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Transformer Less Cascaded Voltage Source Converter Based STATCOM

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ABSTRACT

In this work, a transformer-less voltage source converter (VSC) based STATCOM is proposed with a combination of cascaded conventional three-phase voltage source inverters. This modular structure provides multilevel operation with reduced switch count and independent DC-link capacitors. The actual contribution of this paper is the transformer-less configuration of a conventional cascaded voltage source converter which provides reduced cost and volume as compared to other transformer-less converter configurations. The system provides reactive power compensation with better power quality when connected to the nonlinear power electronics load also. A simple control system is provided for balancing the Dc link capacitor voltage and reactive power compensation. The validation of the proposed model is analyzed with simulation using MATLAB/SIMULINK software and the results are obtained with different linear and nonlinear load configurations.

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1. INTRODUCTION

The Static synchronous compensator (STATCOM) is one of the highly promising devices for providing better power quality and unbalanced load compensation. Static synchronous compensator STATCOM provides fast response, flexible operation, and lesser harmonics injection to the grid. As the demand for better power quality is heading, the interconnection of power is increasing and wider usage of unpredictable wind and PV sources increases the need for better and more advanced STATCOM and other FACTS devices [1].

Unbalanced load compensation and harmonic mitigation are the serious threats in the modern power supply and the sources of these unbalance is the introduction of large power electronics-based loads like traction motors, SMPS, arc furnaces, and generation of electricity through renewables is also a source of these problems [2]. These unbalanced loads cause severe voltage drops and the loads connected to these supplies cause malfunction of motors, harmonics, low power factor, and severe increase in line losses. STATCOM if appropriately controlled is a boon to the power system as it can compensate for unbalanced loading and provide better power quality by supplying the required negative sequence load current.

With the requirement of more developed technology for STATCOM, world interest is moving towards the demand of Modular Multilevel Converters (MMC) for STATCOM applications in medium to high voltage power systems. For efficient power conversion, high power multilevel inverters are considered to be the most popular and effective solution [3, 4, 5]. Among multilevel inverters modular multilevel converters are gaining popularity because of their features like the modular structure, higher degree of redundancies, lower harmonics content, and many more. Modular multilevel converters are the several single-phase H-Bridge voltage source converters that are stacked together to form a phase limb. These limbs of modular multilevel converters can be connected in star and delta configuration, can be called Single Star bridge converter and Single delta Bridge converter. However, balancing capacitor voltages in a large number of modular converter cells is a big challenge [6]. Also maintaining better power quality in modern power systems due to the increase in power electronics loads is a major issue. Several techniques are addressed in the literature for dc-link capacitor voltage balancing and harmonics mitigation. As for harmonics mitigation generally, three filtering methods are preferred active filtering, passive filtering, and hybrid filtering which is the mixture of active as well as passive. For low voltage applications passive filtration is used in which capacitor and inductor are selected in a way to remove specific harmonics, but on the contrary, if we use passive filters for medium to a higher level it will increase the cost as well as the size of the passive filters with subsequent increase in ringing transients and resonance [7]. Other effects that occur are problems in tuning the frequency of the filters and the resonance.

Due to these reasons active filters are used for medium to high power applications. Active power filters are now becoming popular for industrial and power sectors because of their recent development in power semiconductor devices and their ratings. Active power filters offer advantages over passive filters as they remove drawbacks of it and can detect the current harmonics from load and compensate it by proper current controllers. Modular multilevel converters (MMC) because of their modular structure have a low switching frequency of the various sub-modules devices which maintains the high switching frequency of the converters. Thus, MMC without compromising the efficiency of the converter harmonics mitigation and control is possible.

Many investigations for harmonic mitigation are addressed in papers [8, 9, 10]. The investigations show that the hybrid combination of MMC compensates for the harmonics whose value can be supposed to be the number of compensated harmonics. PI controller is used for modulation of each cell through which identified current harmonics are eliminated. This method for harmonics mitigation increases the cost, volume, and complexity of the device with reduced efficiency. Other methods based on APF correction for MMC are investigated which have addressed the use of third harmonics injection and selective harmonics mitigation for the elimination of specific harmonics for light flicker mitigation and sag mitigation but have not given importance to the power quality as per modern grid requirements.

The recent modern grid requires mitigation of current and voltage harmonics which requires specific converter configuration. Many authors have suggested various control schemes for different MMC-based STATCOM structures specially used for reactive power compensation, but MMC-based STATCOM for harmonics mitigation and improvement of power quality with reactive power compensation needs more attention.

