IJCRT.ORG ISSN : 2320-2882

INTERNATIONAL JOURNAL OF CREATIVE RESEARCH THOUGHTS (IJCRT)

An International Open Access, Peer-reviewed, Refereed Journal

PV-Based DC-DC Boost Converter Model Under Different Scenarios

Dr. Suhas M. Shembekar
Associate Professor
Electrical Engineering Department
S.S.B.T.'s College of Engineering and Technology, Jalgaon

Abstract:

In comparison to the preceding ten years, India's renewable energy generation segment is expanding extremely rapidly as the country's reliance on the production of power is growing. Given the increasing growth of the renewable energy industry in India, it is critical to comprehend how certain climatic elements might cause external fluctuations in solar photovoltaic systems. Even though a lot of studies has already been done in this area, there is still room for more research into how temperature fluctuations, shadow effects, and wind affect solar PV system generation. The effect of these previously mentioned external parameter effects on solar energy generation are proposed in this research. The effort has been done to create a MATLAB model for a solar cell, leading to the creation of a PV array—a series combination comprising multiple solar cells. The Boost converter, which uses the MPPT algorithm, receives the solar cells output. This model has been tested under a variety of circumstances, including variations in load resistance, temperature, and light intensity.

Keywords: solar panels, PV curve, boost converter, MPPT

Introduction

Renewable energy comes from sources or processes that are constantly replenished. These sources of energy include solar energy, wind energy, geothermal energy, and hydroelectric power. Renewable energy, often referred to as clean energy, comes from natural sources or processes that are constantly replenished. For example, sunlight and wind keep shining and blowing, even if their availability depends on time and weather. Renewable sources are those that are recyclable, clean energy is those that do not release pollutants like carbon dioxide, and green energy is that which comes from natural sources. While there is often cross-over between these energy types, not all types of renewable energy are fully clean or green. For example, some hydroelectric sources can damage natural habitats and cause deforestation. There are a range of renewable sources that have been developed, with each offering their own advantages and challenges depending on factors such as geographical location, requirements for use and even the time of year.

Solar Power: The potential for the sun to supply our power needs is huge, because enough energy to meet the planet's power needs for an entire year reaches the earth from the sun in just one hour. However, the challenge has always remained in how to harness and use this vast potential.

Wind Power Wind energy works much like old-fashioned windmills did, by using the power of the wind to turn a blade. Where the motion of these blades would once cause millstones to grin together to make flour, today's turbines power a generator, which produces electricity.

3. Hydroelectric Power: Hydroelectric power works in a similar manner to wind power in that it is used to spin a generator's turbine blades to create electricity. Hydro power uses fast moving water in rivers or from waterfalls to spin the turbine blades and is widely used in some countries.

4. Biomass Energy Biomass energy uses organic material from plants and animals, including crops, trees, and waste wood. This biomass is burned to create heat which powers a steam turbine and generates electricity.
5. Geothermal Power: Geothermal energy uses the heat trapped in the Earth's core which is created by the slow decay of radioactive particles in rocks at the center of the planet. By drilling wells, we can bring highly heated water to the surface which can be used as a hydrothermal resource to turn turbines and create electricity.
6. Tidal Power Tidal power offers a renewable power supply option since the tide is ruled by the constant gravitational pull of the moon. The power that can be generated by the tide may not be constant, but it is reliable, making this relatively new resource an attractive option for many.

Energy Scenario in India

Renewable energy sector is the 4th most smart renewable energy market in the world. As in October 2022, India rank 5th in installed renewable energy capacity. According to 2018 environment possibility report India rank 2nd among the developing economics to lead to evolution to clean energy. Installed renewable power generation capacity has improved at a fast pace over the past few years, Posting a CAGR of 19.78 % between FY 14-18. With the better support of Government and developed economics the sector has become attractive from the investors perspectives, as India aspects to meet its energy demand on its own, which is predictable to reach 15820 TWh by 2040, renewable energy is set to play an significant role, As a part of its Paris contract commitments, the government of India has set an ambitious target of attaining of 175 GW of renewable energy capacity by 2022. These contain 100 GW of solar capacity addition and 60 GW wind power capacity. Government strategies to establish renewable energy capacity of 500 GW by 2030[3].

