



Solar Powered DC- DC Converter with Maximum Power Point Tracking Control

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Abstract— Photovoltaic (PV) is a technical name for solar panel in which light (photon) energy from the sun is converted to direct current (DC) Electrical Energy. The power output from the panel is still low, continuous efforts are taken to develop the DC-DC converter and controller for extracting maximum power efficiency and to reduced cost. The maximum power point tracking (MPPT) is a process one which tracks maximum power point from input, varying the ratio between the voltage and current delivered, to get the most power from the solar panel. A number of algorithms have been developed for extracting maximum power. Our project details the study of incremental conductance and perturb and observe MPPT algorithm. And it can be experimentally verified by modeling the PV system with MPPT algorithm in MATLAB/Simulink Software.

Keywords – Photo Voltaic (PV) Module, Incremental conductance, Perturb and Observe, Maximum Power Point Tracking (MPPT), Microcontroller, MATLAB.

I. INTRODUCTION

The boost converter is designed to step up a variable input voltage to a constant output voltage. The microcontroller is used to generate PWM signal to control switching action between Metal Oxide Semiconductor Field Effect Transistor (MOSFET).

The DC to DC boost converter is used to step up the solar panel voltage. The tool that has been used for circuit simulation, validation and PWM generation are MATLAB software.

The input of the boost converter is measured continuously and the values are sent to the microcontroller unit to produce pulse-width modulation (PWM) signal. The PWM signal is used to control the duty cycle of the boost converter. Typical-application of this boost converter is to provide DC power supply for the charging of battery.

II. SYSTEM DESCRIPTION

The block diagram of our project is shown in the figure. The input supply obtained from the solar panel is connected to the boost converter circuit and to the microcontroller through voltage and current sensor. The sensors which reduces the input, which is required for the controller. The output of the sensors were connected to the Analog to Digital Converter of the controller. The controller generates the PWM signal which is given to the boost converter, to perform switching control action. According to the varying inputs of the sensors the controller adjusts the duty cycle of the PWM signal. Thus the constant output is maintained provided at load side under all conditions.

There are different algorithms used for performing Maximum Power Point Tracking of the PV system. Of those algorithms we are choose the best, which offers a good performance under quick changes in weather conditions.

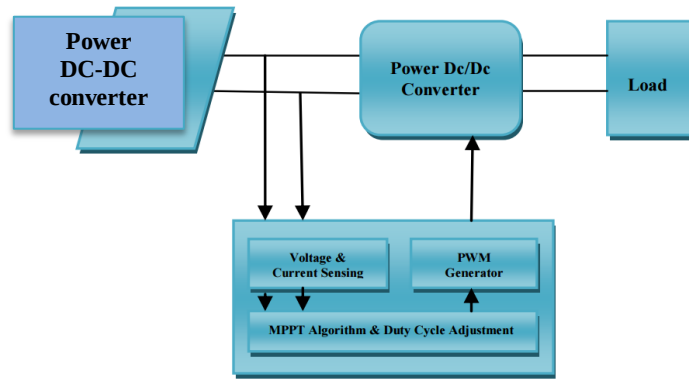


Figure-1 Block Diagram

III. BOOST CONVERTER DESIGN

A. Duty cycle

The duty cycle can be found using the following relation

$$D=1-(V_{in} / V_0)$$

B. Inductor value

The value of inductor is determined using the following relation

$$L_{min} = D (1-D)^2 * R / 2 * F_s$$

C. Capacitor value

The value of capacitor is determined from the following equation, Where

$$C=D / F_s * R * V_r$$

C is the minimum value of capacitance,

D is duty cycle,

R is output resistance,

F_s is switching frequency,

V_r is output voltage ripple factor.

IV. BOOST CONVERTER WORKING

A. Operation of boost converter

The DC-DC boost converter is used to convert the unregulated dc output at a desired voltage level. They generally perform the conversion by applying a dc voltage across the converter which causes current to flow through an inductor for a period of time and stores energy magnetically, then the voltage applied to the gate is off and causing the stored energy to be transferred to the voltage output in a controlled manner. The output voltage is regulated by adjusting the duty cycle. This is achieved using switched-mode, or chopper circuits whose elements dissipate negligible power. Pulse-width modulation (PWM) allows control and regulation of the total output voltage. It is considered as the heart of the power supply, thus it will affect the overall performance of the power supply system.

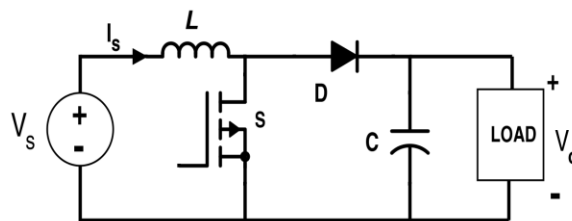


Figure-2 Boost Converter

B. Modes of operation

a. Mode-1 operation

When the MOSFET is in ON state (closed), the whole circuit will be divided into two, one at the input side and another at the output side. The closed circuit at the input consisting of an inductor gets charged by the current flowing through the circuit for a period. This current will increase linearly till the switch is in closed condition. In the same time interval, inductor voltage is also high, it is not delivered to any load but to itself. During this period diode is in OFF state.

