ISSN (Print) : 2337-9030 ISSN (Online) : 2685-9030
PILLAR OF PHYSICS
Vol. 16 (1), 2022, page. 73-82
DOI : 10.24036/13584171074

MAXIMUM POWER POINT TRACKING SOLAR CHARGE CONTROLLER BASED ON INTERNET OF THINGS WITH SMARTPHONE DISPLAY

Muhammad Ajriy Ushalli[1], Yulkifli[1], Mairizwan[1*], Rio Anshari[1]

[1] *Department of Physics, Universitas Negeri Padang, Jl. Prof. Dr. Hamka Air Tawar Padang 25131, Indonesia*
Corresponding author. Email: mairizwan@fmipa.unp.ac.id

ABSTRACT

Electrical energy is a very important thing in life, but the main source at this time is still using limited materials. The solution to this problem requires renewable energy as an alternative source. This research discusses solutions with the use of solar cells. Harvesting of solar cell power is carried out using a Maximum Power Point Tracking (MPPT) based on Internet of Things (IoT). This research is classified as development research. The purpose of this research is the performance specification and design specifications. The data obtained in this study are comparisons of MPPT data and not using MPPT, and also accuracy and precision data of the instrument. Data collection was carried out on August 7, 2022 at 10.00 WIB - 16.00 WIB. In the study, it was found that the power harvested using the MPPT system was much better than without using the MPPT system. The system performance specifications are built with various electronic components and microcontrollers, all components are included in a box measuring 20cm x 15cm x 9cm. design specifications obtained an good data with MPPT based on IoT. The value of accuracy instrument is obtained 93,87% and the precision value of the instrument is obtained 94,944%. And also obtained good data transfer capabilities from the instrument, so that data transfer can be done continuously. with the method used, the research went well and in line with expectations.

Keywords : Solar Charge Controller, Maximum Power Point Tracking, Internet of Things

I. INTRODUCTION

Energy is something that is needed to support everyday human life. Indonesia still uses electrical energy produced by the Perusahaan Listrik Negara (PLN). The electrical energy mostly uses non-renewable fossil energy [1]. Of course, fossil energy supplies are running low, so alternative energy is needed as a renewable energy source in Indonesia. Alternative energy or renewable energy is a process of capturing energy from nature, converting it in the form of electricity and then storing it [2]. As an alternative energy in this research discussed the use of solar cells. Solar cells are semiconductor devices that have the extension of the ability to convert the available energy, both scattered and concentrated solar radiation, into direct current (DC) electricity [3]. The ability to harvest power from solar cells which is still relatively low requires an instrument that is able to track the maximum power point in order to obtain maximum power when harvested. The process of controlling the flow of charge from the solar panel to the battery is also called the solar charge controller (SCC) [4]. While the instrument used to track the maximum power point of solar cells is called Maximum Power Point Tracking [5].

The Maximum Power Point Tracking system is a series of electronic devices that can vary the operating point of solar cells [5]. MPPT is not a mechanical tracking system that physically moves solar cells to point directly at the sun. MPPT is an electronic system that completely varies the electronic operating point of the solar cell module so that it can send the maximum available power [6]. The weakness of the current MPPT is its data access which requires observations to be made directly on the tool. This will make it difficult to monitor the work of the instrument, so a solution is needed. In this research, MPPT is added with the Internet of Things capability so that data access can be done anywhere and anytime as long as it is still connected to the internet.

IoT refers to the connection of everyday objects with the internet equipped with artificial intelligence. IoT increases the usability of the internet by integrating each object to interact through an embedded system, which will connect objects using a network of devices so that they can communicate with humans and other devices [7]. Internet of Things is not a theory, it is an application of technology that can benefit human life [8]. The Internet of Things allows users to manage and optimize electronics by leveraging the internet. The sensor collects raw data in real time and converts it into an understandable machine language so that it will be easily exchanged between various forms of data formats [9]. The microcontroller used as a means of data transfer with the internet is the NodeMCU ESP8266 board. This board consists of ESP8266 which is a Wifi chip with a complete TCP/IP protocol stack. NodeMCU combines the ESP8266 into a compact board with various features such as a microcontroller and the ability to access Wifi as well as a USB to serial communication chip. So to program it, you only need a USB data cable extension, which is exactly the one used for charging the smartphone [10].

