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Photovoltaic Based Three Port Converter with SVPWM for Smart Grid Applications

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Abstract - This paper gives the idea to develop the Hybrid charging for three port converter (TPC) power flow control is implemented with Photovoltaic (PV) charging and storage system. In order to optimize the battery charging performance, three charging strategies, including: the Sun domain (SD), battery charging domain (BCD) and battery discharging domain (BDD) are adopted. Traditionally, in order to realize these charging strategies, the PV charger should abandon the Maximum Power Point Tracking (MPPT) function to maintain the power flow balance and the output power of the PV array will be decreased. Therefore, TPC power flow control strategies are proposed to achieve the maximum PV power utilization as well as to realize the hybrid charging methods. In addition, with the proposed strategies, the TPC charging/discharging capability of the battery is able to achieve the maximum PV power utilization. All the strategies can be realized by the control unit without adding additional circuit, component and communication mechanism. Simulation model shows the performance and feasibility of the proposed strategies.

Index Terms -3 Port Converter, MPPT Algorithm, SVPWM and THD.

I. INTRODUCTION

Over the past few decades, renewable energy generation systems, electric vehicles, advanced consumer electronics and novel energy-saving technologies have been rapidly developed to deal with the fossil fuel usage and carbon dioxide emission issues. Because of the clean, sustainable and low-pollution features, the PV energy has been paid highly addressed. In order to achieve the maximum PV power utilization, the maximum power point tracking (MPPT) is an essential function for the PV power system. Several MPPT algorithms, such as the perturbation and observation (P&O) method and the incremental conductance (INC) method have been widely adopted. Besides, a dc-dc converter with the space vector pulse-width-modulation (PWM) technique should be connected to the PV array to realize the MPPT. In addition, the battery module is a necessary component for the energy storage in PV power systems. In order to charge the battery from the PV array, the dc-dc converter should act as a PV charger. In the meantime, to ensure the maximum PV power harvesting, the MPPT is also an essential function for the PV charger.

Traditionally, the constant-current constant-voltage (CC-CV) charging method is adopted for the battery charger. Because of the simple control and the fast charging features, the CC-CV has become one of the most commonly used charging methods. Unfortunately, the continuous charging current might cause the over-heat phenomenon. As a result, the electrode plates might be damaged, whereas the battery life will be shorten.

In order to overcome this issue, the pulse-ripple-current charging (PRC) and the sinusoidal-ripple-current charging (SRC) technologies were developed. For the PRC charging, there will be only positive charging current and zero charging in one pulse charging cycle.

Three-phase grid-tied inverter integrated with the bidirectional power control capability is proposed in this paper. In order to enhance the battery charging performance, hybrid charging strategies are considered and developed. Aims of this paper can be summarized as follows: Achieve the maximum PV power utilization under different charging methods, realize hybrid charging methods for the battery and Propose bidirectional power flow control strategies for the three-phase grid-tied inverter. Detailed circuit operations, theoretical analysis and

mathematical derivations of the proposed strategies will be presented. Finally, experimental results obtained from a 5kW prototype circuit verify the performance of the proposed control strategy.

Md. Sazib Mollik, and S M Sajjad Hossain Rafin, (2023) proposed a DC to DC Converter is used between the PV modules which indicates the improved closed loop performance with less overshoot [1]. Tole Sutikno and Hendril Satrian Purnama (2022) investigated the modernization of various distinct DC-DC converter topologies for solar photovoltaic energy harvesting systems [2]. B.V. Rajanna (2022) Solar PV system with MPPT with conditions of DC Voltage in an unbalanced situation of a NPC inverter can generate the required AC voltage accurately using the modulation method of three-level vector [3]. Jiangfeng Wang and Cheng Xue 2021 proposed a multiport dc–ac converter (MPC) with differential power processing dc–dc converter to smoothen the power supply from PV systems [4]. Jiangfeng Wang and Kai Sun (2021) A dual-dc-port dc–ac converter with virtual space vector pulse width modulation for flexible power control [5]. Jiangfeng Wang, Kai Sun (2021) has integrated a multi-port dc-ac converter (MPC) with differential power processing dc-dc converter (DPPC) to regulate the active power of PV [6]. Vitor Monteiro and Tiago J. C. Sousa has presents a review about front-end converters for renewable-energy applications [7]. C. Bharatiraja, and K. Lakshmikhandan (2020) proposes the PV Power system with single switch non-isolated high-gain DC to DC converter and reduced switch seven-level MLI inverter. [8]. Shuo Liu, Ying Gao., This paper presents a non-isolated three-port switching boost converter and applies it to photovoltaic systems to expand the three port converter working range [9]. Yuvaraja Teekaraman and Ramya Kuppusamy (2019) implemented The intelligent controller for stabilizing a smart grid is developed by implementing a fuzzy-built advance control configuration to achieve a faster dynamic response [10].

