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An Advanced Control Strategy Based H-Statcom For Power Quality Enhancement

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ABSTRACT:

The performance of power systems decreases with the size, the loading and the complexity of the networks. This is related to problems with load flow, power oscillations and voltage quality. Such problems are even deepened by thechanging situations resulting from deregulation of the electrical power markets, where contractual power flows do no morefollow the initial design criteria of the existing network configuration. Additional problems can arise in case of large system interconnections, especially when the connecting AC links are weak. FACTS devices, however, provide the necessary featuresto avoid technical problems in the power systems and they increase the transmission efficiency.

This paper presents a studyon the design of a shunt connected FACTS device (STATCOM) and investigates the application of this device to control voltagedynamics and to damp out the oscillation in electric power system. STATCOM is one of the key shunt controllers in flexible alternating current transmission system (FACTS) to control the transmission line voltage and can be used to enhance the load ability of transmission line and extend the voltage stability margin. In this paper, the proposed shunt controller based on thevoltage source converter topology as it is conventionally realized by VSC that can generate controllable current directly at itsoutput terminal.

The performance and behavior of this shunt controller is tested in 3-machine 9-bus system as well as the performance is compared in the test system with and without STATCOM at three cases in MATLAB/Simulink. Simulation results prove that the modeled shunt controller is capable to improve the Power quality significantly.

KEYWORDS:
FACTS, H-STATCOM, VSC, CSC, Cascaded MLI, PLL, Wind Energy, PWM.

I.INTRODUCTION:

The traditional steady state stability studies and Transient stability studies take into account the active power flow P andpower angle ∂ and generally assume constant receiving and sending end bus voltage. The reacve power flow Q and voltagefall during heavy current flow is neglected. This approach could not explain the several black-outs in USA, Europe, Japan etc.during the last quarter of the twentieth century. The blackouts were due to voltage collapse. During voltage collapse, the busvoltage starts falling and as a result power transfer P through the transmission line starts reducing resulting in ultimatevoltage collapse and loss of system stability of entire network. That's why voltage stability studies have received moreattention and have acquired a vital place inpower system Studies. Voltage collapse phenomena take place where reactivepower management is inadequate.The application of power electronics in the electric power transmission plays an important role to make the system morereliable, controllable and efficient [1]. Due to deregulation, environmental legislations and cost of construction, it isbecoming increasingly difficult to build new transmission lines. Thus it is essential to fully utilize the capacities of the existingtransmission system. The flexible AC Transmission system (FACTS) has become a popular solution to our large/over extendedpower transmission & distribution system. FACTS devices are proving to be very effective in using the full transmissioncapacity while increasing power system stability, transmission efficiency and maintaining power quality and reliability of Power system.

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These devices are mainly based on either voltage source converter (VSC) or Current Source Converter (CSC) and have fast response time. As an important member of FACTS devices family, STATCOM has been at the centre of attention and the subject of active research for many years. STATCOM is a shunt connected device that is used to provide reactivepower compensation to a transmission line. This controller can either absorb or inject reactive power whose capacitive orinductive current can be controlled independent of the AC line voltage. Thus, STATCOM can enhance the transmission lineload ability by extending the MW margin and improves the oscillation of voltage transients through efficient regulation of thetransmission line voltage at the point of connection [1]-[3].This paper deals with the modeling of a H-STATCOM with a SPWM based controller implemented on a 3- phase system. The device is connected to a load bus with a converter transformer. The modeling of shunt controller and testingis simulated in the MATLAB/Simulink environment. The controller is represented as block diagram that presents practicalelectronic model of shunt controller.

WIND ENERGY CONVERSION:

Wind turbines capture power from the wind by means of aerodynamically designed blades and convert it to rotating mechanical power. The number of blades is three in a modern wind turbine. For multi-MW wind turbines the rotational speed is typically 10-15 rpm. The most weight efficient way to convert the low-speed, high-torque power to electrical power is to use a gear-box and a standard generator including a power electronic interface as illustrated in Figure 1.

