Fuzzy Logic Based MPPT Control in Solar System

Sakshi Jagtap[1] Roshni Rahangdale[2]
[1]M. Tech Scholar [2]Assistant Professor
[1,2]Shri Shankaracharya Technical Campus, Bhilai, Chhattisgarh, India

Abstract— In the modern world, renewable energy is used regularly to increase the importance in the wake of the after effects of consuming conventional sources of energy. These unconventional sources of energy are virtually unlimited power sources and are environment friendly. So, Solar PV energy is the best among all the renewable energy technologies. There has been tremendous growth becasue of the easy availability of relatively efficient and low cost PV modules. In many application renewable energy system are broadly used, especially the use of a photovoltaic power energy panel, because it provides clean, easy and endless energy. To obtain the maximum value, it is necessary to calculate how to keep the system running at the MPP. This method is called the process of Maximum Power Point Tracking (MPPT).

Keywords: Solar Panel, Computational Efficiency, Maximum Power Tracking, Fuzzy Logic

I. INTRODUCTION

One of the advantages of photovoltaic systems is being pollution and maintenance-free, however, on the other hand, their low energy conversion efficiency and high fabrication cost are the main drawbacks [1]. To overcome the earlier mentioned disadvantages, the MPPT controller must conquer the cons of solar panels and extract the maximum produced power from the PV systems, which leads to an increase in the system [2]. These systems are one of the power sources that are rapidly evolving and vastly used in modern electric technologies. The generated power in photovoltaic applications is produced by a solar panel [3]. Maximum Power Point Tracking techniques are an electronic system that imposes the PV modules, making the modules sufficient to produce the full power [4, 5]. A DC/DC power stage is connected with MPPT controls to allow a photovoltaic generator to create the highest persistent power at any value of the metrological seasons (irradiance, temperature) [6]. The MPPT control technology is widely used on the duty cycle automatically to conquer the PV module at its best and optimal output value whatever the exceptions of the weather conditions or the change in the amount of loads, which can happen at any moment [7-8].

Solar panels have been used more and more each day. As the solar panel has been created, the only need is sunlight to produce energy. The economic value of the solar panel is a popular opportunity to battle the rising cost of electricity. The solar energy technology has been created for many years, but it is utilized today more than ever. One main reason for its rising usage is its renewable capability. The sun will always provide the Earth with more energy continuously than a human being can consume.

Solar energy from the sun is profitable without environmental pollution. It does not absorb the Earth's resources and cause global warming. A solar panel comprises several solar cells connected series/parallel units used to convert solar energy into electricity. Solar panels have been used more and more each day. As the solar panel has been invented, the only need is sunlight to create energy. The economic value of the solar panel is a conventional choice to battle the rising cost of electricity. The solar energy technology has been developed for many years, but it is utilized today more than ever. One main reason for its rising usage is its renewable capability. The sun will always provide the Earth with more energy continuously than a human being can consume. The MPPT method automatically finds the maximum voltage or maximum current of a PV module. It will operate to reach the maximum power output under specific temperature and irradiance. To obtain good performance, numerous methods are proposed to be implemented in the PV system. Based on the control algorithm, these proposed MPPT methods can be categorized into conventional and intelligent techniques. The traditional way of MPPT includes perturbation and observation (P&O), incremental conductance (INC), voltage-feedback methods, and so on. Fuzzy logic control (FLC), neural network, genetic algorithm, and so on are based on intelligent algorithms. Thus it is categorized into the smart method. The P&O and INC method is commonly used in the MPPT system because of their simple implementation. However, the P&O process has two drawbacks regarding its performance. The first is power oscillation at the maximum power point (MPP), and the other one is the divergence of the MPP under rapid atmospheric change [5, 6]. The problem of power oscillation at the MPP also occurs in the INC method when fast-tracking of the maximum power is desired. The I-V and P-V characteristics of solar cells are changed nonlinearly by radiation and temperature variation. Therefore, to efficiently use the PV system, the PV system's operating point must always be operated at maximum PowerPoint. The performance of conventional PO and IC depends on the step size. So it has a weakness to be selected optimal step size. Also, MPPT control applying PI and fuzzy control cannot expect satisfactory performance because the PI controller has fixed gain and fuzzy control has a cumulative error by an integral calculus..

