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Reactive Power Compensation using STATCOM

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***Abstract*-The continuous demand in electric power system network has caused the system to be heavily loaded leading to voltage instability. However, Flexible Alternating Current Transmission System (FACTS) devices provide the necessary features to avoid technical problems in the power systems. They also increase the transmission line efficiency. Among the FACTS family is Static Synchronous Compensator (STATCOM). The STATCOM (Static Synchronous Compensator) is the shunt connected FACTS devices which are connected to line via voltage source converter. Use of FACTS device is a best solution to mitigate the problem of reactive power compensation without construction of new transmission lines. It injects the compensating current in phase quadrature with line voltage, it can emulate as inductive or capacitive reactance so as to produce capacitive power for the AC grid or draws inductive power from the ac grid to control power flow in the line.**

Keywords- FACTS, STATCOM, Controller design, PI controller

I. INTRODUCTION

The increasing demand of electricity with high power quality along with more reliable and secure power system is fulfilled by providing the electricity which operates more flexibly and with best utilization. This increasing demand can be fulfilled either by installing new transmission lines or by increasing power transfer capability of the transmission line. The effective and economical solution is to increase transfer capability of transmission line giving attention to more utilization. To operate the power system in a flexible manner, controlling action should be made fast by utilizing the advance research and development in power electronics technology. The power transmission capacity has been enhanced without exceeding the thermal limit of transmission line and is achieved by incorporating Flexible AC Transmission System (FACTS) technology. To compensate for the distorted current drawn by the rectifiers from the utility grid and statcom .

A STATCOM or Static Synchronous Compensator is used for voltage compensation at the receiver end of a transmission lines, thus replacing banks of shunt capacitors. When used for this purpose, STATCOMs offer a number of advantages over banks of shunt capacitors, such as much tighter control of the voltage compensation at the receiver end of the ac transmission line and increased line stability during load variations . It is build based on power electronics Voltage Source Converter and can act as either a source or sink of reactive AC power which is tied to a transmission line. The STATCOM regulates the voltage magnitude at its terminals by controlling the amount of reactive power injected into or absorbed from the power system. When system voltage is low, the STATCOM generates reactive power (STATCOM capacitive). When system voltage is high, it absorbs reactive power (STATCOM inductive). So the shunt controller is therefore a good way to control voltage in and around the point of connection through injection of reactive current (leading or lagging) alone or a combination of active and reactive current for a more effective voltage control and damping of voltage dynamics . The controllable reactive power allows for a rapid control of bus voltage and power factor at the system or at the load end. The linear control is more suitable for STATCOM application reported in. The present paper suggests the design of a linear current controller and voltage controller on the basis of gain and time constant adjustment along with the parameter of the coupling inductor and storage capacitor. These controllers are used in STATCOM and control the reactive power for improvement of power factor on variation of DC link voltage. The interconnected Grids become unstable as the heavy loads vary dynamically in their magnitude and phase angle and hence power factor . Commissioning new transmission systems are extremely expensive and take considerable amount of time to build up. STATCOM has no long term energy support on the dc side and it cannot exchange real power with the ac system.

II. OPERATIONAL PRINCIPLE OF STATCOM

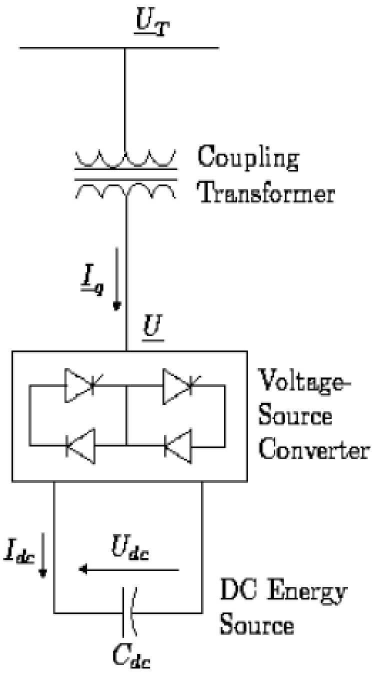

Fig 2.1: Static Synchronous Compensator

A STATCOM is a controlled reactive power source. It provides voltage support by generating or absorbing reactive power at the point of common coupling without the need of large external or capacitor banks. The basic voltage source converter scheme is shown in figure 2.1. The charged capacitor C_{dc} provides a dc voltage to the converter, which produces a set of controllable three phase out put voltages with frequency of the ac power system. By varying the amplitude of the output voltage U, the reactive power exchange between the converter and the AC system can be controlled. If the amplitude of the output voltage U is increased above that of the AC system U_T, a leading current is produced, i.e. the STATCOM is seen as a conductor by the system and reactive power is generated. By decreasing the amplitude of the output voltage below that of AC system, a lagging current results and the STATCOM is seen as an inductor. In this case reactive power is absorbed. If the amplitudes are equal no power exchange takes place.A practical converter is not lossless. The mechanism of phase angle adjustment can also be used to control the reactive power generated or absorbed by increasing or decreasing the capacitor voltage U_{DC} and thereby the output voltage U. The derivation of the formula for the transmitted active power employs considerable calculations.

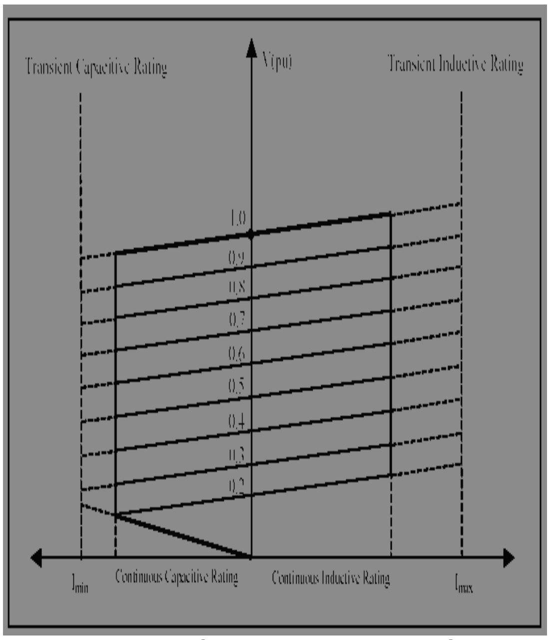

Fig 2.2 :Static Synchronous Compensator V-I Characteristics

The characteristics of STATCOM shown in fig 2.2 tells very clearly that it has the ability to support a very low system voltage; down to about 0.15 per unit, which is the value associated with the coupling transformer reactance. This is in strong contrast with that of a SVC when compared, which at full capacitive output becomes an uncontrolled capacitor bank. A STATCOM can support system voltage at extremely low voltage conditions as long as the dc capacitor can retain enough energy to supply losses.

A. *MODELING OF STATCOM*

The STATCOM is comprised of one voltage controlled source converter along with its associated shunt connected transformer. As there are no moving parts in STATCOM, it can be considered as a STATIC counterpart of rotating synchronous condenser. The absence of mechanical rotating parts makes STATCOM generate or absorb power at a faster rate unlike a regular synchronous generators

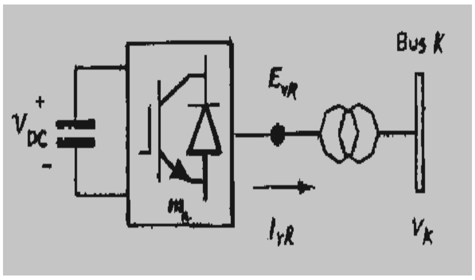

Fig 2.1.1: VSC connected to the AC network via a shunt connected transformer

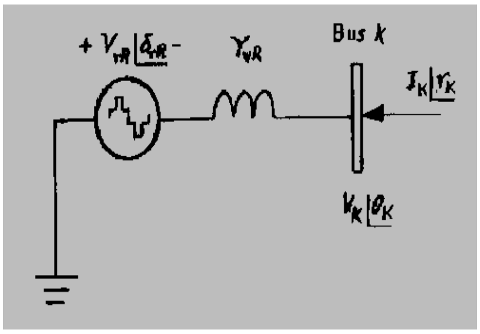

Fig 2.1.2: shunt solid state voltage source

The figures 2.1.1 and 2.1.2 represents the schematic view of STATCOM and the equivalent circuit of it respectively. Fig 2.1.2 also corresponds The equivalent circuit corresponds to the Thevenin equivalent as seen from bus k, with the voltage source E_{vR} being the fundamental frequency component of the VSC output voltage, resulting from the product of V_{DC} and m_a.. In steady-state fundamental frequency studies the STATCOM may be represented in the same way as a synchronous condenser, which in most cases is the model of a synchronous generator with zero active power generation. A more flexible model may be realized by representing the STATCOM as a variable voltage source E_{rR}, for which the magnitude and phase angle may be adjusted, using a suitable iterative algorithm, to satisfy a specified voltage magnitude at the point of connection with the AC network.

The shunt voltage source of the three-phase STATCOM may be represented by

$$E^p_{rR} = V^p_{rR}(\cos\delta^p_{rR} + j\sin\delta^p_{rR}).$$

Where p indicates phase quantities. a, b, c. The voltage magnitude, V^p_{rR} is given maximum and minimum limits, which are a function of the STATCOM capacitor rating.

However δ^p_{Rr} may take any value between 0 and 2π radians. With reference to the equivalent circuit shown in fig and assuming three-phase parameters, the following transfer admittance equation can be written:

$$[I_k] = [Y_{rR} \ \ -Y_{rR}] \, [V_k \ \ E_{vR}]^T$$

Where $I_k = [I_k{}^a \llcorner \gamma_k{}^a \quad I_k{}^b \llcorner \gamma_k{}^a \quad I_k{}^c \llcorner \gamma_K{}^a]^T$

$$E_{vR} = [V^a{}_{rR\llcorner}\theta\delta^a{}_{rRk} \ V^b{}_{rRk\llcorner}\theta\delta^b{}_{rRk} \ V^c{}_{rRk\llcorner}\theta\delta^c{}_{rRk}]^T$$

and Y_{rR} is a diagonal m atrix with $Y^a{}_{rR}$, $Y^b{}_{rR}$, and $Y^c{}_{rR}$ in the principal diagonal.

III. SIMULATION OF STATCOM

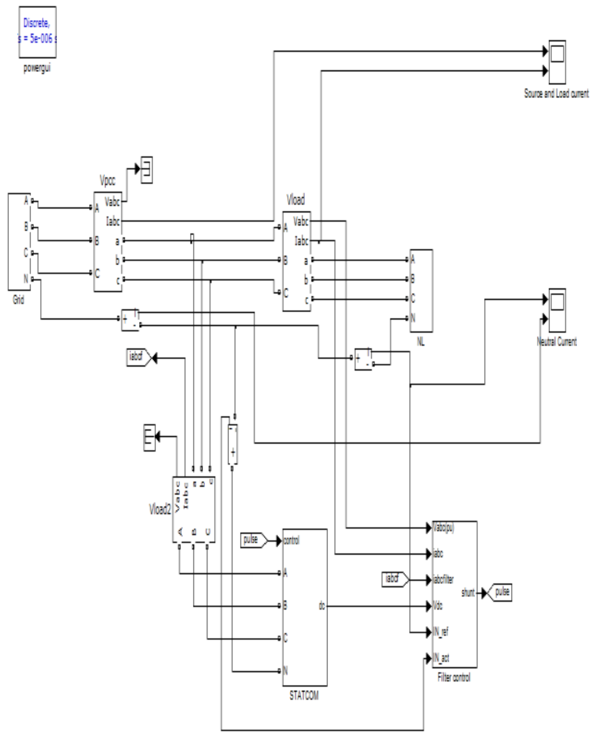

Fig.3.1: Simulation for STATCOM in a grid connected system

Fig.3.1. shows the working of STATCOM controller. The pulse from the STATCOM controller is given to the input of the inverter thus providing compensating the required reactive power and maintaining the dc voltage as constant. The input to the STATCOM controller is control pulse which switches in order of the pulse given.

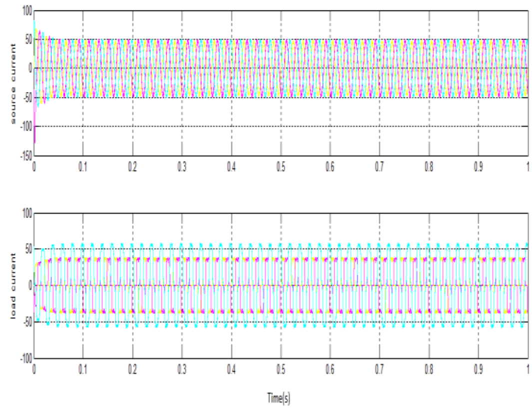

Fig.3.2: Simulink waveform of grid and load current

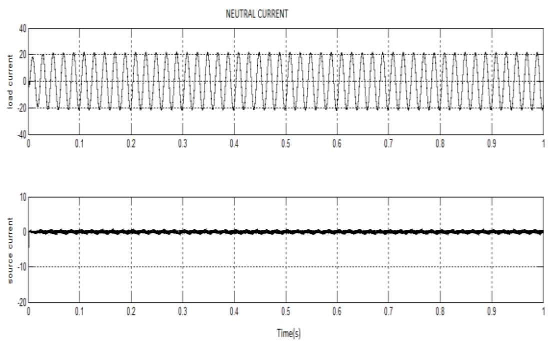

Fig.3.3:Simulink waveform for neutral grid and load current

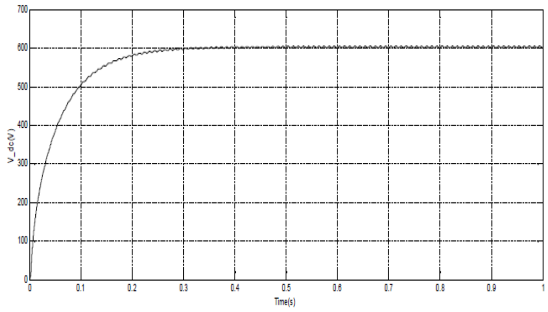

Fig.3.4: Waveform for constant dc link voltage

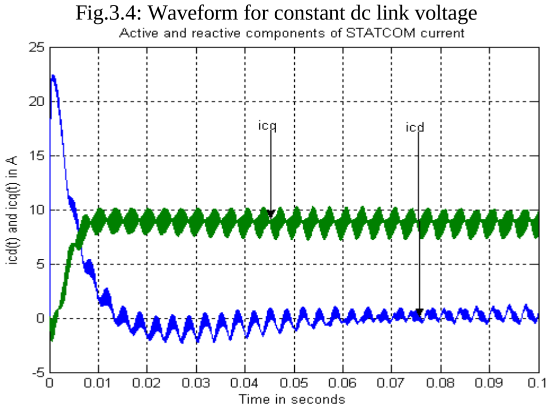

Fig.3.5: Active and reactive components of STATCOM current

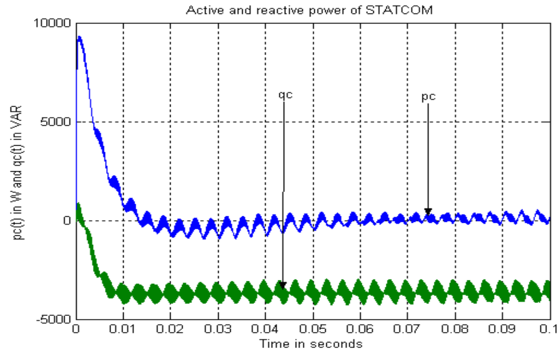

Fig.3.6: Active and reactive power of STATCOM

IV. CONCLUSIONS

STATCOM (Static Synchronous Compensator) is an important device for Flexible AC Transmission System (FACTS),which is the third generation of dynamic VAR compensation device after FC, MCR, and TCR type of SVC (Static VAR Compensator). Its reactive current can be flexibly controlled and compensate reactive power for system automatically. It solves problem of harmonics interfere switching parallel capacitor banks. STATCOM has superior performance in lots of aspect such as responding speed, stabilize voltage of power grid, reduce system power loss and harmonics, increase both transmission capacity and limit for transient voltage. Here we can see that the reactive power is compensated and also harmonics is mitigated by STATCOM.

The STATCOM is used to improve the power factor of the system. The developed vector control strategy gives better results and fast response for power factor improvement. This simulation is done for fixed DC bus voltage and variable modulation index one can make for variable DC bus voltage and fixed modulation index depending on the application.

REFERENCES

[1] Flexible AC Transmission System (FACTS) by Yong Hua Song and Allan T. Johns published by The Institute of Engineering and Technology, London, United Kingdom second edition 2008

[2] C.L.Wadhwa, “*Electrical Power Systems*”, Wiley Eastern Ltd, New Delhi,

[3] P.Kundur, “*Power System Stability and Control*”, EPRI, Power Engineering Series, 1994

[4] Vertika Jain, “Introduction to Fact Devices and Introducing New Generation of Statcom”, International Journal of Scientific Research Engineering & Technology (IJSRET), Volume 1 Issue 5 pp 022-027 August 2012.

[5] Lauttamus, P. ; Inst. of Power Electron., Tampere Univ. of Technol., Tampere ; “Three-level VSI based low switching frequency 10 MVASTATCOM in reactive power and harmonics compensation” Power lectronics, 2007. ICPE '07. 7th Internatonal Conference on 2007.