Journal of Engineering Sciences
Vol 12, Issue 7, July/202J
ISSN NO:0377-9254

SMART MAXIMUM POWER POINT TRACKING (MPPT) SOLAR CHARGE CONTROLLER

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***Abstract*- Continuously monitoring the maximum power point (MPP) of the system is important for optimising photovoltaic (PV) power. PV systems' MPP is affected by solar radiation, ambient temperature, and load demand. PV systems' MPP can be caught using maximum power point tracking (MPPT) techniques. These techniques can be implemented in a variety of hardware and software configurations. With a limited budget, the aim of this project was to design, construct, and test a working solution to the MPP problem. This system is built on a popular Arduino microcontroller.**

***Keywords*- IoT, Solar Charge Controller, Arduino, MPPT, Thingspeak.**

I. INTRODUCTION

Demand for Electricity is growing as everything is going digital and almost every instrument that is used today is electric or battery powered. Electricity consumption has risen drastically in this century and many of the sources of generating electricity might go extinct in the coming future. The resources that today are used to harness energy such as coil might get exhausted in the near future. Petroleum too has no viable future. Wind energy, geothermal energy, hydro energy, tidal energy, solar energy, etc are some of the renewable sources of energy.

Solar energy is a promising alternative as it is renewable and there are almost no chance of Sun being demolished,not until the next century. Also considering the initial cost and maintenance cost of generation of energy solar energy is one of the cheapest of all and can be widely used anywhere to generate energy as long as sunlight reaches that part of the globe.Solar Energy is being considered and been used as an promising alternative source of energy since the very beginning of this century. But considering it as an alternative source of energy it can perform only in the Daylight. India being one of the countries which has most of its region that has ample amount of sunlight throughout the day. But, the problem with the sunlight is that it cannot be static or continuously available. It is called irradiance, this could happen due to clouds or other factors that reduce the total amount of sunlight from reaching towards the earth’s surface.

Many of the researchers in the past faced the same issues regarding harnessing the electrical energy from photovoltaic cells and many solutions were proposed too. One such solution is Maximum Power Point Tracking Technique. But the MPPT also has various algorithms namely Incremental conductance, Perturb and observe, Neural network, Ripple Correlation, etc. Each one of the mentioned algorithms is efficient and helpful, but the system designed by us is focussed on Perturb and Observe Algorithm.

As we chose Solar Energy for our project, let us go in details about some related concepts of Solar Energy. As we know sunlight is not continuously present at any point for the whole day. There are various factors due to which solar irradiance occurs, it may be because of the clouds or due to placement of our solar panels and as earth is spherical, the sun movement too affects the radiance of sun at any given point on earth. Due to which to we calculate the Peak solar hours which tells about the peak solar hours during which the maximum potential can be attained.

This System is called smart system because, generally in the MPPTs available in the market do not have capability to sync the power generation data or the voltage and current generated data over the internet. The old systems use LCD as the only display medium for the said data. But, our system uses IoT platform called as ThingSpeak where the data is continuously synced with the help of ESP8266 module via the internet. This Makes our system Smart. And using ThingSpeak Dashboard the user could monitor the real time power generation values.

We calculate Peak solar hours for our locations by the average data provided by the solargis map. We calculate it as

$$Peak\ Solar\ Hours = \frac{\text{Global Irradiance Per Day}}{Standard\ Tect\ Condition\ of\ Irradiance\ i.e\ 1000w/m^2}$$

According to the above available data average GHI of Maharashtra is about 5.3 kWh/m2

$$Peak\ Solar\ Hours = \frac{5.3\text{kWh}/m^2}{1000w/m^2}$$

$$Peak\ Solar\ Hours = 5.3$$

So, in maharashtra we have about 5.3 hours of average solar radiance per day. Let us say we use our maximum potential using smart MPPT algorithm and harness maximum power out of the said 5.3 hours, we could make a big difference.

II. LITERATURE SURVEY

Weidong Xiao et al.[1] demonstrated an adaptive hill climbing (MAHC) MPPT system that has been modified. It's a development of the traditional hill-climbing algorithm. The suggested MPPT'control prevents monitoring variation and increases efficiency in both dynamic and steady-state reactions, according to modelling and experimental data.

