

Monitoring Current and Voltage in PLTS On-Grid System Based on Internet of Things (IoT) Using Telegram Application

Subuh Isnur Haryudo^{1*}, Edy Sulisty², Agus Wiyono³, P.W. Rusimanto⁴, Deni Wijayanto⁵

{Subuhisnur@unesa.ac.id¹, edysulisty@unesa.ac.id², aguswiyono@unesa.ac.id³,
puputwanarti@unesa.ac.id⁴, deni.18069@mhs.unesa.ac.id⁵}

Faculty of Engineering, Universitas Negeri Surabaya, Surabaya, Indonesia

Abstract. Utilization of solar energy through solar power plants is the right solution to reducing dependence on conventional energy consumption. The amount of electrical energy used can be controlled by mobile devices using the Internet of Things (IoT). The utilization of the Telegram application for monitoring the current and voltage of solar energy-based electrical energy is a new method. This study aims to develop an IoT-based PLTS current and voltage monitoring tool for the PLN On Grid system with the Telegram application. The source of voltage in this study comes from PLN and solar panels. The research method uses an experimental approach by collecting current and voltage data through direct test monitoring using a multimeter and the Telegram application. Telegram Bot is a social media application used to send commands to electrical loads and receive feedback in the form of current (A) and voltage (V) parameters. The test was carried out with a model without a load and with a load. The results of monitoring the current and voltage produced by PLTS based on Telegram data and measurements using a multimeter are not much different. The average percentage value of error between DC source measuring instruments is 0.02%, and that between AC sources is 0.114%. The development of IoT-based current and voltage monitoring is very effective because it can facilitate the monitoring of PV mini-grids.

Keywords: PLTS On Grid, Internet of Things, Telegram.

1 Introduction

The increase in population causes the need for energy to increase, especially the need for electrical energy. The increase in the need for electrical energy greatly affects the amount of energy available in Indonesia [1]. There are two types of energy used, namely conventional energy and new renewable energy (EBT). Conventional energy is energy that is very limited in availability and will run out if used continuously. In addition, the impact of environmental damage using conventional energy in the long term needs attention [2].

Solar Power Plant (PLTS) is the development of new and renewable energy into alternative energy that is environmentally friendly to meet the need for future electrical energy [3]. The use of PLTS as renewable electrical energy has the potential to be combined with other sources of electrical energy (on-grid systems) [4] [5]. However, checking whether the battery is fully charged or not is still done manually, so over-discharge often occurs because the output power of the inverter when on the grid will work at its maximum.

The development of the Internet of Things (IoT) in the current and voltage monitoring systems is getting wider so as to minimize over-discharge. The Internet of Things (IoT) is a development concept on the internet, where the physical system (hardware) in this case is a

microcontroller connected to the internet network [6]. The use of IoT can monitor remotely and will regulate the battery charging and discharging mechanism in the PLTS configuration so that the continuity of inverter operation can be maintained in supplying the load. From this description, it is necessary to monitor and control quickly and precisely, and it can be accessed from anywhere and anytime by utilizing the development of the internet network. One of the concepts of the Internet of Things (IoT) is Telegram [7]. Telegram is messaging software that focuses on security, speed, simplicity, and being free. The advantages of Telegram can also be used on many mobile devices at the same time. In addition, Telegram also provides a forum for developers who want to take advantage of the open API (application programming interface) and protocols provided through the development of the Telegram bot on the official website [8] and [9].

This study aims to develop a current and voltage monitoring system for PLTS performance using the IoT Telegram application. Monitoring is used for optimal monitoring of system work and detecting disturbances as quickly as possible in PLTS from a distance. Furthermore, monitoring the current and voltage in this study is to automatically regulate the charging and discharging mechanisms for the battery in the PLTS configuration so that the continuity of inverter operation can be maintained in supplying the load [10].

2 Research Method

This research is quantitative, with the research and development (R&D) method following the ADDIE model. The ADDIE model shows five stages in the research, namely: analysis, design, development, implementation, and evaluation. This system development model is easy to understand and has simple stages so that the system development procedure will become clearer at each stage.

