IJAREEIE

e-ISSN: 2278-8875
p-ISSN: 2320-3765

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

Volume 12, Issue 4, April 2023

INTERNATIONAL STANDARD SERIAL NUMBER INDIA

Impact Factor: 8.317

| e-ISSN: 2278 – 8875, p-ISSN: 2320 – 3765| www.ijareeie.com | Impact Factor: 8.317|

||Volume 12, Issue 4, April 2023||

|DOI:10.15662/IJAREEIE.2022.1204003 |

MPPT Techniques under Partial Shading Condition: A Review

Bharat Gangal[1], Ravi Kumar Hada[2] and Gaurav Jain[3]

M.Tech Scholar, Department of Electrical Engineering, Global Institute of Technology, Jaipur, India[1]

Associate Professor, Department of Electrical Engineering, Global Institute of Technology, Jaipur, India [2]

Associate Professor, Department of Electrical Engineering, Poornima College of Engineering, Jaipur, India [3]

ABSTRACT- Most of the partial shading maximum power point tracking methods identifies MPP as the global maximum without being stuck at the local maximum. The convergence of the methods on the local peaks signifies the failure of the method and maximum available power does not get extracted from photovoltaics. In order to harness the maximum power from photovoltaics, their operation on the maximum power point on the power versus voltage curve is essential. This power point is the highest point on the power versus voltage curve, the operation on any other point results in underutilization of the available power of photovoltaics.

KEYWORDS: Photovoltaic, MPPT, Partial shading, SIMULINK, MATLAB, Irradiance, Microcontroller, Iteration.

I. INTRODUCTION

Normally to trace this point the voltage of the system is changed using buck/boost converter which results in the change of current of the photovoltaic array, these parameters are changed in the system till the corresponding voltage and current are located at which the maximum power point of the system is achieved. Many methods are available in the literature which can provide this kind of tracking like perturb and observe algorithm or incremental conductance algorithm. However, these methods work only when there is a single peak or single maxima on the power versus voltage curve of the photovoltaics. Under the conditions, when the photovoltaic array receives more than one level of irradiance, the power versus voltage curve shows more than on peak/maxima and there is the presence of local maxima and one global maxima. Thus, the problem shifts to locating the global maxima in the system, this results in the failure of the uniform shading maximum power point tracking methods under these partial shading conditions. These basic hill climbing algorithms like perturb and observe/incremental conductance are reworked to trace the global peak amongst the available multiple peaks of the system. Many methods are available in the literature which works on maximum power point tracking under partial shading conditions. However, these methods have been designed for the static shading pattern of the partial shading conditions, the irradiance pattern may change further when in partial shading mode.

II. LITRATURE REVIEW

Initially we have to understand shading in photovoltaic system. The shading in photovoltaic system is of two types: uniform shading and partial shading. This categorization is based upon the pattern of irradiance received on the module. The various categories of shading are shown in Fig 1. These types are discussed below.

Uniform shading- In uniform shading, all the PV modules receive the same amount of irradiation. The array P-V and I-V characteristics of PVs under uniform shading are shown in Fig. 2 and Fig. 3 respectively, the I-V curve has single step and P-V curve has a single peak. The shape of these curves may change as according to the level of irradiance, the P-V curve expands upon increases irradiance and shrinks upon a decrease in the irradiance level.

| e-ISSN: 2278 – 8875, p-ISSN: 2320 – 3765| www.ijareeie.com | Impact Factor: 8.317|

