1st International Conference on Applied Soft Computing Techniques
22 & 23.04.2017
In association with
International Journal of Scientific Research in Science and Technology

Intelligent Control of Photovoltaic System Using Fuzzy Logic for MPPT

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ABSTRACT

This paper suggests a method for the maximum power point tracking (MPPT) of a solar system under variable insulation conditions. A fuzzy Logic control (FLC) based MPPT technique is proposed to improve the efficiency of a standalone solar energy system. Fuzzy logic controller is applicable to a DC-DC converter device. The various design steps of fuzzy logic controller are presented along with its simulation.A fuzzy system for tracking the maximum power point of a PV system. A simulation model consists of PV panel, Buck converter, and fuzzy based MPPT developed. Maximum power can be tracking by using fuzzy logic controller has been simulated in MATLAB/Simulink.

Keywords: Fuzzy logic, photovoltaic (PV) Module, Maximum Power Point Tracking.

I. INTRODUCTION

The energy demand in the world has been increased due to growth in the industrial revolution. Fossil fuels available are gradually reducing due to the increasing population; therefore energy can be saved by usage of renewable energy sources. Renewable energy is a form of sustainable energy. Renewable energy sources available are wind energy, solar energy, etc.

By using photovoltaic system solar energy can be generated which is a most important renewable energy sources. There are several advantages in PV system such as fuel cost, clean, pollution free, little maintenance and no noise. The efficiency of the solar energy can be increased by using MPPT Technique.

In this technique the maximum power of the PV module can be extracted and it is delivered to the load. While extracting the maximum power of the PV module .the temperature and insulation factors are also taken into account. The objective of this is to work is to maintain the voltage of the PV system closer to the voltage at which maximum power is produced. Because of environmental pollution, global warming PV system is mostly preferred nowadays. But the efficiency of the PV should be increase. This can be done with the help of MPPT control. Voltage and current feedback back methods and P&O technique, incremental conductance method. The proposed work deals with the intelligent fuzzy based MPPT controller to improve the efficiency by tracking the maximum power from the PV system.

II. MODELING AND CHARACTERISTICS OF PV MODULE

Equivalent circuit model of photovoltaic is a major part to analysis the operation of device and the dynamic interactions. In this paper, PV module is described using various mathematical equations and Matlab/Simulink is used to simulate the PV module.

A. Equivalent circuit of PV module

The solar panel consists of many solar cells, by connecting those solar cells in series and parallel that can form a PV module. The single diode model consists of current source, diode and two resistors. Whereas two diode model also available but not consider here. The equivalent circuit of the PV cell is shown in figure.2.1

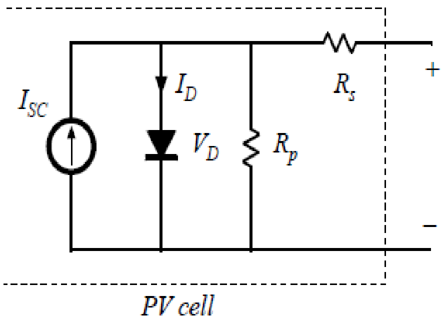

Fig.2.1 Equivalent circuit diagram of PV cell

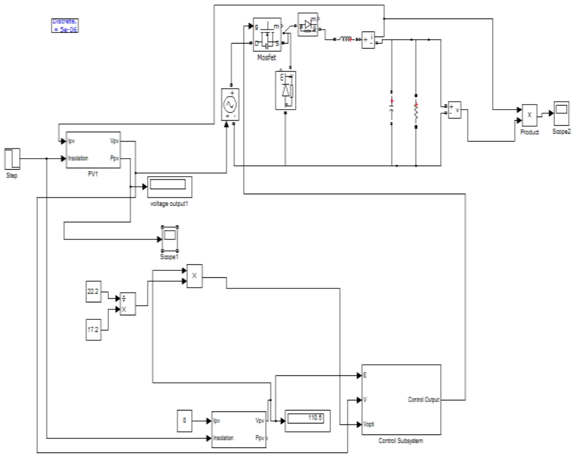

Fig.2.3 Simulink model of MPPT with FUZZY

B. Equations of PV module

From the theory of photovoltaic system, the following are the characteristic equations for a photovoltaic is given by

