PERFORMANCE ANALYSIS OF IMPROVED HYBRID DSTATCOM TO COMPENSATE REACTIVE AND HARMONIC LOADS

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ABSTRACT

This paper proposes an improved hybrid distribution static compensator (DSTATCOM) topology to compensate reactive and non linear loads with reduced VSI rating, DC link voltage and filter size. 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. It will reduce the power losses in the damping resistor as compared with the traditional LCL filter with passive damping. Therefore, the proposed DSTATCOM topology will have reduced weight, cost, rating, and size with improved efficiency and current compensation capability compared with the traditional topology. A systematic procedure to design the components of the passive filter has been presented. The effectiveness of the proposed DSTATCOM topology over traditional topologies is validated through simulation.

INTRODUCTION

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 nonlinear 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

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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 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.

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 is above 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 sees 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.
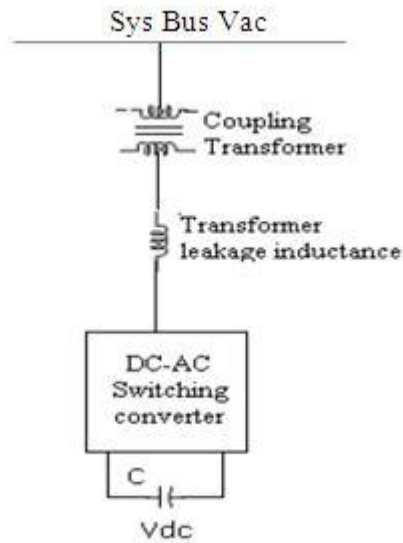
Fig1: Line diagram of DSTATCOM

IMPROVED HYBRID DSTATCOM

The IMPROVED HYBRID DSTATCOM three-phase equivalent circuit diagram is shown below in fig.2.It is realized by using three-phase fourwire 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 L2 and R2 represent resistance and inductance at VSI side; L2 and R2 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 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)
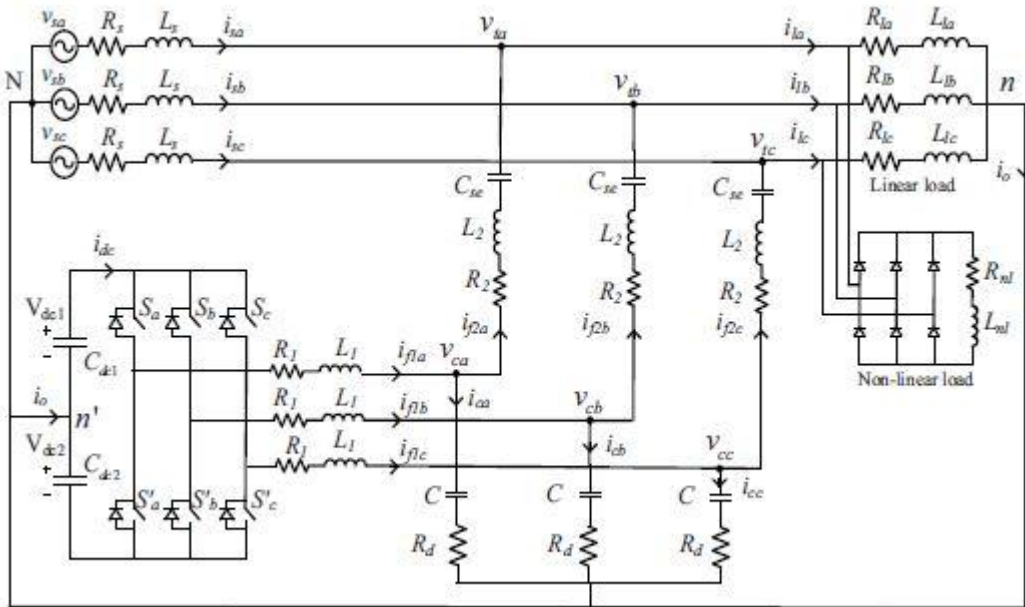
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Fig 2: equivalent circuit of DSTSTATCOM

