International Journal of Advances in Engineering and Management (IJAEM)
Volume 4, Issue 1 Jan 2022, pp: 315-319 www.ijaem.net ISSN: 2395-5252

Design of Solar Based High StepupTransformerless Standalone Inverter Using Controllers based Control Techniques

Tamilarasan Ks[1], Dr.V. Geethas[2],
[1]*PG Scholar, Government College of Engineering, Tamil Nadu, India*
[2]*Professor&Head, Department of Electrical Engineering, Government College of Engineering, Tamil Nadu, India*

Submitted: 02-01-2022 Revised: 09-01-2022 Accepted: 12-01-2022

ABSTRACT: This paper presents the solar-based high step-up transformerless inverter-based control. The proposed topology is a two-stage (DC-DC-AC) power conversion topology. The front-end two-stage boost converter is controlled by the fuzzy logic controller with Perturb and Observe (P&O) MPPT control technique, the inverter stage is controlled by PR controller based current and voltage control technique. The advantages of the proposed FLC - P&O MPPT control technique have high efficiency, low overshoot, and less oscillation time compared to the conventional P&O MPPT technique. The proposed two-stage boost converter proves good steady-state performance, low voltage, and current ripple and constant output voltage with FLC.
The proposed PR controller-based current and voltage control techniques are used to control the inverter output voltage and current by changing the modulation and maintaining zero steady-state error in sinusoidal quantities compared to the PI controller. The proposed inverter proves good steady-state performance, low THD, and constant output voltage with the PR controller.
KEYWORDS:FLC-based P&O MPPT,Proportional resonant Controller (PR), two-stage Boost converter (DC-DC), inverter.

I. INTRODUCTION

Many research works have proposed solar photovoltaic (PV) energy as an alternative energy resource. Photovoltaic energy is the most hopeful renewable energy resource, it is clean and pollution-free. There are two types of power conversion topologies as isolated and non-isolated configuration. Because of the transformer in the isolated inverter structure, there are some drawbacks low power density and complicated control of the output. The conventional P&O MPPT has a low MPPT ratio, more oscillation time, and high overshoot voltage. The main drawback of the converter is output power efficiency is very less and it affects the efficiency of the system performance. The Fuzzy logic controller-based P&O MPPT technique has less settling time, low oscillation time, and low overshoot, and it sable at a change in irradiance. Due to this advantage, it improves the MPPT ratio, reduces oscillation and overshoot voltage. The PI controller cannot produce zero steady-state error in the sine wave. The PR controller can maintain zero steady-state error in sinusoidal quantities. It introduces the combinational features in both conventional P&O MPPT and FLC to form a single algorithm for MPPT of PV dc-dc boost converter is simple and faster.This proposed MPPT method proves better steady state performance with various irradiance conditions. This paperintroduces PR controller based Current and Voltage control techniques for stand-alone inverter to control the inverter output voltage. This proposed PR controller-based control technique proves better steady state performance. This control technique achieves zero steady state error in sinusoidal quantities. The Figure:1 shows block diagram of Proposed model.

SOLAR PV ARRAY: The solar PV array is the primary source of power for the standalone DC-DC two stage boost converter. The power generated by the solar PV array for a given temperature and level of irradiation depends on PV voltage and current drawn by the load. Hence, in order to do load matching, a maximum power point tracking (MPPT)

International Journal of Advances in Engineering and Management (IJAEM)
Volume 4, Issue 1 Jan 2022, pp: 315-319 www.ijaem.net ISSN: 2395-5252

control is used to set the converter at maximum power point (MPP) by varying the duty ratio of the appropriate switch and hence the current drawn by the converter from the solar PV array. There are many algorithms used to track the MPP like constant voltage, perturb and observe (P&O), incremental conductance, particle swam optimization and beta method.

