

Analysis of Voltage and Electric Current in a Web-based Solar Power Plant

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Abstract: Solar Power Plant utilizes solar energy into electricity. Important data generated from electrical energy can be in the form of voltage and current where measurements are made by a multimeter in which its measurement results cannot be done remotely and stored automatically. Therefore, it is necessary to design a tool that can measure voltage and current from electrical energy over long distances in which its value can be automatically stored in a database and displayed on the website. This system is built from GSM SIM800L as a data sender, Arduino Uno as a data processor, Voltage Sensor as a voltage sensor, and ACS712-30A as a current sensor. If the manual measurement is used as a reference, the level of accuracy of measurements on currents is 30%; while, if the automatic measurement as a reference is used, it is 45%. In addition, if the manual measurement is used as a reference in voltage measurements, the level of accuracy is 2%; while, if the automatic measurement is used as a reference, it is 2%. Which is the lower the level of accuracy, the better the value; on the contrary, the greater the level of accuracy, the worse the value?

1 INTRODUCTION

Solar Power Plant utilizes solar energy into electricity where this type of power plant will never run out; it is a power plant in which its main component is sunlight that can always be renewable (Reatti, Kazimierzuk, Catelani, & Ciani, 2017). In addition to solar power as the main component, of course, there are several other components used to support the conversion of solar energy into electrical energy. Some components commonly used include solar panels to capture solar energy and convert it to electrical energy, the battery as a storage place for electrical energy generated, the inverter is used to convert current from DC to AC, and several supporting cables for the installation of the Solar Power Plant components so that it can work well (Gurung et al., 2017).

When solar energy is converted to electrical energy, we can measure the electrical energy obtained through a multimeter (Unger et al., 2014). Usually, the main thing that is measured in electrical energy is the voltage and current generated. Because the electrical energy produced will run continuously to get data through the values that have been recorded from observations of the power plant. Important data that can be obtained include the amount of voltage

obtained and the current entering the battery or battery (Mehne & Nowak, 2018).

From this background, a device that can display data of voltage and current is made, the communication of which data can be done wirelessly, because so far the voltage and current measurements made using a multimeter are limited to the length of the multimeter cable that makes the measurements must be made on the area to be measured (Adhya, Saha, Das, Jana, & Saha, 2016). One of the options to replace it is using GPRS as its data communication. The advantage of the GPRS signal is its long-range distance with a note that as long as there is a GPRS signal in the area, then the data communication can still be done and can run well. Therefore, GPRS signals are used as data communication for devices that will be built using Arduino Uno. Arduino Uno functions to measure and retrieve data from electrical energy obtained from solar power plants, and the existing data is then sent by GSM SIM800L and will be automatically stored in an already available database. Furthermore, data that has been stored in a database can be displayed on the website, and the data can be seen at any time via the internet (Desima, Ramli, Ramdani, & Rahman, 2018).

2 METHODOLOGY

A series of block diagrams is one of the most important parts of the design of an instrument. From the block diagram, it can be seen the working principle of the whole circuit. So that the whole series of block diagrams will produce a system that can function as the working principle of the design of an instrument. The block diagram design can be seen in Figure 1.

