Design Of Real-Time Electrical Power Consumption Monitoring System In Office Buildings Using SCADA Based RS485

Deta Brian Paryogi, Azmi Saleh

Graduate Student, Faculty of Engineering, Department of Electrical Engineering, Universitas Jember
Jalan Kalimantan No 37 Tegal Boto Sumbersari Jember 1st , Indonesia, PH 08566090307
deta.yogik@Gmail.com

Lecturer of the Faculty of Engineering, Department of Electrical Engineering, Universitas Jember,
Jalan Kalimantan No 37 Tegal Boto Sumbersari Jember 2nd, Indonesia, PH +6282334136960
azmi.teknik@unej.ac.id

Abstract: Various automation systems are used to facilitate a human task nowadays. One of them is SCAD (Supervisory Control and Data Acquisition). SCAD is a system that has three basic functions such as telemetering, telecontrol, and telescope. Thus, it has the advantage of being able to supervise plants located far apart. The SCADA system consists of three main parts namely the Master MTU (Master Terminal Unit), Slave RTU (Remote Terminal Unit, and communication media. The master is used as a communication controller while the Slave is used as executing commands from the Master. Meanwhile, the communication from the Master and Slave uses the Modbus protocol which in SCADA media can use ethernet or serial cable. In this study, a SCADA-based monitoring system design was made by implementing the real-time monitoring function (telecontrol) of the use of electrical power in the office building. In this design, a combination of two sensors and a microcontroller as slave RTU (Remote Terminal Unit) and Master MTU (Master Terminal Unit) were used to supervise the RTU. The communication between slaves and master used RS485, the communication protocol used Modbus with cable line communication. Meanwhile, USB RS485 was used for interface communication between the master and PC (Personal Computer) The results of this study showed that the design can be analyzed and utilized to analyze and monitor the availability of a power outage in an office building in real-time and quickly. Thus, maintenance became more efficient.

Keywords: Modbus, Real-Time Monitoring, SCADA, RS 485.

1. Introduction

The current developments in the electrical consumption sector are starting to increase along with the increasing number of people. In other words, the increasing number of population also increases the electrical equipment. Electrical consumption is divided into two, namely in the household sector and the office and industry sector. The office and industry sectors spend more electrical power. This can affect the availability of electricity to meet the two sectors which are quite large in number. To control the use of electrical power, we can save the use of an electrical device that is no longer needed to make the availability of electrical power can be fulfilled. Additionally, to control the electrical consumption, we need a monitoring system that can provide information and data from the electrical power consumption in real-time, one of which is SCADA. SCADA (Supervisory Control and Data Acquisition System) is a system that gathers information or data from the field and sends them to the main computer that will manage and process the data. The SCADA communication protocol is also used in industrial control automation systems as a data communication system for monitoring and controlling the existing equipment in industries and office buildings (Medilla K, 2015). This monitoring aims to obtain opportunities for electrical power efficiency (Yusnan, 2012). Monitoring can also simplify supervision work. This is because there is no need to directly supervise a location which is sometimes quite far. Looking at the monitor screen all the necessary data that is already available is fine. The commonly used communication on SCADA is Modbus by using RS45 as a communication medium. RS485 is a serial communication standard that is multidrop/multipoint. In this multipoint system, data transfer can be done in one transmitter to several receivers at once (Abdus Salam,2012). This study aimed to create a SCADA-based monitoring system design of real-time electrical power consumption in office buildings using RS485 serial cable as a Modbus communication media. The design of sensors and microcontrollers was installed in the electrical panel of the office building. This monitoring was carried out in real-time in the data laboratory to be monitored, including current and voltage. Those data were then sent to the monitoring center through Modbus communication transmission media, RS485. After the data were received, they were processed and displayed on the serial monitor and LCD screen using USB RS485. This was done to determine the condition of the electrical power consumption in office buildings in real-time as well as to monitor the existence of a power failure in the office buildings.

2. Research Method

The purpose of this study was to design a monitoring system to monitor electrical consumption in office buildings. This study was divided into three parts, namely sensor, microcontroller, and RS485 Modbus communication system. The principle of the monitoring was that the two sensors installed in the electrical panel box which sent data changes to the microcontroller. Furthermore, the microcontroller processed analog data from the sensor into digital for further transmission on a PC (Personal Computer) using RS485 serial Modbus communication. The following Figure 1 presents a block diagram of the monitoring system built.