Fangrui Liu et al. [2] They introduced an updated variable step size INC MPPT method in their article, which automatically changes the step size to map the PV series' maximum power point. When compared to a standard fixed stage size system, the suggested method will significantly improve MPPT speed while also improving accuracy.

Obeidi Nabil et al. [3] The goal of this project is to present an implementation of the perturb and observe (P&O) methodology for photovoltaic systems utilising a boost converter operated by an Arduino MEGA 2560 in order to increase PV system efficiency. This method is further characterised by its ability to monitor the (MPPT) quickly and save computing time by utilising the Arduino MEGA 2560 microcontroller's digital controllers.

Mustapha Elyaqouti et al. [4] demonstrated the use of the Arduino Mega type to create two digital MPPT instructions in his article. The two suggested MPPT controls are based on the perturb and observe (P&O) method, with the first having a constant perturbation step and the second having two perturbation steps that change depending on certain variables. In terms of the temporal response and oscillations around the MPP, the experimental findings suggest that the P&O method with variable step perturbation outperforms the P&O method with constant step perturbation.

Michael Bardwell et al. [5] has exhibited and explained in depth the design approach for integrating photovoltaic (PV) maximum power point tracking (MPPT) with the Internet of Things (IoT). Around a common PV system layout, required calculations, popular tracking techniques, and converter linearity quirks are explored. In MATLAB Simulink, a buck converter is simulated to ensure stable functioning when affected by computed values. The average irradiance slope value necessary to compute a minimal duty cycle perturbation step size was calculated using high resolution irradiance data that was statistically analysed.

Mihir Pathare et al. [6] discussed the difficulty with solar energy is that it is not continuous; it fluctuates depending on weather conditions such as sun irradiation and temperature. As a result, a battery is constantly linked between the load and the solar panel to operate as a backup supply. Because the more sunshine there is, the more voltage the solar cells create, and too much voltage might destroy the batteries. MPPT is a technique for getting the most power out of a PV module while also protecting the battery from overcharging. The major functions of an MPPT charge controller are battery protection and energy metering.

O. Oussalem et al. [7] in their research talked about how it is vital to improve the design of all sections of the PV photovoltaic chain to solve the problem of solar panel performance and achieve optimum efficiency. Between the photovoltaic generator (GPV) and the load, we add an adaption step. This step, which is controlled by a microprocessor, allows the system to find and attain its maximum power point (MPP).

III. BLOCK DIAGRAM OF THE SYSTEM

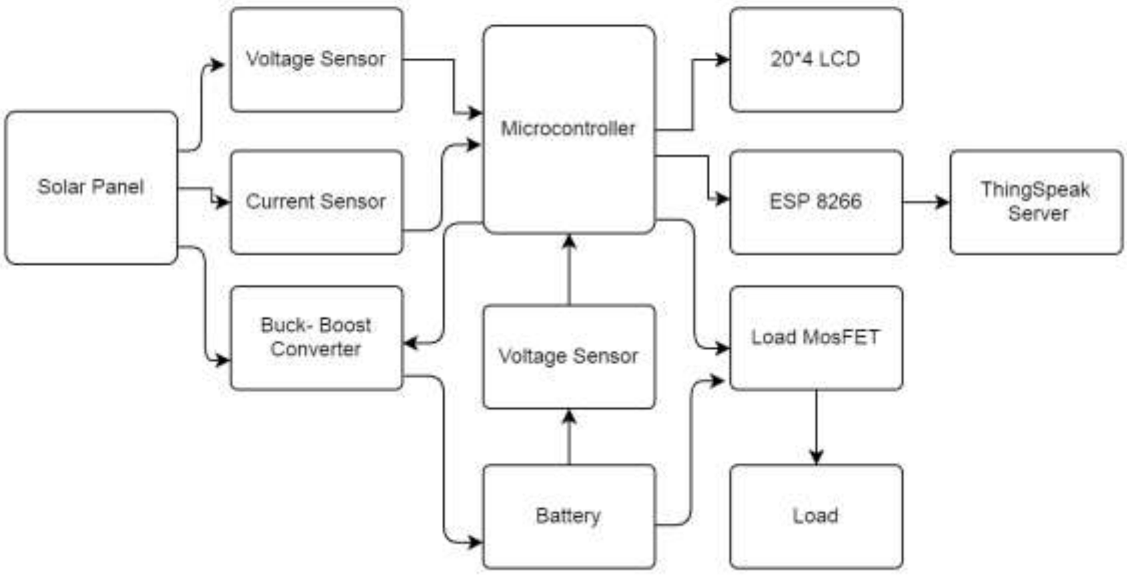

Fig. 1 Block Diagram of the System.