The output current of the solar PV array used in modelling is,

$$I_{PV} = I_L - I_o\left(e^{\frac{q(V+IR_S)}{nKT}} - 1\right) \quad \text{----------} \quad 1$$

I_{PV} =Solar PV current,
I_L =inductor current,
I_o =load current or output current
q = charge of an electron,
K =Boltzmann's constant,
n = diode ideality factor

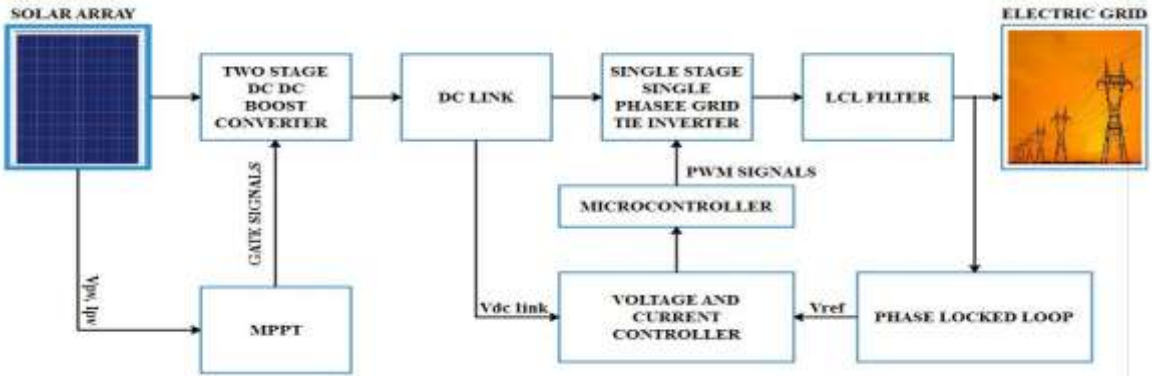

Figure:1 Block diagram of Proposed model

II. LITERATURE SURVEY

2.1 "High Step-up Transformer-less Inverter for AC Module Applications with Active Power Decoupling". Julia Roy, Member, IEEE, Yinglai Xia, Member, IEEE, and RajapandianAyyanar, Senior Member, IEEE. The year 2018.

This paper explores a power conversion system for a single-phase transformerless inverter for the AC module application. In this topology, a non-isolated high gain DC-DC stage is coupled with a doubly grounded dynamic DC-link inverter to implement the microinverter topology. The front-end boost stage steps up the single module voltage to a higher dc voltage, typically to 200 V or 400 V as required for the following inverter stage. It combines the principle of an interleaved boost and switched capacitor concept capable of achieving high gain while simultaneously the reduced voltage and current stress, lowering switching and conduction loss for most of the switches. By directly connecting the grid neutral to the PV negative, the doubly grounded voltage swing inverter has the advantage of zero capacitive-coupled common-mode ground currents, critical for transformerlessPV inverters. The two dc-links of the inverter stage share the double line frequency power decoupling with a high value of mean voltage and relatively large 120 Hz ripple component – the dynamic dc-link approach. The focus of the paper is to explore a transformer-less topology for PV microinverter. The microinverter topology is implemented with a high gain EDR boost as dc-dc stage and doubly grounded voltage swing inverter as the dc-ac stage. The high-efficiency performance is capable of achieving a high and variable gain.

2.2 "A Highly-Efficient Fuzzy-based Controller with High Reduction Inputs and Membership Functions for a Grid-connected Photovoltaic System" Lotfi Farah, Amir Hussain, AbdelfatehKerrouche, CosimoIeracitano, Jamil Ahmad, Mufti Mahmud., IEEE – 2017.

In this paper, an HR FLC-based MPPT method is proposed as an accurate, simple, and representative approach. Both inputs and membership functions are used to reduce, resulting in a Highly Reduced Fuzzy Logic Controller (HRFLC), to proposed model a 100kW grid-connected Photovoltaic Panel (PV) as part of a Maximum Power Point Tracking (MPPT) scheme. A DC-to-DC boost converter is to transfer the total energy to the grid over a three-level Voltage Source Converter (VSC), which is controlled by varying its duty cycle. Fuzzy Logic Controller generates control parameters to operate in different weather conditions. The simulation inputs result in a novel HRFLC which simplifies the solar electric system design with output Membership Functions (MFs). Both are achieved by grouping two rules. A

comparison with different techniques such as Perturb and Observe (P&O) shows that HRFLC can improve the dynamic and steady-state performance of the PV system. The experimental results report a steady-state error of 0.119%, a transient time of 0.28s, and an MPPT tracking accuracy of 0.009s. The design and simulation of the method are discussed in detail. The use of Fuzzy in MPPT control achieves better results than the classical approach, especially for static error and tracking time. in comparison with other controllers like fuzzy, ANNs, and so on, the HRFLC reported higher accuracy and efficiency in tracking time, transit time, and steady-state with a high reduction in variables and functions. This reduction allows not only to simplify the implementation process but also to achieve a significant gain in terms of time and cost.

