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Optimization of Solar Energy Using MPPT Techniques

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Abstract - *Among existing energy generation systems, about 75% of energy generation is thermal energy generation, which takes place by using coal. Considering the increasing use of electricity, the scarcity of non-renewable energy sources, the increasing pollution caused by these energy sources, it is necessary to find an alternative energy source that is sustainable, pollution free, and cost effective as well. There are many renewable energy sources available in nature, of which solar energy is the most sustainable and widely available free energy source. This paper analyses conventional solar energy generation, includes solar panel array and DC-DC converter. DC-DC converter works as a bridge in between PV system and the load. DC-DC converter is aligned with MPPT tracker (Maximum Power Point Tracker) which use to extract maximum energy from solar system, using P&O algorithm.*

Key Words: **Solar Energy, Solar Panel array, DC-DC BOOST Converter, MPPT, P & O Algorithm.**

1.INTRODUCTION

The uninterrupted use of non-renewable energy sources has caused the non-renewable energy source deposits to bring down and has unfavorable effects on environment such as global warming. Looking at the insufficiency of these non-renewable sources solar energy gives possible relief for this [1]. Solar energy is becoming more and more popular now a days, as it offered promising results like, it is pollution free, cost effective, and easy to use which makes it acceptable in every aspect. Considering the weather conditions of India where, approximately we get clear sunny sky for 300 days which allows use of solar energy in great quantity [1]. Solar energy is intensively used for low generation and can be used to full fill household purposes [2]. Solar energy generation system consists of solar panel array which known as (photovoltaic) PV module, this module is used to convert solar energy into electrical energy. The PV system includes electronic converter and control unit to control and convert extracted power [1]. DC-DC BOOST converters are used to satisfy this purpose. Boost converters are having advantage of simple and cost-effective structure; hence these converters are used to effectuate maximum power from solar system [3]. In order to extract maximum energy, the concept of MPPT (Maximum power point tracker) is introduced, which maximizes the output power and eventually increases the efficiency of the system [4].

2. OBJECTIVE

The main aim of this paper is to find supportable alternative to existing generation system by using solar energy and extract maximum power out of it using MPPT techniques.

3. THE PHOTOVOLTAIC POWER SYSTEM

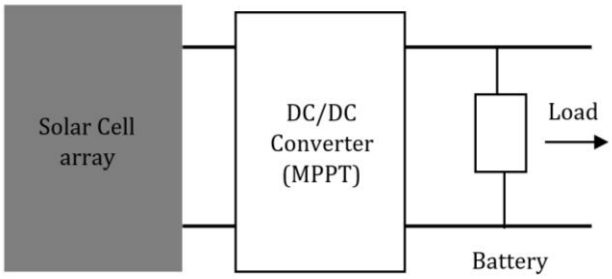

Fig. 3: Block Diagram Representation

The photovoltaic is an incident in which, irradiated energy transformed into electrical energy, and the system which uses this phenomenon is nothing but the photovoltaic system. It basically includes three major parts namely solar cell array, DC-DC converter aligned with MPPT which use to calculate maximum power, battery and the load as shown in figure.

3.1. MODELLING OF THE PV CELL

Solar cell is nothing but the P-N junction semiconductor. Solar cell is used to generate energy from the sun which is then used as DC power. when sunlight projects on solar panel the solar energy utilized and renewed to electrical energy [5]. The PV cell modeling is done on both voltage as well as on current source, consequently series and parallel both connections are practicable with solar cell [1].

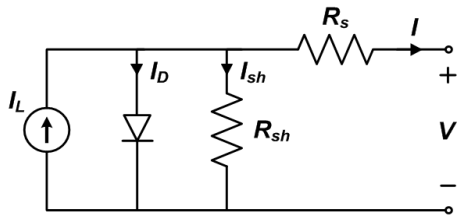

Fig. 3.1: Equivalent circuit of PV cell.

