ISSN (Print) : 2320 – 3765
ISSN (Online): 2278 – 8875

International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering

(An ISO 3297: 2007 Certified Organization)

Website: www.ijareeie.com

Vol. 6, Issue 4, April 2017

A Review of Maximum Power Point Tracking Techniques under Partial Shading Conditions

Karan Gupta[1] , Akash Wazir[2], Anuj Gupta[3] , Owais Rishoo[4], Sanval Khajuria[5], Sarvjeet Wazir[6]

Assistant Professor, Department of Electrical Engineering, GCET Jammu, India[1]

UG Student, Department of Electrical Engineering, GCET Jammu, India[2 3 4 5 6]

ABSTRACT: Power generation through PV system is on the rise in present times. However, there are several issues that need to be addressed so as to make this process an efficient one.A major issue among them being effect of partial shading condition, which mainly occurs due to clouding, dust settled on panels or other such obstacles. Thus partial shading renders the process of power generation through solar energy inefficient. A number of methods or modifications in already existing techniques have been presented & are published in the literature. This paper attempts to classify these techniques under broad categories viz. hardware based & software based & also provides a brief description for a few of them.

KEYWORDS: MPPT,PV , GMPPT , DMPPT ,PSO , Partial Shading Condition(s)

I. INTRODUCTION

Notwithstanding the worries solar power generation costing more than other conventional methods of power generation, commercialization of PV power frameworksis going on at a quick pace all through the world. Further to overcome the inalienable less-efficient operation of PV modules a MPP tracker is utilized and henceforth the one for the most part directs the effectiveness of any PV framework. Research groups are getting pulled-in towards MPPT, in light of its straightforwardness, unwavering quality and the level of control that it offers. The MPPT strategies are fundamental for extricating the most extreme accessible power under the given conditions. A number of techniques have been proposed in this regard. In [1], an intensive depiction and additionally examination of various MPPT strategies is given. For getting certain level of energy different ,PV modules are associated together in different arrangements, viz. parallel& series. At the point when one(or numerous) of the module in a sun based board goes under the impact of shading(which can be because of trees, neighbouring structures, mists and numerous more conditions can be there), its voltage drops, in this way, it acts as a load as opposed to functioning as a generator . A bypass diode is generally connected across the modules which guarantees that specific shaded module doesn't get harmed. Voltage confound can happen in parallel associated modules. In this way, a blocking diode is connected for giving security under such conditions. Under partial shading (when some piece of module is under shading), bypass diode begins conducting. Along these lines, in P-V curve we don't get a unique maximum power point (MPP) yet get a few nearby peaks and one MPP. Bypass diode can be uninstalled from the framework to rearrange the entanglements of such a large number of peaks, yet subsequently power is decreased which altogether increases the cost of sunlight based power generation . Along these lines, a bypass diode is not disconnected, rather unique methods have been concocted in order to handle this issue. It is however worth saying that, building-incorporated PV frameworks are more powerless against partial shading because of the shadows cast by encompassing structures, trees, and utility shafts. Ref [2] presents a case that out of 1000 building incorporated PV frameworks introduced in Germany, 41% experienced partial shading. Loss in power because of following of a Local Point (LP) rather than a Global peak (GP) can be as high as 70% [3]. To manage the partial shading conditions (PSC), exceptional MPPT plans have been produced. The procedures revealed in the writing can be sorted as Equipment (Hardware) based and Programming based methods. Equipment based strategies include: Module Integrated DC-DC Converters, Parallel Connected MPPTs, Multi-level Converters, and Power Electronic Equalizers. Software based techniques include Fibonacci Search Algorithm, Bayesian Fusion Technique, Differential Evolution Technique,

ISSN (Print) : 2320 – 3765
ISSN (Online): 2278 – 8875

International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering

(An ISO 3297: 2007 Certified Organization)

Website: www.ijareeie.com

Vol. 6, Issue 4, April 2017

Artificial Neural Network based, Ant Colony Optimization, Fuzzy Logic based, and Particle Swarm Optimization based MPPTs. Equipment based MPPTs have the inconvenience of diminished unwavering quality and productivity, and expanded framework many-sided quality and execution cost. Programming based procedures as a rule show algorithmic unpredictability and may require capable microcontrollers which actually brings about expanded framework cost. The ordinary methods like P&O and IC are easy to realize yet they can't find genuine MPP and stall out with nearby MPP. Numerous adjustments to regular and furthermore new calculations have been proposed to track the GMPP. The literature on MPPT has expanded so much lately that it has become confusing for any researcher to get acquainted himself with the recent trends unless exact synopses are not given. In this paper just significant work has been cited and papers with minor changes may not be incorporated into reference list.

II. EFFECTS OF PARTIAL SHADING CONDITION ON THE PV ARRAY

A. Characteristics of P-V Curve Under P_{sc}

A PV array usually consists of several PV modules which are connected in series-parallel to obtain the desired voltage and current. Bypass diodes are used in parallel with each PV module to protect modules from hot-spot problems. When the solar irradiance is uniform, only one MPP exists on the P-V characteristic curve. But under non-uniform irradiation (partial shading) conditions, several local maximum power points evolve on the P-V characteristic curve. Fig. 1 shows the P-V characteristic of a partially shaded PV array .