PROPOSED ESTIMATION

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). In Fig (5) (a) and (b) shows, the three-phase source current waveforms and PCC voltages are shown before compensation same as load currents, these currents are unbalanced and distorted due to the presence of unbalanced linear and nonlinear loads. The traditional method simulation results were presented in Fig (6).The three phase source currents are shown in fig 6(a) which are balanced and sinusoidal. Fig 6(b) shows the PCC voltages. From both the wave forms it contains switching frequencies. Fig 6(c) shows the three phase filter currents. Voltage across upper capacitor, lower capacitor and total DC link voltages are shown in Fig 6(d). The Voltage across upper capacitor and lower capacitor maintained at 520V and total DC link voltage is at 1040V with PI controller.
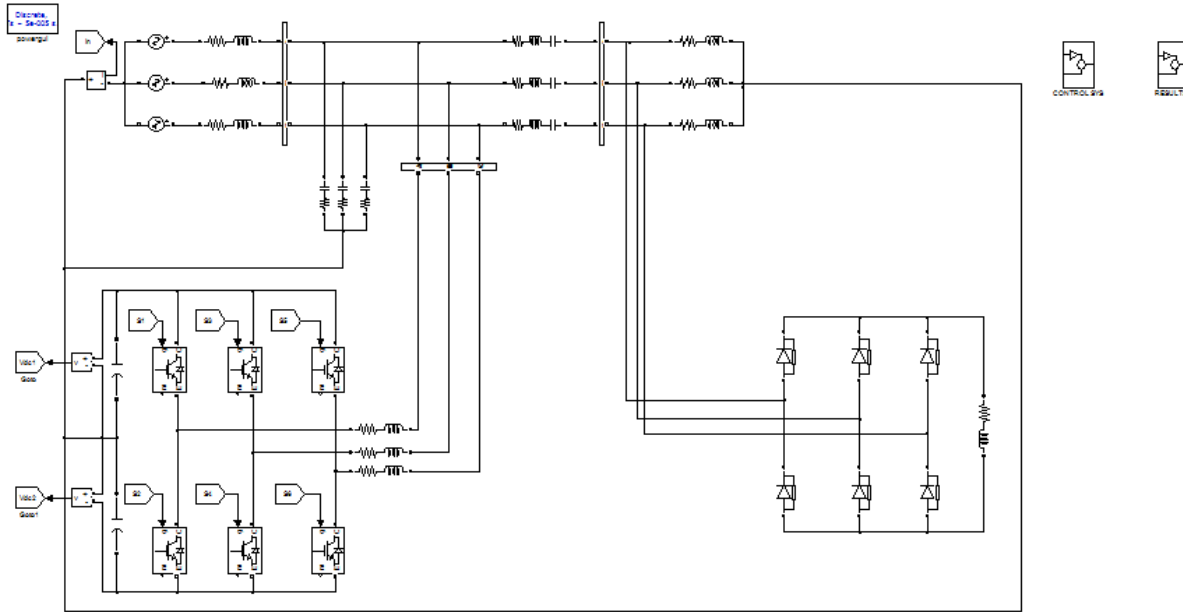
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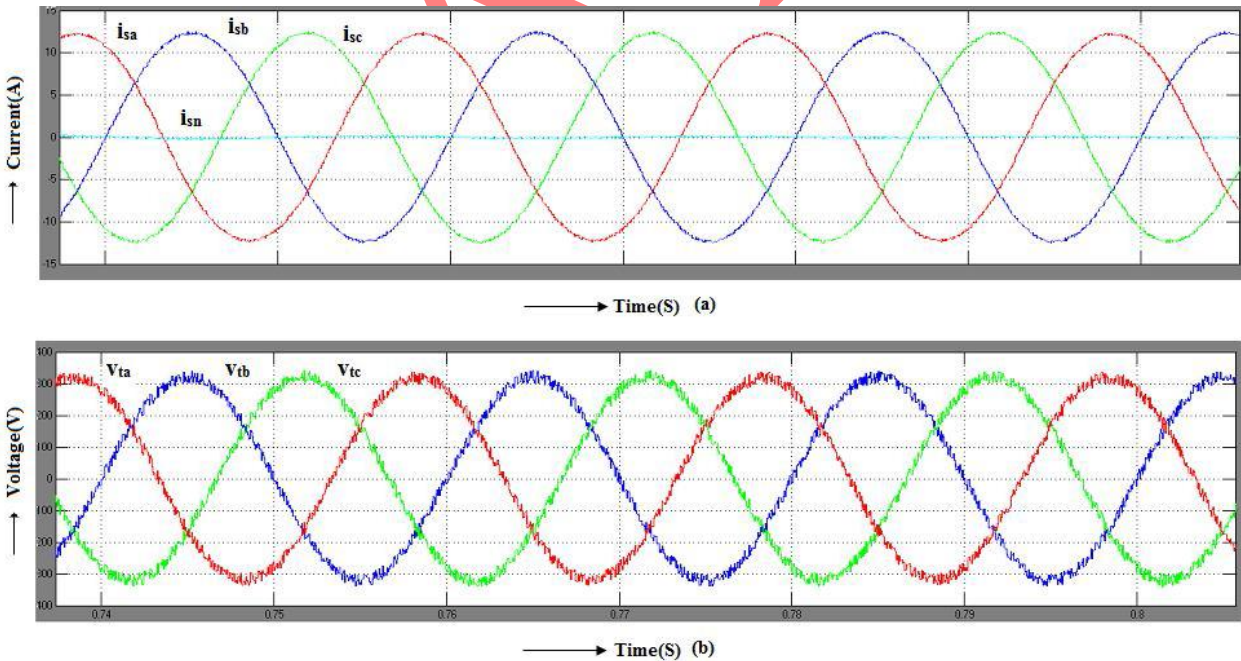Fig 3: Simulation circuit for proposed DSTATCOM

