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Design of an Arduino Based MPPT Solar Charge Controller Using Real PV System Data

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ABSTRACT: Renewable sources such as the Photovoltaic Systems (PV) have been used over decades in order to focus on greener sources of power generation. Today it has become a matter of concern on how to reduce COST and improve EFFICIENCY in order to harness and use these natural resources in a much better way possible. Hence the idea of Maximum Power Point Tracking System (MPPT) has emerged, which is basically a system used by charge controllers for wind turbines and Photovoltaic Systems to employ and also provide a maximized power output. This is mainly concerned with the utilization of such a system in order to achieve a controlled photovoltaic power using MPPT mechanism. The main aim of this project was to track

the maximum power point of the photovoltaic module so that the maximum possible power can be extracted from the photovoltaic systems by varying certain conditions in algorithm and set up mechanism. Finally the output data from this project was compared with the other MPPT algorithms in order to attain an improved performance hence a better MPPT system. Furthermore, the system was interfaced with GSM to get a better access of data from anywhere for analysis thus reducing the physical work of data collection

KEYWORDS: MPPT, UTILITY, ENVIRONMENTAL FRIENDLY, RENEWABLE SOURCES, PHOTOVOLTAIC SYSTEMS

I. INTRODUCTION

One of the most important sources of renewable energy nowadays which have caught the attention of many is the 'Solar Energy' and it is through harnessing this energy that we are meeting some of our energy demands. It is a known fact nowadays that non-renewable resources such as coal, oil and other such sources are almost on the verge of termination. On the other hand renewable energy sources such as the solar energy are plentiful and it has the greatest availability compared to other energy sources. Solar energy is clean and free of emissions, since it does not produce pollutants or byproducts harmful to nature therefore it is nowadays a booming industry of research, where new and more efficient modes of harnessing solar energy is a challenge. The conversion of solar energy into electrical energy has many application fields.

There are mainly two ways in which the solar to electrical conversion can be done, solar thermal and solar photovoltaic. In terms of Solar thermal, it is the conventional AC electricity generation produced by steam turbine; heat extracted from intense solar ray is used to produce steam and apart is stored in thermally insulated tanks for usage during lack of sunshine or night time. Solar photovoltaic use cells made of silicon or certain types of semiconductor materials which convert the light energy absorbed from incident sunshine into DC electricity. To make up for intermittency and night time storage of the generated electricity into battery is needed. India being a country which is concerned about environmental problems, sustainable energy sources is becoming more and more popular here. The flow of converted electricity from PV is determined by charge controller. An efficient charge controller is very crucial in order to do the battery charging and discharging process faster and better. The existing electric grids are not capable of supplying the electricity needed. Even in the rural areas people face the toughest conditions for crisis of electricity hence our aim is to make solar energy popular by increasing its efficiency and make it as one of the best renewable energy sources.

II. NEED OF PROJECT

In India the amount of sunlight which is mostly available does have the potential to meet quite a lot of the demands forelectricity in this country. Over the timethe use of Solar panels are spreading especially throughout many of therural areasbut what remains as a back flaw is the ability of these panels to harness that sunlight with proper efficiency and use it properly. Solar energy is an ideal solution asit can provide griddles power and is totally clean in terms ofpollution and healthhazards. Even after having so much advantage of using solar energy it is still notbeing as widely used as it should be, the main aspect of concern remains in terms of its efficiency and another big question about its operation during cloudy weatherconditions. Hence keeping all these matters in mind we wanted to design a MPPTsolar charge controller in order to adjust charging rates depending on the battery'scharge level to allow charging closer to the battery's maximum capacity as well asmonitor battery temperature to prevent overheating. An MPPT controller is better suited for colder conditions, PV array voltage can be higher than battery voltagehence the MPPT solar charge controller will harvest more power from the solar array. There are quite a few advantages of having aMPPT solar charge controller forthe PV panels which might just increase the use of solar panels to its full potential.

III. OBJECTIVES OF PROJECT

- STUDY OF MAXIMUM POWER POINT TRACKING METHOD
- CONTROLLING PULSE WIDTH MODULATION

IV. WHAT IS MPPT

The MPPT system can be classified based on the algorithms used; power converter in the system and application of the system (Stand alone or grid interconnection).