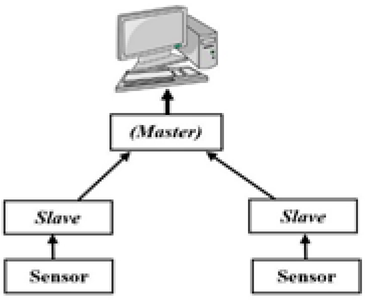

Figure 1. *The block design of a monitoring system using RS485 serial Modbus communication.*

2.1 SCADA System

SCADA (Supervisory Control And Data Acquisition) is a monitoring and controlling system which collect and analyze the data in real-time. SCADA system consists of three main parts namely Master, Slave, and communication media. The application of SCADA system, especially in the industrial worlds, is in the form of the product manufacturing process and power generators. The main function of the SCADA system is for remote measurement (telemetering), monitoring the parameters or variables monitored, and remote control (telecontroling).

2.2 Communication Systems

The communication system used in the delivery system between the two Slaves to the Master. In this study, the delivery was conducted using RS485 Modbus communication with a serial cable. Due to a large amount of data from the sensors to be presented, the Modbus communication system was implemented. The implementation made communication between Slaves (RTU) and Master (MTU) easier. By using a protocol code, reading data sent from Slaves to Master also became easier. The Modbus communication system was chosen because it has a reliable communication system. It also accommodated the number of devices that were connected at the same network with a considerable distance. Thus, the use of communication line cables was more efficient. The following Figure 2 shows the communication system chart.

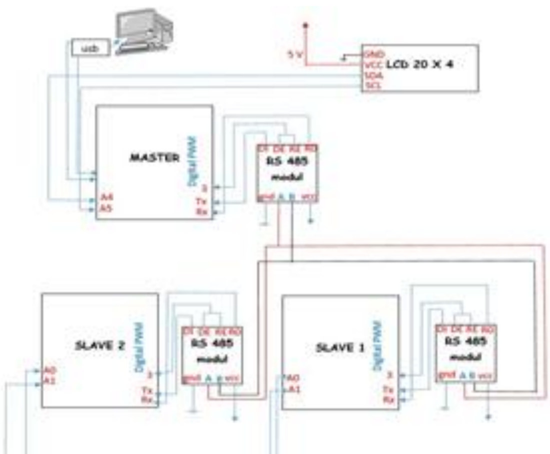

Figure 2. *Communication system block between slaves and master using RS485 Modbus*

2.3 Flowchart

In this study, the flowchart was divided into two sub-sections, namely the Slave which functioned as the sender of the sensor readings and the Master which functioned as the recipient of data from the two Slaves. The flowchart is presented in Figure 3 below.

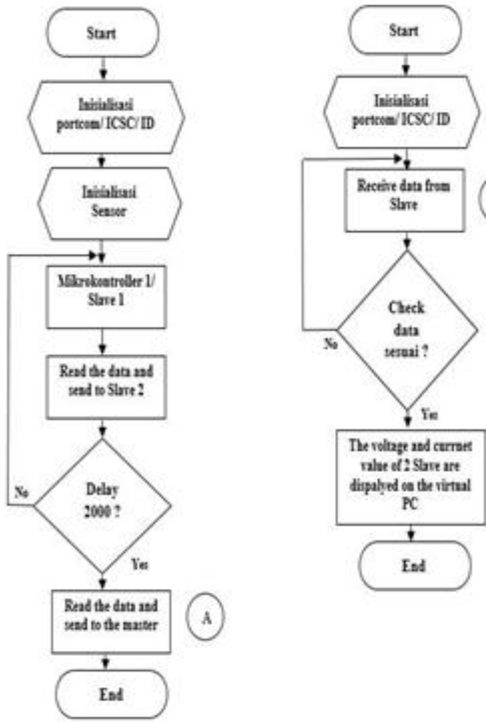

Figure 3. *Flowchart of the data delivery system from Slaves (left) to Master (right)*

Based on the visualization from the Flowchart above, the principle of sending data from Slave was in starting manners from Slave 1 to Slave 2. Therefore, the data sent to the Master were displayed coherently. The use of a delay of 2000ms was to avoid crashes in sending data between the Slaves and the Master. Moreover, it also made it easier for users to read the data in realtime.

