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ANALYSIS OF INCREMENTAL CONDUCTANCE AND PERTURB AND OBSERVE METHODS OF MAXIMUM POWER POINT TRACKING FOR PHOTOVOLTAIC SYSTEM

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ABSTRACT:

Maximum Power Point Tracking (MPPT) algorithms are significant in solar systems because PV systems have non-linear behavior and its power is dependent on solar irradiations. MPPT algorithms are utilized to exploit the efficiency of solar generators and shrink the photovoltaic array cost by decreasing the number of photovoltaic panels essential to attain the chosen solar output power. This paper signifies comparative experimental results of two main MPPT algorithms particularly perturb and observe and incremental conductance. These algorithms are popularly used as its benefits are its low-cost and easy to implement. Some vital constraints such as voltage, current and power output for each special combination have been traced for both algorithms. Hardware experimental design is been implemented for performance investigation of both the algorithms by a 50W photovoltaic (PV) array.

KEYWORDS: Maximum power point tracking (MPPT), Perturbation and observation (P & O), and Incremental conductance (InC).

1. INTRODUCTION:

The solar photovoltaic (PV) generation symbolize at present one of the most hopeful sources of renewable energy. It offers lots of advantages such as the energy produced is not polluting, necessitate little maintenance, and most promising, clean and inexhaustible energy [1] [2]. Therefore, photo-voltaic (PV) systems have fascinated more attention. The aim of the progress of PV systems is maximizing the effectiveness of power conversion and dropping the cost. Indeed, the solar output peak power provided by the photovoltaic module depend on the irradiation, temperature, and electrical loads and it has a maximum (MPP) at a definite effective point [3]. At the MPP (Maximum Power Point), the PV functions at its peak efficiency.

Therefore, to extort the peak power under the different environment stated earlier, a maximum peak power point tracking (MPPT) method is used to control the varying operating output power point of the photo-voltaic array through a DC-DC converter. The MPPT controller can be realizing based on different methods and algorithms. The most popular methods are known as Perturb and Observe (P&O) and Incremental Conductance (INC) [4]. This paper represents, a proportional study between P&O and INC MPP algorithms used to control DC-DC boost converter so as to generate the MPP for 50 Watts PV array. This work is planned as follows: solar cell representation and the experimental setup of the 50 Watts PV module specified in section 2 and 3, respectively. In section 4, the P&O and INC algorithms are discussed. Of course, the experiment results of photovoltaic system are presented and specified in section 5, so as to assess the performance of these algorithms. Eventually, conclusion is presented in section 6.

2. SOLAR CELL MODELING:

Solar cells are fundamentally an incredibly large area p-n junction diode. This kind of diode is created by structuring a connection between the P and N type of semiconductor regions [5]. As solar shines on a photovoltaic cell, the incidental light energy is represented into proportional electrical energy. Solar light is captivated into the semiconductor by utilizing the energy to form free electrons from a low energy band to a higher energy band. When a photo-voltaic cell is shined by light, more electron-hold pairs are produced throughout the material, hence the current will flow [6]. The diagram shown in figure (1) explains the photo-generation of charge carrier.

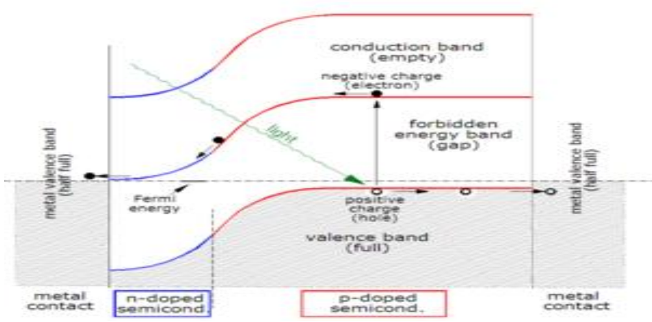

Figure 1: silicon solar cell.

To recognize the electronic performance of a solar cell, it is valuable to create a model which is electronically equivalent, and is dependent on discrete theoretical components whose working is well stated. A theoretical solar cell may be modeled by a current source in shunt with a semiconductor diode; in real no solar cell is ideal, so a parallel resistance and series resistance elements are also represented to the model [7]. The resultant equivalent electrical system of a solar PV cell is shown in figure (2) is a current source in shunt with a diode. The output current provided by the current generator is proportional to the incident light falling on the cell.

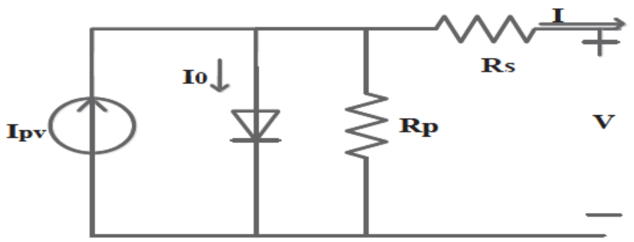

Figure 2: electrical equivalent of solar cell

3. EXPERIMENTAL SETUP:

Experimental setup includes 50 watts solar panels, MPPT unit and sun tracking unit.