Components used in Bike:

1. PhotovoltaicPanels:

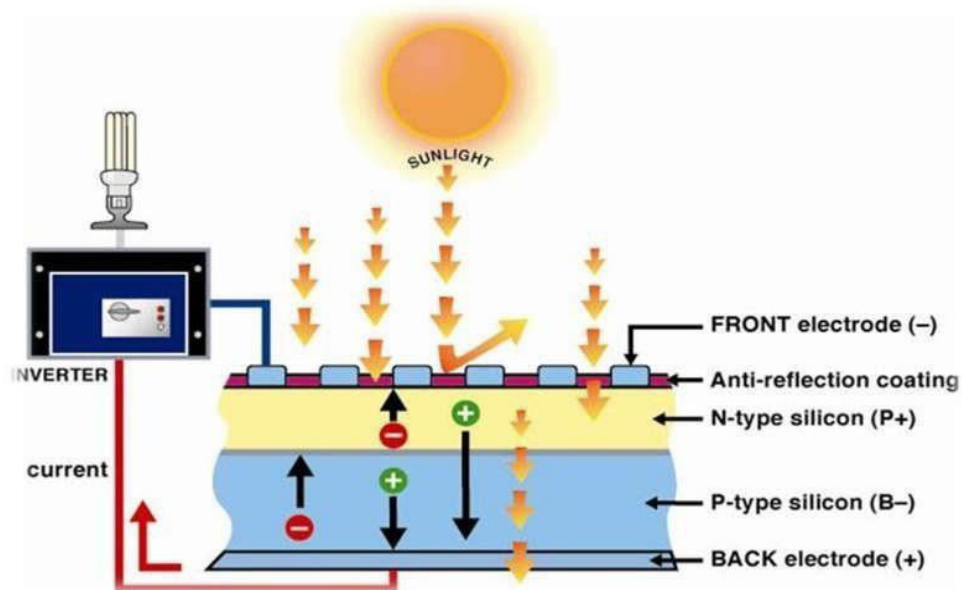


Fig 1.1 Mechanism of a PV Panel

Fig 1:mechanism of a PV Panel



The whole process by which a photovoltaic cell works is fairly complex. To put it quite simply the mechanism is as such; the light excites electrons to move from one layer to another through semi-conductive silicon materials. This ultimately produces an electric current. This whole process is called the photo electric effect. Solar cells called photovoltaic which are made from thin slices of crystal line silicon, gallium arsenide, or other semiconductor materials which are capable of convert in g so lar radiation directly into electricity.

2.Photovoltaic cellmodel :

The characteristics of a PV cell can be further explained using an equivalent circuit shown in the . The PV model consists of a current source, a diode and a series resistance. The effect of parallel resistance represents the leakage resistance of the cell which is very small in a single module. The current source represents the current which is generated by the photons, and its output is constant under constant temperature and constant incident radiation of light. Current-voltage (I-V) curves are obtained by exposing the cell to a constant level of light, while maintaining a constant cell temperature, varying the resistance of the load, and measuring the produced current. When an I-V curve is drawn it normally passes through two points

