Designing of MPPT Charge Controller using PID Controller for PV Cell

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Abstract— this paper presents the implementation of MPPT charge controller using PID controller. The set point given to the controller is the MPP and after the combined operation of PID, output is obtained which controls the parameters of switching and modifies PWM output. The algorithm used for designing the MPPT is Perturb and Observe. The proposed model helps to harvest the maximum power drawn from PV panels and increases the battery life.

Key words: MPPT, PID Controller, Perturb & Observe

I. INTRODUCTION

Presently, there is a significant increase in the demand of energy. Conventional energy sources are unable to fulfill this high demand. Hence, there is an urgent need for an alternative source of energy. Wind energy, tidal energy, solar energy etc. are some of the renewable sources of energy. The United Nations Development Programme in its 2000 world energy assessment found that the annual potential of solar energy was 1,575-49,875 EJ. Due to large magnitude of potential, solar energy is chosen prior to them.

To harness the solar energy efficiently, we make use of solar panels and charge controller. The existing charge controllers such as PWM charge controller has some drawbacks [1], they lock the solar panel voltage to battery voltage by pulling the Vmp down to battery system voltage, and we have to manually feed the value of maximum power point in the controller.

In this paper, we propose an implementation of MPPT charge controller. The algorithm is based on Perturb and Observe method co-operated with PID controller. We have $V_{BATTERY}$, V_{PANEL} and I_{PANEL} given to ADC which is a 10 bit ADC of microcontroller. We get 0 – 1023 levels for working. We have integrated DMM used in the circuit. The output from ADC is given to the register which has 8KB memory. It has sufficient memory provided for 24 hours readings. PID control observes the value of Z. A.I observes the value of Z_{live} which comes from ADC. Z_{live} is the product of V_P and I_P. If $Z_{live} > Z$ then PID control generates PWM and is given to the relay driver. The relays control the chopping and switching and variable DC is converted to fixed DC. Then the DC voltage is given to the panel and then to the battery. To measure the panel current we have used I – V converter and given to the ADC which involves on board multimeter using LM243IC. The relay driver ULN 2003APG is used and is connected to the telephonic relays. All this components are mounted on 15✕10 cm PCB. For display of observation readings we have connected LCD on the PCB.

A. MPPT

The maximum power point tracker (MPPT) is used in grid-tied PV power system MPPT, power electronic device interconnecting a PV power source and a load, maximizes the power output from a PV cell array with varying operating conditions, and thereby maximizing the system efficiency [2].

MPPT is made up of a switch-mode DC-DC converter and a controller. We have selected a MPPT method called as Perturb and Observe algorithm for digital control for MPPT. The design and simulations of MPPT will be carried out with the help of controller. In a Power-Voltage or current-voltage curve of a solar panel, there is an optimum operating point at which the PV delivers the maximum possible power to the load. This unique point is called as the maximum power point (MPP) of solar panel.

The current - voltage curves of a photovoltaic cell depend on temperature and irradiance levels. Therefore, the operating current and voltage will change with environmental conditions. Therefore it is important to track the maximum power point (MPP) for an efficient PV system. So a maximum power point tracker (MPPT) is very essential and needed. In most PV systems a control algorithm, namely maximum power point tracking algorithm is used to have an efficient PV systems.

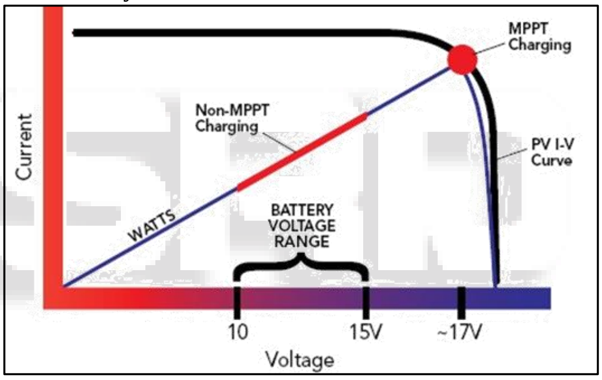

Figure reproduced from http://www.midsummerenergy.co.uk/images/MPPT-diagram.png

Fig. 1: V – I curve for MPPT system

B. PID Controller

The given figure shows the PID controller in which P is the K time's proportion of error, I is the K time's integration of error and D is the K times derivative of error. I is the slow operation and D is the fast operation and the combination of these three gives a good output with fast operation [3]. The set point given to the controller is the MPP and after the combined operation, output is obtained which controls the parameters of switching and modifies PWM output.

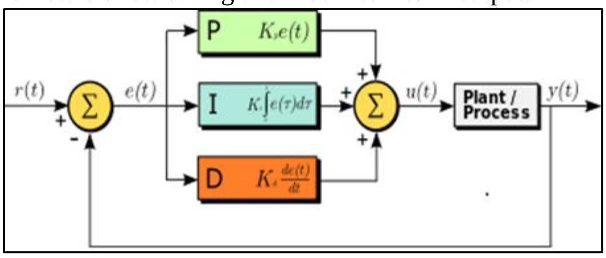

Fig. 2: Block diagram of PID controller

$$u(t) = K_p e(t) + K_i \int_0^t e(\tau)\, d\tau + K_d \frac{de(t)}{dt},$$

C. Perturb and Observe

In P & O there is a perturbation in the operating voltage of the PV panels. When the PV arrays are connected to the power converter, the perturbation in the duty ratio perturbs the PV current and then perturbs the PV voltage [4].

