Power Quality Improvement in Three Phase Grid Connected PV System using Fuzzy Logic

Siddartha Choubey[1], Prof. Manish Prajapati[2], Prof. A. K. Jhala[3]
[1] Research Scholar, [2]Guide, [3]HOD,
Department of Electrical Engineering, RKDF College of Engineering, Bhopal

Abstract - On the basis of above two kinds of inverter control methods, we will present an improved fuzzy control system that can be applied in grid-connected PV generation and uses MATLAB/Simulink software to simulate and analyze. The result of the simulation shows that the improved inverter control system can effectively control the grid current waveform which tends to sine wave, meanwhile it can achieve the maximum power point tracking, besides it is able to put the arbitrary power out to the load or to the grid, while the control system has a good stability. This work presents a novel fuzzy feedback based stabilization scheme for a three-phase grid-connected photovoltaic system to control the current injected into the grid and dc-link voltage to extract maximum power from photovoltaic (PV) units. The photovoltaic (PV) array normally uses a maximum power point tracking (MPPT) technique to continuously deliver the highest power to the load when there are variations in irradiation and temperature. The disadvantage of PV energy is that the PV output power depends on weather conditions and cell temperature, making it an uncontrollable source. Furthermore, it is not available during the night. The scheme is mainly based on the design of a robust controller using a partial feedback linearizing approach of feedback linearization, where the robustness of the proposed scheme is ensured by considering uncertainties within the PV system model. The performance of the proposed stabilization system is evaluated on a three-phase grid-connected PV system with fuzzy controlled logic in terms of delivering maximum power under changes in atmospheric conditions.

Keywords - PV System, GRID Connected, Power, Fuzzy, MPPT, Three Phase.

I. INTRODUCTION

With the increasingly urgent energy issues, the world attach great importance to begin the development of new energy and related technology. At present, large scale photovoltaic power generation and scale of renewable energy has become parts of development strategy, meanwhile it is the way to guide the development of photovoltaic industry[1]. However, because of its own characteristics different from conventional power generation grid connected PV power station and its security, stability, reliable operation become new challenges which power grid and PV power plant need to face.

Grid connected photovoltaic power systems are power system energised by photovoltaic panels which are connected to the utility grid. Grid connected power systems comprise of PV panels, MPPT, Solar inverters, Power conditioning units, Grid connection equipments, Here two inverter control methods are described.

A) Voltage source inverter control method

B) Power type PWM inverter control method

Voltage source inverter control method regulates phase angle of the grid mainly through receiving voltage signals from the dc side of the inverter which is called the outer loop to control the grid voltage while it regulates voltage reference from ac side load voltage to control inverter output current which is called inner loop[2]. However the process of inner loop won't affect results of the outer loop. Power type PWM inverter bridge circuits is formed by two groups, which uses two reverse diodes synchronized transformation. Required power can be got by changing the modulation rate of PWM inverter.

Thus, even the grid-connected PV generation inverter control system is able to achieve maximum power point tracking (MPPT) and to ensure the high power quality of the photovoltaic cells or not are key issues in the electrical power system. Grid connected PV generation system is mainly composed of the PV array, the inverter device with the function of maximum power tracking and the control system.

Photovoltaic system use solar panels to convert sunlight into electricity. A system is made up of one or more solar PV panels, an ac or dc power converter that holds the solar panels, and the interconnections and mounting for the other components. Due to low voltage of the individual solar cell (mainly 0.5v) several cells are wired in series for manufacture of a laminate. Then the laminate is assembled into a protective weather proof enclosure thus making a photovoltaic module or solar panel. Modules are then strung together into a photovoltaic array.

A photovoltaic array is a linked assembly of PV modules. Most PV array use an inverter to convert the dc power produced by the modules into alternating current. The modules in a PV array are connected in series to obtain the desired the voltage, the individual string are then connected in parallel to allow the system to produce more current.

