ISSN No: 2348-4845
International Journal & Magazine of Engineering, Technology, Management and Research
A Peer Reviewed Open Access International Journal

An Advanced Wind Energy based DSTATCOM Topology with Improved Current Compensation Capability

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ABSTRACT:

This paper proposes an improved hybrid distribution static compensator (DSTATCOM) topology to compensate reactive and nonlinear loads with reduced VSI rating, DC link voltage and filter size. An LCL filter with small value of inductor compared totraditional L filter has been used at the front end of a voltage source inverter (VSI), which provides the elimination of switchingharmonics. Voltage of the DSTATCOM can be reduced with capacitor to be connected in series with an LCL filter. Consequentlythe power rating of the voltage source inverter has been decreased. With reduced dc-link voltage, the voltage across the shuntcapacitor of the LCL filter will be also less. It will reduce the power losses in the damping resistor as compared with thetraditional 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. Asystematic 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.

Index Terms:

Distribution static compensator (DSTATCOM), Hybrid topology, passive filter, power quality (PQ).

I.INTRODUCTION:

An electric power distribution system is the final stage in delivery of electrical power; it carries electricity from transmission system toindividual consumers. Except in a very few special situations, electrical energy has been generated, transmitted, distributed, andutilized as alternating current (AC). However, alternating current has several distinct disadvantages. One of these is the necessity ofsupplying reactive power with active power. Due to stored energy in the load and again send back to source, or presence of nonlinearloads 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, furtherequipment cost will increase. This incremental costs of equipment and wastage of energy causes electrical utilities to charge a highercost to industries or commercial customers where there is a low power factor. In traditional method, L-type filters with large value ofinductance were used to increase the quality of current to be injected.

This large value of inductor has low slew rate for tracking thereference 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 thetracking performance, but requires high value of dc-link voltage as that of L filter. In this paper an LCL filter is used to overcome theaforementioned draw backs. Capacitor is used in series with the LCL filter to decrease the voltage of DSTATCOM. This proposedmodel decreases the size of the passive components, rating of dc-link voltage, rating of VSI. It provides good tracking performance.

II.PROPOSED SYSTEM:
Principle of DSTATCOM:

DSTATCOM is power electronics based power quality improving device, which generates and /or absorbs the reactive power whoseoutput can be varied so as to maintain control of specific parameters of the electric power system.

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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 theac system through the reactance of the coupling transformer. Inverter is the main component of the DSTATCOM. The objective of aVSI is to produce a sinusoidal AC voltage with minimal harmonic distortion from a DC voltage.

The operation of the DSTATCOM isas follows: The voltage is compared with the AC bus voltage system (Vs). When the magnitude of AC bus voltage is above that of theVSI magnitude (Vc), the AC system considered that, DSTATCOM as inductance connected to its terminals. Otherwise if the voltagemagnitude of VSI is above that of the AC bus voltage magnitude, the AC system sees the D-STATCOM as capacitance connected toits terminals. If the VSI voltage magnitude is equal to AC bus voltage magnitude, then the reactive power exchange is zero. SupposeDSTATCOM has a DC active element or energystorage elements or devices on its DC side, it can able to deliver real power to thepower system.

This can be done by varying the phase angle of the DSTATCOM terminals and the phase shift of the AC powersystem. When VSI phase angle lags phase angle of the AC power system, the DSTATCOM absorbs the real power from the ACsystem, 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.

The Distribution Static Compensator (DSTATCOM) is a voltage source inverter based static compensator that is used for the correction of line currents. Connection (shunt) to the distribution network is via a standard power distribution transformer. The DSTATCOM is capable of generating continuously variable inductive or capacitive shunt compensation at a level up its maximum MVArating.The DSTATCOM continuously checks the line waveform with respect to a reference ac signal, and therefore, it can provide the correct amount of leading or lagging reactive current compensation to reduce the amount of voltage fluctuations.

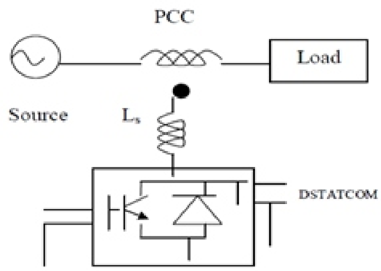

Fig 1.Block diagram of DSTATCOM circuit

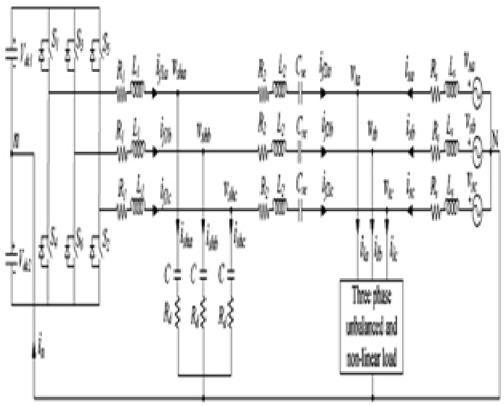

Fig. 2. Proposed DSTATCOM topology in the distribution system to compensate unbalanced and nonlinear loads.

Three-phase equivalent circuit diagram of the proposedDSTATCOM topology is shown in Fig. 1. It is realized usinga three-phase four-wire two-level neutral-point-clamped VSI.The proposed scheme connects an LCL filter at the front end of the VSI, which is followed by a series capacitor Cse. Introduction of the LCL filter significantly reduces the size of the passive component and improves the reference tracking performance.

WIND POWER:

Wind power is extracted from air flow using wind turbines or sails to produce mechanical or electrical power. Windmills are used for their mechanical power,windpumps for water pumping, and sails to propel ships. Wind power as an alternative to fossil fuels, is plentiful, renewable, widely distributed, clean, produces no greenhouse gas emissions during operation, and uses little land.[2]The net effects on the environment are far less problematic than those of nonrenewable power sources.

