Voltage Control of DC to DC Converter in Integrated Renewable Energy System through Fuzzy based GA

Dr.K.Harinadha Reddy*, T.Raghu** and K.P.Prasad Rao***
*Professor, EEE Department, K L University, A.P., India
kadapa.hari@gmail.com
** Research Scholar, EEE Department, K L University, A.P., India
thumuraghu@gmail.com
***Research Scholar, EEE Department, K L University, A.P., India
prasadraokondenti@gmail.com

Abstract: A control plan based on improved dc bus reference voltage parameter is proposed for a photovoltaic (PV) generation system with battery backup energy system. Genetic Algorithm (GA) based MPPT technique was proposed and proposed work consists of design model and control scheme of converters for photovoltaic cells. The pattern with different ways like two grid-connected converters, and one dc/dc converter for battery charging and discharging operation and other is considered for power control. Genetic Algorithm Optimization (GAO) is used to get MPPT signal of solar cell. Fuzzy system is producing a signal for converter module. The available of either grid-connected operation or islanding operation, using the proposed control strategy, the operations of a modular PV generation system are categorized into islanding with battery operation, grid-connected conversion, and islanding with constant voltage invention.

Keywords: Photovoltaic array, Grid connection, Islanding, MPPT algorithm, Genetic Algorithm Optimization.

Introduction

Recently in Power network with solar energy systems are having considerable method are developed for improvement of poor voltage profile due to convertor losses and they effect in power control and charging and discharging operation of battery banks and so these energy systems are most want of voltage profile improvement. PV system has become an important source for generating electricity due in part to the development that has happen in the semiconductor region, which has made it possible to increase the energy output to meet the required load power. Due to environmental pollution and the immanent exhaustion of fossil fuel, distributed generation systems using renewable energy sources, including wind power, microhydro, solar photovoltaic, and landfill gas, have become one of the main power generation points of interest. The main distributed generator (DG) requirements are high power quality, highly efficient operation, and safety. Therefore, the main issue in renewable energy research is to reduce the cost and increase the efficiency of production. In recent years, wind power and PV energy have been the two main areas of the research and development.

Renewable energy sources have many advantages over conventional energy sources, as they are green, do not emit carbon dioxide. Power flow in each stage i.e. with conventional and proposed of power plant is clearly depicted in schematic diagram of Figure.2. Also general load at the stage of generator is considered for test case. Each control area as possible supply its own load demand [4, 5] and power transfer through tie line should be on mutual agreement. All control areas [11] should controllable to the specific range of frequencies control. In totaling, the cost of renewable energy sources [8, 9] is higher than the conventional energy sources when generating large volumes of energy. As the intensity of light falling on the panel varies, its voltage as well as its internal resistance varies. Internal resistance of the panel due to variation in irradiation and temperature causes the mismatch between the source [2] and the load. Hence panel is not able to generate power which it is capable of producing, resulting in lower generation of power. This results in generation of less power than what the panel is actually capable of generating. However, much work needs to be done in this field in order to make renewable as efficient and reliable as possible. Since this method likes a constant, its accuracy cannot be guaranteed. Consequently, the tracked power would most likely be below the MPP, resulting in significant power loss.

The Photovoltaic (PV) generating systems need maximum power point tracker because the output power of the PV panel depends on the operating terminal voltage and current. To extract maximum power from the PV array, the load impedance should be equal to the internal resistance of the panel. However, the use of renewable energy still has a many limitations, as most renewable energy sources stands on the weather conditions, such as wind in wind power generation, rain in hydropower and clear skies in photovoltaic systems.

Modelling of Solar PV Cell

Energy systems are deadly need of voltage profile improvement. Various MPP tracking methods have been proposed. These techniques differ in complexity, accuracy, and speed. Various type of the control variables and they are voltage, current or duty cycle. For the voltage and current-based techniques, approaches are used. The first one is the observation of MPP voltage V_{PV} or current I_{PV} with respect to the open circuit voltage and short circuit current, respectively.

