Data Acquisition for Monitoring Microhydro Power Plant Sengkaling I Based on PZEM004T and Ethernet

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Abstract. The Microhydro Power Plant located at the University of Muhammadiyah Malang already has a manual electrical data monitoring system, in other words the monitoring cannot be done remotely. Infact to find out changes in existing data, operators must be coming directly to the generator site to manually monitoring. To overcome the manual methods, a device is designed to be able to monitor and access the electrical data remotely through the network. The device designed consists of hardware, including: PZEM004T sensor as a power sensor, Arduino Mega as a microcontroller, ENC28J60 Ethernet module which will connect Arduino to the internet via LAN cable to provide data from power plant to the web. As for the software used such as : MySQL database, XAMPP program functions for web server services, and PHP. The method used is to connect the PZEM004T sensor to the R, S, T 3 phase generator which will read the current and voltage, which will then be converted to units of power, frequency, energy, and power factor. After the sensor can read the data properly, the data will be stored in a MySQL database and displayed in a web browser using url address http://pltmh.umm.ac.id/pltmh1/. From the latest results, the data can be sent properly and there is still some delayed time in sending data from the sensor to the web browser approximately 11 seconds.

Keywords: Microhydro Power Plant, PZEM004T, ENC28J60

INTRODUCTION

Sustainable alternative energy or commonly called new renewable energy in Indonesia is increasing, including micro hydro energy power plants that utilize water pressure, water fall height, and water discharge, after that the mechanical energy that occurs will be converted into electrical energy [1]. The operation of micro-hydro power plants certainly requires a monitoring system to check the electrical data at the power plant on a regular basis in order to take action to repairs if needed or doing maintenance within a certain of time. There is no exception, the micro-hydro power plant that located at the University of Muhammadiyah Malang already has an electrical data monitoring system that is done manually.

The supervising or monitoring of electrical data at micro-hydro power plants is generally use manual method, i.e The operator must come directly to the location of the powerplant just for monitoring and checking which will spend more energy and time. The same thing also happened in the electrical data monitoring system of micro hydro power plant that located at the University of Muhammadiyah Malang [1]-[2]. Therefore, the micro-hydro power plants require monitoring tools with the result that electrical data at the power plant can be monitored remotely on purpose that it will save more time and energy.

On previous observation, the design and development of an electrical power monitoring system has been carried out, inter alia an electrical data monitoring system that uses a current transformer as a current sensor, a step down transformer as a voltage sensor, and 89C51 microcontroller as a data processor [3]. This system is the initial design of the electrical data logger at the Sengkaling PLTMH located at the University of Muhammadiyah Malang in 2010. Furthermore, this system was developed with the use of a power meter (PM) Conzerv as an electrical data sensor that uses WiFi communication media for sending sensor data to a web browser [2]. In addition, there are also studies using the GSM Shield module where the data that has been read by the sensor will be sent via an SMS gateway every 5 minutes.

Similar power plant monitoring research has also been developed with the ZMPT101B voltage sensor and the SCT 013-000 current sensor, after that the data can be monitored through the Ubidiots interface using internet access

[4]. Power plant research has also been developed, using the PZEM004T power sensor that can read current and voltage data at the same time. These are the use of the PZEM004T sensor using a Raspberry Pi for processing data that will be stored in a MySQL database and then can be displayed through smartphone [5], and the use of the PZEM004T sensor using the ESP32 Board Microcontroller for processing sensor data and controlling the Internet-based solid state relay (SSR relay). Things (IoT) which uses the Ubidots platform and is connected to the internet via WiFi to transport data to Telegram [1]. Research [6] also discusses power monitoring in buildings using PZEM004, only using WiFi as a data transfer intermediary.

From each results of the research described above, it can be seen that each research has its own advantages and disadvantages.To operate a power meter that can monitor current, voltage and power harmonic data, it is equipped with a data logger as a data storage for measurement and analysis of power usage [7], but this power meter is relativelly expensive. The operation of the SMS gateway system, which has a much wider reach, also has weak point, namely that it requires relatively large pulses so that the costs needed are also relatively large. Compared to Ethernet, the use of WiFi makes it easier to access for various types of devices and can also be used anywhere, but in terms of effectiveness and efficiency, Ethernet is faster and more stable than WiFi.