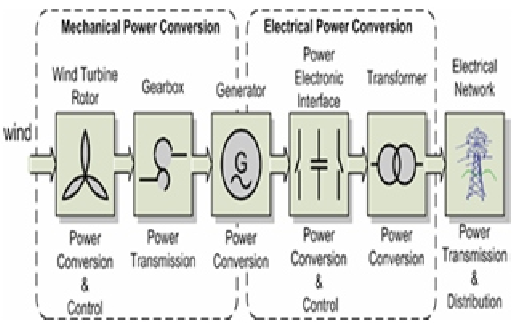

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Fig1.Power conversion stages in a modern wind turbine
The gear-box is optional as multi-pole generator systems are also possible solutions. Between the grid and the generator a power converter can be inserted. The electrical output can either be AC or DC.

II.PROPOSED SYSTEM BASIC CONFIGURATION AND PRINCIPLE OF OPERATION:

Cascaded H-Bridges inverter:

A single-phase structure of an m-level cascaded inverter is illustrated in Figure 31.1. Each separate dc source (SDCS) is connected to a single-phase full-bridge, or H-bridge, inverter. Each inverter level can generate three different voltage outputs, +Vdc, 0, and –Vdc by connecting the dc source to the ac output by different combinations of the four switches, S1, S2, S3, and S4. To obtain +Vdc, switches S1 and S4 are turned on, whereas –Vdc can be obtained by turning on switches S2 and S3. By turning on S1 and S2 or S3 and S4, the output voltage is 0. The ac outputs of each of the different full-bridge inverter levels are connected in series such that the synthesized voltage waveform is the sum of the inverter outputs. The number of output phase voltage levels m in a cascade inverter is defined by m = 2s+1, where s is the number of separate dc sources. An example phase voltage waveform for an 11-level cascaded H-bridge inverter with 5 SDCSs and 5 full bridges is shown in Figure 31.2. The phase voltage van = va1 + va2 + va3 + va4 + va5.

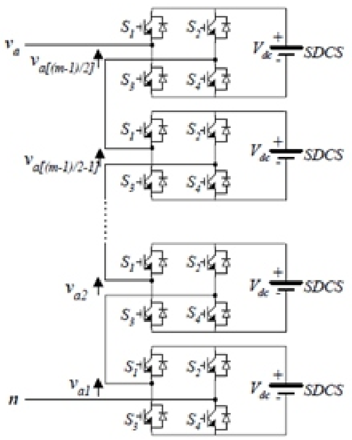

Fig1: Single Phase Cascaded H-Bridges

The above figure shows for single phase whereas in this proposed system is for 3 phase system.

III.CONTROL STRATEGY:

STATCOM can be controlled in voltage control mode and Var control mode.

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The control used in this simulation is ACvoltage control mode. Mainly, the control is divided into two parts. One is for angle order and another is for the order ofmodulation index. The shunt converter is operated in such a way as to demand this DC terminal power from the line keepingthe voltage across the storage capacitor Vdc constant. So, according to equation-1, the angle is ordered in such a way that the net real power absorbed from the line by this shunt FACTS device is equal to the losses of the converters and thetransformer only. The remaining capacity of this shunt converter can be used to exchange reactive power with the line so toprovide VAR compensation at the connection point. The reactive power according to equation-2 is electronically provided bythe shunt converter and the active power is transmitted to the DC terminals. The shunt converter reactive current isautomatically regulated to maintain the transmission line voltage at the point of connection to a reference value.

The line voltage and Dc link voltage across capacitor are measured to calculate the amount of reactive power to regulatethe line voltage and consequently the modulation index is varied in such a way as to calculate reactive power can be injectedat the point of connection and thus the shunt FACTS device acts as a voltage regulator. The SPWM firing pulses to the GTOsare obtained by comparing the PWM carrier signal and the reference sine wave. The following figure shows the block diagram of control strategy to generate only one pulse width modulated signal can be generated.

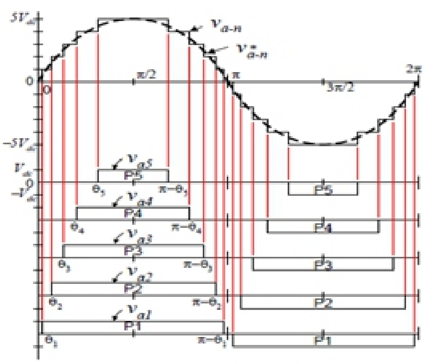

Fig3.voltage levels form example

The above figure shows the example of forming the output voltage levels.

