iJRASET
International Journal For Research in
Applied Science and Engineering Technology

INTERNATIONAL JOURNAL FOR RESEARCH
IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY

Volume: 4 Issue: III Month of publication: March 2016

DOI:

International Journal for Research in Applied Science & Engineering Technology (IJRASET)

An Incremental Conductance MPPT Based Sepic Converter with Battery Charging Unit for Solar PV System

I. Inayath Bathul[1], R. Sivasakthi Priya[2]
[1] Department of Electrical and Electronics Engineering, Anna University Regional Campus, Coimbature,Tamilnadu,India
[2]Department of Electrical and Electronics Engineering, Anna University Regional Campus,Coimbature,Tamilnadu,india

Abstract: This paper This paper is based on the simulation of incremental conductance maximum power point tracking (MPPT) used in solar array. The main difference of the proposed system to existing MPPT systems includes the elimination of the proportional-integral control loop and investigation of simplifying the control circuit. This system is capable of tracking MPPs accurately and rapidly without steady-state oscillation and also, its dynamic performance is satisfactory. The tracking algorithm automatically changes the duty cycle of the SEPIC converter connected to the solar panel. The IncCond algorithm is used to track MPPs conditions. MATLAB and Simulink were employed for simulation. These results indicate the feasibility and improved functionality of the system.
Keywords— Maximum power point (MPP), Single-ended primary-inductor converter (SEPIC), Photovoltaic (PV), Incremental Conductance (IncCond)

I. INTRODUCTION

Solar energy is the one of the most promising energy sources for the present and future generations. It is clean, abundant and non polluting used in many applications .Among all solar power systems attract more attention because they provide excellent while Green house emissions are reduced .Because of these endless advantages of solar energy, it is worth saying that solar energy is a unique prospective solution for energy crisis. In general, the energy production in PV modules, regardless their manufacturing technology, energy conversion efficiency, etc.., highly depends on the environmental conditions. The fluxuations in the amount of received solar irradiance, mostly caused by passing clouds, dramatically affect the module characteristics and change the amount of electrical current production by the module. The mentioned variations in the amount of electrical power generated by PV systems are required to produce desired amounts of electrical power. Taking the mentioned negative effects into considerations, development and application of appropriate methods to enhance the energy production by the systems earns a great importance for an efficient use of solar energy generation systems. This can be obtained by using MPPT method to extract maximum power point from the PV modules under variable environmental conditions by operating them at their maximum power point.

The mentioned variations in the amount of electrical power generated by PV systems are required to produce desired amounts of electrical power. Taking the mentioned negative effects into considerations, development and application of appropriate methods to enhance the energy production by the systems earns a great importance for an efficient use of solar energy generation systems. This can be obtained by using MPPT method to extract maximum power point from the PV modules under variable environmental conditions by operating them at their maximum power point. This paper reviews the basic characteristics of the PV cell. The MPPT Controller is necessary for any solar systems need to extract maximum power from PV module. It forces PV module to operate at close to maximum available power.

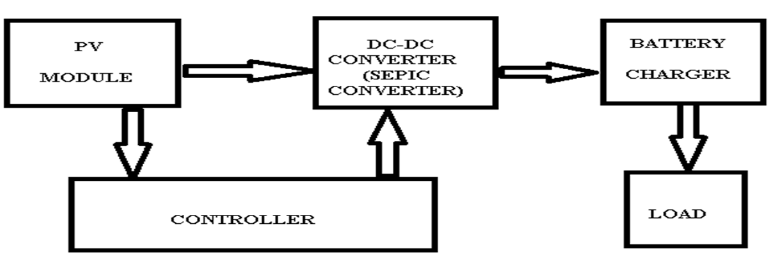


Fig 1.Overall block Diagram

This paper is organized as follows. In Section II, modeling of PV module and array is discussed. The proposed Incremental Conductance MPPT algorithm is designed and analyzed in Section III. SEPIC converter working in CCM is presented in section IV. Simulation study is reported in Section V. Finally, conclusions are summarized in Section VI.