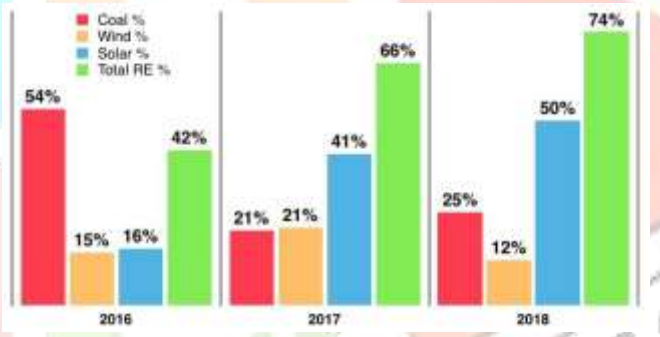

Figure 1: Component of Different Technologies in India's New Power Capacity

Literature Survey:

The article reviews the assessment methods of energy supplied to the surface of solar panels. The need of increase in accuracy of calculation of the solar energy entering on the panel is proved due to the accounting of additional influencing factors. A technique for estimating solar energy to the surface of panels is developed [1].
This paper [2] reviews the rapid advancements being made in the developments of silicon solar cells. The factors to be considered while designing a solar cell are proper selection, solar cell structure and their conversion efficiency.
A "photo electrolytic cell" (photo electrochemical cell), refers either to a type of photovoltaic cell or by using only solar illumination to split water directly into its base elements which are hydrogen and oxygen. The use of MATLAB software is required so as to design the most error free and optimized solar cell using various combinations of materials [3].
The thickness of every i-region is designed to provide maximum absorption for preselected part of the sun spectra. In the current study, we compare for both groups the ability to harvest widest part of sun spectra, efficiency, complexity of design, as well as cost of solar cell production [4].
The objective of this article [5] is to discuss the standard P&O MPPT scheme's behaviour under increased solar irradiation circumstances and under different load conditions. The enhanced MPPT system is incorporated in a DC-DC converter's control circuit. MATLAB/Simulink is used for the simulated investigation.

This paper [6] presents an overview of photovoltaic solar energy, presenting topics such as solar energy, configuration and types of photovoltaic cells, the sizing of photovoltaic panels, and maximum power point tracking algorithms.

This paper examines the execution of a boost converter for a PV framework which was built utilizing four PV cell associated in arrangement to get input as 12 V and the yield voltage of this framework was obtained by employing different MPPT algorithms [7] such as Perturb & Observe algorithm, Incremental Conductance algorithm and Fuzzy based algorithm.

In this paper [8], we have tried to extract the maximum power out of solar PV panels connected in series using a DC-DC boost converter and by employing a MPPT algorithm. The simulation results show that maximum power can be drawn out from a solar panel by varying the operating conditions.

This paper [9] is focused on finding DC/DC converters boost type with the best output through simulation methods by comparing the use of components from several boost converter topologies so that they can be used to maximize solar panel output. Several simulation scenarios are needed using PSpice A/D Lite software.

Boost converter operates in closed loop to control current of Solar PV cell such that it delivers maximum power to incandescent lamp [10]. Dynamic performance of Boost converter with current feed-back loop is tested in simulation with perturbation in input voltage stepped current reference and stepped load variation.

System Development:

Solar cells are composed of a P-N junction fabricated by differently doped semiconductor materials. Thereby the solar cell can be presented by a simple circuit consisting of a current source in parallel with a diode [8]. The output of the current source is directly proportional to the light falling on the cell.

The characteristic P-V has only one maximum power point transfer called MPPT that makes the PV generator generating its maximum power under different environmental conditions. The figure 2 shows PV and IV Curve of solar cell at standard conditions. Therefore, a MPPT technique is required to exploit the maximum power of the module and optimize the efficiency of PV cells [6].

The diagram shows standard PV characteristics and IV characteristic of solar cell. The maximum voltage at open circuit and current at short circuit case. The Peak power is also depicted in image below.

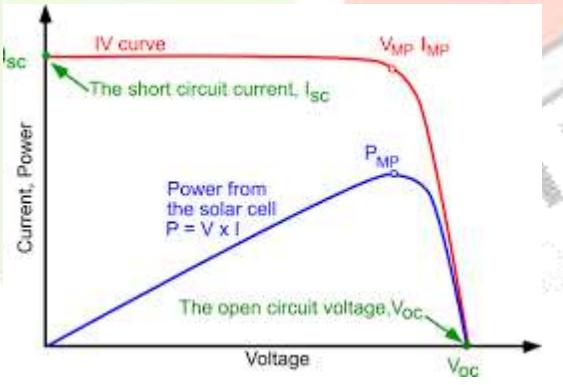

Figure 2: P-V and IV characteristic

MPPT Algorithm

PV solar systems have varying relationships to inverter systems, external grids, battery banks, and other electrical loads. The central problem addressed by MPPT is that the efficiency of power transfer from the solar cell depends on the amount of available sunlight, shading, solar panel temperature and the load's electrical characteristics. As these conditions vary, the load characteristic that gives the highest power transfer changes. The system is optimized when the load characteristic changes to keep power transfer at highest efficiency. This optimal load characteristic is called the maximum power point (MPP). MPPT is the process of adjusting the load characteristic as the conditions change. Circuits can be designed to present optimal loads to the photovoltaic cells and then convert the voltage, current, or frequency to suit other devices or systems.

