Sliding Mode Control and Fuzzy With MPPT Control Based PV Integrated Grid System

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Abstract: In this paper, the photovoltaic (PV) system based energy generation with grid integration of inverter and DC-DC boost converter. To enhance the system transient response and track the PV voltage in the load perturbations, the sliding mode controller (SMC) is implemented. The power conversion of DC-DC is accomplished using the converter controlled using the fuzzy logic controller with the MPPT control system. The proposed system increases the grid system stability, and it is achieving the quick settling time in power converter output, which means DC link voltage improvement. The results are achieved using the MATLAB/Simulink, and the obtained results are verified successfully.

Keywords: Inverter, SMC, Fuzzy with MPPT controller, PV system, DC-DC converter.

1. Introduction

The PV systems are mostly used due to economic feasibility. The essential purpose of generating electricity from the PV array is to avoid the disadvantages of solar energy, reducing low efficiency and harmonics. Generations of pollution-free energy sources are currently one of the biggest obstacles for user-friendly system engineers and scientists [1-4]. The distribution generation (DG) - the distribution level of integrated renewable sources - is challenging because of environmental contamination and global warming. The production of electrical energy is increasing based on renewable energy sources. Normally, the system using alternate energy sources and system development is improved because the energy sources of traditional depletion focus on the greenhouse effect [5-8].

Solar energy is one of the key sources of green energy because it is free of emissions, pure, limitless and plentiful. Solar power has gained tremendous interest across the globe, and one of its key duties is to produce as much solar power as possible in varying weather conditions. In the current applications of electric power, solar photovoltaic technologies are growing aggressively due to rapid development in the relative semiconductor and power electronics industries [9-12]. The global energy system is now built on non-renewable fossil fuels, led by ever more influential global energy depletion and environmental degradation. With the highest levels of all, energy demand is rising worldwide electricity used. As a result of socio-economic prosperity, society faces a huge challenge of never-
ending the rise of energy demand. Researchers’ continuing activities have been illustrated by improved conversion and transportation efficiency of these energy sources. They are also an enticing alternative to traditional solutions [13-15].

The grid’s essential role is to provide power to both local electrical loads and the distribution grid system. Results from the grid can operate with utility grid interface or stand-alone condition. Based on the power flow model and characteristics in the distribution line, the grids are classified into a hybrid system, DC system, and AC system.

The control technique corrects the power factor. It improves and maintains the voltage from the generation unit to the utility grid, which connects with the inverter system. The control system improves the robustness of the system and dynamic response. Conventionally, the predictive model controller has to regulate the inverter current and is increased the total harmonic distortion compared to sliding mode controller. The grid-connected power converter has transferred the power between source and load using the bidirectional converter.

2. Proposed System

The PV system-based grid integration system is controlled to improve the PV-connected grid system’s response and performance in the proposed system as shown in fig. 1. The power conversion of DC-DC is accomplished using the converter controlled using the fuzzy logic controller with the MPPT control system. The PV voltage regulation is achieved by the control of fuzzy with the MPPT control system. The proposed system increases the grid system stability, and it is achieving the quick settling time in power converter output, which means DC link voltage improvement.

![Fig 1: Proposed System Block Diagram](image1)

3. PV System

The solar system generates a DC supply for the boost converter fed grid system using sliding mode controller (SMC). As shown in fig. 2. Single diode PV module is proposed to generate power from the solar irradiation. The resistors are connected in series and parallel with diode using current source.

![Fig 2: PV Single Diode Model](image2)
4. **Fuzzy Logic Controller**

In the proposed system, the fuzzy logic controller is proposed to control the conversion of DC-DC boost converter, which is increasing the supply voltage DC. In this proposed 3*3 rules-based fuzzy logic system in this system. Input data is transformed into acceptable linguistic values by fuzzification, i.e. turn crisp information into linguistic symbols defined in useless collections. The functions of Membership are triangular, trapezoidal. Mainly Mamdani and Sugeno are two fuzzification processes. The plot of input error and output membership attributes are shown in fig. 3 respectively.

![Fuzzy logic converter-based diagram](image)

**Fig 3:** Fuzzy logic converter-based diagram

5. **Sliding Mode Controller (SMC)**

The boost converter's sliding mode controller interfaced with the grid system eliminates overall harmonic distortion in the reverse current. The input error is considered, and the inverter output and reference voltage difference are calculated.

![Control of sliding mode controller](image)

**Fig 4:** Control of sliding mode controller

The sliding mode controller block diagram is illustrated in Figure 4. The sliding mode controllers have to reduce the continuous state error because the converter has kept the frequency stable. The controller enhances the robustness and ability to reduce system order and on semiconductors off the power.