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Wind farms consist of many individual wind turbines which are connected to theelectric power transmission network. Onshore wind is an inexpensive source of electricity, competitive with or in many places cheaper than coal or gas plants.[3][4][5] Offshore wind is steadier and stronger than on land, and offshore farms have less visual impact, but construction and maintenance costs are considerably higher. Small onshore wind farms can feed some energy into the grid or provide electricity to isolated off-grid locations. Wind power is very consistent from year to year but has significant variation over shorter time scales. It is therefore used in conjunction with other electric power sources to give a reliable supply.

As the proportion of windpower in a region increases, a need to upgrade the grid, and a lowered ability to supplant conventional production can occur.[7][8] Power management techniques such as having excess capacity, geographically distributed turbines, dispatchable backing sources, sufficient hydroelectric power, exporting and importing power to neighboring areas, using vehicle-to-grid strategies or reducing demand when wind production is low, can in many cases overcome these problems.

In addition, weather forecasting permits the electricity network to be readied for the predictable variations in production that occur. As of 2014, Denmark has been generating around 40% of its electricity from wind,[14][15] and at least 83 other countries around the world are using wind power to supply their electricity grids.[16] Wind power capacity has expanded to 369,553 MW by December 2014,[17] and total wind energy production is growing rapidly and has reached around 4% of worldwide electricity usage.

III.CONTROL STRATEGY:

The overall control block diagram is shown in Fig.3. The DSTATCOM is controlled in such a way that the source currentsare balanced, sinusoidal, and in phase with the respectiveterminal voltages. In addition, average load power and losses in the VSI are supplied by the source. Since the source considered here is nonstiff, the direct use of terminal voltages to calculate reference filter currents will not provide satisfactory compensation Therefore, the fundamental positive sequence componentsof three-phase voltages are extracted to generate reference filter currents (i*f2a, i*f2b, and i*f2c) based on the instantaneoussymmetrical component theory.

These currents are givenas follows:

$$i^*_{\rm f2a} = i_{\rm la} - i^*_{\rm sa} = i_{\rm la} - \frac{v^+_{\rm ta1}}{\Delta^+_1}(P_{\rm lavg} + P_{\rm loss})$$

$$i^*_{\rm f2b} = i_{\rm lb} - i^*_{\rm sb} = i_{\rm lb} - \frac{v^+_{\rm tb1}}{\Delta^+_1}(P_{\rm lavg} + P_{\rm loss})$$

$$i^*_{\rm f2c} = i_{\rm lc} - i^*_{\rm sc} = i_{\rm lc} - \frac{v^+_{\rm tc1}}{\Delta^+_1}(P_{\rm lavg} + P_{\rm loss}) \qquad (1)$$

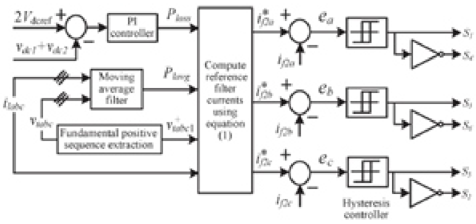

Fig. 3. Controller block diagram..

IV.SIMULATION RESULTS:

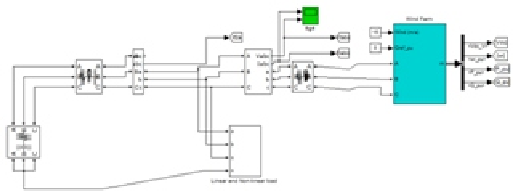

Fig:4 Windfarm based Without dstatcom

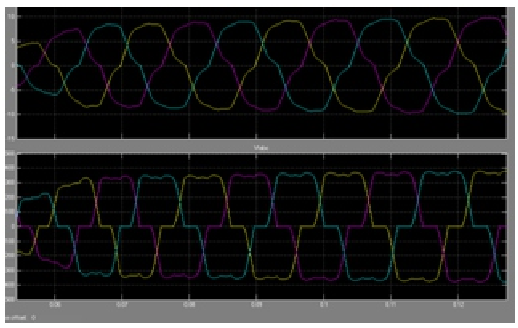

Fig.5: Source current & Load voltage

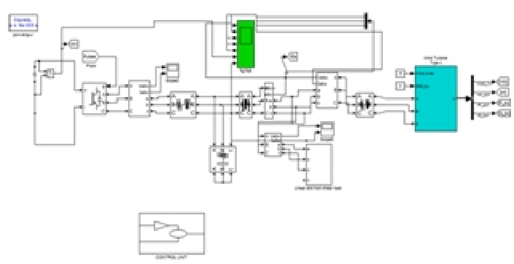

Fig.6: Wind farm based With dstatcom

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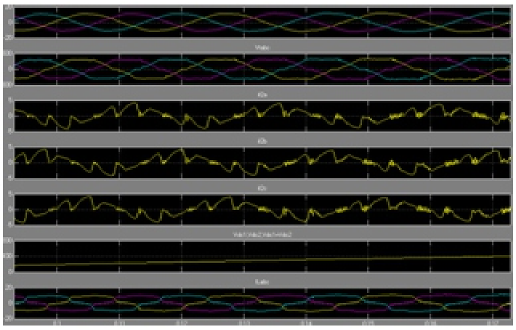

Fig.7 Source current,Load voltage,dstatcom currents (a,b,c), Vdc, Load Current

V.CONCLUSION:

The simulation results given that reduction of dc-link voltage, filter inductance, current through the shunt capacitor and dampingpower 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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