3.2. PHOTOVOLTAIC CELL OPERATING PRINCIPLE

Photovoltaic cell is the main element of larger solar array. When the photons of the light from the sun bombard on solar cell and observed within semiconducting material energy created. Because of this semiconductor electron get excited causing electron to flow which finally generate usable electric current. This current flows in single direction and thus electricity developed is called direct current (DC) [6]. The boundary between two differently doped semiconductor layer is called PN junction diode. one is P type layer (excess holes) and N type (excess electron). The spontaneous electric field at the boundary between P and N area effects the generated electron and holes and determine the direction of the current. If the electron hole pair occur away from the impoverished areas it is possible to recombine before they separated by electric field. Photoelectrons and holes in semiconductor assemble at converse side by that electromotive force is created. If an ingesting device is connected to the system, current start flowing and electricity is generated [2].

3.3. ROLE OF MPPT IN PV SYSTEM

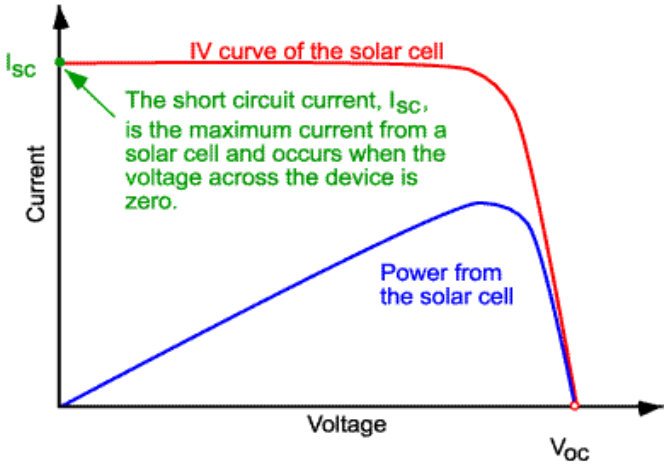

Fig. 3.3: P-V and V-I characteristics of solar panel

The cure shows variegation in current and power in respect of voltage. Maximum power is traced when curve achieve the maximum value of power [4]. The efficiency of solar panel is low so in order to increase the efficiency a proper method should applied to get results matching to the source of the load appropriately. By using MPPT technique we can get maximum power point tracking from the varying source [7].

4. BOOST CONVERTER

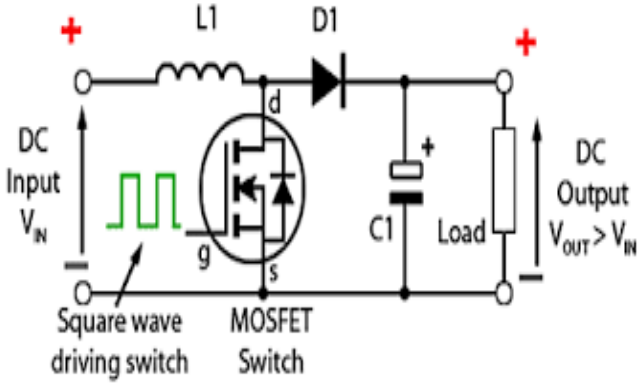

Fig. 4: DC-DC Boost converter

Boost converter is nothing but the switching device. Boost converter is also called as step-up transformer, as output of boost converter is greater than that of the input. Boost converter converts fixed DC voltage source into a variable DC voltage source. It consists of input DC source, switch (S), inductor (L), Diode, Capacitor (C), and Resistor (R) which acts as a load as shown in figure [8]. When switch S_1 is initiated by the pulse of the pulse width modulation (PMW), current stars flowing through inductor (L) causes energy stored in it. When the switch turned off, energy stored in inductor provides an induced voltage over inductor which then adds to the input voltage, as a result voltage across inductor causes charging of capacitor (c) to get volage higher than that of the output. [1]. Switch (s) can be open or closed are depend the output value. Input voltage of boost converter is less than that of the voltage across the load. A boost converter steps up the voltage without a transformer. Simply DC -DC converter converts voltage directly from DC to DC. A DC converter is equivalent to be an AC transformer. It can be step up or step down a DC voltage source, as a transformer. DC-DC boost converter provides high efficiency, good acceleration and very fast response.[9]