II. PV MODULE

The basic structural unit of a solar module is the PV cells. A solar cell converts energy in the photons of sunlight into electricity by means of the photoelectric phenomenon found in certain types of semiconductor materials such as silicon and selenium A single solar cell can only produce a small amount of power. To increase the output power of a system, solar cells are generally connected in series or parallel to form PV modules. PV module characteristics indicate an exponential and nonlinear relation between the output current and voltage of a PV module.

Applying Kirchoff's law to the node where Iph, diode, Rp and Rs meet, we get

$$I_{ph}=I_D+I_{Rp}+I \quad (1)$$

We get the following equation for the photovoltaic current,

$$I=I_{ph}-I_{Rp}-I_D \quad (2)$$

$$I = I_{ph}-I_o[\exp\left(\frac{V+I.Rs}{Vt}\right) - 1] - \left[\frac{V+I.Rs}{Rp}\right] \quad (3)$$

Where,

I_{ph} is the Insolation current,I is the Cell current,I_O is the Reverse saturation current,V is the Cell voltage, R_S is the Series resistance,R_P is the Parallel resistance,V_t is the Thermal voltage (KT/q),K is the Boltzman constant,T is the Temperature in Kelvin, q is the Charge of an electron.

The PV mathematical model used to simplify our PV array is represented by the equation

$$I = n_p I_{ph} - n_p I_{rs}\left[\exp\left(\frac{q}{KTA} * \frac{V}{ns}\right)\right] \quad (4)$$

Where,

I is the PV array output current, V is the PV array output voltage, n_s is the number of cells in series,n_p is the number of cells in parallel, q is the charge of an electron,k is the Boltzmann's constant, A is the P-N junction ideality factor, T is the cell temperature (K)I_{rs} is the cell reverse saturation current. The factor A in equation (4) determines the cell deviation from the ideal p-n junction characteristics; it ranges between 1-5 but for our case A=2.4.

III. INCREMENTAL CONDUCTANCE MPPT

MPPT or Maximum Power Point tracking is the algorithm that included in charge controllers used for extracting maximum available power from PV module under certain conditions. The voltage at which PV module can produce maximum power is called "maximum power point" .MPPT checks output of PV module, compares it to battery voltage then fixes what is the best power that PV module can produce to charge the battery and converts it to the best voltage to get maximum current into battery. It can also supply power to DC load, which is directly connected to the battery .MPPT algorithm converter depending on the system design. In incremental Conductance method, the array terminal voltage is always adjusted according to the MPP voltage it is based on the incremental and instantaneous Conductance of the PV module.

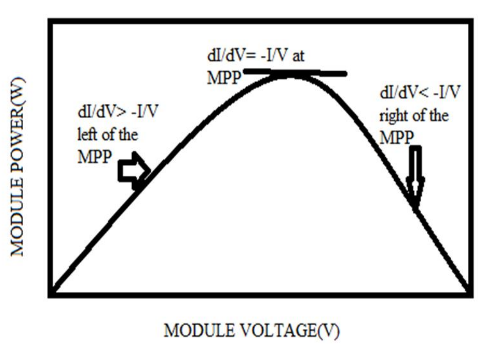


Fig 2. Basic concept of Incremental

Conductance on a PV Curve

dI/dV= -I/V at MPP (5)

dI/dV> -I/V left of the MPP (6)

dI/dV< -I/V right of the MPP (7)

The MPPT regulates the PWM control signal of the dc to dc power converter until the condition (dI/dV) + (I/V) =0 is satisfied.

