Maximum Power Tracking Techniques for PV Array: A Review

Piyush Nehra* Charanjeet Madan**
*M.Tech Scholar, Electrical Engineering Department, HCE, Sonipat
** Assistant Professor, Electrical Engineering Department, HCE, Sonipat

Abstract: ***As solar photovoltaic system are the most emerging technology now days so to increase the energy efficiency of these system there are many different maximum power tracking algorithms have been developed which are working efficiently. The difference comes in these algorithms is in these implementations whether they are analog or digital or on the basis of their design and the hardware requirements or their total cost. Thus this become more important to choose the correct algorithm for the system because they effect the electrical efficiency of the system and also reduce the total cost because the number of solar panels required are decreased which minimize the cost. On the basis of literature survey we here present a total of 62 different techniques for tracking the maximum power tracking point. The main aim of maximum power point tracking system is to manage the power interfaces by which the operational characteristics of load and PV array will match the maximum power points. The present survey is based on the current developments in MPPT techniques.***

Key Words:-Maximum power point tracking system, System efficiency , digital control, Photovoltaic power systems, control systems

I. Introduction

As due to the lack of non-renewable resources photovoltaic power generation becomes the most popular method now days to complete the power needs and from the recent year there is sudden growth in this technology. The latest technology i.e. maximum power point tracking is an self control algorithm by which we can manage the power interfaces and also get the maximum possible power harvest and also cover the point to point changes in power, its temperature and PV module characteristics. Thus this becomes the most emerging tool for evaluation of design performance of photovoltaic power component.

In recent studies there are various ways area being introduced for tracking of maximum power point. In 2006, there has been a comparative study has been carried out in which various techniques have been summarized and a comparison between them is presented in this study [1-2]. Thus in continue with the previous advancements, in this paper we gives an overview about the implementation topology and the current MPPT technologies and also discuss about them in brief and the results thus presented are very useful for the future works.

As form past decade the renewable energy resources are being promoted worldwide thus it focuses towards generating clean energy application. And photovoltaic energy is most widely used technology among all these renewable energy techniques. In this technology we convert the heat energy we get from sun into electrical energy by using photovoltaic cells which are being used with the MPPT technology to increase the output power. The main aim of using MPP in PV system is to maintain the original performing voltage of PV panels to the voltage of MPP, by managing the output power provided by inverter.

As by studying the current voltage characteristic this has been observed that the maximum power is obtained at that point where the product of current and voltage is maximum. That point where the value of power is maximum is called MPP. Thus the main of MPPT module is to take the correct decision for the operation of PV module at its MPP, by taking he maximum power available. If the condition of the system is good then the system will generate the maximum power efficiency with an effective MPPT algorithm which has being used in the system.

In literature, there are plentiful MPPT methods as in

Kamarza man and Tan ; Liu et al. ; Lyden and Haque. used fourcategories to review MPPT algorithms as follows: hill-climbing ripple correlation current Liu et al. provides the behavior of MPPT techniques for the partial shaded situations.. Lyden et al. divided the tracking techniques to three types: conventional MPPT techniques, global MPPT techniques, and power electronics-based approaches.

The complete research paper is described in five sections. The introduction is described in Section I, Section II describes literature review, Section III describes problem formulation, Performance parameter describe in section IV, Finally, Section V describes the conclusion of paper.

II. Literature Survey

This section will provide the brief description and highlights the contribution, remarks and factors of the work done by the researchers. The comparison table is given by Table 1.

Table 1: Literature Review Table
Table 2 Comparison betweendifferent MPPTalgorithms

	MPPT technique	Photovoltaic Array Dependency	**Sensing Device**	**Tuning of circuit**	**Circuit Design**	**Implementation complexity**	**Actual MPPT**	**Speed of Convergence**
[1]	Incremental conductance	No	*V* & *I*	No	Digital	Medium	Yes	Vary

