Design and Simulation of an Novel Single Phase Multilevel Inverter with D-STATCOM controller for Grid Connected wind Energy System

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Abstract:

This paper presents the planning of a completely unique multi-level D-STATCOM electrical converter for renewable energy systems victimization standard cascaded topology. The aim of the work is to represent the electrical converter with FACTS capabilities to supply utilities with the distribution systems, specifically on finish points. The electrical converter is placed between the renewable energy supply, specifically a wind turbine, and therefore the distribution grid so as to control the active and reactive power needed by the grid.

This electrical converter is capable of dominant active and reactive power by dominant its point in time and modulation index, severally. The distinctive contribution of the planned work is to mix the 2 ideas of electrical converter and D-STATCOM employing a novel voltage supply converter (VSC) multi-level(9 level) topology during a single unit with none further value. Simulations of the planned electrical converter, with five levels, are completed in Matlab/Simulink. The simulation results validate the performance of the planned management strategy.

Introduction::

One of the most common power quality problems today is voltage dips. A voltage dip is a short time (10 ms to 1 minute) event during which a reduction in r.m.s voltage magnitude occurs. It is often set only by two parameters, depth/magnitude and duration. The voltage dip magnitude is ranged from 10% to 90% of nominal voltage (which corresponds to 90% to 10% remaining voltage) and with a duration from half a cycle to 1 min. In a three-phase system a voltage dip is by nature a three-phase phenomenon, which affects both the phase-to-ground and phase-to-phase voltages.

A voltage dip is caused by a fault in the utility system, a fault within the customer's facility or a large increase of the load current, like starting a motor or transformer energizing. Typical faults are single-phase or multiple-phase short circuits, which leads to high currents. The high current results in a voltage drop over the network impedance. At the fault location the voltage in the faulted phases drops close to zero, whereas in the non-faulted phases it remains more or less unchanged.

Voltage dips are one in every of the foremost occurring power quality issues. Outage is worse, than a voltage dip, however voltage dips occur a lot of usually and cause severe issues and economical losses. Utilities usually specialise in disturbances from end-user instrumentation because the main power quality issues. This is often correct for several disturbances, flicker, harmonics, etc.,

however voltage dips chiefly have their origin within the higher voltage levels. Faults because of lightning, is one in every of the foremost common causes to voltage dips on overhead lines. If the economical losses due to voltage dips are important, mitigation actions will be profitable for the client and even in some cases for the utility. Since there's no normal resolution which can work for each web site, every mitigation action should be rigorously planned and evaluated.

There are alternative ways to mitigate voltage dips, swell and interruptions in transmission and distribution systems. At present, a large varies of terribly versatile controllers that make the most freshly accessible power physics elements, are rising for custom power applications. Among these, the distribution static compensator and also the dynamic voltage trained worker are best devices; each of them supported the VSC principle.

STATCOM is usually employed in gear mechanism. once it's employed in distribution system, it's referred to as D-STATCOMSTATCOM in Distribution system). D-STATCOM could be a key FACTS controller and it utilizes power physics to unravel several power quality issues usually visaged by distribution systems. Potential applications of D-STATCOM embody power issue correction, voltage regulation, load equalization and harmonic reduction. scrutiny with the SVC, the D-STATCOM has faster latent period and compact structure.

it's expected that the D-STATCOM can replace the roles of SVC in nearly future. D-STATCOM and STATCOM ar completely different in each structure and performance, whereas the selection of management strategy is expounded to the main-circuit structure and main perform of compensators [3], therefore D-STATCOM and STATCOM adopt completely different management strategy. At present, the utilization of STATCOM is wide and its strategy is mature, whereas the introduction of D-STATCOM is rarely according. several management techniques are according like instant reactive power theory (Akagi et al., 1984), power balance theory, etc.

during this paper, AN indirect current management technique (Singh et al., 2000a, b) is utilized to get gating signals for the Insulated Gate Bipolar junction transistor (IGBT) devices employed in current controlled voltage supply electrical converter (CC-VSI) operating as a DSTATCOM. A model of DSTATCOM is developed exploitation MATLAB for work the transient analysis of distribution system underneath balanced/ unbalanced linear and non-linear three-phase and single-phase hundreds (diode rectifier with R and R-C load). Simulation results throughout steady-state and transient in operation conditions of the DSTATCOM ar given and mentioned to demonstrate power issue correction, harmonic elimination and cargo equalization capabilities of the DSTATCOM system.