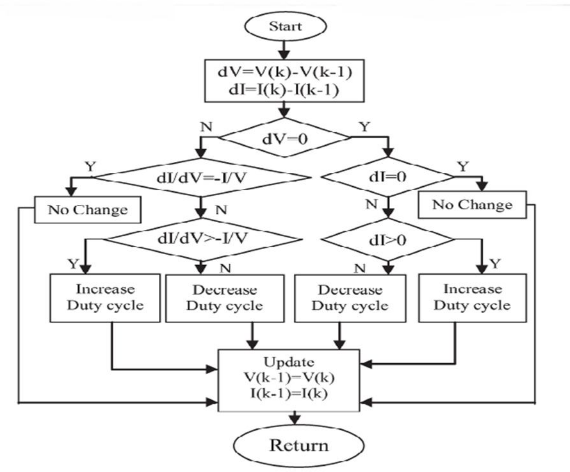


Fig 3. Flowchart of MPPT IncCond MPPT

The flow chart of Incremental Conductance method is shown in the below Fig 5, the output control signal of the incremental conductance method is used to adjust the voltage reference of PV array by Increasing or decreasing a constant value (ΔV) to the previous reference voltage. In this method, the tracking of MPP is accomplished by a fixed step size (± ΔV) regardless to the gap between the operating point of PV and MPP location. In this method the peak power the module lies at above 97% of its Incremental Conductance**.**

IV. SELECTION OF PROPER CONVERTER

DC-DC converters can be used as switching mode regulators to convert an unregulated dc voltage to a regulated dc output voltage. The regulation is normally achieved by PWM at affixed frequency and the switching device is generally BJT, MOSFET or IGBT. There are several different types of DC-DC converter, Buck, Boost, Buck-Boost, Cuk and SEPIC topologies. Among all the topologies, both Cuk and SEPIC converter provide the opportunity to have either higher or lower output voltage compared with the input voltage.

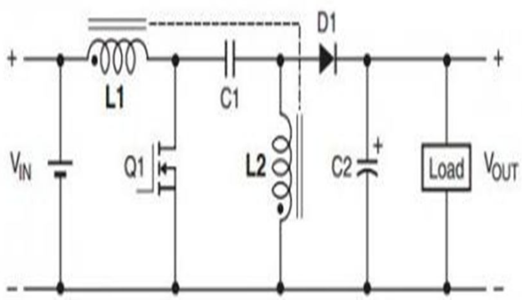


Fig 4 Circuit Diagram of SEPIC Converter

SEPIC is more stable with less power ripple as compared to Cuk converter at maximum power output. On the other hand, the advantage of Cuk converter is the reduction of circuit parameters (capacitor and inductance) as compared to SEPIC converter and hence reduced cost. Selection of one converter from the two depends on the system requirements and budget. For good quality of output power, SEPIC converter is favorable while Cuk converter offers low Cost system. Thus, SEPIC configuration is a proper converter to be employed in designing the MPPT. Single-end primary-inductor converter (SEPIC) is a type of DC-DC converter allowing the electrical potential (voltage) at its output to be greater than, less than, or equal to that at its input; the output of the SEPIC is controlled by the duty cycle of the control transistor. A SEPIC is essentially a boost converter followed by a buck-boost converter, therefore it is similar to a traditional buck-boost converter, but has advantages of having non-inverted output (the output has the same voltage polarity as the input), using a series capacitor to couple energy from the input to the output (and thus can respond more gracefully to a short-circuit output), and being capable of true shutdown, when the switch is turned off, its output drops to 0 V, following a fairly hefty transient dump of charge, SEPICs are useful in applications in which a battery voltage can be above and below that of the regulator's intended output.Fig:4 shows the circuit diagram of SEPIC converter followed with their parameters.

The components for the SEPIC converter used in simulation are as follows:
L1=150µ H, C1=47 µF, L2=150 µH, C2=470 µF, Load =10Ω.
Battery connected with the converter must be chosen such that it is suitable for PV system under different climatic conditions. Lead-acid batteries offer the best balance of capacity per dollar and it's a common battery used in stand-alone power systems. Because of their great advantages like low cost, low maintenance less weight.

