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Control System and Monitoring on Microhydro Power Plant Based on Supervisory Control and Data Acquisition

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ABSTRACT

Micro-Hydro Power Plant (MHPP), is a micro power plant operate by water flow to rotate the turbine generate the desired power. The amount of electricity generated by the MHPP needs to be maintained to continuous for customer convenience. The water debit will have the effect to the amount of electricity generated by the MHPP. Therefore, monitoring and supervision is required for MHPP system operation. In general monitoring and supervision of the MHPP system by checking the amount of electricity generated. Currently, to control of turbine blades still done by manually. To do that it is requires a personnel and fixed time even though the area is far from human. In order to facilitate monitoring and supervision, it is necessary to have a control and monitoring system. Which is control and monitoring will be done remotely using supervisory control and data acquisition (SCADA) system. The main parts of SCADA are Master Station (MS), Remote Terminal Unit (RTU) & Communication System. Communication System in SCADA can be built in several options both wired and wireless. From that, the authors make a tool used to monitor the amount of electricity and control of the turbine blades MHPP that can be done through internet service. As data processing, Arduino is used for monitoring and controlling system. For data communication used Arduino Ethernet Shield in the form of internet communication. The use of this control system makes it easy for users when it comes to monitoring and control.

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Introduction

The rise of MHPP development in remote areas today is in the framework of the even distribution of Indonesia's electricity consumption (Hasan, Mahlia, & Nur, 2012; Susanto & Louhenapessy, 2014). Which every year in line with the increase of national economic growth. Therefore, long-term electricity demands in Indonesia are needed to illustrate for the current and future electrical conditions (McNeil, Karali, & Letschert, 2019; Muchlis & Permana, 2003). By knowing the long term electricity demand between 2003 and 2020, will be able to determine the type and estimated capacity of power plants needed in Indonesia during that period.Currently, SCADA is a monitoring and control system that being developed. SCADA is a process control system that enables local operators to monitor and control the process which disturbed by distances (Bayusari, Caroline, Septiadi, & Suprapto, 2013; Iacob, Andreescu, & Muntean, 2009; Morris et al., 2011). With the support of industrial process, SCADA systems can be monitored and controlled remotely (Ahmed, Desa, Azim, Surti, & Hussain, 2013; Ozdemir & Karacor, 2006). Thereby saving costs, time and effort, monitoring will provide an overview of the real existing conditions in the industrial world (Stojkovic & Vukasovic, 2006).

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Experimental Setup

SCADA System Modeling

Micro hydro is a term for power plant installations that use water energy (Rompas, 2011). Water condition that can be utilized as an electricity generating resource needs to have a certain flow capacity and altitude of the installation (Rompas, 2011). If flow capacity and height of installation greater, energy that can be utilized to generate electrical will be greater too. Using the following formula, we can calculate the power.

The calculation of power generated is:

Power theoretically	$P = k . H. Q$ (watt)	(2.1)
Turbine power	$P = k .\eta t.H.Q$ (watt)	(2.2)

Power generator		(2.3)
P	= Power [Kw]	
H	= Head	Max[Meters]
Q	= Volume Flow	[M3 /S]
ηt	= Turbine Efficiency	
ηG	= Generator Efficiency	
k	= Constants	

The constant k is calculated based: 1 horse power = 0.736 kW, whereas the H plunge height is expressed in meters and the water discharge is expressed in m3/s.

Sistem SCADA

The "primitive" SCADA system has been used by industry for long time ago (Stojkovic & Vukasovic, 2006). By relying on simple indicators such as lamps, analog meters, buzzer alarms, an operator is able to monitor the machines in the factories. Along with rapid growth in computer technology in the last few decades, so that computer important component in a modern SCADA system (Bayusari, Septiadi, & Suprapto, 2013). The system uses a computer to display the status of sensors and actuators in a plant being watched. Besides that the system will display them in various graphic, and store the data in the database as well as can monitored them through the website There are two elements in this SCADA Application:

- Processes, systems, machines to be monitored and controlled - can be a power plants, irrigation systems, computer networks, traffic light systems or anything.
- A network of 'intelligent' equipment with interfaces to the system through sensor and output control. With this network, which is a SCADA system, it allows you to monitor and control the components of the system.

