International Journal of Engineering Applied Science and Management
ISSN (Online): 2582-6948
Vol. 3 Issue 8, August 2022

Harmonics Analysis between Maximum Boost Control of Diode-Assisted Buck–Boost Voltage-Source with SPWM and SVPWM

Alok Patel[1], Nitin Choudhary[2]
Research Scholar, Department of Electrical and Electronics KIST BHOPAL(MP)[1]
Assistant Professor Department of Electrical and Electronics KIST BHOPAL(MP)[2]

Abstract: *In This paper a diode assisted buck boost voltage source inverter is introduced with low voltage input source. The booster circuit is controlled by maximum boost control topology with minimum switching frequency. The inverter is controlled by sinusoidal PWM technique which is further updated with space vector PWM with digital control of the six switches in the inverter. A comparison of improvement in voltage value is taken with sinusoidal PWM and space vector PWM. The results analysis is carried out in MATLAB Simulink software with graphs generated with respect to time.*

Keywords: *Buck-Boost converter, PI controller, SPWM, SVPWM, Minimum switching frequency, closed loop control.*

1. Introduction

Given the efficiency and environmental benefits of emerging solar and fuel cell technology, the distributed generation systems based on the renewable energy sources have rapidly developed in recent years [1]– [3]. In photovoltaic (PV) systems,
it is difficult to realize a series connection of the PV cells without incurring a shadow effect [3]. Fuel cells and lightweight battery power supply systems are promising in future hybrid electric vehicle, more-electric aircraft and vessel. However, the obvious characteristic of these dc sources is low voltage supply with wide range voltage drop. Power electronic interface has to regulate the amplitude and frequency to obtain required high ac utility voltage. These applications raise stringent requirements for power converters such as low cost, high efficiency and wide range voltage buck–boost regulation ability. Traditional voltage-source inverter (VSI) can only perform buck voltage regulation.
Thus, various novel and improved dc–ac topologies with buck– boost capability as well as the related control methods have been proposed to solve the issues [4]–[9].Traditional two-stage VSI shown in Fig. 1 obtains the required output voltage by introducing dc–dc boost circuit in the front. In view of additional power conversion stage increasing cost and lowering efficiency, a family of Z-source inverter [4]–[6] introduces a unique impedance network between the dc source and the inverter bridge. It achieves the desired output voltage that is larger than the available dc source voltage by adopting shoot-through (ST) operation mode. Z-source inverter provides a potential cheap and single-stage power conversion. However, the ST state limits the modulation index and accompanies large ST current. Literature [7] makes comparison between traditional VSI and Z-source inverter based on electric vehicle driver system. The results reveal that Z-source inverter demonstrates low cost and high efficiency under relatively low voltage boost ratio range (1–2).

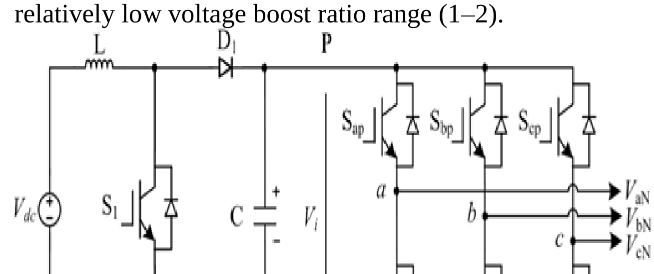

Figure 1 Conventional two-stage buck–boost VSI.

Although both of them can boost output voltage to any desired value without upper limitation in theory, the degradation of efficiency and increasing requirement of switching devices are prominent under high voltage gain.

International Journal of Engineering Applied Science and Management
ISSN (Online): 2582-6948
Vol. 3 Issue 8, August 2022

Literature [8] proposed diode-assisted buck–boost VSI and related modulation strategy. It extends voltage gain and avoids extreme boost duty ratio by introducing a switch-capacitor based high step-up dc–dc circuit between the dc source and inverter bridge. The diodes are naturally conducting to perform capacitive charging in parallel and discharging in series to achieve high voltage gain. In view of chopped intermediate dc-link voltage, the front boost circuit and inverter bridge needs coordinate control. The existing typical modulation strategy in [8] just utilizes intermediate dc-link voltage for ac output in the duration when the two capacitors are connected in series. Therefore, it has the drawback of relatively low dc-link voltage utilization. In order to increase voltage, gain as well as to reduce voltage stress of switching devices, Zhang and Liu [9] proposed the improved PWM strategy to further utilize the intermediate dc-link voltage for ac output in the duration.