[2]	Fractional V_{oc}	Yes	*V*	Yes	Both	Low	No	Medium
[3]	Fuzzy logic control	Yes	Varies	Yes	Digital	High	Yes	Fast
[4]	RCC	No	*V* & *I*	No	Analog	Low	Yes	Fast
[5]	Load *I* or *V* maximization	No	*V* & *I*	No	Analog	Low	No	Fast
[6]	System oscillation method	Yes	*V*	No	Analog	Low	Yes	N/A
[7]	Lookup table method	Yes	*V, I, T & Ir*	Yes	Digital	Medium	Yes	Fast
[8]	Online MPP search algorithm	No	*V* & *I*	No	Digital	High	Yes	Fast
[9]	Linear current control	Yes	*Ir*	Yes	Digital	Medium	No	Fast
[10]	State based MPPT	Yes	*V* & *I*	Yes	Both	High	Yes	Fast
[11]	BFV	Yes	None	Yes	Both	Low	No	N/A
[12]	Temperature method	Yes	*V* & *T*	Yes	Digital	Low	Yes	Medium
[13]	Three point weight comparison	No	*V* & *I*	No	Digital	Low	Yes	Low
[14]	Biological swarm chasing MPPT	No	*V, I, T & Ir*	No	Digital	High	Yes	Varies
[15]	INR method	No	*V* & *I*	No	Digital	Medium	Yes	High
[16]	dP-P&O MPPT	No	*V* & *I*	No	Digital	Medium	Yes	High
[17]	Piolet cell	Yes	*V* & *I*	No	Both	Low	No	Medium
[18]	Estimate Perturb & Perturb	No	*V* & *I*	No	Digital	Medium	Yes	High
[19]	MPP locus characterization		*V* & *I*	No		Low	Yes	High
[20]	Piecewise linear approximation with temperature compensated method	Yes	*V, I, T & Ir*	Yes	Both	Low	Yes	High
[21]	PSO-INC structure	No	*V* & *I*	No	Digital	Low	Yes	High
[22]	Algorithm for stimulated annealing (SA)	Yes	*V* & *I*	No	Digital	High	Yes	High
[23]	Artifical neural network (ANN) based P&O MPPT	No	*V* & *I*	No	Both	Medium	Yes	High
[24]	Ant colony algorithm	No	*V* & *I*	No	Digital	Medium	Yes	High
[25]	Variable DC link voltage algorithm	No	*V*	No	Digital	Medium	Yes	Medium
[26]	Gauss-Newton method	No	*V* & *I*	No	Digital	Low	Yes	Fast
[27]	Steepest-descent method	No	*V* & *I*	No	Digital	Medium	Yes	Fast
[28]	Analytic method	Yes	*V* & *I*	Yes	Both	High	No	Medium
[29]	Newton-like extremum seeking control method	No	*V*	No	Analog	High	Yes	Fast
[30]	Low-power (<1W)	Yes	*V*	No	Analog	Low	Yes	Fast
[31]	Differential evolution (DE)	No	*V* & *I*	No	Digital	Low	Yes	Fast
[32]	Chaos search	No	-	No		Medium	Yes	Fast

III. Problem Formulation

For the moderate and large PV system sun tracking and MPPT has been an effective method for gaining the maximum power. Among available PV systems the MPPT systems have been most widely used and famous system. We use the MPPT system to get the maximum power conditions automatically. This is because that the PV system will work to provide the maximum efficiency. The energy which is gain by the PV system is generally relied on various types of characteristics like the level of irradiance, temperature, and the partial shading. Thus these MPPT algorithms mainly based on these factors they alter these factor to get the maximum power. As the I-V and power voltage characteristics have been displayed on the screen. By these characteristics we

can display the parameters which show the operation of PV cell like open circuit voltage VOC, short circuit current ISC, and the cell voltage and the power at the maximum point, *VMPP*, *IMPP*, and *PMPP*, respectively.

Thus the fill factor FF and the overall efficiency η have also been consider. By FF we can manage the quality of PV array. FF is the ratio between original MPP to the product of VOC and ISC.

The efficiency of an solar cell is define as the ration between the output electric power to the imput solar radiation power.

IV. Performance Parameter

A lot of parameters in the proposed technique that effect on the performance. The performance analysis is given by Table 2.

Table 2. Performance Analysis of PV Array

Sr. No.	Parameter	Statement
1.	Photovoltaic Array Dependency	Without or with knowledge of parameter value & configuration PV array methods can be applied.
2.	Actual Maximum	It means if output

	Power Tracking Technique	power is less than expected power then actual MPP present. MPPT algorithm operate at maxima
3.	Circuit Design	Digital or Analog
4.	Tuning of Circuit	Oscillation is present or not around MPP or not
5.	Speed of Convergence	Time required to achieve MPP
6.	Type of Implementation	Manually or Generally
7.	Sensing Device	Variable dependency

V. Conclusion

In this paper we present an overview about the different 62 MPPT algorithms. Thus for the comparison among these algorithm we use the various parameters like complexity of system, sensors used, type of circuits, and the dependent nature on various parameters. Thus to allow the user to choose an effective algorithm we present the result of various techniques thus its allow user to choose the correct algorithm which fits its specifications. We also present a overview about the three widely used MPPT algorithms.