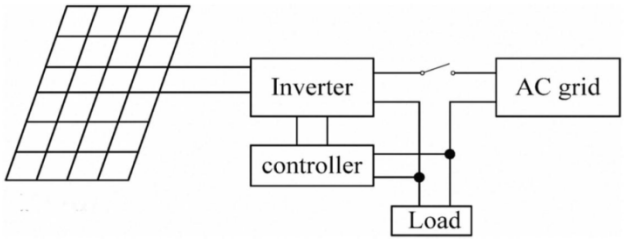

Fig. 1.1 Grid connected PV power generation structure

A solar or PV inverter converts variable direct current(DC) output of the photovoltaic solar panel into a utility frequency alternating current that can be fed into a commercial electrical grid or it is used by the local or off grid electrical network. It is a critical component in the photovoltaic system allowing the use of ordinary commercial appliances. Solar inverters have special functions adapted for use with the photovoltaic arrays including maximum power point tracking and anti islanding protection. Solar inverters use maximum power point tracking to get the maximum possible power from PV array. Solar cells have a complex relationship between solar irradiation, temperature and total resistance that produces a non-linear output efficiency known as the I-V curve. It is the purpose of a MPPT system to sample the output of the cells and determine a resistance to obtain maximum power for any given environmental conditions. A typical solar panel converts only 30 to 40 percent of the incident solar irradiation into electrical energy. Maximum power point technique is used to improve the efficiency of the solar panel. The inverter device with the function of maximum power point tracking can inverse the electrical power into sinusoidal current and connect to the grid. The control system mainly controls the maximum power point tracking of photovoltaic, current waveform and power of the output of grid connected inverter, which makes the output of the grid corresponding with the export by PV array. MPPT is not a mechanical tracking system that "physically moves" the modules to make them point more directly at the sun. MPPT is a fully electronic system that varies the electrical operating point of the modules so that the modules are able to deliver maximum available power. current.

II. PROPOSED MODEL

In a general structure distributed system, the input power is transformed into electricity by means of a power conversion unit whose configuration is closely related to the input power nature. The electricity produced can be delivered to the local loads or to the utility network, depending where the generation system is connected. One important part of the distributed system is its control. The control tasks can be divided into two major parts:

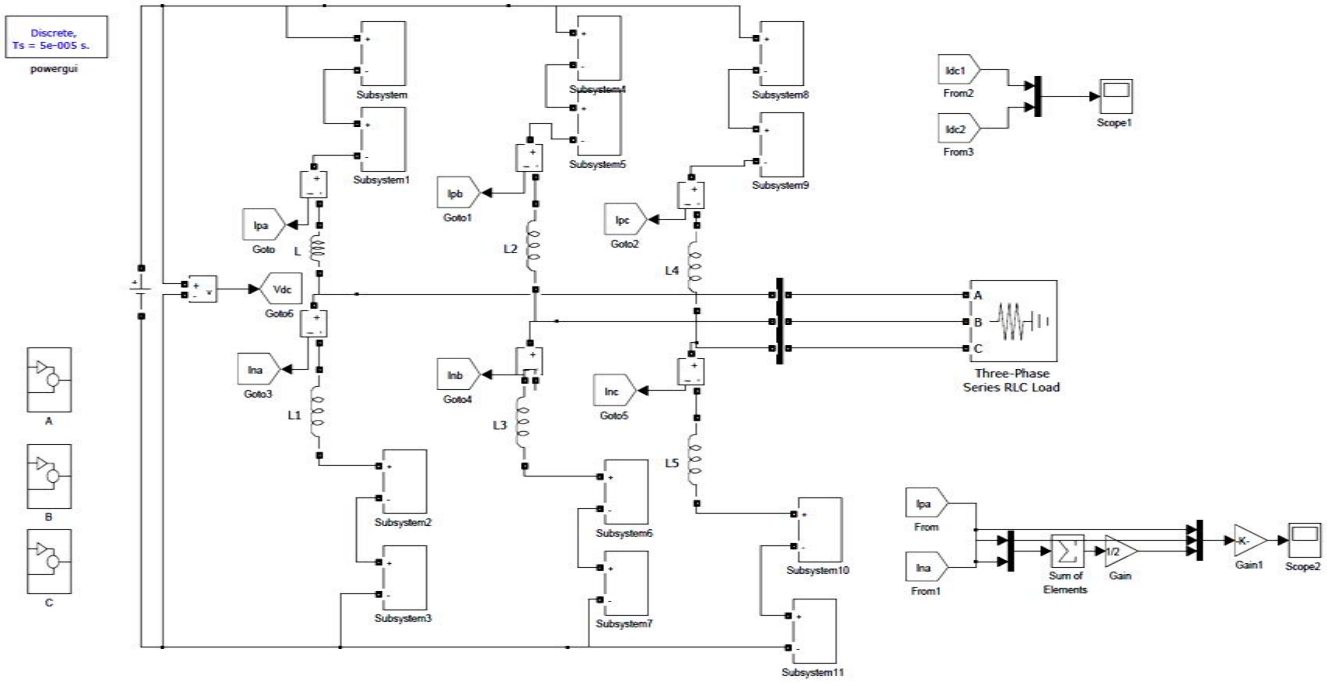

Fig. 2.1 Proposed Model

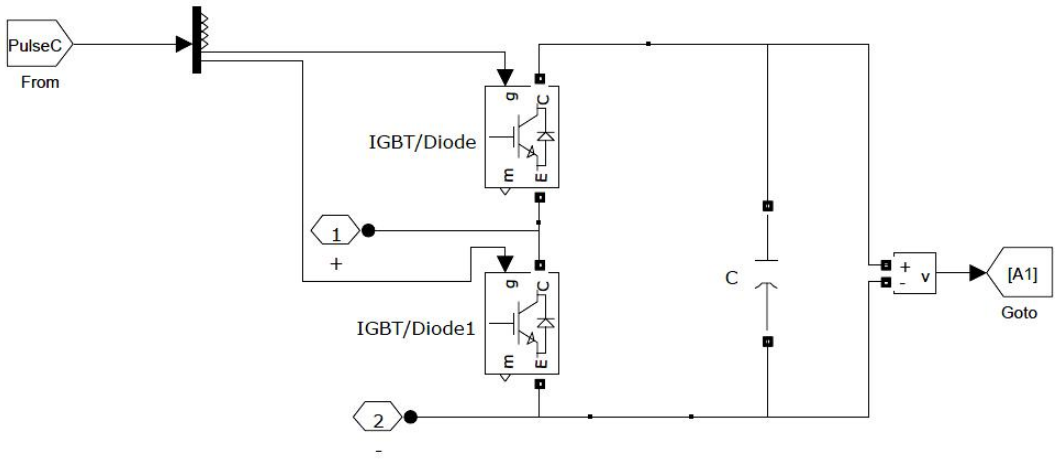

Fig. 2.2 Sub System of Proposed Model

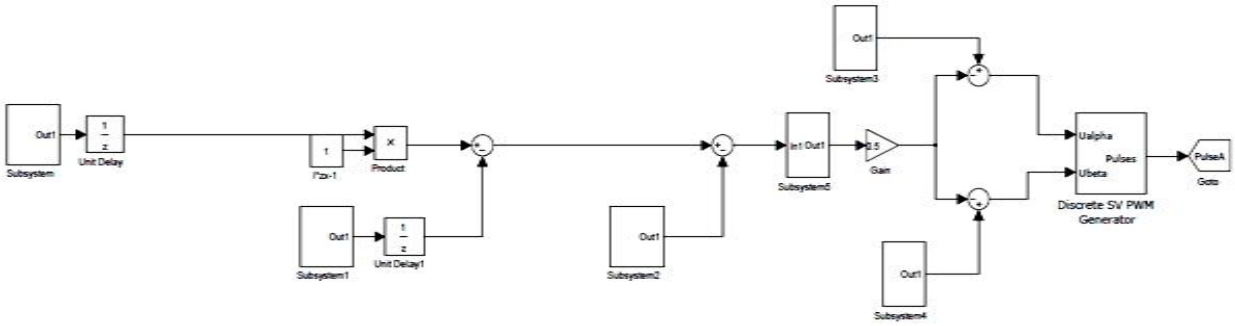

Fig. 2.3 Fuzzy Logic Model of Proposed System

1. Input-side controller: Its main property is that it can extract the maximum power from the input source. Naturally, protection of the input-side converter is also important to be considered.

2. Grid – side controller: It performs the following:

a. It controls the active power generated
b. It controls the reactive power transfer between the DPGS and the grid
c. Control of the dc-link voltage is done by the grid-side controller
d. It ensures high quality of the injected power

The pv array working voltage is set to Ed, the standard voltage Edr should be matched with the working voltage when the PV array is in the maximum power output state. The standard current Ibr should be kept to sinusoidal while the power factor should be kept to one which can be realized by PWM control method.