Working of the system

Solar panels when in contact with light generates electricity, the same electric power in the form of voltage and current are being sent to the microcontroller. But before reaching microcontroller i.e Arduino UNO in our project it passes through voltage sensor and current sensor, this current and voltage sensors sense the electric current and voltage and send it for measuring to the Arduino UNO. Also the Arduino generates pulses in order to charge the battery efficiently and sends it to buck converter. Buck converter reduces the direct high and low impact of the power which might damage the battery. It sends the data through solar panels and buck converter to the battery for charging. In some cases, battery might be empty or full the status needs to be updated and sent to the Microcontroller for efficient charging frequencies.

The microcontroller apart from sending PWM data to the buck converter also dispatches the data to the internet using a ESP 8266 Wi-Fi module. The same data is also displayed on the LCD display that is being attached with Arduino UNO. The power generation data is continuously sent to the Thingspeak server and it is visible on the channels over the internet.

IV. PROPOSED SYSTEM

The Smart MPPT Solar Charger Controller is being designed and built taking price point in accounts. It is cheaper and reliable. Also the proposed system requires following elements.

1. **Hardware Requirements**
2. **Software Requirements**

1 Hardware Requirements

a. Solar Panel:

Solar panel or Photovoltaic panels are the essential part of this project, it is used to harness electrical power from the Sun. we have chosen a 25 Watt panel for our project.

b. Arduino UNO

Arduino UNO is the main microcontroller of our project. It is used to analyse the current and voltage data from the solar panel and then send back pwm waves in order to charge the battery efficiently. Also Arduino its used to send data to LCD and To the cloud using ESP8266 And Thingspeak.

c. LCD

Our project also sends the sensed and analysed data from the solar to the LCD screen, mediated by Arduino UNO. It displays Current Value, Voltage Value and The Total Power generated by the system.

d. ESP 8266

The ESP 8266 module is used to send the data on cloud using Wi-Fi. The module is very useful in this system as the whole IoT module depends on the connectivity of the system to the internet, and ESP 8266 makes it possible.

2 Software Requirements

a. Arduino IDE

Arduino IDE is one of the main requirements in programming the Arduino. In this IDE we could write our code in the inbuilt text editor. Then the IDE verifies and compiles the code, also displays warnings and errors if there is any issue with the code or hardware interfaced. Arduino IDE is also used to burn the hex code in the Arduino UNO.

b. Proteus Design Suite

Proteus design suite is an designing suite in which we can draw schematics, design PCB and simulate it.We have used it for simulating the I V and P V characteristics of our solar panel. The analysis pictures can be found in the result section.

c. ThingSpeak

ThingSpeak is an open-source Internet of Things (IoT) application and API for storing and retrieving data from things over the Internet or over a Local Area Network utilising the HTTP and MQTT protocols. ThingSpeak allows developers to create sensor recording apps, location tracking apps, and a social network of things with status updates. Our project utilizes this tool to simulate the data over the ThingSpeak channels.

