

PV Smart Grid Monitoring System Based on Hybrid Telepot and Web Server

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ABSTRACT

Monitoring system in the smart grid is a key aspect that determines the reliability of transmission and communication systems in the power grid. The aim of this research is to conduct monitoring in smart grid easier and ubiquitous remotely. Measured electrical parameters in smart grid are monitored through Telegram social media and webservice internet-based wirelessly. The role of web service and telepot in the smart grid monitoring system are installed in Raspberry Pi 3 which responsible to receive and process data from sensor module on each nodes and saved in database. The MySQL database accommodates amounts of data containing information on the value of current, voltage, power and time stamp which deliver by sensor node. Web programming is designed using PHP to generate connection to the database and node sensor status that runs continuously. Processed data are conducted in telepot and it is converted in to *.csv file type before sent to the telegram user. The information were also shown in web site as well as in telegram over graph display form that utilize the Highcharts library. Graphs that shows information on voltage, current, and power values can be accessed through a browser using IP address from the Raspberry Pi 3 server. When the users request information to the server, they only need certain command through Telegram social media or open the web broser to access the information from the smart grid system.

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1. INTRODUCTION

Utilization of renewable energy resources can be conducted using smart grid to provide renewable energy in Indonesia utilizing solar energy converted [1]-[5] into electrical energy to improve the efficiency of electricity use and build a micro-scale generator system. Indonesia has abundant renewable energy, but its utilization is relative small. In addition solar cells implementation, to build micro-scale systems can also combine wind turbines. The solar cell module is combined with a wind turbine generator and each section or node consists of generator, storage, control, and load elements supported by converter or inverter [6]. Interconnected nodes are connected to build DC power buses and equipped with communication lines to transmit monitored data directly or using smart control devices applied [7]-[8]. The use of electric energy continues to increase every year. This is due to inefficient use of electrical energy, especially in the household sector. This is shown in the data of sales of the largest electricity energy in Indonesia in 2014 occurred in the household sector which amounted to 42.34% of the total electricity sales. The growing demand for electrical energy is not proportional to the availability of electrical energy in Indonesia. Therefore, it takes a solution by utilizing renewable energy using hybrid experimental approximation [9].

Smart grid is a computerized and automated power grid. In the smart grid, it allows two-way communication between users and energy providers. In addition, transfer of electrical energy that occurs not only from the manufacturer to the user, but also vice versa [10]. Smart grid is one solution that uses renewable electrical energy. The use of smart grid as a renewable energy source needs a way to monitor the smart grid of each node to find out whether the smart grid is installed properly or not. Real time monitoring and display of power system components and performance, along the connection and in large geographic areas, helps operators to understand and optimize the behavior and performance of smart grid system components [11]-[16]. Smart grid monitoring process can be accessed wirelessly by using internet, so electrical parameters value can be monitored remotely through social media. This system is designed using smart grid monitoring system internet-based and application of the IoT for the smart grid system[17]-[19].

The aim of this paper is to provide a technical overview of realizable techniques for monitoring and control of smart grids based on real time information, actions and monitoring for efficient, applied design and information access easier. These techniques are analyzed in detail and their effectiveness has been demonstrated with internet based via web service and telepot bot api. This system requires a server that role to receive and process data sensors installed on each node, so the data can be sent to the user through social media especially Telegram and through a web page. Smart grid monitoring via Telegram social media and the web employ a server run by Raspberry Pi 3 to make cheaper one. The data from the sensor module will be stored in the MySQL database through the PHP program and will be presented in graphical form through a website page. Meanwhile, the server in charge of receiving command from user and sending file (*.csv) via Telegram will be run by Python program. The file sent will contain all the information stored in the database. It is expected that this study will provide an improvement in the problems found in the design of smart grid monitoring systems that can be done remotely through Telegram's social media and websites.

2. RESEARCH METHOD

2.1. System Block Diagram

The wireless smart grid monitoring system active when the sensor module on each smart grid node receive the data of voltage and current values in which the data will be sent to the server via internet. The internet connection is used as a transfer media for smart grid monitoring data. By using the internet, monitoring process can be done remotely. in other hand, the server acts as a center to process data received from each sensor module on the smart grid. Processed data will be displayed on the website and can be accessed through social media telegram. Users can perform smart grid monitoring through social media Telegram by sending certain commands so the data received in accordance with the orders sent message. In general, the overall system design block diagram is shown in Figure 1.