In modular converters, various switching devices per module are incorporated at a lower rating and have the capability to withstand high voltage. But when an MMC comes under the atmosphere of load unbalancing, and due to the flow of active power between converter arms, a severe capacitor voltage imbalance may arise. And in MCC several stacks of modules are composed of separate dc capacitors isolated from each other, so active power exchange is not possible which causes dc-link capacitor voltage to vary [11, 12]. This unbalancing of capacitor voltage causes STATCOM device malfunction and excessive stress across devices. And the methods to compensate for this problem are addressed in one of the methods to address this issue is the injection of zero sequence voltage in single star bridge type converter SSBC and zero sequences current in single delta bridge converter SDBC between phase limbs [13]. The method reduces total capacitor voltage across each limb when subjected to unbalanced loading. Another method given in [14] is by injecting non-sinusoidal harmonics content with zero sequences that can be used for the cluster to mitigate imbalance dc-link voltage. So, several measures are adopted to limit this disadvantage of MMC.

One more concern for STATCOM based MMC is the control method, and to improve the performance of MMC several control futures are adopted to improve the performance of the STATCOM. Several papers [15, 16, 17] have adopted the PI control which is considered to be one of the most common and simple methods for feedback control of MMC. In [18] a new control method for MMC based on proportional resonance (PR) control is used for inner current control in the αβ stationary frame. Another method [19] based on model predictive control is used with zero sequence injection method for unbalanced load compensation. Other methods like model predictive control, sliding mode control, are also addressed in papers [20] for fast response of the converters. But with these predictive control methods, complexity increases as the level of the converter increases. One more aspect of the MMC is the modulation techniques; several Pulse width modulation techniques are discussed in literature like SPWM, space vector, and selective harmonics mitigation [21, 22]. In [23, 24] a redundant submodule of MMC is obtained by phase-shifted pulse width modulation technique. And in [25] fixed pulse pattern is considered for MMC and different switching submodules frequency is analyzed. With this carrier-based system, PWM was addressed for MMC in STATCOM applications. With these several techniques another dual inverter topology with simple two-level voltage source inverter for STATCOM application. It proposes a very simple control by combining three-phase inverters in a cascaded configuration [26].

In this work, a new cascaded converter with a transformer-less structure is developed from a conventional two-level three-phase inverter. This proposed configuration has a modular transformer less structure. This transformer-less structure with the proposed configuration is not addressed before in any paper and has benefits similar to the MMC as it provides advantages like easier control, modular structure, smaller size with reduced cell count, improved voltage, and current waveform. This particular structure removes the requirement of a complex control mechanism for balancing Dc capacitor voltages which is a serious problem in the cascaded modular multilevel. Simple PI control is adopted to obtain good harmonic performance with Dc capacitor voltage control and reactive power compensation. The proposed techniques and results are validated using MATLAB/SIMULINK software simulation.

The proposed paper is structured in the following sections: Section 2 introduces the circuit configuration using a cascaded three level voltage source converter and its modeling architecture. Section 3 shows the proposed configuration simulation and effectiveness of the proposed system configuration is discussed with and without STATCOM and section 4 is the conclusions obtained from the present system.

2. PROPOSED STATCOM

2.1. Circuit Configuration

In this paper, a transformer-less VSC structure with two-level three-phase inverters is proposed for STATCOM application as shown in the figure. 1. With this configuration a low-cost multilevel operation of STATCOM is possible with a lesser number of power semiconductor devices. Here floating Dc capacitors are used despite DC sources which reduce the cost of the converter. Control methods for compensating the reactive power and improving power quality are proposed for the harmonic loads. Also, a separate control scheme used is capacitor voltage regulation, which is one of the serious concerns in multilevel-based applications

