A STUDY OF DIFFERENT CONVERTER AND MAXIMUM POWER POINT TRACKING TOPOLOGY

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ABSTRACT

Due to ready availability of resources, there is a vast spike in the growth of sustainable power sources. Among them solar photovoltaic (PV) world power technique is presently careful, being an of great magnitude substitute influence supplier, for the reason that of the set availability of eminent able PV panels with the aim of eliminate the depressing environmental aspects. Low voltage PV systems require a high voltage gain converter for module’s grid connection through a DC-AC inverter. As the development of power electronics technology is constantly increasing, the prices of semiconductor devices started falling down. In this paper different converters topology like buck, boost, and buck-boost converters and to extract more power different types of tracking algorithm is discussed. A suitable model is adapted to partial shading called cascaded boost converter with sliding mode control to match the impedance of source and load characteristics. It is used to extract maximum power from the panel.

Keywords: Photovoltaic panels (PV), Maximum Power Point (MPP), Maximum Power Point Tracking (MPPT), Pulse Width Modulation (PWM) and Centralized Maximum Power Point Tracking (CMPT).


1. INTRODUCTION

The world’s energy order is amplified in the same way as the time of build-up revolution. The energy need has enlarged since the developing populace along with elevated pattern of living. The issue is the hold of fossil fuel is constrained [1].
In this way, the utilization of substitute and sustainable power source assets to meet the electric energy prerequisites of the present day world has turned out to be progressively vital these days. The requirement for inexhaustible and clean vitality is genuine, which is the reason numerous administration have begun to contribute on them, and new laws enacted to chop down discharges due to non-sustainable sources.

Intrigue is centered around rendering the PV systems all the more enough to the wide use as far as power, productivity, grid compliancy and communication capacity for those lattice associated ones, dependability and service time, wellbeing and security, and so on. In the particular instance of lattice applications, one of the most imperative viewpoints is the MPPT, going for augmenting the separated energy irrespective of the irradiance condition [2].

2. MODELLING OF PV SYSTEM

The marvel in which, illuminated energy changed over into electric energy without mechanical component is called “photovoltaic phenomenon” [3]. PV system for the most part comprises of three sections initially is solar panel or module second is the interface part power converter or inverter and third is load. On the off chance that the conversion ratio of the converter is shifted by controller to continually modify the operating voltage of solar panel to its most extreme power, it is being worked as a MPPT. The essential block diagram is appeared in figure 1 correspondingly.

![Figure 1 Basic Block Diagram of PV Systems](image)

3. DIFFERENT CONVERTER TOPOLOGY

3.1. Converter Interface of PV Panels

Switching DC-DC converters are widely used to interface the DC yield of sustainable power source assets with power distribution system in order to encourage the utilization of energy at the customer side. DC distribution system will present several advantages with respect to the AC systems, in spite of the less expensive assurance circuit breaker and lower maintenance costs of the last mentioned.

First, DC systems are more efficient and can provide higher power quality with lower harmonics. Second, a significant advantage of DC-based approach is the fact that power handling can be completely uninterrupted by having, switched-mode power converters featuring the current limit, allowing the eventual aggregation of sustainable energy source to the main DC grid [4].

The interconnections of domestic scale PV systems to such a principle DC bus can ordinarily be completed by two methodologies. The first comprises of associating arrangement string(S) of PV modules to a central power converter, which enables us to maintain a strategic distance from high-step up conversion ratio, with the disadvantages of high sensitivity to mismatch induced loss and losses due to a concentrated MPPT. The second one utilizes a power converter for every module, with a specific end goal to perform high granularity MPPT, which gives higher adaptability in system layout, bring down affectability to shading, better protection of PV sources, excess in the event of failure, and simpler and more secure establishment and support, other than data gathering.

However, the converter per module approach can exhibit challenges for accomplishing the desired output voltage under mismatched conditions of PV modules, when converters are
connected in series at the output. As an option, PV modules can be associated in parallel to the DC bus. In such a case, one of the key innovation issues is the execution of a power converter that interfaces the conceivably low voltage and energy of the PV module to the principle voltage DC distribution bus of 380 V [5].

Buck, boost, buck-boost, and cuk converter are considered as conceivable DC-DC converters that can be cascaded. The buck and boost converters are appeared to be the most productive topologies, with the buck most appropriate for long strings and the boost for short strings. While adaptable in voltage ranges, buck-boost, and cuk converters are dependably have high effectiveness.

3.1.1. Single string with an inverter

In a private arrangement of say 2 kW or less, all the PV panels on the housetop can be associated electrically in series, to make a high voltage low current DC source. This source is associated with a solitary DC-AC inverter inside the rooftop or house. The AC then rushes to the private switchboard [6].

3.1.2. Micro inverter (Inverter per panel approach)

In this later approach, each PV panel has its own particular DC-AC inverter, mounted at the panel on the rooftop. A 240 V AC association from the switchboard rushes to the rooftop, and loops from inverter to inverter, panel to panel. Each panel is presently viably set in parallel, by means of its own dedicated inverter.

