Development of a High Performance Remote Terminal Unit (RTU) of Wireless SCADA System for Monitoring Performance of Micro Hydro Power Plant

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Abstract. Remote Terminal Unit (RTU) is one part of SCADA system that functions to collect data from the plant, RTU itself is a unit of minicomputer that is equipped with a standalone system with a smaller physical size. The main objective of this research is to develop a high performance RTU for the wireless SCADA system that is applied to monitoring the performance of microhydro power plants (MHPP). Remote terminal units are built using Arduino Uno as a control center that will regulate analog data traffic from sensors connected to the system. The Remote Terminal Unit processes data from sensors that are converted into digital data and then sent via communication devices to the Main Terminal Unit (MTU) section that is located in the remote control center. The data received from sensor consist of voltage, current, frequency and turbine rotation of a MHPP. The Remote Terminal Unit (RTU) has been able to properly acquire data received by the sensor and then send it to the Main Terminal Unit via an AX.25 protocol based communication device.

Keywords: Remote Terminal Unit, wireless SCADA system, MHPP Parameters, Main Terminal Unit, Protocol AX.25.

1. Introduction
Remote terminal unit (RTU) is a component of SCADA equipment that is designed to monitor substation activity in a microhydro power plant system. Basic information about the generating system is obtained from monitoring the status of the equipment and measuring several important parameters such as voltage, current, frequency and rotation of the turbine in the microhydro power plant. These parameters are very important to observe because they determine the performance of a power plant system[1][2][3]. The information is then processed by RTU and then sent to the Control Center. Conversely, the Control Center can send commands to the RTU. RTU can be connected with one or two Master Stations. In addition to the Master Station, the RTU can also be connected to other RTUs (remote RTUs) via communication lines.

The RTU functions to communicate with the Master Station using a partitioned database and different communication protocols, processing the inputs and outputs that are connected to the RTU through digital and analog input / output modules. RTU also functions to communicate with IEDs (Intelligent Electronic Devices) and can acquire data from IEDs such as smart meters and safety relays. RTU can also be used as an event logger by connecting one or two printers and alphanumeric terminals, so if there is a change in status it can be printed locally. RTU users can configure as needed. This
configuration is done using a database system. The database is then loaded into RTU and stored in RAM.[4][6]

In general, RTUs currently use SCADA-based RTUs such as Siemens, ABB, or using PLCs, but are constrained with a high enough price if used to control medium-scale plants. As for the minimum functional requirements that must be fulfilled RTU quite a lot, including being able to receive analog data with a current range of 4-20 mA and voltage of 0-10 Volts, able to receive and process digital data from MTU, able to communicate with MTU, have the ability to start-automatic setup and restoration initialization in case of a power outage, have the ability to download a database from MTU, have a backup battery backup, and others. In addition, it must also have supporting features in providing maximum results on RTU performance, such as supporting the use of analog outputs for standard 4-20mA values, PLC support, etc.[5]

This research will develop a remote terminal unit that has high performance and can acquire data from current, voltage and frequency sensors and turbine rotation sensor on a microhydro power plant. Then the data is sent to the master terminal unit via the ax.25 protocol-based radio communication network and displayed on the master unit using the labview base. This research focuses on the use of hardware that can improve the performance of an RTU, so the data received by the master station is valid data which is sampled directly from the microhydro power plant.[7][8]

2. Literature Review

2.1. Remote Terminal Unit (RTU)

Remote Terminal Unit (RTU) is a unit of microprocessor or microcontroller-based SCADA architecture and is tasked with retrieving data from sensor equipment installed in a plant. The data is then sent to a remote MTU through the communication used. Sending data can be done through a wired communication network or wireless communication network. RTUs are also possible to communicate on a peer-to-peer basis with other RTUs, and can also act as a relay station to other RTUs that cannot be accessed from the MTU. The smallest RTU capacity has less than 10 analog and digital signals to those that have a large capacity above 100 digital signals.[3][6][7]. RTU hardware consist of CPU and memory, analog/digital Input, analog/digital output, counter, digital output interface, power supply and other tools needed to support the work of the RTU. In general the configuration of an RTU is shown in Figure 1.

![RTU Architecture](image_url)

*Figure 1. RTU Architecture*
2.2. Microhydro Power Plant (MHPP)
MHPP in principle utilizes the height difference and the amount of water discharge per second that is in the flow of irrigation canals, rivers or waterfalls. This water flow will rotate the turbine shaft to produce mechanical energy[4]. This energy then moves the generator and generates electricity. The MHP illustration can be seen in Figure 2.

![Figure 2. Illustration of Microhydro Power Plant](image)

The construction of the MHPP needs to begin with the construction of a dam to regulate the flow of water that will be used as a propulsion of MHPP[7]. Dams need to be equipped with sluice gates and garbage filters to prevent the entry of dirt or silt. Near the dam built intake building. Then proceed with the manufacture of a conduit that serves to drain water from the intake. At the end of the overflow channel a settling pond was built. This pool functions to settle sand and filter dirt so that the water that enters the turbine is relatively clean. This channel is made with concrete construction and is as close as possible to the turbine house to save fast pipes. Rapid pipes function to drain water before entering the turbine. Usually made of steel pipes that are pulverized, then welded. Flanges are used for connection between pipes.