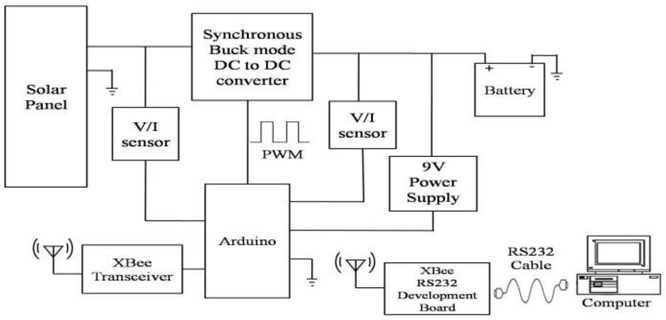

Figure 3: MPPT unit

I have utilized 12V 50W monocrystalline solar panel. As shown in figure 3 the MPPT unit consists of charge controller which is implanted with MPPT algorithm to increase the quantity of current entering into the battery from Photovoltaic module. MPPT is chopper circuit (DC to DC converter) that works by receiving DC input from solar PV module, changing it to alternating quantity and translate it again to a specified direct voltage and direct current to equivalent the solar photovoltaic module to the battery.

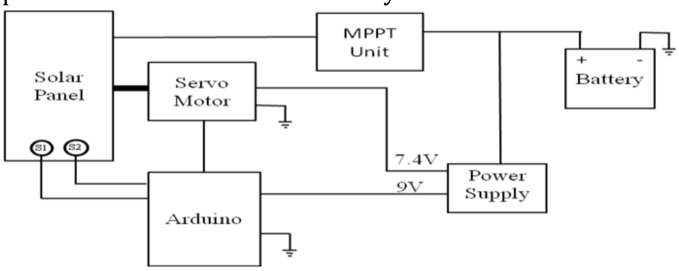

Figure 4: sun tracking unit

Figure 4 Shows block diagram of the sun tracking unit. It consists of servo motor, LDR sensors, battery for supply, power supply unit. The LDR sensors senses light intensity which is then used to move a servo and rotating panel for tracking the strongest light level. Output of these sensors are interfaced to A/D channel of Arduino board on the voltage input using which PWM signal is generated. Arduino is used to operate the servo motor. MPP unit will energize the battery as described previously. Power supply circuit is designed to provide voltage of 7 V for servo motor and 9V for Arduino. Servo motor is connected to solar photovoltaic panel by hardware assembly.

4. MPPT ALGORITHMS:

A. PERTURBATION AND OBSERVE METHOD:

The most popularly used MPP (method) algorithm shown in figure 5 is the Perturb and Observe (P&O), due to its ease of realization in its basic form. In this method the solar module voltage is first perturb and output power is calculated. The perturbation grounds the power of the solar panel to modify continuously. If the solar output power increases on increasing voltage (dP / dV > 0), it is means that the perturbation has made to move the array's operating point toward the MPP and hence the voltage is further increased so as to continue in the same direction. If the power decreases on increase in voltage (dP / dV < 0), then the variation in operating point has made the PV array to move far from the MPP and hence the voltage of panel is decreased to search for higher value of output power. Since the algorithm always keep searching for MPP, the P&O algorithm tracks the panel output power oscillating around MPP in steady state operation; it has slow reaction speed, & also tracing in incorrect way under quickly varying surrounding atmospheric conditions [9].

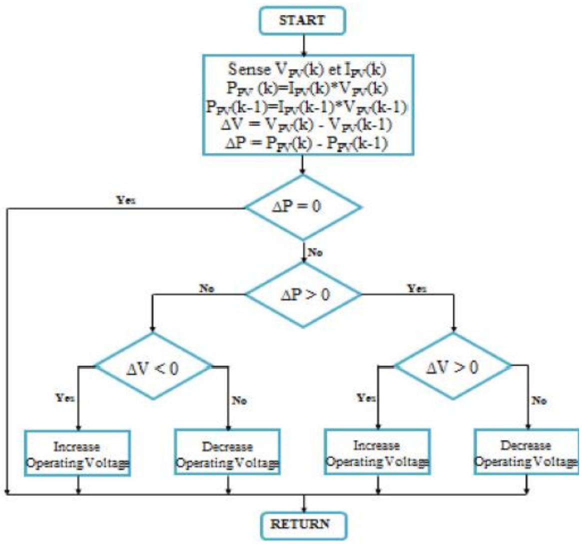

Figure 5: P & O algorithm.

