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SCADA Implementation on Solar Panel Electricity Consumption Monitoring and Regulation System

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ABSTRACT: In an effort to motivate students and understand application of SCADA to the Solar Panel system which is one source potential non - fossil energy to be used as solution to meeting sustainable energy needs. Where in its operation, efficiency and reliability Solar Panel system is still a major problemthat must be overcome.

Utilization of Supervisory Control and Data Acquisition (SCADA) in management Solar Panel Systems (PLTS) have become significant solution to improve loading efficiency .

The purpose of this research is to create a prototypes solar panel practicum as a learning media to motivate student in understanding how solar panels work and can apply the process of monitoring and regulating solar panel system with SCADA in real-time.

The equipment used includes Solar Panels, Solar Charger Controller (SCC), Inverter, Battery , PLC Omron CP1E-NA20DR-A and CP1W AD041, ACS712 Current Sensor , ZMPT101B Voltage Sensor, DHT22 Temperature and Humidity Sensor and Light Sensor (LDR) as well as CX- Programmer software Ver. 9.5 and CX -Supervidor Ver.4.0.

The method used is Research and Development method as the basic for design and manufacture of solar panel practicum tools and the application of SCADA to the monitoring system and electricity usage of solar panels.

From the results of tests conducted with the application of SCADA on solar panels can monitor Voltage , Current , Power, Temperature , Light and load usage regulator electric solar panels based on electrical energy consumption, as well as the condition of electrical equipment connected to the solar panel system with an average error values : Voltage 0.084%, Current 0.155%, Power 0.107% and Temperature 45 0C and Light 658.7 Lux.

KEYWORDS: Solar Panels, Batteries, PLC, SCADA, Sensors

I. INTRODUCTION

This research aims to produce an application of SCADA in solar panel system that can monitor and regulate the usage process solar panel energy remotely in real time. The resulting system can be applied to the Project Base Learning (PBL) process, in order to improve the competence of students . In producing a SCADA application on solar panel systems, it is supported by system support devices, which include sensor equipment as a signal for detecting the condition of the electrical load attached to the solar panel system, the internet network as a wireless communication medium in terms of monitoring or regulating the loading process on the solar panel system and the Programmable Logic Controller (PLC). as a data processing and decision-making center for the work of the solar panel system, where the monitoring and regulation process can be carried out anywhere via the internet and can accessed through user equipment in this case are laptops, computers , or Android gadget .

The monitoring process includes : results voltage , current , electric power based on consumption energy electricity and Temperature , Light on solar panels , as well condition equipment connected electricity with solar panel system . For the process of regulating whether or not the electrical equipment connected to solar panel system is active, based on the monitoring results for electrical load regulation.

II. RESEARCH METHODS

Method used is Research and Development methods and prototypes as base design and manufacture of solar panel practicum tools and the application of SCADA to the monitoring system and electricity usage of solar panels .

Design of SCADA Application on Solar Panel Electricity Usage Monitoring and Regulation System with the following stages : Prototype design of solar panel practicum tools , making system block diagrams, flowcharts , hardware design and software design .

A. Block Diagram

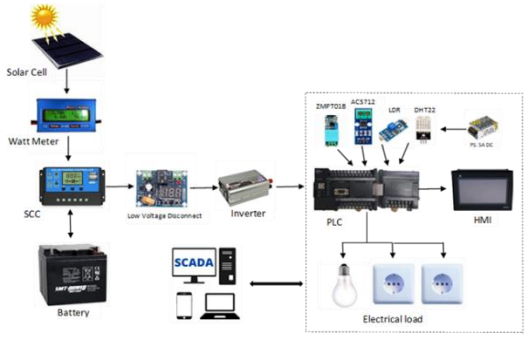

Figure 1. System Block Diagram

Information picture 1 :

