ISSN (Print) : 0974-6846
Indian Journal of Science and Technology, Vol 9(36), DOI: 10.17485/ijst/2016/v9i36/95877, September 2016 ISSN (Online) : 0974-5645

Performance Factors of Grid Interconnected PV System using ANFIS Controller

G. Manusha[1*] and M. Srikanth[2]

KL University, Green Fields Vaddeswaram, Guntur (Dist), AP, India; gujjumanusha@gmail.com, sikanth_ee250@kluniversity.in

Abstract

Objective: This paper proposes new integration to reduce Total Harmonic Distortion (THD) in grid connected system. **Methods/statistical Analysis:** We implementANFIS based controller technique is used in grid integration to reduce THD content**.** Simulation results shows that ANFIS controller has less THD and good efficiency when compared to that of FUZZY logic controller**. Findings:** Now a day's world energy consumption is increasing due to commercialization of world. It reduces non renewable energy resources, because lot of energy generation requires more conventional sources. To meet these increasing loads renewable energy generation is implementing, and many are going to get maximum power extraction from available source. In distribution energy resources solar power generation plays an important role. Solar power generation depends on irradiation level availability. Power generation from (Photovoltaic) system is highly fluctuating because irradiation continuously changes based on climatic conditions. PV system grid integration involves a converter; it injects harmonics source side and grid side. Therefore, ANFIS control can be used to improve the THD in grid connected PV systems. A comparison of PI, hysteresis control and fuzzy logic control, ANFIS control gives the feasibility of the method. Thus the proposed scheme ensures that the THD in the injected grid current remains within the specified limits. MATLAB/Simulink model is developed for the proposed work. Simulation results are given to show the overall system performance. **Applications**: Efficiency and overall performance is good compared to FUZZY controller.

Keywords: ANFIS Control, Fuzzy Control, Grid Integration, MPPT, PV System, THD

1. Introduction

Day by day utilization of renewable energy sources is increased due to increment in world utilization but non renewable sources are reducing. Wind power system and PV system are the leading ones in distribution generation. PV system widely uses due to its compatibility, flexibility, maintenance free and pollution less. Basic factors involved in growing of PV generation are increasing research on high power generating cell design, materials involved in manufacturing and less cost. PV system basically adopted at distribution side and generated power is fed to local grid. Power generation varies with modules involved in its design; the considerable things in its integration are voltage variation, instability, interference, flicker, increase of harmonics and frequency drift. Power quality issues are considered in PV integration to fed power to grid.

Harmonics is the major considerable factor among power quality problems at grid interconnected PV system. The power generation depends on irradiation level and temperature in fall in light and cells in panel, voltage fluctuation are presented due to above factors need to control these fluctuations. In distributed energy integration inverter is involved in between grid and DG to meet the necessary conditions. Generally PV generation is lesser value it needs boosting to integrate PV with grid. Low input to inverter exhibits nonlinearities due to this harmonics are injected in output.

For voltage source inverter control so many methods are available, among that hysteresis current control method is used. Here output current follows the reference current, the difference between reference and measured currents can be controlled by hysteresis controller with fuzzy. The proposed system consist of hysteresis with

*Author for correspondence

ANFIS can perform better then fuzzy. ANFIS is a trained rule base system; it can perform better than fuzzy[1]

2. System Design

The proposed hysteresis control with ANFIS as shown and the Design consists of PV module to generate power, MPPT control to track a maximum value at every instant, boost converter to maintain constant input to inverter and voltage source inverter to maintain required output constraints for grid integration. The dc-dc converter is used to extract the maximum power from the PV source. When the PV output power varies the input to converter also varies it shows savior effect on converter to reduce these stresses dc-dc converters are placed in between PV and inverter. When the PV output changes the V_{dc} value also changes then current also changes. These changes can be observed and controlled by comparing PV output voltage V_{dc} with reference current and the error will reduced by using PI controller. Based on the error only the controlling pulse of dc-dc converter was generated. The voltage source converter control is performed with hysteresis control with ANFIS as shown in Figure 1. By taking grid as a reference to maintain voltage, frequency same as grid, current and voltage are in phase with grid to maintain synchronism and improve power factor of the system. The error presented in between reference DC-link voltage V_{dc} and reference voltage can reduce by hysteresis control with ANFIS[2].

2.1 DC-DC Converter Model

The output power of PV is fluctuating continuously with change in irradiation based on climatic conditions. This regulated dc is given to inverter terminals with a boost converter. The boost converter can regulate it and increases the output voltage. The boost converter design as shown in Figure 2.

