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MPPT Charger with PWM Controller for Photovoltaic Based System

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***Abstract* - Global energy demand is increasing exponentially. This increase in demand causes concern pertaining to the global energy crisis and allied environmental threats. The solution of these issues is seen in renewable energy sources. Solar energy is considered one of the major sources of renewable energy, available in abundance and also free of cost. Solar photo voltaic (PV) cells are used to convert solar energy in to unregulated electrical energy. These solar PV cells exhibition linear characteristics and give very low efficiency. Therefore, it becomes essential to extract maximum power from solar PV cells using maximum power point tracking (MPPT). Perturb and observe (P&O) is one of such MPPT schemes. This paper aims to address the issue of the conventional P&O MPPT scheme under increase solar irradiation condition and its behavior under changed load condition using Digital PWM Controller.**
***Keywords:* PV – Photo Voltaic, MPPT – Maximum Tracking, P & O – Perturb and Observe, PWM – Pulse Width Modulation**

I. INTRODUCTION

A Maximum Power Point Tracker, MPPT is a high frequency DC to DC converter [1]. It takes the DC input, from the solar panels, and changes it to high frequency AC, and then rectifies it back down to a different DC voltage and current to exactly match the panels to the batteries. AMPPT controller “looks” for the point where the sharp peak occurs (below), and then performs a voltage / current conversion to change it to exact values that the battery requires [2]. In reality, the peak will always vary due to changes in light conditions and weather. The application of an MPPT, in the real world, is dependent on the array, climate, and seasonal load pattern [3-6]. If we’re looking for a current boost [22&23], we need a condition in which the V_{pp} is more than about 1V higher than the battery voltage. Ideally, this is most effective when there is cold weather in the winter, because of the high energy use in residential areas, there will be a substantial energy boost [7-10]. In warmer weather, we might not be able to fulfill the V_{pp} condition unless the batteries are low in charge [11&12]. The advantage of high frequency circuits can also contribute to its disadvantage. These circuits can be designed with very high efficiency transformers and small components. However, some parts of the circuit work just like a radio transmitter and “broadcast” signals that causes radio and TV interference. Therefore, noise isolation and suppression becomes very important for a high frequency circuit.

In this paper we have discussed the techniques to increase the light gathering ability of a solar by using solar tracking system and PWM charge controller. We have also tried to improve the efficiency of the solar system by using PWM [14-17& 24]. We have generated PWM by using MPPT control algorithm. Because of the full system is controlled by PWM and MPPT, the efficiency of controller is more. The solar power system which are seen in India at present, are placed in a fixed angle [11]. As a result the solar power system sometimes generate less power or sometimes does not generate any power in a particular time of the day. To get rid of this problem we have made the solar tracking system. The solar panel changes its position with the movement of the sun. Because of the facility of changing position [18-20], it can generate more power than the general solar system.

II. WORKING METHODOLOGY

A. Proposed Block Diagram

In the initial test, the sensor circuit and motor was used to track the sun for a full day. The sensor was mounted on a panel and the motor would rotate the panel to face the sun. The panel would rotate a few degrees at varying time intervals. The setup rotated about 235° for the full day. It was not able to track the sun the next day due to the sensors facing the opposite direction of the sunrise. When sensors detect the sun then it sends a value into the microcontroller. When microcontroller gets those values from sensor then microcontroller use a comparator function and take a decision which sensor has more sun intensity. Thus the panel starts move on this position. Fig.1 shows block diagram.

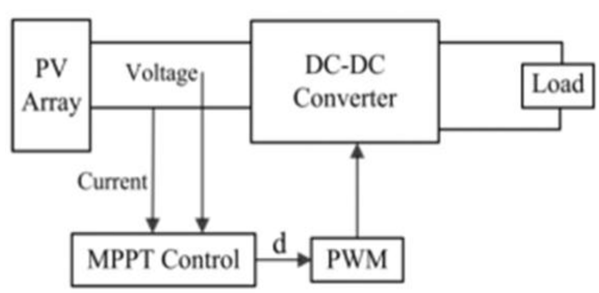

Fig. 1 Overall block diagram

B. Flow Diagram of Pulse Width Modulation (PWM) Charge Controller Using MPPT Algorithm

When solar cell gets proper photon energy then it makes electrical power. It could be approximately 20V. So, it is necessary to control the high current & voltage. For this reason PWM charge controller system is used. This controller works like: When solar cell produces voltage then this voltage is detected by a voltage indicator. After the measurement the detected voltage is controlled by a MPPT controller and using this voltage [21] we can charge our panels battery as show in fig.2.

