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A Review on Enhancement of PV cell

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ABSTRACT: Solar PV system is becoming an important part of renewable energy due to the continuous depletion of conventional sources available for power generation. In this paper, we study the photovoltaic cell, module and its components like multilevel inverter and dc-dc converter. It also focuses on classification of most commonly used MPPT technique. The pros and cons of these MPPT techniques are also discussed.

KEYWORDS: Photovoltaic (PV), Perturb-and-Observe (P&O), Incremental Conductance (INC), Maximum Power Point Tracking (MPPT), Multilevel Inverter (MLI)

I. INTRODUCTION

Electric energy is an indispensable component of economic development, and this goes for all countries. It is relatively very important with increases in connection to technical progress, industrialisation and requirement of modern vantage. Increase in its production translates into better quality of life and the formation of wealth. Electric energy is the most versatile form of energy; it can be converted to any form and vice-versa. Electric energy can be stored also. The generation of electric is mainly from fossil fuels which are depleting at a very fast rate. In 2013 net electricity generation across the globe was 23,322 TWh out of which 41% was generated by coal, 5% by oil, 21% by natural gas, 19% by renewable sources and 10% by nuclear. The renewable energy has become an emergent area of research in the 21st Century with the problem of energy crisis becoming more and more essential, resulting in increased exploitation and research for new power energy resources such as wind, tide, geothermal and solar energy around the world [1, 2]. Solar energy generators are extensively used to harness power from solar irradiation. Solar power is converted into electric power by photovoltaic (PV) panels. The output power of the PV panels depends on the surrounding weather conditions like sun irradiance levels and temperature. The electric characteristics of solar PV panels are affected by these conditions [3,4]. The current versus voltage (I-V) characteristics curve and the power versus voltage (P-V) curve of a typical solar panel or cell observed under certain irradiance levels, unique points exist where the output power from each solar panel is maximum. These points on the P-V curves are known as the maximum power points (MPPs). The idea of MPPT is developed in the solar system to utilize PV panels at the optimal efficiency by tuning the duty cycles of the power converters inserted between PV source and the load [2].

II. PHOTOVOLTAIC CELL

Photovoltaic (PV) cell system has its basic unit as solar cell. A solar cell generates direct current and a power of 1 to 2W which is hardly to power most applications. PV cell is made up of semiconductor material like silicon, cadmium telluride, gallium arsenic etc. which helps in converting sunlight to electricity. The voltage does not depend on solar irradiance but primarily can be dependent of the cell temperature. By connecting solar cells in series at different voltages PV modules can be designed. Absorption of sunlight by solar cells creates free electrons and holes at +ve/-ve junctions.

When +ve/-ve junctions are connected to DC electrical equipment current is delivered to operate electrical equipment. By absorption of photons +ve/-ve charges are created and encouraged to drift to the front and back of solar cell. Back of the cell is covered with a metallic contact to remove charges to electric load. The charges are collected from the front

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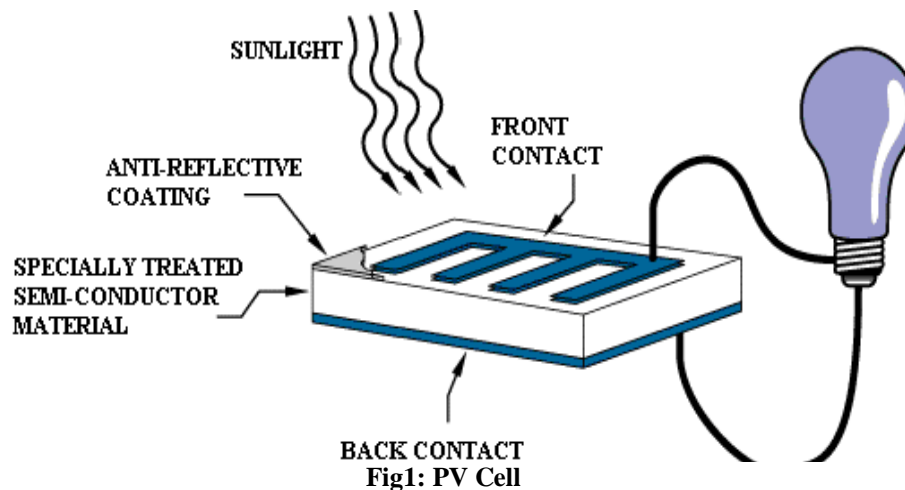
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by a five grid of narrow metallic fingers. Electrical field provided by p-n junction sweeps electrons in one direction and the other side the positive holes. Fermi energy must be uniform throughout if junction is in thermodynamic equilibrium.[8]

Since the energy is uniform & near to top the gap of n-doped material & near the bottom of p-doped side, an electric field must exist at junction providing the charge separation function of cell.