The work has been carried out in MATLAB Simulink. The model containing solar cell, boost converter and MPPT pulse generator are developed and hence connected. This system is simulated and verified for different external conditions.

The output of solar cell is connected to boost converter. The voltage and current signals of this solar cell output are measured and fed to the MPPT. The MPPT is always checking incremental change in voltage and power. It operates boost converter as the change in power has to be increasing for change in voltage. This power signal is compared with reference signal and the error signal is given to relational operator to provide pulses to boost converter.

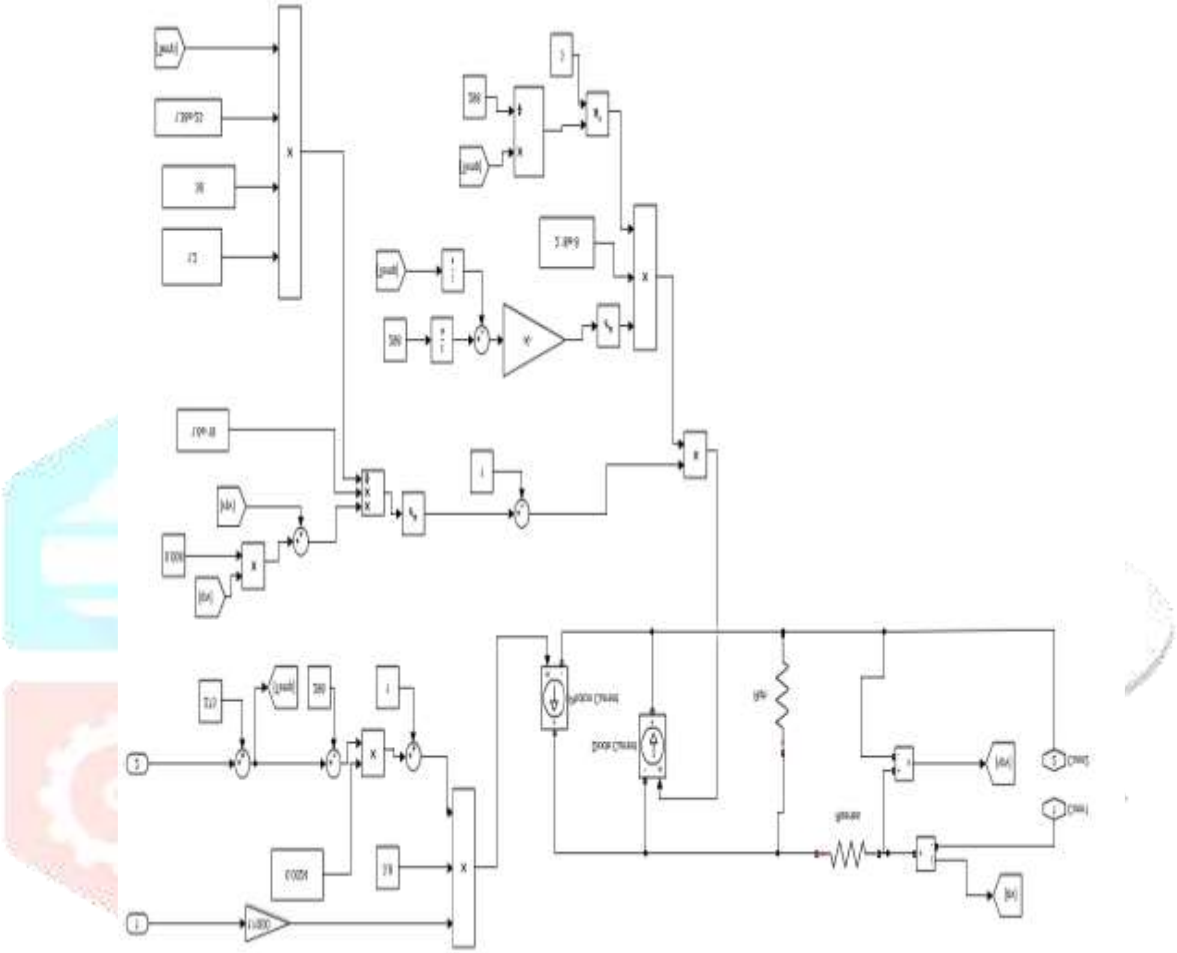

Figure 3: Overall model of Solar Cell

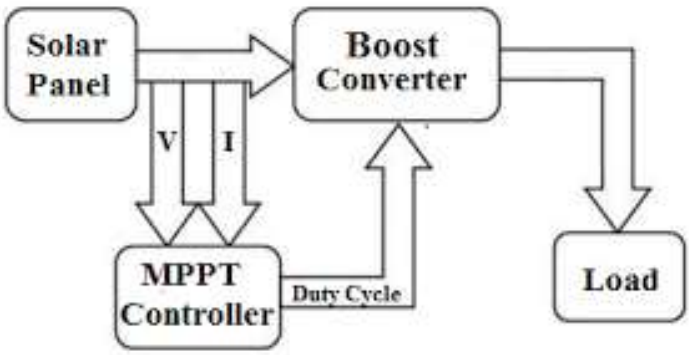

Figure 4: Block Diagram of overall System

Performance Analysis:

The MATLAB simulation modules are useful for the actual design of the performance ratio work. MATLAB software is used due to its extensive scope of application in research and analysis zone. MATLAB software is used to simulate whole system. This software allows assembling the circuit, running the simulation, analyzing the results, and managing the data in a completely integrated graphical environment.

