IMPLEMENTATION OF INCREMENTAL CONDUCTANCE METHOD FOR BATTERY CHARGING USING SOLAR ENERGY

Jay S Mehta
Assistant Professor
Department of Electronics & Telecommunication,
A.P. Shah Institute of Technology, Thane, India

Abstract : A solar powered charger is proposed in this paper, where a photovoltaic (PV) panel is used to convert solar energy into electricity and a DC-DC voltage converter and regulator is employed to regulate the output power of the photovoltaic panel and therefore the charging current for the battery. While simulating, an optimum control algorithmic (incremental conductance) method is applied to get the utmost obtainable power from the sunshine. The simulation and experimental results are presented and compared. The applications of this method may be as light-weight electrical vehicles such as golf carts, scooters, airdrome utility vehicles, also as alternative renewable power stations where batteries are used for energy storage.

***IndexTerms* - Battery chargers, DC-DC converters, Solar Energy.**

I. INTRODUCTION

Applications of alternative energy has been a research topic for many years. In recent years, it has attracted even additional interest thanks to the adverse effects on the atmosphere, crude dependency, oil prices and growth in automotive industries. Exploiting solar energy to charge batteries isn't a brand new idea. A straight forward way to accomplish this is to attach a photovoltaic (PV) panel on to battery. To prevent the reverse current from the battery, a diode is typically used as shown in Figure 1(a). The benefits of such a system are the simplicity and low price. The disadvantages are: 1) the PV panel will solely give charging current when its output voltage is over and above the battery voltage; 2) the charging current will decrease once the voltage difference decreases because of an increasing battery voltage or a decreasing PV output voltage; 3) the system doesn't forever work on the optimum to convert the solar energy into electric energy[1]. To boost the system performance, a controller is often added between the PV panel and the battery as shown in Figure 1(b). The controller is sometimes a DC-DC converter. It would be a buck/boost to take into account conditions where the PV panel voltage is higher or lower than the battery voltage. In such a system an optimum control algorithm can be used to convert maximum solar energy into electrical energy and charge the battery. This paper presents the design of a solar powered battery charger with optimum controller. The goals of the system are: 1) to convert the solar energy into electrical energy under diverse weather condition; 2) to charge the battery as quick as achievable in accordance to the battery lifecycle condition. The uses of the proposed system are lightweight electrical vehicles like golf carts, scooters, airdrome utility vehicles, as well as charging other renewable power stations employing batteries as energy storage[2].

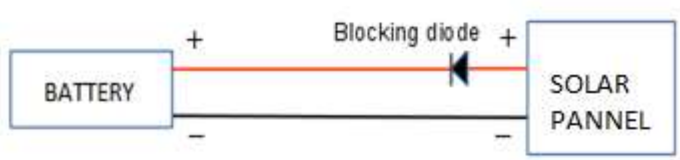


Fig 1 (a): Photovoltaic Panel with Diode

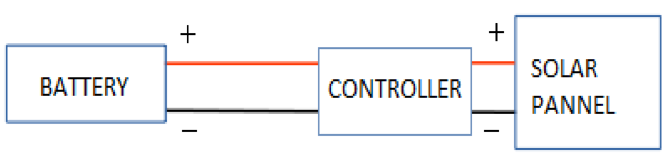


Fig (b): Photovoltaic Panel with Controller

II. SYSTEM DESIGN

The proposed system is shown in figure below (fig. 2) and it consists of the following parts:

a) **A Photovoltaic Panel:** It converts the solar power into direct current. The power output will depend upon the amount of energy incident on the surface of the cell and the operating temperature of the photovoltaic cell. The power output of a single cell can supply small loads like calculators or watches. For the proposed system I have used a solar panel of Power rating of 200W[2].

b) **DC/DC Converter:** In line with the system specification, a step-up (boost) converter is used, which consists of a power MOSFET, a power diode, an inductor, and a couple of input / output capacitors. The topology will be illustrated within the simulation model.

c) **MOSFET Driver:** It is an integrated circuit (IC) chip, that amplifies the PWM control signals from the arduino uno board and control the switching of the power MOSFET[5].