V. FLOWCHART AND ALGORITHM OF THE SYSTEM

Flowchart of the System

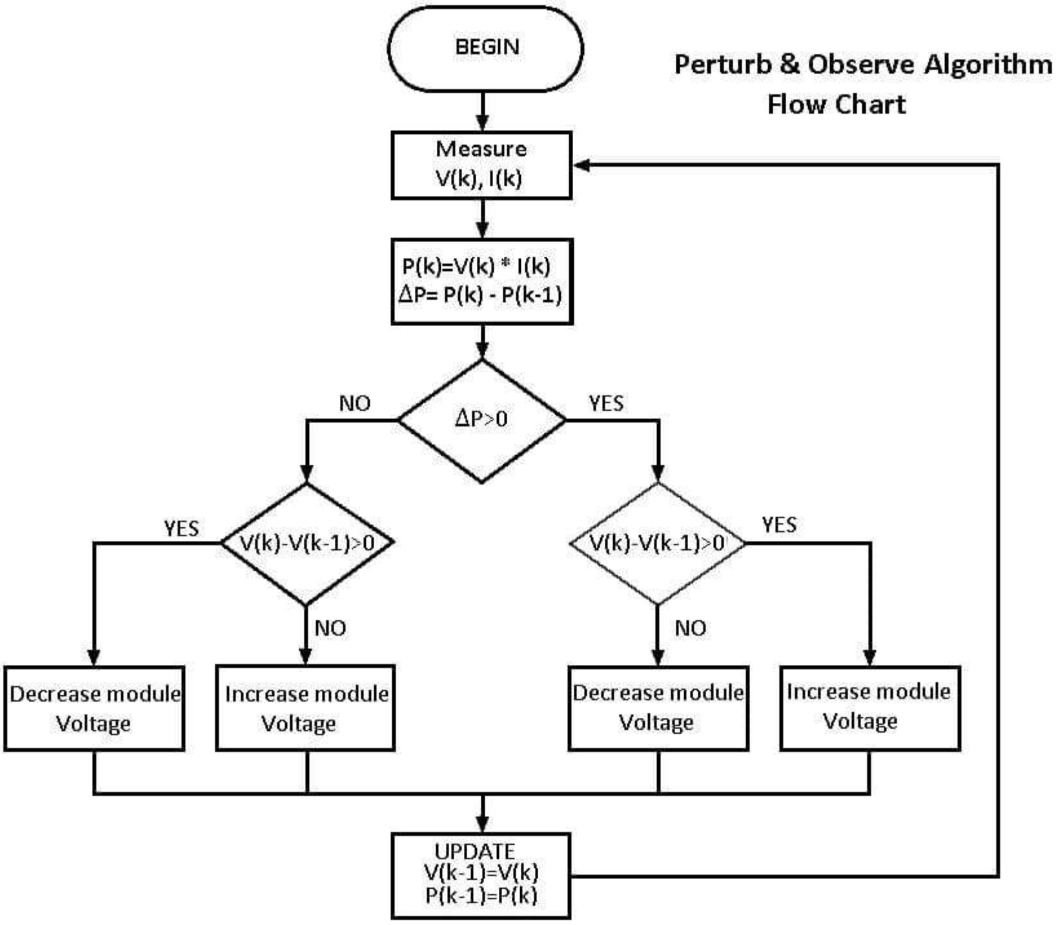

Fig. 2 Flowchart of the system

Algorithm

1) Start the system.
2) Measure Voltage, V(k)
3) Measure Current , I (k)
4) Calculate the Total power, P(k) = V(k) * I(k)
5) Calculate Power difference as Delta P = P(k)- P(k-1)
6) If the new Power difference is greater than zero.
7) If yes check whether Voltage difference, V(k)-V(k-1) is greater than zero.
8) If yes then Increase the module voltage.
9) If no, then decrease the module voltage.
10) If the power difference is not greater than zero then check for voltage difference V(k)-V(k-1) is greater than zero.
11) If no then Increase the module voltage.
12) If yes, then decrease the module voltage.

13) Update the value of V(k-1) =V(k)

14) Update the P(k-1)= P(k)

15) Go to step 2.