||Volume 12, Issue 4, April 2023||

|DOI:10.15662/IJAREEIE.2022.1204003 |

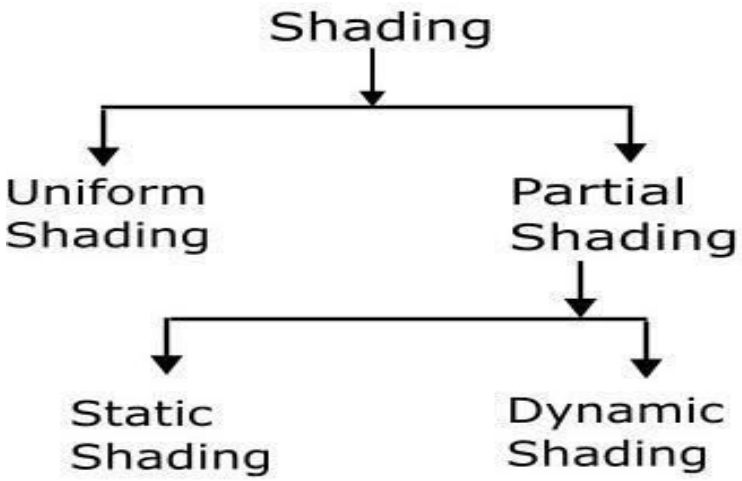


Fig. 1 Types of shading

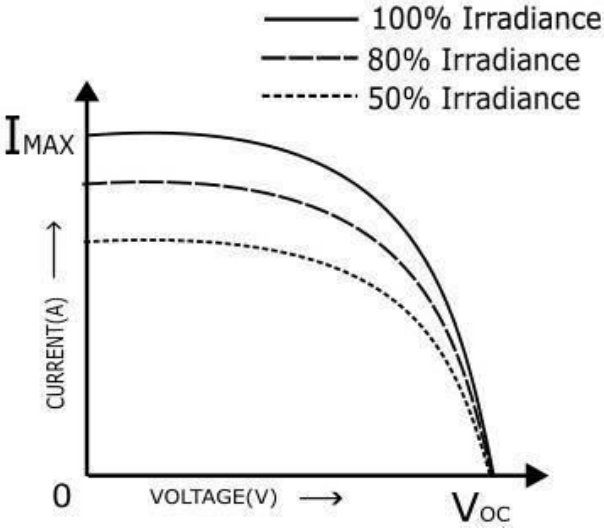


Fig. 2 P-V curve under uniform shading

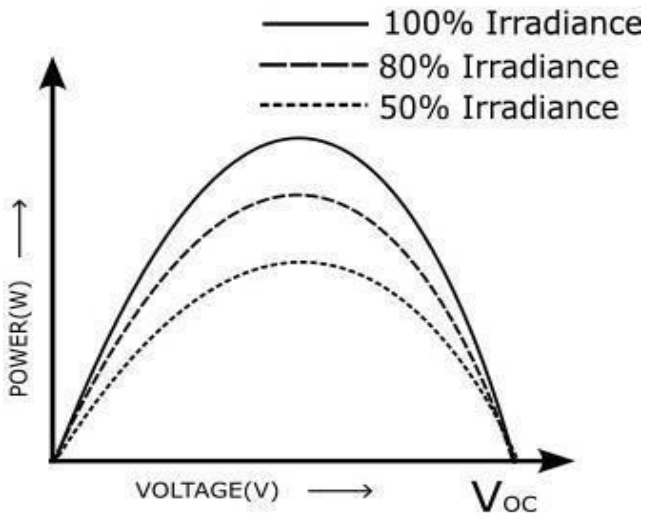


Fig. 3 I-V curve under uniform shading

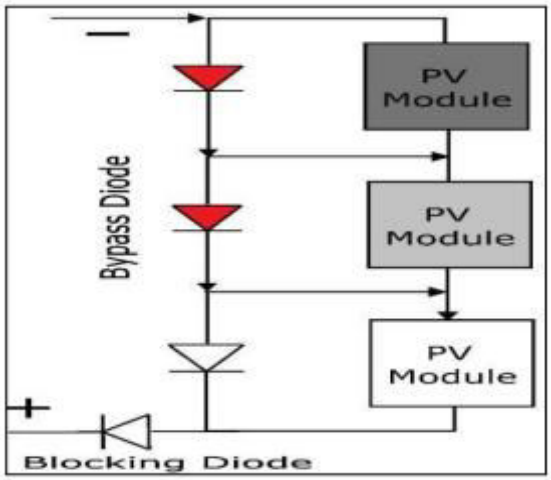


Fig. 4 Under partial shading condition (static)