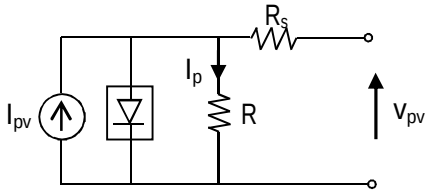

Figure 1. PV Cell Representation

The current source is the photocurrent generated by irradiation on solar cell can be represented by a current source connected in parallel with a PN junction diode

$$I_{PV} = I_{sr}\left(e^{qv/cT} - 1\right) - I_{sc} \qquad (1)$$

The series resistance is the sum of structural resistance of PV panel and it has strong influence when PV panel act as voltage source. The parallel resistance R_{sh} has great influence when PV panel act as current source. The light generated current of the photovoltaic cell depends linearly on the solar irradiation and is influenced by the temperature according to the following equation. The output power of a solar cell is given the product of voltage and current According to the solar cell equation, the output power as a function of the output voltage 'V' is

$$I_{PV} = IV = I_{sc}V - I_{sr}\left(e^{qv/cT} - 1\right)V \qquad (2)$$

$$I_{PV} = I_{sc} - \left[\exp\left(\frac{V_{pv} + I_P R_s}{V_d}\right) - 1\right] - I_p\frac{R_s}{R} \qquad (3)$$

Test system with conventional control gain k_d at voltage measuring system and V_{PV}, I_{PV} are used to obtain the V_{MPPT} signal.
A PV array is the combination of multiple PV panels connected in series and parallel, hence any fault in one PV panel will affect the recital of the overall PV array. This is why some of the case where a small number of PV panels have their proper controller [4]. In this work we consider that the PV array is composed of large number of PV panels and have a sole federal controller with present proposed solution.

Test System with Proposed Fuzzy based GA-MPPT Method

Inputs to a fuzzy logic controller are usually error 'e' and deviation of error. The two inputs for fuzzy logic controller. Linguistic terms used for the membership functions are such that, the terms will be NL(Negative Large), NM(Negative Medium), NS(Negative Small), ZE(Zero), PS(Positive Small), PM(Positive Medium) and PL(Positive Large). Membership Grade NL NM NS ZE. Rules are formed with 49 rule base [9] and expressed in linguistic variables relating input signals to the control signal and shown in Table 1.

Table 1. Knowledge base table with 49 rules

e	Δe						
	NL	NM	NS	ZE	PS	PM	PL
NL	ZE	PS	PM	PL	PL	PL	PL
NM	NS	ZE	PS	PM	PM	PL	PL
NS	NM	NS	ZE	PS	PS	PM	PL
ZE	NM	NM	NS	ZE	PS	PM	PM
PS	NL	NM	NS	NS	ZE	PS	PM
PM	NL	NL	NM	NM	NS	ZE	PS
PL	NL	NL	NL	NL	NM	NS	ZE

Genetic algorithm is popular optimization technique that maps input characteristics to output characteristics with fulfilling of user require constraints. Proposed genetic algorithm in step by step procedure is represented as follows
Step 1: Initialize the output control vector of Fuzzy logic system.
Step 2: With defined fitness function, evaluate the inputs to for mutation of GA process.
Step 3: Individuals of control vector can be determined with selecting the cross over data points,
Step 4: Generate the new set of data for control vector.
Step 5: Calculate the function values for each data of n^{th} data set
Step 6: Check for stopping condition.