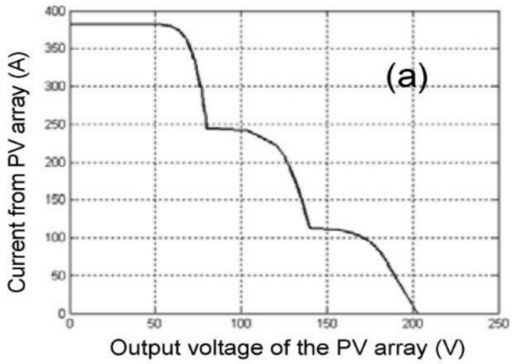


Fig.1 (a) I-V characteristics of a PV array under Partial Shading Conditions

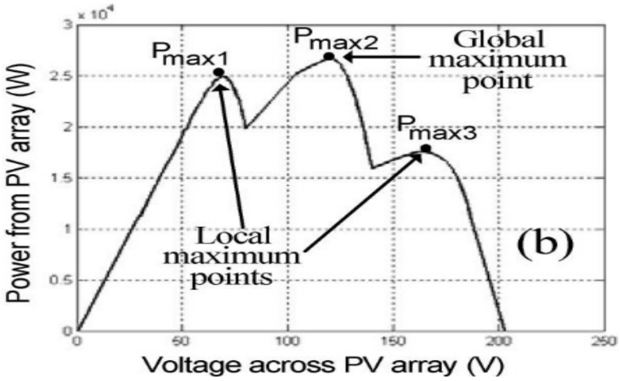


Fig. 1(b) P-V characteristics of a PV array under Partial Shading Conditions

As can be seen in fig. 1(a) & (b), there are several peaks in the output characteristics of a PV array under partial shading conditions . It is also observed that the global peak as shown in fig. 1(b) occurs at a voltage very close to the one at which the normal MPP would have occurred in the absence of partial shading conditions. Since the P-V characteristics of the array under partial shading conditions get changed, hence, partial shading has a strong impact on the performance of the PV system & therefore must be addressed accordingly.

B. Failure of Conventional MPPT techniques

The commonly used MPPT techniques like P & O method, Incremental Conductance method, RCC method etc.work well in tracking the maximum power point under uniform temperature and irradiation conditions as only one MPP exist in the PV characteristic curve. As explained already, under partial shaded conditions, there exists several MPPs on the P-V curve. Also global MPP changes with change in voltage level. So the conventional MPPT tend to stay at voltage close to the one at which the MPP was tracked during uniform shading instead of tracking the GMPP which changes during non-uniform irradiance. The conventional techniques have two drawbacks. The first and most important one is that they can lose track of the MPP if the irradiation changes quickly and continuously.[7]. If the change is instantaneous like in step changes, they can easily track MPP because the curve doesn't keep on changing. However with continuous irradiation changes, the curve on which the algorithms are based also changes, as can be seen in Fig. 1 (a) & (b), so voltage and current changes abruptly without doing a perturbation of voltage. So, it is impossible for the

ISSN (Print) : 2320 – 3765
ISSN (Online): 2278 – 8875

International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering

(An ISO 3297: 2007 Certified Organization)

Website: www.ijareeie.com

Vol. 6, Issue 4, April 2017

conventional techniques to determine whether the change in the power is due to its own voltage in perturbation or due to non-uniform irradiation.

III. REVIEW OF MODIFIED TECHNIQUES

A. Tracking the Global Maxima (Soft-computing Techniques) :

Photovoltaic installations are gaining huge importance as the world is shifting towards non-conventional energy sources. However a major problem arises in PV system which is to track MPP for varying temperature and irradiance. As already mentioned , partial shading causes different maximas in the PV curve rather than one maxima in uniform shading. Partial shading causes non uniform current generation in different PV cells which causes mismatching and it ultimately causes multiple peaks in PV curve. Applying the gradient based MPPT techniques in Partial shading conditions is rather difficult because the global MPP of the PV curve exists usually at a low voltage and also the local MPP occurs at a voltage close to the voltage where MPP was initially tracked for uniform irradiance.

In [4], a new technique has been proposed in order to track the global MPP .It includes a two-stage MPPT along with the measurement of V_{oc} and I_{sc} . This technique is easy to implement however it involves additional circuit to measure V_{oc} and I_{sc}. This technique is only feasible when multiple peak power points happen to be on similar power level. In [6], the method proposed for tracking the global MPP is based on PSO(particle swarm optimisation). This technique has the advantage of tracking the global MPP even under mismatching conditions. The only drawback of this method is its complexity to implement it .Only a specialised engineer can set up the variables used in PSO method. So, a better method for tracking the MPP is the sweeping search by Hill climbing algorithm , across the full operating voltage using sufficiently dense searching which increases the tracking time. [7]. The search is completed in two stages. In the first stage ,global MPP is tracked by causing large changes in the duty cycle ,D .While in the second stage the actual MPP is tracked by carrying a local search around the tracked global MPP by causing small changes in the duty cycle, D so that the tracking time is considerably reduced. Tracking of the global maxima involves mostly an algorithmic approach, hence it's a soft computing technique.