2.3 "Development of adaptive perturb and observe-fuzzy control maximum power point tracking for photovoltaic boost dc-dc converter" Muhammad AmmirrulAtiqiMohdZainuri, MohdAmranMohdRadzi, Azura Che Soh Nasrudin Abd Rahim. The year 2014.

This presents an adaptive perturb and observe (P&O)-fuzzy control maximum power point tracking (MPPT) for photovoltaic (PV) boost dc-dc converter. P&O is a simple MPPT algorithm and is used widely. Fuzzy logic is also simple to be developed and provides a fast response. The existing technique combines both of their advantages. It improves MPPT performance especially with the existence of noise. the algorithms were simulated in MATLAB-Simulink with the PV module of Kyocera KD210GH-2PU connected to PV boost dc-dc converter. For hardware, the proposed adaptive P&O-fuzzy control MPPT was programmed in the TMS320F28335 digital signal processing board.

Performance assessment covers overshoot, time response, maximum power ratio, oscillation, and stability as described further in this study. From the results and analysis, the adaptive P&O-fuzzy control MPPT shows the best performance with fast time response, less overshoot, and more stable operation. It has a high maximum power ratio as compared to the other two conventional MPPT algorithms especially with the existing noise in the system at low irradiance. This paper has presented a new MPPT algorithm with a combination of P&O and FLC algorithms. This algorithm uses simple features available in both P&O and FLC which contribute to a reduction of complexity in its operation without compromising a high-performance target. A wide range of irradiance level has been considered which contribute to the uniqueness of this work especially during operation at low irradiance. Analysis in steady-state operation has widely been used before, and through additional analysis with the dynamic operation, more comprehensive results and findings could be obtained for further assessment. The proposed algorithm has been demonstrated, and comparative evaluation has been carried out with conventional P&O and FLC to obtain results that verify its better performance. Steady-state and dynamic simulation work confirm the best performance of adaptive P&O-fuzzy MPPT algorithm to achieve high MPP ratio with low oscillation and overshoot, which contributes to high stability operation.

2.4 "Design of PR Current Control with Selective Harmonic Compensators using Matlab" Daniel Zammit, Cyril Spiteri Staines, Maurice Apap, John Licari., JESIT – 2017.

This paper presents a procedure to design a Proportional Resonant (PR) current control with additional selective harmonic compensators for Grid-Connected Photovoltaic (PV) Inverters. A 3kW grid-connected PV inverter was designed and built for this research. This paper covered the design of the PR control and also the design of the selective harmonic compensators for the 3rd, 5th, and 7th harmonics. Results from simulations and experimental analysis of the inverter with PR current control and harmonic compensation were presented. Both simulation and experimental results showed the effectiveness of the harmonic compensators to reduce the harmonics in the grid current. The 3rd, 5th, and 7th harmonics in the grid current were reduced from about 5.574%, 4.231%, and 2.435%, respectively, to about 0.378%, 0.641%, and 0.24%, respectively. This reduction in harmonics made the grid-connected inverter compliant with the standard regulations.

This paper presented a procedure to design a Proportional Resonant (PR) current control with additional selective harmonic compensators for Grid-Connected Photovoltaic (PV) Inverters. A 3kW grid-connected PV inverter was designed and built for this research. This paper covered the design of the PR control and also the design of the selective harmonic compensators for the 3rd, 5th, and 7th harmonics. Results from simulations and experimental analysis of the inverter with PR current control and harmonic compensation were presented. Both simulation and experimental results showed the effectiveness of the harmonic compensators to reduce the harmonics in the grid current. The 3rd, 5th, and 7th harmonics in the grid

current were reduced from about 5.574%, 4.231%, and 2.435%, respectively, to about 0.378%, 0.641%, and 0.24%, respectively. This reduction in harmonics made the grid-connected inverter compliant with the standard regulations.