2.3. SCADA
SCADA (Figure 3) is a system that collects data from various sensors at a factory, plant or in another remote location and then sends this data to a central computer which then manages and controls the data. Initially, SCADA was designed to be on a private network that uses communication lines. Because of the greater scope of its use, the use of this communication line has become impractical, because it introduced an integrated wireless communication system for SCADA[2]. In particular, the SCADA system includes several parts including, operating equipment such as pumps, valves, conveyors and branch breakers that can be controlled by actuators or relays. Instruments in the field or in facilities that are sensitive to conditions such as pH, temperature, pressure, power level and flow rate. Then a close communication network between local processors and instruments and operating equipment. This section includes Programmable Logic Controller (PLC), Remote Terminal Unit (RTU), Intelligent Electronic Devices (IED) and Process Automation Controller (PAC)[1][6].
3. Research Methods

Overall the system is designed the same as the general configuration of the SCADA system. Because this RTU was built for the purpose of monitoring the performance of microhydro power plants, the input requirements needed are current sensors, voltage sensors, frequency sensors and turbine speed sensors. The designed RTU is expected to be able to acquire the data with high precision so that the data received by the master station is real data from the microhydro power plant. This RTU was built by using an arduino microcontroller in which there is already an ADC function to convert analog data received from the sensor into digital data.

The system architecture developed consists of two parts. The first part is the RTU circuit consisting of the Arduino Mega 2560 microcontroller, current sensor, voltage and frequency sensor and turbine rotation sensor. The second part is the KYL 1020 radio network communication circuit that functions to send data from the sensor to the MTU section. Changes in parameters that occur in the RTU will be monitored by the Master Terminal Unit (MTU) consisting of personal computers and SCADA Human Machine Interface (HMI) display software.

The design of RTU begins by making a series of simulations using Proteus software, then making software for microcontrollers that will regulate and control the working system as an interface device. The microcontroller then converts the electronic signals received from the sensor device to be processed so that it can be sent using a communication protocol to transmit data via radio communication. Data acquisition devices used are current, voltage and frequency sensors as well as turbine spinning which provide information data from micro hydro power plants that can inform operators about current, voltage and frequency information and turbine rotation. Figure 4 shows the hardware architecture of the proposed systems.

Arduino Mega 2560 Board is an Arduino Board that uses ATmega 2560 Microcontroller IC. This board has relatively many Pin I/O, 54 digital inputs / outputs, 15 of which can be used as PWM output, 16 analog inputs, 4 UART. Arduino Mega 2560 is equipped with 16 Mhz crystals. For relatively simple use, just connect the power from USB to PC / Laptop or via DC Jack using 7-12 V DC adapter.

The data collection section consists of four sensors, namely the current sensor, voltage sensor, frequency sensor and turbine speed sensor. In this study, the ACS712 current sensor was chosen because of its precision and consists of a series of low linear offset Hall effect sensors with copper induction paths located near the mold. When the current enters through the copper conduction path, it will produce a magnetic field which is then felt by the IC Hall effect and converted to proportional voltage. The voltage senor is designed using a parallel resistor that will split the voltage into two parts. Current proportional to the measured voltage must be passed through an external resistor and installed in series with the main transducer circuit. 16x2 LCD is used to display current, voltage, frequency and turbine rotation data and will display all parameters in real time.
To send data from RTU, the YS-1020UA Wireless Transceiver radio communication module is used. RF data transceiver YS-1020UA is a device that can transmit serial data through aerial media. The device performs the process of laying down digital serial data to a carrier frequency with a higher frequency and then transmitted to the air by the transmitter. At the receiver frequency the carrier containing the data is captured and separated from the data carried. YS-1020UA Wireless Data Transceiver Module can send and receive serial data through air media, with a frequency of 433MHz ISM band and water baud rate of 9600bps. The use of these modules is quite practical because in terms of size they are quite small and directly can be connected to RS232[6]. The module works with a supply of between 3.3 to 5 VDC. In one module can be used as a sender and receiver as well.. Serial data that will be transmitted via RF is fed to the YS-1020 module by a microcontroller in series. Similarly, the data received, will be taken by the microcontroller serially. Figure 5 shows the schematic circuit design using Proteus.
4. Result and Discussion

Development of RTU for wireless SCADA systems for monitoring the performance of micro hydro power plants via Radio frequency with the ax.25 protocol serves as a monitoring system for several important parameters in micro hydro power plants. This RTU (Figure 6) can work well and can acquire data from sensors and send it to the Master station, so that the control room operator can see and observe the parameters of micro hydro power plants in real time (Figure 7). If an error occurs or interference with one of the parameters, the system will get a warning from the RTU which will then immediately send a signal to the microcontroller. The microcontroller immediately processes the data received and sends a signal to the KYL 1020 radio communication device. So the operator in charge of the control room is alert and immediately calls maintenance or takes other steps to resolve the problem. In general, the overall set of project and testing schemes works well. However, further research will be carried out for continuous improvement.

![Figure 6. Remote Terminal Unit (RTU) Complete Hardware System](image)

![Figure 7. Display of Data from Remote Terminal Unit (RTU)](image)
5. Conclusion
Remote Terminal Unit (RTU) is a small computerized unit device that can be placed at a location far from the monitoring location. RTU functions as a data collection point at the local level and collects parameters from sensors and sends commands for system control. The contribution of this paper is to provide development in the types of RTU and hardware alternatives for the design and development of a series of new models for Remote Terminal Unit (RTU) hardware and its functions. The developed system is designed to monitor the performance of the parameters in the micro hydro power plant and send the data to the monitoring center so that anticipatory steps can be taken if there is a changing parameter and not in accordance with a predetermined arrangement.

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