International Journal for Research in Applied Science & Engineering Technology (IJRASET)

Power Generation with QUASI-Z-Source Inverter Using ANFIS Based MPPT

Malar Magal. T[1], Dr.K.Elango[2]
[1]PG Scholar , [2]Professor & HOD, Department of Electrical and Electronics , Engineering
Valliammai Engineering College, Chennai, India.

***Abstract*— The paper proposes an new technique for photovoltaic power generation with quasi Z-source inverter (qZSI) using an artificial-intelligence based solution for delivering maximum power .Adaptive neuro-fuzzy interface system (ANFIS) is used to ensure the delivery of maximum power for the load. This system can be used for an isolated load. The closed loop control of qZSI regulates the shoot- through duty ratio and modulation index for the control of voltage, current, and frequency conditions. Simulation is used for the validation of the proposed system.**
***Keywords*- quasi Z source inverter(qZSI), photovoltaic power generation, shoot- through state, adaptive neuro-fuzzy interface system(ANFIS).**

I. INTRODUCTION

In today's climate of growing energy needs and increasing environmental problem, alternatives to the use of non-renewable and polluting fossil fuels have to be perused. One such alternative is solar energy. Photovoltaic cells, by their very nature, convert radiation to electricity. . The major players in renewable energy generation are PV, wind farms, fuel cell, and biomass. These kinds of electrical power solutions tend to be broadly recognized for microgrid purposes.

There are several power converter topologies employed in Photovoltaic systems; however, they differ by several characteristics. twostage or single-stage, with transformer or transformerless, and with a two-level or multilevel inverter[1].single stage are more attractive than two stage module due to their compactness. Transformerless topologies especially deserve attention because of their higher efficiency, smaller size and weight, and a lower price for the PV system [2]. The Z-source inverter (ZSI), as a single-stage power converter with a step-up and step down function, allows a wide range of PV voltages, and has been reported in applications in PV systems[3]. It can handle the PV dc voltage variation in a broad range without overrating the inverter, as well as implementing the voltage boost and inversion simultaneously in a single power conversion stage, thus minimizing system cost and reducing component count and rating, and improving the reliability [4]

The recently proposed qZSIs have some new advantages that are more suitable for PV systems. This makes the PV system simpler and lower its cost. qZSI: draws a constant current from the PV panel, lower component rating, reduces switching ripples. ANFIS: Artificial Neuro-Fuzzy Inference Systems. ANFIS are a group of adaptive networks that are functionally equivalent to fuzzy inference systems. ANFIS represent Sugeno e Tsukamoto fuzzy models. The neural network is a technique for mapping input–output nonlinear function. Sense and it works as a black box. Fuzzy logic has the capability of transforming heuristic and linguistic terms into numerical values through fuzzy rule and membership function.

However, the shortcoming of fuzzy computation is obtaining correct fuzzy rule and membership functions they rely on the prior knowledge of the system. The ANFIS is the one which integrates the neural and fuzzy logic, thus this energy offers the most artificial intelligence technique. This paper thus uses ANFIS method is to determine the maximum power capability of a Photovoltaic module. The proposed technique of using ANFIS-based MPPT offers highly accurate and fast control with the operation and is highly suitable for microgrid application in PV generation.

II. CIRCUIT TOPOLOGY FOR QUASI Z-SOURCE INVERTER

The QZSI is a single stage power converter derived from the ZSI topology, employing a unique impedance network. The conventional VSI and CSI experience the limitation that triggers two switches in the same leg or phase leads to a source short and in addition, the maximum accessible output voltage cannot exceed the dc input, since they are buck converters and can produce a voltage lower than that of dc input voltage. Both Z-source inverters and quasi-Z-source inverters overcome this drawback by utilizing several shoot-through zero states. A zero state is produced when the upper three switches or lower three switches are fired simultaneously to boost the output voltage of the system. Sustaining the six active switching states of a Voltage source inverter, the zero states can be partially or completely replaced by the shoot through states depending upon the voltage boost requirement. QZSI acquire all the advantages of traditional ZSI. The impedance network couples the source and the inverter to Attain voltage boost and inversion in a single stage by using this new topology, the inverter draws a constant current from the Photovoltaic array and is capable of handling a wide input voltage range. It also features lower component

Volume 4 Issue III, March 2016
ISSN: 2321-9653
International Journal for Research in Applied Science & Engineering Technology (IJRASET)

ratings, reduce switching ripples to the PV panel, causes less EMI problems and reduced source stress compared to the traditional ZSI.

