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Comparison of single boost & ILBC multilevel inverter based stat-com system

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Abstract

STATCOM is one of the shunt type FACTS controllers which can supply reactive power and get better bus voltage. STATCOM, a regulating device used on alternating current communication networks, has compensation like transient free switching and smooth variation of reactive power. This paper deals with the comparison of individual -boost and ILBC controlled nine-level based STATCOM systems. Usually DC output from the PV source is amplified using an individual boost converter. The output of the single boost converter is applied to the multilevel inverter system. The ability of STATCOM to improve the receiving end voltage is analysed using the proposed interleaved boost converter. The performance of the inter leaved boost inductor boost multi-level STATCOM systems are compared with the single boost converter multi-level STATCOM systems in terms of THD and receiving end voltage. From the results it has been proved that much decrease in THD and improved receiving end voltages have been obtained by using interleaved boost converter based STATCOM system.

Keywords

Flexible Alternating Current Transmission System (FACTS); Static synchronous Compensator (STATCOM); Static VAR Compensator (SVC); Modular Multi-level Converters (MMC); Total Harmonic Distortion (THD); Photovoltaic cell (PV);single Boost Converter (SINGLE BOOST);Inter Leaved Boost Converter (ILBC)

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1. Introduction

Flexible Alternating Current Transmission Systems (FACTS) are being used lengthily in power system to improve the system utilization, power deportation quantity as well as the power quality of AC system interconnections [1, 2]. As a typical shunt FACTS device, Static Synchronous Compensator (STATCOM) is employed at the Point of Common Connection (PCC) to absorb or bring in the appropriate reactive power, through which the voltage quality of PCC is improved [3]. In recent years, more than many topologies have been enforced to the STATCOM. Amid these various types of topology, H-bridge cascaded STATCOM has been extensively recognized in high-power applications for the following abilities: fast response speed, small volume, far above the ground efficiency, minimal synergy with the supply grid and its individual phase control ability [4–7]. Compare with other types of converter H-bridge cascaded STATCOM can obtain a high numeral of levels more with no trouble and connected to the grid directly without using the bulky transformer. This empowers us to minimize cost and maximize the use of H-bridge cascaded STATCOM [8].

H-bridge cascaded STATCOM is a perplexing system with many H-bridge cells in each phase, so the voltage imbalance problems caused by different active power losses among the cells, various switching patterns for different cells, parameter variation of active and passive components inside cells will power the dependability of the system and even lead to the breakdown of the system. Hence, lots of researches have determined on seeking the solutions to these problems.

In terms of current loop control, recently used line of attack involves linear control method, in which the non-linear equations of the STATCOM model are linearized with a specific equilibrium. The most widely used linear control schemes are PI controllers [9, 10]. In [9], to regulate reactive power, only a simple PI controller is carried out. In [10], through a decoupled lured strategy, the PI controller is em-

ployed in a synchronous d-q frame. Be that as it may, it is elusive the reasonable parameters for planning the PI controller and the execution of the PI controller might degrade with the peripheral disturbance. Thus, a number of bright methods have been proposed to change the PI controller efficiency such as particle swarm optimization [11], neural networks [12], and artificial immunity [13]. In literature [14, 15], adaptive control and linear robust control have been reported for their anti-external disturbance ability. In literature [**?** **?**], a popular dead-beat current controller is used.

This control method has the highest bandwidth and the speedy current tracking reference. The steady-state performance of H-bridge cascaded STATCOM is improved, but the dynamic presentation is not improved. In [**?**], a DC injection removal method called IDCF is proposed to build an added closed loop for the DC component of the output current. It can develop the output current quality of STATCOM. However, the diagram configuration of the cascaded STATCOM is the delta configuration, but not the star configuration. Moreover, an adaptive theory-based improved linear sinusoidal tracer control method is proposed in [**?**] and a absorbent least mean rectangle-based lured methodology is expected in [**?**]. But By using the traditional linear control method, the controller is characterized by its simple control structure and parameter design convenience, but unfortunate dynamic control stability.