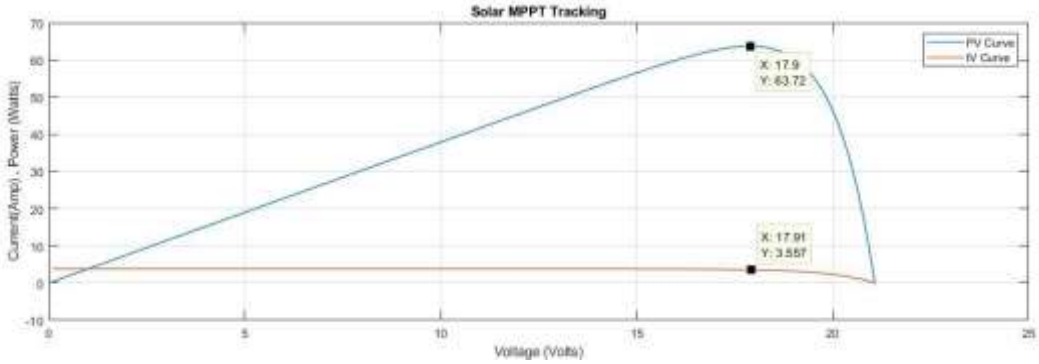

Figure 5: IV and PV curves for the normal temperature and irradiance

The two input values provided to solar panel are temperature and light intensity. The standard value of temperature is 25 and for light irradiation is 1000W/m^2. The MATLAB model is developed with the above discussed block diagram. The output of solar cell is provided to the boost converter which works as a chopper and provides stable dc output at the load. The MPPT algorithm is developed to operate solar panel at the peak point of PV curve. The maximum power tracker is the point which extracts maximum output at specific voltage from solar panel. This model is tested for various change in irradiation and temperature.

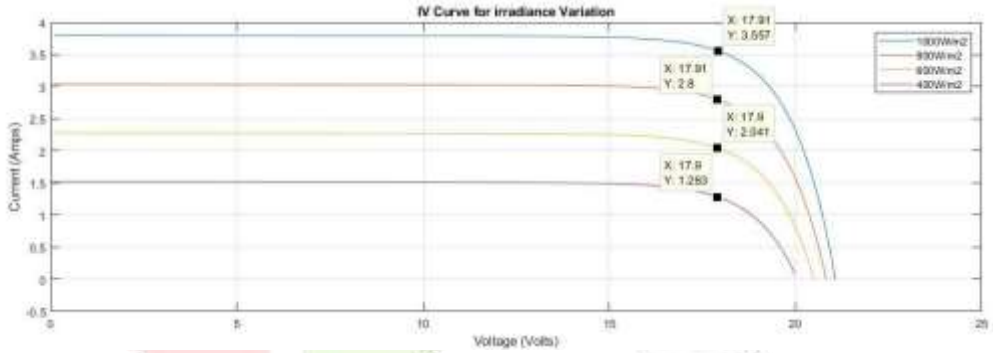

Figure 6: IV curve for the different values of irradiance

The topmost IV curve is for 1000 W/m2 and then the irradiance is decreased at 800, 600 and 400. The output of solar is directly related to the intensity of light and hence as the intensity decreases, the IV curve, that means the output current decreases.