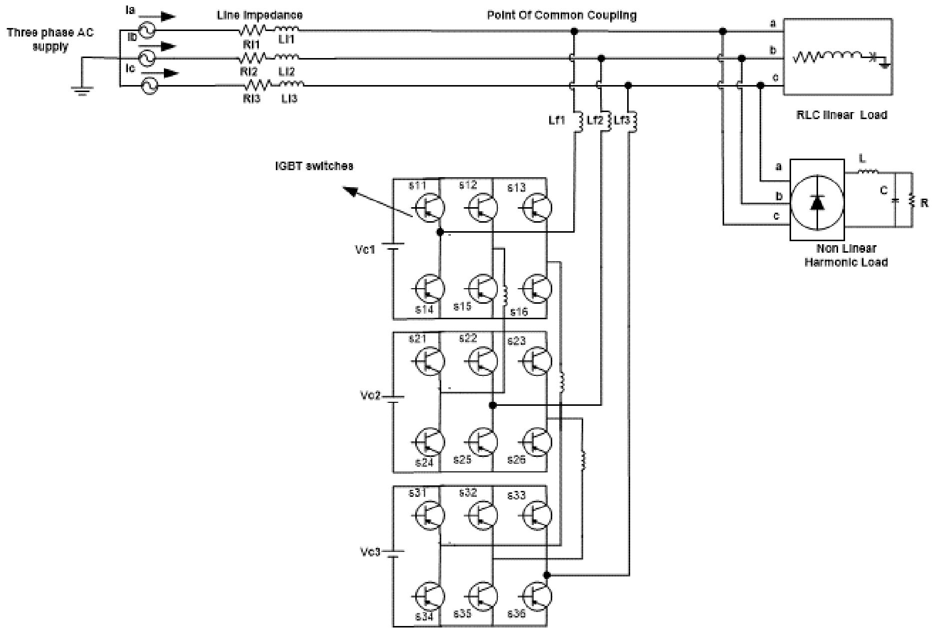

Figure 1. Block diagram of proposed STATCOM module

Furthermore, a control system is enabled which traces the reactive power voltage reference and manages the Dc capacitor voltages. Besides the converter's multilevel operation, this technique permits the extension of the accurate voltage applied at the terminals of the converter which is double the configuration achieved with the Dc voltage capacitor. Another important feature of the proposed VSC STATCOM is its advantage with conventional modulation techniques such as sinusoidal PWM, as no need for complicated control circuitry is required for modulation purposes. The main benefits of the proposed converter configuration for STATCOM applications are:

1. The transformer-less multilevel configuration provides advantages like easier control, smaller size, lesser weight with reduced cell count.

2. This multilevel configuration removes the requirement of a complex control mechanism for balancing Dc- Link capacitor voltages.
3. A simple control mechanism is adopted to obtain good harmonic performance with DC-link capacitor voltage control, reactive power management, and the effectiveness is clearly shown in the simulation results.

The outcome obtained from the proposed converter based STATCOM and its difference with convectional STATCOM structure is summarized in table 1 to present a good understanding of the different convectional converter contributions and their differences. The converter comparision includes the number of power switching devices, stress on the switching devices, number of Dc- link capacitors required, voltage balancing of Dc capacitor voltage control, and utilization of transformers. With these comparsions, it is concluded that the convectional cascaded converters can be extended to several series combinations to achieve desired voltage level but the issue with this converter is the complex control method is utilized for the balancing of the Dc capacitor voltages due to a number of cells [27]. The isolated H-bridge converters is having 18 switches connected to a single dc link capacitor combination, here also a number of cell combinations can be extended to achieve desired voltage level, but the requirement of complex pulse width modulation strategies and additional passive components increases the system cost and the volume of the converter [28, 29]. Whereas a convectional two-level converter requires 12 switch configuration and two capacitors but requires complex modulation technique and have higher switching losses [30]. While comparing, the proposed converter has come up with certain advantages and disadvantages like the modulation technique adopted here is simple and this method does not require a complex control mechanism for controlling the capacitor voltages in each cell. Due to its transformer less structure, it provides a smaller size, lesser weight and is very well suitable for STATCOM applications providing simple control and structure.

Table 1. Comparision of various convectional converter topologies.

Topology	Cascaded three phase converters	Cascaded multilvel converter (with n-level)	Isolated H-bridge converter	Proposed Converter
Number of Power semiconductor devices	12	6(n-1)	18	18
Number of capacitors	2	3(n-1)/2	1	3
DC- Link Capacitor voltage control	simple	very complex	complex	simple
Transformer	necessary	not necessary	necessary	Not necessary
Stress on the power semiconductor devices	0.75Vac_m	2Vac_m/(n-1)	Vac_m	0.5Vac_m
STATCOM applications	**	****	**	****
Effectivenes	**	***	***	****
Cost	medium	medium	more	less
Switching losses	medium	more	less	less

In this configuration the STATCOM converter is configured with a filter circuit to the grid at the point of common coupling (PCC) without any transformer. The three phase voltages at the PCC are given as "(1-3)".

$$V_{sai} = \sqrt{\frac{2}{3}} V_{si} Sinwt \tag{1}$$

$$V_{sbi} = \sqrt{\frac{2}{3}} V_{si} Sin(wt - \frac{2\pi}{3}) \tag{2}$$

$$V_{sci} = \sqrt{\frac{2}{3}} V_{si} Sin(wt + \frac{2\pi}{3}) \tag{3}$$

Expressing these voltages in matrix form as “(4)”

$$\begin{bmatrix} V_{sai} \\ V_{sbi} \\ V_{sci} \end{bmatrix} = \sqrt{\frac{2}{3}} V_{si} \begin{bmatrix} Sinwt \\ Sin(wt - \frac{2\pi}{3}) \\ Sin(wt + \frac{2\pi}{3}) \end{bmatrix} \quad (4)$$

The voltage and current equations are obtained by applying the KVL equation for fig.2. The relationship obtained as “(5 - 7)”

$$R_f i_a + L_f \frac{di_a}{dt} = v_{sai} - v_{cai} \quad (5)$$

$$R_f i_b + L_f \frac{di_b}{dt} = v_{sbi} - v_{cbi} \quad (6)$$

$$R_f i_c + L_f \frac{di_c}{dt} = v_{sci} - v_{cci} \quad (7)$$

Equations “(5 - 7)” are represented as systems differential equations in the ABC reference frame and this equation in matrix form is given as “(2.8)”.