Voltage conversion ratio is given by:

$$\frac{vo}{V_s} = \frac{1}{1-D} \tag{1}$$

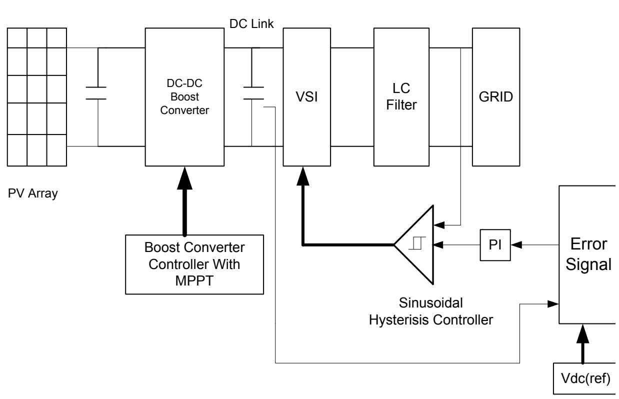


Figure 1. Block diagram of the proposed system.

2.2 PV Array Modeling

The single PV cell SIMULINK design is shown in Figure 3. The array consists of number of cells among that some are connected in series and some are in parallel. Description about series and parallel cells depends on current and voltage rating of PV module required[3].

$$I = I_{ph} - I_{rs}\left(\exp\left[\frac{q(V+IR_s)}{AKT}\right] - 1\right) - \left(\frac{V+IR_S}{R_p}\right) \tag{2}$$

2.3 DC-DC Converter Controller

The boost converter can works on duty cycle given to the converter. Duty cycle was designed based on PV output, for this MPPT technique is used. MPPT is used for extracting maximum power extracting point on PV output. It calculates one maximum point at every instant corresponding to PV dc voltage. The Perturb and Observe algorithm is used in MPPT it is one of efficient method to calculate optimal point as a reference for boost converter controller for duty cycle generation[4].

3. Inverter Control

Hysteresis controller based voltage controllers are used for grid integration of low and medium power rating

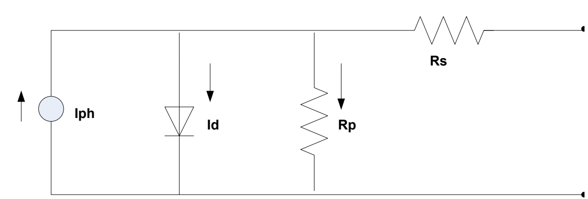


Figure 2. Equivalent circuit of PV cell.

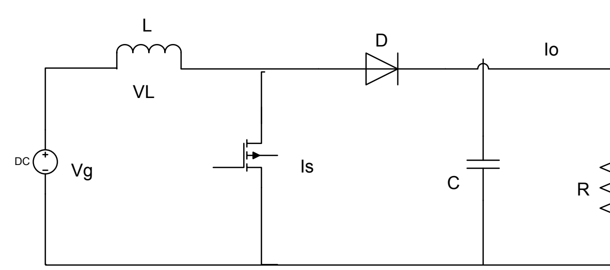


Figure 3. DC–DC converter model.

DG's. It has an ability to track or follow the grid reference current with tolerable deviation. Hysteresis controller can force the inverter to follow reference current. Hysteresis controller design as shown in Figure 4. Hysteresis controller has two limits, one is minimum and maximum these are keeps error in the limits. By keeping error within the limits output current of inverter must follows the reference. The range of error signal reduces the harmonic content presented in the output power[5]. And the single phase grid connected inverter is as shown in the Figure 5.

Mathematical implementation of voltage source inverter used to integrate hysteresis band pass control algorithm for this scheme is given as:

$$i_{ref} = i_{max} \sin \omega t \tag{3}$$

Upper band:

$$i_u = i_{ref} + \Delta i \tag{4}$$

Lower band:

$$i_1 = i_{ref} - \Delta i \tag{5}$$

$$ifi_a > i_u \;, \qquad V_0 = -V_d$$

$$ifi_a < i_u, V_0 = V_d \tag{6}$$

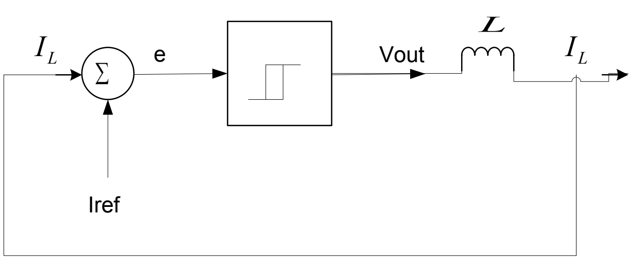


Figure 4. Block diagram of hysteresis current controller.