a) GMPPT using Equilibration algorithm [10]-[11]

This section is based on the work "Maximum Power Point Tracking in Solar Panels under Partial Shading Condition using Equilibration Algorithm - Raja.B, Satheesh Kumar M.R, Vikash.S, Hariharan.K " published in International Conference on Communication and Signal Processing, April 6-8, 2016, India . It proposes a modification to the conventional hill-climbing methods such as P&O & incremental conductance. The proposed algorithm has been developed such that it tracks GMPP under any operating condition under two stages :

(i) A global search with a large perturbation size
(ii) Local search using Equilibration algorithm

The global search determines a global MPP but still that won't be the point of maximum power extraction under the given atmospheric conditions, though it will be near to the actual global MPP. So , to attain the actual global peak local search is carried out using the "Equilibration Algorithm" . Fig. 2(a) & (b) explain the algorithm.

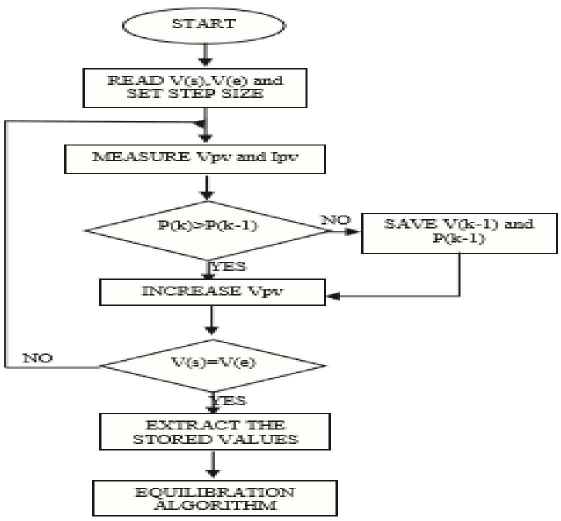
ISSN (Print) : 2320 – 3765
ISSN (Online): 2278 – 8875

International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering

(An ISO 3297: 2007 Certified Organization)

Website: www.ijareeie.com

Vol. 6, Issue 4, April 2017



Fig, 2(a) Global Search algorithm

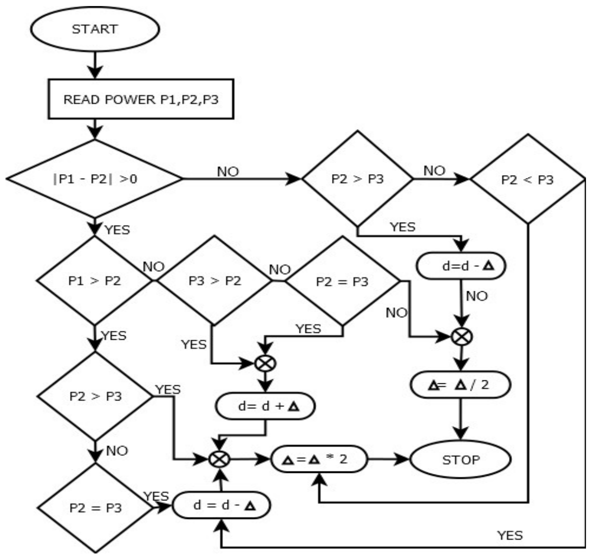


Fig. 2 (b) Equilibration algorithm for local search

b) *Particle-swarm-optimisation-based MPPT* [15]

PSO is a stochastic and a population-based search method which is used to track the MPP in the multi-PV array structure under partial shaded conditions. In [16], the proposed scheme for PSO uses a centralized MPPT controller for controlling the voltage of each solar module to reach the global MPP. The optimization is considered as a multivariable problem. The array power is defined as the objective function, which is a function of the individual module voltages. In this approach, the module voltages are treated as agents that can share information with each other and move in the multidimensional space that has a unique global maximum. Each agent keeps an updating memory of its own best position and the best position achieved among all agents, and uses these pieces of information to update its next position. The iterations continue until all agents converge to positions corresponding to the global optimum. This algorithm is able to track the global peak in the presence of multiple maxima, but a vital condition for this is the proper and accurate selection of the algorithm parameters. Another issue with PSO is that it is designed to optimize systems that are time-invariant which is clearly not the case in PV modules. This issue is resolved in [16] by having an additional constraint that checks for the variation in solar irradiance by computing the incremental power, and reinitializes the process if a large variation is detected. The same problem of PSO was tackled in [17] where a modified version of the algorithm is proposed with ability of dynamic tracking, namely Biological Swarm Chasing or “Bio-MPPT”. It was experimentally reported that the Bio-MPPT has an efficiency improvement of about 12% over the conventional P&O algorithm. A solution vector of duty cycles with ‘*N*p’ dutycycles is determined, i.e.

$$x_i^k = d_g = [d_1, d_2, d_3, \dots \dots \dots d_j] \;\; ; j = 1,2.3 \dots \dots N_p \quad (1)$$

The objective function is defined by

$$P(d_i^k) > P(d_i^{k-1}) \qquad (2)$$

ISSN (Print) : 2320 – 3765
ISSN (Online): 2278 – 8875

International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering

(An ISO 3297: 2007 Certified Organization)

Website: www.ijareeie.com

Vol. 6, Issue 4, April 2017

where*P(s)* is the fitness function.
To start the optimisation process, the algorithm transmits a certain number of duty cycles to the power converter in the first iteration. Fitness value for different duty cycles is measured using the fitness function and the duty cycle with best fitness function is selected. During partial shaded conditions, the global peak is easily determined corresponding to the best duty cycle.

c) Analog Technique

MPPT has the ability to perform in both analog or digital domains. Analog domain is faster as compared to digital domain as we don't need an I-V or a P-V plot and is cheapertoo.Since partial shading is a rapid and a random phenomenon , so a faster response of MPPT is required which can be easily provided by the Analog MPPT. A scheme for analog implementation of MPPT is explained in [26]& is depicted in fig. 3.

