Institute of Technology, Malang. His area of research interest includes analog and digital electronic.