$$\frac{d}{dt}\begin{bmatrix} i_a \\ i_b \\ i_c \end{bmatrix} = \begin{bmatrix} \frac{-R_f}{L_f} & 0 & 0 \\ 0 & \frac{-R_f}{L_f} & 0 \\ 0 & 0 & \frac{-R_f}{L_f} \end{bmatrix} \begin{bmatrix} i_a \\ i_b \\ i_c \end{bmatrix} + \frac{1}{L_f} \begin{bmatrix} v_{sai} - v_{cai} \\ v_{sbi} - v_{cbi} \\ v_{sci} - v_{cci} \end{bmatrix} \quad (8)$$

The above system equation is now converter to the SRF (synchronous reference frame) to control the converter circuit current. The abc reference frame is now changed into the synchronous frame dq0 by parks transformation. In a balanced three-phase system operating under normal conditions, only a positive sequence component exists; this system does not contribute to the generation of zero sequence currents. As here only a balanced system is considered for the system, only d and q components exist in the system and the transformation equation is given as “(9 - 10)”.

$$R_f i_d + L_f \frac{di_d}{dt} = v_{sd} - m\, V_{dc} \cos \propto + L_f w i_q \quad (9)$$

$$R_f i_q + L_f \frac{di_q}{dt} = v_{sq} - m\, V_{dc} \sin \propto + L_f w i_d \quad (10)$$

The above equation represented in the matrix form as “(11)”

$$\frac{d}{dt}\left[i_d \; i_q \right] = \left[\frac{-R_f}{L_f} \; w \; w \; \frac{-R_f}{L_f} \right] \left[i_d \; i_q \right] + \frac{1}{L_f} \left[v_{sid} - v_{cd} \; v_{siq} + v_{cq} \right] \quad (11)$$

In a synchronous frame reference, the instantaneous active power value and reactive power value can be written as

$$p = \frac{3}{2}\left(v_{sid} i_d + v_{siq} i_q\right) = \frac{3}{2} v_{sid} i_d = \frac{3}{2} v_{si} i_d \quad (12)$$

$$q = \frac{3}{2}\left(v_{siq} i_d + v_{sid} i_q\right) = -\frac{3}{2} v_{sid} i_d = -\frac{3}{2} v_{si} i_q \quad (13)$$

Equation “(12)” and “(13)” shows that the performance of STATCOM is controlled by the id and iq component of current and the synchronous reference frame control algorithms can control the d component and q component of the current to obtain the desired control objective.

2.2. Control Method for Proposed Architecture

In the proposed multilevel structure-based STATCOM, the control method is implemented for Dc capacitor voltage control and the reactive power compensation control for different load conditions. The separate control method for the Dc capacitor voltage balancing method is implemented and a control circuit mechanism is implemented for reactive power control. Thus, both control methods effectively control the desired active power and reactive value of the STATCOM for compensating the power losses. Figure. 2 shows the control system representation for the proposed STATCOM.

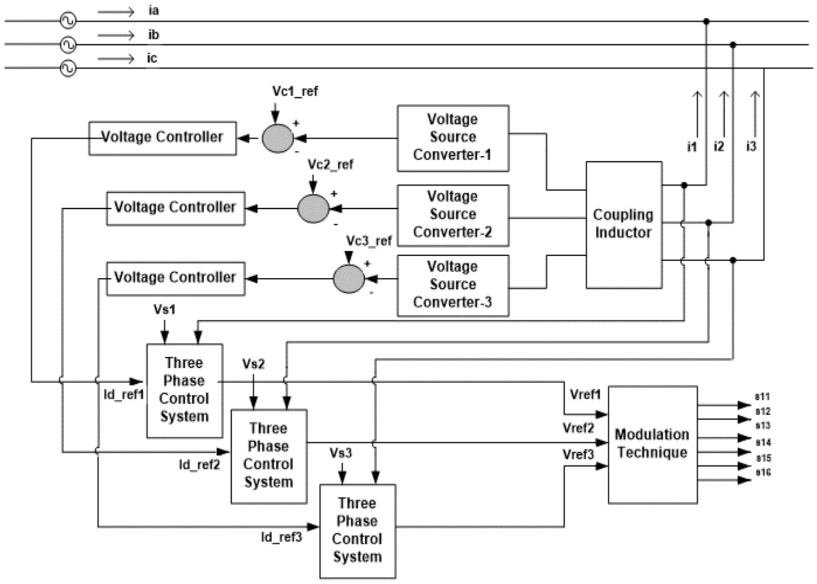

Figure 2. Control system for proposed STATCOM module

The three-phase grid voltages and Dc capacitor voltages are regulated by the proportional Integral (PI) controller in cascaded three-phase control mode. As stated above the two basic control methods involved are for ac grid reactive power compensation at PCC and the other is the Dc capacitor voltage regulation.

