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Development of solar panel monitoring system on automatic meter reading

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Abstract

In dealing with era society 5.0, a gas company uses the Automatic Meter Reading (AMR) system, which is a remote data reading automation technology system for measuring instrument data in the field, which then conveys the information to the center via communication media data. In the Metering/Regulating Station (M/RS) installation, AMR is connected to the Electronic Volume Converter (EVC) which functions to transmit data from measuring instrument readings in the EVC to the data collection server. The modem on the AMR system uses a power supply from the solar panel system during the day and the battery system at night. The system for handling incomplete data disturbances is currently still in corrective action due to the unavailability of a solar panel monitoring system in the AMR system, causing difficulties for the team in conducting root cause analysis due to problems with battery voltage which are unable to cure AMR. To change the operation and maintenance activities of the AMR system, which was previously corrective action into preventive action, the authors will design and build a long-distance integrated solar panel monitoring system at AMR with the following features monitoring temperature, voltage, and current modules of solar panels, monitoring temperature and battery loading, and AMR remote restart function.

Keywords:

Automatic meter reading, batteries, monitoring, solar panels.

1 Introduction

Era society 5.0 or society 5.0 is a concept of collaboration between humans and Artificial Intelligent (AI) and Internet of Things (IoT) technology to solve integrated social problems between virtual and real-world spaces. In this era, people's lives will be integrated with AI and IoT technology systems that can process big data and analyze that data. The collaboration of community life and technology systems will help a company to be able dealing with conditions of Volatility, Uncertainty, Complexity, and Ambiguity (VUCA), conditions where every organizational leader will be faced with an environment that is constantly changing and difficult to predict.

In facing era society 5.0, a gas company uses an Automatic Meter Reading (AMR) system, an automated technology system for remote data reading that measuring instrument data in the field, which then conveys the information to the center via data communication media. In the metering/regulating station installation, AMR is connected to the Electronic Volume Converter (EVC) which functions to transmit data from measuring instrument readings on the EVC to the data collection server. The modem on the AMR system uses a power supply from the solar panel system during the day and the battery system at night. Other research is proposed to apply the GPRS network to the water meter reading, the result is automatically read data according to the set time [1].

An indication of an AMR system working well if the complete measurement data sent reaches the data collection server on D+1. However in the implementation of the AMR system, incomplete data disturbances often occur due to problems with the power supply. The incomplete data disturbance handling system is currently still in corrective action due to the unavailability of a solar panel monitoring system in the AMR system, causing the team to have difficulties in carrying out a root-caused analysis due to problems with battery voltage which is unable to supply AMR.

In carrying out a root-caused analysis related to constraints on battery voltage, previous studies have been carried out on evaluating solar panel systems. The research was conducted for three months by evaluating the tilt angle of the solar panels and measuring their output power, with the results of the research showed that the tilt angle of the solar panels greatly affects the output power of the solar panels [2]. In another study, it was found that the light efficiency of solar panels could be increased by solar tracking and concentrating mirrors. Still, the more light received, the hotter the solar panel module. Heat absorbed by solar panels, the efficiency of the output power will be worse. To reduce heat, you can use a cooling system, both active and passive. However, in this study, the researchers converted heat energy into electricity using TEG, so that it could increase the output power of solar panels without using cooling system [3]. In addition to previous studies conducted by other researchers, it is known that the uncontrolled depth of discharge in the battery will affect the performance of the battery [4]. Subsequently, research found that the results of battery temperature will affect battery performance, so it is very important to maintain battery temperature by using a cooling system [5]. Based on the four studies above, it is known that the output power of the solar panel is affected by the tilt/orientation of the solar panel module and the heat from the solar panel module, besides that battery performance is also affected by the depth of discharge and battery temperature.

After understanding the parameters that affect battery voltage to monitor these parameters, previous researchers have conducted several studies. A real-time PV monitoring system via a smartphone using the Arduino ATMega 2560 and using current, voltage, and temperature sensors on the solar panel module has been successfully carried out [6]. In 2018 a real-time PV monitoring system was created using IoT using the CC3200 with current sensors, voltage sensors, and humidity sensors [7]. Making real-time PV monitoring using IoT with an alarm if there is an anomaly, the microcontroller used is Arduino Uno, wifi module ESP8266, voltage, current, and temperature sensors for solar panels have also been carried out [8]. Meanwhile, real-time monitoring of the battery charging system at a solar power plant is carried out using an Arduino and a PZEM voltage sensor [9].

