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Incremental Conductance Maximum Power Point Tracking Algorithm for Photovoltaic System

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Abstract - Solar energy is one of the most important renewable energy sources that have been gaining increased attention in recent years. The foremost way to increase the efficiency of a solar panel is to use a Maximum Power Point Tracker (MPPT), a power electronic device that significantly increases the system efficiency. By using it the system operates at the Maximum Power Point (MPP) and produces its maximum power output. Thus, an MPPT maximizes the array efficiency, thereby reducing the overall system cost. In addition, we attempt to design the MPPT by using the algorithm of a selected MPPT method which is “Incremental Conductance” and implement it by using a DC- DC Converter. Photovoltaic generation systems generally use a microcontroller based charge controller connected to a battery and the load.

Key Words: *Photovoltaic Cell, Incremental Conductance (IC) MPPT Algorithm, ARM7TDMI, DC-DC Converter.*

1. INTRODUCTION

Renewable energy sources are fast becoming an alternative to traditional fossil fuels due to their advantages of being clean and inexhaustible mainly. Solar power is one of the renewable energy sources and although it has a high potential its generation efficiency (conversion of solar energy to electricity) is low with most commercial solar panels having efficiencies of less than 30%. With this already low power generation efficiency of solar panels it is only necessary that the maximum power is sourced from that generated by solar panels to ensure high efficiency in delivering power to the load to make solar power an effective alternative and justify its high installation costs too. e. g. solar tracking to track the sun as it moves across the sky or by indirect methods e.g. Maximum power point tracking the latter being in the purview of this document.

Using MPPT charge controllers reduces the number of PV modules that need to be installed to generate a certain power by maximizing the power generated from the critical number of PV modules needed to generate the power at high efficiency.

In order to address the challenges of low efficiencies in solar harvesting some of the causes being significant energy loss when the solar panel is directly connected to a battery and the non-linear I-V operating characteristics of solar panels which vary with atmospheric characteristics such as insolation and ambient temperature. Several MPPT charge controllers have been proven to boost efficiency while increasing the maximum charging current delivered to load by 30% in comparison to PWM charge controllers -which do not track maximum operating power point of PV modules - and the project aims at building an economical microcontroller based MPPT charge controller to be part of the solution.

2. SYSTEM CONCEPT

The proposed system is to present a novel cost effective and efficient microcontroller based MPPT system for solar photovoltaic system to ensure the maximum power point operation at all changing Environmental condition. The P&O MPPT algorithm is used to control the maximum transfer power from a PV panel. This algorithm is executed by pic microcontroller using the PV voltage and current data to control the duty cycle of a pulse width modulation signal applied to a DC/DC converter.

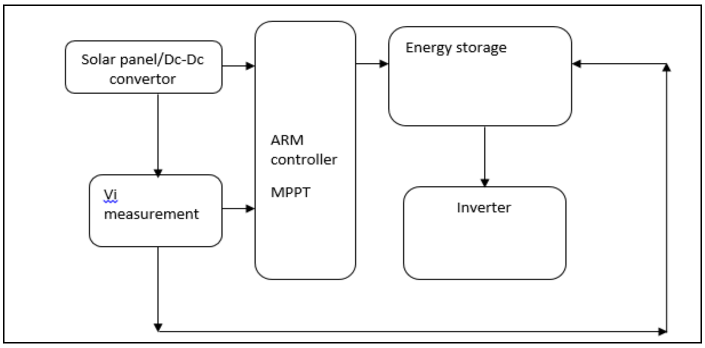

Figure -1: *Block diagram of MPPT controller*

The MPPT control circuit is implemented in a microcontroller, that has eight 10-bits analog-to-digital (A/D) converters and two four PWM mode signals. The buck converter is controlled by the microcontroller. It read the voltage and current of the solar panels through the A/D port of controller and calculates the output power. It also calculate power by reading the voltage and current of battery side in same way and send corresponding control signal to the buck converter and control the duty cycle of the converter by PWM signal through controller to accordingly increase, decrease or turn off the DC to DC converter.

The commonly used a converter in PV systems is a DC/DC power converter. It ensures, through a control action, the transfer of the maximum of electrical power to the load. The structure of the converter is determined according to the load to be supplied. In this article we focus on the step-down DC/DC converter (Buck converter). MPPT uses the same converter for a different purpose, such as regulating the input voltage at the Maximum power point and providing load matching for the maximum power transfer.

It is proposed to use Incremental Conductance Maximum Power Point Tracking algorithm. Due to ease of implementation and cost effectiveness, it is the most commonly used Maximum Power Point Tracking method. The voltage to a cell is increased initially, if the output power increase, the voltage is continually increased until the output power starts decreasing. Once the output power starts decreasing, the voltage to the cell decreased until maximum power is reached. This process is continued until the Maximum Power Point Tracking is obtained. This result is an oscillation of the output power around the Maximum Power Point. Photovoltaic module's output power curve as a function of voltage at the constant irradiance and the constant module temperature, assuming the Photovoltaic module is operating at a point which is away from the Maximum Power Point.

2.1 Maximum Power Point Tracking

The use of MPPT is the extracting the concentrated power at any environmental condition. Using the MPPT technique, definitely improve the efficiency of PV panel. Here we are using Incremental Conductance (IC) MPPT technique.