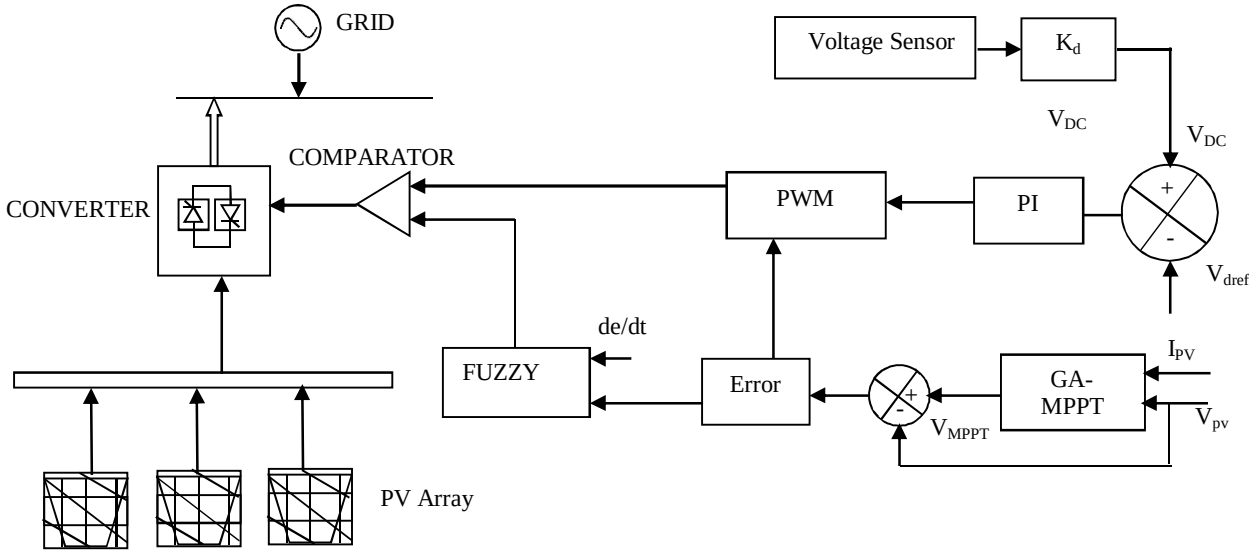

Figure 2. PV Array Module with GA-MPPT Method

The output is the MPPT based PI method is used and compared with the GA method. Test system shown in Figure 2 illustrates the controller configuration. The GA is a swarm intelligence-based algorithm used to find the global optimal solutions. GA-MPPT techniques mostly rely on perturb and observe steps and use the hill-climbing concept in subsequent iterations. While doing so, these methods constantly compare present and previous power values, and when they reach the first local maximum, the algorithm stops progressing [3] in the forward. The DC to DC boost converter is used to regulate a chosen level of the solar photovoltaic module output voltage and to keep the system at the maximum power point.
The proposed method is mainly useful for PV maximum power tracking purposes, where the objective is to draw maximum possible power from solar panels at all times, regardless of the load. It can able to regulate the perturbed voltage by increasing or decreasing the voltage reference of the PWM (Pulse width modulation) signal.A Fibonacci search-based MPPT [5] realization for PV sources has been reported. It compares the values of measured power at two operating points and then determines the operating point movement. The GA algorithms are developed for two separate dataset points and swarm region is obtained from the output of them. The data set is (n_1 p_i) □ and the second one is (n_1 p_i P_{bi})β. It is similar to the hill-climbing method with variable step size; the only difference here is that the step size is determined by the Fibonacci sequence. The MPPT search performance, however, is almost identical to that of the conventional hill-climbing algorithm, and hence this scheme, Fibonacci based-search, also settles to local MPP under certain operating conditions.

Results and Analysis

The PV module current and voltage are fed to the converter and the MPPT controller simultaneously. The presentation of the fuzzy based MPPT technique is compare with the conventional P&O MPPT. It shows that the conventional MPPT tracks the maximum power point at 0.1s and also it does not have the ability to reduce the anxious voltage.
The voltages at converter terminal during constant voltage control are shown in Figure 3. Voltage at converter of solar array during maximum power tracking is observed and plot shown in Figure 4. Power curve with MPPT-GA is improved to as that of conventional PI controller. The active and reactive powers are also plotted by exporting data to MATLAB workspace from successful execution of simulation.