The means used to transfer data to smartphones from the MPPT system are through thingspeak and App Inventor. Thingspeak is an open source platform and API for the Internet of Things that allows you to collect, store, analyze, visualize, and act on data from sensors or actuators of an internet-based cloud application [11]. While App Inventor is a tool used to create android applications, the nice thing about this tool is that it is based on visual block programming [12]. Thingspeak acts as a storage cloud, and App Inventor as an application embedded in the smartphone. The development of IoT is mostly carried out in the agricultural, livestock, smarthome, and automotive sectors. Arafat's research on 2016 discusses door security based on IoT [13]. And in Iqbal's research on 2019 discusses the temperature and humidity measurement system using the SHT75 sensor with a smartphone display for weather monitoring based on IoT [14]. This proves that the potential for utilizing internet connectivity can continue to be developed so as to produce many benefits in various fields.

This research aims to determine the performance specifications and design specifications of the resulting tool. Performance specifications are detailed descriptions of the materials or components that make up the system and identify the functions of each component forming the system. Design specifications are metric values that must be achieved by a product and how the product should work [15]. So that in this study the performance specification is about the description of the components that make up the tool, while the design specification discusses the ability of the tool to harvest solar cell power and also the ability to transfer data from the device to a smartphone.

II. METHOD

This research is classified into development research. Research and development is a process or method used to validate and develop products. Validating the product means that the product already exists and the researcher only tests the effectiveness or validity of the product. Developing products in a broad sense can be in the form of updating existing products so that they become more practical, effective, and efficient or creating new products [16]. In development research there are steps that must be implemented. The steps in development research include: potential and problems, data collection, product design, design validation, design revision, product testing, product revision, usage testing, product revision.

Data collection techniques in this research were carried out by measuring the physical quantities contained in the system. Starting from the voltage, current, and power from solar cells. To prove the MPPT's ability to harvest solar cell power, it can be seen by comparing the data with the buck converter which is set in one resistance value. Before the comparison data with the buck converter is taken, it is necessary to test the accuracy and precision of the tool first. The accuracy and precision of the tool is done by comparing the data obtained by the tool and the data read by the multimeter.

The building components of the MPPT based on IoT system are arranged geometrically according to their respective functions. The block diagram of an MPPT based on IoT transmitter system with a smartphone display can be seen in Figure 1.

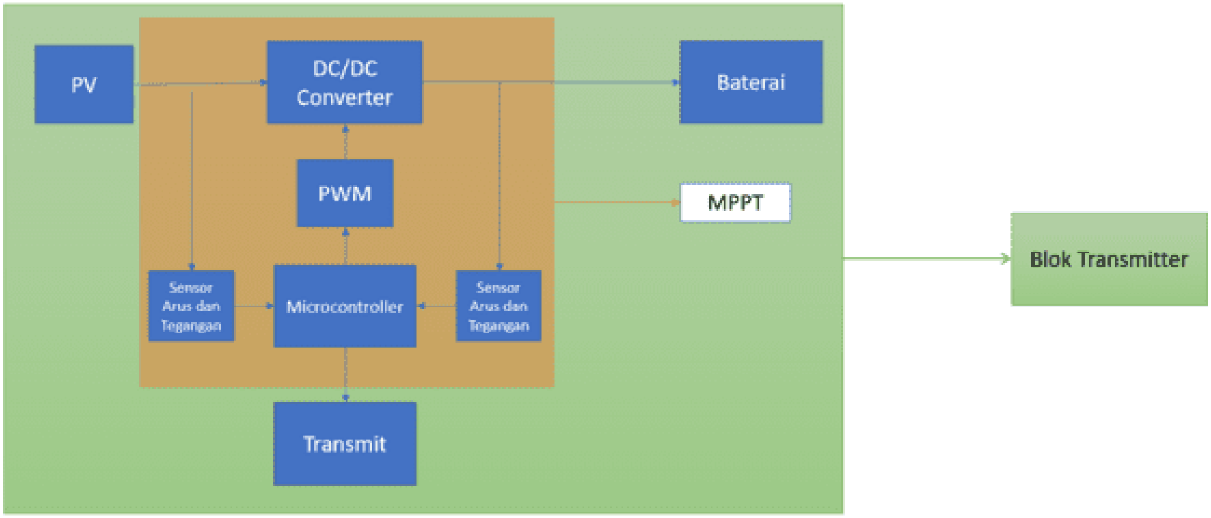

Fig. 1. Block Diagram Transmitter MPPT Based on IoT

Based on Figure 1, it can be seen that the components of the MPPT system builder. Starting from current and voltage sensors, PWM microcontrollers, and DC/DC converters. There are two microcontrollers used in this study, first is Arduino pro mini as MPPT controller and second is NodeMCU ESP8266 as data transmitter. This is done so that system programs do not interfere with each other. The MPPT programming block diagram on Arduino can be seen in Figure 2.