| e-ISSN: 2278 – 8875, p-ISSN: 2320 – 3765| www.ijareeie.com | Impact Factor: 8.317|

||Volume 12, Issue 4, April 2023||

|DOI:10.15662/IJAREEIE.2022.1204003 |

Partial Shading- In partial shading, the modules of the same array take in different level of irradiance i.e., one module may receive an irradiance value of 1000 W/m2 whereas other panel may receive a value lower than 1000 W/m2, this kind of irradiance pattern give rise to complicities in the operation of PV system. There are many reasons for generation of partial shading, in building integrated systems the shadow of nearby buildings, telephones towers, electricity poles, deposition of animal waste, etc. causes the partial shading. In PV plants partial shading is due to shadow caused by the clouds [1-2]. Partial shading can be further classified into two categories i.e. the static shading and dynamic shading, in static shading, the shade remains constant on panel and in dynamic shading the shade travels on the panel. The situations of dynamic shading are quiet difficult to handle. A scenario of static shading is shown in Fig. 4, under the partial shading the shaded module produces a lower value of current due to which the additional series current travels through the connected bypass diode. This phenomenon gives rise to step waveform of I-V curve and more than one peak in P-V curve. Under these scenarios the bypass diode plays a crucial role in mitigating the effects of partial shading, without these diodes the output and the efficiency of PV system decreases significantly.

Some MPPT techniques under partial shading condition are as follows :-

i. Perturb and Observe (P&O)
ii. Direct Search Algorithm
iii. Artificial Neural Network Method
iv. Firefly Algorithm Based MPPT
v. Global MPPT Control

III. MPPT TECHNIQUES UNDER PARTIAL SHADING CONDITION

1. Perturb and observe (P & O) :-

The nature of operation of P&O algorithm is such that it does not guarantee the convergence to the MPP under partial shading condition. The P&O algorithm cannot differentiate between the local and global peak, the algorithm converges to the first peak it encounters whether local or global. However, in this operation, if the first peak encountered is the local peak, then the algorithm gets stuck on this peak only and cannot search the neighborhood for global peak. To understand this issue, the scenario of Fig. 5 is used as an example.

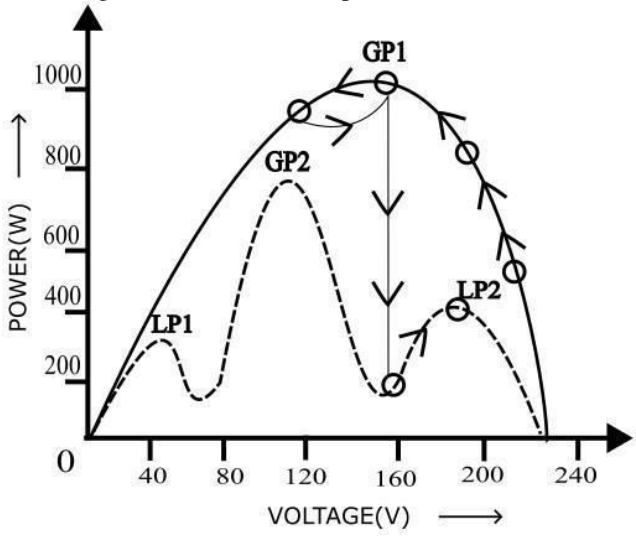


Fig. 5 Example searching of MPP

The scenario depicted in the above example is of the movement of operating point with the change in the shading conditions from uniform to partial. Initially, with the help of P&O algorithm the operating point converges to GP1 on the P-V curve. After partial shading occurs, the MPP changes and the operating point drops to the nearby location of LP2, the P&O sets the operating point at LP2. However, the true global point is GP2 and not LP2. The solution to the

| e-ISSN: 2278 – 8875, p-ISSN: 2320 – 3765| www.ijareeie.com | Impact Factor: 8.317|