Arduino

Arduino is an open-source single-board micro controller, derived from Wiring platform, designed to ease the use of electronics in various fields (Zhou et al., 2013). The hardware has an Atmel AVR processor and the software has its own programming language. Currently Arduino is very popular all over the world (Candelas et al., 2015). The language used in Arduino is not a relatively difficult assembler (Jamieson, 2011), but the simplified C language with the help of Arduino libraries (Teikari et al., 2012).

Design of SCADA at MHPP

In design of the tool, it will be created a concept in block diagrams. It used to make form and the flow more clearly. To make a system, there are several designs that must do:

1. Construction design The hardware design is to determine the components used, such as: Arduino, Wifi Router, Ethernet Shield, Current Sensor, Voltage Sensor, Relay and several other supporting devices.
2. Software designThe first thing to do is to create a description of the system operation in the form of block diagram, so in programming there has been a reference that can simplify the programming.

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The system work automatically to read the amount of electricity that will be monitored using the sensors that have been installed in accordance with its function. The sensor will provide an output signal to Arduino Mega 2650 which is directly connected to the sensor. The Arduino data processing will be monitored using PCs and Smartphones that have been programmed using Arduino software.

Results and Discussions

Before the system is realized, it is necessary to do some test to know how the device works and analyzes the level of reliability, weaknesses and limitations of the function specifications of the applications created. In addition, this test is done in order to find out how the system conditioning so that this application can be used optimally.

Testing was done in 3 ways:

- Hardware Testing.
- Software Testing.
- Testing the whole system (Hardware and Software)

The testing method that used in this research is block per block system. The testing was done by using centimeters and water level sensors HC-SR04. The data obtain from hardware testing (digital measurement) will be compared with the data obtained by manual (analog) measurement. The aim of comparison is to determine the accuracy of digital measurements and manual measurement. Percentage (%) error on measurement needs to be analyzed in order to know the level of accuracy of measurement on the designed tool.

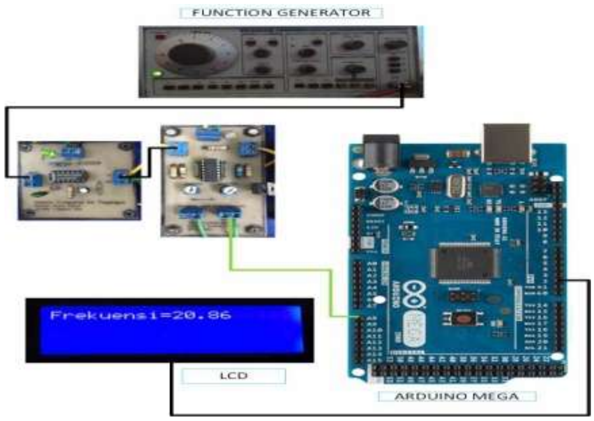

Figure 1. Frequency Response Testing scheme

Table 1. Frequency Response Measurement

Frequency Measurement	
LFG-1300 (Hz)	Frequency Sensor (Hz)
20	20.86
30	30.78
40	40.71
50	51.93

After testing using the LFG-1300 Function Generator it is necessary to analyze the workings of the system. The digital measurement results of the SCADA system using this arduino must be compared with the measurement result of the analog measuring instrument. It aims to determine the accuracy of digital measurements made by the tool. Percentage (%) error on measurement needs to be analyzed in order to know the level of accuracy of measurement on the designed tool.

In the testing of energized of 24 Vdc to PLC used a relays as NO (Normaly Open) and NC (Normaly Close) that connected to PLC digital ports to provide logic 1 and 0 for automatic and manual control of the motor. The aims of this test are to determine whether the relay operates well or not. It could be seen on test of voltage energized to PLC with Relay via WEB.