IV.SIMULATION RESULTS:

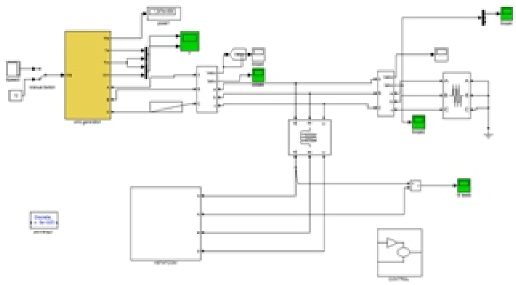

Fig -4: Extension circuit

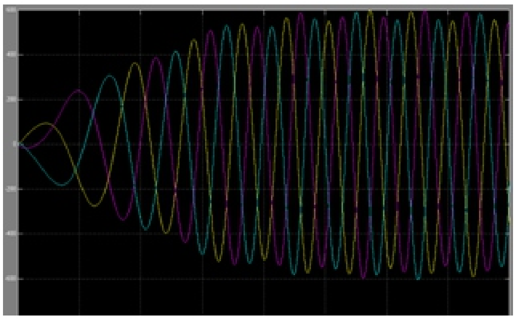

Fig .5: Source voltage

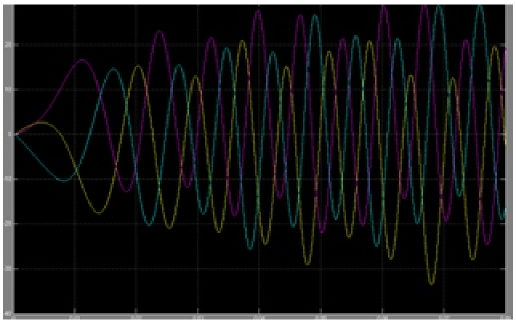

Fig 6.Source current

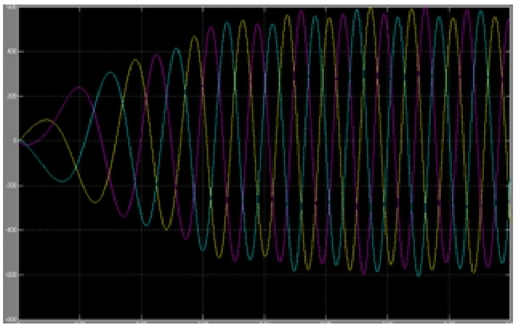

Fig 7.Load voltage

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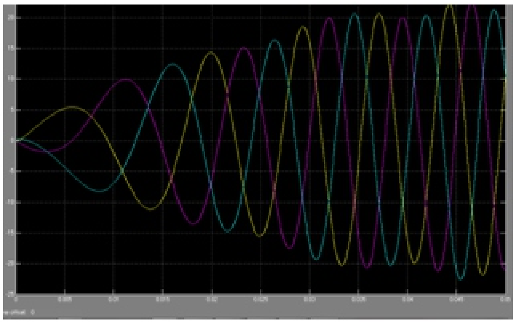

Fig8. Load current

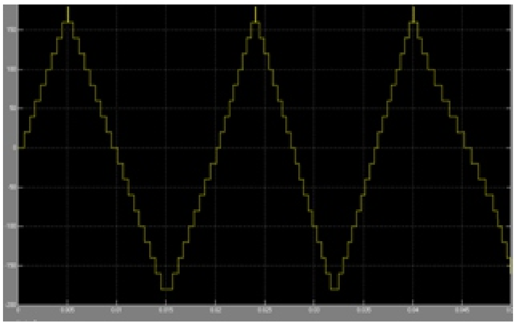

Fig 9. 19 level output voltage of multilevel inverter

V.CONCLUSION:

In simulation, worst events are considered to examine the performance of modeled shunt connected FACTS device. Thesimulation results show that the modeled STATCOM is capable enough to control the transmission line voltage dynamics aswell as the same shunt controller can be used in VAR control mode. Vdc is regulated by controlling proper phase shift andtransmission voltage is regulated by varying the modulation index. Cascaded H-bridges for 3 phases are used. The response of controller is very fast due to apply direct control method. The simulation results alsoprove that the shunt device with proposed switching scheme functions successfully as the real time voltage controller and itimproves the dynamic stability with a wide range of control.

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