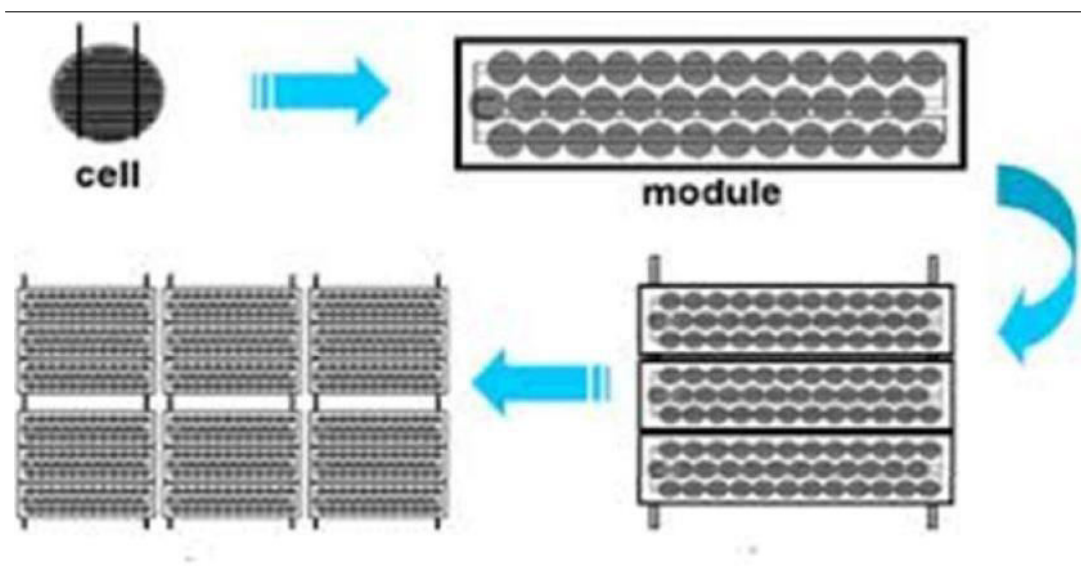


Fig 2: Solar Panel module



Fig 3: Solar Panel

3. Maximum Power Point Tracking:

The Power-Voltage or current-voltage curve of a solar panel, there is a peak operating point at which the Solar Panel delivers the maximum possible power to the load. This unique point is called the maximum power point (MPP) of solar panel. The photovoltaic nature of the solar panels makes the (Power-Voltage or current-voltage) curves depend on temperature and irradiance (the flux of radiant energy per unit area) levels. In other words depending on the amount of sunlight per unit area of the panels the curve will vary hence the peak point or MPP will vary accordingly. Therefore it can be deduced that the operating current and voltage which maximize power output will change with environmental conditions. From the figure it can be seen that the MPP depends on certain conditions such as the irradiance for instance which is given by the symbol 'G'. At different values of G from the graph it can be seen how the values of MPP have slightly shifted. It is hence the work of charge controller using certain algorithm to calculate the MPP at every instance providing the maximum power hence making the system more efficient. In these applications, the load can demand more power than the PV system can deliver. There are many different approaches to maximizing the power from a PV system, this range from using simple voltage relationships to more complex multiple sample based analysis.

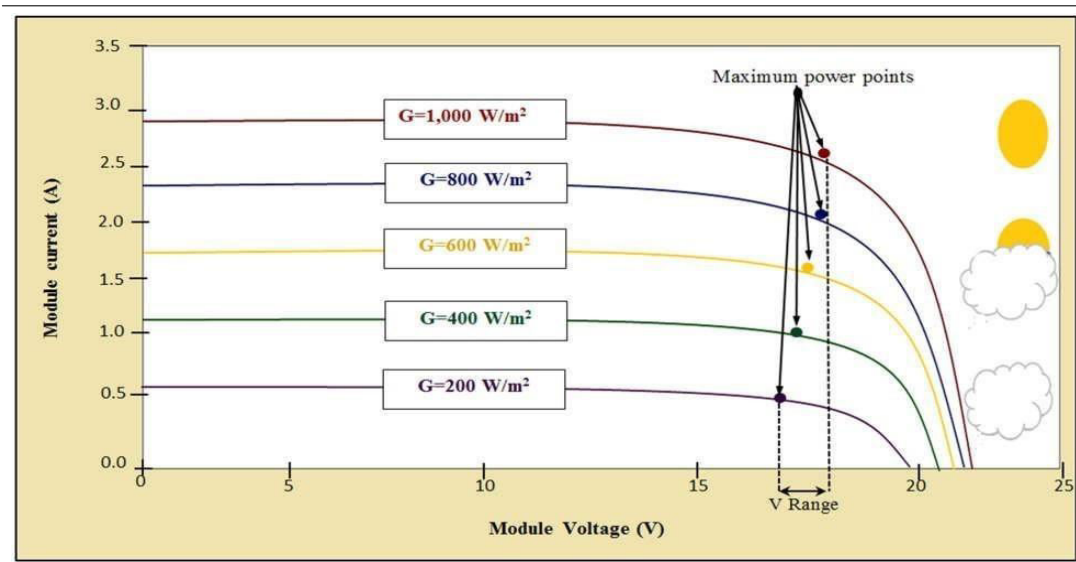


Fig 4: Shows the variation of maximum Power Point (MPP) at different sunlight conditions

4. MPPT Methods:

There are some conventional methods for MPPT. Seven of them are listed here.

These methods include:

- 1) Constant Voltage method
- 2) Open Circuit Voltage method
- 3) Short Circuit Current method
- 4) Perturb and Observe method
- 5) Incremental Conductance method

5. Buck-Boost converter

In order to achieve a stable voltage from an input supply (PV cells) that is higher and lower than the output, a high efficiency and minimum ripple DC-DC converter is required in the system for residential power production. When it comes to converting a DC voltage to either a lower or higher voltage Buck-Boost converters make it possible and it happens quite efficiently. Buck-boost converters are especially useful when it comes to PV maximum power tracking purposes. In these cases the objective is to draw maximum possible power from solar panels at all times, despite the type of load

being used. By cascading the connection of two basic converters a buck boost converter can be obtained, which could be step up (Boost) and step down (Buck) converter. In PV applications, the buck type converters are normally used for cases like charging batteries. On the other hand the boost topology is used for stepping up the voltage. The grid-tied systems use a boost type converter to step up the output voltage to the utility level before the inverter stage. In PV applications, the buck type converter is usually used for charging batteries. The boost topology is used for stepping up the voltage. In cases of the grid-tied systems, they use a boost type converter which steps up the output voltage to the utility level before the inverter stage. Buck-boost DC-DC switching converter is good for home appliances for high efficiency. Minimum ripple voltage. Programmable without external components.