From above figure the process of inverter control system is complex which uses the former class system voltage fluctuations and waveform distortion signal to control the next class system. To ensure power supply the switch or reenter of inverter output will make frequency management control complex and difficult. It will increase the complexity of the control system of the main circuit if setting another AC switch, meanwhile the single phase system will have big power fluctuation.

In photovoltaic applications the grid interface between source (solar array) and load (utility grid) consists of the inverter. To maximize the system efficiency the inverter must be optimized in design and control. For a 2.5kw photovoltaic power system a single phase voltage source inverter is developed which requires only a minimum number of components. Most commercial inverters for photovoltaic applications include a transformer and several sections of power conversion. To reduce the degree of complexity it is proposed to omit the transformer and to use only one section of power conversion. Thereby system losses, size and costs decreases. By the mode of operation of a voltage source inverter, the solar array voltage is not free eligible. For the voltage source inverter and the current

source inverter, the use of gate turn-off thyristor or the IGBT which has self-extinguishing capability, has several merits.

III. SIMULATION OUTCOMES

The practical implemental of the system is done and simulation results are obtained. PV system has to be studied to understand its source response, hence its I-V characteristics can be studied. The MPPT method is applied and results are obtained. The control strategy which is applied to the grid-side converter consists primarily of two cascaded loops. Generally, there is a fast internal current loop, which is responsible for the regulation of the grid current, and an external voltage loop, which is responsible for the control of the dc-link voltage. The current loop takes care of matters related to power quality and current protection. Hence, harmonic compensation and dynamics are important properties of the current controller. The dc-link voltage controller is designed so as to balance the power flow in the system. The control of grid-side controller is based on a dc-link voltage loop cascaded with an inner power loop in place of a current loop so that the current injected into the utility network is controlled indirectly.

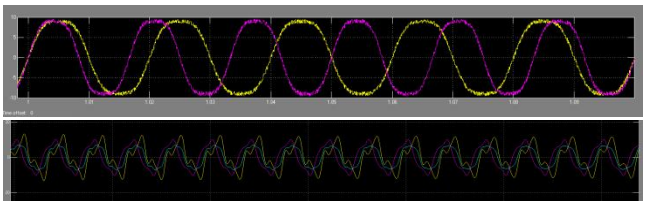

Fig.3.1. Performance under standard atmospheric conditions (Case A)

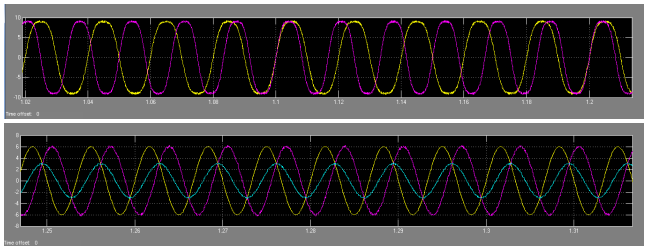

Fig. 3.2.Performance under changing atmospheric conditions (Case B)

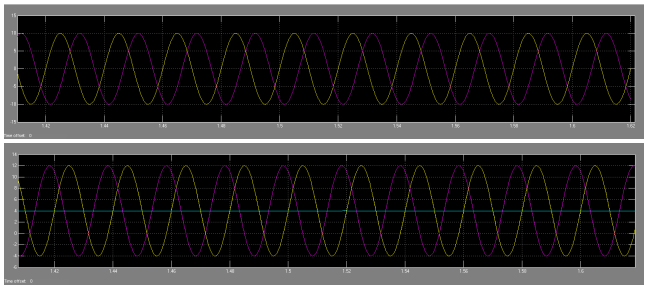

Fig. 3.3.Performance under a three-phase short-circuit fault (Case C)