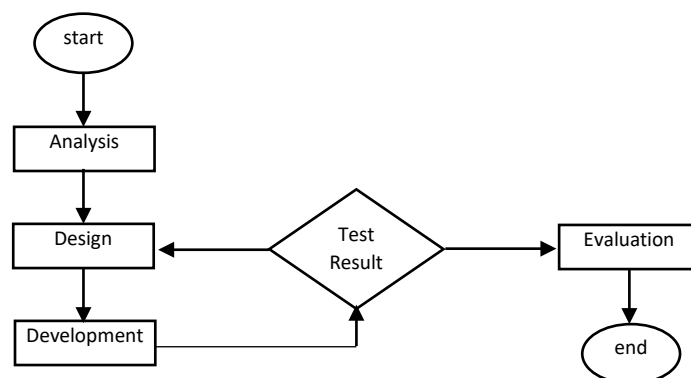


Figure 1. Research FlowChart

Figure 1 explains the research flow chart: data analysis is quantitative to determine the effectiveness and feasibility of the model empirically. The results of the analysis are used as the basis for the design of the tool and its continued development. The next stage of development is to design an IoT-based PLTS on-grid system equipped with a current and voltage monitoring unit based on the design results. Furthermore, testing and evaluating the results of the trial Equipment testing and data collection in this study were carried out at the

Electrical Power Transmission and Distribution Laboratory, A8.02.13 Building, and the rooftop of the A8 Unesa Building.

The functional block diagram of the system made in this research design [11] [12] in general can be seen in the following figure:

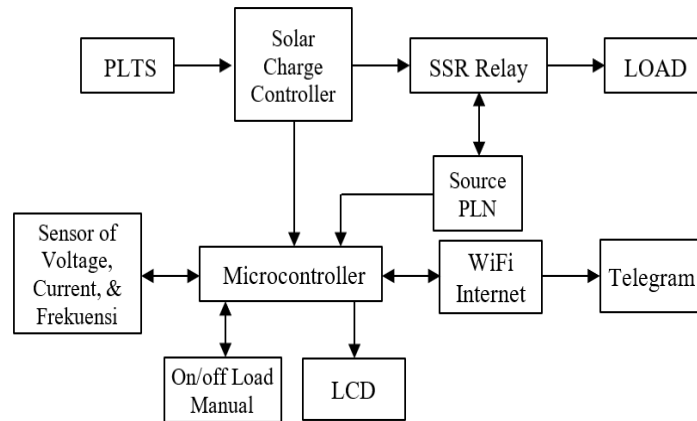


Figure 2. Voltage and Current Monitoring Functional System Diagram

In designing the tool, it is adjusted to the research objective, which is to make a series of current and voltage monitoring in PLTS on an IoT-based On Grid system with the Telegram application [13]. The design of the tool can be seen in Figure 3 as follows:

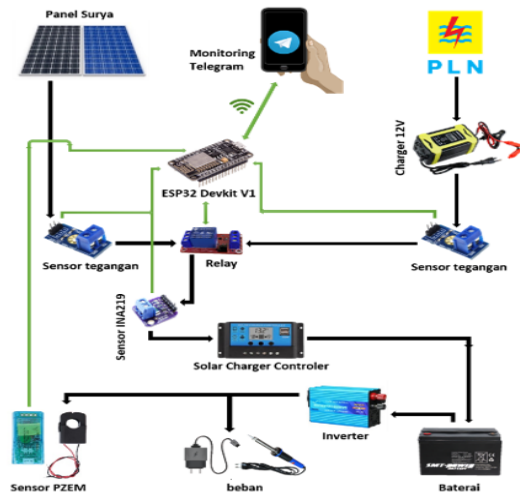


Figure 3. On-Grid PLTS System Installation Design

Figure 3 shows that there are two color lines: (1) the black line is the process of electricity flow from the source to the load, and (2) the green line is a process for monitoring current and voltage from sensor data retrieval to Telegram. The working principle of monitoring the ESP32 Microcontroller is that it and the Telegram application must be

connected via Wifi first before the data reading process from the sensor is carried out [11]. Data readings from the voltage sensor, the INA219 sensor connected to the battery, and the reading data from the PZEM-004T, which is located between the inverter and the socket, will be sent to the microcontroller. Data on the microcontroller in the form of analog data will be sent to the ESP32 network and converted into digital data [14]. The modified sensor reading data will be displayed on the Telegram application.

3 Results and Discussion

The results of the development of PLTS current and voltage monitoring equipment on the grid system using the Telegram application as shown in Figure 4.



Figure 4. On-grid based IoT PLTS circuit

Testing equipment in sunny and cloudy conditions, solar panels can absorb solar energy into electrical energy, and panel output has flowed towards SCC. Furthermore, from the SCC, the panel output will be stored in the battery and can be directly used with a DC load or flown to the inverter for AC loads. Table 1 shows the results of current and voltage testing on solar panels in bright conditions.

Table 1. Results of Current and Voltage Measurements in Sunny Conditions.