3. The Design

3.1 Voltage and Current Sensors

In designing this monitoring system, two sensors were used, namely the current sensor tye SCT-013 with a maximum current of 10A and a voltage sensor type MPT101b. The sensors then were paired on each Arduino and put on the electrical panel box. The following Figure 4 visualized a voltage sensor and current sensor.

Figure 4. *ZMPT 101 voltage sensor and SCT-013 101 current sensor in the monitoring system*
Source: Nyebar Ilmu 2019

The design of the two sensors was as follows. The current sensor used was SCT-013. It used to change the value of the reading results of the current on this sensor using ADC (Analog Digital Converter). Meanwhile, the design of the voltage sensor using MPT101 was directly connected to the AC voltage source. The use of the principle of voltage divider circuit aimed to facilitate the reading of the sensor to the microcontroller.

3.2 Master and Slave Microcontroller Communication

This study designed the communication system using IC MAX 487 as communication between the microcontroller (Slave) and the Master. The use of TX and RX facilities on the microcontroller along with the use of Modbus protocol ID made the communication between Slaves and Master possible. The communication design between Slaves and Master in Figure 5 below

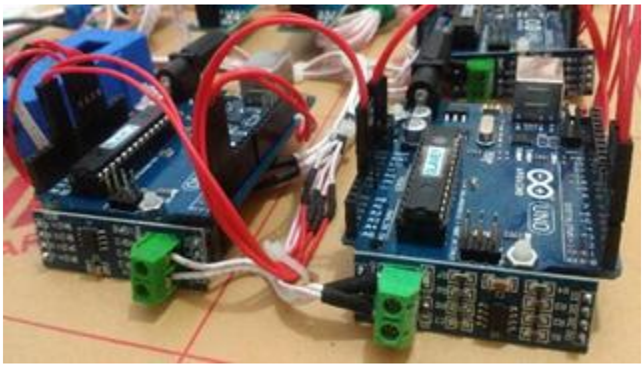

Figure 5. *The microcontroller communication between the Master and the Slave using IC MAX 487*

3.3 Design of Electrical Power Monitoring System-Instrument

In designing an electrical power consumption monitoring system, this study used 3 microcontrollers. Two of which were used as slaves sending data from sensors. Meanwhile, the other one was used as a Master to receive the data from the two Slaves. This study also used 4 sensors, 2 SCT-013 current sensors, and 2 ZMPT101 voltage sensor. The overall design of the monitoring system was presented in Figure 6.

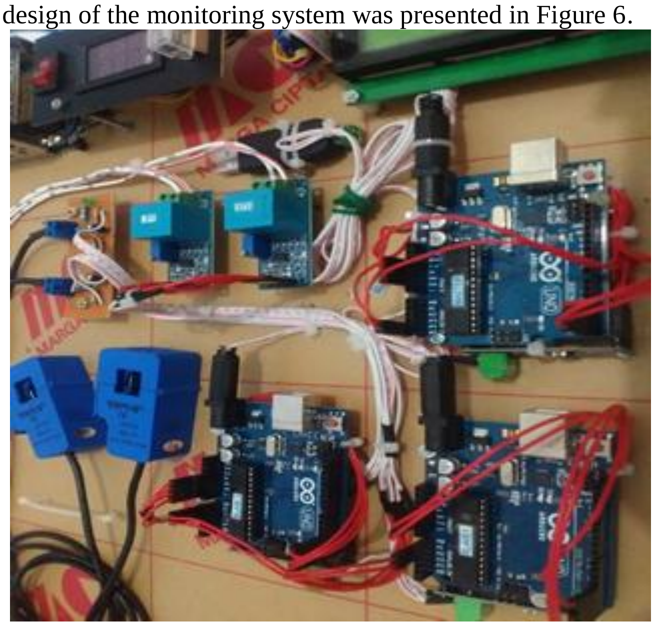

Figure 6. *The overall design of the monitoring system instrument*

4. Results and Discussion

The next stage was the test on the monitoring system performance, especially in the system of sending data from each Slave to the Master. The test was conducted repeatedly to get good data reading from the sensor using a predetermined time. Figure 7 below presents the test results of the current and voltage sensor readings.