Distribution static compensator (STATCOM):

A D-STATCOM (Distribution Static Compensator), which is schematically depicted in Fig.1, consists of a two-level Voltage Source Converter (VSC), a dc energy storage device, a coupling transformer connected in shunt to the distribution network through a coupling transformer. The VSC converts the dc voltage across the storage device into a set of three-phase ac output voltages. These voltages are in phase and coupled with the ac system through the reactance of the coupling transformer. Suitable adjustment of the phase and magnitude of the D-STATCOM output voltages allows effective control of active and reactive power exchanges between the DSTATCOM and the ac system. Such configuration allows the device to absorb or generate controllable active and reactive power. The VSC connected in shunt with the ac system provides a multifunctional topology which can be used for up to three quite distinct purposes:

1. Voltage regulation and compensation of reactive power;

2. Correction of power factor; and

3. Elimination of current harmonics.

Here, such device is employed to provide continuous voltage regulation using an indirectly controlled converter.

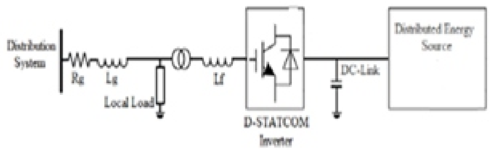

Fig 1: Complete configuration of the proposed D-STATCOM inverter system

Proposed D-Statcom inverter:

At this time, the cascaded multilevel converter is the newest topology for large scale commercial applications. Fig. 2 shows the configuration of the cascaded topology.

The structure of this topology is based on several modules in which each module consists of a floating capacitor and two switches. This topology is an ideal choice for FACTS applications if the capacitor voltages are kept balanced.

It requires only one DC source which is proper for renewable energy inverters, it is easy to design for higher levels, and it can deliver active and reactive power regardless of the load characteristics. Cascaded topology has a modular design based on identical converter cells which make it a suitable choice for high-level applications.

The main drawback of this topology is that it requires large capacitors in comparison with similar topologies which may affect the total cost of the inverter.

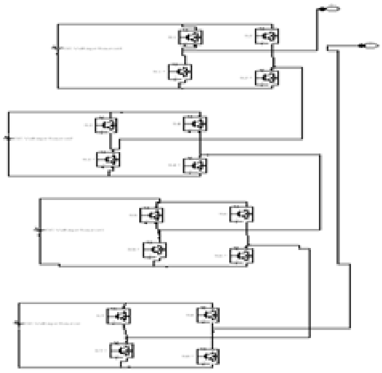

Fig 2: Cascaded 9 level inverter

Proposed Control Strategy:

This electrical converter is meant to regulate the flow of active and reactive power between the turbine and therefore the grid. it's able to offer utilities with distributive management of volt-ampere compensation and power issue (PF) on feeder lines.

to reinforce the reactive power management of the projected electrical converter it's equipped with the extra D-STATCOM choice. this feature permits the electrical converter to deliver reactive power totally freelance from the wind speed.

once the wind speed is just too low to get active power, the electrical converter acts as a supply of reactive power to regulate the PF of the grid, sort of a D-STATCOM.

The electrical converter is in a position to regulate the active and reactive power in spite of the input active power needed by the DC link. Generally, there square measure 2 modes of operation for D-STATCOM electrical converter once it's connected to the grid: 1) once active power is gained from the turbine, that is termed electrical converter mode, 2) once no active power is gained from the turbine, that is termed D-STATCOM mode.

The active and reactive power flow of the D-STATCOM is ruled by

$$P_S = \frac{mE_S E_L}{X}\sin\delta \qquad \& \qquad Q_s = \frac{mE_s E_L \cos\delta - E_L^2}{X}$$

Where Es,El,$,m and X are the voltage of the STATCOM, voltage of the line, power angle, modulation index, and inductance between the inverter and the grid, respectively.