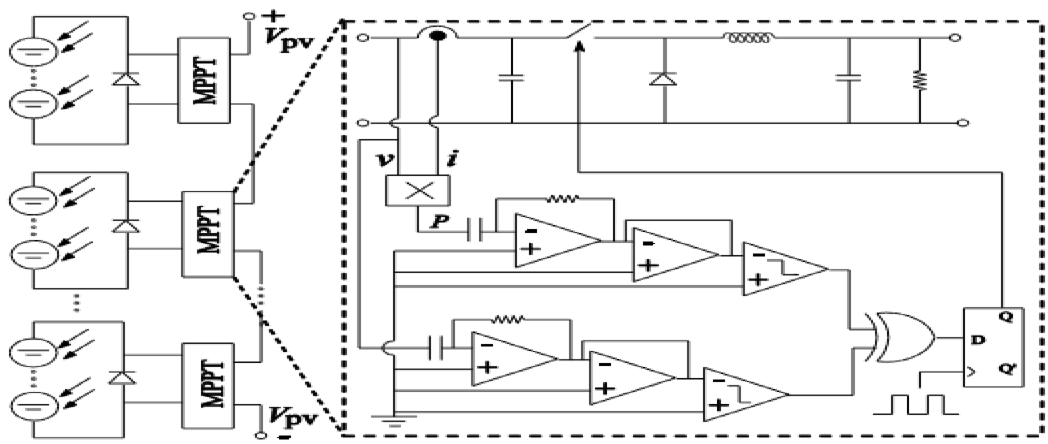


Fig. 3Analog implementation of MPP

d) Direct Search Algorithm

In [18] , another approach for determining the global maxima is given ,which is called the Dividing Rectangles or DIRECT algorithm.In this method , instead of tracking the global peak on the PV curve , use of certain "Lipschitz function" is made (since it has been proved that the PV characteristics of the PV cell is a member of this group of function [19]). As the first derivative of the PV curve is continuous in an interval say [a, b], hence the function peak lies within this interval. So taking the voltage as the control variable , an interval is selected , which can be anywhere between 0 & V_{OC} of the PV array. Then the algorithm is run from a point which is at the centre of the initial interval as shown in fig. 4 . Once this happens , the new voltage level corresponding to relatively large power becomes the centre of new interval & such iterations are run until the global peak is achieved.

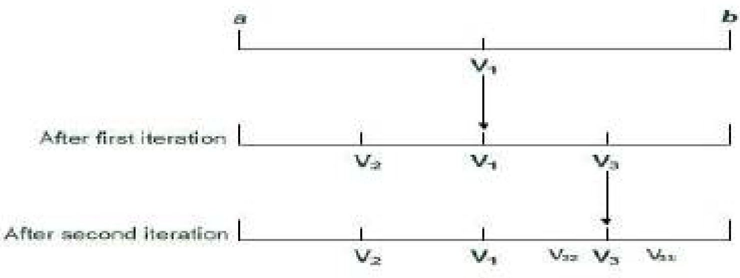


Fig.4Illustration Of Direct Search Algortihm

ISSN (Print) : 2320 – 3765
ISSN (Online): 2278 – 8875

International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering

(An ISO 3297: 2007 Certified Organization)

Website: www.ijareeie.com

Vol. 6, Issue 4, April 2017

B. Distributed Maximum Power Point Tracking (Hardware Based):

To enhance the yield of PV systems in case of mismatched states panels because of shadowing , clouding or module tolerances numerous techniques have been devised. These methods address both stand-alone as well as grid-connected applications equally well using dc-dc converters . The stand-alone systems use dc-dc converter which changes the power from PV systems according to the load. In the grid-connected systems two different approaches are taken viz. single-stage & double-stage (DS) inverters. In the DS structures as shown in fig.5 , the power is optimised by means of a DC/DC converter,& a DC-link transfers the PV power to the grid-connected or stand-alone inverters .