$$I_D = I_0(e^{\frac{V_D}{V_T}} - 1) \quad (1)$$

$$I_{SC} - I_D - \frac{V_D}{R_P} - I_{PV} = 0 \quad (2)$$

$$V_{PVcell} = V_D - R_S I_{PV} \quad (3)$$

C. Matlab/Simulink modelling of PV module

The simulation model used for the implementation of the required PV module is as shown in figure.2.1.In this paper, I described current-input PV module, it has two inputs and two outputs. The .inputs are PV current Ipv [A] and insulation [W/m^2] and outputs are PV voltage [V] and PV output power Ppv [W]. This design is used for this method when the modules are connected in series, it shares the same current.Here temperature effect is not designed. The data –sheet parameters are shown as below:

1. Short-circuit current Isc
2. Open-circuit voltage Voc
3. Rated current Ip at maximum power point(MPP)
4. Rated voltage VR at MPP

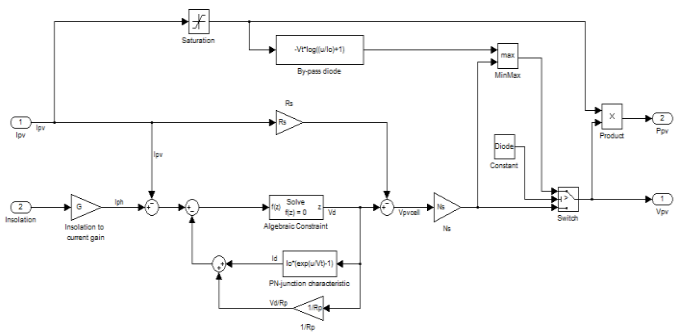

Fig.2.2 Matlab/Simulink model of PV module

III. NEED FOR MAXIMUM POWER POINT TRACKING

Due to changes in extrinsic and intrinsic factors in power voltage (P-V) and nonlinear current voltage (I-V) characteristics, we can achieve maximum efficiency at anytime in PV and also reduce the cost of energy. The PV system gives maximum power, when the maximum power point is unique point. There are many factor that can be considered, where the most important one is power point tracking in PV generation. The MPPT is nonlinear control problem. This is due to the nonlinearity present in the PV or parameter variations in PV.

To overcome this problem control methods like P&O, incremental conductance, neural and fuzzy are used. These control techniques requires high cost and these are complex. MPPT are simplicity and low cost, ease of implementation quick tracking under changing conditions, and small output power fluctuation.

IV. INTELLIGENCE MPPT TECHNIQUES

The photovoltaic system operation based on the load characteristics. When the direct connection between the source and load, the operating point is not optimal and output of PV module is soldem maximum. We use adaption device to overcome those problem that are MPPT controller with a DC-DC converter between source and load.

Whenever the insulation variation arises the MPPT controller track new modified maximum power point. The proposed Matlab/Simulink model of FUZZY based maximum power point tracking controller is depicted in Fig. 2.3

Many MPPT control technique are distinguish as:

1. Voltage feedback based method by comparing the reference voltage and PV operating voltage to generate PWM.
2. Current feedback based methods is done by computing short circuit of PV as a feedback to compute optimal current(maximum Power)
3. Power based method is used to track the maximum power point with the help of voltage and current of PV system.

A.FL-Based MPPT Technique:

Intelligent based MPPT shows better performance and lesser steady state error without any overshoot for fast changing temperature and irradiance. This proposed controller has two inputs and one output. One input is error (E) and another one is change in error (CE).

The following are the error (E) and change in error (CE) equations are shown as below:

$$e(k) = dP/dV(K) - dP/dV(K-1) \qquad \textbf{(4)}$$

$$\mathbf{C_e(K) = e(K) - e(K-1)} \qquad \textbf{(5)}$$

Thus e (K) implies error at Kth instant. Fuzzy inference system used is Mamdani’s and defuzzification is done by centre of gravity method, of this fuzzylogic-based MPPT as shown in Fig. 2.3. The rules are shown in below table.1

E / CE	NB	NS	Z	PS	PB
NB	NB	NB	NS	NS	Z
NS	NB	NS	NS	Z	PS
Z	NS	NS	Z	PS	PS
PS	NS	Z	PS	PS	PB
PB	Z	PS	PS	PB	PB

Table.1.Rules

V. RESULTS AND DISCUSSION

Simulation of PV module is done using fuzzy logic based MPPT controller is shown in section II .In this work DC-DC buck converter is connected between the load and PV for maximum power point tracking. Here fuzzy performance the control of duty cycle for buck converter in order to transfer maximum power to load and also comparison is done between PV with fuzzy and PV without controller.