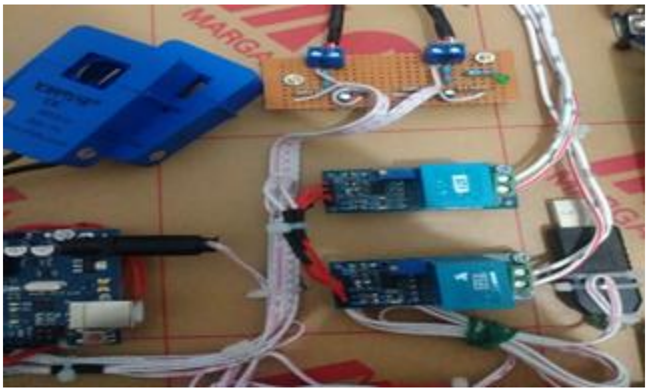

Figure 7. *The Test on the current and voltage sensors*

The test on the SCT-013 current sensor was conducted by clamping on one of the cable networks in the box to provide a variable current value to the load reading of the current sensor.

4.1 Results of the Current Sensor Test

This testing was done by calibrating the sensor with a digital multimeter. The test results were presented in Table 1 below.

Table 1. The current sensor test

No	Sensor Range	Result
1	10%	2.08 mA
2	15%	1.03 mA

4.2 Results of the Voltage Sensor Test

The voltage sensor test was done by calibrating the variable resistor on the voltage sensor by using a digital multimeter.

Table 2. The voltage sensor test

No	Sensor	Multimeter (V)
1	200	219
2	210	220
3	209	219
4	214	219

In the next test phase, a full monitoring system was run to see the performance of data sending from Slave 1 to Slave 2 to the Master. It was also conducted to see the results of the reading of the two sending data from Slaves to the Master in realtime. Figure 8 below presents the running results of a monitoring system simulation.

Figure 8. *The running results of the monitoring system*

The data reading results from the Slaves to Master were displayed on the serial monitor and LCD. The results of the data transmitter from reading these 4 sensors appeared simultaneously on the LCD. The display on the LCD was appropriate and could change in realtime. This proved that the delivery system was working properly.

4.3 The Test on the Delivery System from Slave to Master

Table 3. Monitoring system data transmission test

Date/Time	Slave 1		Power (W)
	A1	V1	
4/ 09.00 am	2,1	220	462
4/ 09.30 am	2,0	209	418
4/ 10.00 am	1,9	210	399
4/10.30 pm	1,8	215	387
4/11.00 pm	2,0	215	430
Date/Time	**Slave 2**		**Power (W)**
	A1	**V2**	
4/ 09.00 am	2,0	210	420
4/ 09.30 am	1,7	220	374
4/ 10.00 am	1,9	209	397
4/10.30 pm	2,1	210	441
14/11.00 pm	1,8	210	378

Table 3 above shows that sending data from 2 Slaves to the Master was working according to the data from the sensor readings. To see a comparison in sending data from Slave to Master, the sensor value was changed by testing the period of 30 minutes. Additionally, the change can also show different power consumption results on the second side of the slave. The results of electrical power consumption in the two monitored slaves were presented in Figure 9.

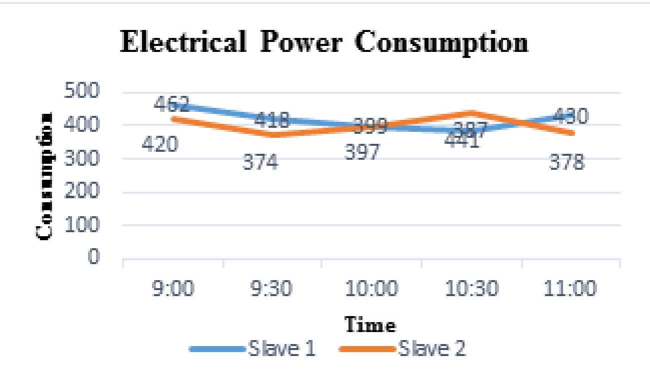

Figure 9. *Graph of changes in electrical power consumption over an interval of 30 minutes*