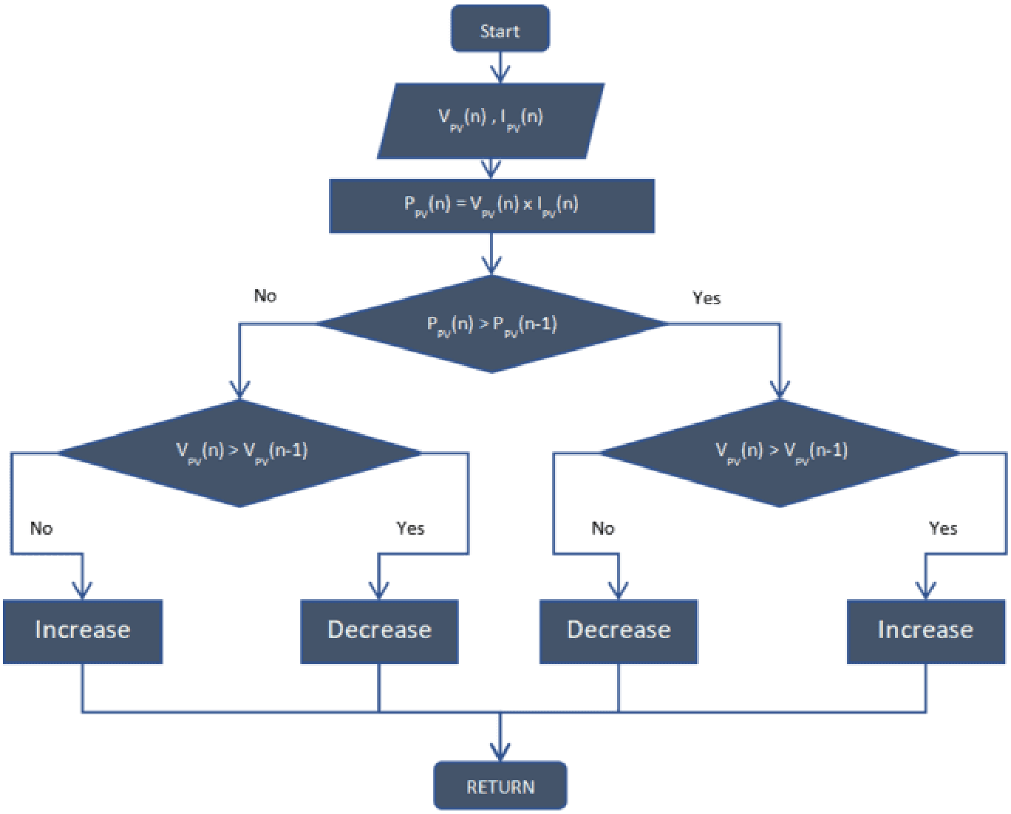

Fig. 2. Block diagram MPPT

In Figure 2, can see the procedure for setting the power from low to staying at the peak power position. This cannot be separated from the current and voltage sensor reading system. After reading the sensor, the PWM will act as a modifier of the reference voltage value of the DC/DC converter. The block of receive data can be seen in Figure 3.