VI. RESULT

Fig. 3 I V analysis of Solar generator

Fig.4 P-V analysis of the solar generator

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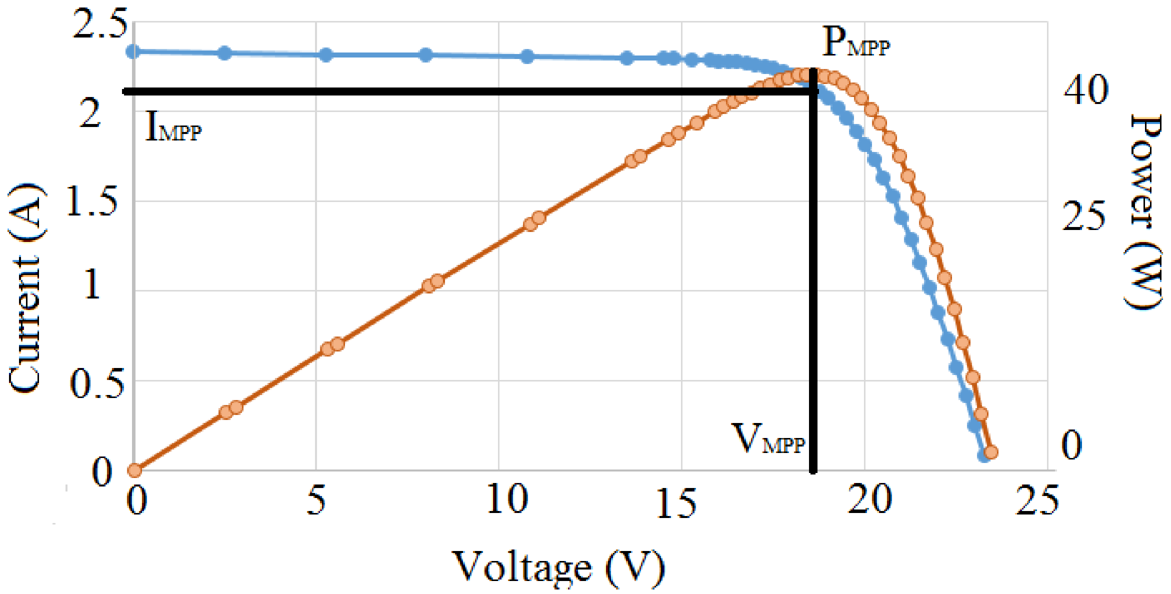

Fig. 5 Maximum Power Points Of Current, Voltage And Power For The Solar Panel.

Current (A)	**Voltage (V)**	**Power (W)**
2.04	19.07	38.90
1.97	19.95	39.30
1.89	21.02	39.65
2.10	18.57	38.99
1.93	19.25	37.15
2.19	18.21	39.88

Table 5. Power Generated by Solar Panel Using MPPT P&O Algorithm

Table 1. Power Generated by Solar Panel Using MPPT P&O Algorithm

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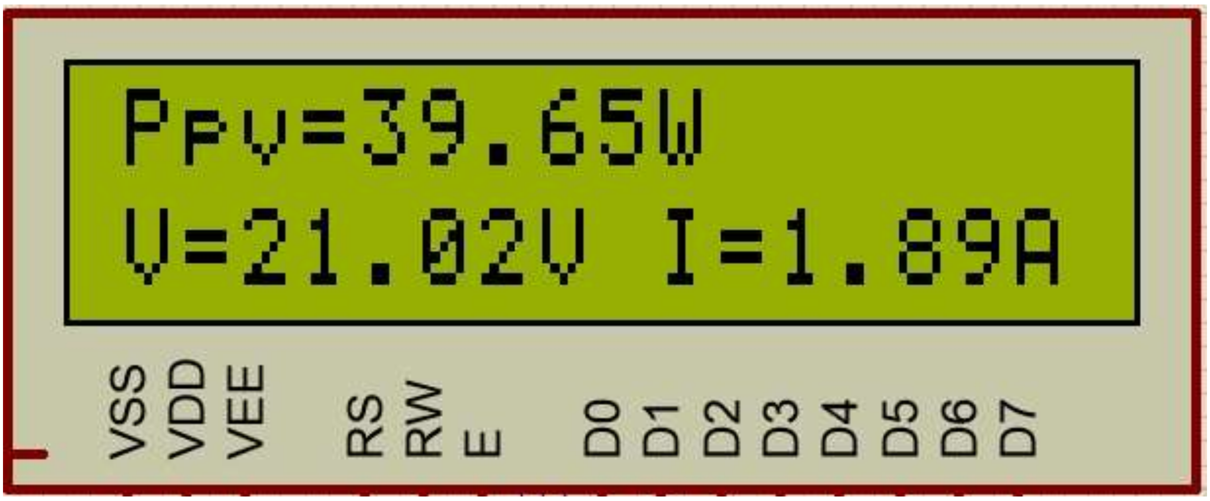