Time	Solar Cell							
	Monitoring		Manual		Deviation		Error (%)	
	V	A	V	A	V	A	V	A
10:30	14,8	0,96	14,5	0,95	0,2	0,01	1,4	1,05
11:30	15,0	0,94	14,9	0,93	0,1	0,01	0,6	1,07
12:30	14,8	0,92	14,7	0,91	0,1	0,01	0,6	1,09
01:30	14,7	0,91	14,5	0,89	0,1	0,02	0,6	2,24
02:30	15,0	0,91	14,8	0,88	0,1	0,03	0,6	7,85

Table 1 shows the current and voltage obtained from a solar cell of 20 WP in bright conditions. On manual measurements with a multimeter, an average voltage of 14.68V and a current of 0.912A were obtained, while on the sensor an average voltage of 14.86V and a current of 0.928A were obtained. The average percentage error between the multimeter and the sensor is 0.082% for voltage and 2.66% for current.

Table 2. Results of Current and Voltage Measurements in Cloudy Conditions.

Time	Solar Cell							
	Monitoring		Manual		Deviation		Error (%)	
	V	A	V	A	V	A	V	A
10:30	13,5	0,62	13,3	0,61	0,2	0,01	1,5	1,6
11:30	13,8	0,69	13,6	0,67	0,2	0,02	1,4	2,9
12:30	14,3	0,73	14,2	0,72	0,1	0,01	0,7	1,4
01:30	12,9	0,52	12,8	0,50	0,1	0,02	0,8	0,02
02:30	13,6	0,68	13,4	0,67	0,2	0,01	1,5	1,5

Next Table 2, the current and voltage obtained from the Solar Cell in cloudy conditions in manual measurements with a multimeter get an average voltage of 14.6V and a current of 0.874A while the sensor gets an average voltage of 14.82V and a current of 0.888A and the average percentage of error between the multimeter and the sensor is 1.18% for voltage and 1.4% for current.

Based on Tables 1 and 2, the results of data collection were carried out in different conditions (clear and cloudy) with an interval of 1 hour, and the PLTS equipment was still working to produce stable electrical energy. Furthermore, the load test was carried out, and the total current generated by the PV 20 WP was 1.2 A in the trials in this study. The loads used were a fan, a soldier, a cellphone charger, and a laptop charge. Loaded test results are shown in Table 3:

Table 3. Test Results of Loaded Inverter Output Current and Voltage

Time (minutes)	Output Inverter							
	Monitoring		Manual		Deviation		Error (%)	
	V	A	V	A	V	A	V	A
5	219,8	0,99	218,7	0,98	1,1	0,01	0,5	1,02
10	219,7	0,89	218,5	0,87	1,2	0,02	0,5	2,30
15	219,5	0,86	218,2	0,86	1,3	0,00	0,6	0,00
20	219,4	0,77	218,1	0,76	1,3	0,01	0,6	1,31
25	219,0	1,3	218,8	1,4	0,2	0,1	0,01	7,1

It can be seen from Table 3 that the current and voltage issued by the inverter under load conditions based on manual measurements with a multi meter get an average voltage of 218.26V and a current of 0.97A, while the sensor gets an average voltage of 219.48V and a current of 0.96A, and the average percentage of error between the multi meter and the sensor is 0.44% for voltage and 2.32% for current. Load testing is carried out in stages with a time-change duration of 5 minutes. When the overload reaches the 5th minute, the relay works to switch the voltage source to the main grid (PLN). The control of the voltage source by the SSR relay automatically works well and has a delay of 2.5 seconds.

Furthermore, after testing the Telegram application, Figure 5 shows the results of the current and voltage monitoring operation using the Telegram application. The appearance of the Telegram application when monitoring the current, voltage, and output power of PLTS is as follows:



Figure 5. Telegram Application Display

This test aims to determine whether sending notifications in the form of Telegram messages has gone well or not. To start monitoring, we send the command "start." After that, the telegram bot gives the options: (1) /voltage_panel_surya (to see the voltage of the solar panel), (2) /condition_source (to see the current source condition along with the resulting current and voltage), and (3) /load_ac (to see the current and voltage of the inverter output ac). This test is carried out by setting the conditions for sending notifications to the event feature on the Telegram platform. Telegram messages will be sent with the PLTS operating conditions in real-time through the Telegram application by paying attention to the internet network connection.

4 Conclusions

Based on the development of current and voltage monitoring tools, it can be concluded:

- 1) The development of current and voltage monitoring tools in IoT-based PLTS On-Grid systems can function according to the purpose of making it easier and more effective in monitoring current and voltage in real-time. The results of current, voltage, and output readings from the inverter that are read by the sensor based on Telegram data and measurements using a multi meter are not much different. The average percentage value of the error test results when loaded between the multi meter and the sensor is 0.44% for voltage and 2.32% for current.
- 2) In addition to monitoring, the Solid State Relay (SSR relay) equipment works well in disconnecting and connecting (breaker control) the voltage source from the PLTS to the main grid voltage source (PLN) with a delay of fewer than 3 seconds depending on the internet connection. Equipment can provide notifications in the form of Telegram messages when PLTS is off or when the tool loses an Internet connection.