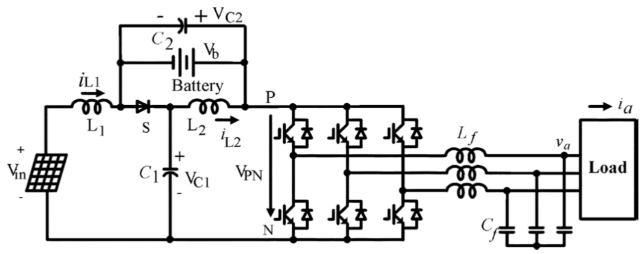

Fig. 1. Quasi Z-Source Inverter Topology

The two modes of operation of a quasi z-source inverter are:
Non-shoot through mode
Shoot through mode

A. Non-Shoot through Mode

In the non-shoot through mode, the switching design for the QZSI is similar to that of a VSI. The inverter bridge, viewed from the DC side is equivalent to a current source. The input dc voltage is available as DC link voltage input to the inverter, which makes the QZSI behave similar to a VSI

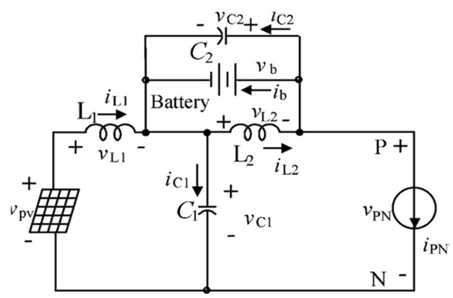

Fig.2. Nonshoot-through state.

B. Shoot through Mode

In the shoot through mode, switches of the same phase in the inverter bridges are switched ON simultaneously for a very short duration. The source however does not get shortcircuited when attempted to do because of the presence LC filter, while boosting the output voltage. The DC link voltage during the shoot-through states is boosted by boost factor, whose value depends on the shoot through duty ratio for a given modulation index

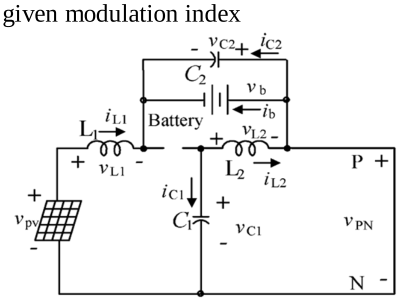

Fig.3.shoot-through state

$$P_{PV}=i_{pv}.v_{pv}=i_{L1}.v_{pv} \quad (1)$$

Power of battery can be calculated using

$$P_{battery}=i_b .v_b=i_b.v_{c2} \quad (2)$$

Load can be expressed using

Volume 4 Issue III, March 2016
ISSN: 2321-9653
International Journal for Research in Applied Science & Engineering Technology (IJRASET)

$$P_{load} = v_{pn}.i_{pn} \quad (3)$$

The power relationship in the system can be derived as

$$P_{PV} - P_{load} = P_{battery} \quad (4)$$

As mentioned previously, it has the able to handle the shoot-through state therefore, it is more reliable than the conventional VSI.

III. PROPOSED CONTROL STRUCTURE

The objectives to be achieved by the proposed control system

Maximum power point tracking.

To obtain desired stable output power to the isolated AC load.

Extracting maximum available power. The ANFIS is trained for giving voltage output crisp value corresponding to the maximum power delivery from the PV panel

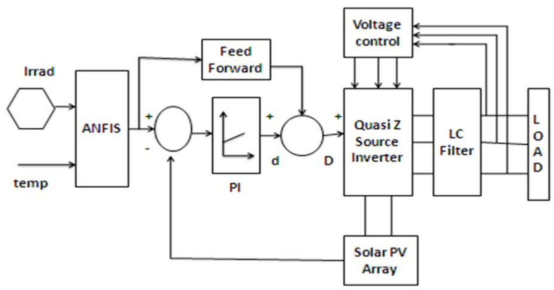

Fig.4. Proposed control scheme with ANFIS based MPPT

There are two control variables for this qZSI control system, i.e., the shoot-through duty and modulation index Both control variables must be cooperate to achieve the above set goals. a closed-loop control of the input voltage is merged with the trained ANFIS to implement the MPPT control

At constant temperature, the change of solar irradiation will result in change of PV current at the maximum power point (MPP), when compared to the resultant change of PV voltage. Maximum power point tracking (MPPT) is a technique that charge controllers use for wind turbines and solar system to employ and maximize power output. PV solar comes in different configurations. The most basic version where power goes from collector panels to the inverter and from there directly onto standalone system. The solar irradiance is measured by standard industrial solar pyranometer and the temperature and other weather data are collected using weather transmitters arrangements