The resulting outputs of voltage and current at insolation level of 900W/m2 are given in Figs. 5.1, 5.2 respectively. The proposed method results shows various from FUZZY based MPPT method shows several advantages when compare to other conventional methods of MPPT. FUZZY based MPPT method does not consume power in perturbation for maximum power point unlike the conventional P&O method. The major benefits of the presented MPPT method is that it can easily pick the rapidly changing environmental conditions without producing intrinsic steady state oscillations near the maximum power point.

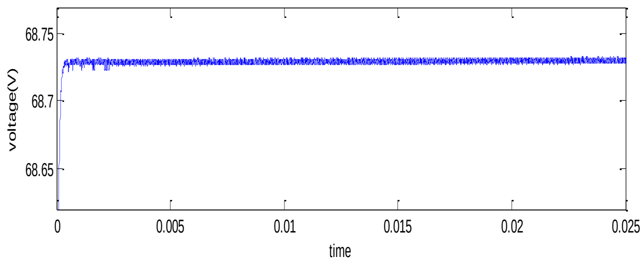

Fig.5.1 Output voltage vs time at 900W/m2 insolation

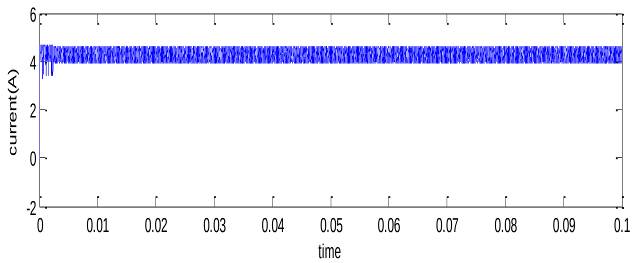

Fig.5.2 output current Vs time at 900w/m2 insolation

VI. CONCLUSION

From the above results it is inferred that MPP is tracked faster by using proposed MPPT method. Further it is observed that performance of the system is improved better by the implementation of FLC based MPPT method. For non-linear system, this controller finds to be more effective than other controllers.

VII. Future work

Hardware implementation of the proposed FUZZY based MPPT controller by connecting Matlab with PV module and buck converter. An efficient MPPT controller of low cost and small size can be realized using a microcontroller and FUZZY based control scheme.

VIII. References

[1] Carlos A.P.Tavares1.Karla T. F. Leite2, Walter 1. Suemitsu3, Maria D. Bellar (2009)”performane evaluation of photovoltaic solar system with different MPPT methods,” IEEE transactions pg978-1-4244-449.

[2] Huan-Liang Tsai, Ci-Siang Tu, and Yi-Jie Su, “Development of Generalized Photovoltaic Model Using MATLAB/SIMULINK”, Proceedings of the World Congress on Engineering and Computer Science 2008 WCECS 2008, October 22 - 24, 2008, San Francisco, USA.

[3] G.J. Yu, Y.S. Jung, J.Y. Choi and G.S. Kim, ‘A Novel Two-Mode MPPT Control Algorithm Based on Comparative Study of Existing Algorithms’, Solar Energy, Vol. 76, N° 4, pp. 455 – 463, April 2004.

[4] H. Buhler, ‘Réglage par LogiqueFloue’, Presses PolytechniquesetUniversitairesRomandes, CH-1015, Lausanne, 1994.

[5] Jee-Hoon Jung, and S. Ahmed, “Model Construction of Single Crystalline Photovoltaic Panels for Real-time Simulation”, IEEE Energy Conversion Congress & Expo, September 12-16, 2010, Atlanta, USA.

[6] K.M. Passino and S. Yurkovich, ‘Fuzzy Control’, Addison, Wesley, 1998._

[7] K. Punitha, D.Devaraj, S.sakthivel (2012),”development and analysis of adaptive fuzzy controllers for photovoltaic system under varying atmospheric and partial shading condition,” science direct on applied soft computing vol.13, pp.4320-4332.