To be small, light and ease, module-coordinated converters for the most part utilize high recurrence switched mode techniques. To productivity change over the panel’s low DC voltage to the 240 V AC system voltages they constantly require a transformer isolated converter. Most methodologies correct to a high voltage DC bus which is trailed by an AC inversion stage and line side filtering [7].

3.1.3. Power Optimizer (Module per DC-DC converter approach)

Each panel has its own converter, yet these converters are DC-DC converters, and the panels with their related converters are as yet put in arrangement to frame a DC string. A single DC-AC inverter is then required to associate with the grid. Every converter module can freely control thus optimize the power stream to or from its source. For a battery string, every converter can freely and optimally charge its associated battery, decreasing adjustment time expanding charge efficiency. In a solar power application, every converter can independently perform MPPT for its own PV panel. Its advantage is the greater tolerances confined shading of panels. These reasons taken together are the most important advantage of per-panel distributed converters in PV applications. Existing PV panel strings could be extended by including new high yield panels without compromising overall string dependability or execution [8].

http://www.iaeme.com/IJMET/index.asp

(a) A single string with inverter
A “converter-per-panel” approach offers many points of interest including
1. Individual panel MPPT, which gives extraordinary adaptability in panel design, substitution, and insensitivity to shading.
2. Better assurance of PV sources and converter failure or redundancy in the case of source.
3. Easier and more secure installation and maintenance.

In any case, DC-AC per panel inverters must step from a low DC voltage to a high AC voltage. Each panel must have an AC inverter and related protection and filtering components. This forces effectiveness and cost penalty on this approach. A non-isolated per panel DC-DC converters can be arranged with a high voltage string associated with a single inverter. The benefits of per-panel converters are accessible without the cost or efficiency penalty.

4. SLIDING MODE CONTROL

Sliding mode control (SMC) is a nonlinear control technique featuring remarkable properties of precision, robustness, and simple tuning and implementation.

SMC systems are intended to drive the system states onto a specific surface in the state space, named sliding surface. Once the sliding surface is achieved, sliding mode control keeps the states on the nearby neighbourhood of the sliding surface. Henceforth the sliding mode control is a two section control design. The initial segment includes the plan of a sliding surface so that the sliding movements fulfill design specification. The second is incorporated
with the selection of a control law that will make the switching surface attractive to the system state.

There are two principle preferences of sliding mode control. To start with is that the dynamic behaviour of the system might be custom fitted by the specific decision of the sliding capacity. Furthermore, the closed loop response turns out to be absolutely obtuse to some specific uncertainties. This standard reaches out to demonstrate parameter uncertainties, disturbance and non-linearity that are bounded.

From a functional perspective SMC takes into account controlling nonlinear procedures subject to external disturbance and heavy model instabilities

4.1. Cascaded Boost Converters using Sliding Mode Control for an Impedance Matching Technique in Photovoltaic Systems

A system connected with a PV panel comprising of two cascaded DC-DC boost converters under sliding mode control and working as loss free resistors is considered. First, an ideal reduced-order sliding mode dynamics model is derived from the full-order switched model considering the sliding imperatives, the non-linear characteristics for the PV module, and the progression of the MPPT controller [9]. It is not a “Distributed MPPT”. By executing impedance matching, can all the more accurately and rapidly find the exact optimal operating point and avoid putting expensive and relatively low efficiency electronics on each module. It is not a “Micro inverter”.

This development can accomplish considerably higher (2.5% to 3% more) system transformation efficiencies, increased reliability and lower costs than a conventional inverter topology scaled down to 200 W. In addition, DC generation and central AC conversion, PV projects are more qualified to meet the energy demand of direct DC loads (ex. Data centres, manufacturing machinery and electric automobile) and the requirement for energy storage.

![Figure 3](image.png) PV panel is connected to DC grid through Cascaded DC-DC Converter

The process begins with the optimizer detecting the input parameters at every module. This data is transmitted from every module in the system to the Memory Management Unit (MMU). The MMU gathers voltage, current and temperature of every module.

The central processor at the MMU can get the correct I-V properties of every module (including its desired $V_{mp}$), calculate their impedance matching factors and transmit these back to the Optimizers. With access to the input variables, computation of working point to amplify the yield of the module and the string has been inferred by a few mathematicians.

5. MAXIMUM POWER POINT TRACKING (MPPT)

MPPT is an electronic system. That enables the modules to create all the power they are capable of. Many MPPT studies have focused on improving the tracking algorithm either for steady state performance or response speed. Developing new MPPT control techniques has received less attention [10].
The most surely understood control techniques referred are voltage control techniques where the control variable is voltage reference and vary the duty cycle till the MPP point is reached. Both control techniques are based on input sensing (PV side sensing) as illustrated in figure 4.

To protect the load from over voltage or current a load side current controller along with single and multiple-step forward backward difference algorithm is proposed.