METHODS

The proposed structure should be verified, in that case a prototype was designed, build, and proved. The aquisition was made using microcontroller Arduino Mega 2560, by placing it inside the MCB of our building. The point is to acquire building electricity data supplied from the 220 VAC 50 Hz national grid, these sensors should be able to determine the root mean square (RMS) of voltage (Vrms), current (Irms), and AC frequency (Hz). Based on these basic properties, other derivative parameters such as apparent power (VA), real power (W), and power factor (PF) can be calculated [8]. The apparent power which is the trigonometric result of active and reactive power is shown in equation (1) while the real power is an equation (2) [6].

$$VA = Vrms \, . \, Irms \tag{1}$$

$$W = VA \, . \, PF \tag{2}$$

In this case, the microcontroller should be connected to a sensor that will read data from the generator output, and then the data will be process by the microcontroller and transport to the computer server via the Ethernet shield module. The data will be saved to the database and displayed to the web browser through the configured WiFi network. The block diagram of the system is shown in Figure 1.

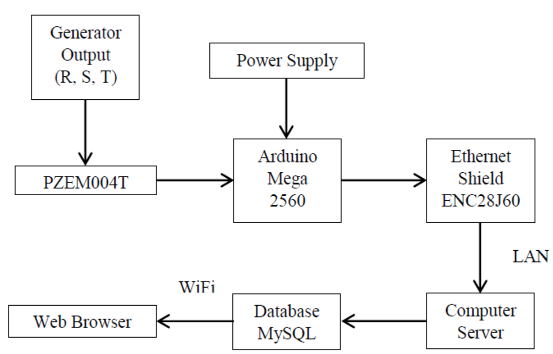

Figure 1. Block Diagram of System

1) Sensors

In this observation, PZEM004T-100A sensor was used for sensing voltage, current, active power, total energy, frequency, and power factor. This device is already attached to the MCB panel of our building and PZEM004T has operating capability at voltages from 80 up to 260 V, with current up till 100 A, AC frequency from 45 to 65 Hz, and for power factor (PF) as well from 0 to 1.

Signals of RMS voltage, RMS current, and frequency are read by signaling block, after that the measurement block is analyzing these signals, and finally it will be able to determine the value of VA, PF, and W. The values are stored in 8-bit registers and retrieved through the TTL interface at 9600 bps speed in every 1000 ms.

2) Microcontroller

This microcontroller has 54 digital inputs/outputs, there is a 16 MHz crystal oscillator, USB connection, power, ICSP, and reset button, 16 pins are used as PWM outputs, and 16 analog inputs. The performance of this microcontroller must be connected to a computer with a USB cable to turn it on using AC or DC current or battery would do the same [9].

Microcontroller Arduino Mega 2560 function is to consistantly acquire the data from the TTL interface before transmitting it to the application layer. This microcontroller unit can be programmed via the Arduino IDE, because this microcontroller is an open-source platform for IoT prototyping. Open-Source library code for PZEM004T Power and Energy meter needs to be compiled and installed on the Arduino Mega 2560. A private API that work in machine-to-machine (M2M) has been develop to automatically prepared the data to be ready to transport in nearly real-time without human intervention. At the client-side, the Arduino Mega 2560 employs the EthernetClient Arduino library [6].

3) Ethernet

ENC28J60 Ethernet module which has a clock speed of 25 Mhz is the internet module that act as a data sender from the microcontroller to the internet server. SPI or serial [10] is the interface system that used by the ENC28J60 Ethernet module. This Ethernet module will be the connector to the Arduino Mega, the Arduino pins that used to connect Ethernet and Arduino are pins 50, 51, 52 and 53, so that these pins cannot be used by Arduino for input-output purposes. The wiring diagram on ethernet and microcontroller is illustrated in Figure 2.