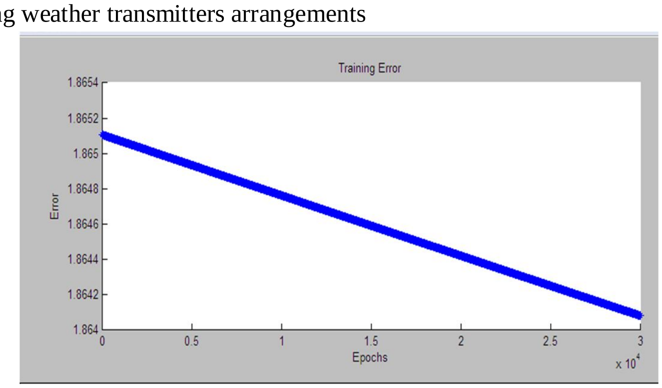

Fig.5.Training error versus epochs for ANFIS.

further process or implementation of real-time control using ANFIS controller. The schematic outline for the ANFIS controller is shown in Fig. 5

IV. APPLICATION OF ANFIS FOR MPPT TRACKING

ANFIS generates the set of fuzzy rule in order to obtain proper output for different values of input. Parameters of membership functions are adjusted or changed till the error is reduced to min value. Once all the parameters of membership function are

Volume 4 Issue III, March 2016
ISSN: 2321-9653
International Journal for Research in Applied Science & Engineering Technology (IJRASET)

adjusted, the ANFIS model becomes a learning model which is ready to be implemented in MPPT control scheme.But before using ANFIS learning model for MPPT control, its results are checked by using checking data which has different from training data. Again if error occured is more than desired value parameter of membership function are adjusted to bring down the error.

To validate the proposed control scheme, the simulated model is developed using Matlab/Simulink for the whole system. Each model is elaborated on next. The temperature of cell varies from 10 C to 70 C in a step of 6 C and the solar irradiance varies from 50 to 1000 W/m in a step of 50 W/m . Two hundred sets of obtained data are then used to train. the ANFIS network for the purpose of MPPT. The training is done offline using Matlab tool. The network is trained for 30 000 epochs. The target error is set to 1.1% and the training waveform is depicted in Fig. 5. By varying the slider on the figure, all the conditions can be accessed. It can be shown that the temperature varies from 10 C to 70 C, the solar irradiance
varies from 50 to 1000 W/m , and correspondingly, the maximum power point voltage varies as shown in the last column.

Fig. 6. Membership function of solar irradiance .

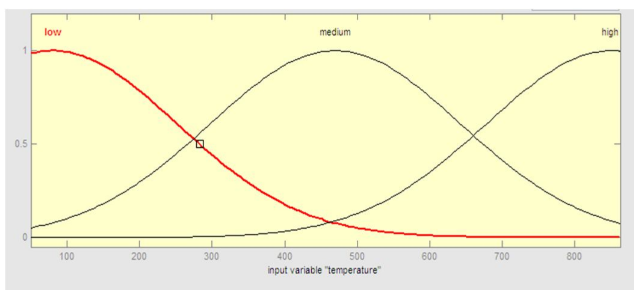

Fig. 7. Membership function of PV cell temperature.

There are totally nine rules that can follow, and more filled cells means high values and the blank or less filled cells represents low values for example rule 8 can be read as if temperature input is low (follow membership function “low,” Fig. 6) and the solar irradiance is medium (followmembership function “medium,” Fig. 7) then the maximum power point voltage (output of ANFIS controller). The rulers (the vertical red line) shown in the temperature and irradiance can be moved to check the rules for other operating conditions. The variation of the MPP voltage with the changes of the PV cell temperature and solar irradiance are shown in the surface plot The surface depicts the typical behavior. The proposed ANFIS-based MPPT is stable and faster than the traditional based MPPT method. This can be observed from The simulation is made for an initial solar radiation of 450 W/m .

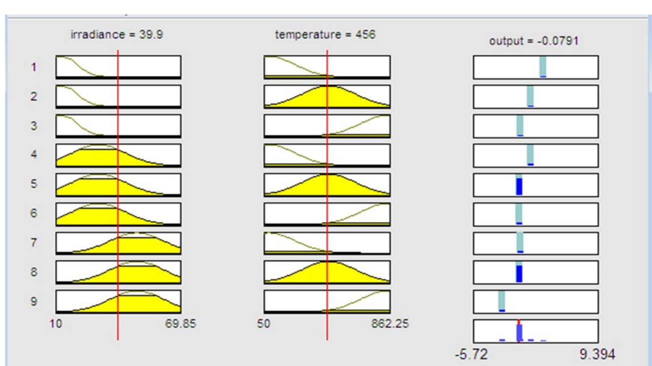

Fig. 8. Rule base of ANFIS controller.