II. OBJECTIVE

This review paper proposes the Fuzzy based MPPT control system that solves the cumulative error and activity response characteristic. The Fuzzy based MPPT control method proposed analyses control characteristics about situation of radiation changing and correlates with conventional methods.

III. REVIEW WORK

Although a variety of paintings has already been done in the area of Solar System. In recent years, the power system has been an exciting topic and there have been many grids schemes proposed. The demand for renewable energy has risen significantly over the years due to the shortage of fossil fuels. Also, the need for pollution-free green energy has created a keen interest in renewable energy sources. Solar energy is the most natural and sufficient renewable energy source to meet the rapidly increasing energy requirements [1]. The maximum power from the solar PV array is to be tracked for its efficient implementation. Many algorithms are available in the literature for tracking maximum power from solar panels. In this paper, Perturbation and Observation, the algorithm is considered due to its simplicity. A boost converter is used to perform the maximum power point tracking algorithm [2]. The output power generated from the solar panels is periodically and transforms with the irradiance level. Hence to make the system more stable, a battery is included in the system. A bidirectional converter is also used to control the power flow from and into the battery [3]. Since the inverter is used in a PV system, a proportional-integral (PI) controller scheme is employed to preserve the output current sinusoidal and to control the power factor unity and to have a high dynamic appearance under rapidly changing atmospheric conditions. Simulation results are providing to verify the offered control system.

IV. METHODOLOGY

Disturbance observation (P&O) is also associated as the climbing method[7-10]. Its principle is that the photovoltaic system's output voltage is disturbed, the output power changes of the system before and after disturbances are judged, and the system is controlled according to the principle of improving the output power. The photovoltaic system controller in each control period uses a smaller step length to change the photovoltaic array's output. The changing step length is certain, the direction can be improved and can also be reduced, and the control object can be the output voltage or current of the photovoltaic array. This method is called "disturbance"; the schematic diagram is shown in Figure 1,

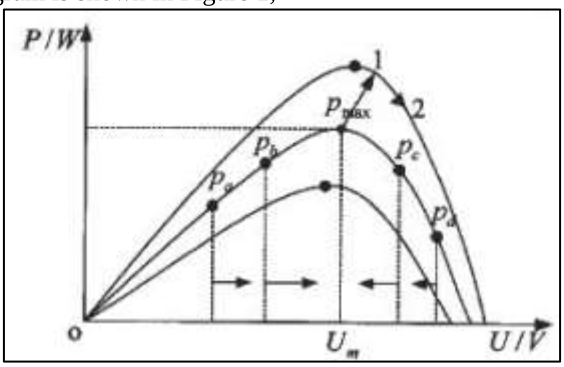

Fig. 1: P&O Schemetic algorithm

Considering that the initial point power of the photovoltaic battery working is Pa, as the voltage amplification, the operating point moves to Pb at the next time, at this time HP=(Pb-Pa)>0, it gives voltages "disturbance" is in the right direction, and can continue "disturbance" according to the original order, if the initial point of power is Pc, use the disturbance HP=(Pd-Pc)<0 of stated above methods, it presents voltage "disturbance" is in the wrong direction, at this moment, the order of disturbance is reduced to make the effective point climb to the summit of the mountain from the other direction, so control repeatedly the change of the photovoltaic battery functional point voltage, to obtain that the operating point can work steadily near a Pmax of maximum power point in the end. Since the P&O algorithm has the advantages of a simple structure and easy to implement hardware circuits, it is widely used in maximum power point tracking of the photovoltaic system.

But when external conditions such as the light change temperature change quickly, the tracking algorithm may fail to get the wrong tracking direction by judging.

A. *Fuzzy based MPPT Control technique*

There are many various implementation purposes for solar power systems to achieve maximum power point tracking control. One of the most conventional methods used is P&O, which can be easy to implement, but there are some limitations. For example, power will oscillate near the maximum point resulting from reducing solar panels' energy efficiency. Here, we use the fuzzy controller method for MPPT instead of the simple P&O one [1-3]. The fuzzy controller can reduce the time required to track the MPPT and reduce the fluctuation of power output. A simple fuzzy maximum power tracking control law is proposed only with three fuzzy if-then control rules to complete the ultimate power tracking work from PV panel power and voltage curve in Figure 2.