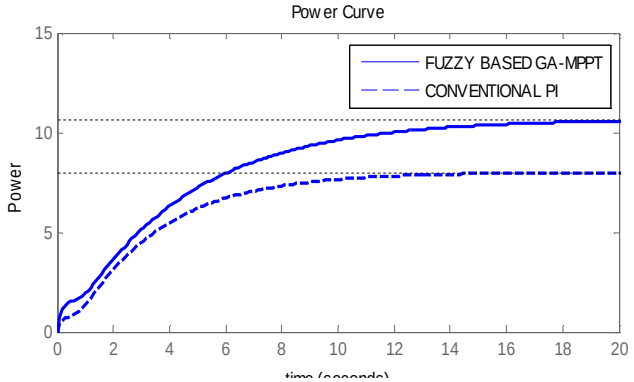

Figure 3. Coverter Power with Fuzzy based and GA-MPPT Technique

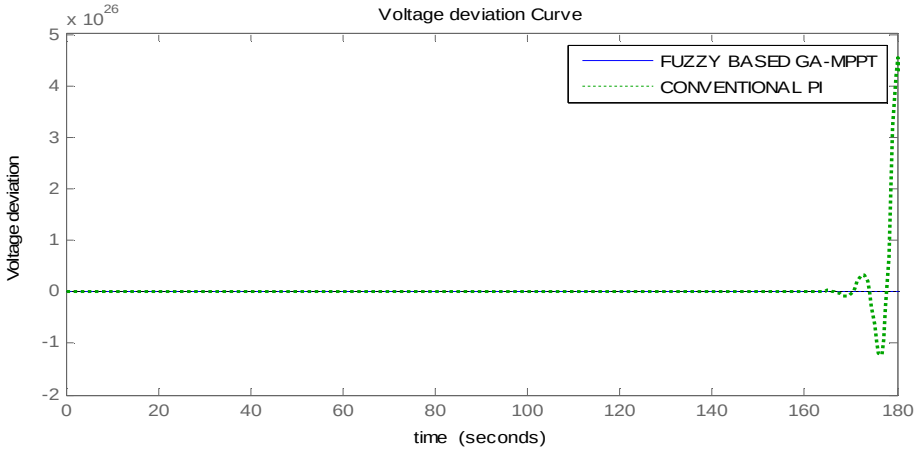

Figure 4. Control of voltage with proposed Fuzzy based and GA-MPPT Technique

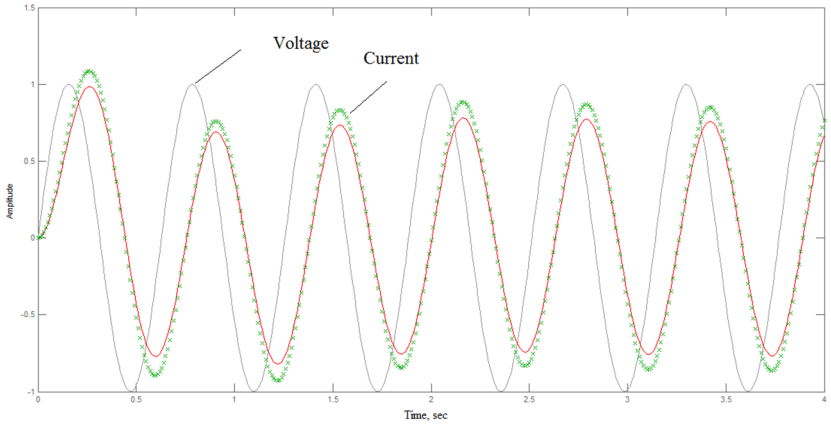

Figure 5. Wave forms of voltages and currents at converter terminals

Power at proposed method at converter terminals is shown in Figure 5. Is observed in simulation and with proposed GA-MPPT method. Active and reactive powers and output voltages are shown in Figure 6 and Figure 7 shows the Control region for active and reactive powers with proposed GA-MPPT method.

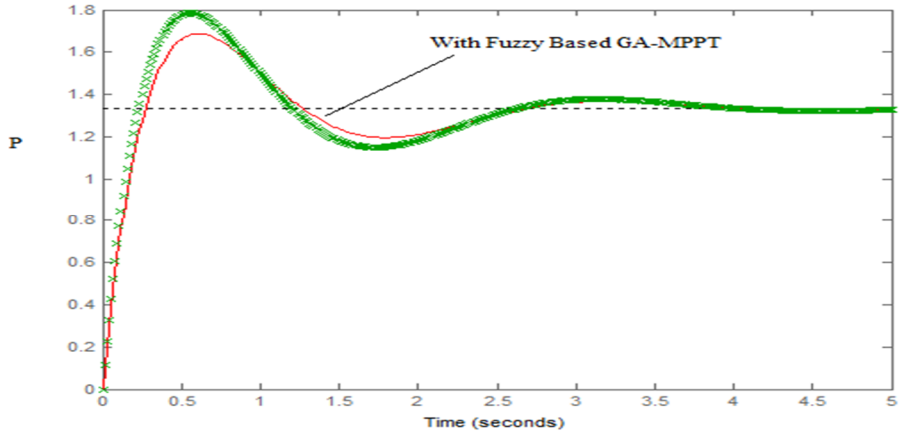

Figure 6. Power with 2% increase in load

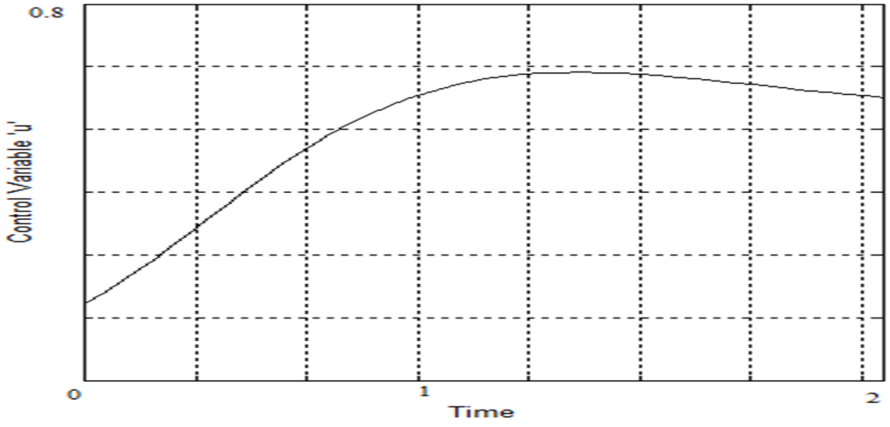

Figure 7. Control vector region for power control

Conclusion

Solar PV array with battery bank is tested during charging and discharging operation. The GA-MPPT is better than the conventional PI method. The power with increase in load is also tested for proposed fuzzy based GA-MPPT technique. The simulation results show the effectiveness of the MPPT control strategy in the case of the attendance of the data set with GA tuned vector. Converter voltage during the test condition is maintaining enhanced profile with proposed optimized voltage profile based on proposed method.

