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# DESIGN OF DATA ACQUISITION FOR THE PRODUCTION AND UTILIZATION OF 500kWP SOLAR POWER PLANT AT CAMPUS-II ITN MALANG USING SCADA HAIWELL SOFTWARE

Widodo Pudji Muljanto[1], Sugeng Priyanto[2], Muhammad Farhan Salam[3], Irrine B Sulistiawati[1*]

[1]Electrical Engineering ITN Malang, Indonesia
[2]Postgraduate Electrical Engineering student ITN Malang, Indonesia
[3]Undergraduate Electrical Engineering student ITN Malang, Indonesia
***Corresponding author: irrine@lecturer.itn.ac.id**

**ABSTRACT**: Monitoring or data acquisition is defined as monitoring or tracking activities. The existence of a 500Kwp solar power plant at Campus-II ITN Malang in 2021 requires monitoring of its production in real-time. So far, data has been collected manually and generally only if further analysis is to be carried out. Data monitoring is observed locally at the monitoring terminal and does not yet provide system-specific data in real-time. This research conducts periodic monitoring to accurately and precisely determine the production power of a solar power plant in real-time. The tool consists of hardware design (Toky DS9L series 3 phase power meter, USR-DR302) and software (Scada Haiwell) used for online monitoring using the Modbus TCP/IP protocol with RS-485 to Ethernet. This system configuration displays the parameters of current, voltage, power, and energy (Kwh) from the production of solar power plants as measured by a power meter and displayed on the Scada Haiwell dashboard.

*Keywords: Data acquisition, Modbus TCP/IP, 500kWP Solar Power Plant ITN-II Malang, Scada Haiwell*

## 1. Introduction

Monitoring or data acquisition of an activity has constraints, including limitations on monitoring the observed object [1]. Watching that is carried out manually by humans still depends on the operator performing the monitoring object, requires an allocation of time and effort, and requires initial analysis to obtain the monitoring results. Data can only be monitored locally at the monitoring terminal as homework, which requires a long process before the data can be used. Recent technological developments have provided faster, safer features that anyone can monitor or predict in real-time [1]–[3].

This research is about periodic monitoring of solar power plants to obtain accurate, precise and real-time information on power production at any time, including data related to electricity production, output, current, voltage and power [4].

This research designed hardware and software with an online Scada monitoring system using Scada Haiwell and the Modbus RS-485 protocol [5], [6]. The Toky Power Meter hardware is installed in the Rusunawa panel room and the ITN Malang Campus-II Genset panel room. It is recording data in seconds, per minute and hour. This system configuration makes it easier for operators to monitor the 500Kwp PLTS ITN Malang Campus-II production accurately and precisely in real-time. This will provide another advantage that can be anticipated if there is a tendency for the system not to run normally or other conditions that can disrupt the overall system.

Knowing the importance of the data collection process, this research will discuss how to design a data acquisition system at the 500 kWp Solar Power Plant Campus II ITN Malang using Scada Haiwell software so that monitoring results can be directly used and read on the display system in real-time [5].

## 2. Methodology

### 2.1. Monitoring System

According to Fadilla [7], monitoring is tracking, which can be described as awareness of what you want to know; follow-up tracking is done to make measurements from time to time that show movement towards or away from a goal [7]. Monitoring provides information about status and trends, and completed measurements and evaluations are repeated from time to time; monitoring is usually carried out for a specific purpose: to study the process of following objects or to evaluate progress towards conditions or management objectives, results to effects—several different types of operations to maintain continuous control between other operations [8].

Acquisition is obtaining and entering (data) into a data processing tool. According to Cwilla [9], the data collection system can be interpreted as retrieving, collecting and compiling data and processing it to obtain the desired data. Data acquisition is the process of taking samples from actual physical conditions and converting the resulting samples into numerical values that can be manipulated and manipulated by computers or other processing devices [9]

## 2.2. Solar Power Plant

A solar power plant is a power plant that converts solar energy into electricity. A solar cell is a device that uses the photoelectric effect to convert light energy into electrical energy. It was invented by Charles Fritts in 1880. Photovoltaics are modules that are used to convert light into electrical energy. A system of lenses or mirrors concentrates solar energy combined with a tracking system to direct solar energy to a point and drive a heat engine [10].

A photovoltaic type solar power plant is a power plant that uses the voltage difference resulting from the photoelectric effect to generate electricity. A solar panel consists of three layers: a P-panel layer on top, a barrier layer in the middle, and an N-panel layer below. In the photoelectric effect, sunlight releases electrons in the P panel layer, causing protons to flow to the N panel bottom layer, and this proton current transfer is an electric current [11].

Based on the installation location, solar power generation systems are divided into two types, namely centralised solar power plants and distributed solar power plants. Based on the configuration and application, solar power generation systems are divided into off-grid, stand-alone and grid-connected solar power plants or grid-connected solar power systems. When this generator is combined with other types of power plants, it is called a hybrid system [10], [11].

## 2.3. Scada Haiwell Application

Surveillance Control and Data Acquisition (SCADA) systems have recently been used for process monitoring and control in various industries because of their high robustness [12]. The power grid is an example of a system that utilises SCADA integration. In recent years, another joint development in power systems has been dedicated to integrating Photovoltaic (PV) systems in existing grids. PV system control and monitoring are essential because of the impact on power flow. The core part of a grid-tied PV system is the DC/AC inverter. Many studies have been conducted on controlling inverters to meet grid needs [13]. In particular, SCADA systems are used in critical infrastructure assets such as chemicals, power plants, transmission and distribution systems, water distribution networks and wastewater treatment facilities. The SCADA system has the advantage of having a small percentage of errors or the possibility of a malfunction in the system.

## 2.4. Modbus

The Modbus protocol was developed by Modicon in 1979. Modbus is a fundamental communication protocol widely applied in the industry because it is universal, open, and easy to use [14]. Widely used new industrial products such as PLCs, PACs, and I/O instruments have Ethernet, serial, or wireless interfaces. The Modbus protocol can be used across all types of communication media, including twisted pair cable, wireless, fibre optic, Ethernet, etc. Modbus devices have a memory for data storage. This memory is divided into four parts: discrete input, discrete coil, input register and holding register. The discrete input and coil are 1-bit, while the input and hold registers are 16-bit. Commonly used communication protocols are Modbus RTU, Modbus ASCII, and Modbus TCP [13]. The Modbus protocol was developed by Modicon in 1979. Modbus is a fundamental communication protocol widely applied in the industry because it is universal, open, and easy to use. Widely used new industrial products such as PLCs, PACs, and I/O instruments have Ethernet, serial, or wireless interfaces. The Modbus protocol can be used across all types of communication media, including twisted pair cable, wireless, fibre optic, Ethernet, etc. Modbus devices have a memory for data storage. This memory is divided into four parts: discrete input, discrete coil, input register and holding register. The discrete input and coil are 1-bit, while the input and hold registers are 16-bit. Modbus RTU, Modbus ASCII, and Modbus TCP are commonly used communication protocols.

The Modbus/TCP protocol is commonly used in SCADA systems for communication between a human-machine interface (HMI) and a programmable logic controller (PLC)[15], [15]–[17]. Modbus TCP/IP is becoming the industry standard communications protocol and is widely used to build sensor-cloud platforms on the Internet. However, many existing data acquisition systems are built on traditional single-chip microcontrollers without adequate resource support. The complete Modbus TCP/IP protocol depends on the operating system and occupies abundant hardware resources. This research uses the compact Modbus TCP/IP protocol to make the system run efficiently and stably, even on hardware platforms with limited resources.

The Modbus TCP message cycle consists of four steps, shown in Figure 1. In the first step, the client sends a query (connection request) to the

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server, and in the second step, the query is acknowledged or accepted by the server. Then, in the third step, the server sends a response for the function code, and in the fourth step, the client gives a confirmation signal to the server, which will disconnect the TCP connection [15].

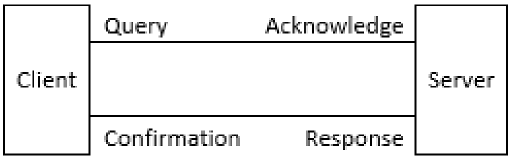


**Figure 1** The Modbus TCP message cycle

## 2.5. RS-485

Network loads can be computers, microcontrollers, and other devices connected using the RS-485 standard [18]. RS-485 is a differentially balanced transmission mode with two signals, A and B, with a voltage difference. Because line A is connected to B, the signal is high when it receives a low input and low when it receives a high input. RA-485 in communicating, all electronic devices are in receive mode until data has been sent. Then, the device enters transmitter mode, sends data, and returns to receiver mode. Every time an electronic device sends data, it must first be checked whether the path used as the data transmission medium is busy. If the line is still active, the device must wait until the line is empty. So that the data sent only reaches the intended electronic device, for example, to one of the enslaved people, the transmission starts with the Slave ID and continues with the data sent. Other electronic devices will receive the data. However, if the data received does not have the same ID as the Slave ID sent, the device must reject or ignore the data. However, if the sub-ID sent matches the recipient's electronic device ID, the following data will be processed further.

## 2.6. Local Area Network (LAN)

LAN, or Local Area Network, consists of several computers connected to a network [19]. In this network shown in Figure 2, each computer can access information from other computers. In addition, computers connected to a LAN have different IP addresses. Computers in this network can also use devices such as printers from other computers, chat with other computer owners, or play games together. The number of computers connected via LAN to the network is usually not too many, such as computers in homes, internet cafes, boarding houses and many other places related to a local network in the same building.

1. Switches

The function is the same as a bridge (connecting two LANs). A switch consists of several ports, so a switch is called a multi-port bridge. If one of the switch ports is busy with this function, the other port will still work. However, bridges and switches cannot forward IP packets to other computers that are logically separated from the network.

2. Routers

A router is a device that connects two networks with different OSI layers I, II and III, for example, a LAN with Netware connected to a network using UNIX.

3. Wireless Point To Point (PTP)

Point-to-point in a network is a data communication protocol usually used to establish a direct link between two network nodes.

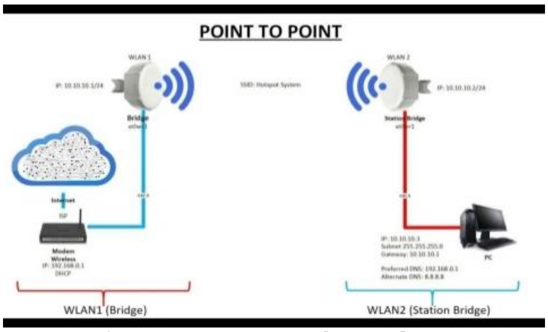


**Figure 2** PTP Network Topology

## 2.7. USR-DR302

It is used for transparent data transmission between the Ethernet interface and the RS-485 Serial Port, as shown in Figure 3. Users can configure parameters via the web page, set the software once, and keep parameter settings forever. The USR-DR302 is easy to use as you only need to connect it to a LAN network router using a UTP cable.

**Figure 3** USR-DR302

### 2.8. Toky DS9L Series 3 Phase Power Meter

This series of power meters can be used for control systems, SCADA systems and energy management systems, transformer substation automation, customer electric power monitors, industrial automation, intelligent switchboards, switch cabinets, etc. It is easy to install, has an easy maintenance system, simple connection, and programmable setting parameters on a meter or computer.


**Figure 4** Toky DS9L Series 3 Phase Power Meter

Features of this tool:
• It can measure 3-phase voltage, current, active power, reactive power, frequency, power factor, and many more, with a total of 28 parameters.
• Has two switch inputs and two switch outputs (4 switch inputs can be ordered). • The measurement result is the practical value
• the RS485 interface is used as a Modbus RTU communication protocol.
• Can record the kwh function forward and backwards. So that it can record the import and export of separate KWh.

## 3. **Flowchart and System**

This section will discuss the design of tools, starting from software design and hardware design.

### 3.1 Block Diagram System

This research uses the Toky DS9L Series 3 phase Power meter in Figure 4 as a monitoring tool to determine the AC output output on a 500 KWp PLTS. Parameter data include voltage, current, power and total energy consumption (kWh). The data collection method was carried out by designing electronic systems, installing devices, preparing servers, testing connectivity, testing reading data and integrating hardware into software, namely Scada Haiwell. Research data calibration is distributing data communicated using the Modbas RS-485 protocol using the RS-485 TCP/IP Converter, namely USR-DR302. The data obtained will be processed using programming and displayed on the Scada Haiwell dashboard to monitor the reading data in real time and online. The block diagram system can be seen in Figure 5.

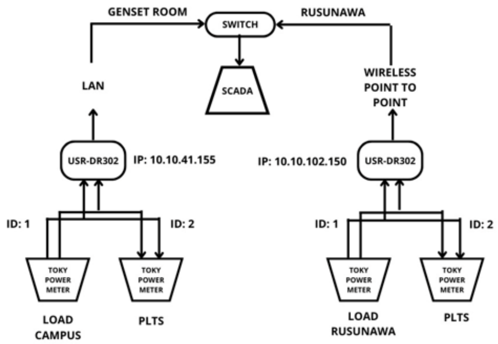


**Figure 5** Block Diagram System

### 3.2 Flowchart of Data Acquisition

This data acquisition flowchart is illustrated in Figure 6. The figure shows how to make a data acquisition system for the production output of a 500 kW solar power plant, starting from preparing the hardware (TOKY DS9L SERIES 3 PHASE POWER METER, USR-DR302, ROUTER) and software (SCADA HAIWELL). Then, assemble the cable (wiring) and set up the ID Toky power meter, setting up IP USR-DR302. Next, communicate between the software and the Toky power meter with the USR via the USR's IP address and power meter ID. Then, access the reflection address parameter in the Toky power meter datasheet table. Suppose the power meter and software are successfully connected, and the parameter data sheet is configured. In that case, the data will be read in the software at the current value of the device. Configuration and re-connection are performed if the output data is unreadable or has an error. Errors can occur due to incorrectly calling the power meter ID or IP USR and selecting the wrong PC board or COM port.

### 3.3. Scada Monitoring Process

Figure 7 illustrates the outline of the SCADA monitoring flow by processing data that has been acquired and read on the software. Create a task script program, design the Scada monitoring Dashboard display and call the programmed data to the Scada monitoring parameter display. If the data is successfully retrieved and according to the data parameters, it will appear on the display screen. Scada can monitor PLTS output data in real-time using Scada Haiwel software, and its users can further process the data. Suppose the output data is not displayed and does not match the parameter data. In that case, it is necessary to calibrate and reprogram the task script until the output parameter data matches the parameter data.

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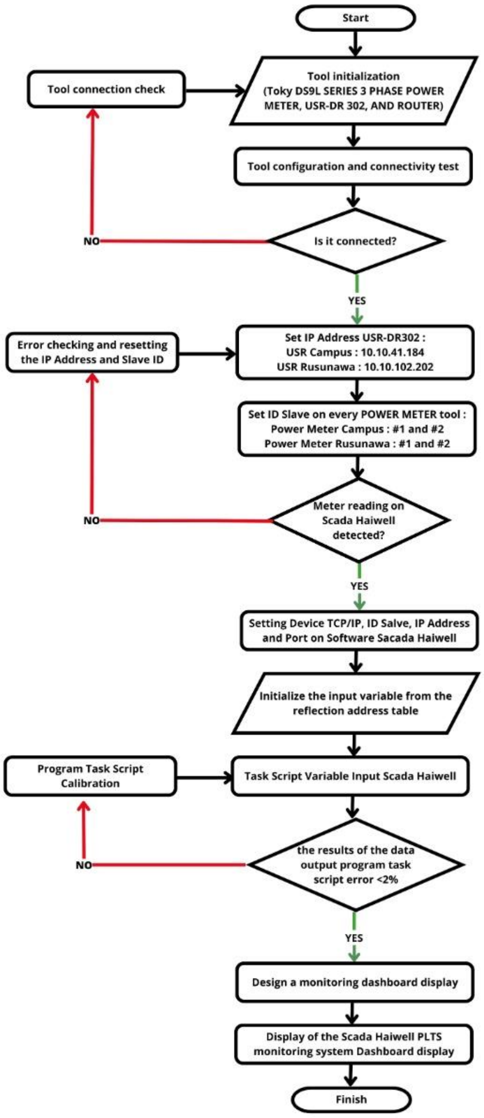


**Figure 6** Flowchart Of Data Acquisition Design

## 3.4. Calibration Process

Tool calibration is done by comparing and equating the measurement values obtained from the display data software with the actual measuring instrument. Calibration in this study was carried out through several stages in figure 8, adjusting the parameter addresses on the measuring instrument data sheet with the parameters that will be displayed on the SCADA parameters; adjustment for calibration data is carried out by creating a task script program on the data that the measuring instrument has acquired by adding value ranges to the data type function, then adjust the parameter output value on the power meter measuring instrument with the software parameter data display.

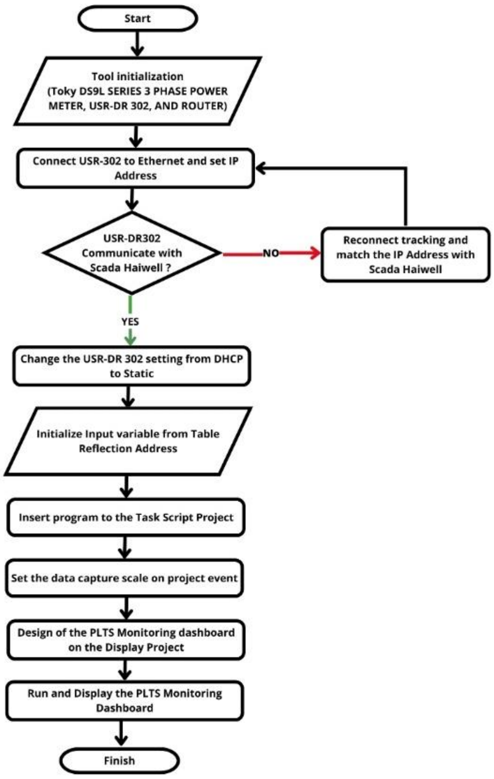


**Figure 7** Scada Monitoring Flowchart

## 3.5. Testing System

There are several steps in testing the system that will be used. The system can be seen in Figure 9. The testing following:

- Calibrate address address parameters that will be used in the system.
- Install the system and place the components on each panel used for monitoring.
- Perform wireless data connection testing.
- Operate a power meter and data transmission device equipped with a data acquisition system in the panel room where monitoring will occur.
- Make observations and store the results of the data obtained from measurements.
- Observing the parameter output data and displaying software parameter output data using Scada Haiwell.

## 3.6. Hardware Designing

The hardware design for this monitoring system requires a Toky DS9L, USR-DR302, and a router. Table 1 shows that it is configured and compatible to write this journal. The measurement results from the tools and readings on the Scada Haiwell dashboard are, by an error, 0.001%.

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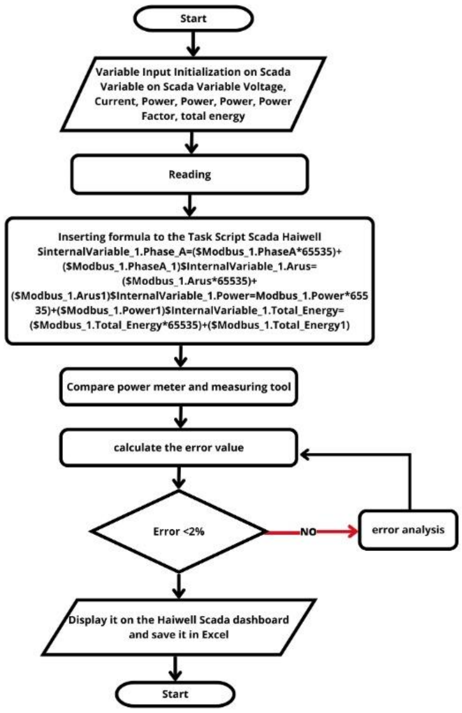


**Figure 8** Flowchart of the Calibration Process

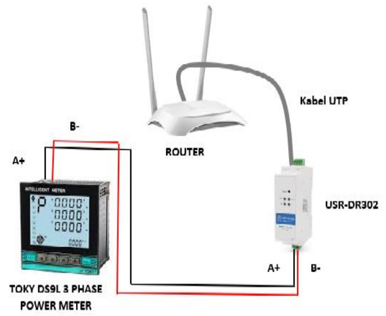


**Figure 9** Testing System

**Table 1** Configuration of Toky Pin with USR-DR302

| | |
|---|---|
| TOKY DS9L #1 and #2<br>TOKY DS9L #1 and #2 | USR-DR302 campus IP: 10.10.41.155<br>USR-DR302 rusunawa IP: 10.10.102.150 |
| RS-485 A+ | RS-485 A+ |
| RS-485 B- | RS-485 B- |

### 3.7. Software Designing

The software was designed using Scada Haiwell. Scada Haiwell, in this research, was used to process the results of measurement data and then create a PLTS monitoring system and display or parameter container that will be called up on the monitor, which contains parameters of voltage, current, power and total energy consumption (kWh) etc. Through the TCP/IP Modbus message cycle.

## 4. RESULT AND DISCUSSION

### 4.1. Configuration of USR-DR302

The USR-DR302 configuration aims to provide a compatible IP Address as a communication bridge between the meter and Scada Haiwell. This system employs two data transmission devices (USR302) for measuring devices on campus with the IP address 10.10.41.184 and measuring devices in flats with the IP address 10.10.41.184.

### 4.2. Device Configuration for Scada System

After the SCADA system's device configuration is completed, as shown in Figure 10, each parameter is assigned a tag name and address.

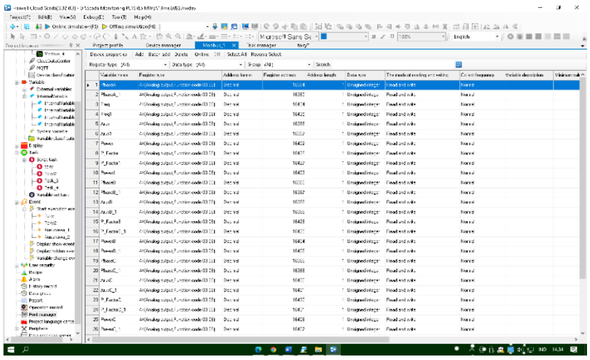

**Figure 10** Scada System

Alarms, trends, and reports are some of the other device configuration tasks mentioned above. The management alarm alerts the operator when a parameter exceeds the desired limit. In a chart, a trend displays every change in the value of a parameter over a given period. Meanwhile, the reporting module generates log data reports for display on the screen. The display of SCADA programs can be seen in Figure 11.

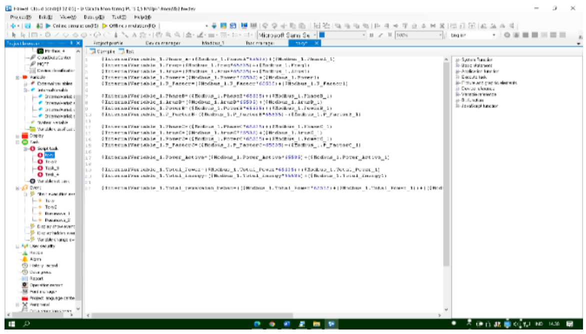

**Figure 11** Display Scada Program

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### 4.3. Monitoring Result

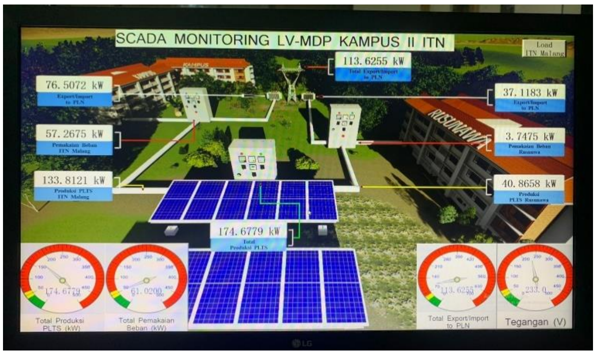


**Figure 12** First Dashboard Display

Figure 12 shows the first appearance of the Scada Haiwell monitoring dashboard, which describes the on-grid production output of the campus-II Solar Power Plant ITN Malang in detail and in real-time.