5. Conclusion

In the designing phase, the design of the monitoring system of electrical power consumption in realtime was made to see the principle of sending data from sensors placed in a panel box to the personal computer. The first stage was designing and building a data transmission system using Mobus communication between Slave and master. The results of the design of this monitoring system explained that the data transmission system from Slave, Master, and PC that used Modbus communication had good performance in the sending system. Therefore, this communication system is feasible to be implemented in the form of products that can be sold in the market.

6. References

[1] Agus Tiono,Sudjadi dan Iwan Setiawan, (2011) [Sistem terkontrol SCADA dengan fungsi dasar Modbus dengan menggunakan mikrokontroller AT89S51 dan komunikasi serial RS 485].

[2] Abdus Salam, Mukhidin dan Tasma Sucita, (2012) [Rancang bangun sistem jaringan multridrop menggunakan RS 485 pada aplikasi pengontrollan alat penerangan kamar hotel]. Jurnal ELECTRANS 11 (1-11).

[3] Dani Usman, (2018) [Sistem komunikasi sensor jarak pada jaringan SCADA bebrbasis RS 485]. Jurnal Rekayasa Teknologi 1 (10).

[4] Dwi Hanto dan Prawito, (2012) [Sistem komunikasi jamak dengan serial RS 485]. Jurnal Ilmu Pengetahuan dan Tekhnologi Vol 30 (37-44).

[5] Farid Hidayat, Slamet W.,(2015) [Sistem SCADA Untuk Kontrol Dan Monitoring Level Air Pada Pintu Air Untuk Meningkatkan Kewaspadaan Banjir] jurnal Komputer.

[6] Heribertus H, Catur Supriyanto dan Adrin T., (2015) [Design of prepaid energy meter based on PROTEUS] Jurnal IEEE.

[7] Kadek Suar W, Oka Sudana dan Putu Wira B, (2016) [Sistem komunikasi modul sensor jamak berbasis mikrokontroller menggunakan serial RS 485 mode multi prosessor communication (Mpc)] Jurnal Lontar Komputer 7 (2).

[8] Medilla Kusriyanto dan Muhammad Syarifuddin, (2015) [Mini SCADA berbasis mikrontroller Atmega 32 dengan komunikasi Modbus RS 485 dan sistem monitoring menggunakan visual basic].

[9] Mukhlas Arihutomo dan Muhammad Rivai, (2012) [Sistem monitoring arus listrik jala-jala menggunakan Power Line Carrier]. Jurnal Teknik ITS 1.

[10] Nyebar ilmu.2018. Akses sensor tegangan [serial on line] https://www.nyebarilmu.com/cara-mengakses-

sensor-tegangan-220v-zmpt101b/. [diakses 3 Oktober 2018].

[11] Nyebar ilmu. 2019 . [serial on line] https://www.nyebarilmu.com/alternatif-sensor-arus-menggunakan-module-sct-013/ [diakses 3 Januari 2019].

[12] Qurat.ul, Mudassir S dkk, (2015) [Implementation of SCADA for multiple telemetry units while using GSM for communication] Jurnal IEEE.

[13] Paavni Sukhla, Sonal singh dkk, (2017) [Design and development of a MODBUS automation system for industrial application] Jurnal IEEE.

[14] V.Tipsuwanporn, A. Numsoram dkk, (2014) [Development of redundant bus library for arduino to apply in SCADA system] Jurnal ICCAS.

[15] Yusnan Badruzzaman, (2012) [Real time monitoring data besaran listrik gedung Laboratorium Teknik Sipil Politeknik Negeri Semarang]. Jurnal JTET 1 (50-59).

Author Profile:

Deta Brian Prayogi is a graduate student in the Electrical Engineering Master program at Universitas Jember. Deta obtained his Bachelor of Engineering Degree in 2016 with the concentration in Electronics and Control Systems in the Electrical Engineering Department, Faculty of Engineering, Universitas Jember. Currently, he is interested in researching IoT (Internet of Things) in the electricity system.