References

[1] Abdalla, I., Zhang, L., &Corda, J. (2011). "Voltage-Hold Perturbation & ObservationMaximum Power Point Tracking Algorithm (VH-P&O MPPT) for Improved Tracking over the Transient Atmospheric Changes," presented at Power Electronics and Applications (EPE 2011) of the 2011-14th European Conference, (pp.1–10).

[2] Abdulmajeed, Q. M., Kazem, H. A., Mazin, H., AbdMalek, M. F., Maizana, D.,Alwaeli, A. H. A., Albadi, M. H., Sopian, K., & Said Al Busaidi, A. (2013). "Photovoltaicmaximum tracking power point system: review and researchchallenges," International Journal of Advanced Trends in Computer Scienceand Engineering (IJATCSE), Vol. 2, No. 5. (pp.16–21).

[3] Ali, A., Saied, M., Mostafa, M., &Moneim, T. (2012). A survey of maximum PPTtechniques of PV Systems. *Energytech*, 2012 IEEE.Amrouche, B., Belhamel, M., &Guessoum, A. (2007). "Artificial intelligencebased P&O MPPT method for photovoltaic systems," Revue des EnergiesRenouvelables ICRESD, Vol. 7, (pp. 11–16).

[4] Azab, M. (2008). A new maximum power point tracking for photovoltaic systems.*World Academy of Science, Engineering and Technology*, *44*, 571–574.

[5] Brito, M., Galotto, L., Sampaio, L., Melo, G., &Canesin, C. (2013). Evaluation ofthe Main MPPT Techniques for Photovoltaic Applications. *IEEE Transactionson Industrial Electronics*, *60*(3), 1156–1167.

[6] Busa, V., Narsingoju, K. K., & Kumar, G. V. (2012). Simulation analysis of maximumpower control of photo voltaic power system. *International Journalon Advanced Electrical and Electronics Engineering (IJAEEE)*, *1*(1), 9–14.

[7] Chen, C. J. (2011). *Physics of solar energy*. New Jersey: Wiley.Coelho, R., Concer, F., & Martins, D. (2010). "A MPPT Approach Based on TemperatureMeasurements Applied in PV Systems," IEEE/IAS InternationalConference on Industry Applications, (pp. 1–6).

[8] Esram, T., & Chapman, P. (2007). Comparison of photovoltaic array maximumpower point tracking techniques. *IEEE Transactions on Energy Conversion*,*22*(2), 439–449.

[9] Faranda, R., &Leva, S. (2008a). Energy comparison of MPPT techniques for PVsystems. *Wseas Transaction on Power Systems*, *3*, 446–455.

[10] Faranda, R., &Leva, S. (2008b). Energy comparison of MPPT techniques for PVsystems. *Wseas Transaction on Power Systems*, *3*, 446–455.

[11] Ghazanfari, J., &Farsangi, M. (2013). Maximum power point tracking usingsliding mode control for photovoltaic array. *Iranian Journal of Electrical &Electronic Engineering*, *9*(3), 189–196.

[12] Go, S., Ahn, S., Choi, J., Jung, W., Yun Yun, S., & Song, II. "Simulation and Analysisof Existing MPPT Control Methods in a PV Generation System." Journal ofInternational Council on Electrical Engineering, Vol. 1, No. 4, pp. 446-451,2011.

[13] Hohm, D. P., &Ropp, M. E. (2003). "Comparative Study of Maximum PowerPoint Tracking Algorithms," Progress in Photovoltaic: Research and Application,(pp. 47–62).

[14] Hu, J., Zhang, J., & Wu, H. (2009). *"Novel MPPT control algorithm based on numericalcalculation for PV generation systems," presented at Power Electronics andMotion Control Conference* (pp. 2103–2107). China: Baoding.

[15] Israel, J. (2015). "Summary of maximum power point tracking methods forphotovoltaic cells," electronic matter, retrieved on May 2015.

[16] Jain, S., &Agarwa, V. (2007). Comparison of the performance of maximumpower point tracking schemes applied to single-stage grid-connectedphotovoltaic systems. *The Institution of Engineering and Technology PowerAppl.*, *1*(5), 753–762.

[17] Ji, Y. H., Jung, D. Y., Won, C. Y., Lee, B. K., & Kim, J. W. (2009). Maximum powerpoint tracking method for PV array under partially shaded condition.Energy Conversion Congress and Exposition, 2009. ECCE 2009. IEEE. (pp.307–312).