[8] L. J.L. Santos, F. Antunes, A. Chehab and C. Cruz, ‘A Maximum Power Point Tracker for PV Systems Using a High Performance Boost Converter’, Solar Energy, Vol. 80, N°7, pp. 772 - 778, 2006.

[9] M. Veerachary, T. Senjyu, and K. Uezato, ‘Voltage-Based Maximum Power Point Tracking Control of PV Systems’, IEEE Trans. Aerosp. Electron. Syst., Vol. 38, pp. 262 - 270, Jan. 2002.

[10] P. S. Revankar, W. Z. Gandhare and A. G. Thosar Government College of Engineering, Aurangabad, “Maximum Power Point Tracking for PV Systems Using MATLAB/SIMULINK”, 2010 Second International Conference on Machine Learning and Computing.

[11] Ramos Hernanz, JA., Campayo Martín, J.J. Zamora Belver, I., LarrañagaLesaka, J., Zulueta Guerrero, E. Puelles Pérez, E., “Modeling of Photovoltaic Module”, International Conference on Renewable Energies and Power Quality (ICREPQ’10) Granada (Spain), 23th to 25th March, 2010.

[12] R.Sridhar, Dr.Jeevananathan, N. ThamizhSelvan, Saikat Banerjee, “Modeling of PV Arrayand Performance Enhancement by MPPT Algorithm", International Journal of Computer Applications (0975 – 8887) Volume 7– No.5, September 2010.

[13] Sandeep Kumar, Vijay Kumar Garg, “A Hybrid model of Solar-Wind Power GenerationSystem”, International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering (IJAREEIE), Vol. 2, Issue 8, August 2013, pp. 4107-4016.

[14] S.Chowdhury, S.P.Chowdhury, G.A.Taylor, and Y.H.Song, “Mathematical Modeling and Performance Evaluation of a Stand-Alone Polycrystalline PV Plant with MPPT Facility” IEEE Power and Energy Society General Meeting - Conversion and Delivery of Electrical Energy in the 21st Century, July 20-24, 2008, Pittsburg, USA.

[15] T. Takagi and M. Sugeno, ‘Fuzzy Identification of Systems and Its Applications to Modeling and Control’, IEEE Transactions on Systems Man and Cybernetics, Vol. 15, N°1, pp. 116 - 132, 1985.

[16] Vinodhini. R, Rajitha.G, Kiran Kumar B and prof.Arun Kumar .G,”dSPACE based 12/24v closed loop boost converter for low power application.” VIT unersity 2014 International conference on computation of power, energy, Information and communication (ICCPEIC) 978-1-4799-382-11/14IEEE.

[17] X. Liu and L.A.C. Lopes, 'An Improved Perturbation and Observation Maximum Power Point Tracking Algorithm for PV Arrays', Power Electronics Specialists Conference, PESC' 04, 2004.

[18] Yi –Hua.Chun-Liu, Jia-Wei Huang, Jing-H siau Chen(2013)" neural network –based maximum power point tracking methods for photovoltaic systems operating under fast changing environments" Science Direct on solar energy 89 pg:42-53

[19] W.Xiao,W.G.Dunford,P.R.Palmer,A.capel, Application Of Centered differentiation And Steepest Descent To Maximum POWER POINT TRACKING,IEEE transactions on industrial electronics,vol.54,No.3 pp.2539-2549,may2007.

[20] C. Liu, B.Wu, and R. Cheung, "Advanced algorithm for MPPT controlof photovoltaic systems," in Proc. Canadian Solar Build. Conf., Montreal,QC, Canada, Aug. 20–24, 2004.

[21] N. Pongratananukul, "Analysis and Simulation Tools for Solar ArrayPower Systems," Ph.D. dissertation,Dept. Electrical and Computer Engineering,Univ. Central Florida, Orlando, FL, 2005.

[22] D. P. Holm and M. E. Ropp, "Comparative study of maximum powerpoint tracking algorithms," Progr. Photovolt.: Res. Applicat., vol. 11,no. 1, pp. 47–62, 2003.

[23] D. Shmilovitz, "On the control of photovoltaic maximum power point tracker via output parameters," Proc. Inst. Elect. Eng., vol. 12, no. 2, pp. 239–248, 2005.