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Simulation & Performence Analysis Of HVDC Multigrid Transmission System Using Statcom

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***Abstract*— This The increasing demand of power supply in modern time increases the complexity of power system and due to quality and performance of power it becomes more noticeable. High Voltage Direct Current (HVDC) Transmission Systems are economically more beneficial than High Voltage Alternating Current (HVAC) Transmission Systems for long distances. The factors to be considered are Cost, Technical Performance, Reliability and High power rating. There are many advantages of HVDC over the HVAC systems for stability analysis. The system's point of view, operation and control of AC transmission system is too complex than DC. The main objective of DC link controllers at either end (rectifier and inverter) is to operate the link efficiently, under normal and abnormal conditions. In modern technical era, Flexible Alternating Current Transmission System (FACTS) devices are one of the popular controllers which can achieve and established a desired power condition at certain points. A FACTS device is used to enhance controllability and increases power transfer capability of the power system network. This paper deals with the stability problem at either end of rectifier and inverter of a HVDC link with STATCOM (Static Compensator), when connected to a weak AC system which has the stability enhancement for power instability and commutation failures. In this paper, the proposed shunt controller is based on the voltage source converter topology as it is conventionally realized by VSC that can generate controllable current directly at its Output terminal. The performance and behavior of this shunt controller is tested in power transmission network as well as it is compared in the test systems with and without STATCOM in MATLAB/Simulink. Simulation results prove that the modeled shunt controller is capable to improve the Performance of system significantly.**

***Index Terms*— FACTS;HVDC;STATCOM;VSC.**

I. Introduction

In modern era, increasing demand of power supply and improving transmission capabilities is important issues. HVDC transmission network is better than HVAC transmission for long transmission system. Due to the significant progress in power electronics technology during the past two decades, the use of High Voltage Direct Current (HVDC) power transmission is becoming more and more attractive. HVDC transmission offers significant advantages for the transfer of bulk power over a long distance transmission. But HVDC transmission connected converters inherently consume large amounts of reactive power; typically, the reactive power demands of the converter are 50% - 60% of the DC power being transferred. There are important concerns for the proper design and safe operation of HVDC thyristor converters, when it is connecting to weak AC systems such as low frequency resonances, high temporary over voltages (TOVs), risk of voltage instability, harmonic instability, long fault recovery times and increased risk of commutation failure. Many of these concerns are closely related to the AC voltage regulation at the converter bus. Generally, the associated reactive compensators and HVDC systems are operated and controlled independently and the interaction between them considered only under steady state condition. If the control become coordinates between the HVDC system and reactive power compensator, the performance in transient state and dynamic performance of HVDC system will be improved. The transient performance of HVDC system is very important. Since, the increasing demand of power in industries forced integration of HVDC system with AC system. After the development of FACTS controllers, the transmission capability becomes improved. These controllers improve the controllability and stability of power networks. STATCOM (Static Synchronous compensator) is one of the most important Flexible AC transmission system (FACTS) devices because of its ability to regulate voltages in transmission lines, to improve transient stability and to compensate variable reactive power. In this paper, the topology which is considered is that the characteristics of the line-commutated HVDC with a STATCOM at the inverter end. This proposed system comprises a black start function and a HVDC- STATCOM coordination control scheme. Furthermore, this paper investigates the advantages of cost reduction of the HVDC link filter design, overvoltage control and performance of HVDC system connected with STATCOM and without STATCOM.

II. HVDC Statcom System

Statcom is one of contrivance of FACTS family. Figure 1.1, shows high voltage Dc transmission utilizing STATCOM connected at the inverter side. It shows a property of mitigation of sag, swell and notches. It provides better power flow control. And additionally ameliorate the potency of transfer capability in a high voltage transmission line[2]. Customarily due to line charging, and withal due to thyristor switching at converter end, certain harmonics and voltage sag, swell takes place. so it directly affects the puissance quality, and reaches to the receiving end, and this poor quality power is given to the load, which leads to the malfunctioning and inefficient performance of the system. If STATCOM is connected at the receiving end afore the load then in case of

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any voltage instability or any fault. The astringency and quality is mitigated. So there by incrementing the puissant quality. And in today's arena power quality is main concern. In this Figure firstly AC supply is provided by alternator, and by designates of (customarily three phase) transformer voltage level is rectifier converter (thyristor cumulation, in this thesis 6 pulse is adopted), so afore alimenting to the rectifier it is called HVAC (high voltage AC transmission). And by rectifier DC output is taken, and it is called as a Dc link. This Dc supply is inverted by betokens of Inverter (which is a 6pulse arrangement of thyristor). And after getting Ac output from inverter, this is again alimented to the STATCOM for mitigation.