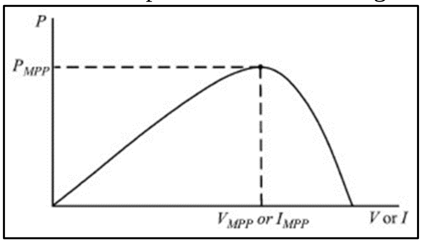

Fig. 3: Reproduced from Comparison of Photovoltaic Array Maximum Power Point Tracking Techniques.pdf

The fig 3 shows that when the voltage increases, the power increases on the left of the MPP and decreases on the right of the MPP. If the power increases the subsequent perturbation will be same and if the power decreases the perturbation gets reversed. P & O method also works for instantaneous PV array voltage and PV array current. This process is periodically repeated till the MPP is achieved. The system generally oscillates at maximum power point and these oscillations do not give accurate MPP. These oscillations can be prevented by reducing the perturbation size which leads to slow down the MPPT system.

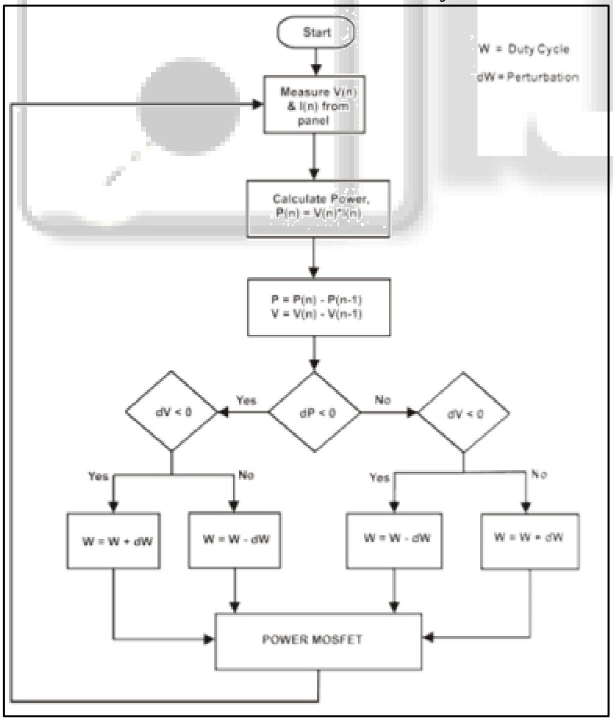

Fig. 4: Flow graph

II. Block Diagram of Our Proposed System

Relay can be used in switching PV cell voltage to battery. If battery goes below 6V then direct charging starts and the controller stops working. The relays go back to their default position and the panel is connected to battery for charging. We are using Atmega8 which has an inbuilt ADC to avoid external current - meter and voltage – meter. Relays are mainly used for switching. DC – DC chopper is used to convert the specific value of DC to another value of DC. It is mainly used to control PWM to avoid overcharging of the battery. If the battery is fully charged then the extra voltage is absorbed by the transistors used in the chopper and thereby avoiding the damage caused to the battery due to overcharging. Diode is used for main purpose of unidirectional flow of current. Only solar panel can charge the battery and not in the reverse way.

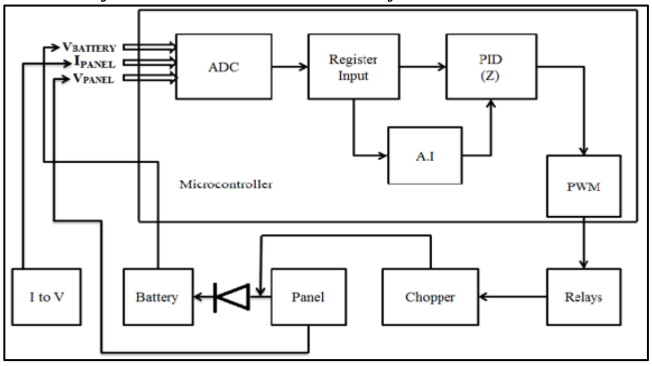

Fig. 5: Block Diagram

III. Results

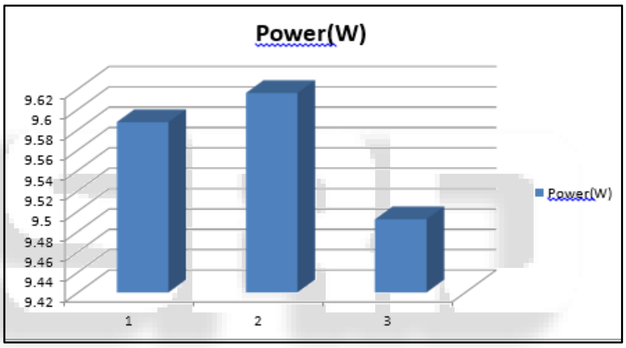

Fig. 6: Results

Plotting the values of P_{MAX} on power versus day graph.

The values of maximum power on each day is obtained by multiplying the maximum voltage values and maximum current values shown in above figures. These values of maximum power are plotted in the power versus day graph. It is seen in the fig.6.6 that the power increases till 2nd day and reduces on third day.

IV. Conclusions

The main purpose of MPPT system is to obtain the maximum solar power which can be converted into the electrical energy. By adjusting the operating voltage of solar cells, the maximum power point can be achieved irrespective of the atmospheric conditions such as temperature; irradiance etc. and whole power of the solar panels can be transferred to the battery for charging. It is seen that among all the MPPT techniques, perturb and observe method is very efficient and its algorithm is used widely in the PV systems. We have used perturb and observe algorithm to achieve the maximum power point by daily keeping a track of the product of VMPP and IMPP calculated by the microcontroller. The MPP tracking efficiency is observed and confirmed by results obtained on carrying out various experiments. Thus the maximum solar energy is consumed and converted into electrical energy which is used by many electrical appliances and so the main objective of our project is fulfilled.

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