Volume 4 Issue III, March 2016
ISSN: 2321-9653
International Journal for Research in Applied Science & Engineering Technology (IJRASET)

The PV array module is implemented using a generalized photovoltaic model using MATLAB Simulink software package. The effect of solar irradiation cell temperature, output current and power characteristics of PV module are simulated, analyzed and optimized. A simple mathematical relation is used to model the non-linear characteristics of solar cell. The solar irradiation level is controlled by varying the short circuit current in the characteristic equation. From the characteristics the maximum power point is calculated. The simulation of solar cell is performed using the MATLAB software.

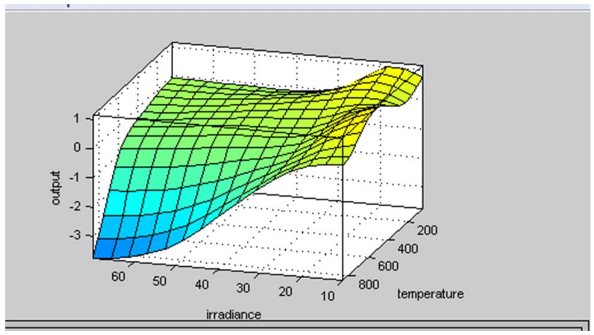

Fig. 9. Surface view created by ANFIS.

V. SIMULATED RESULT

The PV array module is implemented using a generalized photovoltaic model using MATLAB Simulink software package. The effect of solar irradiation cell temperature, output current and power characteristics of PV module are simulated, analyzed and optimized. A simple mathematical relation is used to model the non-linear characteristics of solar cell. The solar irradiation level is controlled by varying the short circuit current in the characteristic equation. From the characteristics the maximum power point is calculated. The simulation of solar cell is performed using the MATLAB software.