- Solar Cell (Solar Panel) to convert sunlight energy into electrical energy.
- Wattmeter to measure Voltage , Current , Electrical Power produced by Solar Panels
- Solar Charge Controller (SCC) is used to regulate the charging current to the battery, avoiding overcharging and over voltage.
- Low Voltage Disconnect to automatically disconeect the system load when the battery voltage is less than the set voltage.
- Inverters convert DC voltage electricity into AC voltage.
- AC Voltage Sensor, Current Sensor, Temperature Sensor and Light Sensor as PLC input signals.
- PLC (Programmic Logic Control) is a control center and data processing center from input to output process
- HMI (Human Machine Interface) is an interface to control load and monitoring Voltage, current, Power, temperature, and Light in the field.
- SCADA to control and monitor loads with Internet communication
- Power supply as a source voltage for sensors.

B. Series Solar Panel Practical Equipment Wiring

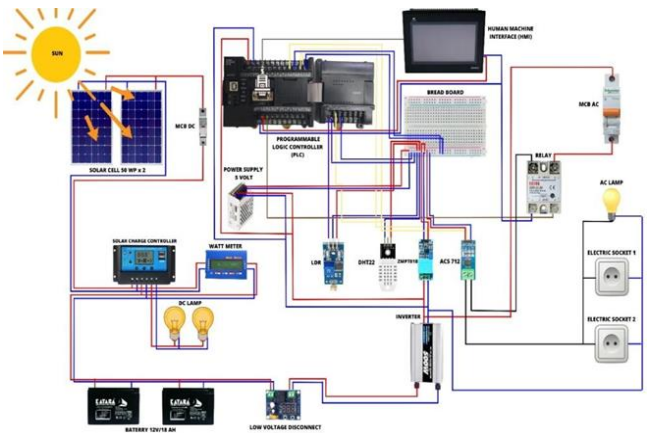

Figure 2. Design Solar Panel Practical Equipment Wiring

C. System Flowchart

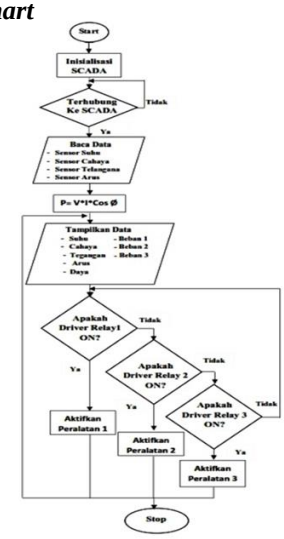

Figure 3. System Flowchart

Note.

After The SCADA application is activated and connected to the internet network, sensors will read data on temperature, light, voltage and current. Furthermore, the PLC process and sends the results to SCADA monitoring and control and so on until SCADA application is terminated.

D. Design Software

Software design consists of two parts, namely program design for PLC and SCADA design. PLC program design uses CX- Programer v 9.5 software with CP1E NA20 PLC, CP1W-AD041 analog input expansion unit and for SCADA design using CX-Supervisor v 4 software.

D.1 SCADA software design

SCADA (Supervisory Control And Data Acquisition) is a system that refers to combinations telemetry and data acquisition. This SCADA displays the design of controlling and monitoring the Solar Panel practicum tool so that it makes it easier for operators to monitor active equipment .

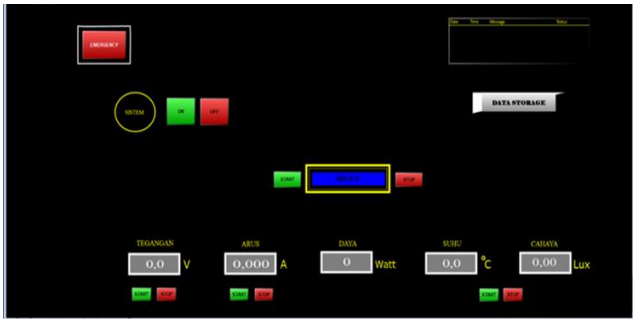

Figure 4. Monitoring and Tool Settings Display Solar Panel Practicum

D.2 Alarm Design

An alarms is notification or warning when an abnormal process occurs. In the CX-Supervisor program the alarm display is designed as follows:

Figure 5. Alarm display on CX-Supervisor

Description Status:
Cleared : Already normalized
Acknowledged : This process indicates an alarm has been known (not fixed) operator

Alarm conditions in CX-Supervisor are discrete conditions. Where the alarm only consists of two states (true or false).