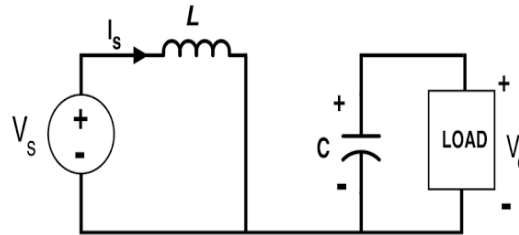


Figure-3 Mode-1 Operation

b. Mode-2 operation

When the switch is in OFF state (Open), there will be a closed loop consisting of power source, inductor and load. The energy stored in the inductor during ON state is discharged to the load through the diode. Thus an inductor current is reducing linearly, charging the capacitor at the load side.

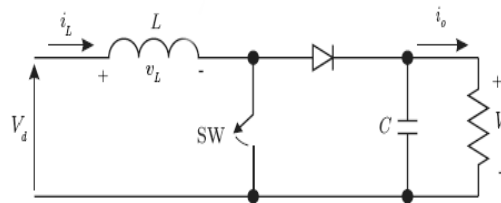


Figure-4 Mode-2 Operation

V. MPPT ALGORITHM

Maximum Power Point Tracking (MPPT) is a technique used to extract maximum power from the wind turbine and solar systems under all conditions.

A. MPPT Implementation

The MPPT can be implemented by various algorithms, generally these algorithms are implemented by microcontroller or microprocessor. The MPPT algorithm can be implemented by frequently taking samples of voltage and current from the solar panel and it is sent to the microcontroller, which adjust duty cycle of the converter. In this project MPPT is implemented by incremental conductance and perturb and observe algorithm.

B. Perturb and Observe

In this method, the controller adjusts the voltage according to the change in solar panel and power, if the power increases adjustments are made until the power no longer increases. It is most common method used in the system and it is also referred to as hill climbing method. In this algorithm voltage and current are measured periodically, then power is calculated accordingly. After that voltage is compared to previously measured and then the PWM is produced i.e., either increase or decrease. This method is ease of implementation and result in top-level efficiency.

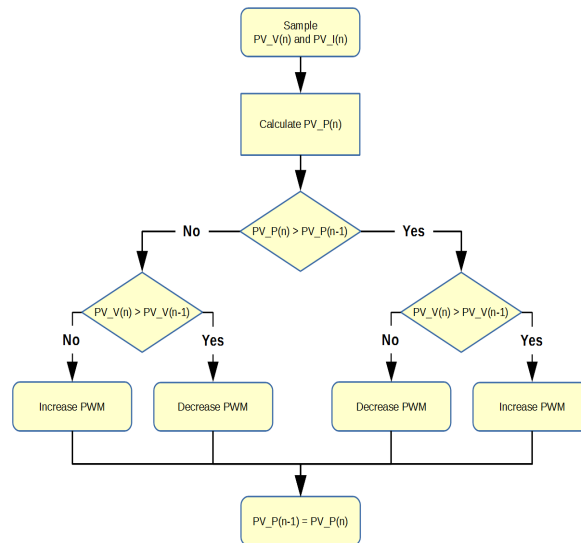


Figure-5 Perturb and Observe Algorithm

C. Incremental Conductance

In the incremental conductance method, the controller measures the voltage and the current of the solar panel rapidly to identify the effect of voltage change. This method is more efficient than the Perturb and Observe and also it requires more computations in the controller. The incremental conductance method the maximum power point is set at one point in the PV array and finds the incremental conductance (change in current I / change in voltage V), then it is compared with the array conductance(I / V). The above two are same, then the output voltage is the maximum power point voltage. The controller adjusts the duty cycle when irradiation changes to maintain the voltage and the process is repeated. The incremental conductance value changes, when the previous maximum point is lesser than the new measured maximum point.

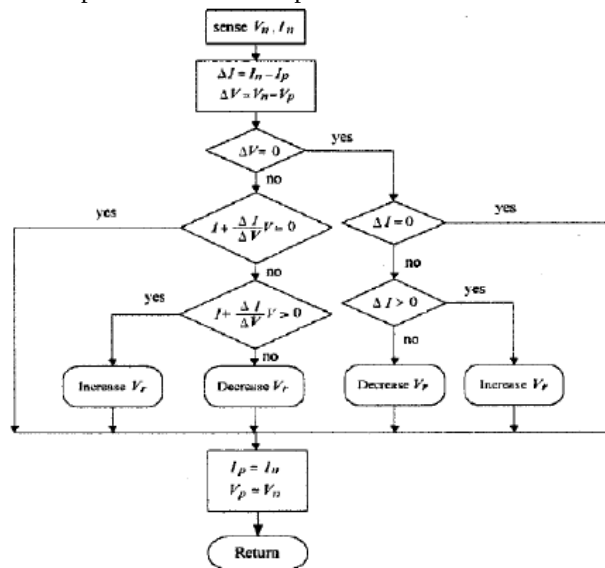


Figure-6 Incremental Conductance

VI. MATLAB SIMULATION

A. I-V and P-V characteristics of solar panel

It is a graphical representation that provide information required for operating PV system to its peak power point (MPP). It gives the characteristics of current and voltage of a photo-voltaic cell, module or array. It helps in determining the solar efficiency.