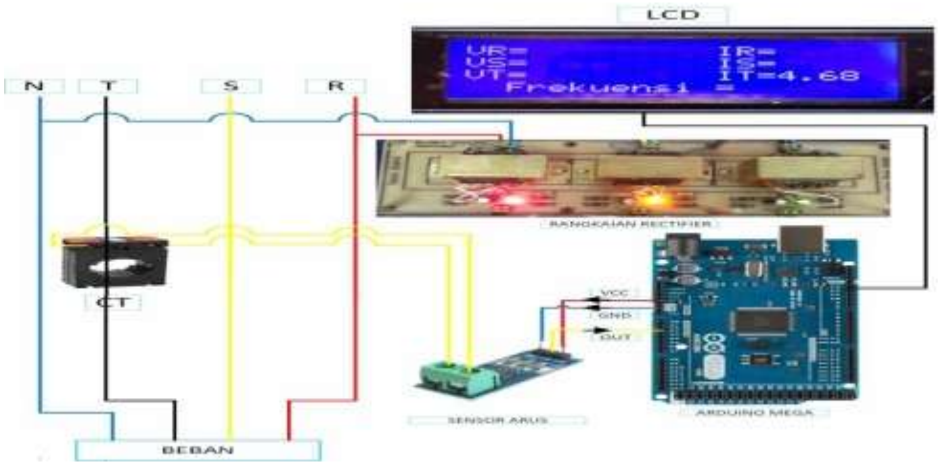

Figure 2. Monitoring Measurements on Phase T using ACS712 30A current sensor with smartphone.

Figure 3. Monitoring Measurements on Phase T using ACS712 30A current sensor with smartphone.

Testing is a step used to determine the extent to which the suitability between the design with the reality on the tool that has been made. Testing tools are also useful to know the level working after testing.

To perform the whole test the circuit it is required to use the following procedure:

1. Locate the tool on the control panel.
2. Each block of the circuit must be interconnected in accordance with the input of the input and output of the predetermined output.
3. Supplying voltage to each block of circuit.Connect the voltage sensor cable to the phase R, S and T.
4. Connect the current sensor cable to the CT at phase R, S and T.
5. Connect the water level sensor to the Arduino.
6. Connecting Arduino and PLC.
7. Connect the frequency sensor to the Arduino.
8. The first test is performed using clamp ampere meter.
9. The second test is performed using a centimeter to measure the water level.
10. The third test is performed using Function Generator to measure the frequency.
11. The third test is performed by WEB to control motor rotation.

A working system test tool is performed to find the percentage of errors when all the circuit is connected. Connectivity test Wifi router is done to determine the ability or range of data communication between Websites on tools designed with Wifi network. This is done through two ways that is connected with Wifi network and not connected. This test aims to determine whether the Wifi router is running well or not. It can be seen on various PC testing and control panel.

From the test results seen that the existence of internet network connectivity, the system can be accessed from anywhere and anytime. In contrast to the absence of internet network connectivity will not be accessible even if the position close to the server. By connecting the tool to the control panel on the PLTMH with the source 220 Vac voltages. Then the voltage is reduced using a power supply of 5V, 12V and 24 Vdc. When all components are active, wait until the orange led on the mega arduino is on. If the Led is on, then the system can be operated.

Next connect the ethernet shield to the router, then connect the modem through the usb port on the router. Once everything is connected, make sure everything is active which can be viewed with the active indicator LED. Once the router is connected to the network, the operator can open the web in mozilla, google chrome, and internet explorer to monitor and control the PLTMH system by opening the link provided. The system can work if the phases R, S, T are ON, with the active system then all the sensors will work and monitored or controlled via the web. Thus, the result can be measured by using the digital and analog instruments.

Based on the results obtained from these measurements then we can find the percentage error of the measuring instrument that we have designed. The percentage of errors occurring at the time of testing is between 0 and 2.85%. The percentage of error that occurred at the time of testing is between 0 to 2.85%. This value still below 5% of errors that occur in the measuring tool and still be tolerated. By looking at the data obtained it can be concluded the percentage of error that occurs in the designed tool is very small.

Conclusions

- Prototype SCADA tool applied to PLHMH Microhydro Power Plant is designed by using Personal Computer and Smartphone to monitor and display the measurement results and display the performance of the tool in real time.
- Ethernet Shield is used for data communication media connected to PC or personal computer. This design uses current and voltage sensors to detect the state of the appliance when operated so that it can be monitored through smarphone.
- To further improve I-SCADA system design performance using web-based arduino that will run in the future, then there are some suggestions that need to be considered

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