Other control approaches apply nonlinear control which directly compensates for the system nonlinearities without requiring a linear approximation. In [**?**], a transfer function linearization controller is designed. By adding a damping term, the oscillation amplitude of the internal dynamics can be effectively decreased. However, the stability cannot be guaranteed [**?**]. Then, many new modified damping controllers are designed to enhance the stability and performance of the internal dynamics [**?** **?** **?** **?**]. However, the implementation of these controllers is complex. To enhance robustness and make things easier the controller layout, a Passivity-Based Controller (PBC) based on fault dynamics is proposed for STATCOM [**?** **?** **?** **?**]. Furthermore, the exponential cohesion of system equilibrium point is guaranteed. Nevertheless, these methods are not designed on the basis of STATCOM with the H-bridge cascaded groundwork and no literature is verified experimentally.

In terms of DC voltage assessment control in capacitor, there are three most important issues: overall voltage stabilization clustered stabilizing control, and exact balancing control. In literature [**?**], under the guess of all DC capacitors being equally charged and balanced, they can only remove the imbalances caused by the inconsistent drive pulses without detecting all DC capacitor voltages. In [**?** **?** **?**], additional hardware circuits are required in the methods based on AC bus energy swap and DC bus energy exchange, which will maximize the cost and the complexity of the system. In [**?**], a method based on zero sequence voltage interjection is enhanced and it will increase the DC capacitor voltage endurance capacity. On the confliction, the methodology using negative-sequence current in [**?**] do not require the maximum mar-gin of DC capacitor voltage, but the action of STATCOM is minimized. In [8], the individual phase with active power cluster is lured independently. In [**?**] and [**?**], it is super imposing the cosine component of the system voltage with clustered output voltage, but it can be easily affected by an inaccurate phase-locked loop (PLL). In [**?**], the active voltage vector superposition method is enhanced. The selective harmonic elimination modulation method is used in [**?**] and [**?**], in which DC voltage balancing control and low-frequency modulation are achieved.

Compared with the method in [**?**] and [**?**], a methodology shifting phase angle for DC voltage stabilization control is proposed in [**?**] and [**?**], through which the desirable effect can be easily achieved, whereas it is limited by the capacity of STATCOM. In [**?**], the DC voltage and reactive power are lured. yet, it cannot be extensively used due to fact that many non-ideal factors are neglected. In [**?**] and [**?**] , the proposed method assumes that all cells are distributed with equal reactive power and it uses the cosine value of the current phase angle. It could lead to system instability, when using the zero-crossing point of the cosine value. In [**?**] and [**?**], the results of experiments are obtained in the downscaled laboratory system. Thus, they are not very persuasive in this condition.

Active disturbances rejection controller (ADRC) is first pro-posed by Han in his proposed work [**?**], and extensively used [**?** **?** **?** **?**]; furthermore, it finds its new application in H-bridge cascaded STATCOM for clustered balancing control. It realizes the best dynamic compensation for the outside disturbance. By moving the modulating wave vertically for self stabilizing control, it is much accessible to be accomplished in field-programmable gate array (FPGA) correlated with existing methods. H-bridge cascaded STATCOMs rated at 10 kV and 2 MVA are constructed and sequences of verification tests are executed.

The higher than literature does not deal with comparison of Singe Boost and ILBC controlled MLI based STATCOM systems. This work deals with presentation comparison of Single Boot and ILBC controlled seven level STATCOM systems.

2. Configuration of the STATCOM System

Fig.1.1 shows the circuit configuration of the STATCOM. By controlling the current of STATCOM directly, it can absorb or provide the required reactive current to achieve the purpose of dynamic reactive current compensation. Finally, the power worth of the grid is improved and the grid offers the active current only. The block diagram of proposed system is shown in Fig.1.2.

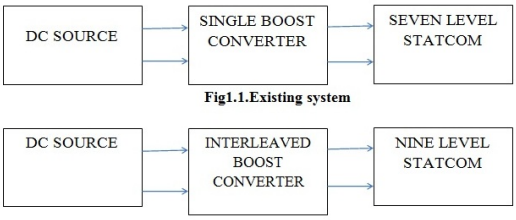

Fig1.1.Existing system

Fig.1.2.Block diagram of proposed system

3. Simulation Results

Circuit diagram for single boost controlled seven level STATCOM system is shown in figure 2.1. The solar output voltage is shown in figure 2.2.and its value is 50 V. Single boost converter circuit is shown in figure 2.3. Switching pulses for single boost converter are shown in figure 2.4. The Output voltage of single boost converter is shown in figure 2.5 and its value is 260 V. The output ripple voltage is shown in figure 2.6 and its peak to peak value is 1V.