**5.1. Single and Multiple Forward/Backward Difference Algorithms**

First-order, forward/backward central difference algorithms (single step forward backward) require three-point measurements: \((R_{i-1}, P_{i-1}), (R_i, P_i),\) and \((R_{i+1}, P_{i+1})\) to find the MPP. Where: \(P_i, P_{i-1},\) and \(P_{i+1}\) symbolize the sequence of PV power, and \(R_i, R_{i-1},\) and \(R_{i+1}\) represent the equivalent impedances seen by the PV panel.

**5.2. Perturb and Observe Algorithm**

Major focus is on the hill climbing, perturb & observe methods (P&O) [12]. Perturb and observe technique include perturbation in the duty ratio of the power converters, and perturbing the duty ratio of the power converter perturbs the PV module current and perturbs the PV module voltage.

In this algorithm a slight perturbation is presented. Because of the perturbation the energy of the module will be changes. If the power increases due to the perturbation then the perturbation is continued in that direction.
After the peak power is achieved the power at the next instant decreases and hence after that the perturbation reverse. At the point when the steady state is achieved the algorithm wavers around the peak point. In order to keep power variation small the perturbation size is kept very small [13]. The flowchart of the P&O algorithm is shown in figure 6 correspondingly.

The algorithm reads the estimation of current and voltage from the solar PV module. Power is calculated from the deliberated voltage and current. The estimation of voltage and power at kth moment is put away. At that point (K+1)th next moments are measured again and power is calculated.

The power and voltage at (k+1)th moment. On the off chance that the observe the power voltage curve of the PV module in the right hand side curve where the voltage is practically steady the incline of power voltage is negative dp/dv<0 whereas in the left hand side the slope is certain dp/dv>0 as shown in figure 4. The right side curve is for the lower duty cycle, though in the left hand side slope is for higher duty cycle [14-15].

The drawbacks of the P&O technique to track the peak power under varying climatic condition are overcome by INC method. The INC can discover that the MPPT has come to the MPP and stop perturbing the working point. If this condition is not met, the direction in which the MPPT working point must be perturbed can be calculated using the connection between dI/dV and –I/V.

![Figure 6 Perturb and Observe Flowchart](image-url)

This relationship is derived from the way that dP/dV is negative when the MPPT is to one side of the MPP and positive when it is to one side of the MPP. This algorithm has advantages over P&O in that it can decide when the MPPT has reached the MPP, where P&O wavers around the MPP. Additionally, incremental conductance can track quickly increasing and
decreasing irradiance conditions with higher exactness than perturb and observe. One disadvantage of this algorithm is the increased complexity when compared with P&O[16].

5.3 Incremental conductance Algorithm
The incremental conductance method depends on the way that the slope of the PV array power curve is zero at the MPP, positive on the left of the MPP, and negative on the all right by:

\[
\frac{dP}{dV} \geq 0 \text{ left of MPP}
\]

\[
\frac{dP}{dV} \leq 0 \text{ right of MPP}
\]

\[
\frac{dP}{dV} = 0 \text{ at MPP}
\]

Since,

\[
\frac{dP}{dV} = \frac{d(IV)}{dV} = I + V \frac{dI}{dV} \approx I + V \frac{dI}{dV}
\]

Equation (1) can be rewritten

\[
\frac{dI}{dV} \geq -\frac{I}{V} \text{ right of MPP}
\]

\[
\frac{dI}{dV} \leq -\frac{I}{V} \text{ left of MPP}
\]

\[
\frac{dI}{dV} = -\frac{I}{V} \text{ at MPP}
\]

This method based on the whether the array voltage is greater than or less than peak power point voltage [17]. That maximum power point can be tracked by comparing the instantaneous conductance to the incremental conductance. Incremental conductance technique beats the disadvantage of Perturb and Observe strategy by utilizing PV exhibits incremental conductance to figure 7 the indication of (dV/dP) without annoyance.

![Figure 7: Typical PV curve for incremental conductance for varying irradiance](image)

This decides the Maximum power point strategy has achieved the greatest power point and quit irritating the working point. In spite of the fact that this strategy has the downside is
that it expands the multifaceted nature contrasted with Perturb and Observe technique, requires more opportunity for calculation. Equation (3) showing that at maximum power point both instantaneous and incremental conductance has same esteem [18-20]. Along these lines maximum power point can be followed. This strategy has the preferred standpoint over the Perturb and Observe of not swaying around the maximum power point under quickly changing natural conditions.

6. CONCLUSION

In these paper different types of converter and maximum power point tracking algorithm has been discussed to extract maximum power from PV panels. The future scope of this project is to improve a high efficiency solar PV system using impedance matching technique for an existing PV system. To implement impedance matching technique cascaded boost converter is adopted and it is controlled using sliding mode control.

REFERENCES

[8] Reham haroun, abdelali el aroudil, angel cid-pastor, germain garcia, carlos olalla and luis martinez-salamero impedance matching in photovoltaic systems using cascaded boost converters and sliding-mode control, ieee transactions on power electronics, volume. 30, no. 6, june 2015.


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