2.5"Design and control of Proportional Resonant Controller-Based Photovoltaic Power Conditioning" Hanju Cha, Trung-Kien Vu, Jae-Eno Kim., IEEE – 2009.

This paper presents a current control technique for a single-phase grid-connected DC/AC inverter which is used in a Photovoltaic power conditioning system (PV PCS). A Proportional – Resonant (PR) controller is used for replacing the conventional Proportional – Integral (PI) controller in this system. By comparison with the conventional PI control method, the PR control can introduce an infinite gain at the fundamental frequency and hence can achieve zero steady-state error. A theoretical analysis of the PR controller is presented and verified by experiment. Furthermore, a pseudo synchronous d-q transformation is employed in the current control scheme and an all-pass filter-based single-phase digital phase-locked loop (PLL) is introduced to detect the phase of grid voltage. Based on the theoretical analysis, the control strategy is implemented on a 32- bit fixed-point TMS320F2812 DSP and tested in a 3kW prototype PV PCS. Simulation and experimental verify the high performance of the implemented control scheme. In this paper, a current-based control scheme has been presented for a single-phase grid-connected DC/AC inverter in PV PCS with the PR controller. The modulation and control strategy is simulated by using Matlab/Simulink and implemented by using the 32-bit fixed-point DSP TMS320F2812. The theoretical analysis has been performed to enable a single-phase grid-connected DC/AC inverter system to achieve high performance and experimental results of a 3kW PV PCS prototype have verified the performance of the system. Simulation and experimental results show that the PR controller can overcome drawbacks of PI controller: inability to track a sinusoidal reference with zero steady-state error and poor disturbance rejection capability.

III.CONCLUSION

In this paper, fuzzy logic controller-based P&O MPPT and voltage control scheme and PR controller-based voltage and current control scheme are implemented for high step-up DC-DC boost converter fed single-phase transformerless inverter. Based on the investigations following points are concluded. The FLC in the boost converter side has low oscillation and settling time, low in overshoot, zero steady-state error, and P&O MPPT have high efficiency at changes in temperature and irradiance. The PR controller is inverter side so the results show zero steady-state error in sinusoidal quantity and low in this. In the proposed system a stable DC voltage is supplied to the inverter through the Boost converter by FLC and a controlled AC output voltage is obtained by adjusting Sinusoidal Pulse Width Modulation through the PR controller. The Unipolar SPWM technique improves the quality of output voltage, current, and power.

REFERENCES

[1]. Jinia Roy, Yinglai Xia, RajapandianAyyanar, 'High Step-up Transformer-less Inverter for AC Module Applications with Active Power Decoupling'.

[2]. Muhammad AmmirrulAtiqiMohdZainuri, MohdAmranMohdRadzi, Azura Che Soh, Nasrudin Abd Rahim, 'Development of adaptive perturb and observe-fuzzy control maximum power point tracking for photovoltaic boost dc–dc converter'.

[3]. Lotfifarah, Amir hussain, AbdelfatehKerrouche, CosimoIeracitano, Jamil Ahmad, Mufti Mahmud, "A Highly-Efficient Fuzzy-Based Controller with High Reduction Inputs and Membership Functions for A Grid-Connected Photovoltaic System".

[4]. Daniel Zammit, Cyril Spiteri Staines, Maurice Apap, John Licari, "Design of PR Current Control with Selective Harmonic Compensators using MATLAB".

[5]. Hanju Cha, Trung-Kien Vu, Jae-Eon Kim, "Design and Control of Proportional-Resonant Controller Based Photovoltaic Power Conditioning System".

[6]. S. H. Lee, W. J. Cha, J. M. Kwon, and B. H. Kwon, 'Control strategy of flyback microinverter with hybrid mode for PV ac modules,' vol. 63, no. 2, pp. 995–1002, Feb 2016.

[7]. J. Ahmed and Z. Salam, 'A Modified P&O Maximum Power Point Tracking Method with Reduced Steady State Oscillation and Improved Tracking Efficiency', IEEE Transactions on Sustainable Energy, vol. 7, no. 4, pp. 1506-1515, 2016.

[8]. H.T. Yau, C.H. Wu 'Comparison of extremum-seeking control techniques for maximum power point tracking in photovoltaic systems', Energies, vol. 4, pp. 2180-2195, 2011.

