Reactive Power Control of Single Phase Grid Connected Photovoltaic System

V Iniya¹, P Maniraj², S Anushiya³, M Sarathapriya⁴, S Sowmiya⁵, Suresh M⁶, Srinivasan M⁷

¹ PG Student, M.Kumarasamy College of Engineering, Karur, TamilNadu, India
² Assistant Professor, Electrical and Electronics Engineering, M.Kumarasamy College of Engineering, Karur, Tamilnadu, India
³,⁴,⁵ UG Student, M.Kumarasamy College of Engineering, Karur, TamilNadu
⁶,⁷ Assistant Professor, Electrical and Electronics Engineering, Kongu Engineering College, Perundurai, Erode-638052, Tamilnadu, India
Email: iniyavelusamy21@gmail.com, maniraj.angu@gmail.com

Abstract. This paper illustrates the compensation of reactive power delivered to the grid connected inverter of photovoltaic system. By reason of weather condition sun irradiance will change, it does not deliver constant power to the grid it seems to voltage drop, poor power factor and so on. Usage of line frequency transformer can be removed while integrating the renewable energy sources to the grid without affecting the system characteristics. Here, LUO converter is designed and implemented along with the single phase inverter to integrate the solar PV to the grid without transformer usage. Fuzzy logic controller is developed to retrieve larger power from the photovoltaic system and also PI controller is used to regulate active and reactive power transfer to grid. MATLAB Simulation result shows the controlled reactive power of the grid connected photovoltaic system.

1. Introduction

Natural energy sources such as solar, wind etc., plays an major role for producing electricity nowadays. In India the production of electrical power is grown up significantly in recent years due to high penetration of a renewable energy source². Nowadays, photovoltaic PV systems become an unavoidable power source which delivers power to majority of the loads. Usually PV system operates under unity power factor, so it is necessary to include inverter to deliver reactive power to the load and also challenges in power system also increased. Power electronics is an enabling technology that enhances system stability, reliability and more efficient³. Maximum power point tracking is a controller which is used to extract larger power from the photovoltaic source. Many of the algorithm is available to track the maximum power from the PV module⁴. The LUO converter is dc-dc converter is used to boost the voltage and it is controlled by the duty cycle of the controller. Fuzzy logic controller is most widely used in the control system⁵, ⁶. Many system are too complex and seems to difficult mathematical derivation but fuzzy logic controller provides a feasible solution to define the operating characteristics of the system. PI controller is a feedback loop used to increase the gain value of the grid connected photovoltaic system.
2. Performance of the controllers

2.1. Fuzzy logic controller loop
LUO converter is connected next to the solar panel to increase and regulate the output voltage produced by the solar panel. Fuzzy logic controller is a feedback loop it will increase duty cycle when the desired output is low [8, 9]. Obtained output is compared with the reference voltage and the error signal is used to generate PWM pulse and later which is used to produce controlled output voltage. If there is a deviation between output voltage and reference signal, amplified error signal vary the duty cycle until the error becomes zero. The rules are made to improve the gain value of the photovoltaic grid connected system and it tends to improve the efficiency of PV system with transformer less single phase grid connected condition.

2.2. PI Controller
PI controller is a feedback loop and it is compared with reference voltage to increase gain loop of the grid connected PV system.

![Figure 1: Performance of PI controller](image)

3. Proposed System
PV system connected with the grid has an infeasible solution. PV system connected to the LUO converter feedback from the converter is connected with fuzzy logic controller it has twenty five set of rules to boost the voltage connected with PV system. Dc supply from the converter is transferred to the inverter to convert dc supply into ac supply. Figure 3 shows converter pulse with respect to time.
The output from the inverter feedback is taken and is given to PI controller to boost gain of the output signal. By comparison of repeating waveform of the grid and current waveform of inverter PWM of the inverter topology can be improved. By the proposed technique, grid connected voltage can be achieved. Fig.5 shows the PWM of the pulse inverter.
4. Simulation Result
Simulation result shows improvement of efficiency by the compensation of reactive power in photovoltaic system in grid connection. A 12V panel is designed has an output voltage of 21v and 255watt. After performance of the controller the inverter of the PV system reference signal is compared with repeating waveform of single phase grid tie connected system so sinusoidal waveform can be obtained. The efficiency 92.6 can be achieved by improving the system performance by using the controller.
5. Conclusion
Thus a control technique is presented in this paper to control the output voltage of grid connected photovoltaic system. The control technique is to control the converter and inverter gating pulse by using controllers. The quasi sinusoidal waveform of the inverter injecting reactive power by performing mathematical models. So the efficiency of the transmission line can be improved of the grid connected PV system. Also, the result obtained by the MATLAB simulation shows the controlled output voltage and constant reactive power supply