2.3. Reference Currents generation for STATCOM

The proposed STATCOM controls the desired active as well as reactive power of the AC load currents in the dq reference frame of the converters using the parks transformation technique. Thus, the active power and reactive power representation in p-q power is given by the relation shown in “(14)”

$$\begin{bmatrix} p \\ q \end{bmatrix} = \begin{bmatrix} v_{sid} & 0 \\ 0 & -v_{sid} \end{bmatrix} \tag{14}$$

Equation “(14),” shows the relation between the active power and reactive power which will depend on the Id and Iq components. Thus, STATCOM can control the grid reactive power by controlling iq component and the system's active power is utilized for controlling the dc capacitor voltage regulation. The reference voltage for capacitor voltage control is given as “(15)”, where the error signal is obtained by comparing Dc capacitor voltage Vdc with the reference voltage Vdc $_{ref}$.

$$i_{dref} = (K_p + \frac{K_i}{S})(V_{DCref} - V_{DC}) \tag{15}$$

The current controller will realize the active power and reactive power by controlling the reactive power with iq and the reference for control will be given by “(15)”. Thus, whole functions can be controlled and realized by the current controller. Equations “(16)” and “(17)”, will control the inverter voltages and to avoid any interference d-q current controller is applied between active and reactive power.

$$v_d = V_{dref} \text{-} L_f wiq + vs_{id} \tag{16}$$

$$v_q = V_{qref} \text{-} L_f wid + vs_{idq} \tag{17}$$

Id components are generated to control the three inverter’s capacitor voltages independently. three control systems are required for all three-phase systems. With this, each phase component is considered as a three individual phase system for one third value of the desired system power. The development of each phase system configuration is obtained through the generation of individual line currents (ia, ib, and ic). The block diagram of the aforesaid control system is shown in figure 3.

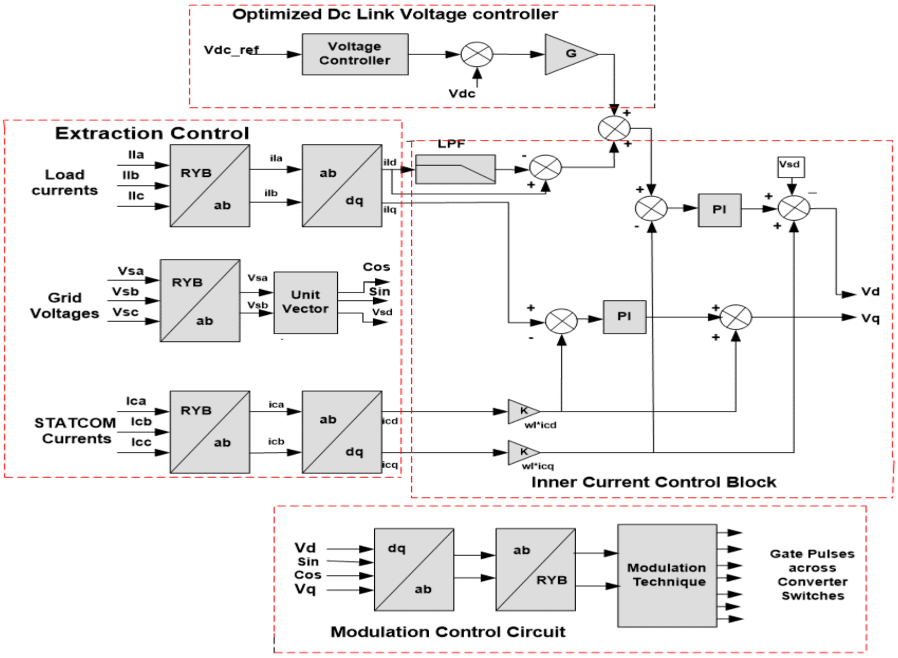

Figure 3. Control Circuit block diagram

2.4. Capacitor Voltage Balancing

A separate PI controller is enabled to match the sum of actual capacitor voltage to the reference value. This system allows reference voltages with different amplitudes [31]. The converter losses established between three cascaded inverters are not the same, so the dc capacitor voltages are of different amplitudes. To remove this severe issue, a system is developed to control the capacitor voltages across each phase. Each capacitor voltage has a separate voltage control system that determines the control of the value of the id component for each phase in the three-phase system. The output obtained across each phase of the system controller is the reference for the PWM generator. In this way, the different charging and discharging of capacitor values obtained are balanced through a PWM generator controlled by different values of three id components. The magnitude of the capacitor voltage is maintained stable at their prescribed referred values when the system's condition is changed.