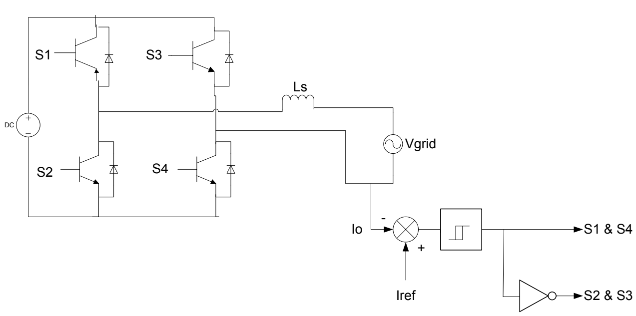


Figure 5. Single phase grid connected inverter (source: from ref 6).

In Sinusoidal Band Control the hysteresis bands vary sinusoidal over a fundamental period. The upper and lower bands are given[6] as:

$$i_{ref} = i_a^* = i_{max} \sin \omega t \tag{7}$$

$$i_u = (i_{max} + \Delta i) \sin \omega t \tag{8}$$

$$i_1 = (i_{max} - \Delta i) \sin \omega t \tag{9}$$

for

$$ifi_a > i_1, V_0 = V_d \tag{10}$$

For

$$ifi_a > i_u \;, \qquad V_0 = V_d$$

$$ifi_a > i_1, V_0 = -V_d \tag{11}$$

4. ANFIS with Hysteresis Current Controller

Hysteresis controller band width shows impact on switching frequency, switching frequency decreases with decrement in band width. But increases ripple content in the output power, to reduce ripple content ANFIS is used. It reduces ripple content up to a greater extent, i.e., the % THD due to ripples is in fundamental is less compared to fuzzy based hysteresis controller and it is shown in the Figure 6.

4.1 Adaptive Neuro-Fuzzy Mechanism

Adaptive neuro-fuzzy technique (or Adaptive Neuro-Fuzzy Inference controlling System, ANFIS)

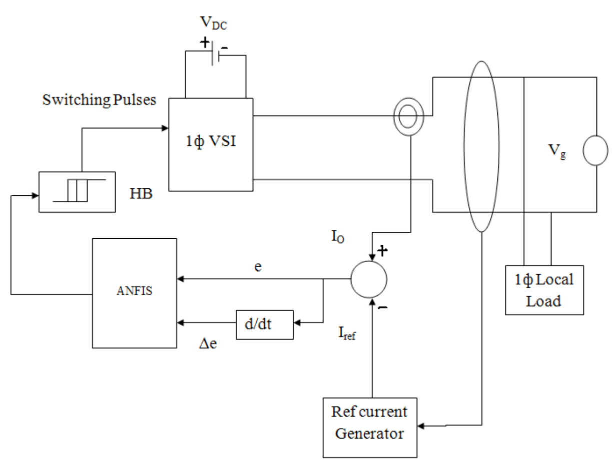


Figure 6. Block diagram for ANFIS with hysteresis controller (source: from ref 6).

has been suitably involved in the designing of Fuzzy Inference System (FIS). And its architecture is as shown in the Figure 7. In this context, the designing has been accomplished with sugeno type technique that lines out the input characteristics to input membership functions. Fuzzy inference is applicable to only modeling system whose structure is virtually designed by the users perception of the variable characteristics modeled in the inference system. In some sort of designing conditions it may not be easy to analyze the data of the membership functions it should be more correlate with the membership function promptly. A network-type design same as neural network system has been adopted to strengthen and improvise the input/output map such a way that it is ample to measure the input units through the pre mentioned membership functions of input/output parameters that are correlated with the membership functions which can be altered through the learning procedure. In the process of calculation, the variable parameter changes are supplemented with a gradient vector, which has been used as reference to the FIS to measure the input/output data in correspondence with the pre-determined parameters[7].