PV module

- i. PV modules are arranged in series & parallel to meet energy requirements. PV modules are commercially available in size 60W to 170W.
For example: for small scale desalination plant requires few thousand watts of power. PV energy increases interest electrical power applications. PV energy is pollution free and inexhaustible.
- ii. PV cell is connected in series and parallel, if connected in series then voltage in module is increased and if connected in parallel then current is increased. When inverted diode is connected parallelly to current source a solar cell is modeled having its own series and || resistance.
- iii. When there is hindrance in the path of flow of electrons from n to p-junction then its series resistance and when current is leaked its || resistance.
- iv. To increase output efficiency of PV arrays PV energy conversion system is operated near the maximum power point.
- v. The output power of PV arrays always change with solar irradiation and atmospheric temperature [4].

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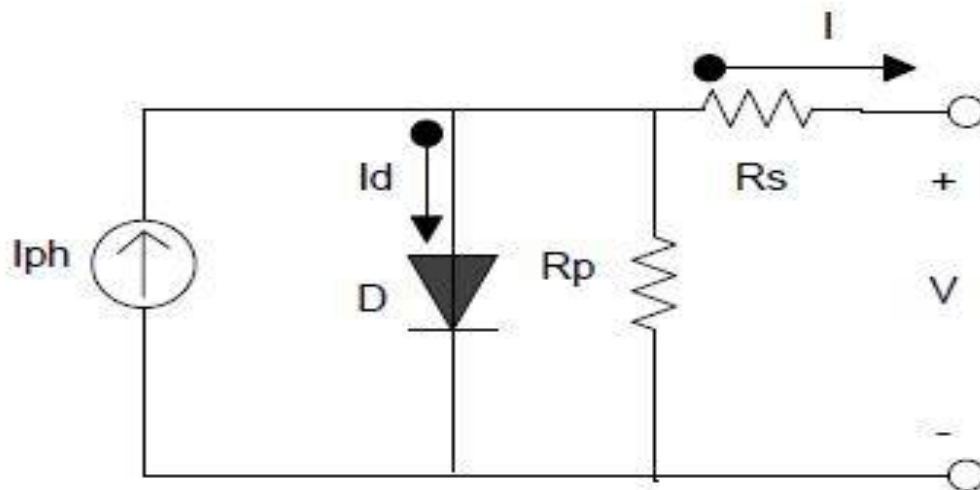


Fig2: Single diode model of solar cell

I_c = cell output current

V_c = cell output voltage

I_{ph} = light generated current

I_o = reverse saturation current

R_s = series resistance of the cell

The performance characteristics of a photovoltaic module depend on its basic materials, manufacturing technology and operating conditions.

III. MULTILEVEL INVERTER

The smallest number of multilevel converter topologies is the voltage level of three. The multilevel VSC can work in both rectifier and inverter modes due to presence of bi-directional switches. Due to this reason it is mostly referred as converter in place of inverter in research.

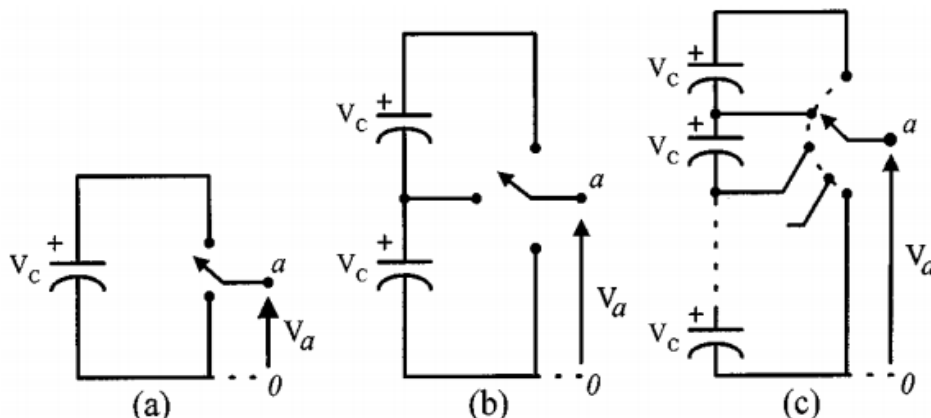


Fig 3: One phase leg of an inverter with (a) two levels, (b) three levels, and (c) n levels

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Switching of either input or output nodes between multiple levels of voltage or current can be performed with the help of multilevel converter. The THD output approaches to zero when the level reaches to infinity. The limitation of achieving voltage levels is by voltage imbalance problems, voltage clamping requirements, circuit layout and packaging constraints complexity of the controller, and, mainly the capital and maintenance cost.[6]

IV. DC-DC CONVERTER

It Operate as a main part of the MPPT. A DC/DC device (step up/ step down) serves the aim of transferring most power from the PV module to the load. A DC/DC device acts as associate interface between the load, once proposing associate MPP, the foremost job is to settle on and style a extremely economical device, that is meant to control because of main part of the MPPT.