V. SIMULATION RESULTS

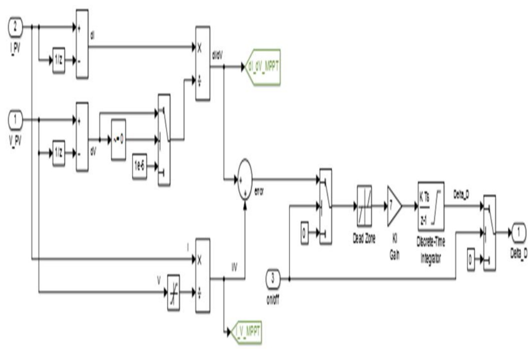


Fig 5.Incremental Conductance algorithms in Simulink modeling

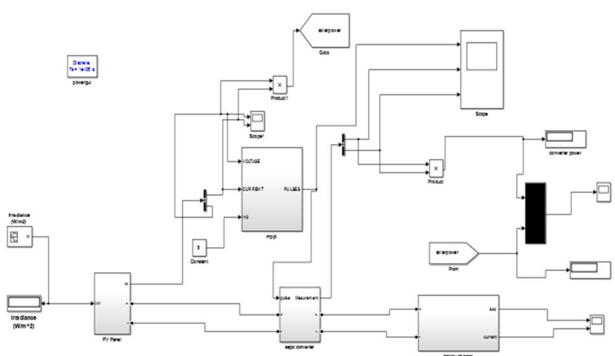


Fig 6. Modeling of PV Module with MPPT of SEPIC converter

Fig 5 shows the simulation diagram of the incremental conductance MPPT algorithm and Fig 6 represents the whole PV system with MPPT along with the SEPIC converter has been implemented in the Matlab/Simulink.

Volume 4 Issue III, March 2016
ISSN: 2321-9653
International Journal for Research in Applied Science & Engineering Technology (IJRASET)

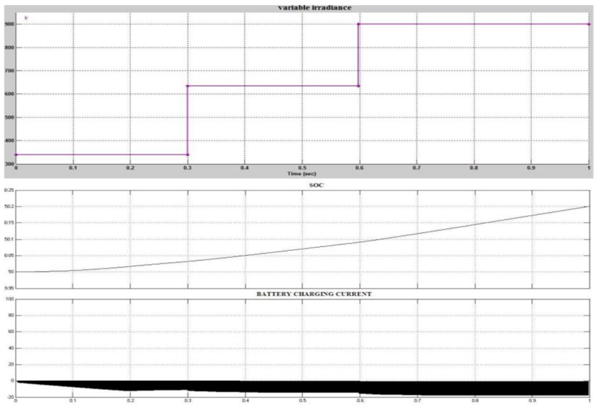


Fig 7. At variable irradiation

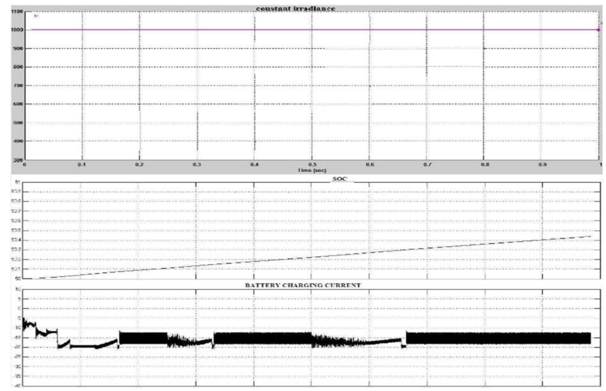


Fig 8. At irradiation of 1000 W/m^2

Fig 7 shows the simulation output waveform of battery, charging at sudden change in solar irradiation with respect to time. It is seen that the charging of the battery increases with the increase in irradiation which is achieved by extracting maximum power from the panel using Incremental conductance MPPT method. Fig 8 shows the simulation output waveform of battery, charging with respect to time at constant solar irradiation of 1000 W/$m^{2.}$. This shows that the SOC of battery is increasing quite fast .Hence compared to conventional algorithm, this Incremental Conductance method extract maximum power from the PV panel at maximum irradiation.

VI. CONCLUSION

Thus the simulation of the PV system with Incremental conductance MPPT algorithm has been successfully implemented in the Matlab/simulink.So that it forces the PV module to operate at close to maximum power operation point to draw maximum power shows that it is achieving the maximum extracting power and it is constantly working near the maximum operating point of the module. From the results acquired during the simulations, it was confirmed that, with a well-designed system including a proper converter and selecting an efficient and proven algorithm, the implementation of MPPT is simple and can be easily constructed to achieve an acceptable efficiency level of the PV module. The results also indicate that the proposed control system is capable of tracking the PV array maximum power and thus improves the efficiency of the PV system and reduces low power loss and system cost.