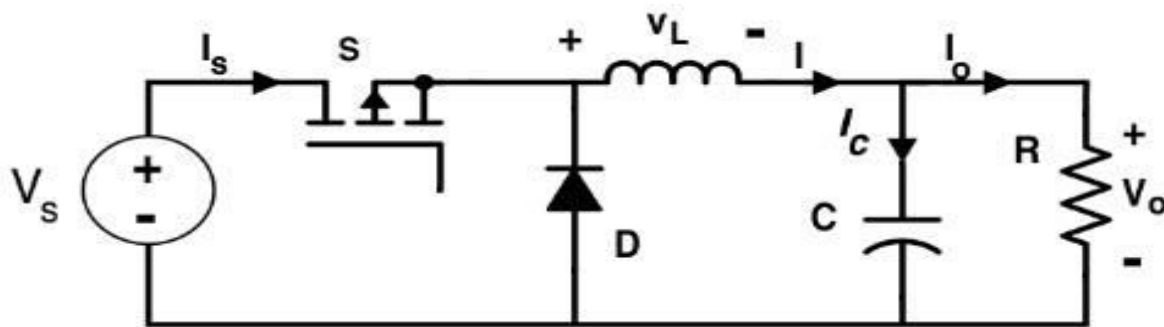


Fig 4: Buck-Boost Converter

6. Buck Converter (step-down converter)

A Buck Converter is mainly a DC-DC power converter which (while stepping up the current) steps down the voltage from its input (supply) to output (load). The converter is mainly composed of transistors, diodes, capacitors (mainly as an energy storage element) and inductors. In order to reduce the voltage ripples there are filters made of capacitors or with inductors and are added to the output of such converters. In other words there are load side filters and input filters added. Buck converters mainly act as switching converters which deliver a much higher power efficiency as DC-DC converters than linear regulators. Buck converters are typically very efficient about 90% which makes them an ideal tool for tasks like converting a computer's mass supply voltage down to lower voltages which are required for the CPU and DRAMS.

7. Hardware Section

The PV module we used is based on polycrystalline silicon diode. Usually, this type of PV module is used in home usage, project based work where the cost should be in a reasonable range. The specifications provided with our PV module is given below.

Power (max) : 50W

Cell type efficiency: polycrystalline

Dimensions: 666mm * 610mm * 35mm

Tolerance : 0 ± 3

Voltage at maximum point (V_{mp}): 17.0 V

Current at maximum point (I_{mp}) : 2.95A

Open circuit voltage (V_{oc}): 21.0 V

Short circuit current (I_{sc}): 3.10 A

Module application : class A

Test condition: 1000W/m² , AM 1.5, 25°C

8.Current Sensor:

To sense the current generated by the PV module in different conditions we used a hall-effect current sensor that is manufactured commercially for sensing AC, DC current to use in industrial or research or communication systems. Most importantly, it is the most preferable microchip assembled IC to be used with microcontrollers as Arduino. (MicroSystems, 2016) For establishing the current sensing equation we tested the current sensor and gathered calibration data. We set up the sensor with our 50w PV module. The connections were made as the pin out configuration described above. With the help of the Arduino we ran the program and we varied the supplied current of the PV module by shading it partially or fully and collected data for 10 instances. Then we put the data in MATLAB and did regression analysis. Henceforth, we used polyfit function of MATLAB to get the most fitted output and to establish our equation. The equation we got is $Y = 1.5625*(X)-3.7375$