References

- [1] Ahmad, T., & Dongdong, Z. (2020). *A critical review of comparative global historical energy consumption and future demand: The story told so far*, Energy Reports, Volume 6, 2020, Pages 1973-1991, ISSN 2352-4847. <https://doi.org/10.1016/j.egyr.2020.07.020>
- [2] Zhang, H., Jiale, Z., Xiao, Z., Qijia, S., Daolin, X., Ze S., Ye, L., & Bo, W. (2021). *Robust performance improvement of a raft-type wave energy converter using a nonlinear stiffness mechanism*, International Journal of Mechanical Sciences, Volume 211, 2021, 106776, ISSN 0020-7403. <https://doi.org/10.1016/j.ijmecsci.2021.106776>
- [3] Al-Shetwi, A. Q. (2022). *Sustainable development of renewable energy integrated power sector: Trends, environmental impacts, and recent challenges*, Science of The Total Environment, Volume 822, 2022, 153645, ISSN 0048-9697. <https://doi.org/10.1016/j.scitotenv.2022.153645>
- [4] Gielen, D., Francisco, B., Deger, S., Morgan, D. B., Nicholas, W., & Ricardo, G. (2019). *The role of renewable energy in the global energy transformation*, Energy Strategy Reviews, Volume 24, 2019, Pages 38-50, ISSN 2211-467X. <https://doi.org/10.1016/j.esr.2019.01.006>
- [5] Liu, Z., Boqian, L., Xiaoyin, D., & Fei, W. (2022). *Research on optimization of energy storage regulation model considering wind-solar and multi-energy complementary intermittent energy interconnection*, Energy Reports, Volume 8, Supplement 7, 2022, Pages 490-501, ISSN 2352-4847. <https://doi.org/10.1016/j.egyr.2022.05.062>
- [6] Guevara, N. E., Bolaños, Y. H., Diago, J. P., & Segura, J. M. (2022). *Development of a low-cost IoT system based on LoRaWAN for monitoring variables related to electrical energy consumption in low voltage networks*, HardwareX, Volume 12, 2022, e00330, ISSN 2468-0672. <https://doi.org/10.1016/j.ohx.2022.e00330>
- [7] Atzori, Luigi., Iera, Antonio., Morabito, Giacomo. (2019). *The Internet of Things: A survey*, Computer Networks, Volume 54, Issue 15, 2019, Pages 2787-2805, ISSN 1389-1286, <https://doi.org/10.1016/j.comnet.2010.05.010>
- [8] Rachman, F.Z (2015). *Prototype development of monitoring system in patient infusion with wireless sensor network*, IEEE, 329-402
- [9] Botero-Valencia, J. S., Mejia-Herrera, M., & Pearce, J. M. (2022). *Low cost climate station for smart agriculture applications with photovoltaic energy and wireless communication*, HardwareX, Volume 11, 2022, e00296, ISSN 2468-0672. <https://doi.org/10.1016/j.ohx.2022.e00296>
- [10] Gurung, A., & Qiao, Q. (2019). *Solar Charging Batteries: Advances, Challenges, and Opportunities*, Joule, Volume 2, Issue 7, 2019, Pages 1217-1230, ISSN 2542-4351. <https://doi.org/10.1016/j.joule.2018.04.006>
- [11] Yang, X., & Xuan P. (2022). *15 - Hybrid system for powering unmanned aerial vehicles: Demonstration and study cases*, Editor(s): Massimiliano Lo Faro, Orazio Barbera, Giosué Giacoppo, In Hybrid Energy Systems, Hybrid Technologies for Power Generation, Academic Press, 2022, Pages 439-473, ISBN 9780128237939. <https://doi.org/10.1016/B978-0-12-823793-9.00014-0>
- [12] Amrouche, S. O., Belhamel, M., Malek, A., & Maafi, A. (2019). *DC/AC Solar inverter for solar applications*. In World Renewable Energy Congress VI (pp. 821-824). Pergamon, 2019, Pages 821-824, ISBN 9780080438658. <https://doi.org/10.1016/B978-008043865-8/50164-1>
- [13] Han, Z., Jun, H., Licheng, L., & Jinliang, H., (2022). *Micro-cantilever electric field sensor driven by electrostatic force*, Engineering, 2022, ISSN 2095-8099. <https://doi.org/10.1016/j.eng.2022.06.017>

- [14] LokeshReddy, M., Kumar, P. P., Chandra, S. A. M., Babu, T. S., & Rajasekar, N. (2017). *Comparative study on charge controller techniques for solar PV system*. Energy Procedia, 117, 1070-1077, ISSN 1876-6102. <https://doi.org/10.1016/j.egypro.2017.05.230>