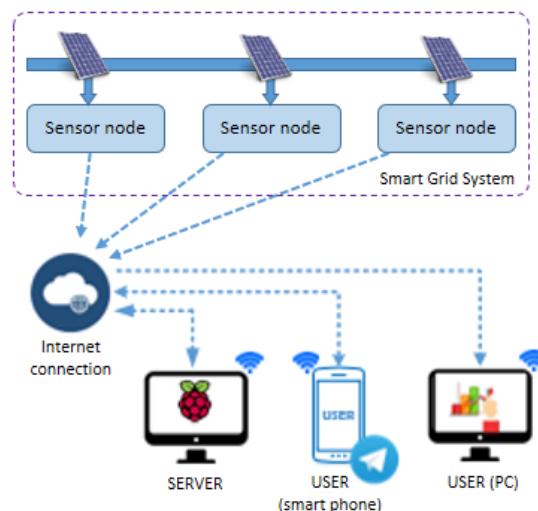


Figure 1. Block Diagram of Smart Grid Monitoring System

2.2. System Specification

Device specification consist of Raspberry Pi 3 which used as a server that receives and processes data readings of sensors. Monitoring system using social media Telegram and website are combined to access

the information. The process of sending data to social media Telegram is done by sending certain commands to the Python server. The bandwidth used is 15 Mbps of internet connection and the system send to the user (smartphone) in *.csv format by request automatically.

2.3. Software Design

The design of the software is used to control and manage the work of the tool as a whole. Server is designed by Python and Bot Api Telegram. Python software design works to run programs that are able to read the database, receive the command from the user, create a *.csv file, and send it to the user. The design of PHP software is used to receive data from the smart grid sensor module and put it into the MySQL database. In addition, the PHP program is used to create graphical views of data stored in the MySQL database. Data delivery process of each block is done wirelessly. The proposed smart grid monitoring system is used 3 sensor nodes and the data transmit wirelessly. Each node will transmit data of measured voltage, current, and power in the tables in the database that have been created. Smart grid monitoring is done through social media Telegram through Python program. Python will send files that can be opened with android applications such as Excel or WPS Office. Block diagram of transmitting data to MySQL database shown in Figure 2.

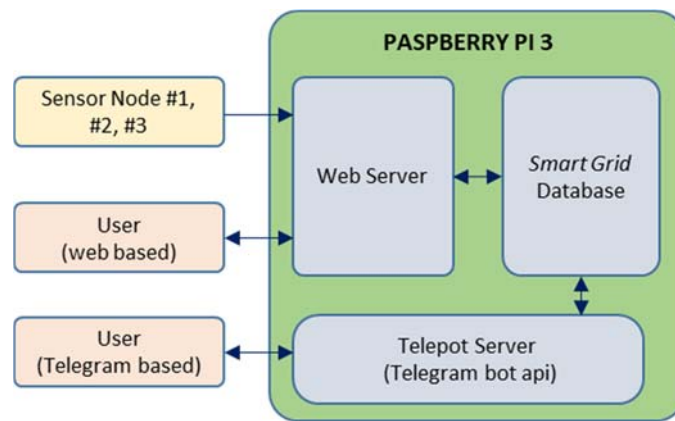


Figure 2. Block Diagram of data transmission from sensor nodes and users to the database

The database is created to hold all data of sensor readings on each node-1, node-2, node-3. The database for each node is constructed with a 5 column structure that will contain the information id, voltage, current, power, and time as shown in Table 1.

Table 1. Smart grid database table structure

Column name	Data Type	Extra	Primary Key
ID	Integer	Auto_Increment	√
Voltage	Decimal (5,2)	-	-
Current	Decimal (5,2)	-	-
Power	Decimal (5,2)	-	-
Time	Datetime	-	-

3. RESULTS AND ANALYSIS

3.1. Sensor Data Transmitting

The purpose of testing is to know the data received MySQL database is the same as that sent by the sensor module installed on the smart grid node. Transmitted data were constructed through PHP programming is shown in Table 2. The data delivery is sent by node-1 to the server directly. In this test, a packed of data was sent to the database that has been provided through the web by determining local IP address in Raspberry Pi 3.

Table 2. Data transmission sensor node 1 to the database

Data in Database		
V	I	P
0,3	0,42	0,12
1,7	0,4	0,68
3,29	0,42	1,37
4,9	0,43	2,11
6,3	0,5	3,13
7,95	0,62	4,89
9,41	0,74	7
10,99	0,89	9,82
12,51	1,05	13,17

3.2. Database Test

The purpose of testing is to determine the duration of data transmission from the smart grid sensor module to the MySQL database. Testing the speed of delivery is done by providing a delay (delay time) that varies on the sensor module to send data to the MySQL database. Delay given is 5 seconds, 8 seconds, 10 seconds, and 15 seconds. Obtained a stable delay is 10 seconds. Table 3 shows the most stable delay is 10 seconds with an average of 10.3 seconds.