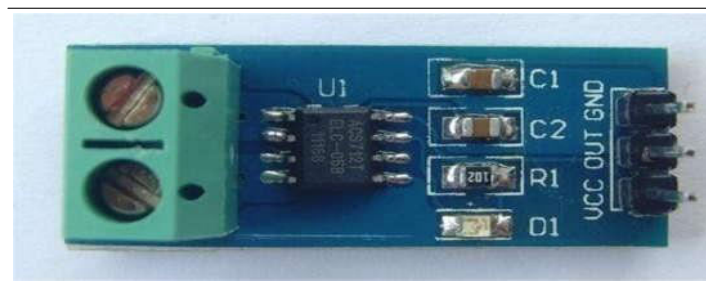


Fig6: current sensor

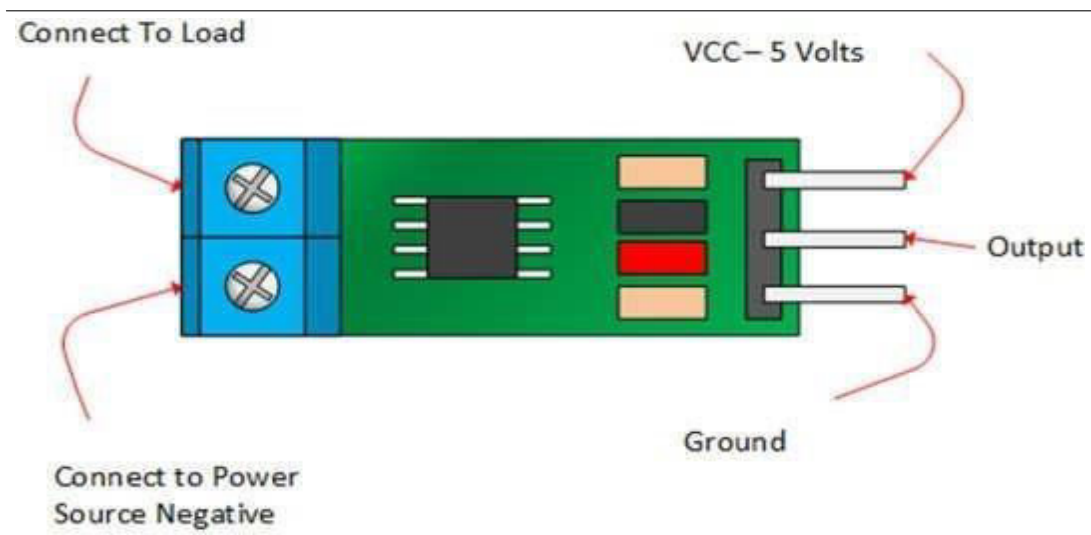


Fig 7: pin configuration

9.voltage sensing:

The main target of charge controller is to charge up the battery by supplying it the required level of voltage. It is achieved by Arduino by the preset algorithm of MPP. Notably, Arduino microcontroller chip consists of a built-in analog to digital converter. By this conversion it enables the analog AC input to convert into quantized digital values and then fed to the algorithm to compare the voltage level with previous output level.

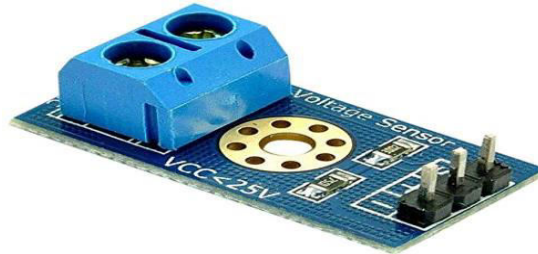


Fig 8: Voltage Sensor

Since, in our proposed system we used a buck converter to stepdown the panel output voltage so we had to implement a voltage division setup to acquire our desired value. Purposely, two sets of voltage divider configuration is introduced in our system. Correspondingly, one is used in input side and other in the output side before the voltage is fed to the battery. The voltage level sensed in those parts is supplied to Arduino by connecting them to Arduino analog pin and therefore it gets converted to digital quantized values. Ultimately, voltage of the battery and PV module is sensed in this way

V. RESULT

In the final analysis, this thesis presents an efficient photo voltaic system with the capability of tracking the maximum power point using incremental conductance method. Each component of this system such as the solar panel, charge controller, DC-DC converter has all been discussed about. The coding in terms of flowchart and MATLAB simulations of the I-V characteristics for load and irradiations variation has been presented. Since the purpose of this thesis was to design a more efficient MPPT solar charge controller using an Arduino, so we have explained the maximum power point tracking and the procedure we have followed to achieve that point. A brief comparison has been made between perturb and observe method. The use of an Arduino and its advantages has been provided in this paper along with the converter used for our design of the solar charge controller. We have later done the hardware implementation and matched the data we collected to differentiate the efficient method between the two. Comparatively incremental conductance method showed more promising output than perturb and observe method

VI. CONCLUSION

Solar Energy is the ultimate source of ultra clean, sustainable and natural energy. Most importantly it is the most cost efficient energy source we can use in our favor and for securing financial benefits. In this regard developing more efficient charge controller is a progressive step to fulfill the need of power generation using green energy. For that purpose it is our wish to continue further study on making the PV module more efficient. To be specific, the charge controller can be more improved by making the circuit more integrated and coming up with new algorithm to make the maximum power point tracking more efficient. Additionally, more digital logic can be implemented for maximizing the output hence reducing the physical work.

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