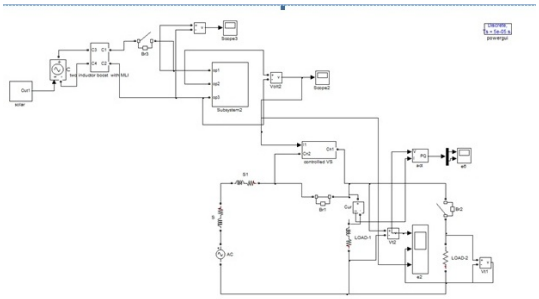

Fig 2.1 Circuit diagram for single boost with 7-level inverter

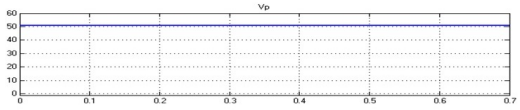

Fig 2.2.Solar output voltage

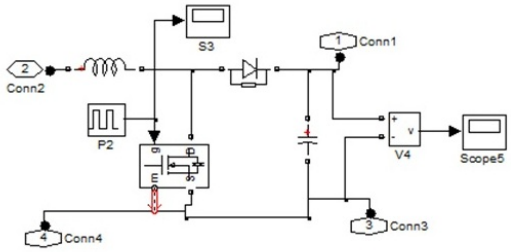

Fig 2.3.Single boost converter circuit

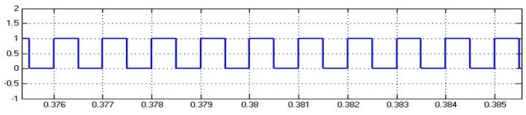

Fig 2.4 Switching pulse for Single boost converter

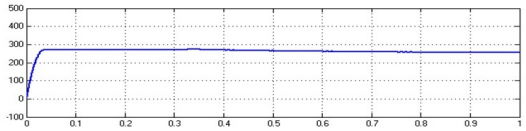

Fig 2.5 Output voltgae of Single boost converter

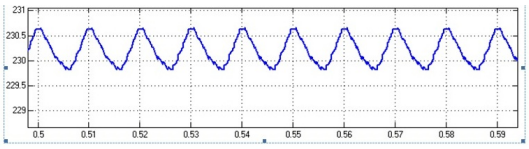

Fig 2.6 Output ripple voltage

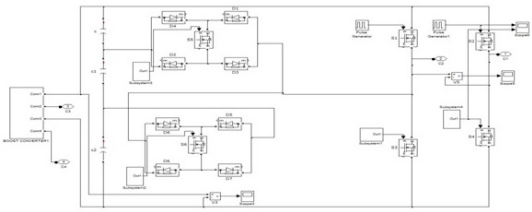

Fig 2.7 Multilevel inverter circuit diagram

Multilevel inverter circuit diagram is shown in figure 2.7. Switching pulses for switches M1 and M3 of multilevel inverter are shown in figure 2.8. The output voltage of multilevel inverter is shown in figure 2.9 and its peak value is 250V. Voltage across load 1, load 2 and STATCOM output voltage are shown in figure 2.10.

The load voltage reaches normal value due to the addition of STATCOM real power and reactive power are shown in figure 2.11 and value of real power is $1.98 * 10^5 W$ value of reactive power is 1200VAR. The frequency spectrum is shown in figure 2.12 THD content is 6.94%