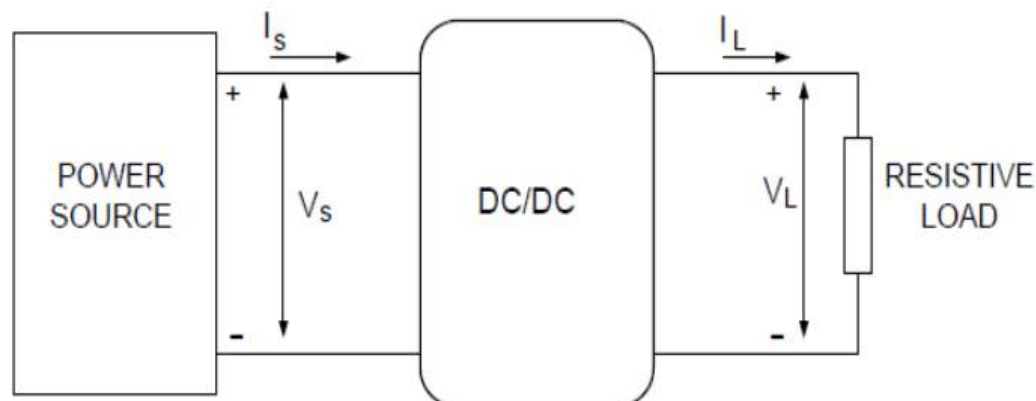


Fig 4: DC-DC Converter

The potency of switch-mode dc–dc converters is wide mentioned. Most switching-mode power provides square measure elegant to operate with high potency. Among all the topologies out there, each Cuk and buck–boost converters give the chance to own either higher or lower output voltage compared with the input voltage. Though the buck–boost configuration is cheaper than the Cuk one, some disadvantages, such as discontinuous input current, high peak currents in power parts, and poor transient response, build it less economical.

V. MPPT TECHNIQUES

A conventional solar array is capable of converting 30 to 40 percentage of the incident sunlight into useful electrical energy. Maximum power point tracker serves as the medium to enhance the productivity of the solar array. In accordance to Maximum Power Transfer theorem, the output power is maximum for a circuit when the load impedance is equal to Thevenin's impedance. Thus challenge for tracking maximum power point is now just reduced to case of impedance matching. By altering the duty cycle of the converter accordingly, load impedance can be matched with source or for say Thevenin's impedance.

The choice of algorithm for selection of tracking techniques depends upon various factors like computation time, complexity level, cost and effectiveness. In practical use there are various MPPT techniques few of them are listed below:

- Perturb and Observe
- Incremental Conductance

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(i) Perturb and Observe:- The most commonly used MPPT algorithm is P&O method. This algorithm uses simple feedback arrangement and little measured parameters. In this approach, the module voltage is periodically given a perturbation and the corresponding output power is compared with that at the previous perturbing cycle. In this algorithm a slight perturbation is introduced to the system. This perturbation causes the power of the solar module. If the power increases due to the perturbation then the perturbation is continued in the same direction. After the peak power is reached the power at the MPP is zero and next instant decreases [7].

(ii) Incremental Conductance:- This method overcomes the disadvantage of perturb and observe method to track the peak power under fast varying atmospheric conditions. The IC can determine that the MPPT has reached the MPP and stop perturbing the operating point. If this condition is not met, the direction in which the MPPT operating point must be perturbed can be calculated using the relationship between dI/dV and I/V . This relationship is derived from the fact that dP/dV is negative when the MPPT is to the right of the MPP and positive when it is to the left of the MPP [8]. This algorithm has advantages over P&O in that it can determine when the MPPT has reached the MPP, where P&O oscillates around the MPP. Also, incremental conductance can track rapidly increasing and decreasing irradiance conditions with higher accuracy than P & O.

VI. CONCLUSION

In this paper, a general presentation of the photovoltaic cell, module and its components like multilevel inverter and dc-dc converter has been made. This review article also provides a detailed classification of available MPPT techniques. The pros and cons of these MPPT techniques are also discussed and it is observed that Incremental Conductance is superior to other all MTPP techniques.

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