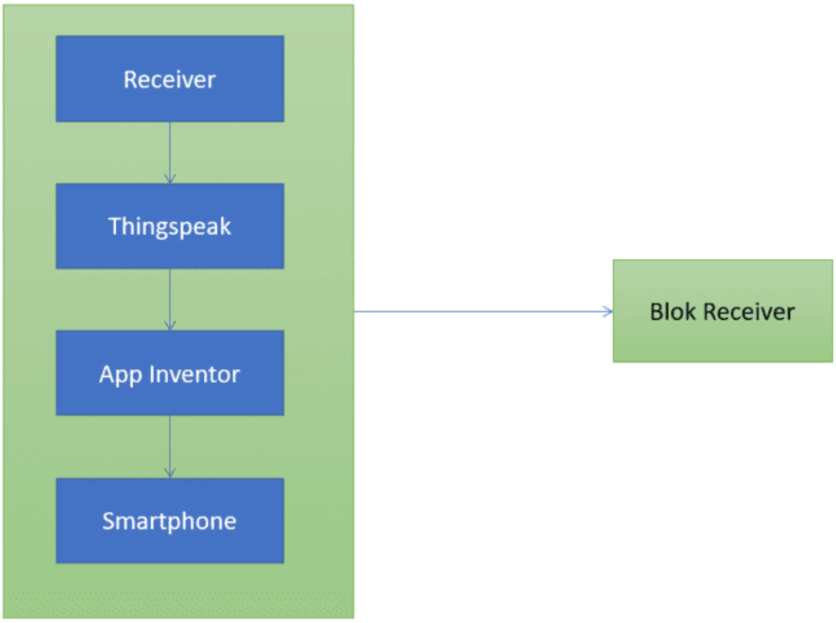

Fig. 3. Block diagram receiver MPPT based on IoT

Based on Figure 3, it can be seen the flow of data transfer from the previous transmitter block. Starting from receiving data by Thingspeak, then forwarded to App Inventor, so that it can be seen on the smartphone screen.

III. RESULTS AND DISCUSSION

Based on the definition of the previous performance specification, it can be said that this performance specification contains a description of the instrument. Through the transmitter block diagram, a series of MPPT based on IoT system builders can be formed. The system circuit can be seen in Figure 4.

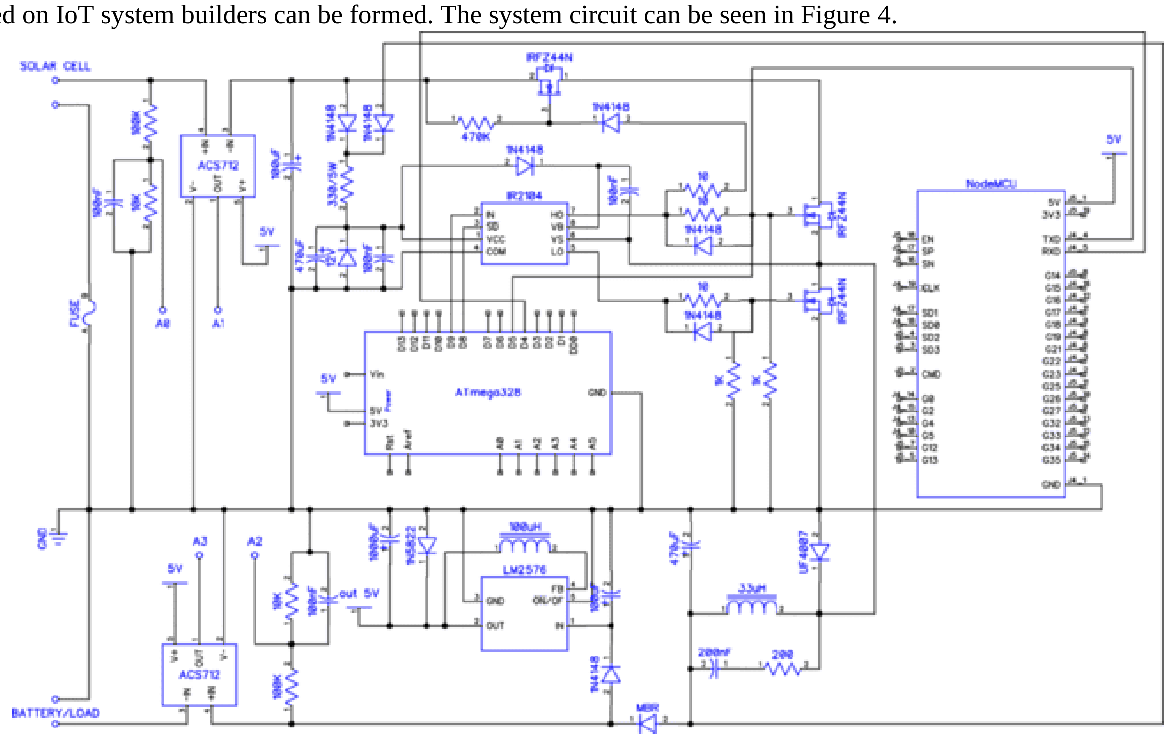

Fig. 4. MPPT based on IoT system circuit design

Based on Figure 4, you can see a circuit of MPPT based on IoT system builders. Starting from the basic components of electronics to the microcontroller used. Based on the design of the system circuit, a complete system circuit is made which can be seen in Figure 5.