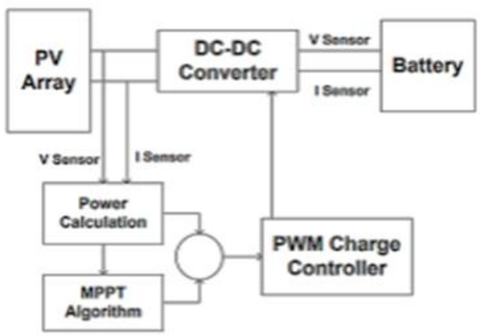

Fig. 2 Flow diagram

III. DESIGN AND IMPLEMENTATION

The overall goal of this work is, to design and implementation of solar Tracker with PWM charge controller. The tracker uses the sun sensor to follow the sun across the sky throughout the day. While building the tracker, some additional physical analysis of the design are made.

A. PWM Charge Controller

Charge controllers, as the name implies, control the flow of charge from the battery and to the battery. They protect the battery by preventing over-charge or deep discharge of batteries to preserve their life and performance. When the battery gets overcharged by solar PV modules, a charge controller will cut it off from the circuit so that no more charging is possible. Similarly, if a battery goes into a deep discharge (or over-discharge) due to excessive use of batteries by the load, a charge controller detects and disconnects the battery from the circuit so that no current can be drawn from the battery. In this way, a charge controller protects the battery. In this paper, we desire to design the Pulse Width Modulation (PWM) charge controller to be used in our tropical country. The PWM charge controllers have same nominal voltage across battery bank and PV array, the Maximum Power Point Tracking (MPPT) which is more electronically sophisticated but functions best at low temperature conditions.

The PWM controls, adjusts the duty ratio of the switches as the input changes to produce a constant output voltage. The DC voltage is converted to a square-wave signal, alternating between fully on and zero. PWM is a way of digitally encoding analog signal levels. It also controls the amount of current charging the battery and provides trickle charging. We have the voltage mode PWM controller which contains all of the features necessary for basic voltage mode operation. This PWM controller has been optimized for high frequency primary side control operation. This type of controller has its unique features with benefits which include;

1. A sink/source gate drives for high efficiency operation.
2. Up to 1MHz frequency which helps to optimize for size or efficiency.
3. External voltage reference also gives reduced component count

B. Mode of Operation

The PWM charge controller also has programmable Pulse-By-Pulse overcurrent protection and overvoltage protection with programmable hysteresis. Fig.1 is a complete circuitry diagram that shows the mode of operation of the PWM charge controller. The Fig.3 also shows how PWM controller is capable of being configured as Forward, boost or battery charge controller.

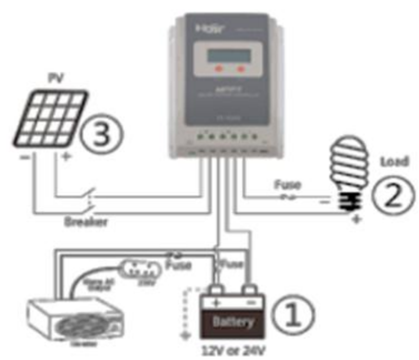

Fig. 3 Connection diagram

C. Design of PWM and MPPT Based Solar Charge Controller

Pulse Width Modulation (PWM) is the most effective means to achieve constant voltage battery charging by switching the solar system controllers' power devices [16]. In PWM regulation [22-25], the current from the solar array tapers according to the battery's condition and recharging needs. The MPPT algorithm operates based on the truth that the derivative of the output power (P) with respect to the panel voltage (V) is equal to zero at the maximum power point. In the literature, various MPP algorithms are available in order to improve the performance of photovoltaic system by effectively tracking the MPP. The controller uses two stages charging algorithm. According to the charging algorithm it gives a fixed frequency PWM signal to the solar panel side p- MOSFET. The duty cycle 0−100% is adjusted by the error signal [12]. The controller gives HIGH or LOW command to the load side p-MOSFET according to the dusk/dawn and battery voltage. The charge controller (Fig.4) is designed by taking care of the following points:

1. *Prevent Battery Overcharge:* The energy supplied to the battery by the solar panel is limited. When the battery becomes fully charged. This is implemented in charge cycle ( ) of the code.

2. *Prevent Battery over discharge:* To disconnect the battery from electrical loads when the battery reaches low state of charge. This is implemented in load control.

3. *Provide Load Control Functions:* This function is to automatically connect and disconnect an electrical load at a specified time. The load will ON when sunset and OFF when sunrise. This is implemented in load control.

4. *Monitoring Power and Energy:* This is to monitor the load power and energy and display it.

5. *Protect from abnormal Condition:* This condition is to protect the circuit from different abnormal situation like lightening, over voltage, over current and short circuit etc.

6. *Indicating and Displaying:* To indicate and display the various parameters.