RESULTS

Fig 7: Simulation Result of proposed DSTATCOM (a) Source Current (b) PCC Voltages
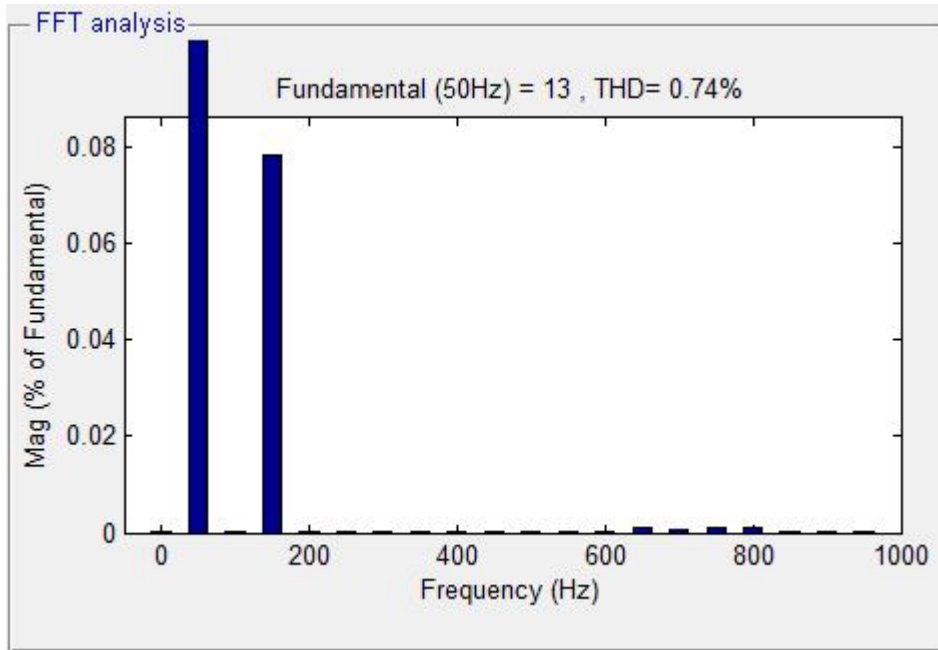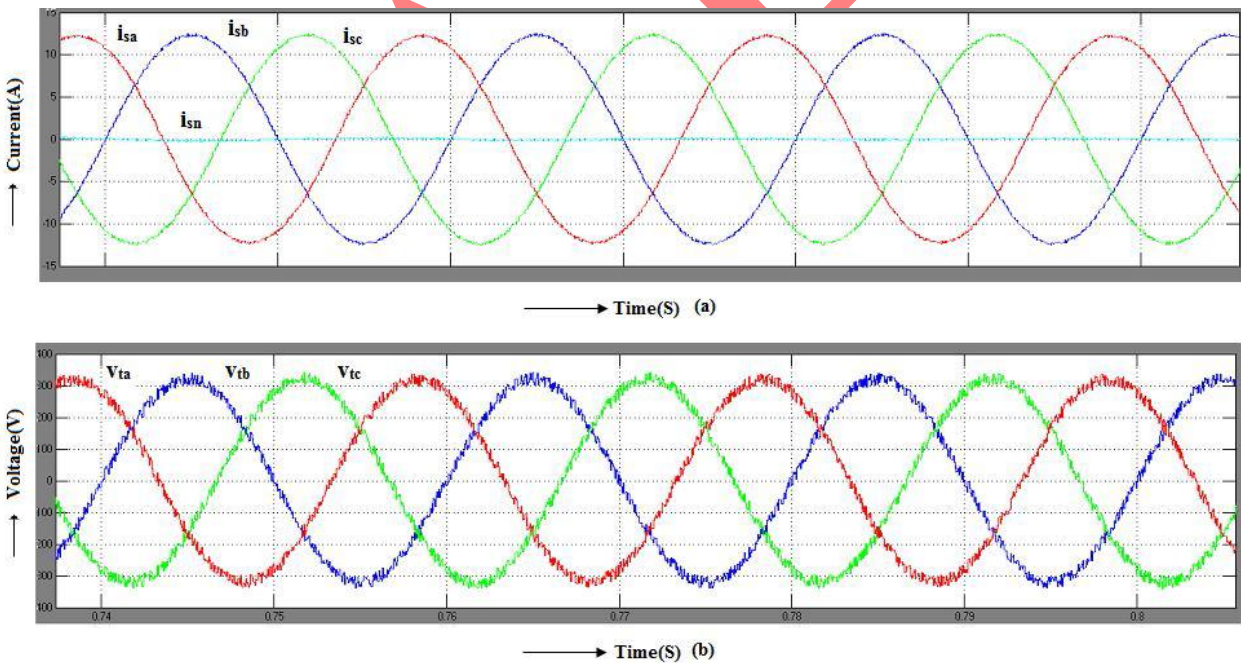
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Fig 8: THD analysis of proposed DSTATCOM

Fig 9: Simulation Result of DSTATCOM with RC nonlinear load (a) Source Current (b) PCC Voltages

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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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