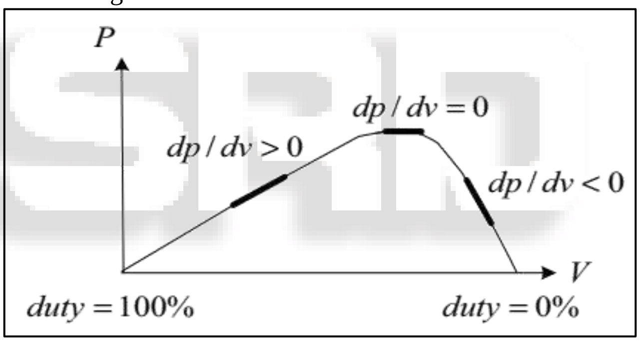

Fig. 2: The PV panel power and voltage curve

One can see that the slope of PV curve can be partition into three parts, i.e. slope of $\Delta p/\Delta v > 0$, slope of $\Delta p/\Delta v = 0$, and slope of $\Delta p/\Delta v < 0$. Therefore; according to the slope of PV located in which part, the rate of increase of $\Delta u(k)$ is selected as one of the P, Z, or N, which denote positive, zero, and negative, respectively. The input of the proposed fuzzy logic controller is the slope / Δ Δ p v and the output is rate change in duty ratio $\Delta u(k)$. The slope of $\Delta p/\Delta v$ is fuzzified into three partitions with triangular membership function labelled with P, Z, and N as shown in Figure 7(a). Similarly, the rate of increase of $\Delta u(k)$ is also fuzzified into three partitions with triangular membership function labelled with P, Z, and N as shown in Figure 3.

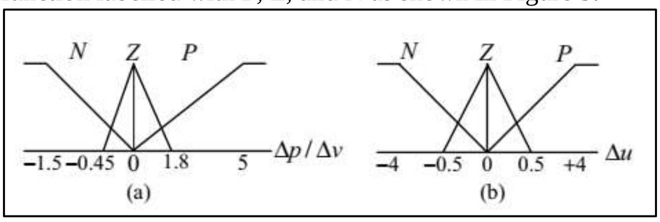

Fig. 3: The membership functions of $\Delta p/\Delta v$ and Δu

Thus; the fuzzy maximum power tracking control rules are given by

If Δ p/ Δv is P Then Δu is N
If Δ p/ Δv is Z Then Δu is Z
If Δ p/ Δv is N Then Δu is P

The rate of increase of Δp and Δu are defined as follows:

$$\Delta = p(k) - p(k-1)$$
$$\Delta = v(k) - v(k-1)$$

The final control output is given by

$$u(k) = u(k-1) + \Delta u(k)$$

V. EXPECTED OUTCOMES

The fuzzy component with two input-parameters, which are E=¨P/¨V and its change ¨E, enhanced by an initial evaluation for the MPP voltage VMPP using the fractional open circuit voltage technique leads to a suitable power response. This technique can achieve the maximum possible output power from the PV module (185 W) without any steady-state error in a little searching time (10 msec). The suggested technique can achieve improvement compared to the traditional fuzzy approach that appears in the MPP's short searching time by reducing the searching time to 20% from its expected value. The advanced MPPT technique shows a better response even supporting variable atmospheric conditions depending on the temperature evolution of the initial estimation of VMPP and the closed-loop advantage of the fuzzy control technique.

VI. CONCLUSION

In this suggested methodology, an MPPT technique is designed to control the photovoltaic system. This scheme takes into concern the random chance of atmospheric situations. The system examined included a 240 W photovoltaic panel, a DC-DC boost converter, and a resistive load. The integral sliding mode control (ISMC) takes the reference voltage produced by the fuzzy logic. It applies to convert DC, DC, its duty cycle to follow the maximum power. The simulation results clearly explained this approach (speed of response, robustness, and accuracy) to track the MPP under variant and non-uniform weather situations. The fuzzy controller has successfully managed a charged current so that the battery voltage can reach the aspired value, 0.1C set current command, and 0.01C floating assigned current knowledge.