In this system the alarm is used on the EMG button. When the EMG button is pressed system will be off and the date, time, short message and Alarm Status will be active and red.

When it is fixed / normal Status Cleared, For date, time, short message and Alarm Status will be passive and green.

D.3 Real Time Trend Designing

Trend is a graph showing data from a process or measurements made by certain tools. For example, temperature graph, pressure graph, speed graph, voltage graph of a sensor, conveyor, solenoid and others. The trend type in CX- Supervisor is a trend graph. Trend graph serves to display graph in real time. Trend graph that will be displayed on the system are voltage sensors, current sensors, temperature sensors and light sensirs and power values.

Figure 6. Window Trend Graph display

IV. RESULTS AND DISCUSSION

E. Results of Designing Solar Panel Practical Equipment

The results of the design of practicum tool can seen in Figure 7. SCADA- based Solar Panel Practicum Tool only includes the system after inverter output or AC current. With this SCADA system We can control AC load and monitor electrical quantities such as voltage, current and power from the inverter output. In this SCADA system we also can also monitor the temperature and light values received by solar panel.

Figure 7. SCADA- Based Solar Panel Practicum Tool

E.1 Testing SCADA Monitoring and Setup

In the SCADA based solar panel practicum tool functioned to monitor equipment and sensors that are working as a whole both input/output PLC. Analog sensor values are displayed such as voltage , current , power , temperature and light.

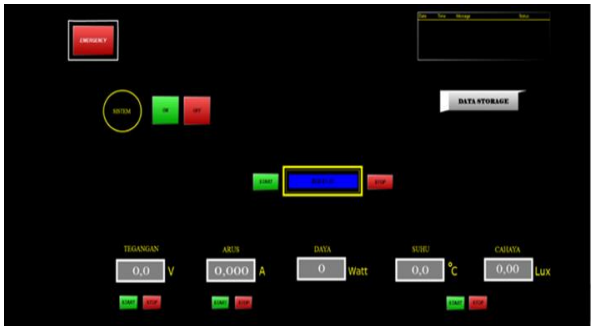

Figure 8. SCADA Tool display Solar Panel Practicum

If the system is actively working, press AC load Start button on the SCADA screen for activate AC load.

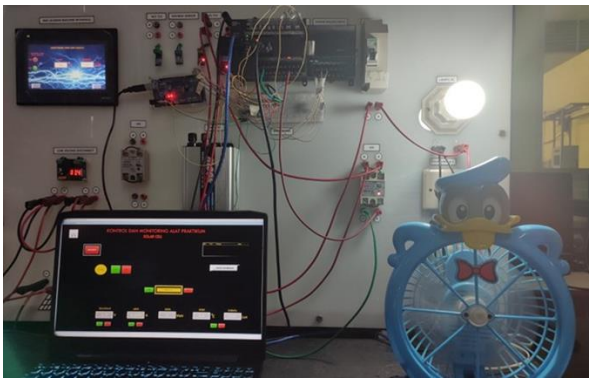

Figure 9. Testing AC loads on SCADA

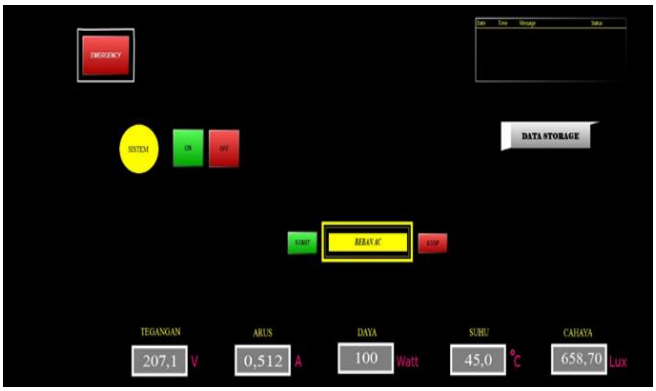

Figure 10. Monitoring and Setting Solar Panels in SCADA

E.2 Alarm Testing

The function of this alarm is to warn to the operator or technician If there is an abnormal condition on the equipment that is working. This alarm provide the location, place and time of disturbance.