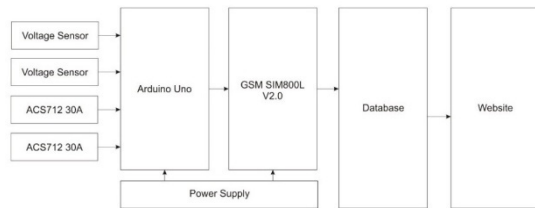


Figure 1: Block Diagram

- a. **Arduino Uno**
Used for the calculation process and pin-gathering place of the sensor, which will then be inserted a script that will be able to calculate the desired output value.
- b. **GSM SIM800L V2.0**
As a tool used to send data to databases on the internet.
- c. **Voltage Sensor**
As a tool used to obtain the value of the voltage of an electronic device that is powered by electricity.
- d. **ACS712-30A**
As a tool used to get the current value of a load.
- e. **Resistor**
It is an electronic component that has two pins and is designed to regulate electrical voltage and electric current. The resistor in the device to be built is used as a voltage divider that serves to reduce the voltage from the voltage source to be measured.
- f. **Breadboard/PCB**
Used to install components and connect electronic components with other electronic components.
- g. **Power Supply**
To convert AC into DC which is then converted into power or energy needed by the components
- h. **Cable**
Used to connect electronic components through pins on components.
- i. **Antenna**

An electrical device that can convert an electrical signal into electromagnetic waves and then emit it into free space or vice versa, namely capture electromagnetic waves from free space and convert it into electrical signals.

- j. **Laptop**
Used to add, delete, and edit program languages that are used to send program languages to Arduino devices.
- k. **USB Cable**
As a connecting device between Arduino and laptops.

Figure 2 shows a flowchart of research that has been done.

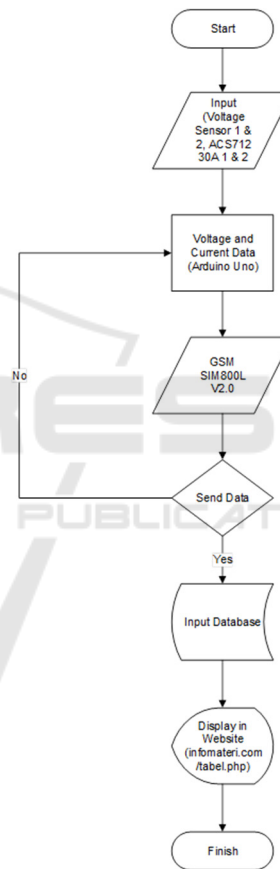


Figure 2: Research Flowchart

It is designing a device that can send the results of voltage and current measurements using a voltage sensor and an ACS712-30A sensor where the voltage and current values are sent to the database and displayed on the website. The data that has been obtained will be sent via GSM SIM800L V2.0 (Septiana, 2018). Sending the value obtained to the database uses the GPRS network that has been set on Arduino Uno will make the values occur continuously to the database. On the website page, there are several

columns namely the voltage column, the current column, the voltage usage column, the time column and the date column; where the last two columns are automatically created when the value is stored in the database (Moghimi, Bennett, Leskarac, Stegen, & Lu, 2016).

3 RESULT AND DISCUSSION

3.1 Instrument Design Result

The design of this tool uses a Voltage Sensor and ACS712-30A to get the measured voltage and current value, and the main component for data communication is the GSM SIM800L V2.0 module, which will be set to send the measurement results to the database (Turahyo, 2017). Figure 3 shows the design of a wireless data acquisition instrument.

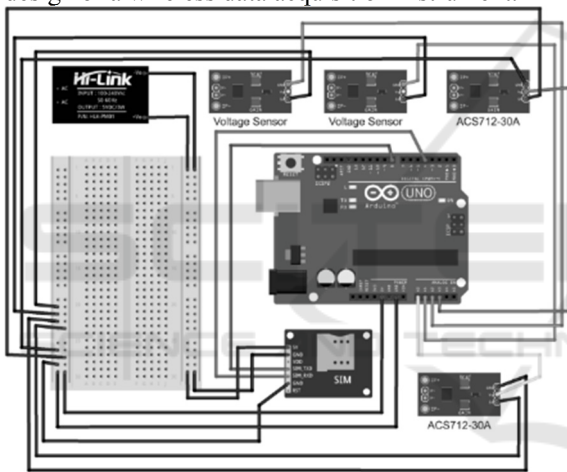


Figure 3: Design of a Wireless Data Acquisition Instrument

Figure 3 shows a power supply with a 5VDC voltage and 3A current to run the GSM SIM800L V2.0 module. On the voltage sensor, there are three pins, namely signal pins (S), plus pins (+) and minus pins (-). At the end of the voltage sensor, there are two wires to connect to the voltage source, which was measured. For the current sensor, ACS712-30A uses three pins on ACS712-30A, namely VCC pin, OUT pin and GND pin. At the other end, there are two wires connected to the load to measure the current. The voltage sensor and ACS712-30A are assembled on a breadboard that has been installed on the chassis.