6. **Simulation And Results**

The PV integrated grid system, as in fig. 5, is controlled, and the unbalanced voltages are controlled as well as the stability improvement. The boost converter's output voltage is fed to the three-phase inverter, which the proposed sliding mode controller controls. PV system is generating 12V, as shown in fig. 6. The converter provides power supply to the inverter, as shown in fig. 7, around 82V. The PV integrated grid system voltage and current is shown in fig. 8.
Fig 5: Simulink Model of Proposed System

Fig 6: PV input voltage

Fig 7: DC link voltage
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7. Conclusion
In this paper, the power from the PV source is extracted using power DC-DC boost converter which regulated by the PV based MPPT control of incremental and conductance with the fuzzy logic controller. The DC bus voltage is regulated too, and it is fed to a grid-connected system. The sliding mode controller is used to control the proposed method, and it controls the grid side feeder current. The conversion ratio of the converter is high as compared with the conventional systems. The power extraction from the solar system providing controlled voltage to the grid system is implemented, and the obtained results are verified successfully.

References
[1] Wang, Z., Wu, W., & Zhang, B. (2016). A distributed quasi-newton method for droop-free primary frequency control in autonomous microgrids. IEEE Transactions on Smart Grid, 9(3), 2214-2223.
[2] Varma, R. K., & Salehi, R. (2017). SSR mitigation with a new control of PV solar farm as STATCOM (PV-STATCOM). IEEE Transactions on Sustainable Energy, 8(4), 1473-1483.
[3] Manie, N., & Pattanaik, B. (2019). Zeta DC-DC converter based on MPPT technique for BLDC application. International Journal of MC Square Scientific Research, 11(2), 1-12.
[4] Ramaprabha, R., Balaji, K., Raj, S. B., & Logeshwaran, V. D. (2013). Comparison of interleaved boost converter configurations for solar photovoltaic system interface. The Journal of Engineering Research [TJER], 10(2), 87-98.
[5] Kivimäki, J., Kolesnik, S., Sitbon, M., Suntio, T., & Kuperman, A. (2017). Design guidelines for multiloop perturbative maximum power point tracking algorithms. IEEE Transactions on Power Electronics, 33(2), 1284-1293.
[6] Huang, Y., Xiong, S., Tan, S. C., & Hui, S. Y. (2017). Nonisolated harmonics-boosted resonant DC/DC converter with high-step-up gain. IEEE Transactions on Power Electronics, 33(9), 7770-7781.
[7] Wang, S., Janabi, A., & Wang, B. (2020, October). Generalized Optimal SVPWM for the Switched-Capacitor Voltage Boost Converter. In 2020 IEEE Energy Conversion Congress and Exposition (ECCE) (pp. 2708-2711). IEEE.
[8] Gibbons M. S., Gilbert C. L., Deshpande M. S. (2019 May2). inventors; Lear Corp, assignee. Methodology of maximizing charging power transfer for electric vehicle when ac voltage sags. United States patent application US 15/801,772.
[9] Anitha, S., Keerthana, A., Kaviya, S. and JayaRajan, R., 2017. QUADRIPLEGIC AMBULATING ADDENDUM. *International Journal of MC Square Scientific Research*, 9(2), pp.15-23.

[10] Anjana, R. (2019, Feb). Fuzzy and PI Based Speed Control of BLDC Motor using Bidirectional Converter for Electric Vehicle Application. *Trends in Electrical Engineering*, 8(3), 35-45.

[11] Yadav, D., Parekh, U., Patel, K., Parmar, R., & Prakash, M. (2019). Application of Modified Three Phase Conduction Method to Minimize Torque Ripple in BLDC Motor. *IJRAR*, vol. 6(1), 155-156.

[12] Rajkumar, S., Sundaram, C. S., Sedhuraman, K., & Muruganandhan, D. (2019, March). Performance Analysis of Hub BLDC Motor Using Finite Element Analysis. In 2019 *ICSCAN*, (pp. 1-5). IEEE.

[13] Gibbons, M. S., Gilbert, C. L., & Deshpande, M. S. (2019). *U.S. Patent Application No. 15/801,772*.

[14] Nasiriani, K., & Pasandi, M. (2020). Dynamic Voltage Restorer (DVR) For Protecting Hybrid Grids. *arXiv preprint arXiv:2006.16452*.

[15] Pal, R., & Gupta, S. (2020). Topologies and Control Strategies Implicated in Dynamic Voltage Restorer (DVR) for Power Quality Improvement. *Iranian Journal of Science and Technology, Transactions of Electrical Engineering*, 44(2), 581-603.