2. Voltage Source Inverter

In order to interconnect the renewable sources (PVA) to the grid system a conversion is required to convert the DC to three phase AC. The three phase AC has to be in synchronization with the grid in parameters of voltage, frequency and phase. The VSI (Voltage source Inverter) is a three legged six IGBT switch inverter, where the DC side is connected to PVA and the three phase AC side connected to the grid through LC filter. The LC filter is connected to damp out the generated harmonics form the VSI avoiding the harmonics into the grid.

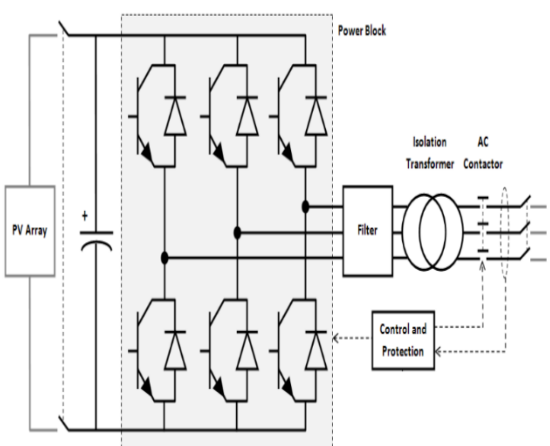

Figure 2 VSI connected to grid using RES

Any disruption in the switching of the VSI while connected to the grid system may also disrupt the grid voltage increasing the vulnerability of equipment connected to the system. It is very mandatory to maintain the switching of the VSI with optimal control techniques.

There are many control techniques that can control the VSI producing six pulses for each and every IGBT. The control techniques are

1) SRF (synchronous reference frame) theory
2) id iq theory
3) IRP (Instantaneous reactive power) theory

All the above techniques use different PWM techniques which can be

a) Sinusoidal PWM
b) Space Vector PWM
c) Hysteresis current loop control

The controller senses the voltages and currents at the source side and also the load side generating reference values for the generation of pulses to VSI. The grid system contain linear and non-linear loads, the effect of non-linear loads is higher than the linear loads. As the non-linear load works on DC an AC to DC converter is used with the help of power electronic switches. Load is only inductors or resistors, we do not have any capacitor loads. The total impedance of the load connected to the AC to DC converter introducing harmonics in the system creating a severe problem of PQ balancing. These load current harmonics caused by the power electronic devices can be compensated through the APF (Active Power Filter) with RES by injecting required active and reactive power. The compensation reduces emphasize on main source increasing the power factor and improving the power quality. The operational cost of the APF is very less as RES is interconnected for the compensation to the grid.

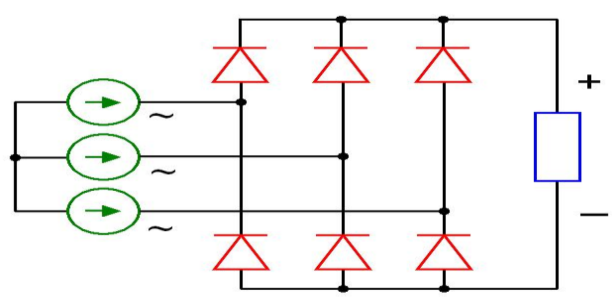

Figure 3 Rectifier of non-linear load

The main aim of grid system is to incorporate the renewable sources into the grid with maximum penetration and to replace the conventional sources with the renewable sources. The VSI should be controlled effectively using optimum control techniques with less conduction losses to utilize the power from the renewable sources and inject active power, with reactive power compensation and reduction of harmonics in the grid system. The load flow can be controlled by controlling the modulation index of the fundamental reference waveform of the VSI.

IJEASM
International Journal of Engineering Applied Science and Management
ISSN (Online): 2582-6948
Vol. 3 Issue 8, August 2022

3. Methodology

3.1 Proposed System

The proposed modified diode assisted buck –boost voltage source inverter consists of two stages. And gate pulse is providing by two different techniques. And we are comparing to between sinusoidal pule width modulation and space vector pulse width modulation techniques. Here conventional and proposed block diagram is shown in figure .4

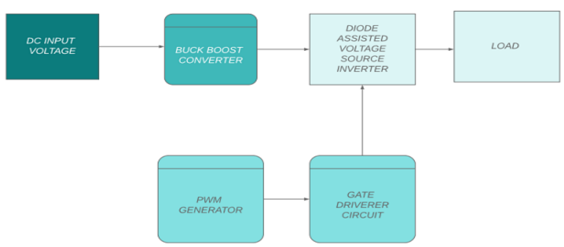

Figure 4. Block Diagram of Diode-Assisted Buck–Boost VSI

3.2 Diode Assisted Buck –Boost Converter

A new PWM strategy to achieve the instantaneous maximum utilization of intermediate dc-link voltage, as well as to reduce the switching frequency of power devices in diode-assisted buck–boost VSI. It extends voltage gain and avoids extreme boost duty ratio by introducing a switch-capacitor based high step-up dc–dc circuit between the dc source and inverter bridge. The diodes are naturally conducting to perform capacitive charging in parallel and discharging in series to achieve high voltage gain.