REFERENCES

[1] Hussein KH, et al. "Maximum photovoltaic power tracking: an algorithm for rapidly changing atmospheric conditions" IEE Proceedings on Generation,Transmission and Distribution 1995; 142:59–64.
[2] Hohm D, Ropp M. "Comparative study of maximum power point tracking algorithms. Progress in photovoltaics" Research and Applications 2003;11: 47–62.
[3] Azadeh Safari and Saad Mekhilef"Simulation and Hardware Implementation of Incremental Conductance MPPT With DirectControl Method Using Cuk Converter" IEEE Transactions on industrial electronics, vol. 58, no. 4, April 2011.
[4] Her-Terng Yau, Qin-Cheng Liang, Chin-Tsung Hsieh "Maximum powerpoint tracking and optimal Li-ion battery charging control for photovoltaic charging system" Science direct, Computers and Mathematics with Applications 64 (2012) 822–832.
[5] James Dunia, Bakari M. M. Mwinyiwiwa "Performance Comparison between ĆUK and SEPIC Converters for Maximum Power Point Tracking Using Incremental Conductance Technique in Solar Power Applications" Vol:7 No:12, 2013.
[6] A.Pradeep Kumar Yadav, S.Thirumaliah, G.Haritha," Comparison of MPPT Algorithms for DC-DC Converters Based PV Systems" Vol. 1, Issue 1, July 2012.
[7] Saravana Selvan. D,"Modeling and Simulation of Incremental Conductance MPPT Algorithm forPhotovoltaic Applications Volume No.2, Issue No.7, pp : 681-685 1 July 2013.
[8] Faranda,R. Leva,S. and Maugeri,V. (2008) 'MPPT Techniques for PV Systems: Energetic and Cost Comparison.' Milano, Italy: Elect. Eng. Dept. Politecnico di Milano, pp. 1-6.
[9] Femina,N. Petrone,G. Spagnuolo.G.and Vitelli,M.(2005)'Optimization of perturb and Observe maximum power point tracking methodIEEE Trans. Power Electron., vol. 20, no.4,pp.963-973.
[10] Jain,S. and Agarwal,V. (2004) 'A new algorithm for rapd tracking of approximate Maximum power point in photovoltaic systems,' IEEE Power Electron. Lett., vol. 2 , no.1,pp.16-19.
[11] utroulis,E. Kalaitzakis,K. and Voulgaris,N.C. (2001) 'Development of a Microcontroller-based, photovoltaic maximum power point tracking Control system.' IEEE Trans. Power Electron., vol.16,no.1,pp.46-54.
[12] Kuo,Y.C.Liang, T.J and Chen,J.F (2001) 'Novel maximum-power-point tracking controller for photovoltaic energy conversion system', IEEE Trans. Ind. Electron., vol.48, no.3, pp.594-601.
[13] Liu,B.Duan,S.Liu,F.and Xu,P.(2007)'Analysis and improvement of maximum power point Tracking algorithm based on incremental conductance mehod for

International Journal for Research in Applied Science & Engineering Technology (IJRASET)