Based on the research above, this research applied in a rural area and to carry out continuous improvements by changing the operation and maintenance activities of the AMR system which were previously corrective actions to preventive actions, this study created a design for an integrated remote solar panel monitoring system on AMR that can monitor the temperature of the solar panel module, voltage and solar panel charging current, temperature, battery voltage, and current.

2 Design System

Automatic Meter Reading (AMR) is an automated technology system for reading data remotely against an instrument in the field, and then the information is conveyed to the data center via communication media. In the M/RS installation, the AMR is connected to the Electronic Volume Converter (EVC) with the function of sending data from the measuring instrument readings on the EVC to the data collection server (AVE) modem on the AMR system uses a power supply from the solar panel system for daylight and the battery system at night etc. The AMR system can be seen in Fig. 1.

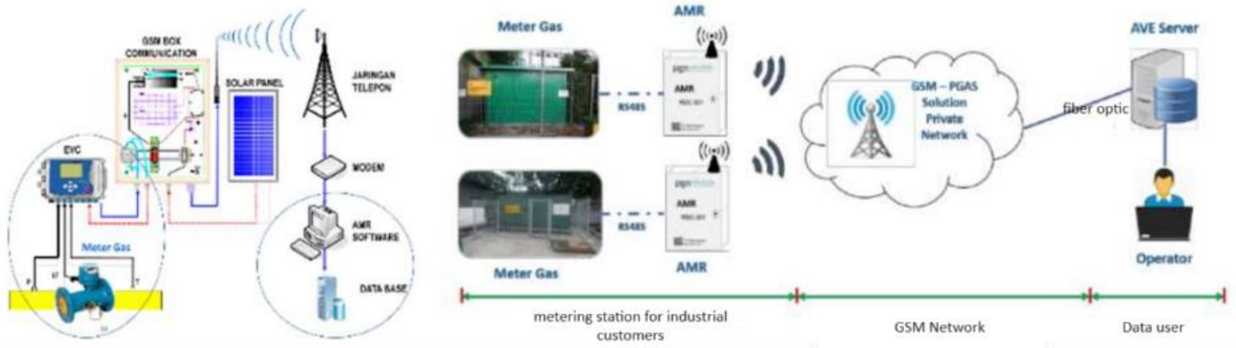

Fig. 1. AMR system.

2.1 System Block Diagram

Fig. 2 shows six variables measured in AMR, namely solar panel temperature, charging current and voltage, loading current and voltage, and battery temperature. In addition, there is also a relay that can be controlled remotely to restart the AMR. For the process sequence, six variables will be read by the sensor mounted on the AMR. They will be collected on the microcontroller to send the data using wifi communication to the HMI on the smartphone. Technicians will use this data to analyze the performance of solar panels and batteries on AMR. Through the smartphone HMI, technicians can also give instructions to restart the AMR remotely using the installed microcontroller.

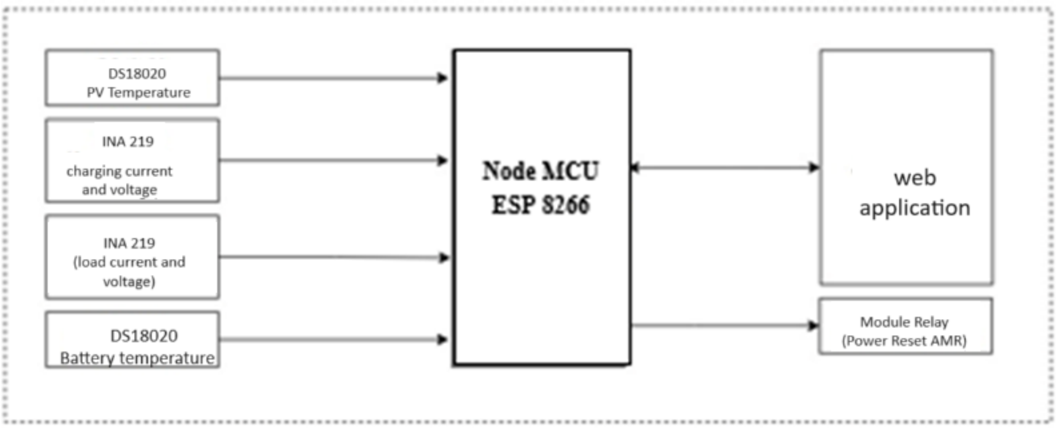

Fig. 2. Block diagram of solar panel monitoring system on AMR.