2.5. Switching Modulation Technique

Modulation indices generated by the sinusoidal pulse width modulation technique are m_a, m_b, and m_c. The phase modulation indices are obtained from dq transformed into abc [32]. The transformation matrix is given in "(18)"

$$\begin{bmatrix} m_a(t) \\ m_b(t) \\ m_c(t) \end{bmatrix} = \begin{bmatrix} \cos(\omega t) & -\sin(\omega t) \\ \cos\left(\omega t - \frac{2\pi}{3}\right) & -\sin\left(\omega t - \frac{2\pi}{3}\right) \\ \cos\left(\omega t - \frac{2\pi}{3}\right) & -\sin\left(\omega t + \frac{2\pi}{3}\right) \end{bmatrix} \begin{bmatrix} m_d \\ m_q \end{bmatrix} \tag{18}$$

In sinusoidal PWM the generated signals obtained are now compared with the triangular carrier pulses. The switching pulse signals for each converter leg are achieved by comparing reference voltage and the carrier signal and similarly other pulses are obtained. The output pulses obtained is then fed to the switches, the averaged output is a sinusoidal voltage waveform.

3. RESULTS AND DISCUSSION

The effectiveness of the proposed cascaded multilevel inverter based STATCOM has been verified by simulation. MATLAB/Simulink (R2019a) simulation environment is taken to develop a model of STATCOM connected to the grid with three different loads. The system parameters defined for the model are listed in Table-2.

Table 2. Specifications and Parameters used for the Simulation

Parameters	***Value***
Ac grid voltage	400 V
Fundamental Frequency	50Hz
DC bus voltage	1000V
AC filter L_f	400μH
Dc bus capacitor	2500μF
PWM carrier Frequency	3kHz
Load -1	RL load
Load -2	RC load
Load -3	Non-Linear harmonic load

The case study for simulation considers the three operational conditions:

• Case 1: $0 \leq t \leq 0.1$ seconds: load -1 linear RL load is injected into the power grid;

• Case 2: $0.1 \leq t \leq 0.2$ seconds: Load -2 linear RC load is injected into the power grid;

• Case 3: $0.2 < t \leq 0.3$ seconds: Load-3 the three-phase non-linear power electronics load is added with linear RL and RC load injected into the power grid.

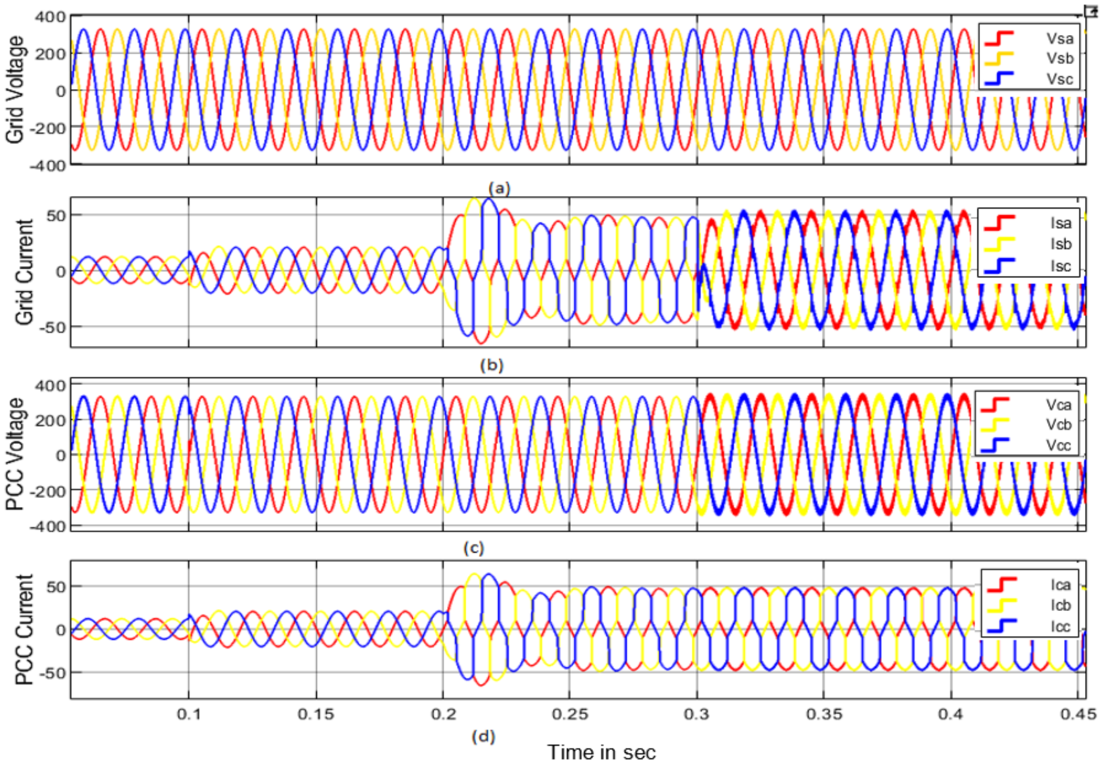

Figure 4. Simulation waveform of three phase (a) grid voltage, (b) grid current, (c) PCC voltage and (d) PCC current