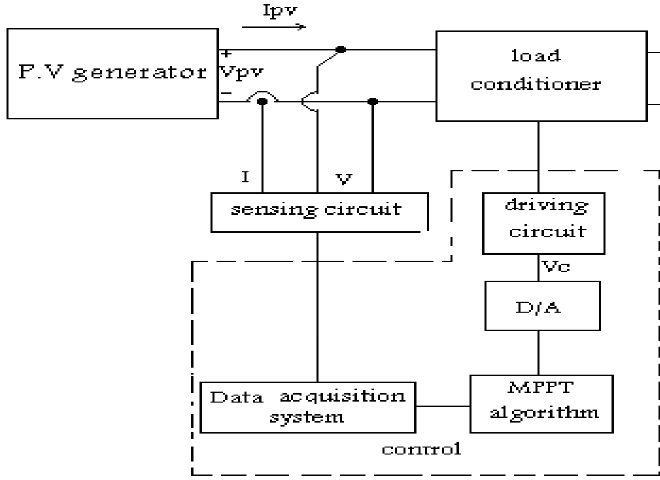


Fig. 2: Block Diagram of the Proposed System

d) **Input Sensing Circuit:** Sensors measuring the input voltage (Vin) and current (Iin). Based on the measurement, the input power of PV panel will be calculated as Pin= Vin× Iin.

e) **Output Sensing Circuit:** Sensors measuring the output voltage (Vo) and current (Io). The output voltage (Vo) represents the charge level of the battery, and the charging current (Io).

f) **Arduino Uno Rev3:** It is a microcontroller board based on the ATmega328. It has 14 digital input/output pins (of which 6 can be used as PWM outputs), 6 analog inputs, a 16 MHz crystal oscillator, a USB connection, a power jack, an ICSP header, and a reset button. It contains everything needed to support the microcontroller; simply connect it to a computer with a USB cable or power it with a AC-to-DC adapter or battery to get started.

III. INCREMENTAL CONDUCTANCE ALGORITHM:

The Incremental Conductance method has been proposed to avoid the drawbacks of the P&O MPPT method. It is based on the fact that the derivative of the output power with respect to the panel voltage is equal to zero at maximum power point. The output voltage and current from the PV panel are monitored upon which the MPPT controller relies to calculate the conductance and incremental conductance, and to make its decision (to increase or decrease duty ratio output). From the PV characteristic of PV panel that shown in Figure (8). The derivative is positive to the left of the maximum point and negative to the right of the MPP. Mathematical of the Inc.Cond. algorithm is discussed below[4].

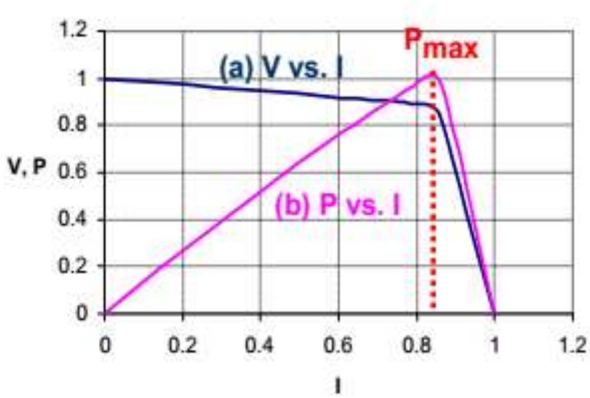


Fig. 3: Typical Output Characteristics of a PV Panel

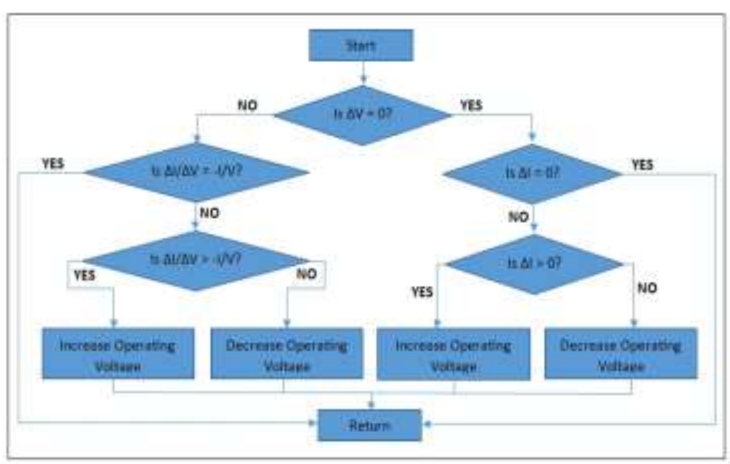


Fig. 4: Flowchart of Incremental Conductance Method

The derivative of output power is,

$$\frac{dP}{dV} = V\frac{dI}{dV} + I = 0 \quad \text{(1)}$$

$$\therefore \frac{dI}{dV} = -\frac{I}{V} \quad \text{(2)}$$

This leads to the following set of equations:

$$\frac{dP}{dV} > 0 \text{ at the left of MPP} \quad \text{(3)}$$

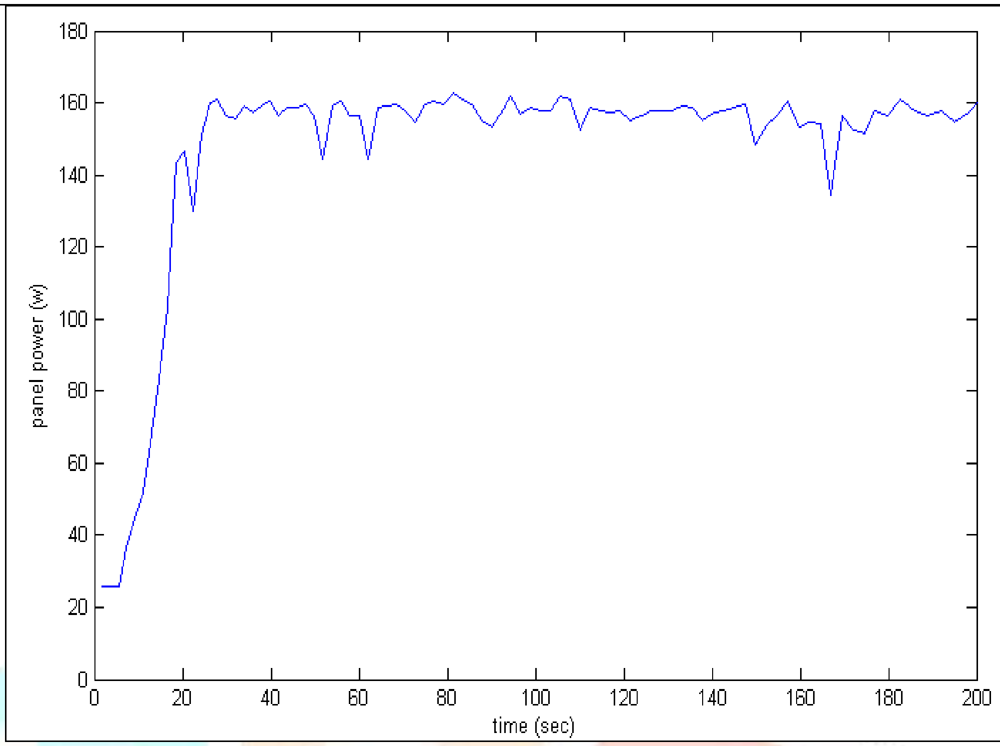
$$\frac{dP}{dV} = 0 \text{ at MPP} \quad \text{(4)}$$

$$\frac{dP}{dV} < 0 \text{ at the right of MPP} \quad \text{(5)}$$

The main goal of the incremental conductance algorithmic program is to get the utmost out there solar energy from the PV panel. The input voltage (Vin) and current (Iin) of the system are the output voltage and current of the PV panel. The relationship of Vin vs. Iin is the key feature of a PV panel. Figure below presents the standard characteristics of a PV panel, which has the following 2 curves: (a) V vs. I curve, (b) Power (P) vs. current (I) curve. The curve (b) indicates clearly that there is a maximum point of output power. This maximum power is going to vary in accordance with the atmosphere condition[6].

IV. Experimental Results

Figure 5 shows a measured start-up process, where C the output power to the battery. It can be seen from the waveform, that the output voltage is controlled at a constant value after the start-up process. The controller is increasing the input current gradually, the input voltage from the PV panel decreases according to its I-V curve. The battery charging current increases accordingly until the maximum power is achieved. Then the battery charging current will decrease due to the decreasing power. The controller will shut down the PWM signal when the PV voltage drops below the under voltage protection limit (18V), and starts again after the PV voltage resumes. Since the battery voltage dose not change very fast, the maximal power is achieved when the battery current reaches its maximal value.



V Conclusion:

This paper presents the design of a solar powered battery charger using incremental conductance method. It consists of a DC/DC converter and a arduino uno, where the algorithm is implemented in the software of the micro-controller. Simulation is conducted on the DC/DC converter, and the results are plotted. A prototype is built following the design, and the experiment results indicate that the prototype is working properly.

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