||Volume 12, Issue 4, April 2023||

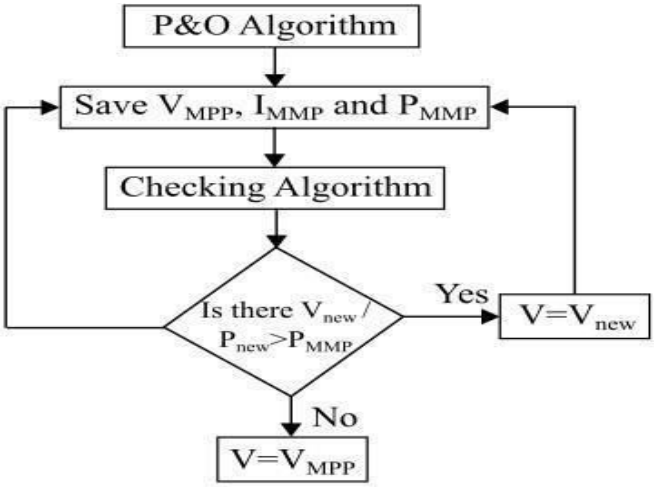
|DOI:10.15662/IJAREEIE.2022.1204003 |

problem is a two-step global MPP algorithm which searches for the Vmax and reaches the nearest MPP Pmpp. In the first stage, the MPP is assumed to be at the 80% of Voc value, in the second stage, the algorithm scans through some specific points in the range of Vmin to Vmax on the P-V curve. Where, Vmin and Vmax are the minimum and maximum voltage of a PV system respectively. In this searching process, an assumption is made that the distance between two consecutive peaks be dmin, which is represented by the following equation (1).

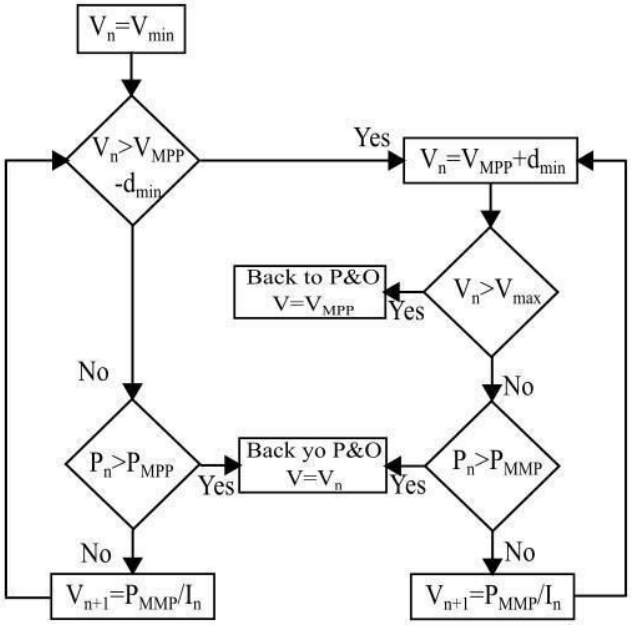
dmin = VMPPoc / n (1)

Here VMPPoc is the maximum power point voltage (VMPP) closest to the open circuit voltage (Voc), and n reflects the number of connected bypass diodes. The algorithm search scan starts from the Vmin, the values of voltage and power are measured and recorded at each step, if the current power value is greater than the previous value, then the current operating point becomes the new operating point. However, if the current power value is smaller than the previous value, than the new voltage sample value is changed to:

Vn+1 = PMPP / (I*n) (2)



a. Main Algorithm



b. checking Algorithm Fig. 6 MPP search (a), (b)

| e-ISSN: 2278 – 8875, p-ISSN: 2320 – 3765| www.ijareeie.com | Impact Factor: 8.317|

||Volume 12, Issue 4, April 2023||

|DOI:10.15662/IJAREEIE.2022.1204003 |

The entire P-V curve is scanned in the similar manner to achieve the global MPP value. The flow chart and checking algorithm
[3] are represented in Fig. 6.