Fig.6 LCD Output of The System

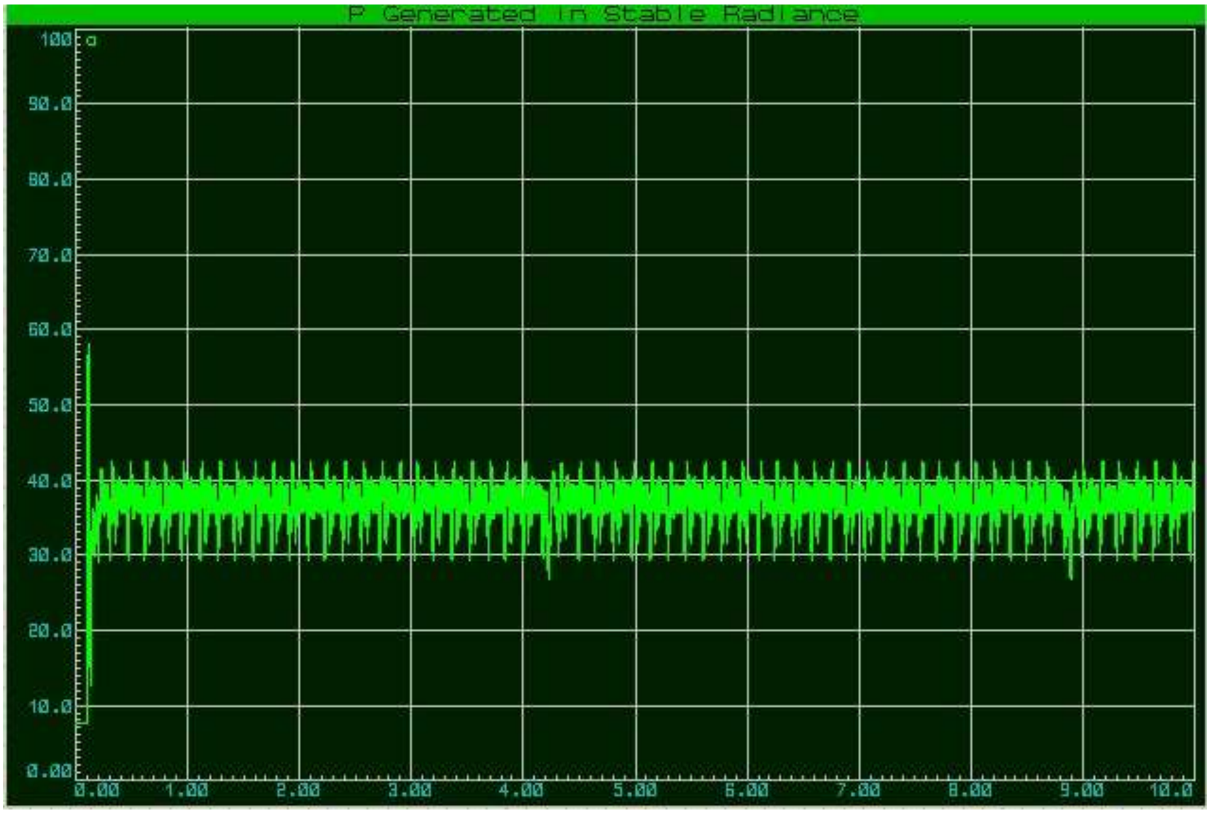

Fig. 7 Graph Analysis of the power generated by Smart MPPT using P&O MPPT at Stable irradiance conditions.