In Figure 5, you can see the MPPT based on IoT instrument. LCD is used as a means to directly view the output data from the solar cells used. NodeMCU is used as a means of transferring data from the instrument to the smartphone via the internet. The solar cell port is where the solar cell output cable is connected and the battery port is where the battery is connected to the MPPT based on instrument system. And all these components are arranged in a box measuring 20cm x 15cm x 9cm. As for the results of the application design on smartphones, it can be seen in Figure 6.

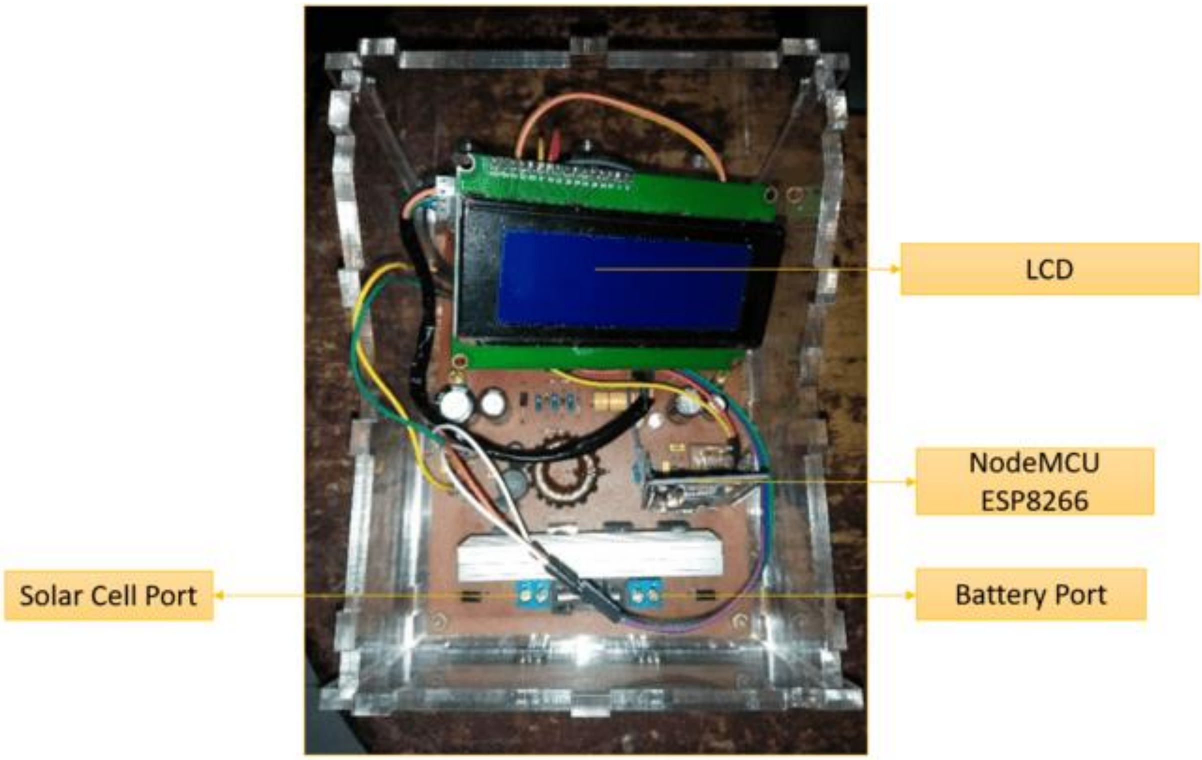

Fig. 5. MPPT based on IoT instrument

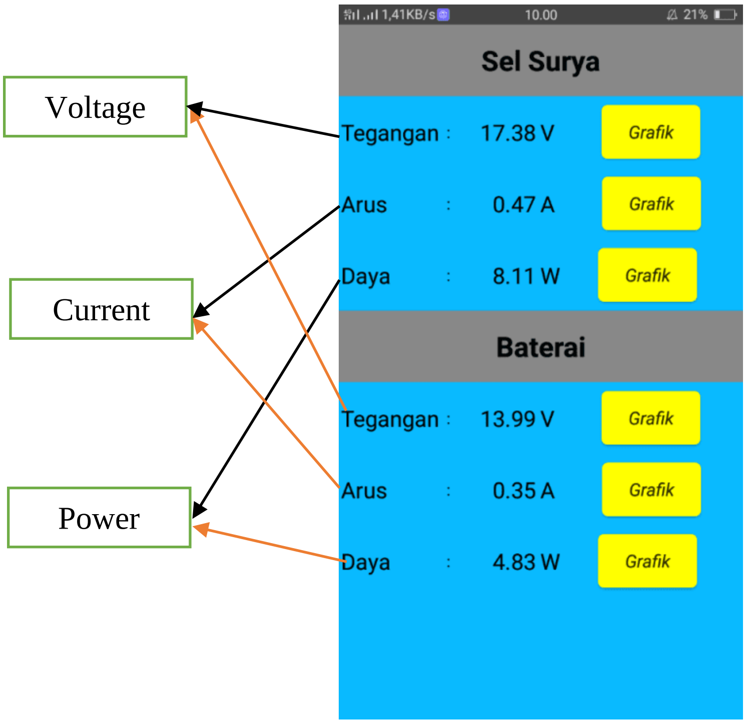

Fig. 6. Aplication display on smartphone

And if you want to see a graph, the default graph from the Thingspeak application will appear as can be seen in Figure 7.

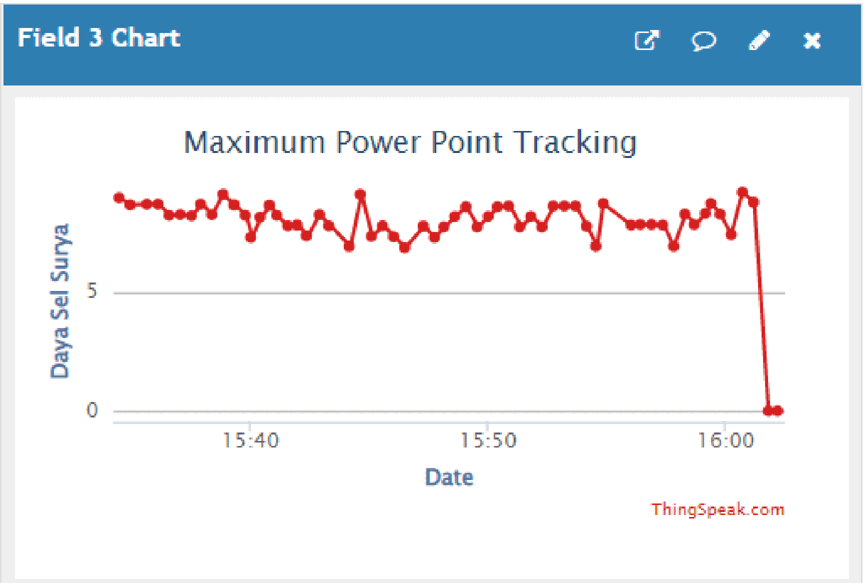

Fig. 7. Graphics display on Thingspeak

The design specification discusses the capability data of the instrument, starting from the comparison of the tool's capability data with a buck converter with a fixed resistance value. And also the value of the