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Application of hybrid D-statcom topology to Compensate Reactive and Nonlinear Loads for Power-Quality Improvement

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ABSTRCT:

This paper proposes design and operation of an improved hybrid distribution static compensator (DSTATCOM) topology to compensate reactive and non linear loads. An LCL filter with small value of inductor compared to traditional L filter has been used at the front end of a voltage source inverter (VSI), which provides the elimination of switching harmonics. Voltage of the DSTATCOM can be reduced with capacitor to be connected in series with an LCL filter. Consequently the power rating of the voltage source inverter has been decreased. With reduced dc-link voltage, the voltage across the shunt capacitor of the LCL filter will be also less. As compared with the traditional LCL filter with passive damping proposed method will minimizes the power losses in the damping resistor. And hence the proposed DSTATCOM topology will have the advantage of reduced weight, cost, rating, and size with improved efficiency and current compensation capability compared with the traditional method. In this designing of the components of the passive filter and operation has been presented. The striking performance of the proposed DSTATCOM topology over traditional topologies is validated through simulation.

Index Terms — Distribution static compensator (DSTATCOM); Hybrid topology; passive filter; power quality (PQ)

1 INTRODUCTION:

An electric power distribution system is the final stage in delivery of electrical power; it carries electricity from transmission system to individual consumers. Except in a very few special situations, electrical energy has been generated, transmitted, distributed, and utilized as alternating current (AC). However, alternating current has several distinct disadvantages. One of these is the necessity of supplying reactive power with active power. Due to stored energy in the load and again send back to source, or presence of non-linear loads that distorts the wave shape of the current drawn from the source, due to this the apparent power will be greater than the real powers, which will effects the power factor. Due to this high currents energy lost in distribution system will increase, further equipment cost will increase. This incremental costs of equipment and wastage of energy causes electrical utilities to charge a higher cost to industries or commercial customers where there is a low power factor. In traditional method, L-type filters with large value of inductance were used to increase the quality of current to be injected. This large value of inductor has low slew rate for tracking the reference currents, and produces large voltage drop across it, intern it requires high value of dc-link voltage for the compensation. Therefore L-filters increases cost, size, and power rating. AN LCL

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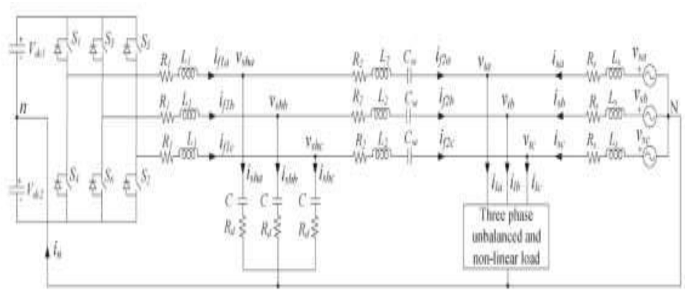
filter is used at the front end of the VSI which will improve the tracking performance, but requires high value of dc-link voltage as that of L filter. In this paper an LCL filter is used to overcome the aforementioned draw backs. Capacitor is used in series with the LCL filter to decrease the voltage of DSTATCOM. This proposed model decreases the size of the passive components, rating of dc-link voltage, rating of VSI. It provides good tracking performance.

2 PRINCIPLE OF DSTATCOM: DSTATCOM is power electronics based power quality improving device, which generates and /or absorbs the reactive power whose output can be varied so as to maintain control of specific parameters of the electric power system. The DSTATCOM comprises of coupling transformer with internal leakage reactance, a three phase voltage source inverter (VSI) with self commutating switches (GTO/IGBT), and a DC-link capacitor. Fig.1 shows the basic configuration of DSTATCOM. The VSI converts the dc voltage across the storage device into ac output voltages. These ac voltages are in phase and coupled with the ac system through the reactance of the coupling transformer. Inverter is the main component of the DSTATCOM. The objective of a VSI is to produce a sinusoidal AC voltage with minimal harmonic distortion from a DC voltage. The operation of the DSTATCOM is as follows: The voltage is compared with the AC bus voltage system (Vs). When the magnitude of AC bus voltage isabove that of the VSI magnitude (Vc), the AC system considered that, DSTATCOM as inductance connected to its terminals. Otherwise if the voltage magnitude of VSI is above that of the AC bus voltage magnitude, the AC system considered that the D-STATCOM as capacitance connected to its terminals. If the VSI voltage magnitude is equal to AC bus voltage magnitude, then the reactive power exchange is zero. Suppose DSTATCOM has a DC active element or energy storage elements or devices on its DC side, it can able to deliver real power to the power system. This can be done by varying the phase angle of the DSTATCOM terminals and the phase shift of the AC power system. When VSI phase angle lags phase angle of the AC power system, the DSTATCOM absorbs the real power from the AC system, if the phase angle of VSI leads phase angle of AC power system, the DSTATCOM supplies real power to AC supply mains. The main feature is governing of bus voltage magnitude by dynamically absorbing or generating reactive power.