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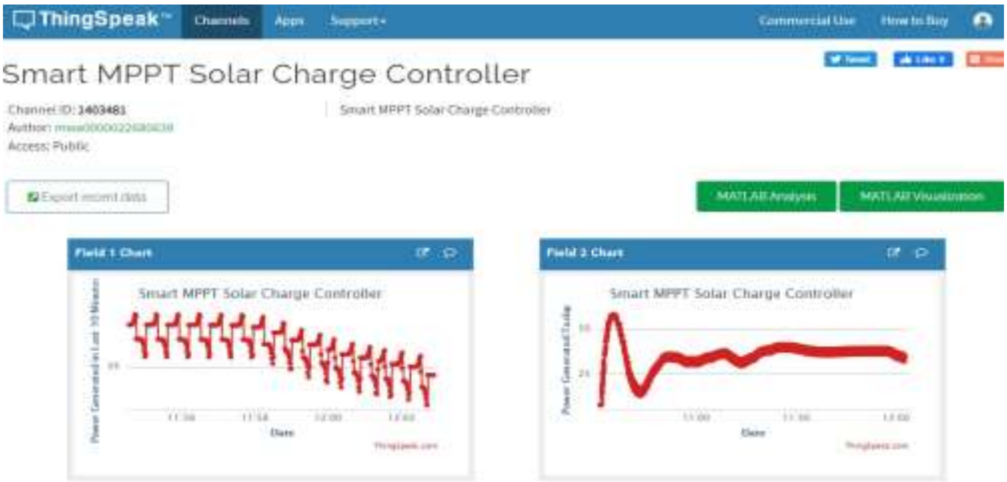

Fig. 8. Generated Power Data Available on Thingspeak (IoT)

Fig. 9 Graph Analysis of the power generated by Smart MPPT using P&O MPPT at Stable irradiance conditions.

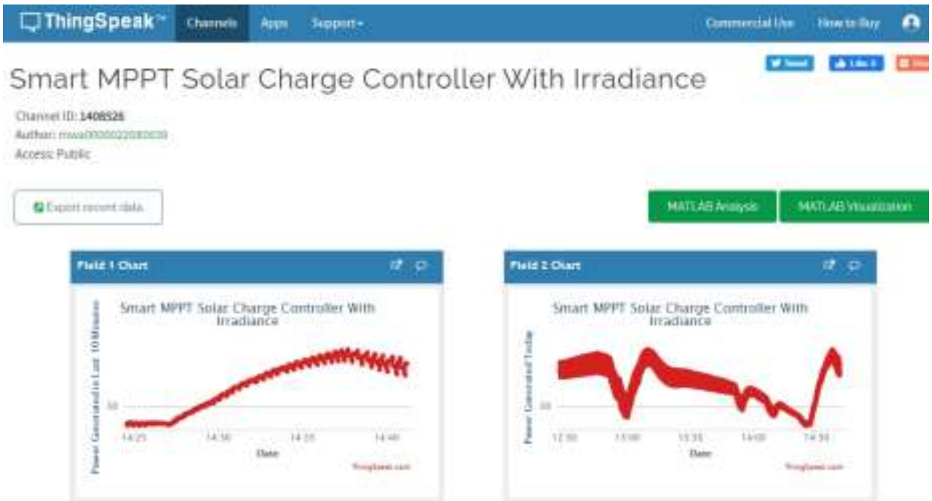

Fig. 10. Generated Power Data with Solar Irradiance Available on Thingspeak (IoT)

This Project or system presents a reference model for the feasibility of implementing the P&O MPPT algorithm, which was analysed using an experimental setup in order to demonstrate the MPPT controller's efficiency, which was later validated. Experimental setup included a Computer, Solar panels, Arduino Uno and ESp8266 as important elements. Also Proteus software was used to simulate the system, Arduino IDE was used to write and program the Arduino UNO Board and Thingspeak was used to Display data over the internet.

VII. CONCLUSION

It will be marked as one of the low cost MPPT solar charged controller, which is based on IoT using Arduino. We are expecting good results in terms of Solar charging time of the battery and also the improved battery cycle.

The MPPT controller continuously monitors the MPP, which is required to understand fluctuations in the solar generator's output power and change the duty cycle of the static converter to guarantee that the solar generator and the load are matched. We have suggested a Perturb and observe approach built on an Arduino UNO board based on the work described in this research, which allows us to reduce the cost of the MPPT controller while increasing the efficacy of solar power generation.

VIII. ACKNOWLEDGEMENTS

We are really grateful to our project guide and head of department of Electronics Engineering, Mrs. S. S. Lavhate ma'am for her support throughout this project and the whole engineering journey. We also take immense pleasure in thanking our project coordinator, Mr. S. A. Shaikh. He has been a inspiration and of great help not only in this project but since his first lecture that we attended.

Our family and friends are to be greatly thanked too, for helping us making this project to life in this time of pandemic. Moral supporters and everyone who helped is hereby thanked too.

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