2. Direct Search Algorithm :-

Direct search algorithm is based on global MPPT [4]. For the purpose of scanning the entire PV curve of PVs, the search area is divided into several intervals as shown in Fig. 7. In the first trek the power at 50% of VOC is measured. In the second trek, the search area is divided into three samples i.e. 25% of Voc, 50% of Voc and 75% of Voc. After the comparison of the sample values collected at different points on the search area, the region around the optimized maximum power (here A2) is further divided into three parts. The process continuous till the power values of two consecutive samples read out to be same. Further the selected global MPP region is directed to P&O for the accurate location of global MPPT.

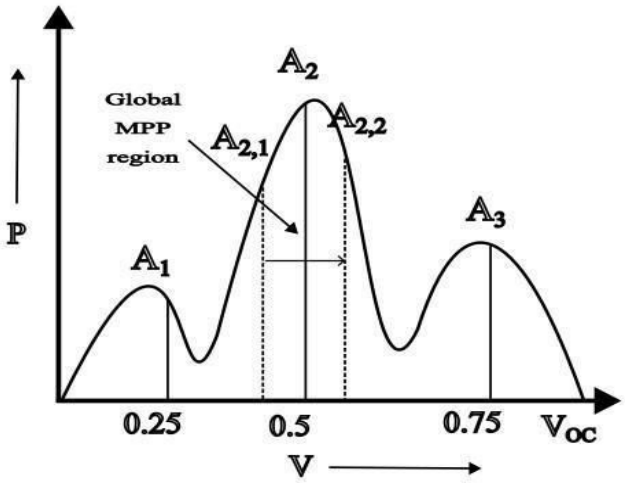


Fig. 7 Track for direct search algorithm

3. Artificial Neural Network Method :-

The artificial neural networks can be employed for searching the MMPT in PVs [5]. There are three layers in an artificial neural network: (a) input layer (b) hidden layer and (c) output layer. On the input layer the different irradiance levels E1, E2, E3 (E is irradiance) are used as inputs as shown in Fig. 8.

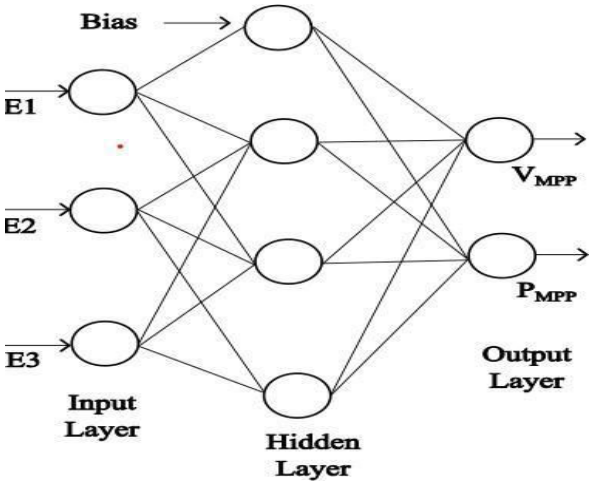


Fig. 8 Configuration of artificial neural network

| e-ISSN: 2278 – 8875, p-ISSN: 2320 – 3765| www.ijareeie.com | Impact Factor: 8.317|

||Volume 12, Issue 4, April 2023||

|DOI:10.15662/IJAREEIE.2022.1204003 |

In the above figure, the input is in form of irradiance which is send to the hidden layer and finally the output is in the form of MPP voltage (VMPP) and power (PMPP).For this method the placement of sensor on each and every module is compulsory, in this method an assumption is made that the sensor of each module records the average value of the irradiance and not the instantaneous value. The assumption decreases the calculation burden.