[18] Jiang, J., Huang, T., Hsiao, Y., & Chen, Ch. (2005). Maximum power tracking forphotovoltaic power systems. *Tamkang Journal of Science and Engineering*,*8*(2), 147–153.

[19] Jusoh, A., Sutikno, T., Guan, T. K., &Mekhilef, S. (2014). A Review on favourablemaximum power point tracking systems in solar energy application.*Telkomnika*, *12*(1), 6–22.

[20] Kamarzaman, N., & Tan, C. W. (2014). A comprehensive review of maximumpower point tracking algorithms for photovoltaic systems. *Renewable andSustainable Energy Reviews*, *37*, 585–598.

[21] Khatib, T. T. N., Mohamed, A., &Amim, N. (2010). An improved indirectmaximum power point tracking method for standalone photovoltaicsystems," presented at Proceedings of the 9th WSEAS InternationalConference on Applications of Electrical Engineering, Selangor, Malaysia,pp. (56–62).

[22] Kulaksiz, A., &Akkaya, R. (2012). Training data optimization for ANNs usinggenetic algorithms to enhance MPPT efficiency of a stand-alone PVsystem. *Turk J ElecEng and Comp Sci*, *20*(2), 241–254.Kumar, Ch., Dinesh, T., &Babu, S. (2013). Design and Modelling of PV Systemand Different MPPT Algorithms. *International Journal of Engineering Trendsand Technology (IJETT)*, *4*, 4104–4112.

[23] Kumari, J., &Babu, Ch. (2011). Comparison of maximum power point trackingalgorithms for photovoltaic system. *International Journal of Advances inEngineering and Technology*, *1*, 133–148.

[24] Lapeña, O., Penella, M., &Gasulla, M. (2010). A New MPPT Method for Low-Power Solar Energy Harvesting. *IEEE Transactions on Industrial Electronics,57*(9), 3129–3138.

[25] Lee, J. (2011). *Advanced electrical and electronic engineering*. Berlin: Springer.

[26] Lee, J. S., & Lee, K. B. (2013). Variable DC-link voltage algorithm with a widerange of maximum power point tracking for a two-string PV System.*Energies, 6*, 58–78.

[27] Leyva, R., Olalla Martinez, C., Zazo, H., Cabal, C., Cid-Pastor, A., Queinnec, I., &

[28] Alonso, C. (2012). "MPPT Based on Sinusoidal Extremum-Seeking Controlin PV Generation,".*International Journal of Photoenergy, 2012*, 1–7.

[29] Libo, W., Zhengming, Z., &Jianzheng, L. (2007). A single-stage three-phasegrid-connected photovoltaic system with modified MPPT method andreactive power compensation. *IEEE Transactions on Energy Conversion,22*(4), 881–886.

[30] Liu, Y., Chen, J., & Huang, J. (2015). A review of maximum power point trackingtechniques for use in partially shaded conditions. *Renewable and SustainableEnergy Reviews, 41*, 436–453.

[31] Liu, C., Wu, B., & Cheung R. (2004). "Advanced Algorithm for MPPT Control ofPhotovoltaic System," presented at Canadian Solar Buildings Conference,Montreal.

[32] Lyden, S., &Haque, M. E. (2015). " Maximum Power Point Tracking techniquesfor photovoltaic systems: A comprehensive review and comparativeanalysis," Vol. 52, (pp.1504–1518).

[33] Mandour, R., &Elamvazuthi, I. (2013). Optimization of maximum power pointtracking (MPPT) of photovoltaic system using artificial intelligence (AI)algorithms." *Journal of Emerging Trends in Computing and InformationSciences*, Vol. 4, No. 8.

[34] Mastromauro, R., Liserre, M., & Aquila, A. (2012). Control issues in single-stagephotovoltaic systems: MPPT, current and voltage control. *IEEE Transactionson Industrial Informatics, 8*(2), 241–254.

[35] Morales, D. S. (2010). *"Maximum power point tracking algorithms for photovoltaicapplications, "A thesis presented to the faculty of electronics*. Communicationsand Automation: Aalto University, Finland.

[36] Qiang, F., & Nan, T. (2013). A Strategy Research on MPPT Technique in PhotovoltaicPower Generation System. *Telkomnika, 11*(12), 7627–7633.

[37] Rahman, Md, Poddar, S., Mamun, M., Mahmud, S., &Yeasin, Md. (2013). Efficiencycomparison between different algorithms for maximum powerpoint tracker of a solar system. *International Journal of Scientific Researchand Management (IJSRM), 1*, 157–167.