Press the emergency button to shut down the entire circuit a activates the alarm.

Figure 11. Alarm Testing with push Emergency button

E.3 Testing Graphic Trends and Real Time Data

To display the movement of a running equipment and the time when the equipment is in working / non-working condition then the graph and time data can be saved on an excel sheet by pressing the Data Storage button .

E.3.1 Trend Graphics and Real Time Voltage Data

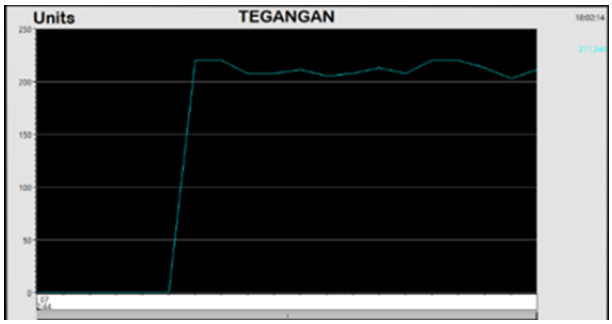

Figure 12. Graphic Trend and Realtime Voltage Data

Table 1. Realtime Graph Trend Data for Voltage Values

Breaks	Date	Time	Millisecs	Voltage Data
Open	03/06/2024	12:56:25	581	201.08
	03/06/2024	12:56:25	670	189.82
	03/06/2024	12:56:26	673	212.96
	03/06/2024	12:56:26	785	202.08
	03/06/2024	12:56:26	878	207.54
	03/06/2024	12:56:27	701	189.58
	03/06/2024	12:56:27	808	201.32
	03/06/2024	12:56:27	902	196.34
	03/06/2024	12:56:28	19	202.74
	03/06/2024	12:56:28	213	204.96
	03/06/2024	12:56:28	310	207.52
	03/06/2024	12:56:28	711	212.8
	03/06/2024	12:56:28	827	210.74
	03/06/2024	12:56:28	916	196.9
	03/06/2024	12:56:29	28	205.92
	03/06/2024	12:56:29	115	199.72
	03/06/2024	12:56:29	723	201.08
	03/06/2024	12:56:29	836	194.7
	03/06/2024	12:56:29	923	202.68
	03/06/2024	12:56:30	39	200.66
	03/06/2024	12:56:30	130	199.82
	03/06/2024	12:56:30	556	201.74
Close	03/06/2024	12:56:48	322	201.74