Fig.5 Double stage PV-grid connected system

Now , to address the problem of solar panel mismatching connected to a central inverter the PV generator is divided in many subfields , & each PV module is connected with its own dedicated MPPT based inverter . So rather than taking a MPP of the whole field (FMPPT), the task becomestracking of MPP from each module .
The adoption of a dedicated DC/DC converter for each PV panel is known as “Distributed Maximum Power Point Technology (DMPPT)” , where each PV panel is driven to its optimal operating point .This term was firstly introduced in [20] and nowadays it is used to refer to MPPT systems with dedicated inverters . This goal can be obtained by means of two different methods [21]. The first, and older, one is the adoption of one DC/DC converter per PV module, so that the dedicated converter, whose output terminals are connected in series or in parallel with those ones of the converters dedicated to the other panels, runs the MPPT. This solution requires a careful choice of the DC/DC converter topology and control, depending on the chosen electrical connection and on the maximum stresses the switching devices can be subjected to. The second tool is used mainly for grid-connected PV systems and it includes a dedicated DC/AC converter (micro-inverter) per PV panel. For this situation the small scale inverter output terminals are direct associated with the network, so that the circuit needs to assume responsibility for the significant boosting of the low DC voltage at the module terminals up to the maximum voltage value at the AC mains .In many cases ,and particularly when the DC/AC converter includes a DC interface which connects to a PWM stage, a DC/DC converter with a high voltage transformation proportion is required for boosting up the PV panel voltage by 10-15 times. Up to now, any DC/DC converter having such a component has the disadvantage of a low efficiency, so that the fundamental constraint of the most flexible DMPPT arrangement, i.e. the individual panel inverter, is the very low efficiency.
DMPPT converters are the front part in a dual-stage conversion. Here the DC power delivered by the PV modules is supplied to the AC utility network by employing an inverter. The two phase structure in this way contains a high-voltage dc-interface between the DC-DC converters and the inverter. There would be different individual converters that would transfer power into the dc-link which would be common. There are two general structures of DMPPT systems & are represented by figure 6& figure 7 . In fig. 6 the series configuration is shown , where the individual dc-dc converter output terminals are connected in cascaded form. Thus the dc-link voltage is spread between the converter output terminals. Whereas in the parallel configuration , as the name suggests the inverter is connected in parallel configuration to the output of DC-DC converters.

ISSN (Print) : 2320 – 3765
ISSN (Online): 2278 – 8875

International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering

(An ISO 3297: 2007 Certified Organization)

Website: www.ijareeie.com

Vol. 6, Issue 4, April 2017

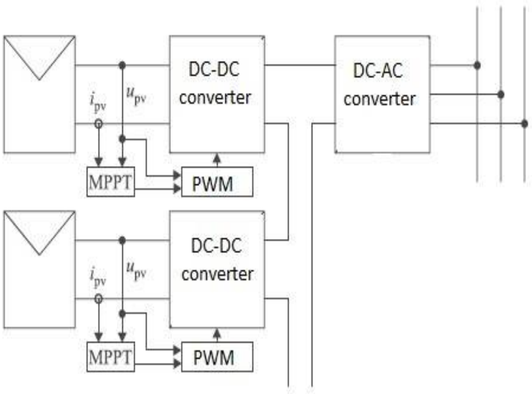


Fig.6 PV system in series DMPPT configuration

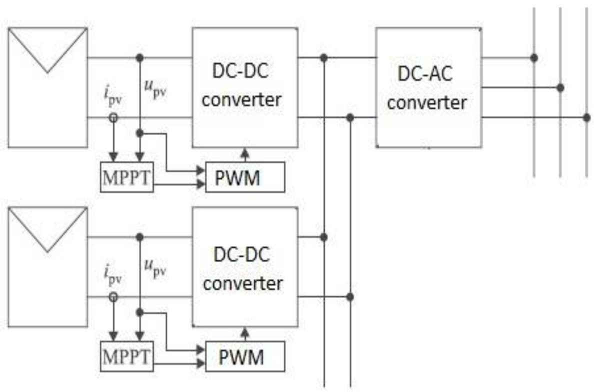


Fig.7PV system in parallel DMPPT configuration

As seen in figures 6 and 7, albeit every module is provided with a dedicated converter, they still are sharing either a common current (when in cascade arrangement) or common voltage (when in parallel) . This creates a "cross-coupling effect" , due to which a turbulence in voltage of one module occurs if , the current or duty cycle of the adjacent module is varied & vice-versa . Thus the cross-coupling effects are not desirable at all & different measures are undertaken to ensure their elimination. Further it is also observed that the series arrangement is more susceptible to the cross-couplings whereas in the parallel arrangement these effects are negligible , since the system doesn't introduce any distortion but only the load does , thus making the parallel arrangement free of there cross-coupling effects. Where as in parallel setup, the impact of cross couplings is substantially less as the framework doesn't present the cross couplings yet just the heap does. While in arrangement setup, the framework itself presents cross couplings. Henceforth one could state that parallel arrangement is for all intents and purposes free of these cross coupling impacts. Input voltage of both modules will be distinctive and the current through every modules ,will likewise be not quite the same as each other, so that each will recognize their corresponding MPP. Both the converters then are connected together in parallel DMPPT setup and finally it is connected with an inverter which may be connected to a load or a grid. Thus a DMPPT setup offers more efficiency whereas on the other side the only con being the increase in installation cost.

a) DMPPT using Power Optimisers :