accuracy and precision of the tool as an indicator of the correctness of the work of the instrument. In this research, solar cells with specifications as can be seen in Table 1.

Table 1. Solar cell Specification

Customer code:	20-921
PM	20W
VOC	21.6V
ISC	1.3A
VMP	17.2V
IMP	1.17A
Max system voltage	1000V
size	639*294*23mm
TEST CONDITION	AM1.5 1000W/m^{2}25^{o}C

Based on table 1, it can be seen that the maximum power harvesting capacity of solar cells is 20 watts in adjusted conditions. In this research, the buck converter has been set with an output of 15V. this is because the value of the battery voltage that can reach 14V. After the data collection process is complete, data on the capability of the MPPT based on IoT system is obtained as can be seen in table 2.

Table 2. Results data using MPPT System and fixed resistance

Time	**MPPT**	**Fix Resistance**
	P (W)	P (W)
10.00	10,62	6,54
10.30	9,48	5,29
11.00	10,75	6,14
11.30	11,02	6,72
12.00	9,34	5,49
12.30	10,82	6,95
13.00	9,94	7,06
13.30	10,11	6,07
14.00	9,12	7,25
14.30	5,57	4,20
15.00	9,55	6,95
15.30	10,06	7,69
16.00	9,27	6,45

If it is presented in an x-y graph, it can be seen in Figure 8.