Fig. 3 shows is a series of stages in designing a tool. First, conduct a literature study that discusses related to prototype design as a reference. Second, the authors identify the need for tools and materials. Third, do the design. Fourth, prepare the components needed for the prototype design. Fifth, carry out the stages of designing hardware that has been prepared, namely making a solar panel monitoring system. Sixth, make a sketch program. Seventh, carry out the stage of installing instrumentation tools, namely sensors and relays on AMR, and the prototype trial stage, until the system runs well. Next, ensure that the measurement data can be read on the HMI and that the relay can properly restart the AMR.

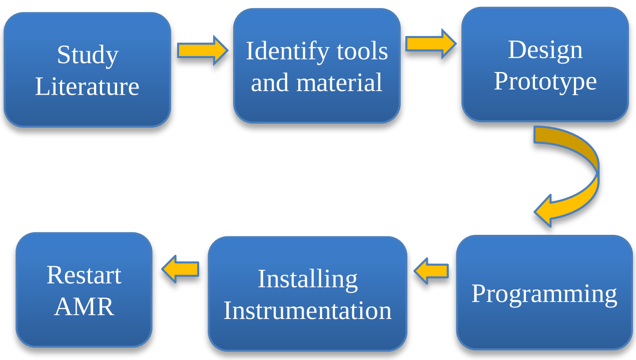

Fig. 3. Prototyping flow.

2.2 Design Hardware

The hardware and wiring design is composed of several components, namely the NodeMCU ESP 8266 microcontroller because is a cheap microcontroller, uses open source software and is capable of producing data processes, this tool has been used for smart monitoring systems using NodeMCU for maintenance of production machines [10], the DS18b20 temperature sensor, the INA 219 current and voltage sensor, the Blynk IoT Application, and the relay module as shown in Fig. 4. NodeMCU is a board electronics based on the ESP8266 chip that serves as a microcontroller and an internet connection (wireless internet access). So multiple I/O pins can be used in the application monitoring and control of the project IoT. The NodeMCU ESP8266 is programmable with the Arduino compiler, with Arduino IDE [11]. The INA 219 is a fairly precise and sensitive current sensor, this sensor is good for small DC measurements. The sensor can read the load current up to milliamps. In addition to current, this sensor can also measure voltage at the sensor's input source pin. This sensor can read voltages and currents at the same time [12].

Solar cells, or photovoltaic cells, are electrical devices that convert the energy of photons that hit them into electrical energy. The cell units are connected to a frame module, also known as a solar panel [13]. The power supply from the solar panel system is used during the day and the battery system is used at night. The power system is made using a 30 WP solar panel, 12 Volt battery.

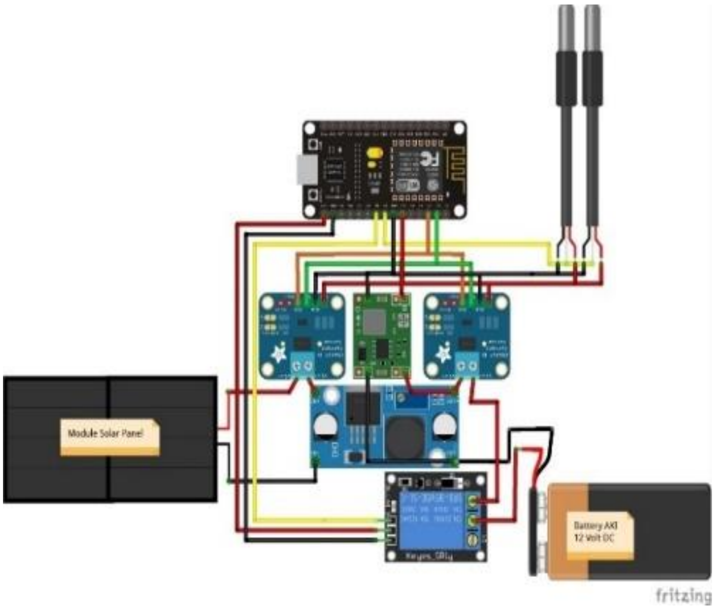

Fig. 4. Wiring system monitoring solar panel on AMR.