4. Simulation model and result analysis

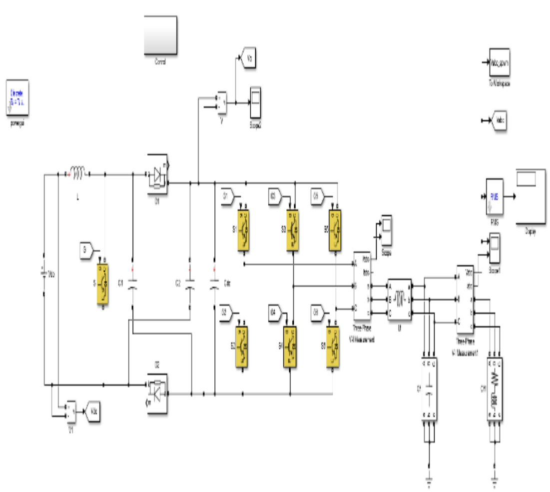

Figure 5 proposed circuit of Maximum Boost Control of Diode-Assisted Buck–Boost Voltage Source Inverter using capacitor

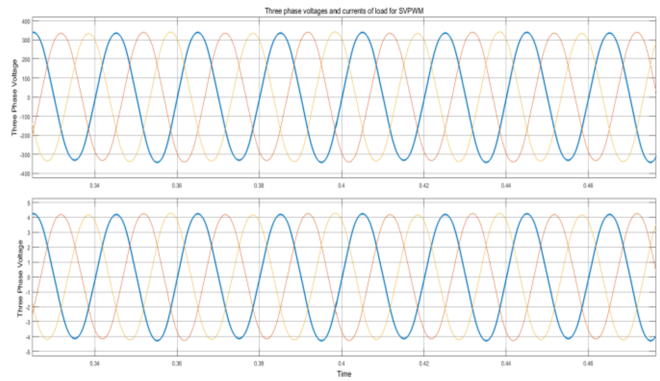

Figure 6 Three phase PWM voltage and current output of inverter for SVPWM

4.1 Harmonics Comparison between SPWM and SVPWM

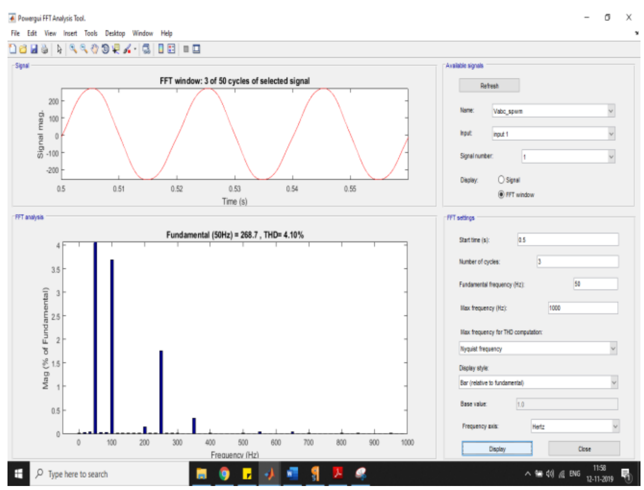

Figure 7 THD of phase voltage for SPWM

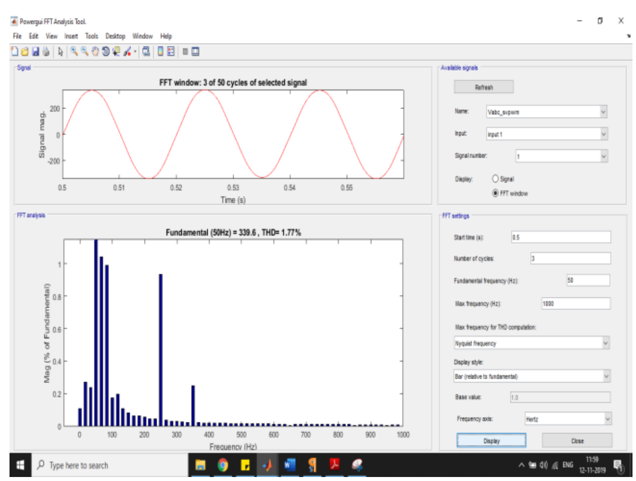

Figure 8 THD of phase voltage for SVPWM

The above are the harmonic analysis of the output voltage from the voltage source inverter with sinusoidal and space vector PWM techniques.