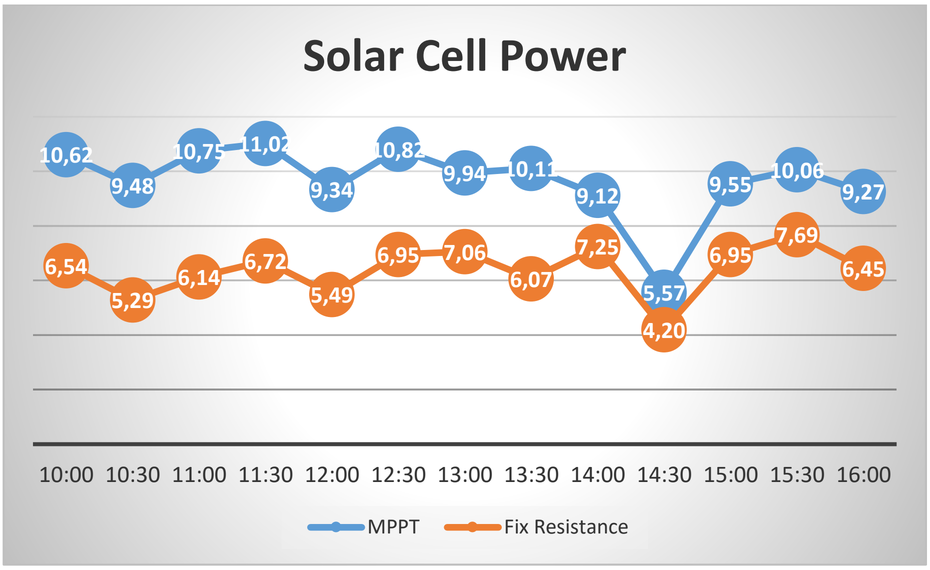

Fig. 8. Solar cell power graph using MPPT and Fix Resistance

Based on the graph presented, it can be seen that the ability to harvest solar cell power with the MPPT system is much better than without using the MPPT system. This proves the ability of the MPPT system to harvest power from solar cells. For power accuracy data from solar cells can be seen in table 3.

Table 3. Power value accuracy data

Measurement	MPPT	Multimeter	%Error	Accuracy	%Accuracy
	P (W)	P (W)			
1	10,0164	10,3933	3,626	0,964	**96,374**
2	9,0576	9,3333	2,954	0,970	**97,046**
3	10,1775	10,332	1,495	0,985	**98,505**
4	6,068	6,6528	8,790	0,912	**91,210**
5	4,0595	3,45	17,667	0,823	**82,333**
6	8,8452	8,6904	1,781	0,982	**98,219**
7	8,8128	9,483	7,067	0,929	**92,933**
8	10,506	10,8748	3,391	0,966	**96,609**
9	10,0377	10,596	5,269	0,947	**94,731**
10	8,315	9,163	9,255	0,907	**90,745**
Average			**6,130**	**0,939**	**93,870**

Based on the data presented in Table 3, it can be said that the ability of the instrument is quite good in terms of accuracy. The data is compared between the values obtained by the MPPT based on IoT instrument with manual data collection using a multimeter. Power Precision data can be seen in table 4.

Table 4. Power value precision data

Measurement	P (W)	Precision	%Error	%Precision
1	7,044	0,934	6,604	**93,396**
2	7,845	0,960	4,009	**95,991**
3	7,411	0,983	1,749	**98,251**
4	7,845	0,960	4,009	**95,991**
5	6,996	0,928	7,246	**92,754**
6	7,018	0,930	6,954	**93,046**
7	7,869	0,957	4,334	**95,666**
8	7,869	0,957	4,334	**95,666**
9	8,191	0,914	8,592	**91,408**
10	7,337	0,973	2,725	**97,275**
Average	7,543	0,949	5,056	**94,944**
SD		**0,434**		
KR		**5,759**		

Based on table 4, it can be said that the instrument has a fairly thorough ability. Where obtained an accuracy of 94.944%. This value is obtained from repeated measurements 10 times. Measurements were made in a solar cell with an open voltage value of 18.5V and a short-circuit current of 0.81A.