2.3 Design Software

The implementation of Internet of Things (IoT) for monitoring system has been significantly developed [14]. Wikapti et al. was developed IoT monitoring system to monitor the output power of solar power plant in a real-time [15]. Our research implemented IoT and making software for HMI needs on tools, two software are needed, namely Arduino IDE and Blynk IoT. Arduino IDE is used to program the microcontroller, while Blynk IoT is used to create a Human Machine Interface (HMI). Fig. 5 is an interface display scheme used on the prototype to start the application.

Fig. 5. Interface menu.

On the interface menu, there are three main functions, namely the Solar Cell Module (PV) button, the Battery button, and the AMR Restart button. The PV Module button will display information in the form of PV surface temperature, voltage on the PV, and current on the PV. The Battery button will display battery temperature, voltage, and current information on the battery. Meanwhile, the Restart AMR button functions to restart the AMR system.

3 Experiments Results

The solar panel monitoring system on AMR has been installed as shown in Fig. 6, and then the tool testing process.


Fig. 6. Solar panel monitoring system.

The trial of the solar panel monitoring system on AMR was carried out on June 16, 2023, from 10.14 to 17.26 with data collection every 20 seconds. The simulation results shown in 3.3 and 3.4, that starting from data 173 (at 11.10) there has been an increase in PV temperature reaching 40°C with a current reaching 0.29 A and then at the peak point at data 347 (at 12.05) with the PV temperature was 52.94 and the current reached 1.1 A. Then the PV temperature and current began to fall at data 532 (13.07 hours) with a current of 0.06 A, this condition was because the solar panels were covered in tree shadows and the weather was starting to get cloudy. Fig. 7 and Fig. 8 are observational data which is Fig. 7 shows data from a solar cell, and Fig. 8 is data from a battery. Based on data collection on that day, the system was working and was able to carry out the solar panel monitoring system on AMR. Fig. 6 shows the results of designing a solar panel monitoring system on AMR in real-time using the NodeMCU ESP 8266 microcontroller and HMI using the Blynk application.

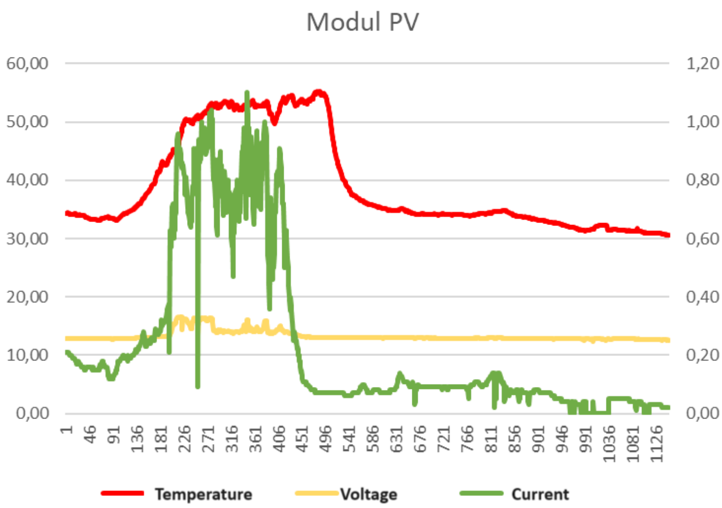

Fig. 7. PV module observation data.