Figure 4 shows an instrument that has been created from the results of the design. Almost all pins of the component are connected to Arduino Uno. Arduino Uno sends the processed data through pin four, which is received by GSM SIM800L V2.0. The

data that has been processed is sent to the database by GSM SIM 800L V2.0 through the GPRS network.

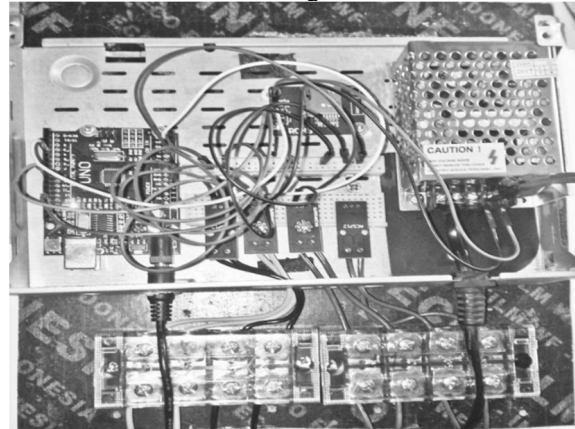


Figure 4: Instrument created from the research design

3.2 Results of Design in Database and Website

After the tool has been completed, as seen in Figure 4, the next step is to set the website to be used in this study. The first step is to open a browser on a laptop and then enter the database by filling in an existing username and password (Abidin, Jusoh, James, Al Junid, & Mohd Yassin, 2015). Select the database, then select the table that has been saved in the database. Figure 5 shows the names of the columns made in the table named table tb_tes in the database. In addition to the columns in the database, there is also a list of columns on the website that has been created and have been uploaded at <http://infomateri.com/tabel.php>, as shown in Figure 6.

#	Name	Type	Collation	Attributes	Null	Default	Comments	Extra	Action
1	id	int(11)			No	None		AUTO_INCREMENT	Change @ Drop ▾ More
2	tanggal	varchar(20)	latin1_swedish_ci		No	None			Change @ Drop ▾ More
3	waktu	varchar(20)	latin1_swedish_ci		No	None			Change @ Drop ▾ More
4	tegangan1	varchar(10)	latin1_swedish_ci		No	None			Change @ Drop ▾ More
5	tegangan2	varchar(10)	latin1_swedish_ci		No	None			Change @ Drop ▾ More
6	arus1	varchar(10)	latin1_swedish_ci		No	None			Change @ Drop ▾ More
7	arus2	varchar(10)	latin1_swedish_ci		No	None			Change @ Drop ▾ More
8	vbat	varchar(10)	latin1_swedish_ci		No	None			Change @ Drop ▾ More

Figure 5: Names of columns in the database



Figure 6: Column that has been made

After the database and tables on the website have been completed, the next step is to send the created program to Arduino Uno. Figure 7 shows the Arduino Uno source code that has been created to connect the Arduino Uno with the database.