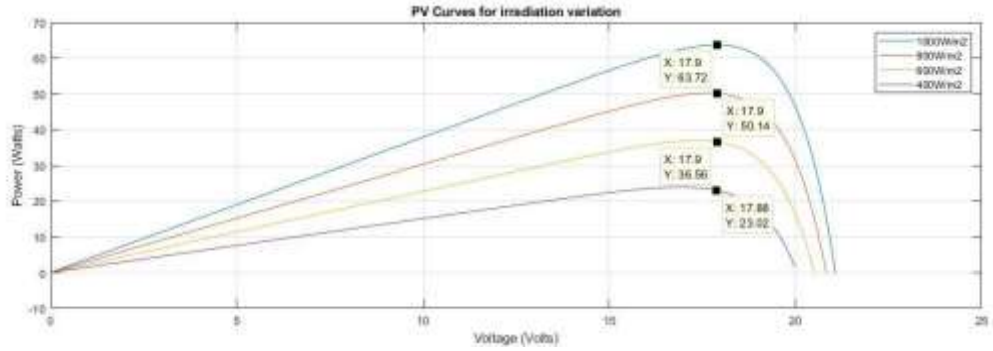

Figure 7: PV curve for the different values of irradiance

The following figure shows the PV curve for different variations in in irradiance. The curve of power verses voltage for light intensity of 1000w/m^2 is shown by the topmost curve. The irradiance is decreased from 1000 to 800, 600 and 400 W/m^2 and the power verses voltage gets decreases relatively with respect to light intensity.

Conclusions:

The MPPT-based solar powered boost converter is represented by a MATLAB model. The model is simulated at 25 degrees and 1000 irradiance. The model is then evaluated against external circumstances such as light intensity, temperature, and load resistance. The graphs for the corresponding IV and PV curves are presented and analysed. Additionally, the change in input current and voltages is investigated. The conclusion can be drawn since solar production is dependent on external conditions and characteristics.

References:

1) E. V. Platonova, A. S. Toropov and A. N. Tulikov, "Simulation of Energy Input to Solar Panels," 2019 International Ural Conference on Electrical Power Engineering (UralCon), 2019, pp. 133-137.
2) B. R. J, J. Samuel Varghese, V. Du John H and D. Jackuline Moni, "Design of Solar Cells for Dual Charging Capability using Seebeck Effect," 2021 3rd International Conference on Signal Processing and Communication (ICPSC), 2021, pp. 373-376.
3) R. Ramprabhu, K. Sanjay, V. S. Kumar, A. C. Santhosh, M. Saravanan and J. Ajayan, "An Overview of Recent Developments in Silicon Solar Cells," 2019 5th International Conference on Advanced Computing & Communication Systems (ICACCS), 2019, pp. 1120-1122.
4) S. Mil'shtein and D. N. Asthana, "Brief Comparison of Tandem and Cascaded Solar Cells," 2021 IEEE 48th Photovoltaic Specialists Conference (PVSC), 2021, pp. 2260-2263.
5) A. K. GB, Shivashamkar and K. N. S. Kumar, "Optimum Power Point Tracking Technique for Standalone Solar Photovoltaic System," 2021 International Conference on Recent Trends on Electronics, Information, Communication & Technology (RTEICT), 2021, pp. 805-808,
6) R. Fuentes, D. Rojas, M. Rivera, J. Riveros, J. Muñoz and P. Wheeler, "Technologies and MPPT algorithms for solar energy applications," 2021 IEEE CHILEAN Conference on Electrical, Electronics Engineering, Information and Communication Technologies (CHILECON), 2021, pp. 1-8,
7) H. U. Prabhu and M. R. Babu, "Performance Study of MPPT Algorithms of DC-DC Boost Converters For PV Cell Applications," 2021 7th International Conference on Electrical Energy Systems (ICEES), 2021, pp. 201-205,
8) R. Das, S. De, S. Sinha and S. Hazra, "Modelling of PV based DC-DC boost converter using P&O algorithm under varying environmental conditions," 2021 Innovations in Energy Management and Renewable Resources(52042), 2021, pp. 1-5.
9) T. W. Hariyadi and A. Adriansyah, "Comparison of DC-DC Converters Boost Type in Optimizing the Use of Solar Panels," 2020 2nd International Conference on Broadband Communications, Wireless Sensors and Powering (BCWSP), 2020, pp. 189-194.
10) S. Prasad and S. Parui, "Current Perturbed MPPT for Solar PV cell using Boost Converter," Michael Faraday IET International Summit 2020 (MFIIS 2020), 2020, pp. 100-105.