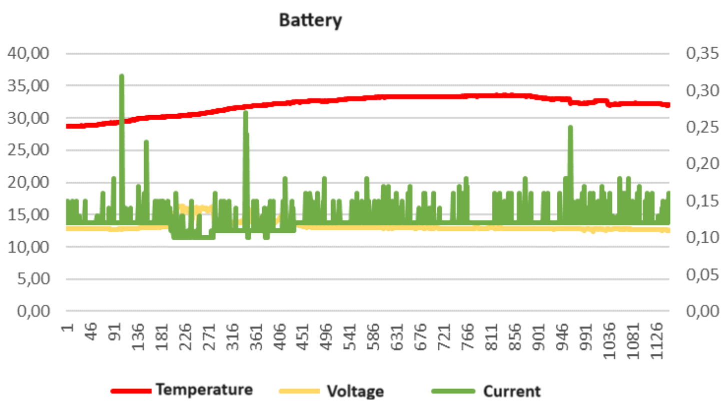

Fig. 8. Battery observation data.

4 Analysis of Results

In the solar panel monitoring system on AMR, the following test scenarios are carried out: the first is testing the PV temperature, voltage, and current measuring instruments by comparing sensor readings with multimeters and thermohydrometers, the second test is testing temperature, voltage, and battery current measuring instruments, the test is carried out by comparing the sensor readings with a multimeter and thermohydrometer and the third is the AMR restart test, the test is carried out by observing the length of the AMR restart process.

In testing the temperature measuring instrument on the PV, it can be seen in Table 1 that it is known that the average error of the temperature sensor is -1.1%. In the PV voltage test, it is known that the average error on the voltage sensor is -0.3% as shown in Table 2. In Table 3, the average error on the current sensor is 0.0%.

Table 1. PV temperature sensor testing

Temperature sensor (^oC)	Termohygro-meter (^oC)	Deviation (^oC)	Percentage (%)
34.6	35	-0.4	-1.1%
34.6	35	-0.4	-1.1%
34.1	34.3	-0.2	-0.6%
33.6	34.1	-0.5	-1.5%
33.5	33.9	-0.4	-1.2%

Table 2. PV voltage testing

Voltage sensors (V)	Multimeter (V)	Deviation (V)	Percentage (%)
12.75	12.74	0.01	0.1%
12.74	12.78	-0.04	-0.3%
12.75	12.78	-0.03	-0.2%
12.74	12.78	-0.04	-0.3%
12.75	12.78	-0.03	-0.2%

Table 3. PV current sensor testing

Current (A)	Multimeter (A)	Deviation (A)	Percentage (%)
0.03	0.03	0	0.0%
0.03	0.03	0	0.0%
0.03	0.03	0	0.0%
0.03	0.03	0	0.0%
0.03	0.03	0	0.0%

Then from the measurement results of the temperature sensor, voltage, and current on the battery, there is an error as shown in Table 4. The result of measuring the temperature on the battery there is an error of -2.5%.

Table 4. Battery temperature sensor testing

Temperature Sensor (^oC)	Thermohygro-meter (^oC)	Deviation (^oC)	Percentage (%)
33.1	33.9	-0.8	-2.4%
32	33.8	-0.8	-2.4%
32.8	33.7	-0.9	-2.7%
32.8	33.6	-0.8	-2.4%
32.8	33.7	-0.9	-2.7%

Table 5. Battery voltage testing

Voltage sensor (V)	Multimeter (V)	Deviation (V)	Percentage (%)
12.76	12.91	-0.015	-1.2%
12.74	12.94	-0.2	-1.5%
12.75	12.86	-0.11	-0.9%
12.73	12.9	-0.17	-1.3%
12.74	12.95	-0.21	-1.6%

In Table 5 it is known that the average error on the voltage sensor is -1.3%. In Table 6 it is known that the average error on the current sensor is -5.8%.

Table 6. Battery current testing

Current sensor (A)	Multimeter (A)	Deviation (A)	Percentage (%)
0.12	0.13	-0.01	-7.7%
0.12	0.13	-0.01	-7.7%
0.12	0.13	-0.01	-7.7%
0.12	0.13	-0.01	-7.7%
0.12	0.12	0	0.0%

5 Conclusion

Development of the solar panel monitoring system on AMR has been completed and testing has been carried out on the device. The AMR system restart test lasted 1 minute and 20 seconds. This duration can change depending on the signal from the modem user. For further research there needs to be improvements or additions to the Human Machine Interaction (HMI) application.

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