4. Firefly Algorithm based MPPT :-

The Firefly algorithm is a searching algorithm for MMPT [6]. In the natural intercourse process of fire flies, the less bright fire flies are attracted by the brighter fireflies, this ecological movement of fireflies has been used in method [7]. In the Firefly algorithm, the multiple duty ratio sample is considered as population of fireflies and PV module output is considered as brightness. The following steps are involved in this algorithm:

i. In the first step, the population of fireflies start from F1, F2, F3, F4 and separated into possible spaces. The duty ratio samples of the Fireflies are considered to be placed on P-V curve in the range of minimum to maximum duty cycle ratio (between dmin and dmax)
ii. In the second step, the PV power is measured and stored across the position of fireflies on the P-V curve.
iii. In the third step, the fireflies with brightest glow remains in its original position and remaining of the fireflies shifts toward the brightest firefly.
iv. In the final, when two fireflies collide with similar brightness (PV power), then GMPPT is said to be reached. Fig. 9 shows the pictorial presentation of all the above steps.

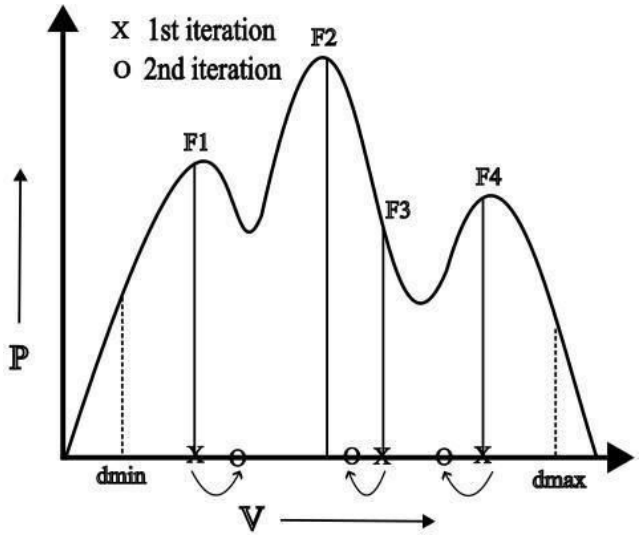


Fig. 9 Fireflies optimization algorithm

5. Global MPPT Control

In this control technique three major processes are included to reach the MPP [8]. The first step is the global MPPT process in which the PV voltages are increased in step to maximum limit, after that the corresponding values are stored in the microcontroller. The second step involves the voltage regulation stage, in the step, the converter reduces the duty cycle until the system voltage reach of MPPT. To maintain the operation at GMPP, P&O algorithm is applied in the final step. Fig. 10 shows these steps.

| e-ISSN: 2278 – 8875, p-ISSN: 2320 – 3765| www.ijareeie.com | Impact Factor: 8.317|

||Volume 12, Issue 4, April 2023||

|DOI:10.15662/IJAREEIE.2022.1204003 |

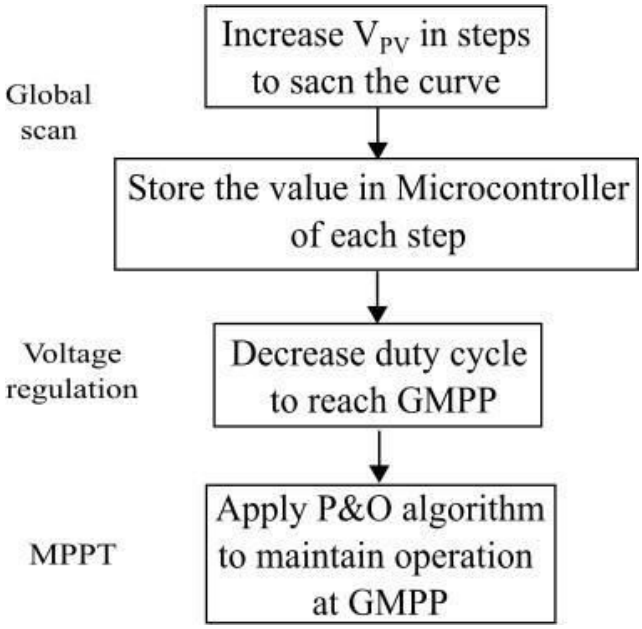


Fig. 10 Steps of Global MPPT control

IV. RESULTS AND DISCUSSION

Generally, the MPPT techniques initially scans the power verses voltage curve in the presence of partial shading. Some of the MPPT techniques blindly scan the power verses voltage curve, but some of MPPT techniques firstly set a reference andscan the entire curve. The blindly scanning of P-V curve is wastage of power. Few MPPT techniques are conventional and power saving, these MPPT techniques are discussed in this paper.