The simulation results of the source side grid current with balanced loads connected to the system without STATCOM is shown in Figure-4. At time $0 \leq t \leq 0.1$ seconds the load is connected to RL load, with peak current range up to 12 A and as soon as RC load gets enabled at time $0.1 \leq t \leq 0.2$ seconds current value extends up to 20 A. At $0.2 < t \leq 0.3$ seconds with power electronics load -3 it exceeds to 5% and then reduces to its normal range. With the insertion of STATCOM in the system at 0.3t, it is clearly shown that from 0.2 seconds due to harmonic load the current first rise to 10% showing an unstable operation, but with STATCOM insertion at 0.3 seconds again maintains its stable operation. From waveforms, it is considered that currents are steady and track the change in the reference value in accordance. In figure 6 (c) and (d) PCC voltage is shown with and without STATCOM. From the simulation results it can be considered that under transient operations, the behaviour of the STATCOM shows a substantial change in the reactive current and voltage. In this test, the amplitude of the voltage is smoothly changing to its reference amplitude following the change in the reference signal following the system. Table 3 shows the results obtained for converter operating with and without STATCOM for a linear and non-linear load.

Table 3. Magnitude of grid current and voltage with and without proposed STATCOM

Configuration	Time(sec)	Grid Current	Grid voltage	Load Current	Load Voltage
Without STATCOM	0.1	10.2	324.5	10.2	324.6
	0.2	22.4	325.2	26.8	324.5
	0.25	46.5	329.3	26.9	328.2
With proposed STATCOM	0.3	48.8	330.5	56.3	330.2
	0.35	48.8	330.5	56.3	330.1
	0.4	48.8	330.4	56.3	330.1

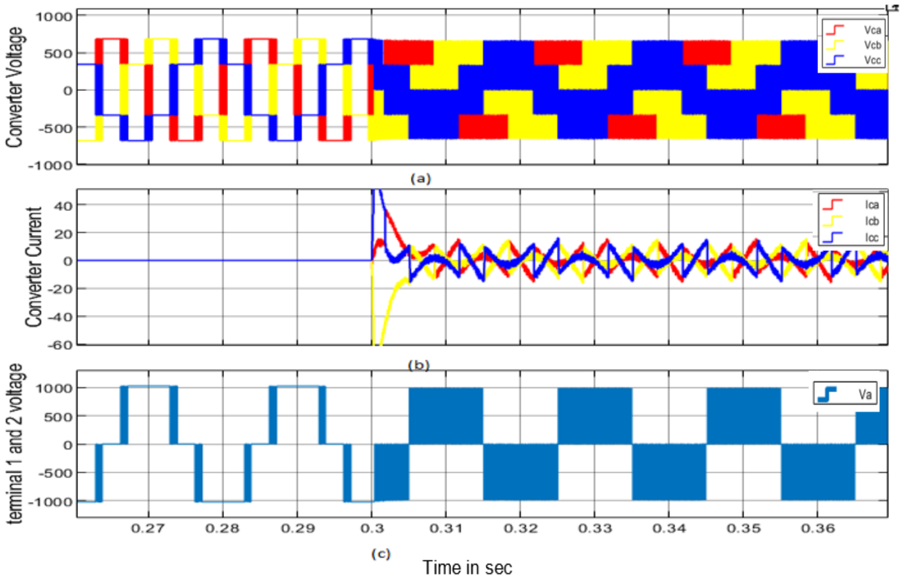

Figure 5. Simulation waveform of the STATCOM power converter output terminals (a) converter output voltage, (b) STATCOM converter output compensating current (c) waveforms of the AC voltages generated by inverter 1 (legs 1 and 3).

The multilevel configuration of the STATCOM power converter output is shown in Figure-5. The five-level voltage output is shown (a), which is the highest voltage obtained having positive and negative DC voltage levels with each phase of the inverter. Also, the simulation waveforms of the AC voltage by inverter leg 1 and 2 are shown (c). The waveforms of the STATCOM currents are shown in (b). The compensating STATCOM current waveforms shown are due to the nonlinear harmonic load connected in the system. STATCOM supplies the required compensating harmonic current to the load, such that the current obtained is sinusoidal.

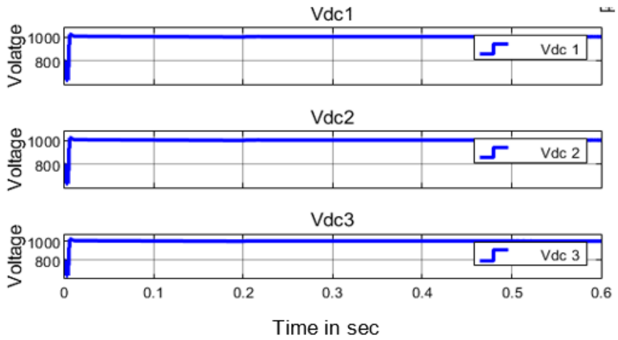

Figure 6. DC- link Capacitor voltage waveform across all cascaded converters with STATCOM.