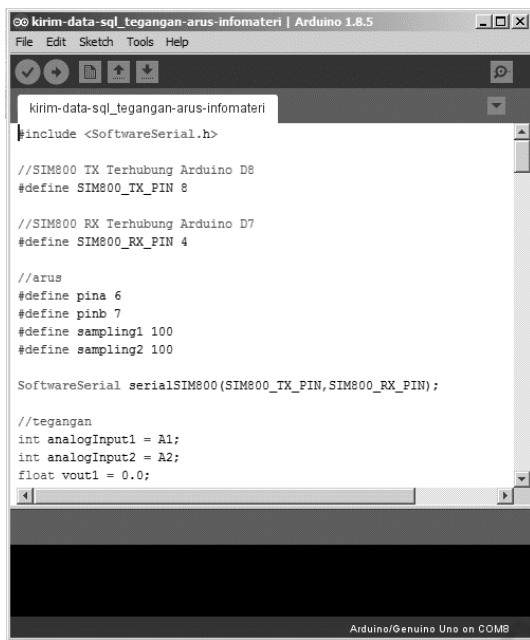


Figure 7: Source Code for Arduino Uno Connection to Database

When the program has been successfully sent to Arduino Uno, we can monitor the results of programs that have been made through the Serial Monitor in the Arduino IDE application. Besides, this application can also see the course of programs that we have made. Figure 8 shows the Serial Monitor results of a successful connection between Arduino Uno and the database.



Figure 8: Results of the Connection between Arduino Uno and the Database

The following is a detailed explanation of the source code in Figure 8.

- a. TIEM NON-REG Data Download Program
The title when the program is first to run
- b. Submit HTTP request - started
Program markers can run
- c. AT+CSQ
Check the signal quality of the provider of the SIM Card used
- d. AT+CFUN=1
Prepare the function of the module, which has value 1, where value 1 means "full functionality," and the power taken is the highest level.
- e. AT+CGATT=1
The command is used to attach or disconnect the device to the domain package service, where command 1 is to activate the attachment.
- f. AT+SAPBR=3,1,"CONTTYPE","GPRS"
As a bearer regulator for IP-based applications, where number 3 is the bearer parameter setting, and number 1 is the identification of the bearer's profile. "CONTTYPE" means a type of internet connection, and "GPRS" means the type of connection used.
- g. AT+CSTT="Telkomsel","wap","wap123"
To start setting APN, username, and password on the SIM Card that is used. Since the service used is Telkomsel, then the APN, username and password settings follow Telkomsel settings
- h. AT+SAPBR=1,1
Bearer settings, where the first 1 value to open the bearer and the second 1 value to connect the bearer.
- i. AT+HTTPIPINIT
To initialize or activate the HTTP service, this command must be used first before using the HTTP service
- j. AT+HTTTPARA="URL","http://infomateri.com/dataku.php?tegangan".
Set HTTP parameters and to regulate sending data to the URL address on the website
- k. AT+HTTPACTION=0
Delivering HTTP parameters that have been set up, where the value 0 gives a command with the POST Method, which means sending data or values directly to the action to be contained, without displaying the URL.
- l. AT+HTTPTERM
Terminate the HTTP service

When the program successfully runs and sends data, the table in the database will enter the data sent

from GSM SIM800L V2.0. Figure 9 shows data that has been successfully sent and stored in a database.

	id	tanggal	waktu	tegangan1	tegangan2	arus1	arus2	vbat
✖ Edit 📄 Copy 🗑 Delete	35	2019-05-07	14:41:15	8.99	5.23	0.41	-2.88	99
✖ Edit 📄 Copy 🗑 Delete	36	2019-05-07	14:41:39	9.01	5.20	0.42	-3.18	100
✖ Edit 📄 Copy 🗑 Delete	37	2019-05-07	14:42:03	8.99	5.23	0.41	-3.96	99
✖ Edit 📄 Copy 🗑 Delete	38	2019-05-08	12:02:30	0.00	5.20	0.41	-3.56	0
✖ Edit 📄 Copy 🗑 Delete	39	2019-05-08	12:02:53	0.00	5.20	0.39	-3.86	0
✖ Edit 📄 Copy 🗑 Delete	40	2019-05-08	12:03:17	0.00	5.23	0.40	-5.64	0
✖ Edit 📄 Copy 🗑 Delete	41	2019-05-08	12:03:42	0.12	5.23	0.37	-7.09	1
✖ Edit 📄 Copy 🗑 Delete	42	2019-05-08	12:04:06	9.06	5.20	0.37	-2.16	100
✖ Edit 📄 Copy 🗑 Delete	43	2019-05-08	12:04:30	9.06	5.23	0.37	-6.66	100
✖ Edit 📄 Copy 🗑 Delete	44	2019-05-08	12:04:55	9.09	5.18	0.38	-4.79	100
✖ Edit 📄 Copy 🗑 Delete	45	2019-05-08	12:05:18	9.06	5.18	0.38	-3.03	100
✖ Edit 📄 Copy 🗑 Delete	46	2019-05-10	10:22:08	9.14	5.40	0.34	-2.32	101
✖ Edit 📄 Copy 🗑 Delete	47	2019-05-10	10:22:32	9.09	5.38	0.34	-0.94	100
✖ Edit 📄 Copy 🗑 Delete	48	2019-05-10	10:23:04	9.11	5.40	0.34	-3.87	101