5. MAXIMUM POWER POINT TRACKING

There is a distinctive point from where we can draw out peak power or maximum power for given temperature this point in nothing but the maximum power tracking point [10]. The main purpose of using maximum power point tracking is to extract maximum energy from solar system and transfer to load. The solar system can work without MPPT as well but with lower efficiency as only 30-40% energy we can draw from panels whereas with MPPT the percentile is much more. As the solar temperature is not constant and it keep changing all over the day, we need to track it. There are various algorithms available to implement on MPPT, the selection of these algorithms is totally depending on cost and conversion speed [10].

5.1. CONVENTONAL P&O ALGORITHM FOR MPPT

The basic concept of Perturb and Observe (P&O) algorithm uses the perturbation of solar PV operation point reference to the sign of the last increment of PV power [11,12]. If any changes are there in Perturb voltage ΔV are commanded by the algorithm to the PV module operating voltage. Just after observing the output power; P&O will help to determine that the operating voltage should be increased or decreased by ΔV [3].

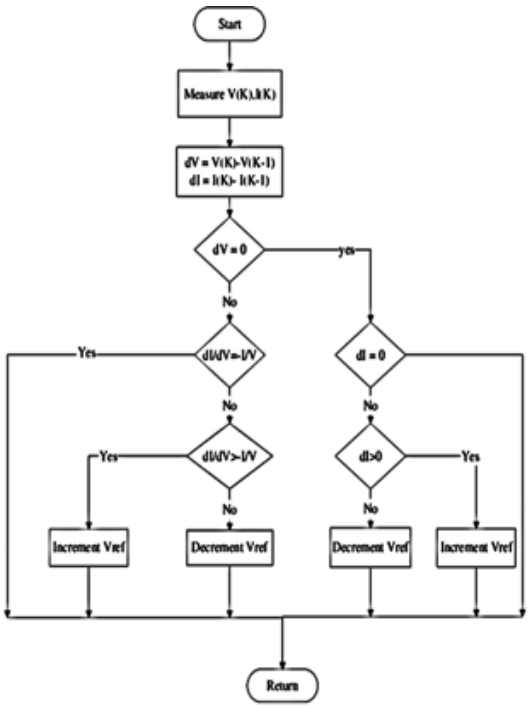

Fig. 5.1: P&O Algorithm

Figure shows the detailed about the conventional P&O algorithm. Based on the obtained information, P&O algorithm can predict that when the operating voltage is approaching the VMPP by comparing the actual and the previous state of the power "P" and voltage "V". In short, the next perturbation to reach the MPP will be the same if there is an increase in "P" and vice versa [4], as shown concluded in the below "Table".

Perturbation	Power	Next perturbation
Positive	Positive	Positive
Positive	Negative	Negative
Negative	Positive	Negative
Negative	Negative	Positive

Fig. 5.1.1: Summary of P&O algorithm

The perturbation and observation algorithm process continues until the systems reach to the MPP. As in Reference [5] stated the two important parameters for P&O algorithm are the perturbation step size and the time between algorithm iteration. To speed up the response somehow large perturbation step size requirement is there but because of that large perturbation step size power loss will occur due to imprecise tracking. The MPP tracking system will slow down the response, as the step size is reduced. Consequently, time taken for the completion of the algorithm becomes longer. To modify the algorithm, many studies had been done so that the tracking speed and algorithm accuracy can be improved. As fixed step size does not provide a good trade-off so many researchers have proposed variable step size concept.

6. CONCLUSION

DC-DC BOOST converter allows you to track and extract maximum energy of solar panel by using MPPT techniques. DC-DC Boost converter is easy to implement having simple construction and cost-effective at the same time along with good performance which makes it more favorable. Good practice implementation of this system will definitely lead towards maximum energy generation and will work as a best alternation for the existing energy system.

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