[9]. C. Li, Y. Chen, D. Zhou, J. Liu, J. Zeng, 'A High-Performance Adaptive Incremental Conductance MPPT Algorithm for Photovoltaic Systems', Energies, vol. 9, no. 4, pp. 288, 2016.
[10]. H. Rezk, M. Aly, M. Al-Dhaifallah, and M. Shoyama, 'Design and hardware implementation of new adaptive fuzzy logic-based MPPT control method for photovoltaic applications', IEEE Access, vol. 7, pp. 106427–106438, 2019.
[11]. V. R. Kota and M. N. Bhukya, 'A novel global MPP tracking scheme based on shading pattern identification using artificial neural networks for photovoltaic power generation during partial shaded condition', IET Renew. Power Gener., vol. 13, no. 10, pp. 1647–1659, Jul. 2019.
[12]. W.-M. Lin, C.-M. Hong, and C.-H. Chen, 'Neural-network-based MPPT control of a stand-alone hybrid power generation system', IEEE Trans. Power Electron., vol. 26, Dec. 2011.
[13]. J. Roy and R. Ayyanar, 'Sensor-less current sharing over wide operating range for extended-duty-ratio boost converter', IEEE Transactions on Power Electronics, vol. 32, Nov 2017.
[14]. Kotsopoulos, J. L. Duart, M.A.M Hendrix, "A predictive control scheme for DC voltage and AC current in grid-connected photovoltaic inverters with minimum DC link capacitance", in the 27th annual Conference of the IEEE Industrial Electronics Society, vol.3, pp. 1994- 1999, 2001.
[15]. D. G. Holmes and D. A. Martin, "Implementation of a direct digital predictive current controller for single and three phase voltage source inverters", in Proc. 1996 IEEE IAS Annu. Meeting, pp. 906–913.
[16]. R. D. Lorenz, T. A. Lipo, and D. W. Novotny, "Motion control with induction motors", in Proc. 1994 IEEE, vol. 82, iss. 8, pp. 1215-1240.
[17]. Cha, Hanju, Lee, Sanghoey, "Design and Implementation of Photovoltaic Power Conditioning System Using a Current Based Maximum Power Point Tracking", in Industry Application Society Annual Meeting, pp. 1-5, Oct. 2008.
[18]. Guo Xiaoqiang, Zhao Qinglin and Wu Weiyang 'A Single-Phase Grid Connected Inverter System with Zero Steady-State Error', in CES/IEEE 5th International Power Electronics and Motion Control Conference, 2006, vol. 1, pp. 1-5, Aug. 2006.
[19]. Zmood, D.N.; Holmes, D.G.; Bode, G., "Frequency domain analysis of three phase linear current controllers", in Industry Applications Conference and Thirty-Fourth IAS Annual Meeting Conference Record of the 1999 IEEE, vol. 2, pp. 818-825.
[20]. R. Teodorescu; F. Blaabjerg; M. Liserre and P.C. Loh "Proportional-resonant controllers and filters for grid-connected voltage-source converters", in IEE Proceedings - Electric Power Applications, vol. 153, iss. 5, pp. 750-762, 2006.
[21]. M. Liserre, R. Teodorescu, Z. Chen, "Grid Converters and their Control in Distributed Power Generation Systems", IECON 2005 Tutorial, 2005.
[22]. M. Ciobotaru, R. Teodorescu, F. Blaabjerg, "Control of a Single-Phase PV Inverter", EPE2005, Dresden, 2005.
[23]. C.B. Salah, M. Ouali, "Comparison of fuzzy logic and neural network in maximum power point tracker for PV systems," Electr. Power Syst. Res., vol. 81, no. 1, pages 43-50, 2011.
[24]. L. Chun-Liang, C. Jing-Hsiao, L. Yi-Hua, and Y. Zong-Zhen, "An Asymmetrical Fuzzy-Logic-Control-Based MPPT Algorithm for Photovoltaic Systems," Energies, vol. 7, pp. 2177-2193, 2014.
[25]. X. Tang and G. Wei, "Multiple Attribute Decision-Making with Dual Hesitant Pythagorean Fuzzy Information," CognComput, vol. 11, no. 2, pp. 193-211, 2019.