In this proposed article a new mitigating solution for Three Phase Maximum Power Point Tracking of PV system with grid connected SVPWM is proposed in this project. By doing so, the output current can be effectively reduced due to the distribution of the frequency spectrum with less THD when compared to existing system.

This paper begins with the introduction in Topic I. Topic II briefs about the block diagram and work of the proposed system. Topic III discuss about proposed system Simulation Diagram and work, In Topic IV, the simulation results are discussed briefly. Topic V dicuss about conclusion & advantages of proposed system. Finally, it is concluded in the topic VI.

II. PROPOSED SYSTEM

A new mitigating solution for Three Phase Maximum Power Point Tracking of PV system with grid connected SVPWM is proposed in this project. By doing so, the output current can be effectively reduced due to the distribution of the frequency spectrum with less THD when compared to existing system. The frequency spectrum of the output current can be smoothening and the amplitude of the dominant inter harmonics can be significantly reduced by controlling gating pulse sequence. One solution to reduce the dominant inter harmonics in the output current is by employing a different PWM technique, in our proposed system we used space vector as pulse width modulation methodology. The proposed method randomly switches the operation using space vector pulse width modulation technique. By doing so, the inter harmonics in the output current can be effectively reduced due to the distribution of the frequency spectrum. With the proposed SVPWM implementation, the system performance of the proposed mitigating solution can be maintained close to the conventional method. The performance of the proposed method has been validated using Simulink model and its THD and efficiency is improved.

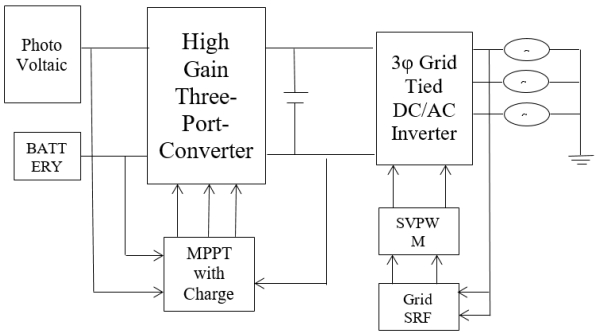

Figure.1 Block Diagram of Proposed System

III. PROPOSED SYSTEM SIMULATION DIAGRAM AND WORK

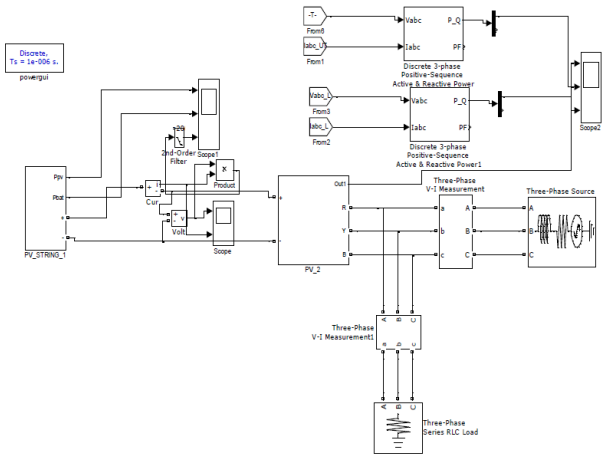

Figure.2 Simulation Diagram of PV based three port converter with SVPWM technique for smart grid applications.

Photo voltaic array is an arrangement which consists of extra photo voltaic cells to change sunlight into electrical energy. In the proposed integrated magnetic three port converter, photo voltaic array with a DC-DC converter is connected with a battery function and this combination is

connected to the load. Three- port DC/DC converter in renewable applications should be able to handle both the renewable source that is PV array and battery port; the renewable sources are not regular in nature it depends on climatic conditions, temperature and irradiance. Hence battery port is used; its utility period of life should be taken into consideration. Three-port DC/DC converters in this report are, one port is for PV array, the second port is for battery and finally the output port. Power may be obtained from both input voltages simultaneously or each one independently that is single stage power conversion between any two of the three ports can be accomplished. Battery port is used whenever it is required; this results in an increase the lifetime of battery. Also when the solar power is not available for example during night, the system automatically takes energy from battery port without any change, only when the MPPT optimize the renewable source.