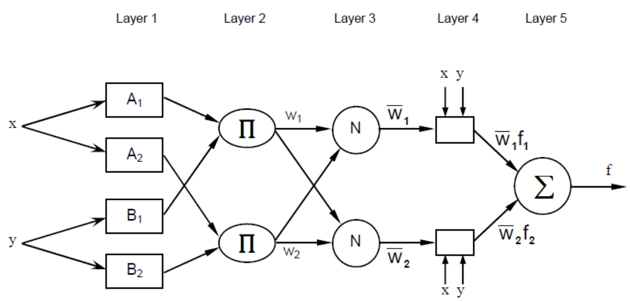
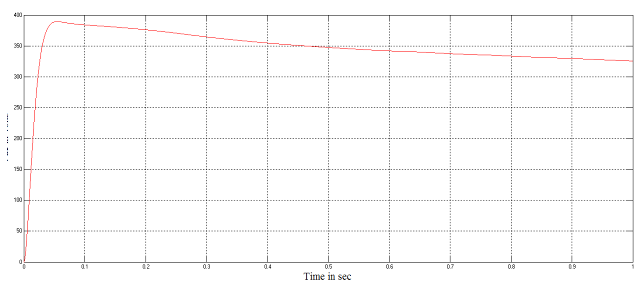
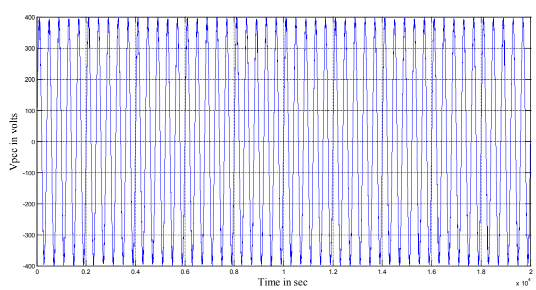


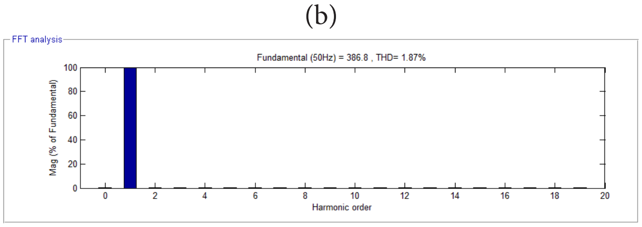
Figure 7. Architecture of ANFIS controller.



(a)



(b)



(c)

Figure 8. Simulation results. **(a)** PV output voltage **(b)** Output voltage $V_{pcc.}$ **(C)** % THD of $V_{pcc.}$

Table 1. Comparison of FUZZY and ANFIS controller

Type of controller	% THD
Fuzzy	2.41
ANFIS	1.87

5. Simulation Results

The PV module power generation depends on irradiation level and DC-DC boost converter performance with MPPT control. The performance of the proposed control system analyzed by comparing ripple content presented in converter output, it can be analyzed by calculating % THD of inverter output at conventional (using FLC) case and proposed case (using ANFIS controller). PV dc link voltage and voltage at PCC (V_{pcc}) shown in Figure 8.

6. Conclusion

Power quality issues presented in integration of PV system with grid, among those issues harmonic distortion is major issue for current injection to grid.

To reduce these issue hysteresis control with fuzzy and hysteresis control with ANFIS are tested. In this two hysteresis control with ANFIS can give better performance in harmonic reduction of injected current. The THD content present in grid integrated PV system with ANFIS control is less compared to FLC control. The analysis of % THD for both control conventional and proposed case shown in Table 1.

7. References

1. Zhang J. Simplified variable band hysteresis current control for grid connected inverter. IEEE Transactions on Power Delivery Beijing. 2003; 14(3):1-4.
2. Jena SR, Babu BC. Power quality improvement of 1-Φ grid-connected PWM inverter using fuzzy with hysteresis current controller. IEEE 10th International Conference on Environment and Electrical Engineering (EEEIC); 2011.
3. Tripathi A, Sen PC. Comparative analysis of fixed and sinusoidal band hysteresis current controllers for voltage source inverters. IEEE Transactions on Industrial Electronics. 1992 Feb; 39(1):63-73.
4. Das D, Pradhan SK. Modeling and simulation of PV array with boost converter: An open loop study. Rourkela: National Institute of Technology; 2011. p. 1-56.
5. Ebrahimi A, Farokhnia N. A novel topology for power quality improvement of grid-connected photovoltaic system. IEEE Conference on Power Engineering and Renewable Energy; 2012 Jul.
6. Sunny R, Anto R. Harmonics control and performance analysis of grid connected PV system, International Conference on Advanced Computing and Communication Systems (ICACCS'13); Coimbatore, India. 2013 Dec 19–21.
7. Rezvani A, Izadbakhsh M, Gandomkar M, Vafaei S. Implementing GA-ANFIS for maximum power point tracking in PV system. Indian Journal of Science and Technology. 2015 May; 8(10):1-10.