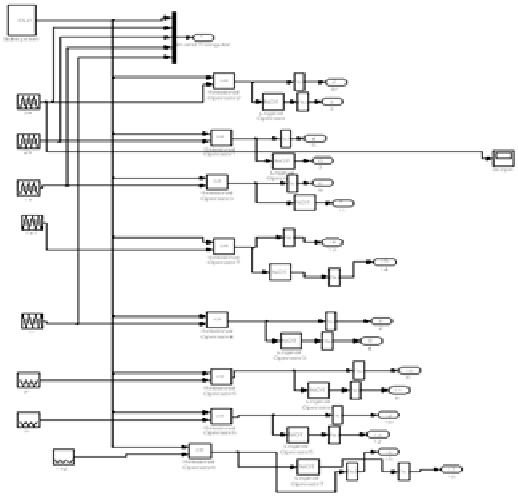

Fig 3 Proposed converter control strategy

SIMULATION RESULTS:

All the simulations of the proposed 9-level cascaded multilevel inverter were done in MATLAB/Simulink. The time of the simulation is T seconds which divides into three time frames.

The first time frame is before the 7th second being assumed that the wind speed is too low or zero. The simulated output voltage of the D-STATCOM inverter before filter is shown in below Fig. The power factor of the grid which is constant on the target PF of 0.90 regardless of the input power from wind turbine.

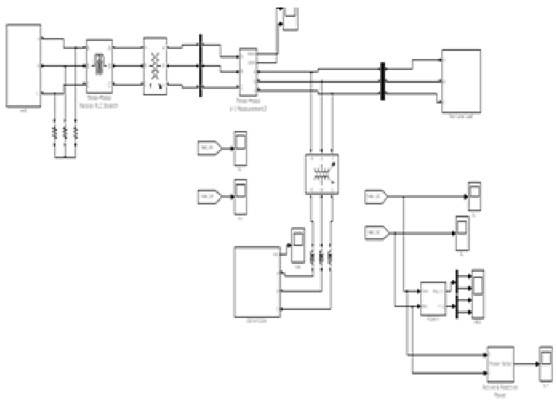

Fig 4: simulation circuit diagram for proposed and conventional system.

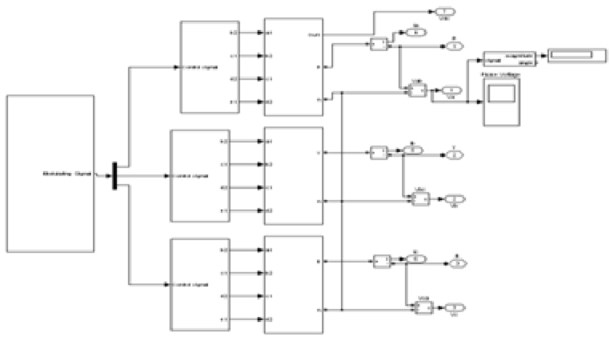

Fig 5: simulation model for DSTATCOM.

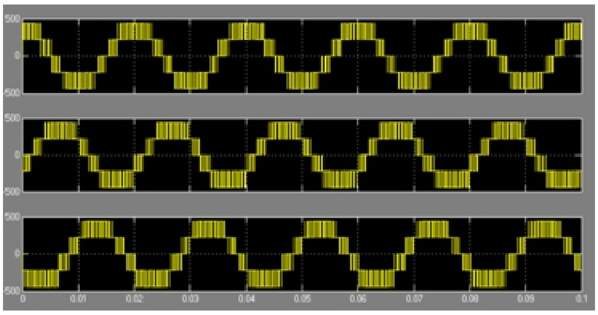

Fig 6: conventional s/ystem phase voltages.