E.3.2 Trend Graphics and Real Time Flow Data

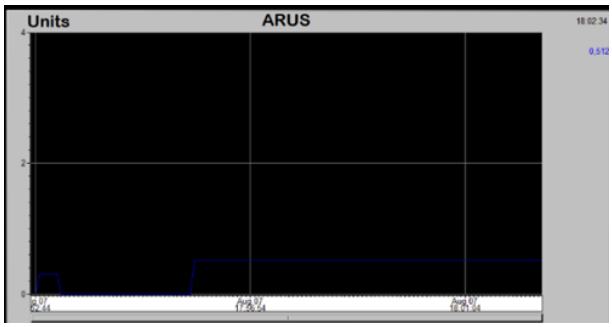

Figure 13. Trend Graphics and Realtime Flow Data

Table 2. Trend Data of Real Time Current Values Graphs

Breaks	Date	Time	Millisecs	Flow Data
Open	03/06/2024	12:56:01	620	0.302
	03/06/2024	12:56:03	153	0.304
	03/06/2024	12:56:04	58	0.304
	03/06/2024	12:56:04	156	0.302
	03/06/2024	12:56:05	280	0.304
	03/06/2024	12:56:06	409	0.302
	03/06/2024	12:56:06	512	0.304
	03/06/2024	12:56:07	111	0.304
	03/06/2024	12:56:08	323	0.302
	03/06/2024	12:56:08	426	0.304
	03/06/2024	12:56:10	686	0.304
	03/06/2024	12:56:14	579	0.304
	03/06/2024	12:56:15	589	0.302
	03/06/2024	12:56:16	411	0.304
	03/06/2024	12:56:18	131	0.302
	03/06/2024	12:56:19	67	0.304
	03/06/2024	12:56:20	375	0.302
	03/06/2024	12:56:20	482	0.304
	03/06/2024	12:56:25	867	0.302
	03/06/2024	12:56:26	71	0.304
	03/06/2024	12:56:27	902	0.302
	03/06/2024	12:56:28	18	0.304
	03/06/2024	12:56:29	923	0.304
	03/06/2024	12:56:30	556	0.304
	03/06/2024	12:56:31	669	0.302
Close	03/06/2024	12:56:48	321	0.302

E.3.3 Trends Graph and Real Time Power Data

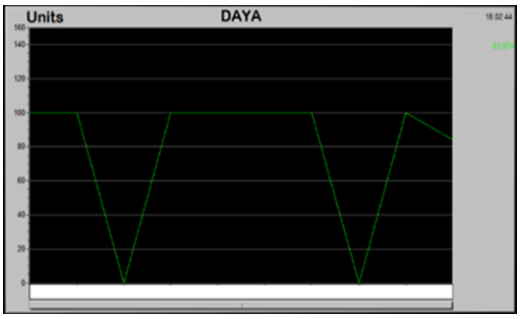

Figure 14. Graph Trend and Realtime Power Data

Table 3. Trend Data of Real Time Power Values Graph

Breaks	Date	Time	Millisecs	Power Data
Open	03/06/2024	12:56:23	833	13.9018
	03/06/2024	12:56:23	937	80,1977
	03/06/2024	12:56:24	46	100
	03/06/2024	12:56:24	454	100
	03/06/2024	12:56:25	54	65.5854
	03/06/2024	12:56:25	464	21.1307
	03/06/2024	12:56:26	181	15.9252
	03/06/2024	12:56:26	470	87.3185
	03/06/2024	12:56:26	878	91.0102
	03/06/2024	12:56:27	93	29.9351
	03/06/2024	12:56:27	295	27,819
	03/06/2024	12:56:27	807	100
	03/06/2024	12:56:28	212	72.2892
	03/06/2024	12:56:28	309	96.2311
	03/06/2024	12:56:29	722	86.9941
	03/06/2024	12:56:29	835	100
	03/06/2024	12:56:30	129	65.5854
	03/06/2024	12:56:30	249	100
Close	03/06/2024	12:56:48	321	100