Distributed Maximum Power Point Tracking (DMPPT) permits to beat the disadvantages related to partial shading conditions. As mentioned above two different DMPPT methodologies can be used. The first one depends on the selection of micro integrated inverter(MII) [22] for each PV module, so as to convert their dc output into ac ,that can be fed to grid . Such an approach will be discussed in the next section. The second approach rather utilizes a module devoted DC/DC converter responsible for tracking the MPP for every module (Fig. 6&7). Examples of devices available in the market designed with reference to the architecture shown in Fig.6 are the Solar Edge Power Box, the Tigo Energy Module Maximizers, the Xandex Sun Mizers. The main technical characteristics of such commercial devices are presented and discussed in detail in [20].

b) DMPPT using Micro-Inverter **:** [22]

The basic framework of DMPPT is based on Module Integrated Inverter(MII) which has a sole objective of making PV module “plug & play” system, hence can be connected directly to grid without any grid without any auxiliary device and additional personnel without any prior knowledge of electrical installations. Looking on safety side, MII systems are not severely altered by electric arcs and lightning thereby shrinking the cost the cost of installation as no equipments such as dc cables, dc connectors, fuses are employed. Conventionally, Ac installations are needed and system is planned in easier way to high level of modularity. The commercial viability of such systems is due to lower power PV systems for residential purposes on account of high efficiency and reliability.

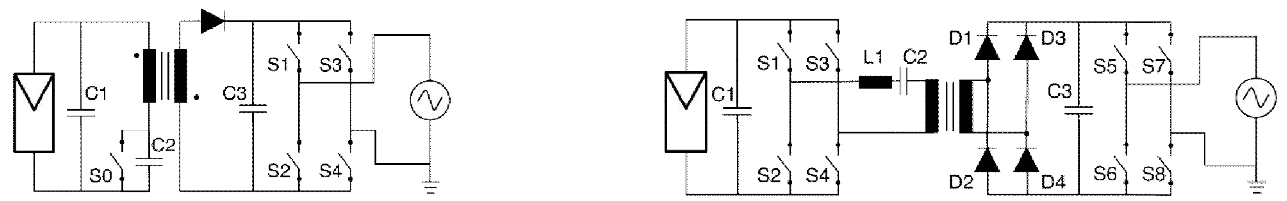
ISSN (Print) : 2320 – 3765
ISSN (Online): 2278 – 8875

International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering

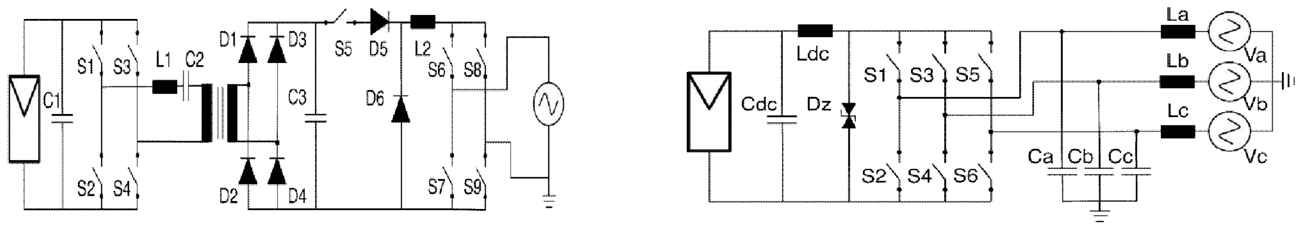
(An ISO 3297: 2007 Certified Organization)

Website: www.ijareeie.com

Vol. 6, Issue 4, April 2017



a) Inverter with quasi-resonant flyback converterb) Inverter with resonantly controlled HF transformer



c) Inverter with HF transformer buck converter andd) three phase grid solution. Line frequency full bridge

Fig. 8 PV-MII multistage architectures

The above fig. 8 illustrates few PV-MII architectures employed in various products. A thorough description of different MII architectures is presented in [22]-[25] .

a) *TEODI :*

In [26] a new technique for MPP tracking is presented which is based on “equalising of output operating points in correspondence with forced displacement of input operating points” of two identical PV systems & is referred as TEODI. In this each PV panel module of a given array has an individual DC-DC converter which is centrally controlled by a single control block. To understand this , consider a system with two subsystems A and B operating in parallel and under same ambient conditions (insolation and temperature).Each unit has an individual DC-DC converter. This method is also popularly known as Switched mode photovoltaic source. The schematic representation of TEODI operation is shown in fig. 9.

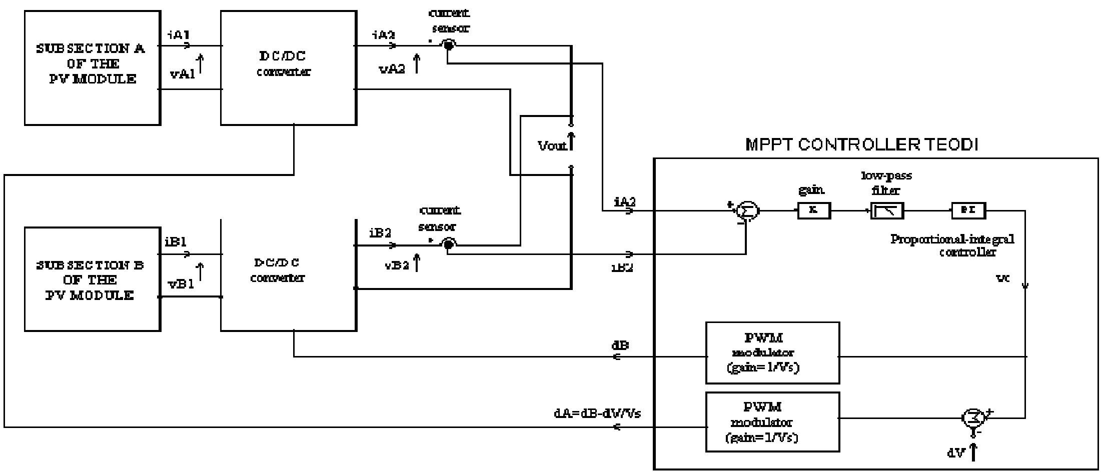


Fig.9 Schematic representation of the operating principle of TEODI

ISSN (Print) : 2320 – 3765
ISSN (Online): 2278 – 8875

International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering

(An ISO 3297: 2007 Certified Organization)

Website: www.ijareeie.com

Vol. 6, Issue 4, April 2017

As two sections are in parallel, so ,$V_{a2}=V_{b2}=V_{out}$. Hence, we need to control the currents I_{a1}, Ib1 such that $I_{a2}=I_{b2}$.
Therefore power obtained is same
Power output=$V_{out}*I_{a2}=V_{out}*I_{b2}$
Assuming efficiency E_a, E_b are equal, input powers can be calculated,$P_{in}=V_{ou}t*(I_{a2}/E_a)=V_{out}*(I_{b2}/E_{b2})$, above results can be obtained for voltages which are situated at the opposite side with respect to MPP other than trivial case of $V_{a1}=V_{a2}$.

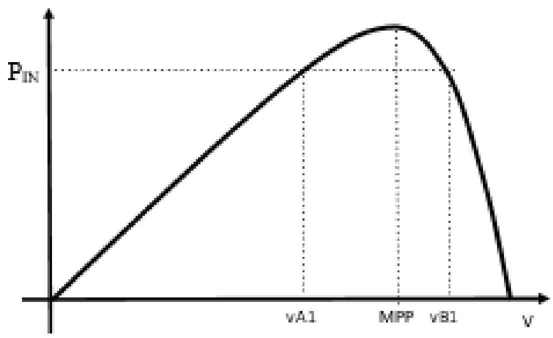


Fig.10Power vs voltage characteristic of each subsection

IV. CONCLUSION

This study summarizes the problems in maximum power point tracking under partial shading conditions. As mentioned earlier under PSC the output characteristics of PV array are drastically changed ,& instead of a unique MPP , there exists different local peaks as well as a global peak . Such a condition of partial shading cannot be easily avoided, since the sunlight direction changes from sunrise to sunset in a day period. The shading can be caused by obstacles, such as clouding, dust settled on panel, or birds etc. This generally results in irregular photovoltaic output when photovoltaic panel are connected in series. This generally makes it difficult to perform the maximum power tracking. Hence intelligent solutions are required to overcome this problem . A number of techniques have been proposed to address this problem & a hefty amount of literature is also available for this. These different techniques, in this paper have been categorised in simply two groupsas: hardware based (DMPPT) & software based (GMPPT)& also a brief review for some of them is also provided.Further a brief description of avery recent analog technique suitable for DMPPT application is also given (TEODI). The authors hope that this paper will immensely help those who are newly introduced to the field of PV power generation & will be used as a review in future research work.

REFERENCES

[1] T. Esram and P. L. Chapman, “Comparison of photovoltaic array maximum power point tracking techniques,” IEEE Trans. Energy Conv., vol. 22, no. 2, pp. 439–449, Jun. 2007.
[2] E. Koutroulis, "A new technique for tracking the global maximum power point of PV arrays under partial shading conditions," IEEE Journal of Photovoltaics, Volume 2, Issue 2,April 2012, PP.184-190.
[3] G. Petrone, G. Spagnuolo, R. Teodorescu, M. Vitelli, “Reliability issues in photovoltaic power processing systems”, IEEE Trans. Ind. Electron. Vol. 55, No. 7, pp. 2569-2580, July 2008.
[4] K.Kobayashi, I.Takano, and Y.Sawada, “A study on a two stage maximum power point tracking control of a Photovoltaic system under partially shaded conditions,” in Proc. IEEE Power Eng. Soc. Gen. Meet, pp. 2612- 2617, 2003.
[5] H.Patel ,V.Agarwal, “Maximum power point tracking scheme for PV systems operating under partially shaded conditions,” IEEE Trans. Ind. Electron., vol.55, no.4, pp. 1689-1698, Apr.2008.
[6] M.Miyake, F.Toriumi, T.Endo, and N.Fujii, “ A novel maximum power tracker controlling several converters connected to photovoltaic arrays with particle swarm optimization technique,” in Proc. Power Electron. Appl. Eur. Conf , pp. 1-10, 2007.
[7] R. Bruendlinger, B. Bletterie, M. Milde, and H. Oldenkamp, “Maximum power point tracking performance under partially shaded PV array conditions,” in Proc. 21st EUPVSEC, Dresden, Germany, pp. 2157–2160, Sept 2006.
[8] G .Shobana, P.Sornadeepika and R .Ramaprabha, “Global Maximum Power Point Tracking of Photovoltaic Array under Partial Shaded Conditions”, International Journal of Engineering Research , Vol.No.2, Issue No.3, pp : 219-223, July 2013.
[9] Bader Alajmi . and Khaled Ahmed H, “A Maximum Power Point Tracking Technique for Partially Shaded Photovoltaic Systems in Microgrids”, IEEE Transaction on Industrial electronics, Vol. 60, no. 4,pp. 1596-1606, April 2013.

ISSN (Print) : 2320 – 3765
ISSN (Online): 2278 – 8875

International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering

(An ISO 3297: 2007 Certified Organization)

Website: www.ijareeie.com

Vol. 6, Issue 4, April 2017

[10] Raja.B, Satheesh Kumar M.R, Vikash.S, Hariharan.K , “Maximum Power Point Tracking in Solar Panels under Partial Shading Condition using Equilibration Algorithm” , International Conference on Communication and Signal Processing, April 6-8, 2016, India .
[11] RexalineInfancia.X ,Kavya.K, Hariharan.K , “Equilibration Algorithm for Maximum Power Point Tracking in Solar Panels” , Computational Intelligence and Computing Research (ICCIC), 2013 IEEE International Conference .
[12] Bruendlinger R., Bletterie B, Milde M and Oldenkamp H, “Maximum power point tracking performance under partial shaded PV Array conditions”, proc.21st EUPVSEC, Dresden, Germany, pp.2157-2160, 2006.
[13] Kai Chen, Shulin Tian, Yuhua Cheng, and Libing Bai, “An Improved MPPT Controller for Photovoltaic System Under Partial Shading Condition,” IEEE Transactions on sustainable energy, Vol. 5, no. 3, pp.978-985. July 2014.
[14] Trishaw Esram, Patrick L. Chapman, “Comparison of Photovoltaic Array Maximum Power Point Tracking techniques”, IEEE Transactions on energy conversion , Vol 22, pp.439-449, June2007.
[15] Weidong Xiao, Member, IEEE, Ammar Elnosh, Student Member, IEEE, Vinod Khadkikar, Member, IEEE and Hatem Zeineldin, Member, IEEE , “Overview of Maximum Power Point Tracking Technologies for Photovoltaic Power Systems”
[16] M. Miyatake, et al., "Maximum Power Point Tracking of Multiple Photovoltaic Arrays: A PSO Approach," Aerospace and Electronic Systems, IEEE Transactions on, vol. 47, pp. 367-380, 2011
[17] . L.-R. Chen, et al., "A Biological Swarm Chasing Algorithm for Tracking the PV Maximum Power Point," Energy Conversion, IEEE Transactions on, vol. 25, pp. 484-493, 2010.
[18] N. Tat Luat and L. Kay-Soon, "A Global Maximum Power Point Tracking Scheme Employing DIRECT Search Algorithm for Photovoltaic Systems," Industrial Electronics, IEEE Transactions on, vol. 57, pp. 3456-3467, 2010.
[19] D. R. Jones, et al., "Lipschitzian optimization without the Lipschitz constant," J. Optim. Theory Appl., vol. 79, pp. 157-181, 1993.
[20] N. Femia, G. Lisi, G. Petrone, G. Spagnuolo, M. Vitelli:“DistributedMaximumPowerPointTracking of Photovoltaic Arrays: novel approach and system analysis”,IEEETrans. onIndustrialElectronics,Vol. 55, No. 7, July 2008.
[21] Giovanni Petrone, Giovanni Spagnuolo, Massimo Vitelli, “Distributed Maximum Power Point Tracking : Challenges and Commercial Solutions” ISSN 1848-3380, Print ISSN 0005-1144
[22] B.Burger,B.Goeldi, S.Rogalla , H Schmidt , “Module Integrated Electronics - An Overview”, 25th European Photovoltaic Solar Energy Conference and Exhibition, September 2010, Valencia, Spain.
[23] Quan Li, Wolfs P. , “A Review of the Single Phase Photovoltaic Module Integrated Converter Topologies With Three Different DC Link Configurations”, IEEETransactionsonPowerElectronics,Volume23, Issue 3, May 2008, Page(s):1320 – 1333.
[24] KjaerS.B. , Pedersen J.K. , BlaabjergF.,"Areview of single-phase grid-connected inverters for photovoltaicmodules,"IndustryApplications,IEEETransactions on , vol.41, no.5, pp. 1292- 1306, Sept.-Oct. 2005.
[25] B. Sahan, A. Vergara, N. Henze, A. Engler, and P. Zacharias, “A single-stage pv module integrated converter based on a low-power current-source inverter,” IEEE Transactions on Industrial Electronics, Vol.55, Issue 7, July 2008 pp: 2602-2609.
[26] N. Femia, G. Petrone, G. Spagnuolo, M. Vitelli: “A new analog MPPT technique : TEODI ”, Progress in Photovoltaics: Research and applications, WileyBlackwell, 2010, Vol. 18, pp. 28-41.
[27] Tulika Dutta Roy, “Simulation and Analysis of Photovoltaic Stand-Alone Systems,” M.Tech..dissertation, Dept. of Elect. Eng., NIT Rourkela , India, May 2013.