IV.SIMULATION RESULTS OF PROPOSED SYSTEM

The power management of power converter is required in order to meet output power. Three-Port DC/DC converter is best for standalone PV system applications. IMPTC has advantages of less component count, lower cost higher reliability and fewer conversion stages. Due to considerable advantages of the IMPTC, a variety of topologies have been proposed in different fields, like hybrid electric vehicles. PV system with battery backup.

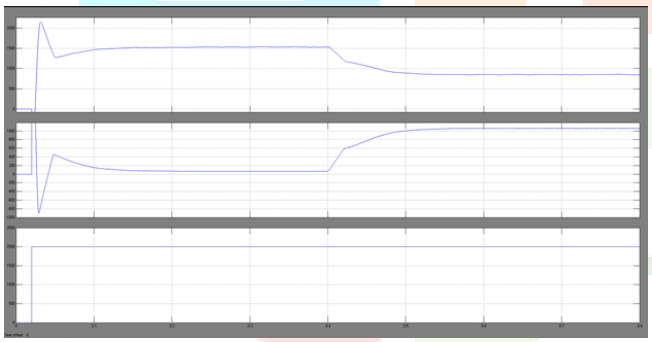

Figure.3 Output Waveform of Existing Inverter Power/Grid Power/Load Power

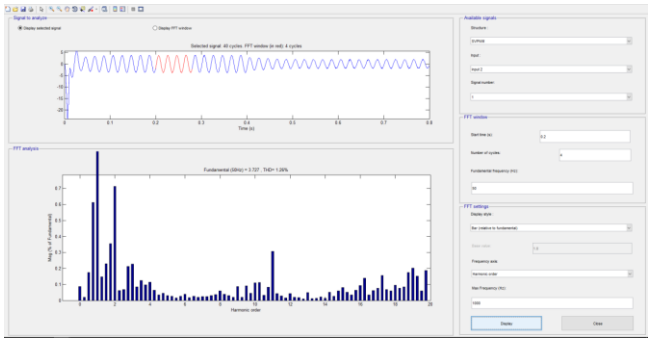

Figure.4 Output waveform of Proposed THD =1.26%

In this paper, a non-isolated integrated magnetic three port DC/DC topology and control method have been proposed for interfacing a PV port, a battery port, and a load port simultaneously. The working principle of the proposed converter has been analyzed and the DC voltage relationship among the three ports has been given. Also, the proposed converter's single module and paralleling control methods have been proposed. According to the PV generation power, load power demand and battery management command and efficiency of the power system can work in both MPPT mode and conductance mode, and the transition between these two modes is autonomous. Finally, Lamp load simulation results are validated and this proposed converter has exhibiting high dynamic response, low output impedance, and a high phase stability margin. SVPWM scheme is proposed based on power relations among three-ports. All three modes are simulated using MATLAB/SIMULINK environment. The proposed topology can be applied in the scenario of aerospace, renewable power system and so on. Figure.3 & 4 illustrates the fast Fourier transform (FFT) analyzes to the current that flows in the PV- MPPT Grid Connected Inverter without SVPWM and with SVPWM, in that Figure 6.13 THD is 4.66 % for PV- MPPT Grid Connected Inverter without SVPWM and in Figure 6.19 THD is 1.26 % for PV- MPPT Grid Connected Inverter with SVPWM. The results of the newly introduced technique's efficiency & THD are better compared to the available technique explained in this research work.

V.CONCLUSION

This project has presented a non-isolated three-port DC-DC converter system, based on an improved integrated magnetic topology. The converter can provide a high step-up capability for power conversion systems including the battery storage, and the non-isolated load consumption. Three operating modes are analyzed and have shown the effective operation of the proposed topology for various applications. From simulation results, it can be seen that the output voltage and can be controlled independently by the phase angle shift and SVPWM, respectively. The integrated control approach is a simple but effective way to achieve the regulation of output voltage, input voltage and battery voltage, which is important for systems. The proposed technology is capable of achieving high gain, high conversion ratio and multiple operating modes whist still making the converter relatively simple, good battery management, maintain good bus voltage regulation and power management. The results of simulation indicate that performance and satisfaction of the work goals are achieved. The performance of the proposed method has been validated using simulink model with SVPWM technique and it is compared without SVPWM model (e.g., THD and efficiency improvement). At last, the proposed system THD of the overall system performance is better when compared to the existing system.