Comparison of MPPT techniques:-

Different MPPT techniques are survived in the above sections, Table 1 systematically summarizes these GMPPT algorithms based on various criteria's such as sensors used, complicacy, PV module dependency, expenditure, converter type and hardware verification.

Table 1 Comparison of MPPT algorithm

MPPT Algorithm	Sensor Used	Complicacy	PV module Dependency	Expenditure	Converter Type	Hardware Verification
Perturb & Observed [3]	V, I	Low	No	Very high	Buck- Boost	Yes
Direct Search Algorithm [4]	V, I	Low	No	Low	Boost	Yes
Artificial Neural Network [5]	V, I	High	No	Very high	Buck-Boost	Yes
Fireflies Algorithm [6-7]	V, I	Medium	No	High	Boost	Yes
Global MPPT [8]	V, I	Medium	Yes	Low	Boost	Yes

| e-ISSN: 2278 – 8875, p-ISSN: 2320 – 3765| www.ijareeie.com | Impact Factor: 8.317|

||Volume 12, Issue 4, April 2023||

|DOI:10.15662/IJAREEIE.2022.1204003 |

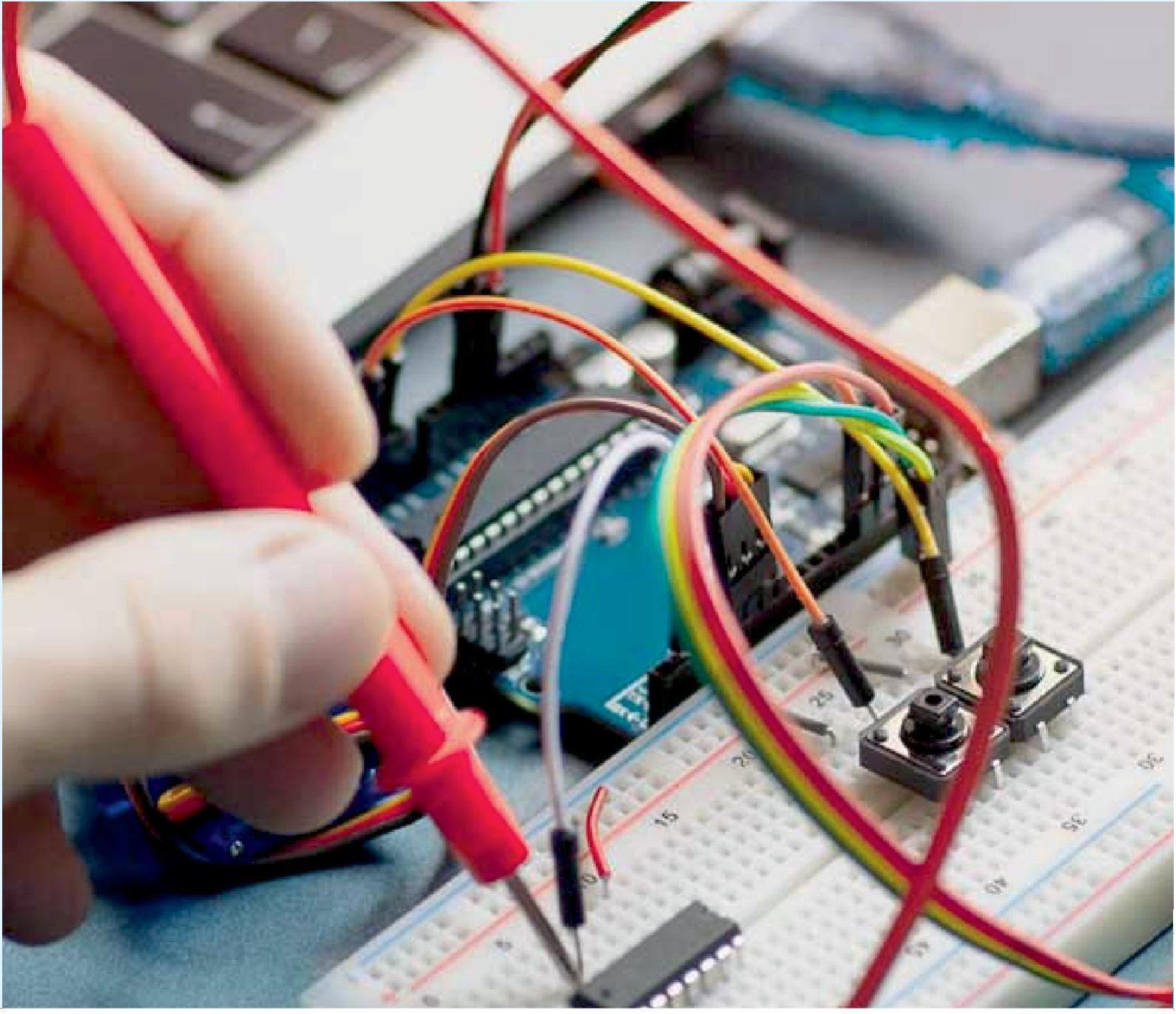
V. ACKNOWLEDGEMENT

Foremost, I would like to express my sincere gratitude to my guide and supervisor Mr. Ravi Kumar Hada, Head of Department, Dept. of Electrical Engineering, Global Institute of Technology, Jaipur for the continuous support for my research.

It is an honor for me to pay my gratitude to my co-supervisor Dr. Gaurav Jain, Associate Professor, Dept. of Electrical Engineering, Poornima College of Engineering, Jaipur for the continuous support for providing me a path to research.

REFERENCES

1. Jubaer Ahmed, Zainal Salam A critical evaluation on maximum power point tracking methods for partial shading in PV systems. Renewable and Sustainable Energy Reviews 47 (2015) 933–953.
2. Patel H, Agarwal V. Maximum power point tracking scheme for PV systems operating under partially shaded conditions. IEEE Trans Ind Electron 2008, p.1689–98.