E.3.4 Trends Real Time Temperature Charts and Data

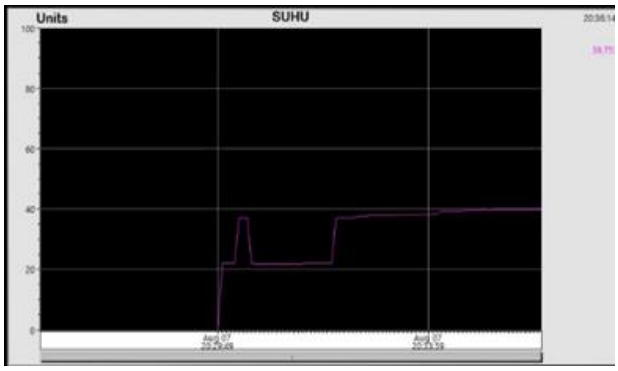

Figure 15. Graphic Trend and Realtime Temperature Data

Table 4. Trend Data of Real Time Temperature Value Graph

Breaks	Date	Time	Millisecs	Temp Data.
Open	03/06/2024	11:47:20	789	34,845
	03/06/2024	11:47:21	613	34,665
	03/06/2024	11:47:21	705	34,695
	03/06/2024	11:47:22	26	34,695
	03/06/2024	11:47:22	516	34,695
	03/06/2024	11:47:22	630	34,635
	03/06/2024	11:47:23	844	34.68
	03/06/2024	11:47:23	944	34,815
	03/06/2024	11:47:24	38	34.86
	03/06/2024	11:47:24	146	35.04
	03/06/2024	11:47:24	266	35.28
	03/06/2024	11:47:24	665	36.33
	03/06/2024	11:47:24	761	36,765
	03/06/2024	11:47:24	868	45
	03/06/2024	11:47:51	921	36,825
	03/06/2024	11:47:52	414	36,825
Close	03/06/2024	11:47:52	524	45

E.3.5 Trends Graph and Real Time Light Data

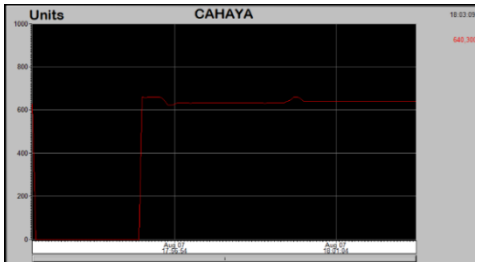

Figure 16. Trend Graphics and Realtime Light Data

Table 5. Trend Data of Real Time Light Value Graph

Breaks	Date	Time	Millisecs	Light Data
Open	03/06/2024	12:56:01	729	499.65
	03/06/2024	12:56:02	331	499.55
	03/06/2024	12:56:03	358	499.55
	03/06/2024	12:56:03	449	499.65
	03/06/2024	12:56:03	655	500.35
	03/06/2024	12:56:03	849	500.45
	03/06/2024	12:56:04	674	501.2
	03/06/2024	12:56:04	979	501.85
	03/06/2024	12:56:05	883	502.55
	03/06/2024	12:56:05	998	499.65
	03/06/2024	12:56:06	408	499.55
	03/06/2024	12:56:06	697	499.6
	03/06/2024	12:56:07	617	499.65
	03/06/2024	12:56:07	709	500.1
	03/06/2024	12:56:09	848	500.35
	03/06/2024	12:56:09	895	500.45
	03/06/2024	12:56:13	857	628.9
	03/06/2024	12:56:13	951	628.85
	03/06/2024	12:56:14	170	628.85
	03/06/2024	12:56:14	886	628.9
Close	03/06/2024	12:56:15	85	628.9

F. Load Usage Calculation Results

Calculation of load on the inverter output with load :

1. Load 1
   Lamp 7 Watts , Voltage = 220 V
2. Load 2
   Fan 70 Watts , Voltage = 220 V

Total Power of both loads 77 Watt

Completion :

I =P/V

I = 77/220=0.35 A

Table 6. Average Values of Real Time SCADA Data

	Voltage	Current	Power
Theoretical Value	220	0.35	77
Experimental average value	202.79	0.303	69.52

Calculating the Error Value

$$\frac{Nilai\ Teoritis - Nilai\ Rata - Rata\ Eksperimen}{Nilai\ Rata - Rata\ Eksperimen} \times 100\% = Persen\ Error$$

Voltage Error Value

$$\frac{220 - 202{,}79}{202{,}79} \times 100\% = \mathbf{0{,}084}\%$$

Current Error Value

$$\frac{0{,}35 - 0{,}303}{0{,}303} \times 100\% = \mathbf{0{,}155}\%$$

Power Error Value

$$\frac{77 - 69{,}52}{69{,}52} \times 100\% = \mathbf{0{,}107}\%$$

V. CONCLUSIONS

From the results of tests conducted with the application of SCADA on solar panels can monitor Voltage, Current, Power, Temperature, Light and load usage regulator Electric solar panels based on electrical energy consumption, as well as the condition of electrical equipment connected to the solar panel system . With an average error values: Voltage 0.084%, Current 0.155%, Power 0.107% and Temperature 45 0C and Light 658.7 Lux.

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