ADVANTAGES OF PROPOSED SYSTEM

- Increases the tracking performance of the MPPT algorithm.
- Increases the MPPT efficiency and thus the PV energy yield, especially during changing environmental conditions.
- Overall System Performance improved.
- Overall Stability improved.
- Overall Efficiency of the system improved.
- Overall THD is improved.

V. REFERENCES

[1] Wu, H.; Wang, J.; Liu, T.; Yang, T.; Xing, Y. Modified SVPWM Controlled Three-Port Three-Phase AC-DC Converters with Reduced Power Conversion Stages for Wide Voltage Range Applications. IEEE Trans. Power Electron. **2017**, 33, 6672–6686.

[2] Faraji, R.; Farzanehfard, H. Soft-switched Non-Isolated High Step-up Three-port DC-DC converter for Hybrid Energy Systems. IEEE Trans. Power Electron. **2018**, 33, 10101–10111.

[3] Bayat, P., and Baghramian, A. (2020). Partly isolated three-port DC-DC converter based on impedance network. IET Power Electron. 13, 2175–2193. doi:10.1049/iet-pel.2019.1348

[4] Bhaskar, M. S., Ramachandaramurthy, V. K., Padmanaban, S., Blaabjerg, F., Ionel, D. M., Mitolo, M., et al. (2020). Survey of DC-DC non-isolated topologies for unidirectional power flow in fuel cell vehicles. IEEE Access 8, 178130–178166. doi:10.1109/ACCESS.2020.3027041

[5] Chandrasekar, B., Nallaperumal, C., Padmanaban, S., Bhaskar, M. S., Holm-Nielsen, J. B., Leonowicz, Z., et al. (2020). Non-isolated high-gain triple port DC-DC buck-boost converter with positive output voltage for photovoltaic applications. IEEE Access 8113649–113666Zdoi:10.1109/ACCESS.2020.3003192

[6] E. B. Ssekulima and A. A. Hinai, "Coordinated voltage control of solar PV with MPPT and battery storage in grid-connected and microgrid modes," 2016 18th Mediterranean Electro technical Conference (MELECON), Lemesos, pp.1-6, 2016.

[7] N.Kebir and M. Maaroufi, "Decision-support model for battery energy storage system inclusion in grid-connected PV systems for medium voltage applications," 2016 IEEE International Conference on Renewable Energy Research and Applications, Birmingham, pp. 897- 902, 2016.

[8] N. R. Tummuru, M. K. Mishra and S. Srinivas, "Dynamic Energy Management of Hybrid Energy Storage System with High-Gain PV Converter," in IEEE Transactions on Energy Conversion, Vol. 30, No. 1, pp. 150-160, March 2015.

[9] Chen, Z. (2014). "Three-port ZVS converter with PWM plus secondary-side phase-shifted for photovoltaic-storage hybrid systems," in Conference Proceedings - IEEE applied power electronics conference and exposition - APEC (Fort Worth, TX: Institute of Electrical and Electronics EngineersInc.), 3066–3071. doi:10.1109/APEC.2014.6803742.

[10] Chen, Z., Wu, Q., Li, M., Xu, Y., and Wang, Q. (2015). "A three-port DC-DC converter with low frequency current ripple reduction technique," in Conference Proceedings - IEEE applied.

[11] Ding, S., Wu, H., Xing, Y., Fang, Y., and Ma, X. (2013). "Topology and control of a family of non-isolated three-port DC-DC converters with a bidirectional cell," in Conference Proceedings - IEEE applied power electronics conference and exposition APEC,10891094 .doi:10.1109/APEC.2013.6520435.

[12] Falcones, S., and Ayyanar, R. (2010). "Simple control design for a three-port DC-DC converter based PV system with energy storage," in Conference Proceedings - IEEE applied power electronics conference and exposition - APEC, 2149–2153. doi:10.1109/APEC.2010.5433534.

[13] Faraji, R., DIng, L., Rahimi, T., Kheshti, M., and Islam, M. R. (2021). Soft-switched three-port DC-DC converter with simple auxiliary circuit. IEEE Access 9, 66738–66750.doi:10.1109/ACCESS.2021.3076183.

[14] Hu, W., Wu, H., Xing, Y., and Sun, K. (2014). "A full-bridge three-port converter for renewable energy application," in Conference Proceedings-IEEE applied power electronics conference and exposition -APEC (Fort Worth, TX: Institute of Electrical and Electronics Engineers Inc.), 57–62. doi:10.1109/APEC.2014.680328.