Figure 9: Data has been successfully sent to the database

When the data has been inputted to the database, the data on the website will be automatically updated. The data stored on the website can be seen at <http://infomateri.com/tabel.php>. Figure 10 shows the display of data on the website.

ID	Tanggal	Waktu	Teg. Batere (V)	Teg. Panel Surya (V)	Arus Batere (A)	Arus Panel Surya (A)	V Bat (%)
21	2019-05-06	12:59:54	10	13	10	10	10
20	2019-05-06	12:59:38	10	13	10	10	10
19	2019-05-06	12:59:06	10	13	10	10	10
18	2019-05-06	12:58:41	10	13	10	10	10
17	2019-05-06	12:58:18	10	13	10	10	10

Figure 10: Data display on the website

In Figure 10, the incoming data is in the form of Teg 1 (V) for voltage measurement 1, Teg 2 (V) for voltage measurement 2, Current 1 (A) for current measurement 1, Current 2 (A) for current measurement 2 and V Bat (%) for the percentage of battery conditions.

3.3 Measurement Tests on 9VDC Batteries

This test was done to compare the value displayed on the website with the value measured using a multimeter. This started with a 9VDC battery as a trial sample. The battery used is connected to a voltage sensor. The first thing to do is to measure the voltage value on the battery using a multimeter with the voltage measurement result obtained is 8.79VDC. Figure 11 shows the 9VDC Battery Voltage Measurement.

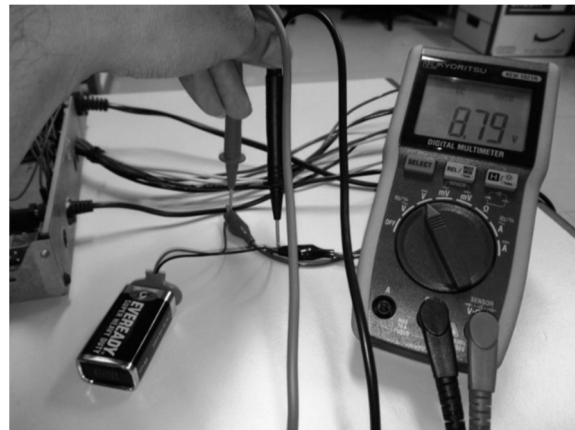


Figure 11: 9VDC Battery Voltage Measurement

After the measurement using a multimeter, the next step is to measure through a device that has been made. The trick is to connect the battery to the voltage sensor to calculate the voltage obtained. After all the tools are installed, it needs to wait for 1 minute, and the measurement results can be seen on the website on <http://infomateri.com/tabel.php>. Figure 12 shows a 9VDC battery data display.