REFERENCES

[1] T. Esram and P. L. Chapman, “Comparison of Photovoltaic Array Maximum Power Point Tracking Techniques,” IEEE Transaction on Energy Conversion, Vol. 2, Issue 2, 2007, page 439-449.
[2] G. M. S. Azevedo, M. C. Calvalcanti, K. C. Oliveira, F.A.S. Neves, and Z.D. Lins, “Comparative Evaluation of Maximum Power Point Tracking Methods for Photovoltaic Systems,” Journal of Solar Energy Engineering, August 2009, Vol. 131, page 031006-1 - 031006-8.
[3] C.Y. Won, D.H. Kim, S.C. Kim, W.S. Kim, and H.S. Kim, “A New Maximum Power Point Tracker of Photovoltaic Arrays Using Fuzzy Controller,” 25th Annual IEEE Power Electronic Specialist Conference, Jun 1994, Vol 1, page 396-403.
[4] R. Faranda, S. Leva and V. Maugeri, “MPPT Techniques for PV Systems: Energetic and Cost Comparison,” IEEE Power and Energy Society General Meeting – Conversion and Delivery of Electrical Energy in the 21st Century, 2008, page 1-6.
[5] Guohui Zeng and Qizhong Liu, “An Intellegent Fuzzy Method for MPPT of Photovoltaic Arrays,” Second International Symposium on Computational Intellegence and Design, 2009, page 356-359.
[6] S. N. Sivanandam, S. Sumathi, and S.N. Deepa, “Introduction to Fuzzy Logic using Matlab,” Springer, 2007.
[7] B.J. Choi, S.W. Kwak, and B.K. Kim, “Design of a Single-Fuzzy Logic Controller and Its Properties,” Fuzzy Sets and Systems 106, 1999, page 299-308.
[8] B.J. Choi, S.W. Kwak, and B.K. Kim, “Design and Stability Analysis of Single-Input Fuzzy Logic Controller,” IEEE Transactions on Systems, Man & Cybernetics, Part B: Cybernetics, April 2000, Volume 30, Issue 2, page 303-309.
[9] Jerry M. Mendel, “Fuzzy Logic System for Engineering: A tutorial,” Proceedings of IEEE, Vol. 83, March 1995, page 345-377.
[10] Kwang H. Lee, "First Course on Fuzzy Theory & Applications," Springer-Verlag Berlin Heidelberg 2005.
[11] bp Solar, “BP350-High-efficiency photovoltaic module using silicon nitride multi-crystalline silicon cells,” 6802.0036 BP350J Rev. C Datasheet, 2007.
[12] X.B. Li, Ke Dong, Hao Wu, “Study on the Intelligent Fuzzy Control Method for MPPT in Photovoltaic Voltage Grid System,” 3rd IEEE Conference on Industrial Electronics and Applications, 2008, ICIEA, page 708-711.
[13] Tom Markvart and Luis Castaner, “Solar Cell Materials, Manufacture and Operation,” Elsevier, 2005.
[14] Mohan, Undeland, and Robbins, “Power Electronics: Converter, Applications, and Design,” John Willey & Sons, Third Edition, 2003.
[15] Zheng Biwei, Cai Fenghuang, Wang Wu. Analysis and Research of MPPT Algorithm for a Single-Stage PV Grid-Connected Power Generation System [J].Transactions of China Electrotechnical Society, 2011, 26(7):90-96.
[16] Li Xiaolei, SHAO Zhijiang, QIAN Jixin, “An Optimizing Method Based on Autonomous Animats:Fish-swarm Algorithm”,. Systems Engineering-theory & Practice, 2002,(11):32-38.
[17] ZHANG Chao, HE Xiangning, ZHAO Dean, “Research on Variable Perturb Step MPPT Control of Photovoltaic System”, Power Electronics, 2009, 43 (10):47-49.
[18] LIU Fei, DUAN Shanxu, YIN Jinjun, ZHOU Yan, “The MPPT Realization and Stability Study of the Single-stage photovoltaic Power System”, Power Electronics, 2008, 42 (3):28-30.
[19] Li Jing, Dou Wei, Xu Zhengguo, et al. Research on MPPT Methods of Photovoltaic Power Generation System[J].Acta Energiae Solaris Sinica, 2007, 28(3):268-273.

[20] Altas I H, Sharaf A M. A novel maximum power fuzzy logic controller for photovoltaic solar energy systems [J]. Renewable Energy, 2008, 33(3): 388- 399.
[21] ZHOU Wenyuan, YUAN Yue, FU Zhixin, et al. Constant Voltage Tracking Combined with Newton Method MPPT Control for Photovoltaic System[J].Proceedings of the CSU-EPSA, 2012, 24 (6):6-13.