3. Taheri H, Salam Z, Ishaque K. A novel maximum power point tracking control of photovoltaic system under partial and rapidly fluctuating shadow conditions using differential evolution. In: Proceedings of the 2010 IEEE Symposium on industrial electronics and applications (ISIEA); IEEE. 2010. p. 82–7.
4. Tat Luat Nguyen and Kay-Soon Low, "A Global Maximum Power Point Tracking Scheme Employing DIRECT Search Algorithm for Photovoltaic Systems," IEEE transactions on industrial electronics, vol. 57, no. 10, october 2010.
5. S. E. Karatepe, T. Hiyama, "Artificial neural network-polar coordinated fuzzy controller based maximum power point tracking control under partially shaded conditions," IET Renew. Power Generation., vol. 3, no. 2, pp. 239–253, 2009.
6. K. Sundareswaran, S. Peddapati, and S. Palani, "MPPT of PV Systems Under Partial Shaded Conditions Through a Colony of Flashing Fireflies,"IEEE Transactions on Energy Conversion, vol. 29, no. 2, June 2014.
7. Farzaneh, J.; Keypour, R.; Khanesar, M.A. A new maximum power point tracking based on modified firefly algorithm for PV system under partial shading conditions. Technology and Economics of Smart Grids and Sustainable Energy 2018, 3(1): 9-23.
8. Eftichios Koutroulis, Frede Blaabjerg, "A New Technique for Tracking the Global Maximum Power Point of PV Arrays Operating Under Partial-Shading Conditions," IEEE Journal of Photovoltaics, vol. 2, no. 2, April 2012.



INNO SPACE
SJIF Scientific Journal Impact Factor

Impact Factor: 8.317

International Journal of Advanced Research

in Electrical, Electronics and Instrumentation Engineering

9940 572 462 6381 907 438 ijareeie@gmail.com

Scan to save the contact details