ID	Tanggal	Waktu	Teg. Batere (V)	Teg. Panel Surya (V)	Arus Batere (A)	Arus Panel Surya (A)	V Bat (%)
83	2019-05-11	12:36:56	0.00	0.14	0.04	0	0
79	2019-05-11	12:36:34	0.02	0.14	0.05	0	0
79	2019-05-11	12:36:10	0.00	0.14	0.04	0	0
77	2019-05-11	12:35:46	0.00	0.13	0.05	0	0
76	2019-05-11	12:35:22	0.00	0.14	0.05	0	0
75	2019-05-11	12:34:57	0.02	0.14	0.04	0	0
74	2019-05-11	12:34:35	0.00	0.14	0.05	0	0
73	2019-05-11	12:34:09	0.00	0.13	0.04	0	0
72	2019-05-11	12:33:45	0.02	0.00	0.13	0.05	0
71	2019-05-10	19:27:20	0.00	0.12	0.09	0	0
70	2019-05-10	19:26:56	0.00	0.12	0.09	0	0
69	2019-05-10	19:26:32	0.00	0.12	0.09	0	0
68	2019-05-10	19:26:06	0.00	0.14	0.12	0.08	0
67	2019-05-10	19:25:44	0.00	0.12	0.12	0.08	0

Figure 12: 9VDC Battery Data Display

3.4 Voltage Divider

Because the voltage obtained from the solar panel is in the range of 28-40 VDC and the voltage sensor can only measure a maximum of 25 VDC, a voltage divider is made using a resistor to avoid the value entered into the voltage sensor exceeding 25 VDC. A voltage divider is a simple circuit that converts large voltages into smaller voltages. It functions to divide the input voltage into one or several output voltages needed by other components in the circuit. Using two or more resistors and input voltage, a simple voltage divider circuit can be made. Figure 13 shows an example of a voltage divider that has been made.

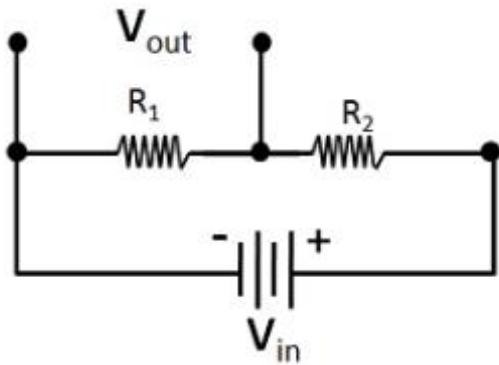


Figure 13: Voltage Divider

3.5 Deviation

In statistics and probabilities, the standard deviation is the most common measure of statistical distribution. In short, this method measures the values of scattered data so that the values that have been scattered can be seen whether close to the original or not. In this study, the standard deviation is used to see whether the values on the website are similar to those on the multimeter.

3.5.1 Battery Current without Solar Power Plant

Figure 14 shows the acquisition of battery current data without solar panels taken 12 times. Meanwhile, Figure 15 shows the display of battery current data without a solar power plant on the website.

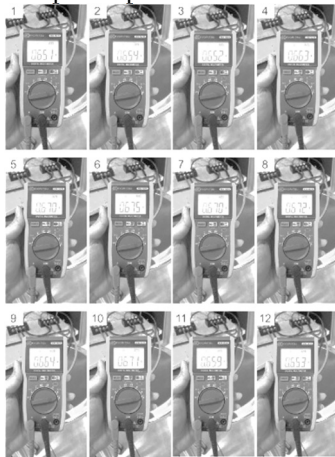


Figure 14: Battery Current Data Acquisition without Solar power plant

Table 1: Standard Deviation of Battery Current Data without Solar Panels

Sample	Seconds	Value (A)
1	0	0.651
2	2	0.654
3	4	0.652
4	6	0.663
5	8	0.670
6	10	0.675
7	12	0.670
8	14	0.672
9	16	0.664
10	18	0.671
11	20	0.659
12	22	0.653
Average		0.663
Standard Deviation		0.009