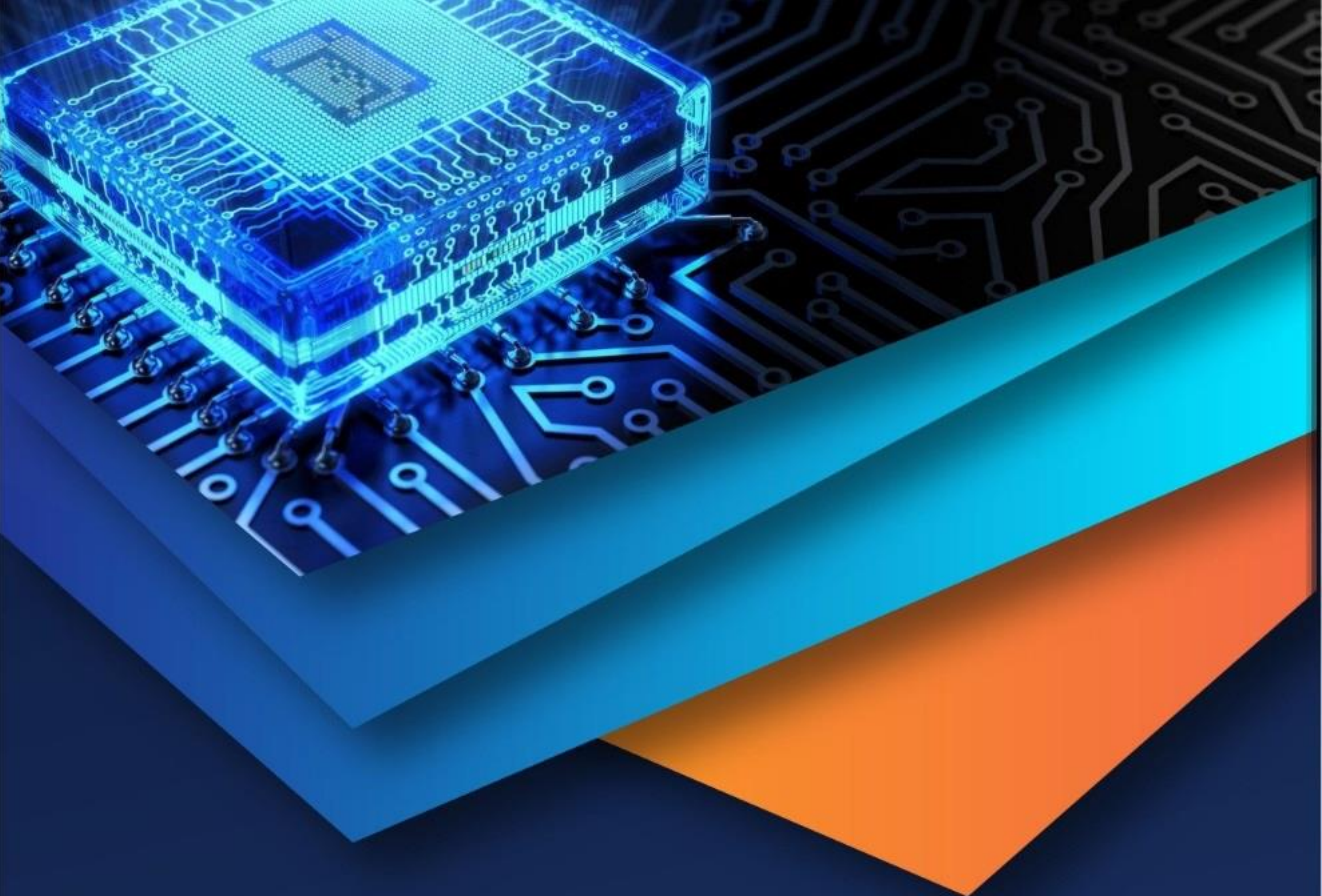
photovoltaic array'in Proc.IEEE PEDS,pp 637-641.

[14] H.Hussein, I. Muta, T. Hoshino, and M. Osakada, "Maximum photovoltaic power tracking: An algorithm for rapidly changing atmospheric conditions," Proc. Inst. Elect. Eng., Generation, Transmission and Distribution, Vol. 142, No. 1, January 1995, pp. 59–64.

[15] T. Esram and P. L. Chapman, "Comparison of photovoltaic arraymaximum power point tracking techniques," IEEE Transactions on Energy Conversion, Vol. 22, No. 2, June 2007, pp.439–449.

[16] N. Mohan, T. M. Undeland, and W. P. Robbins, Power Electronics:Converters, Applications and Design, Third Edition, John Wiley,NewYork,2003.

[17] M. H. Rashid, Power Electronics, Circuits, Devices and Applications,Third Edition, Prentice Hall, Upper Saddle River, NJ, 2004.



10.22214/IJRASET

INDEX COPERNICUS 45.98

IMPACT FACTOR: 7.129

IMPACT FACTOR: 7.429

INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY