Harmonic Current Compensation Capability in Grid Connected DG System by Using STATCOM

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Abstract- This paper presents a new nonlinear current control strategy based on back-stepping control and high-order Sliding Mode Differentiator (SMD) in order to employ Distributed generation (DG) unit interfacing converters to actively compensate harmonics/inter-harmonics of local loads. The converter-based DG unit is connected to a weak grid (with uncertain impedance) and local load (that can be parametrically uncertain and topologically unknown) through an Inductor-Capacitor-Inductor (LCL) filter. The proposed strategy robustly regulates the inverter output currents and delivers pure sinusoidal, three-phase balanced currents to the grid, the drawbacks of Higher Order SMD is better and it may lead to limit cycle if the switching gain is not properly taken, Switching losses ,Voltage Fluctuation. To overcome existing system drawbacks is done using Distribution static compensator (D-STATCOM) is a shunt connected FACTS device which supplies reactive power to the load to improve the voltage stability of the load busses. The D-STATCOM in multi bus system and is capable of reducing the losses and improving the voltage regulation.

Keywords- AC transmission, FACTS power flow controller, inverter

I. INTRODUCTION

Power Generation and Transmission is a complex process, requiring the working of many components of the power system in tandem to maximize the output. One of the main components to form a major part is the reactive power in the system. It is required to maintain the voltage to deliver the active power through the lines. Loads like motor loads and other loads require reactive power for their operation. To improve the performance of ac power systems, we need to manage this reactive power in an efficient way and this is known as reactive power compensation. There are two aspects to the problem of reactive power compensation: load compensation and voltage support. Load compensation consists of improvement in power factor, balancing of real power drawn from the supply, better voltage regulation, etc. of large fluctuating loads. Voltage support consists of reduction of voltage fluctuation at a given terminal of the transmission line. Two types of compensation can be used: series and shunt compensation. These modify the parameters of the system to give enhanced VAR compensation. In recent years, static VAR compensators like the STATCOM have been developed. These quite satisfactorily do the job of absorbing or generating reactive power with a faster time response and come under Flexible AC Transmission Systems (FACTS). This allows an increase in transfer of apparent power through a transmission line, and much better stability by the adjustment of parameters that govern the power system i.e. current, voltage, phase angle, frequency and impedance.

II. STATCOM

Statcom is mostly used in power system for improving quality of power transmitted form source to load. Everyday we are dealing with real and reactive power which can determine the quality of power transmitted from source to load.

A static synchronous compensator is also known as a “static synchronous condenser” ("STATCOM"), is a regulating device used on alternating current transmission networks. It is based on a power electronics voltage-source converter and can act as either a source or sink of reactive AC power to an electricity network. If connected to a source of power it can also provide active AC power. It is a member of the FACTS family of devices.

STATCOM or Static Synchronous Compensator is a power electronic device using force commutated devices like IGBT; GTO etc. to control the reactive power flow through a power network and thereby increasing the stability of power network. STATCOM is a shunt device i.e. it is connected in shunt with the line. A Static Synchronous Compensator (STATCOM) is also known as a Static Synchronous Condenser (STATCOM). It is a member of the Flexible AC Transmission System (FACTS) family of devices.

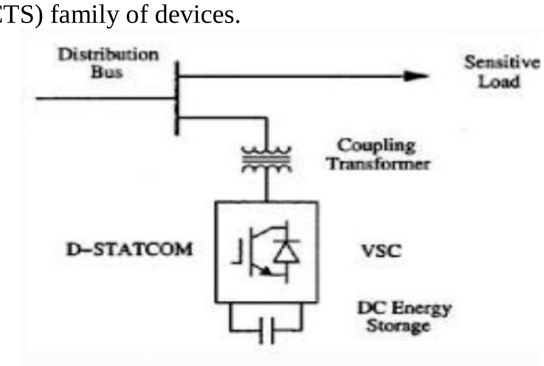

Fig.1: STRUCTURE OF STATCOM

The terms Synchronous in STATCOM mean that it can either absorb or generate reactive power in synchronization with the demand to stabilize the voltage of the power network.

a. VOLTAGE SOURCE CONVERTER, VSC

The main requirement in a powe transmissionsystem is the precise control of active and reactive power flow to maintain the system voltage stability. This is achieved through an electronic converter and its ability of converting electrical energy from AC to DC or vice versa.

b. IGBT

The Insulated Gate Bipolar Transistor (IGBT) is a minority-carrier device with high input impedance and large bipolar current-carrying capability. Many designers view IGBT as a device with MOS input characteristics and bipolar output characteristic that is a voltage-controlled bipolar device. To make use of the advantages of both Power MOSFET and BJT, the IGBT has been introduced. It's a functional integration of Power MOSFET and BJT devices in monolithic form. It combines the best attributes of both to achieve optimal device characteristics [2]. The IGBT is suitable for many applications in power electronics, especially in Pulse Width Modulated (PWM) servo and three-phase drives requiring high dynamic range control and low noise. It also can be used in Uninterruptible Power Supplies (UPS), Switched-Mode Power Supplies (SMPS), and other power circuits requiring high switch repetition rates. IGBT improves dynamic performance and efficiency and reduced the level of audible noise. It is equally suitable in resonant-mode converter circuits. Optimized IGBT is available for both low conduction loss and low switching loss

c. DC CAPACITOR

DC Capacitor is used to supply constant DC voltage to the voltage source converter, VSC.

d. INDUCTIVE REACTANCE

A Transformer is connected between the output of VSC and Power System. Transformer basically acts as a coupling medium. In addition, Transformer neutralizes harmonics contained in the square waves produced by VSC.

e. HARMONIC FILTER

Harmonic Filter attenuates the harmonics and other high frequency components due to the VSC. A simplified diagram along with equivalent electrical circuit of STATCOM is shown in figure below.

f. EQUIVALENT CIRCUIT

The figure shows the equivalent circuit of a STATCOM system. The GTO converter with a dc voltage source and the power system are illustrated as variable ac voltages in this figure. These two voltages are connected by a reactance representing the transformer leakage inductance. Using the classical equations that describe the active and reactive power flow in a line in terms of Vi and Vs, the transformer impedance (which can be assumed as ideal) and the angle difference between both bars, we can defined P and Q. The angle between the Vs and Vi in the system is d.

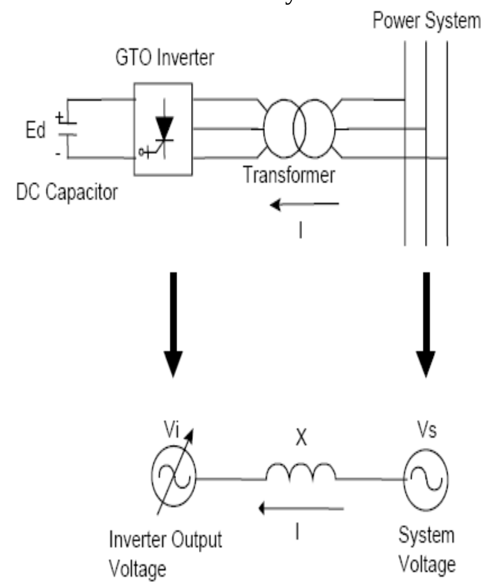

Fig.2: EQUIVALENT CIRCUIT

When the STATCOM operates with d=0 we can see how the active power send to the system device becomes zero while the reactive power will mainly depend on the voltage module. This operation condition means that the current that goes through the transformer must have a +/-90º phase difference to Vs. In other words, if Vi is bigger than Vs, the reactive will be send to the STATCOM of the system (capacitive operation), originating a current flow in this direction. In the contrary case, the reactive will be absorbed from the system through the STATCOM (inductive operation) and the current will flow in the opposite direction. Finally if the modules of Vs and Vi are equal, there won´t be neither current nor reactive flow in the system. Thus, we can say that in a stationary state Q only depends on the module difference between Vs and Vi voltages. The amount of the reactive power is proportional to the voltage difference between Vs and Vi.

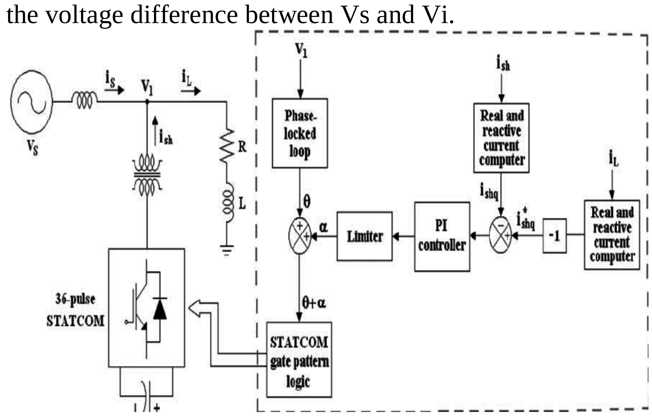

Fig.1: BLOCK DIAGRAM OF STATCOM

A. USES

Usually a STATCOM is installed to support electricity networks that have a poor power factor and often poor voltage regulation. There are however, other uses, the most common use is for voltage stability. A STATCOM is a voltage source converter (VSC)-based device, with the voltage source behind a reactor. The voltage source is created from a DC capacitor and therefore a STATCOM has very little active power capability. However, its active power capability can be increased if a suitable energy storage device is connected across the DC capacitor. The reactive power at the terminals of the STATCOM depends on the amplitude of the voltage source. A Transformer is connected between the output of VSC and Power System. Transformer basically acts as a coupling medium. In addition, Transformer neutralizes harmonics contained in the square waves produced by VSC.

B. SIMULATION

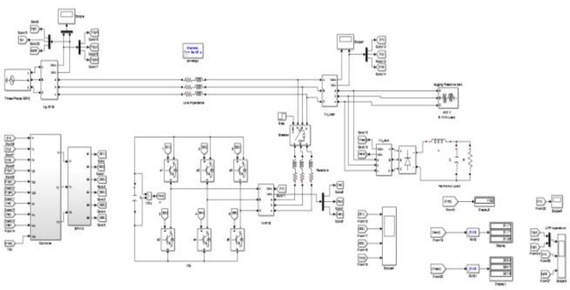

Fig.2: SIMULATION DIAGRAM

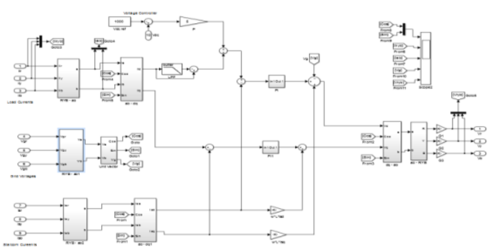

Fig.3:SUB SYSTEM

C. WAVEFORMS

Fig.4: INPUT AND OUTPUT VOLTAGE

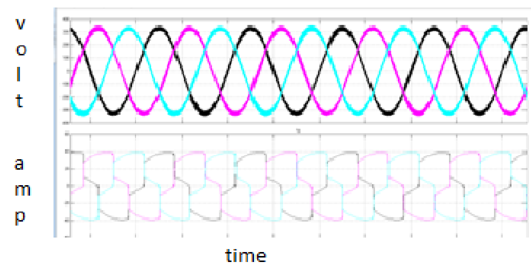

Fig.5: OUTPUT VOLTAGE AND CURRENT

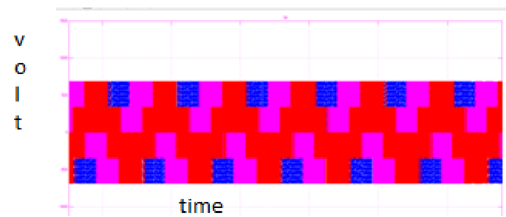

Fig.6: INVERTER OUTPUT VOLTAGE

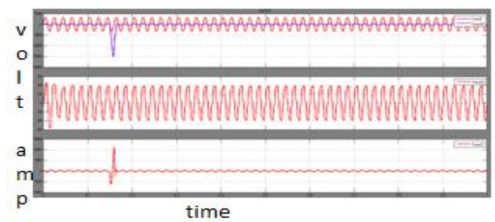

Fig.7: UPF OPERATION

S.NO	BASE PAPER	EXTENSION PAPER
THD	24.2%	6.01%

Fig.8: TABLE OF THD

III. CONCLUSION

The study of the basic principles of the STATCOM is carried out as well as the basics of reactive power compensation using a STATCOM. A power flow model of the STATCOM is attempted and it is seen that the modified load flow equations help the system in better performance. The bus system shows improved plots and the thus we can conclude that the addition of a STATCOM controls the output of a bus in a robust manner.

 ISSN: 2393-9028 (PRINT) | ISSN: 2348-2281 (ONLINE)

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