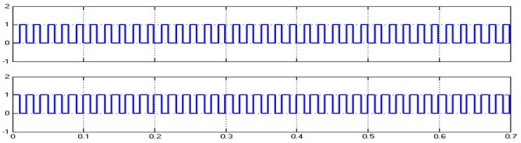

Fig 2.8 Switching pulses for switch M1, M3 of multilevel inverter

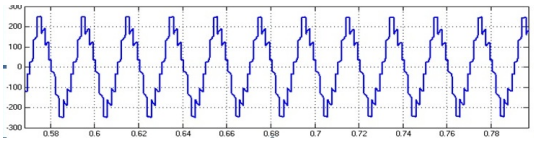

Fig 2.9. Output Voltage Of Multilevel Inverter

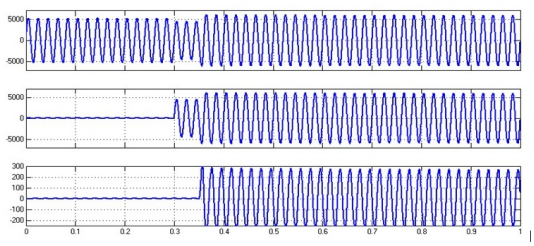

Fig 2.10. Voltage Across Load 1,Load2 & Statcom Output Voltage

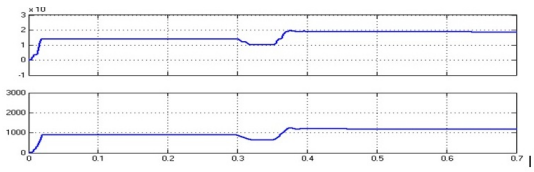

Fig 2.11 Real & Reactive Powers

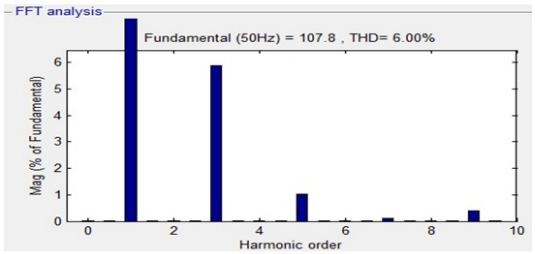

Fig 2.12 Frequency Spectrum

The circuit diagram with nine level inverter is shown in figure 3.1. The input voltage is shown in figure 3.2 and its value is 51V. Two stages ILBC converter system is shown in figure 3.3. Switching pulses for MI of ILBC converter is shown in figure 3.4. Switching pulses for switches M1, M3 of multilevel inverter is shown in figure 3.5. The output voltage of multilevel inverter is shown in figure 3.6.

The output voltage of ILBC is shown in figure 3.7 and its value is 335v. The output ripple voltage is shown in figure 3.8 and the peak to peak ripple is 0.0005v. The multilevel inverter circuit diagram is shown in figure 3.9. The voltage across load 1, load 2 and output voltage of STATCOM is shown in figure 3.10. The Real power and Reactive power are shown in figure 3.11. The real power is $2 * 10^5$ w and reactive powers is 1400VAR.

The frequency spectrum is shown in figure 3.12. The THD content is 2.23%. The simulation of parameters is shown in Table 1. The summary of results is shown in Table 2.