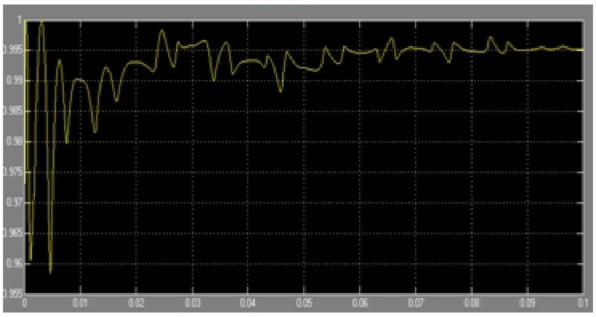

Fig 7: power factor of the grid for proposed system.

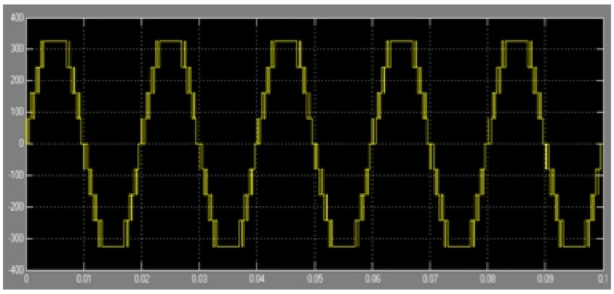

Fig 8 : proposed converter phase voltages.

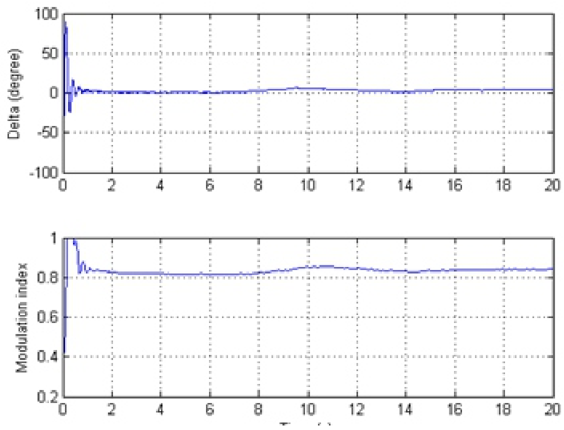

Fig.9. Power angle and modulation index

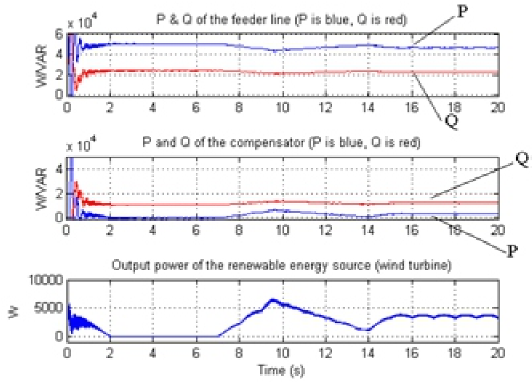

Fig 10 Active and reactive power of the feeder line, active and reactive power of the D-STATCOM inverter, and the output power of the wind turbine.

Conclusion:

In this proposed system the concept of a D-STATCOM electrical converter is bestowed. The projected electrical converter suggests a brand new approach during which tiny renewable sources may be wont to offer management and support in distribution systems. The cascaded 9 level DSTATCOM electrical converter has the flexibility to supply utilities with electrical phenomenon volt-ampere compensation and decreases the total harmonic distortion.

The distinctive work of this analysis is to mix the 2 ideas of D-STATCOM and electrical converter victimisation the foremost advanced multi-level topology to form one unit known as D-STATCOM electrical converter.

within the current analysis a brand new D-STATCOM electrical converter victimisation the foremost advanced multi-level topology known as cascaded is bestowed.

during this project, cascaded multilevel topology is employed because the voltage supply device (VSC) topology to form a D-STATCOM that's not solely able to regulate reactive power, however is ready to link to a turbine and regulate the active power transferred to the grid.

The projected device provides associate electrical converter and D-STATCOM during a single unit with none further value.

The projected DSTATCOM electrical converter will offer utilities with additional information at finish points of the distribution lines. The goal is to extend the penetration of renewable energy systems, specifically wind, to the distribution systems.

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