IV. CONCLUSION AND FUTURE SCOPE

Improved fuzzy controlled system is based on the voltage type control method and the fuzzy logic control method. The result of simulation and conclusions shows that the improved fuzzy logic control method can make the voltage and the current waveform of the grid tend to sine wave effectively and quickly, and the power factor will reach to one. The power can be sent to the grid or load arbitrary through controlling the fuzzy, while the control system has a good stability. It also shows that as the increasing number of inductive load penetrate the grid, the load waveform distortion is produced, but it will not affect the reliability of power supply. There are many inverter control system which are used at present but there are several problems which is to be solved for better stability of the grid connected system. So, it's very important and researches are being done for grid connected PV generation control system. The PV array is simulated in the open circuit case and its characteristics are obtained. The MPPT method used here is found to be more efficient than other MPPT methods and hence better results are obtained using the incremental conductance method. the simulation results obtained of the inverter voltage and DC voltage are as per the system design and are having minimum harmonics. The MPPT method used in this system can be varied with other methods and a better efficient tracking can be obtained. The various current control methods and dc voltage controllers used are not of very high efficiency and can be replaced with other types to get a better result.

REFERENCES

[1] Welter P. Power up, prices down, grid connected inverter market survey (Leistung rauf, Preise runter, MarkituÈ bersicht netzgekoppelter Wechselrichter, in German). PHOTON-das Solarstrom Magizin (German Solar Electricity Magazine) 1999;3:48±57.

[2] Calais M, Agelidis VG. Multilevel converters for single-phase grid connected photovoltaic systems Ð an overview. In: Proceedings of the IEEE International Symposium on Industrial Electronics. Pretoria, South Africa, vol. 1, 1998, p. 224±9.

[3] Martina Calaisa,*, Vassilios G. Agelidisb Michael S. Dymondc, "A cascaded inverter for transformerless single-phase grid-connected photovoltaic systems, Renewable Energy, volume 22, Issues 1-3, January – March 2011, page 255-262.

[4] Al-Mohamad, Ali. "Efficiency improvements of photo-voltaic panels using a Sun-tracking system." Applied Energy 79, no. 3 (2004): 345-354.

[5] Rob W. Andrews, Andrew Pollard, Joshua M. Pearce, "The Effects of Snowfall on Solar Photovoltaic Performance ", *Solar Energy* 92, 8497 (2013).

[6] "Small Photovoltaic Arrays". *Research Institute for Sustainable Energy (RISE), Murdoch University*. Retrieved 5 February 2010.
[7] Reflective Coating Silicon Solar Cells Boosts Absorption Over 96 Percent Scientificblogging.com (2008-11-03). Retrieved on 2012-04-23.
[8] Solar Cells and their Applications Second Edition, Lewis Fraas, Larry Partain, Wiley, 2010,ISBN 978-0-470-44633-1, Section10.2.
[9] Yuhua Cheng, Chenming Hu (1999). "§2.1 MOSFET classification and operation". *MOSFET modeling & BSIM3 user's guide*. Springer. p. 13. ISBN 0-7923- 8575-6
[10] U.A.Bakshi, A.P.Godse (2007). "§8.2 The depletion mode MOSFET" Electronic Circuits. Technical Publications. pp. 8–2. ISBN 978-81-8431-284-3 Power Electron., vol. 9, no.3, pp 676-684.
[11] Hanju Cha and Trung-Kien Vu ,"Comparitive analysis of low pass output filter for single- phase grid-connected photovoltaic inverter ",Department of Electrical Engineering, Chungnam National University, Daejon, Korea.
[12] E-Habrouk M., Darwish M.K., Mehta P., "Active power filters: a review", IE Proceedings-Electric Power Applications, Vol. 147, Iss. 5, pp. 403-413, 2000 53
[13] Akagi H., "Active harmonic filters", Proceedings of the IEEE, Vol. 93, Iss. 12, pp. 2128-2141, 2005
[14] Marco Liserre, Frede Blaabjerg, Steffan Hansen, "Design and Control of an LCL-Filter- Based Three-Phase Active Rectifier", IEEE Transactions on Industry Application, Vol. 41, No. 5, pp. 1281-1291, 2005.
[15] IEA-PVPS, *Cumulative Installed PV Power*, Oct. 2005. [Online]. Available: http://www.iea-pvps.org
[16] M. Shahidehpour and F. Schwartz, "Don't let the sun go down on PV," *IEEE Power Energy Mag.*, vol. 2, no. 3, pp. 40–48, May/Jun. 2004.
[17] G. Saccomando and J. Svensson, "Transient operation of grid-connected voltage source converter under unbalanced voltage conditions," in *Proc. IAS*, Chicago, IL, 2001, vol. 4, pp. 2419–2424.