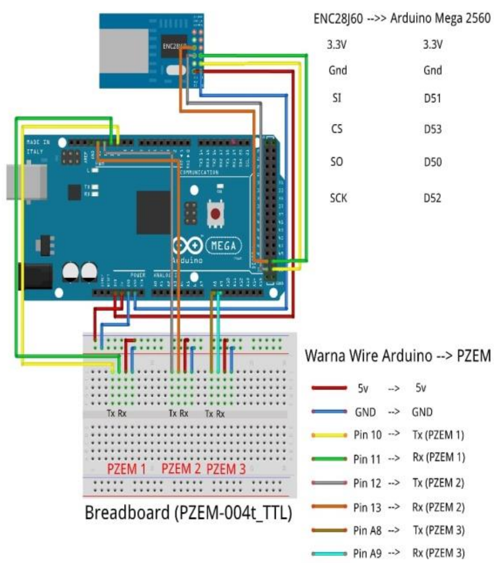

Figure 2. Wiring Diagram on Ethernet and Microcontroller

From the circuit illustration above, it can be found that this system uses 3 power sensors mounted on the R, S, T sections at the power plant generator output, this sensor module will read the current, voltage, and frequency values at the generator output, and the data will be processed by the microcontroller Arduino Mega. This sensor is connected to a 5V voltage on the microcontroller and each Tx-Rx on the sensor is connected to the pins of the microcontroller as shown above, these pins are optional or in other words the Tx-Rx sensor can be connected to a different pin unlike the Illustration above. And for the ENC28J60 Ethernet module, it is connected to the 3.3V pin on the microcontroller.

Installation of the voltage pins on the module or microcontroller, must be done with very carefull action , because if there is an error in installing a different voltage pin it will be fatal to the component and even damage can occur at once After the data is processed by the microcontroller, the data is sent to the MySQL database through the ethernet module and then will be displayed in the form of a web browser with the url address http://pltmh.umm.ac.id/pltmh1/, with time interval approximately 11 seconds.

Here is a circuit of systems that connect the entire system from the microcontroller, Ethernet, sensors, to the MCB at the generator output.

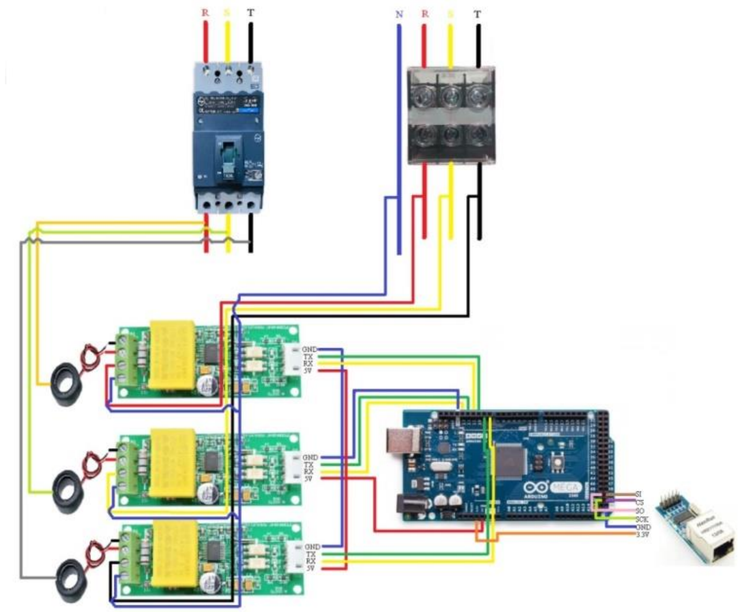

Figure 3. Wiring Diagram of the System

From the picture above, it can be seen that the CT on the PZEM004T sensor is connected to the R, S, T outputs on the MCB for current readings at the Microhydro Power Plant, and for reading the sensor voltage values it should be connected to R, S, T in the terminal block or port connector. Meanwhile, the database design used is shown in the following table.