3 PROPOSED DSTATCOM WITH LCL-FILTER AND SERIES CAPACITANCE: The proposed DSTATCOM three-phase equivalent circuit diagram is shown below in fig.2.It is realized by using three-phase four-wire two-level neutral-point-clamped VSI. An LCL filter is connected at the front end of voltage source inverter with series capacitance.



This LCL filter reduces the size of the passive components required and capacitance will reduce the DC-link voltage and hence power rating of voltage source inverter. Here and represent resistance and inductance at VSI side; and represents inductance and resistance at load end side of the system. C is filter capacitance which forms LCL filter in all three phases. Rd is damping resistance used in series with the

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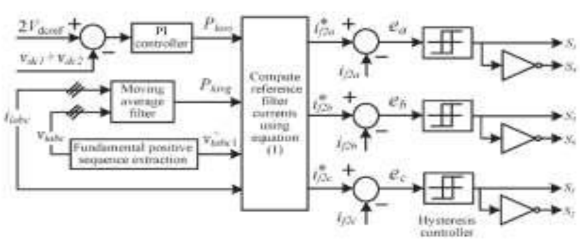
capacitance C, provides passive damping of the overall system and damp out the resonance. Here if1a and if2a are filter currents in phase-a and similar in all three phases. vsha is voltage across LCL filter and isha is current through LCL filter, this is similar for other two phases. The voltage across the DC_link capacitors are maintained constant i.e. Vdc1=Vdc2=Vdcref. The source and load of DSTATCOM are connected to a common point called point of common coupling (PCC).

4 CONTROL OF DSTATCOM



The DSTATCOM is controlled, such that all source currents are balanced, sinusoidal, and in phase with the terminal voltages. In voltage source inverter losses and load power are supplied by the source. Control diagram is as shown in fig.3. Here source is considered to be nonstiff, therefore the voltages to calculate reference filter currents will not provide satisfactory operation with the direct use of terminal current. And hence the fundamental positive sequence component of three-phase voltages are used to

SECTION-5 SIMULATION VERIFICATION

This proposed topology uses lower rating VSI and smaller value of filter inductor, reduces the damping power loss and provides good current compensation. This effectiveness of DSTATCOM can be verified by simulation. The simulation diagram is shown below in fig (4).

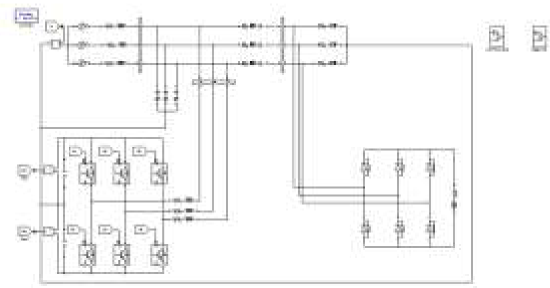


Fig.4. Simulation circuit for proposed DSTATCOM The compensation performance of the proposed topology is shown in Fig.5. The load and source parameters are same as in Table I. In Fig.5 (a), the three-phase source current waveforms are shown, which are balanced, sinusoidal, and have negligible switching ripple compared with the traditional topology. In addition, neutral current is nearly zero. The Fig.5 (b) shows the three-phase compensated PCC voltages with reduced switching harmonics. Additionally, source currents are in phase with their respective phase voltages. The filter currents, as shown in Fig. 5(c), have smaller ripples as compared with that of the traditional topology. The voltages across each capacitor and the total dc-link voltages are shown in Fig. 5(d), mainting at 110 and 220 V, respectively. The performance of the proposed topology is compared with that of traditional DSTATCOM topologies, simulation parameters and corresponding percentage THDs in voltages and currents are illustrated in Table I & II. It is clear from Table II that the percentage THDs in three-phase source currents and in PCC voltages are considerably lesser in the proposed topology. Moreover, these confirm that the reduced dc-link voltage is sufficient for the DSTATCOM to achieve its current compensation performance.

CONCLUSION:

The simulation results given that reduction of dc-link voltage, filter inductance, current through the shunt capacitor and damping power loss are reduced with DSTATCOM with LCL filter followed by series capacitance. This contribution shows reduction in cost, weight, size, and power rating of the traditional DSTATCOM topology. Effectiveness of the proposed topology has been validated through extensive computer simulation.

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