Tabel 3 Kecepatan pengiriman data ke *database*

Delay (ms)	Time (H:M:S)	Delay at Database (s)	average Delay (s)
5000	15:59:23	-	10.5
	15:59:29	6	
	15:59:35	6	
	15:59:56	21	
	16:00:19	23	
	16:00:25	6	
	16:00:39	14	
	16:00:46	7	
	16:00:52	6	
	16:00:58	6	
8000	16:30:06	-	9.5
	16:30:16	10	
	16:30:25	9	
	16:30:35	10	
	16:30:45	10	
	16:30:54	9	
	16:31:04	10	
	16:31:13	9	
	16:31:23	10	
	16:31:32	9	
10000	16:05:57	-	10.3
	16:06:09	12	
	16:06:20	11	
	16:06:31	11	
	16:06:43	12	
	16:06:54	11	
	16:07:05	11	
	16:07:17	12	
	16:07:28	11	
	16:07:40	12	
15000	16:12:53	-	16.4
	16:13:10	17	
	16:13:26	16	
	16:13:42	16	
	16:13:59	17	
	16:14:15	16	
	16:14:31	16	
	16:14:48	17	
16:15:04	16		
16:15:21	17		

3.2. Graph Display

The purpose of this test is to determine whether the data presented on the graph in accordance with the data stored on the database. The test displays the graph shown in Figure 3. Based on Figure 3, we get the values of voltage, current, and power respectively of 2.24 V, 0.25 A, and 0.56 W. The values appear on the graph correspond to the values contained in the MySQL database. But the time shown is different from the time stored in the database.

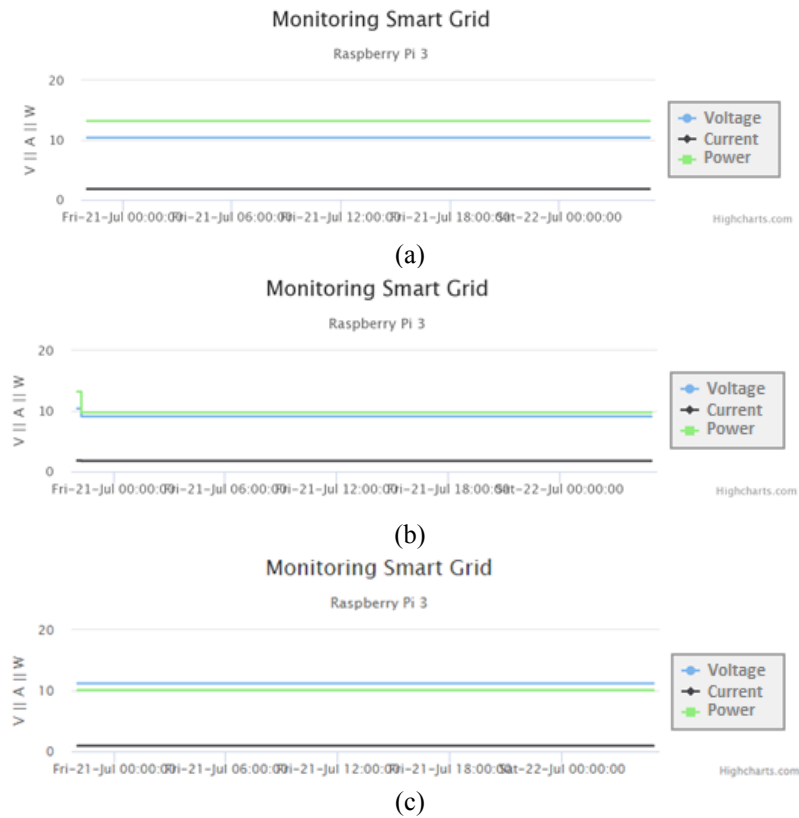


Figure 3. Monitoring graph of smart grid on website (a) node #1 (b). node #2 (c). node #3.

3.4. Command Testing

Testing the delivery of commands from social media Telegram is to determine whether the messages sent users through social media Telegram can be accepted by Python program. Testing is conducted by typing messages through social media Telegram and sending to the server run by Python program.

Table 4. Testing Result of Sent Command

Sent message	Received message	Respon Server Python
/start	/start	-
Tes	Tes	Test
Roll	Roll	Random value 1-100
Time	Time	Current time
Test	Test	-
Bot Telegram	Bot Telegram	-
Monitoring	Monitoring	-
Smart Grid	Smart Grid	-
Raspberry Pi 3	Raspberry Pi 3	-

Based on Table 4, it can be concluded that the process of sending messages from social media Telegram can run well. All messages can be received in accordance with the sent by the user is shown in Figure 4.

```

File Edit Shell Debug Options Windows Help
Python 2.7.9 (default, Sep 17 2016, 20:26:04)
[GCC 4.9.2] on linux2
Type "copyright", "credits" or "license()" for more information.
>>> ----- RESTART -----
>>>
>>> I am listening ...
>>> Got Command: /start
Got Command: Tes
Got Command: Roll
Got Command: Time
Got Command: Test
Got Command: Bot Telegram
Got Command: Monitoring
Got Command: Smart Grid
Got Command: Raspberry Pi 3
    
```

Figure 4. Python Shell Program Window

Messages sent by the user will get a response from the server if the message is defined in the Python program. If the message sent is not in the program definition then the server will not respond or reply.