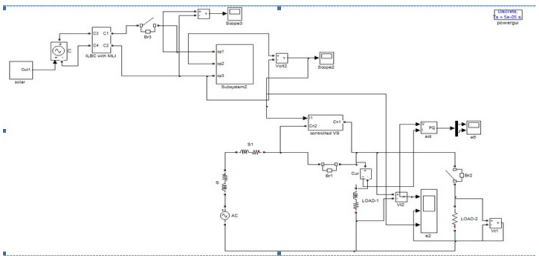

Fig 3.1. Circuit Diagram With 9-Level Inverter

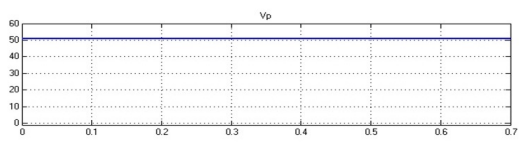

Fig 3.2.Input Voltage

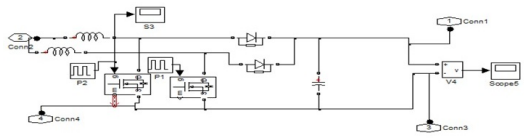

Fig 3.3.Two Stage ILBC Converter

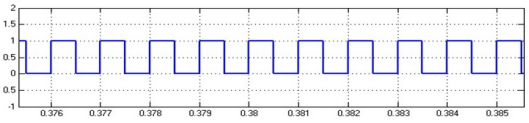

Fig 3.4.Switching Pulse for M1 Of ILBC Converter

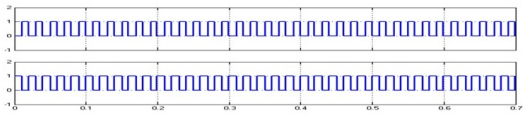

Fig 3.5 Switching Pulses for Switches M1, M3 Of Multilevel Inverter

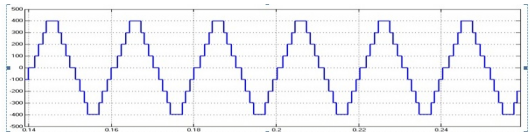

Fig 3.6 Output Voltage of Multilevel Inverter

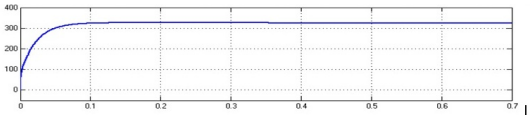

Fig 3.7 Output Voltage Of ILBC

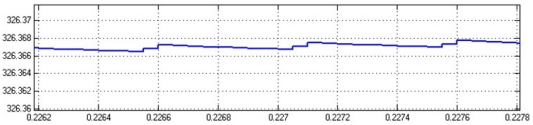

Fig 3.8 Output Ripple Voltage

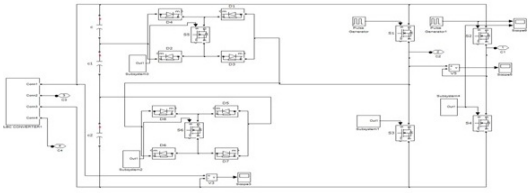

Fig 3.9 Multilevel Inverter Circuit Diagram

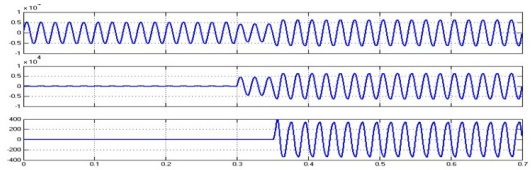

Fig 3.10 Voltage Across Load 1,Load2 & Statcom Output Voltage

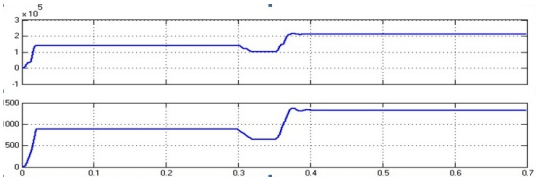

Fig 3.11 Real & reactive powers

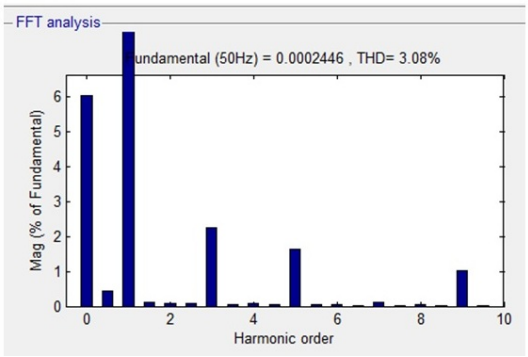

Fig 3.12 frequency spectrum

Table -1 Simulation Parameters

PARAMETERS	SINGLE BOOST CONVERTER	INTERLEAVED BOOST CONVERTER
Vin	50v	50v
L1,L2	1μH	140μH
Cin	10μF	10μF
Cbo	100μF	100μF
RL	100Ω	1K
MOSFET(IRF840)	500V/8A	500V/8A
DIODE	230V/1A	230V/1A
V0	263V	325V

Table 2:Summary of Results

MULTILEVEL INVERTER	VIN	VO	RIPPLE VOLTAGE	THD
Seven level SINGLE BOOST converter	48v	263v	0.95v	6.94%
Nine level ILBC converter	48v	325v	0.07v	2.23%

4. Conclusion

Single boost converter and ILBC based nine level STATCOM system are successfully designed, modelled and simulated using MATLAB and the corresponding results are presented. The result identified that ripple voltage and THD are minimum in the case of ILBC controlled nine level STATCOM system.therfore this system is a viable alternative to the existing STATCOM system. The present work deals with open loop controlled single boost and ILBC based STATCOM systems. The investigation on closed loop system will be done in future.

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