B. INCREMENTAL CONDUCTANCE METHOD:

Incremental Conductance (IC) method overcome the limitation of perturbation and observes method in tracking the output power under rapid changing atmospheric condition. It is probable to show that, at the MPP dI/dV=-i/v. This process can find whether the MPP has searched the MPP and then stops finding the operating point. If this situation is not achieved, the direction in which the MPPT operating point must be perturbed can be calculated using the condition between dl/dV and –I/V. This correlation is obtained from the sense that change in power with respect to voltage is negative and if the MPPT is on the right side of the MPP and positive if it is on the left side of the MPP [l0] [11]. The INC can trace the rapidly varying irradiation conditions with greater correctness than P&O. The limitation of this algorithm is the design complexity when related to perturb and observe indirectly extending calculation time [l1]. The algorithm can be studied by the following operational flow-chart diagram which is shown in figure 6.

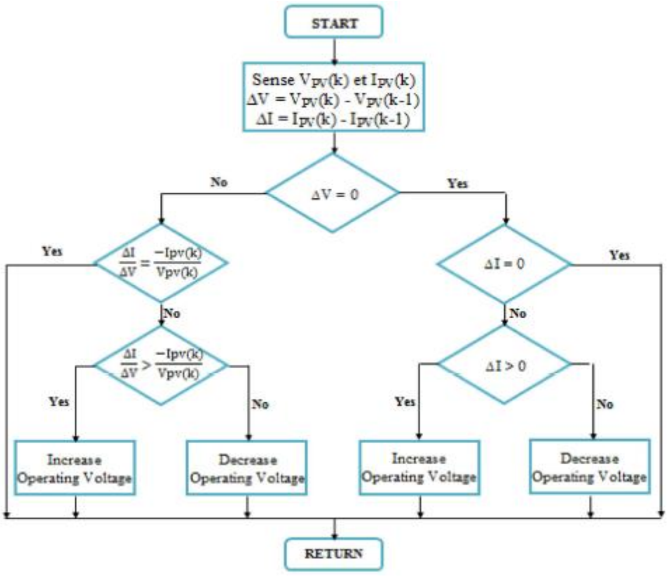

Figure 6: InC algorithm

C. RESULTS:

The hardware setup results are also implemented with the same solar PV panel. In the solar tracking strategies, a servo motor is used as the source to rotate the solar photovoltaic panel. This motor is run with the output signals which are received from the LDRs. The block diagram and setup of the experiment are shown in Fig 4. The experimental results of obtained maximum output power using the P&O and InC algorithm under the stable solar irradiation are as shown in figure 7 and 8 respectively and is examined by measuring the voltage and current for the same load at different times; and calculating the total power. These results also show that the output power always tracks the MPPs.

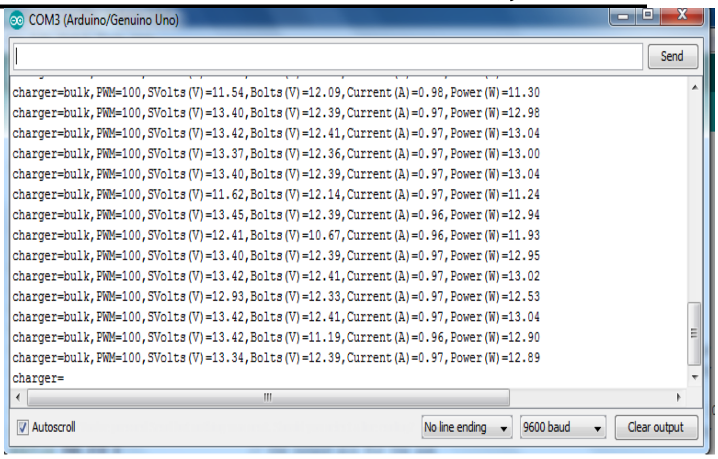

Figure 7: results of P&O

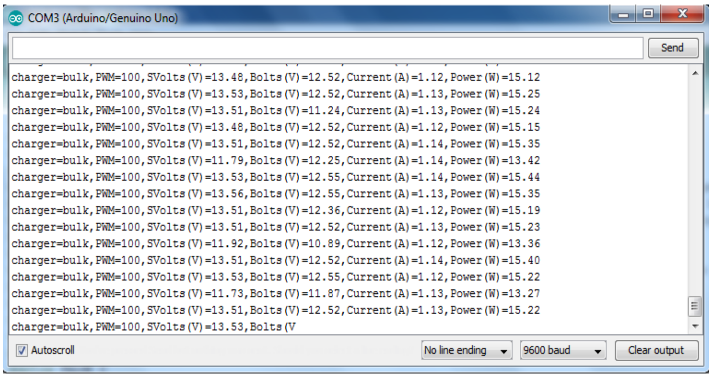

Figure 8: results of InC

D. CONCLUSION:

From the above observations, the incremental conductance (InC) algorithm is suitable as it is able of reducing the ripple about the maximum operating power point and has advantages of exact perturbing and tracking direction and steady maximum operating voltage whereas P & O algorithm have oscillations around the MPP.

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