References
[1] A. Cagnano, E. De Tuglie, M. Liserre and R. A. Mastromauro, "Online Optimal Reactive Power Control Strategy of PV Inverters," in IEEE Transactions on Industrial Electronics, vol. 58, no. 10, pp. 4549-4558, Oct. 2011, doi: 10.1109/TIE.2011.2116757.
[2] A. Gabash and P. Li, "Active-reactive optimal power flow for low-voltage networks with photovoltaic distributed generation," 2012 IEEE International Energy Conference and Exhibition (ENERGYCON), Florence, 2012, pp. 381-386, doi: 10.1109/EnergyCon.2012.6347787.
[3] D. Li, C. N. M. Ho, L. Liu and G. Escobar, "Reactive Power Control for Single-Phase Grid-Tie Inverters Using Quasi-Sinusoidal Waveform," in IEEE Transactions on Sustainable Energy, vol. 9, no. 1, pp. 3-11, Jan. 2018, doi: 10.1109/TSTE.2017.2710340.

[4] S. L. Brunton, C. W. Rowley, S. R. Kulkarni and C. Clarkson, "Maximum Power Point Tracking for Photovoltaic Optimization Using Ripple-Based Extremum Seeking Control," in IEEE Transactions on Power Electronics, vol. 25, no. 10, pp. 2531-2540, Oct. 2010, doi: 10.1109/TPEL.2010.2049747.

[5] A. Alexander and M. Thathan, "Power quality improvement in solar photovoltaic system to reduce harmonic distortions using intelligent techniques", J. Renewable Sustain. Energy, vol. 6, no. 4, Jun. 2014.

[6] L. Collins, J.K. Ward, Real and reactive power control of distributed PV inverters for overvoltage prevention and increased generation hosting capacity, Renewable Energy, Volume81.2015, Pages464-471, ISSN0960-1481

[7] Alexander, S.A. and Thathan, M. (2015) Optimal Harmonic Stepped Waveform Technique for Solar Fed Cascaded Multilevel Inverter. Journal of Electrical Engineering and Technology, 10, 261-270.

[8] M. A. De Rooij, and J. S. Glaser, “High efficiency, multi-source photovoltaic inverter”, US Patent US7929325 (B2), 2011-04-19

[9] R. Tonkoski, L. A. C. Lopes and T. H. M. El-Fouly, "Coordinated Active Power Curtailment of Grid Connected PV Inverters for Overvoltage Prevention," in IEEE Transactions on Sustainable Energy, vol. 2, no. 2, pp. 139-147, April 2011, doi: 10.1109/TSTE.2010.2098483.

[10] Alexander SA, Manigandan T. Design and Development of Digital Control Strategy for Solar Photovoltaic Inverter to Improve Power Quality. CEAI 2014;16(4):20–9.

[11] S. Bolognani and S. Zampieri, "A Distributed Control Strategy for Reactive Power Compensation in Smart Microgrids," in IEEE Transactions on Automatic Control, vol. 58, no. 11, pp. 2818-2833, Nov. 2013, doi: 10.1109/TAC.2013.2270317.

[12] AL Kumar, SA Alexander, M Rajendran, Power Electronic Converters for Solar Photovoltaic Systems, 2020 - Academic Press

[13] S. B. Kjaer, J. K. Pedersen and F. Blaabjerg, "A review of single-phase grid-connected inverters for photovoltaic modules," in IEEE Transactions on Industry Applications, vol. 41, no. 5, pp. 1292-1306, Sept.-Oct. 2005, doi: 10.1109/TIA.2005.853371.

[14] A. Alexander, M. Thathan, "Modelling and Simulation of Artificial Neural Network Based Harmonic Elimination Technique for Solar-Fed Cascaded Multilevel Inverter", International Review of Modelling and Simulations (IREMOS), 6(4) 1048-1055, 2013.

[15] A. A.Stonier, S. Murugesan, R. Samikannu, S. K. Venkatachary, S. Senthil Kumar and P. Arunugam, "Power Quality Improvement in Solar Fed Cascaded Multilevel Inverter With Output Voltage Regulation Techniques," in IEEE Access, vol. 8, pp. 178360-178371, 2020, doi: 10.1109/ACCESS.2020.3027784

[16] Sampath Kumar Venkatachary, Ravi Samikannu , Srinivasan Murugesan ,Narasimha Rao Dasari , Ragupathy Uthandipalayam Subramaniyam , Nov. 2020, Economics and impact of recycling solar waste materials on the environment and health care, “Environmental Technology & Innovation”, Vol.20, no.101130, pp. 1-14.

[17] Vijayalakshmi, S., Sivaraman, P.R., Karthick, R., Nazar Ali, A.”Implementation of a new Bi-Directional Switch multilevel Inverter for the reduction of harmonics” IOP Conference Series: Materials Science and Engineering, 2020, 937(1), 012026