5. Conclusion

This paper by analysing the modulation principle of three-phase VSI and then proposes a new PWM strategy to achieve the instantaneous maximum utilization of intermediate dc-link voltage, as well as to reduce the switching frequency of power devices in diode-assisted buck–boost VSI. The voltage at 190V is considered as deficit to the load as the load needs 220-240Vrms to operate. Also, the THD of the sinusoidal PWM technique is recorded at 4.1% whereas the space vector PWM technique is recorded at 1.77%.

Reference

[1] J. Momoh, Renewable Energy and Storage. New York, NY, USA: Wiley, 2012.

[2] W. Li and X. He, "Review of nonisolated high-step-up DC/DC converters in photovoltaic grid-connected applications," IEEE Trans. Ind. Electron., vol. 58, no. 4, pp. 1239–1250, May 2011.

[3] Y.-P. Hsieh, J.-F. Chen, and L.-S. Yang, "A novel high step-up DC–DC converter for a microgrid system," IEEE Trans. Power Electron., vol. 26, no. 4, pp. 1127–1136, Apr. 2011.

[4] F. Z. Peng, "Z-source inverter," IEEE Trans. Ind. Appl., vol. 39, no. 2, pp. 504–510, Mar. 2003.

[5] Y. P. Siwakoti, F. Z. Peng, F. Blaabjerg, P. C. Loh, and G. E. Town, "Impedance source network for electric power conversion—Part I: A topological review," IEEE Trans. Power Electron., vol. 30, no. 2, pp. 699–716, Feb. 2015.

[6] Y. P. Siwakoti, F. Z. Peng, F. Blaabjerg, P. C. Loh, G. E. Town, and S. Yang, "Impedance-source networks for electric power conversion Part II: Review of control and modulation techniques," IEEE Trans. Power Electron., vol. 30, no. 4, pp. 1887–1906, Apr. 2015.

[7] M. Shen, J. Wang, and F. Z. Peng, "Comparison of traditional inverters and Z-source inverter for fuel cell vehicles," IEEE Trans. Power Electron., vol. 22, no. 4, pp. 1453–1463, Jul. 2007.

[8] F. Gao, P. C. Loh, and R. Teodorescu, "Diode-assisted buck–boost voltage-source inverters," IEEE Trans. Power Electron., vol. 24, no. 9, pp. 2057– 2064, Sep. 2009.

[9] Y. Zhang and J. Liu, "Improved pulse-width modulation of diode-assisted buck-boost voltage source inverter," IEEE Trans. Power Electron., vol. 28, no. 8, pp. 3675–3699, Aug. 2013.

[10] Y. Zhang, J. Liu, X. Ma, and J. Feng, "Operation modes analysis and limitation for diode-assisted buck-boost voltage source inverter with small voltage vector," IEEE Trans. Power Electron., vol. 29, no. 7, pp. 3525– 3536, Jul. 2014.

[11] M. Shen, J. Wang, and F. Z. Peng, "Constant boost control of the Z-source inverter to minimize current ripple and voltage stress," IEEE Trans. Ind. Appl., vol. 42, no. 3, pp. 770–778, Jun. 2006.

[12] F. Z. Peng, M. Shen, and Z. Qian, "Maximum boost control of the Z-source inverter," IEEE Trans. Power Electron., vol. 20, no. 4, pp. 833–838, Jul. 2005.

[13] Y. Tang, T. Wang, and Y. He, "A switched-capacitor-based active-network converter with high voltage gain," IEEE Trans. Power Electron., vol. 29, no. 6, pp. 2959–2968, Jun. 2014.

[14] S. Kwak and J.-C. Park, "Predictive control method with future zero-sequence voltage to reduce switching losses in three-phase voltage source inverters," IEEE Trans. Power Electron., vol. 30, no. 3, pp. 1558–1566, Mar. 2015.

[15] C. Charumit and V. Kinnares, "Discontinuous SVPWM techniques of three-leg VSI-fed balanced two-phase loads for reduced switching losses and current ripple," IEEE Trans. Power Electron., vol. 30, no. 4, pp. 2191–2204, Apr. 2015.

[16] D. Li, P. C. Loh, M. Zhu, F. Gao, and F. Blaabjerg, "Generalized multi cell switched-inductor and switched-capacitor Z-source inverters," IEEE Trans. Power Electron., vol. 28, no. 2, pp. 837–848, Feb. 2013.