The simulation waveforms of Dc capacitor voltage with STATCOM are shown in Figure 6. Each DC link capacitor voltage has the simultaneous rise in voltage magnitude and then with reference tracking it maintains its voltage to the prescribed voltage magnitude of the system. The different charging and discharging of capacitor values obtained are balanced through a PWM generator controlled by different values of the id component. The balanced capacitor voltage is shown, in which the capacitor voltage first crosses to its range of 1000 V and then slowly comes down to its normal voltage range by tracking its reference.

The grid voltage and grid current waveforms with and without STATCOM connected to the system are shown in Figure-7(a). It is shown that up to time 0.2 t current waveforms have no distortion but with the addition of harmonic load at 0.2 t, considerable distortion in current waveforms can be noticed. At 0.3 t STATCOM is enabled in the system with grid functioning with both linear and nonlinear load. It is shown that before the connection of the STATCOM, the grid current is in-phase with the grid voltage but with substantial distortion. After the STATCOM is attached the source current comes in phase with the grid voltage and the current waveforms are distortion-free. Thus, it is analyzed that when STATCOM can enhance the system performance by providing the required compensating current to the system, with this the grid voltage and current become sinusoidally smooth and distortion-free. In this way, it improves the quality of power irrespective of the nature of the load. The waveform of the capacitive and inductive mode of operation is shown in figure 7 (b) and (c) respectively. The system performs well in both modes of operation by maintaining the need for reactive power when required by the desired load.

Thus, the proposed system can provide the reactive power compensation providing better power quality with a linear as well as nonlinear load connected to the grid. Also, simple control systems very efficiently regulate the Dc capacitor voltage which can be verified by the results obtained during simulation.

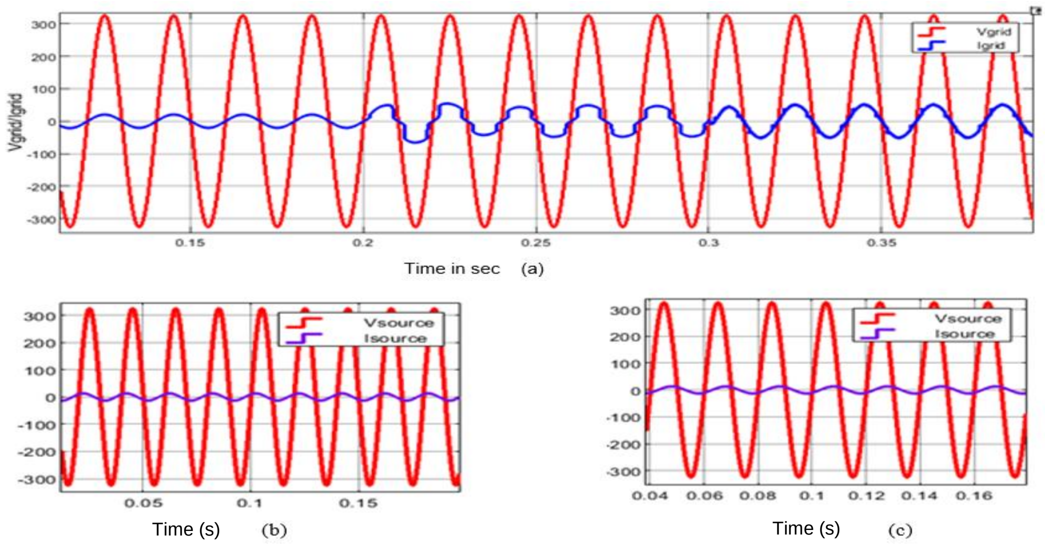

Figure 7. (a) Waveforms of the grid voltage and grid current with and without STATCOM in the system. (b)Capacitive mode of operation, and (c) Inductive mode of operation

4. CONCLUSION

In this paper, a transformerless conventional three phase voltage source converters connected in cascade configuration is proposed for STATCOM applications. The cascaded multilevel operation is achieved using classical three phase voltage source convectional converters. The proposed system provides dc-link capacitor voltage regulation, better power quality and reactive power compensation and a simple sinusoidal PWM modulation technique is utilized for switching the converters semiconductor switches. To validate the effectiveness of the proposed converter simulations are performed for linear and non-linear load. The proposed converter offers good capability in achieving capacitor voltage balancing, reactive power compensation and better distortion free power quality under different load configurations. This proposed STATCOM converter introduces a transformer-less structure with a simple design, easy control mechanism. This structure achieves higher reliability, lower weight, and size compared to conventional multilevel converter technologies. In future work, it is planned to extend the proposed converter based STATCOM operational limit by testing it for other uncertainties in the power system.

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