Panel Surya Teknik Instrumentasi Elektronika Migas Balikpapan

ID	Tanggal	Waktu	Teg Baterai (V)	Teg Panel Surya (V)	Arus Baterai (A)	Arus Panel Surya (A)	V Bat (%)
3540	2019-05-19	15:49:07	26.37	0.20	-1.37	-1.22	109
3547	2019-05-19	15:48:43	26.32	0.00	-1.38	-1.23	109
3546	2019-05-19	15:48:19	26.37	0.10	0.42	-1.11	109
3545	2019-05-19	15:47:54	26.22	0.05	0.45	-1.21	109
3544	2019-05-19	15:47:30	26.17	0.00	0.46	-1.21	109
3543	2019-05-19	15:47:06	25.93	0.05	0.49	-1.22	108
3542	2019-05-19	15:46:42	25.78	0.00	0.47	-1.21	107
3541	2019-05-19	15:46:18	25.83	0.05	0.45	-1.22	107
3540	2019-05-19	15:45:05	25.83	0.15	0.46	-1.22	107

Figure 15: Data Display of Battery Current without Solar power plant

It can be seen in Figures 14 and 15 that the difference from the average value and the results on the website is 0.19 A, and the deviation distance is plus or minus 0.009 from the average value that can be seen in Table 1. Therefore, the results of comparison with multimeters towards the measurements which are displayed on the web page are not within the standard deviation range.

3.5.2 Battery Current with Solar Power Plant

Figure 16 shows the acquisition of battery current data with solar panels taken 12 times. Meanwhile, Figure 17 shows the display of battery current data with the solar power plant on the website.



Figure 16: Battery Current Data Acquisition with Solar power plant

Table 2: Standard Deviation of Battery Current Data with Solar Panels

Sample	Seconds	Value (A)
1	0	-1.447
2	2	-1.398
3	4	-1.379
4	6	-1.411
5	8	-1.426
6	10	-1.431
7	12	-1.436
8	14	-1.411
9	16	-1.454
10	18	-1.430
11	20	-1.421
12	22	-1.409
Average		-1.421
Standard Deviation		0.021

Panel Surya Teknik Instrumentasi Elektronika Migas Balikpapan

ID	Tanggal	Waktu	Teg. Baterai (V)	Teg. Panel Surya (V)	Ara. Baterai (A)	Ara. Panel Surya (A)	V Bat (V)
3000	2019-05-19	15:41:31	28.66	0.05	-0.26	-1.25	110
3001	2019-05-19	15:41:55	28.61	0.05	-0.26	-1.25	110
3002	2019-05-19	15:42:19	28.56	0.05	-0.26	-1.25	110
3003	2019-05-19	15:42:43	0.00	0.00	-0.27	-1.30	8
3004	2019-05-19	15:43:07	0.00	0.00	-0.26	-1.22	8
3005	2019-05-19	15:43:31	28.56	0.00	-1.26	-1.14	110
3006	2019-05-19	15:43:55	28.51	0.10	-1.26	-1.21	110
3007	2019-05-19	15:44:19	28.76	0.06	-1.27	-1.21	110
3008	2019-05-19	15:44:43	28.76	0.06	-1.26	-1.21	110
3009	2019-05-19	15:45:07	28.66	0.10	-0.86	-1.21	110

Figure 17: Data Displays of Battery Current with Solar power plant

Figures 16 and 17 show that the difference from the average value and the results on the website is 0.17 A, and the deviation distance is plus or minus 0.021 from the average value that can be seen in Table 2. Therefore, the results of comparison with multimeters towards measurements which is displayed on the web page are not within the standard deviation range.

3.5.3 Battery Voltage with Solar power plant

Figure 18 shows the battery voltage data taken six times, while Figure 19 is a display of battery voltage data that is on the website.