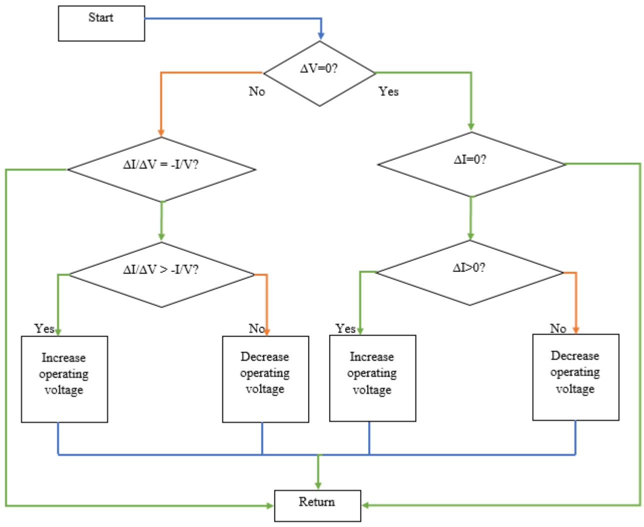

Figure-2: *Flowchart of IC MPPT*

In this technique, first of all the current and voltage of PV is sensed. The power is given by the reproduction of voltage and current of solar panel. The output power is increasing due to the PV current increases. So the reference current is also increased otherwise the reference current is decreased. If the output power reduced with increasing solar panel current, the reference current is decreased by one step; otherwise the reference current is increased by one step. If the power is increasing, the perturbation will be in the forward direction otherwise direction will be inverted. Due to this continuous process PV panel is able to extract maximum power in any environmental condition.

2.2 Results

Hardware and software portions of the project were separated into stages while developing the overall system. The portions consisted of panel testing, battery testing, sensor testing and MPPT charge controller software testing. Building and testing smaller individual sections of the system on the PCB made the project more manageable and increased efficiency by decreasing debugging time.

The voltage and current sensors were the key to determining the solar panel output power which is key in the IC Algorithm and also to determine the charging mode of the battery. The sensors thus had to inadvertently be accurate for efficient and effective performance. The voltages and currents displayed on the LCD as measured by the microcontroller and the results found an outstanding degree of accuracy as shown in the tables below.

Time	Normal panel voltage	MPPT	Battery charging
7AM	9V	11.12V	10V
8AM	10V	12.6V	10.8V
9AM	10.8V	13.7V	11.9V
10AM	12V	13.9V	13.3V
11AM	12.7V	14.3V	13.5V
12PM	13.8V	14.5V	13.8V
01PM	14.9V	14.0V	13.9V
02PM	14.6V	14.0V	14.2V
03PM	14.0V	13.5V	14.3V
04PM	10.9V	13.2V	14.3V
05PM	9V	13.0V	14.0V
06PM	8V	12.0V	13.9V

Table-1: *MPPT charge controller efficiency test*

The software tested at different times and different conditions to see if it the system status indicators displayed the actual system status. The results were tabulated below Figure on MATLAB for Battery charging and discharging.

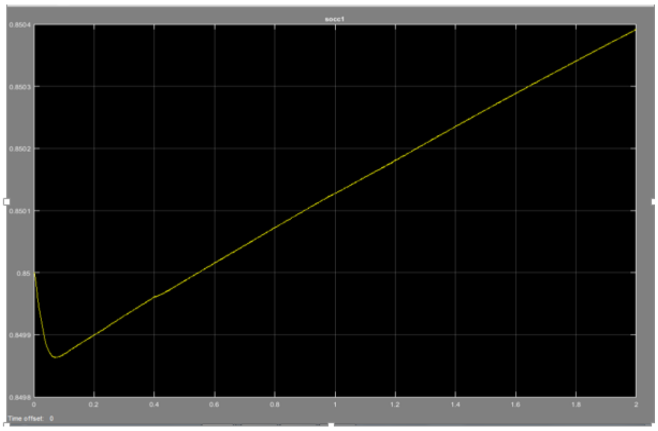

Figure-3: *Battery SOC while charging*

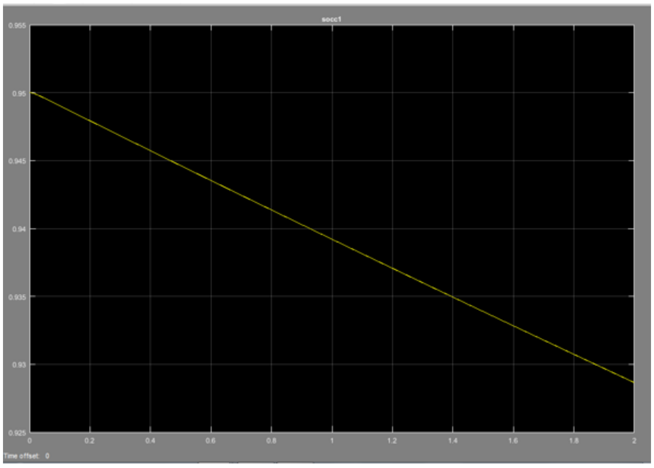

Figure-4: *Battery SOC while discharging*

3. CONCLUSIONS

The focused on creating a MPPT charge controller with a maximum charging current of 20A to help encourage the use of renewable energy in the form of solar power throughout the world by building a basic, cheap, adaptable, elementary and durable one. An introduction to solar panels and their electrical characteristics has been presented in the literature review. The P-V and I-V curves of the solar panel were of noteworthy importance and based on these characteristics, the significance of maximum power point tracking has been shown. This was followed by carefully designing the hardware and software that constitute an MPPT charge controller in order to address the challenges of the non-linearity in a solar panel power curve. A buck converter was decided on, with a Incremental Conductance algorithm implementing the tracking.

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