7. *Serial Communication:* To print various parameters in serial monitor.

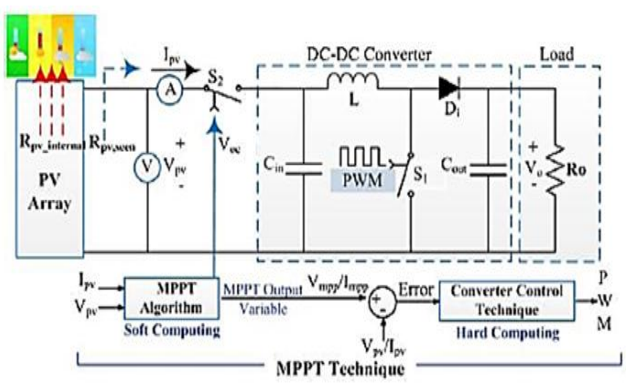

Fig. 4 Internal Circuit Diagram

D. Charging Algorithm & Flowchart

```
#include "mppt_pno.h"
mppt_pno mppt_pno1 = mppt+pno_DEFAULTS;
//mppt pno macro initializations
mppt_pno1.DeltaPmin = 0.00001;
mppt_pno1.MaxVolt = 0.9;
mppt_pno1.MinVolt = 0.0;
mppt_pno1.Stepsize = 0.005;
mppt_pno1.Ipv = IpvRead; \\normalized panel current
mppt_pno1.Vpv = VpvRead; \\normalized panel voltage
mppt_pno_MACRO (mppt_pno1);
        Vpvref_mpptOut= mppt_pno1.VmppOut;
```

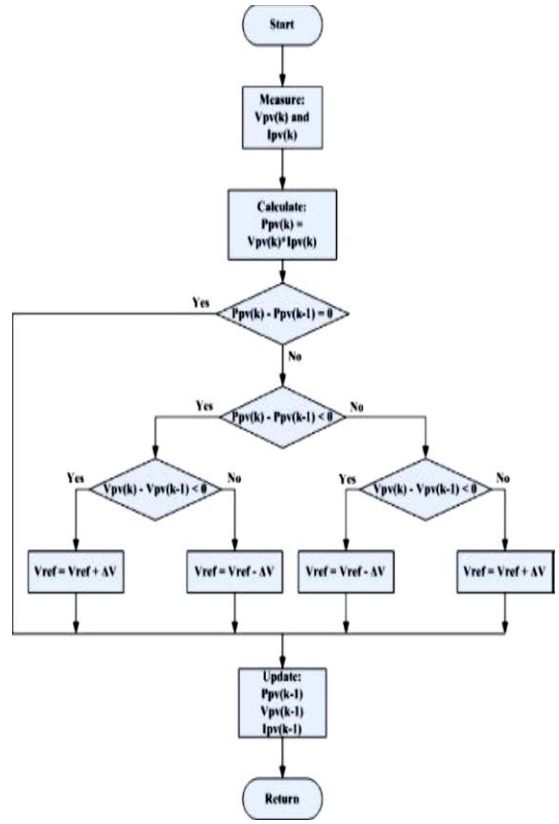

Fig. 5 MPPT algorithm flow chart

IV. CONCLUSION

Renewable energy solutions are becoming increasingly popular. Photovoltaic or solar systems are one good example. In order to maximize power output from the solar panels, one needs to keep the panels aligned with the sun. This is a far more cost effective solution than purchasing additional solar panels when dealing with large panel arrays. In this thesis, the study of the photovoltaic system with maximum power point controller has been developed. We can see the world energy resources depletion to be a major problem & global warming, which is a major concern. Switching to solar power, which is clean and green and enhancing its efficiency by using sun trackers is a great option in the near future. To conclude, this work turned out well and met the original requirements of maximizing the output power from solar using P&O MPPT technic.

V. FUTURE SCOPE OF THE WORK

Different algorithms for maximum power control may be developed for application on other renewable energy sources such as fuel cells and wind power. Artificial neural network algorithms can be developed to improve the performance of the solar energy conversion function of the MPPT. Intelligent devices like microprocessors, Programmable Logic Controllers (PLC) may be added to the system to keep the operating point (maximum power point) for maximum efficiency. To take care of the uncertainty in the insolation level, use of fuzzy control may be done. Use of feedback path for automatic control-position control servo for changing the transformation ratio of variac can be used. The simulation of the PV with three-phase inverter and current control can be performed. Grid Connected PV system with Smart Grid functionality, there is a great need of designing the control system that would control the designed inverter power. The control would be able to integrate the inverter with other renewable energy sources available. The control strategy plays an important role of making the system smart by coordinate with the IT systems such as internet synchronization.

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