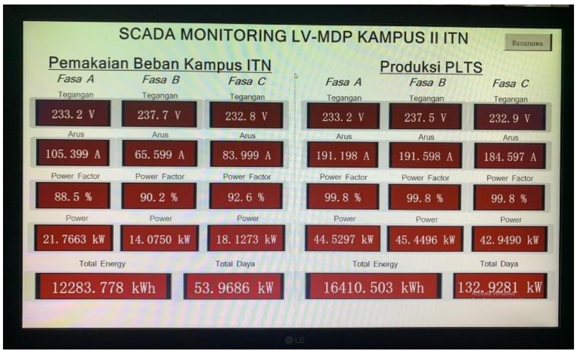


**Figure 13** Second Dashboard Display

Figure 13 shows the second display of the Haiwell Scada monitoring dashboard, which shows the 3-phase output in real-time, as well as the results of measuring the power meter on campus load usage and the production of Solar Power Plant, which is located on the panel in the campus generator room.


**Figure 14** Third Dashboard Display

Figure 14 shows the real-time display of three Scada Haiwell monitoring dashboards with 3-phase output, displaying the results of a power meter measurement of the dormitory load usage and the production of the Solar Power Plant located on the dormitory panel.

In this test, a comparison was made of the accuracy of the PLTS power meter output data with the Haiwell scada software output data using three trials. The data we compare is the current, voltage, and power results, each shown in Tables 2 to 5.

**Table 2** Comparison Of The Voltage

| No | V Design | V Power Meter | Error (%) |
|---|---|---|---|
| 1 | 231,5 V | 232,1 V | 0,25% |
| 2 | 258,7 V | 259,3 V | 0,23% |
| 3 | 263,3 V | 264,9 V | 0,60% |
| Average | | | 0,36% |

The average error is 0.36% based on comparing the output voltage in the table above.

**Table 3** Comparison Load Current

| No | I Design | I Power Meter | Error (%) |
|---|---|---|---|
| 1 | 81,19 A | 82,40 A | 1,46% |
| 2 | 85,40 A | 85,90 A | 0,05% |
| 3 | 87,55 A | 85,22 A | 0,78% |
| Average | | | 0,76% |

The average error is 0.76% based on comparing the table's current output above.

**Table 4** Comparison Load Power

| No | P Design | P Power Meter | Error (%) |
|---|---|---|---|
| 1 | 25,97 Kw | 25,30 Kw | 0,26% |
| 2 | 28,14 Kw | 27,43 Kw | 0,25% |
| 3 | 31,56 Kw | 31,06 Kw | 0,16% |
| Average | | | 0,22% |

Table 4 shows the performance of the design by calculating the power from the design and comparing it with the measured power from the power meter. The results show an average error of 0.22%.

**Table 5** Comparison of Energy

| No | Energy Design | Energy Power Meter | Error (%) |
|---|---|---|---|
| 1 | 23656 kWh | 23656 kWh | 0% |
| 2 | 23656 kWh | 23656 kWh | 0% |
| 3 | 23656 kWh | 23656 kWh | 0% |
| Average | | | 0% |

Based on the table 5, the average error value is 0%. This means that the design results match the measurements made.

## 5. CONCLUSION

This research is designing, installing, testing, and designing Scada monitoring so that it can be concluded.

The data acquisition system for monitoring the production of a 500kWp solar power plant at Campus-II ITN Malang using Scada Haiwell software provides real-time results.

The simulation results with Scada Haiwell have an error value < 2%, so it can be concluded that the design meets the accuracy requirements referring to the output value of the actual measuring instrument.

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