References

[1] Lasseter R.H. and Paigi P., "Microgrid: A conceptual solution", in Proc. IEEE Power Electron. Spec. Conf. (PESC'04), Vol. 6, June 2004, PP.4285– 4290.
[2] Esram T. and Chapman P., "Comparison of Photovoltaic Array Maximum Power Point Tracking Techniques", IEEE Trans. on Energy Conversion, Vol.22, No.2, 2007, PP.439-449.
[3] Femia N. and al., "Optimization of perturb and observe maximum power point tracking method" IEEE Trans. on Power Electronics, Vol.20, 2005, PP.963-973.
[4] Aldeen M. and Marah J.F., "Decentralized Proportional-Plus-Integral Design Method for Interconnected Power Systems", IEE Proceedings C - Generation, Transmission and Distribution, Vol. 138, No. 4, 1991, PP.263-274.
[5] Li Y.W. and Kao C.N., "An accurate power control strategy for power electronics- interfaced distributed generation units operating in a low voltage multibus microgrid", IEEE Trans. Power Electronics, vol. 24, No. 12, 2009, PP.2977–2988.
[6] Kakigano H., Miura Y., and Ise T., "Configuration and control of a DC microgrid for residential houses," in Proc. IEEE Transmission & Distribution Conference & Exposition: Asia and Pacific, Oct. 2009, PP.1–4.
[7] Kakigano H., Miura Y., Ise T. and Uchida R., "DC micro-grid for super high quality distribution-system configuration and control of distributed generations and energy storage devices", in Proc. IEEE Power Electron. Spec. Conf. (PESC'06), June 2006, PP. 1–7.
[8] Spooner J.T., Maggiore M., Ordonez R., Passino K.M., "Stable adaptative control and estimation for nonlinear system, Neural and fuzzy approximator techniques", Willey-Interscience, May 2002.

[9] Dr.K.Harinadha Reddy., "Power Control using Fuzzy Logic Controller in DFIG Wind Farm", IJST, Vol. 2, No. 11, 2014, PP.47-51.
[10] Shayeghi H., Shayanfar H.A., "Power system load frequency control using RBF neural network based on μ-Synthesis theory", Proceeding of IEEE conference on cybernetics and intelligent systems , Vol. 1, Dec 2004, PP.93-98.
[11] Hua C. and Shen C., "Comparative study of peak power tracking techniques for solar storage system", in Proc. APEC, Vol.2, Feb. 1998, PP.679–685.
[12] Hohm D.P. and Ropp M.E., "Comparative study of maximum power point tracking algorithms using an experimental, programmable, maximum power point tracking test bed", in Proc. Photovoltaic Specialist Conference, Sep 2000, PP.1699–1702.
[13] Hussein K.H., Muta I., Hoshino T. and Osakada M., "Maximum power point tracking: an algorithm for rapidly changing atmospheric conditions", IEE Proc.-Gener. Transm. Distrib., Vol. 142, 1995, PP.59–64.
[14] Sun X., Wu W., Li X. and Zhao Q., "A research on photovoltaic energy controlling system with maximum power point tracking", in Power Conversion Conference, Vol. 2, 2002, PP.822–826.
[15] Quaschning V. and Hanitsch R., "Numerical simulation of current-voltage characteristics of photovoltaic systems with shaded solar cells", Solar Energy, Vol. 56, No. 6, 1996, PP.513-520.
[16] Villalva M. G., Gazoli J. R. and Filho E. R., "Comprehensive Approach to Modelling and Simulation of Photovoltaic Arrays", IEEE Trans. on Power Electronics, Vol. 24, 2009, PP.1198-1208.
[17] Nakayama H., Hiraki E., Tanaka T., Koda N., Takahashi N. Noda S., "Stand-alone photovoltaic generation system with combined storage system using EDLC", in Proc. IEEE Ind. Electron. Ann. Conf. Soc., 2009, PP.883–888.