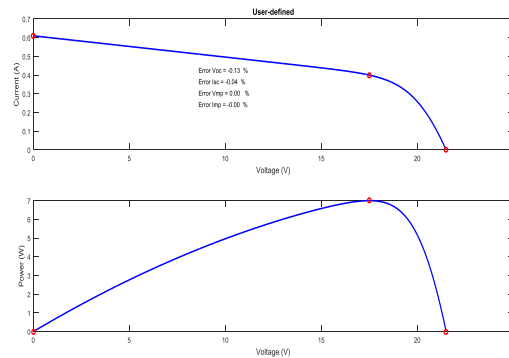


Figure-7 P-V and I-V characteristics

B. Perturb and Observe algorithm

This is the MATLAB Simulation of the project using perturb and Observe algorithm. PV voltage and current measured are given to the MPPT Block and it produces pulse for the DC-DC converter circuit.

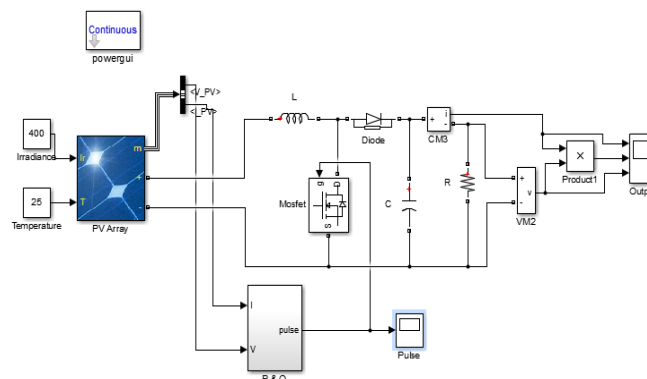


Figure-8 Simulation of P and O Algorithm

C. Incremental Conductance algorithm

This is the MATLAB Simulation of the project using Incremental Conductance algorithm. PV voltage and current measured are given to the MPPT Block and it produces pulse for the converter circuit.

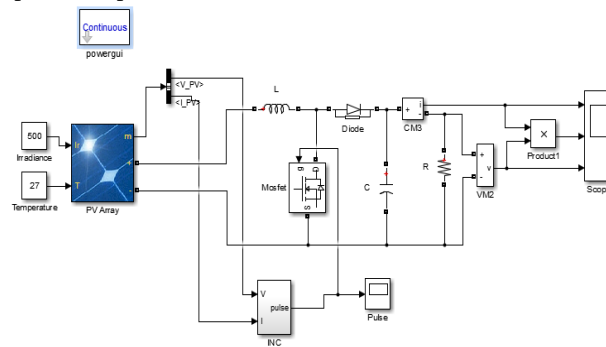


Figure-9 Simulation of Incremental Conductance Algorithm

VII. IMPLEMENTATION IN MICROCONTROLLER USING MATLAB

The whole system has been implemented in MATLAB Simulink and run in Microcontroller in the real time. The inputs and outputs can be viewed through the Simulink and in hardware. The below Simulink blocks represent the implementation of Perturb and Observe algorithm and Incremental Conductance Algorithm by MATLAB and microcontroller.

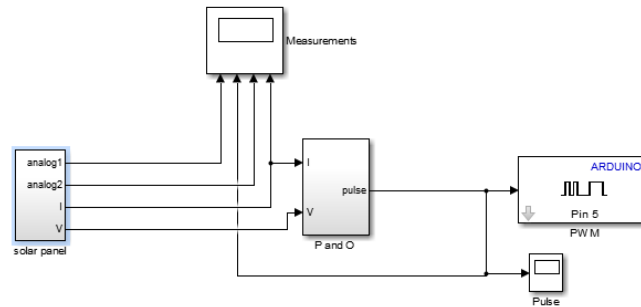


Figure-10 Implementation of P and O Algorithm

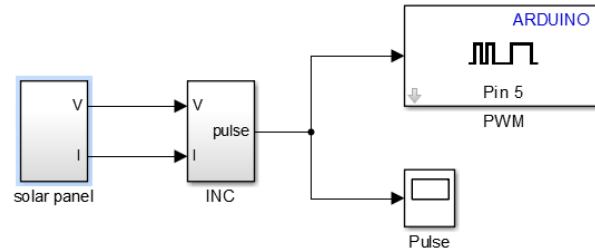


Figure-11 Implementation of Incremental Conductance Algorithm

VIII. CONCLUSION

In this project a low cost high performance DC-DC boost converter has been designed. For extracting maximum power we have implemented two algorithms. By using any one of the algorithms we can track maximum power. The complete system has been designed and simulated in MATLAB and implemented with the help of microcontroller. A laboratory prototype board has been built and experimentally tested.

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