3.5. Testing of Data

This test aims to determine whether the file (*.csv) can be sent by the server to the user or not. This test is performed with the user sending messages with a specific format that contains date and time information. So the Python program will execute the function to read the data in the database in accordance with the desired time range. The data transmission tests are shown in Figure 5.

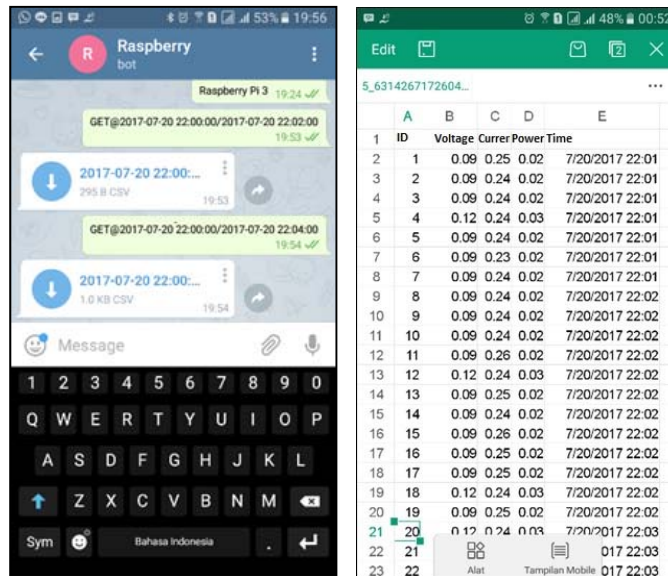


Figure 5. Telegram Message and File Delivery *.csv to User on Telegram

Database test aims to determine the capacity (size) of data stored in the database. Testing is observed by filling the database of 100 to 1000 lines containing the information values of voltage, current, power and time when the data is stored in the database. The memory size testing is shown in Table 5.

Table 5. Memory size on database

Row (Database)	Memory
100	16 KB
200	16 KB
300	16 KB
400	48 KB
500	48 KB
600	64 KB
700	64 KB
800	64 KB
900	64 KB
1000	64 KB

The overall test is performed to determine the performance of the system that has been designed.

Tests conducted include:

1. Deliver messages from the user to the server to send * .csv files. The result of sending message and files are shown if Table 6.

Table 6. Testing the sending of commands and files

Test No	Telegram Messages		File delivery	
	Sent	Not Sent	Sent	Not Sent
1	√	-	√	-
2	√	-	√	-
3	√	-	√	-
4	√	-	√	-
5	√	-	√	-
6	√	-	√	-
7	√	-	√	-
8	√	-	√	-
9	√	-	√	-
10	√	-	√	-
<i>Error</i>		0 %		0 %

2. Testing file size * .csv and long delivery time. The result of testing file zise and delivery time are shown in Table 7.

Table 7. File size * .csv and long delivery time

Row	Memory	Time (s)
100	3,8 KB	5.18
200	7,7 KB	7.24
300	11,7 KB	9.69
400	15,6 KB	11.36
500	19,5 KB	14.79
600	23,4 KB	17.01
700	27,3 KB	20.29
800	31,2 KB	23.69
900	35,1 KB	25.64
1000	39,0 KB	30.12

According to the Table 6, it is obtained the test results sending * .csv file to the user that the largest file size that is 39.0 KB with 30.12 seconds of delivery time. The transmitted file contains 1000 lines of smart grid sensor reading module data. As for the file containing 100 rows of data has a size of 3.8 KB and the required delivery time is 5.18 seconds. This is proportional to the amount of data read by the server and stored in the file. The result of sending * .csv file to user can be opened with android application such as MS Excel or WPS Office.

4. CONCLUSION

According to the design on PV smart grid monitoring system, all of the parts have been successfully implemented and characterized. The designed PHP program successfully receives data from the sensor module and stores it into the table of each node in the MySQL database. The time required by the sensor module to send data to the database wirelessly requires a 10 second with an average time of 10.3 seconds. MySQL database reading through Python program works well. The database read has 3 tables which each has 5 columns. Smart grid monitoring graphs successfully display data in accordance with the data stored in the database. The message delivery and file delivery *.csv are working with 100% success rate.

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