SOLAR BASED MPPT CONTROL USING ADVANCED FUZZY LOGIC TECHNIQUE IN SIMULINK

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Abstract—*The use of renewable energy systems has gained a lot of importance in the wake of consuming conventional sources of energy. These unconventional sources of energy are virtually inexhaustible and are environment friendly. Among all the renewable energy technologies, solar PV has seen tremendous growth due to the availability of relatively efficient and cheap PV modules. At present, renewable energy is one of the features that has been used in many applications, especially the use of a photovoltaic (PV) panel because it provides endless, clean and easy to use the energy of the PV panel. The use of a PV panel at maximum efficiency is to extract the Maximum Power Point (MPP) of the PV panel. 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

Worldwide energy consumption has increased quickly due to world population growth. Solar energy from the sun is fruitful without environmental pollution. It does not consume the earth's resources and cause global warming. A solar panel is a device comprised of a number of solar cells connected series/parallel units which are used to convert solar energy into electricity. Solar panels have been used more and more each day. As the solar panel has been constructed, the only need is sunlight to create energy. The economic value of the solar panel is a popular 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 human being can consume.

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Objective

This paper proposes the Fuzzy PI MPPT control method that is supplementing cumulative error and activity response characteristic. The Fuzzy PI MPPT method proposed analyses control characteristics about condition of radiation changing and compares with conventional methods.

II. 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.

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III. METHODOLOGY

Disturbance observation (P&O) is also known as climbing method[7-10], its principle is that the output voltage of the photovoltaic system 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 increasing the output power. Photovoltaic system controller in each control period use smaller step length to change the output of the photovoltaic array, the changing step length is a certain, the direction can be increased and can also be reduced, and the control object can be the output voltage or current of photovoltaic array, this process is called "disturbance"; the schematic diagram is shown in Figure 1,

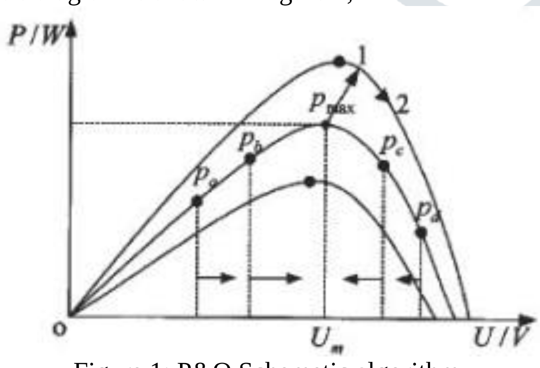

Figure 1: P&O Schemetic algorithm

Assuming that the initial point power of the photovoltaic battery working is Pa, as the voltage increases, the operating point moves to Pb at the next time, at this time HP=(Pb-Pa)>0, it shows voltages "disturbance" is in the right direction, and can continue "disturbance" according to the original direction, if the initial point of power is Pc, use the disturbance HP=(Pd-Pc)<0 of stated above methods, it shows voltage "disturbance" is in the wrong direction, at this moment, the direction of disturbance is changed to make the working point climb to the summit of the mountain from the other direction, so control repeatedly the change of the photovoltaic battery working point voltage, in order to realize 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 circuit, it is widely used in maximum power point tracking of photovoltaic system.

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

Fuzzy based MPPT Control technique

In general, there are many different implementation methods for solar power systems to achieve maximum power point tracking control. One of the most standard methods used is P&O one which can be easy to be implemented, but, there are some disadvantages, for example: power will oscillates near the maximum point resulting to reduce energy efficiency of solar panels. Here, we use the fuzzy controller method for MPPT instead of the simple P&O one [1-3]. The fuzzy controller not only can reduce the time required to track the MPPT but also can reduce the fluctuation of power output. A simple fuzzy maximum power tracking control law is proposed here only with three fuzzy if-then control rules to complete the maximum power tracking work. From PV panel power and voltage curve in Figure 2.

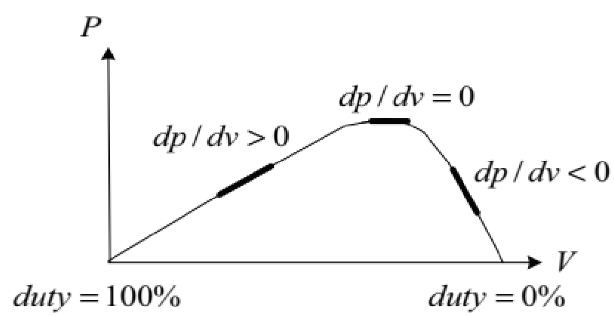

Figure 2: The PV panel power and voltage curve

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.

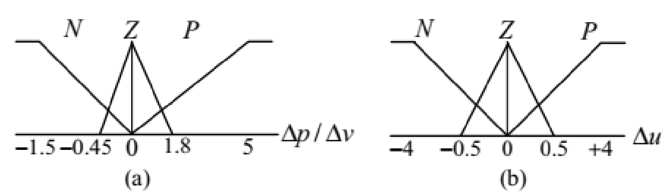

Figure 3: The membership functions of $\Delta p/\Delta v$ and Δu

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

If $\Delta p/\Delta v$ 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:

$Δ = p(k) − p(k\text{-}1)$

$Δ = v(k) − v(k\text{-}1)$

The final control output is given by

$u(k) = u(k\text{-}1) + Δu(k)$

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V. Expected outcomes

The fuzzy agent with two input parameters, which are E=¨P/¨V and its change ¨E, enhanced by an initial estimation for the MPP voltage VMPP using the fractional open circuit voltage technique leads to a good power response. This technique can achieves the maximum possible output power from the PV module (185 W) without any steady state error in a small searching time (10 m sec). The improvement can achieve by the proposed technique compared to the traditional fuzzy technique appears in the small searching time of the MPP by reducing the searching time to 20% from its traditional value. The developed MPPT technique shows a good response even under variable atmospheric conditions depending on the temperature adaptation of the initial estimation of VMPP and the closed loop advantage of the fuzzy control scheme

VI. conclusion

In this proposed methodology, an MPPT technique is designed to control the photovoltaic system. This command takes into consideration the random change of the atmospheric conditions. The system studied 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 generated by the fuzzy logic and applies to convert DC, DC its duty cycle in order to follow the maximum power. The results of the simulation clearly showed the performance of this approach (speed of response, robustness and accuracy) to track the MPP under variant and non-uniform weather conditions. The fuzzy controller has been successfully to maintain a charged current so as that the battery voltage can reach to desired value, 0.1C charged current command and 0.01C floating charged current command.

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]. Kwang H. Lee, "First Course on Fuzzy Theory & Applications," Springer-Verlag Berlin Heidelberg 2005.

[9]. 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.

[10]. bp Solar, "BP350-High-efficiency photovoltaic module using silicon nitride multi-crystalline silicon cells," 6802.0036 BP350J Rev. C Datasheet, 2007.

[11]. 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.

[12]. Jerry M. Mendel, "Fuzzy Logic System for Engineering: A tutorial," Proceedings of IEEE, Vol. 83, March 1995, page 345-377.

[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.

[22]. Chao Zhang, Dean Zhao. MPPT with asymmetric fuzzy control for photovoltaic system[C]. 2009 4th IEEE Conference on Industrial Electronics and Applications, Xi'an, 2009: 2180-2183.

[23]. ZHU Xianglin, LIAO Zhiling, LIU Guohai. Research on the Initial Values of MPPT Algorithm for Solar Cell [J].Power Electronics,2010,44(2):7-9.