Table 1. Database Design for Storing Energy Data

Field	Type	Null	Key
ID	char(15)	NO	PRI
voltage_R	decimal(7,2)	YES	
ampere_R	decimal(7,2)	YES	
watt_R	decimal(10,2)	YES	
frequency_R	decimal(5,2)	YES	
powerfactor_R	decimal(5,2)	YES	
voltage_S	decimal(7,2)	YES	
ampere_S	decimal(7,2)	YES	
watt_S	decimal(10,2)	YES	
frequency_S	decimal(5,2)	YES	
powerfactor_S	decimal(5,2)	YES	
voltage_T	decimal(7,2)	YES	
ampere_T	decimal(7,2)	YES	
watt_T	decimal(10,2)	YES	
frequency_T	decimal(5,2)	YES	
powerfactor_T	decimal(5,2)	YES	
reading_time	datetime	NO	

RESULTS AND DISCUSSION

The Development of testing sets had been done to evaluate the performance. For this experiment, based on PZEM004T sensors, a Arduino Mega 2560 microcontroller, including a web server has been setup as in Figure 3 for the projected structure. The aquisition block has been installed inside the MCB box of our building, and then connecting it through WiFi to a server that located at our local campus building.

Last 20 @WIB	R					S					T				
	v(V)	I(A)	W	f(Hz)	PF	v(V)	I(A)	W	f(Hz)	PF	v(V)	I(A)	W	f(Hz)	PF
2021-03-16 13:36:45	234.60	2.25	517.30	50.1	0.98	234.30	1.48	299.70	50.0	0.87	235.80	1.09	207.80	50.1	0.81
2021-03-16 13:36:34	234.60	2.26	518.00	50.1	0.98	234.30	1.49	305.20	50.1	0.87	235.80	1.08	207.20	50.1	0.81
2021-03-16 13:36:23	234.60	2.26	518.00	50.1	0.98	234.30	1.49	305.20	50.1	0.87	235.80	1.09	208.10	50.1	0.81
2021-03-16 13:36:12	234.60	2.25	517.10	50.0	0.98	234.30	1.50	306.30	50.0	0.87	235.80	1.10	209.90	50.1	0.81
2021-03-16 13:36:01	234.60	2.25	517.30	50.0	0.98	234.30	1.50	307.10	50.0	0.87	235.80	1.11	211.30	50.1	0.81
2021-03-16 13:35:50	234.60	2.26	519.80	50.0	0.98	234.30	1.49	305.10	50.0	0.87	235.80	1.10	209.40	50.1	0.81
2021-03-16 13:35:39	234.60	2.26	519.00	50.1	0.98	234.30	1.50	306.00	50.1	0.87	235.80	1.10	210.50	50.1	0.81
2021-03-16 13:35:28	234.60	2.26	520.00	50.1	0.98	234.30	1.50	307.00	50.1	0.87	235.80	1.10	210.00	50.1	0.81
2021-03-16 13:35:17	234.60	2.21	507.30	50.1	0.98	234.30	1.51	308.90	50.1	0.87	235.80	1.12	213.90	50.1	0.81
2021-03-16 13:35:06	234.60	2.47	568.40	50.0	0.98	234.40	1.50	306.00	50.0	0.87	236.00	1.10	210.30	50.1	0.81
2021-03-16 13:34:55	234.60	2.41	555.10	50.0	0.98	234.30	1.51	309.60	50.1	0.87	236.00	1.09	208.90	50.1	0.81

Figure 4. Display of Sensor Data Results on a Web Browser

From the latest research result, the picture above shows that the sensor data at the micro-hydro power plant has succeeded in reading the voltage, current, power, frequency, and power factor data on each of the R, S, T generator outputs. From many trials and errors, the most common problem is the disconnection between the device and the web browser. This is happening due to the occurrence of active and inactive Micro-Hydro Power Plants, usually when Micro-Hydro Power Plants are reactivated, it doesn't reactivate the sensor . In addition, sometimes there is a connection in the device that is detached due to the susceptibility of vibrations that occur in the installation area of the tool, while for the wiring that is used only ordinary jumper cables are used, in that case the connection/wiring need to be fixed in initial experiments such as the use of adhesives on some connections that susceptible to cut off, regularly.

CONCLUSIONS

Data Acquisition for monitoring microhydro power plant Sengkaling I based on PZEM004T and Ethernet has been customized and proved. Both pertinence and performance tests has been checked and work as expected. This system also can be used for other things, empower building managers or others energy stakeholders to have more knowledge in controlling and maintaining power quality whether onsite or online. Function development is needed, future work will be required as well as to use LoRa or other possible media to improve sensor network scalability if it used in buildings where LAN coverage is still the issue. Also, the development of other energy anomaly analytics such as voltage, frequency, and power factor will be useful for further needs.

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