Figure 18: Battery Voltage Data Acquisition with Solar power plant

Table 3: Standard Deviation of Battery Voltage Data with Solar Panels

Sample	Seconds	Value (A)
1	0	27.32
2	5	27.28
3	10	27.32
4	15	27.32
5	20	27.34
6	25	27.33
Average		27.32
Standard Deviation		0.02

Panel Surya Teknik Instrumentasi Elektronika Migas Balikpapan

ID	Tanggal	Waktu	Teg. Baterai (V)	Teg. Panel Surya (V)	Ara. Baterai (A)	Ara. Panel Surya (A)	V Bat (V)
3014	2019-05-19	16:55:14	49.95	0.80	-0.59	-1.22	200
3015	2019-05-19	16:55:38	28.81	0.85	-0.61	-1.16	110
3016	2019-05-19	16:56:02	28.81	0.85	-0.62	-1.22	110
3017	2019-05-19	16:56:26	28.86	0.80	-0.62	-1.15	110
3018	2019-05-19	16:56:50	28.76	0.80	-0.62	-1.24	110
3019	2019-05-19	16:57:14	28.76	0.80	-0.62	-1.24	110
3020	2019-05-19	16:57:38	28.76	0.85	-0.62	-1.25	110
3021	2019-05-19	16:58:02	28.71	0.85	-0.62	-1.24	110
3022	2019-05-19	16:58:26	28.61	0.85	-0.65	-1.25	110

Figure 19: Display Data Battery Voltage with Solar power plant

It can be seen in Figure 18 and 17 that the difference from the average value and the results on the website is 0.56VDC, while the standard deviation distance is plus or minus 0.02 from the average value that can be seen in Table 2. Therefore, the results of comparison with multimeters towards the

measurements which is displayed on the web page are not within the deviation range.

4 ANALYSIS

Comparison of data obtained on battery currents without solar panels, battery currents with solar panels and voltage on the battery against the multimeter has not shown the appropriate result, and there is a significant difference in value, where the constraints that occur due to the elaboration and definition of the programming language made are incorrect. Therefore, there are still differences in the value produced.

If the manual measurement is used as a reference, the level of accuracy of measurements on currents is 30%; while, if the automatic measurement is used as a reference, it is 45%. In voltage measurements, if the manual measurement is used as a reference, the level of accuracy is 2%; while, if the automatic measurement is used as a reference, it is 2%. In this case, the lower the level of accuracy, the better the value, while, if the greater the level of accuracy, the value is worse.

Manual and automatic data acquisition has advantages and disadvantages. The advantage of manual data acquisition is to be able to carry out measurements directly and be able to do physical checking on the tool and directly take action if there is damage on the tool; meanwhile, its disadvantages include that data recorded is easily damaged, and recorded errors can occur in data collection. The advantage of automatic data acquisition is that data can be used together; data security is guaranteed; data can be accessed anywhere via the internet and can analyze data faster. Meanwhile, its disadvantages are that it takes skilled personnel in managing data and measurement results that are not accurate when compared to measurements using a multimeter.

5 CONCLUSIONS

Voltage and current gauges can send data to databases through the internet and can be built using GSM SIM800L and GPRS as data communication. Data communication occurs during the measurement process in a simplex manner. The results of the current measurement with the multimeter measuring instrument can be said to be almost the same, the value that comes out is the result of the processing of the programming language that is made where the

output is very dependent on the translation and definition of the programming language. In current data without solar power plant case, if the manual measurement is used as a reference, the level of accuracy of measurements on currents is 30%, while if the automatic measurement as a reference is used, it is 45%. In current data with solar power plant case, if the manual measurement is used as a reference, the level of accuracy of measurements on currents is 12%, while if the automatic measurement as a reference is used, it is 13%. In voltage measurements, if the manual measurement is used as a reference, the level of accuracy is 2%; while, if the automatic measurement is used as a reference, it is 2%. In this case, the lower the level of accuracy, the better the value; while, the greater the level of accuracy, the value is worse.

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