IV. CONCLUSION

The results of the IoT-based MPPT instrument performance specifications can be seen from the various circuits used so that the tool is able to work as expected. From the electronic circuit used, current and voltage sensors, as well as microcontrollers, both Arduino promini or NodeMCU ESP8266. And all these components are arranged in a box measuring 20cm x 15cm x 9cm. For the design specifications, good capabilities are obtained from the IoT-based MPPT which is seen from the comparison with the buck converter. For the value of the accuracy of the tool in taking the power value, it was obtained 93.87% and for the accuracy of the tool in the power value it was 94.944%. And also in the design specifications, the IoT capabilities of the tool run well so that data can be accessed on a smartphone continuously.

REFERENCES

[1] Muhammad Ihsan Fadriantam, "Analisis Perbandingan Kinerja Algoritme Perturb And Observe (P&O) Dan Incremental Conductance (IC) Pada Sistem Kendali Maximum Power Point Tracker (MPPT) Untuk Sistem Photovoltaic (PV) Paralel," *J. Chem. Inf. Model.*, 2013, doi: 10.1017/CBO9781107415324.004.

[2] Mairizwan, R. Anshari, and W. Satria Dewi, "Optimization of harvesting solar cell energy based on MPPT to be applied during the rainy season in the tropics," 2020, doi: 10.1088/1742-6596/1481/1/012007.

[3] A. Makki, S. Omer, and H. Sabir, "Advancements in hybrid photovoltaic systems for enhanced solar cells performance," *Renewable and Sustainable Energy Reviews*. 2015, doi: 10.1016/j.rser.2014.08.069.

[4] A. Ashiquzzaman, "Energy-Efficient Sensor Calibration Based on Deep Reinforcement Learning," *Int. J. Artif. Intell. Appl. Smart Devices*, 2019, doi: 10.21742/ijaiasd.2019.7.1.02.

[5] I. Winarno and L. Natasari, "Maximum Power Point Tracker (MPPT) Berdasarkan Metode Perturb and Observe Dengan Sistem Tracking Panel Surya Single Axis," *umj*, 2017.

[6] A. Faizal and B. Setyaji, "Desain Maximum Power Point Tracking (MPPT) pada Panel Surya Menggunakan Metode Sliding Mode Control," *J. Sains, Teknol. dan Ind.*, 2016.

[7] F. Xia, L. T. Yang, L. Wang, and A. Vinel, "Internet of things," *International Journal of Communication Systems*. 2012, doi: 10.1002/dac.2417.

[8] L. Tan and N. Wang, "Future Internet: The Internet of Things," 2010, doi: 10.1109/ICACTE.2010.5579543.

[9] A. Junaidi, "INTERNET OF THINGS, SEJARAH, TEKNOLOGI DAN PENERAPANNYA : REVIEW

Apri," *J. Ilm. Teknol. Inf.*, 2015.

[10] M. Fajar Wicaksono, "IMPLEMENTASI MODUL WIFI NODEMCU ESP8266 UNTUK SMART HOME," 2017.

[11] A. I. Abdul-Rahman and C. A. Graves, "Internet of things application using tethered MSP430 to thingspeak cloud," 2016, doi: 10.1109/SOSE.2016.42.

[12] G. Hamdi and Krisnawati, "Membangun Aplikasi Berbasis Android 'Pembelajaran Psikotes' Menggunakan App Inventor," *J. DASI Vol. 12 No. 4 DESEMBER 2011*, 2011.

[13] Arafat. S.Kom. M.Kom, "Sistem Pengaman Pintu Rumah berbasis Internet of Things (IoT) Dengan ESP8266," *J. Ilm. Fak. Tek. "Technologia,"* 2016.

[14] M. Iqbal, Yulkifli, and Y. Darvina, "RANCANG BANGUN SISTEM PENGUKURAN SUHU DAN KELEMBABAN UDARA MENGGUNAKAN SENSOR SHT75 BERBASIS INTERNET OF THINGS DENGAN DISPLAY SMARTPHONE," *Berk. Fis.*, vol. 22, no. 3, 2019.

[15] I. T. Handini, Yulkifi, and Y. Darvina, "Rancang Bangun Sistem Pengukuran Tekanan Udara Menggunakan DT-Sense Barometric Pressure Berbasis Internet of Things dengan Tampilan pada Smartphone," *J. Teor. dan Apl. Fis.*, vol. 08, no. 01, 2020.

[16] Sugiyono, "Metode Penelitian Kuantitatif, Kualitatif dan R & D.Bandung:Alfabeta.," *Metod. Penelit. Kuantitatif, Kualitatif dan R D.BandungAlfabeta.*, 2012, doi: 10.1017/CBO9781107415324.004.