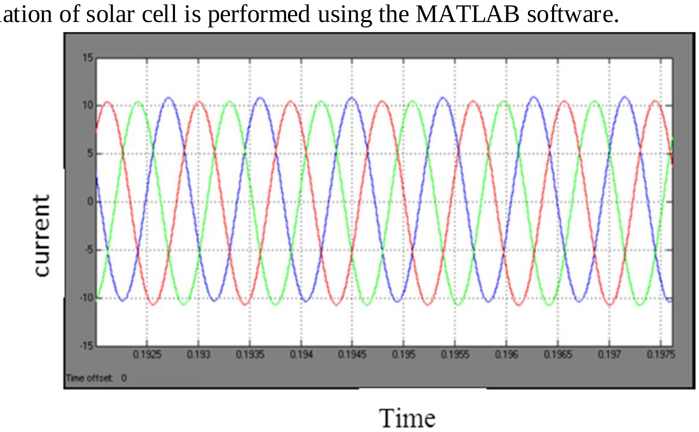

Fig.10 Three phase current

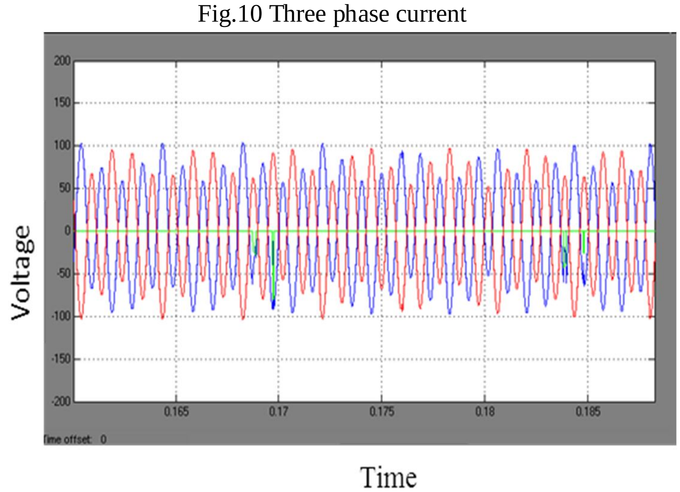

Fig.11 Three phase voltage

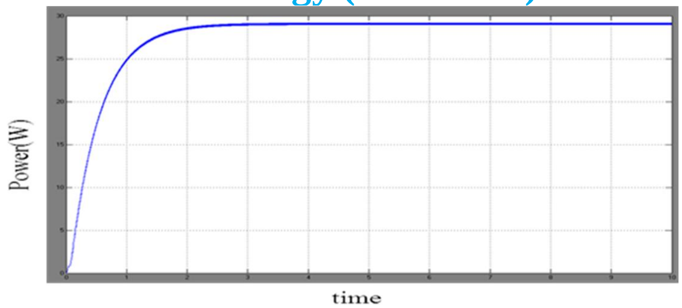

Fig.12 Power output

VI. CONCLUSION

In this proposed ANFIS-based PV power generation system operating in a standalone mode . The interface between source and load is accomplished by quasi z source inverter. The shoot through duty ratio is controlled using ANFIS. The load sides voltage and frequency are regulated by controlling the modulation index of the interface of the qZSI. Maximum power is obtained using Maximum Power Point Tracking based ANFIS. The control objectives achieved. Simulations are provided to verify the proposed control approach.

REFERENCES

[1] B. M. T. Ho and S.-H. Cheng, "An integrated inverter with maximum power tracking for grid-connected PV systems," IEEE Trans. Power Electron., Vol. 20, No. 4, pp. 953–962, Jul. 2005.

[2] P. Xu, X. Zhang, C.-W. Zhang, R.-X. Cao, and L. Chang, "Study of Z-source inverter for grid-connected PV systems," in Proc. 37th IEEE Power Electronics Specialist Conf. (PESC'06), Jun. 2006, pp. 1–5.

[3] Y. Li, J. Anderson, F. Z. Peng, and D. Liu, "Quasi-Z-source inverter for photovoltaic power generation systems," in Proc. 24th Ann. IEEE Applied Power Electronics Conf.

[4] M. Boxwell, Solar Electricity Handbook, 3rd ed. Warwickshire, U.K.: Greenstream Publishing, Apr. 2010.

[5] Y. Huang, M. Shen, F. Z. Peng, and J. Wang, "Z-source inverter for residential photovoltaic systems," IEEE Trans. Power Electron., Vol. 21, No. 6, pp. 1776–1782, Nov. 2006

[6] J. Selvaraj and N. A. Rahim, "Multilevel inverter for grid-connected PV system employing digital PI controllers," IEEE Trans. Ind. Electron., Vol. 56, No. 1, pp. 149–158, Jan. 2009.

[7] Hoang Le-Huy.,"Modeling and Simulation of Electrical Drives using MATLAB/Simulink and Power System Block set", The 27th Annual Conference of the IEEE on Industrial Electronics Society, IECON '01. Vol. 3 (2001): Page(s): 1603-1611.

[8] M. N. Uddin and M. A. Rahman "Fuzzy logic based speed control of an IPM synchronous motor drive," in Proc. 1999 IEEE Canadian Conf.Electr. Comput. Eng.,May 9–12, 1999, pp. 1259–1264.

[9] Fang Zheng Peng, "Z-Source Inverter", IEEE Transactions on Industry Applications, Vol.39,No.2, pp. 504–510, March/April 2003.

[10] Feng Guo, L.Fu, Chien-Hui Lin, C.Li and Jin Wang, "Small Signal Modeling and Controller Design of A Bidirectional Quasi-Z-Source Inverter for Electric Vehicle Applications", 2012 IEEE Energy Conversion Congress.

[11] Miaosen Shen and Peng.F.Z, "Operation Modes and Characteristics of the Zsource Inverter with small inductance", IEEE IAS Vol.2,pp.1253-1260, 2005.

[12] Yuan Li Joel Anderson, F.Z.Peng and Dichen Liu, "Quasi Z-Source Inverter for Photovoltaic Power Generation System", 24th Annual IEEE, Applied Power Electronics Conference, pp.918-924, 2009.

[13] B. Yang, L. Wuhua, Y. Zhao, and H. Xianging, "Design and analysis of a grid-connected photovoltaic power system," IEEE Trans. Power Electron., vol. 25, no. 4, pp. 992–1000, Apr. 2010.

[14] B. M. T. Ho and S.-H. Cheng, "An integrated inverter with maximum power tracking for grid-connected PV systems," IEEE Trans. Power Electron., vol. 20, no. 4, pp. 953–962, Jul. 2005.

[15] H. Dehbonei, S. R. Lee, and H. Nehrir, "Direct energy transfer for high efficiency photovoltaic energy systems part I: Concepts and hypothesis," IEEE Trans. Aerosp. Electron. Syst., vol. 45, no. 1, pp. 31–45, Jan. 2009.

[16] R. A. Messenger and J. Ventre, Photovoltaic Systems Engineering, 2nd ed. Hoboken, NJ: Wiley Interscience, 2003.