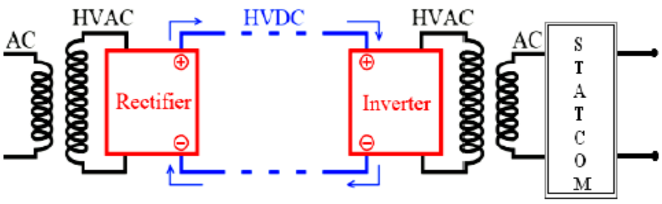

Figure 1: Statcom with HVDC system

Afore restarting the system, it will be compulsory to disconnect the load from the HVDC inverter. The STATCOM is precharged to supply the puissance to HVDC system through the small generator and a rectifier. The DC capacitor to be fed by the auxiliary power supply until the HVDC converter commences. When the DC capacitor is plenary charged, the STATCOM output voltage is ramped up (giving smooth energization of the transformer) and then the HVDC converter can be deblocked to commence transmitting active power. After HVDC system has recuperated, the disconnected switch is opened to isolate the auxiliary power supply to the DC capacitor of the STATCOM. Short term active power variation can be buffered and together with the reactive power perturbation to the main grid can be mitigated efficaciously.

III. Modeling Of Statcom

A STATCOM is a modern reactive power compensator that is based on the voltage source converter technology. Although it is made of power electronic circuits like an SVC, its behaviour is more like that of an SC. It is actually a fully controllable active compensator, as shown in Figure 3 (a). A STATCOM works as a controllable voltage source that holds the bus voltage before its limits are reached. The limit of a STATCOM is the current limit that it allows to flow through its power electronic circuit. Figure 3 (b) shows the voltage-current (VI) characteristics of a STATCOM. It should be noted that a STATCOM can provide its maximum current even if the voltage is dropped to a very low value. Its reactive power output beyond its controllable value is proportional to the bus voltage instead of proportional to the square of the bus voltage, as is the case with an SVC. This feature gives a STATCOM more capability to support the system voltage and improve the system voltage stability. The current limit of a STATCOM is normally imposed in the control system, for example limiting the Iq order in the DQ decoupling control. The current limits of the steady state and transient state are usually implemented with the same mechanism. Although they can be designed to allow a certain short-time over current in some circumstances, the difference between the limits of the steady state and the transient state would not be very large.

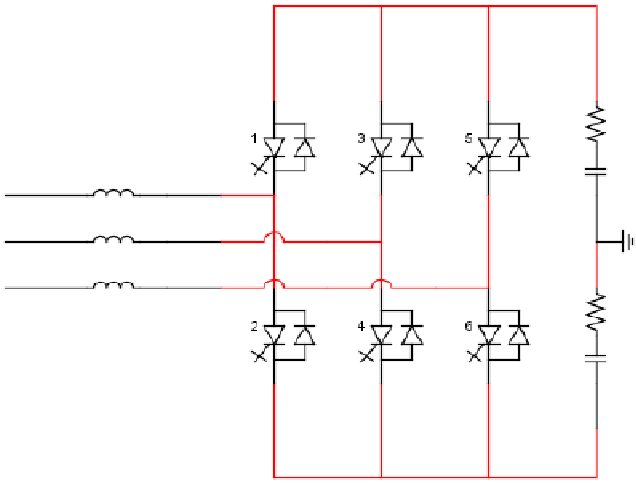

Fig (a)

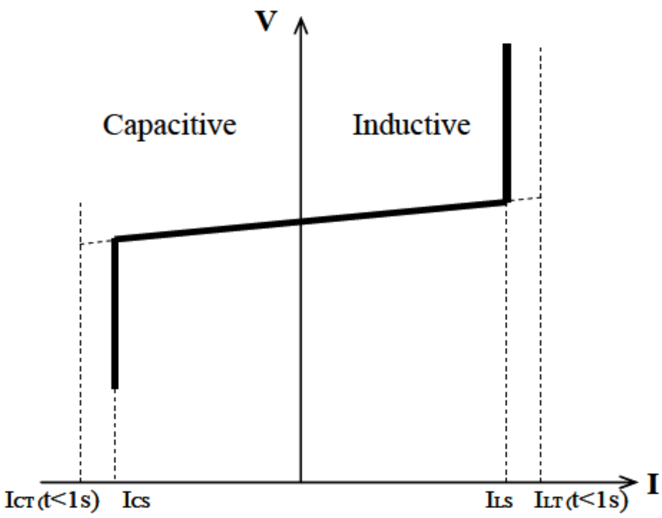

Fig (b)

Figure 3: STATCOM Circuit and VI Characteristic

3.1: Modelling of STATCOM

The terminal voltage and current of the STATCOM, at the point of connection, can be modelled by a vector representation [8-10]. This vector representation is ex- tended by a *d-q* model which leads to the definitions of instantaneous reactive current and active current. The voltage equations in the stationary *a-b-*c frame are:

$$e_a = L\frac{dIa}{dx} + V_a\ ,\ e_b = L\frac{dIb}{dx} + V_b\ ,\ e_c = L\frac{dIc}{dx} + V_c\ \text{...........(1)}$$

Also, the voltage equations in the rotating *d-q* frame and the input voltages in the rotating *d-q* frame are shown on Equation (2).

$$e_d = L\frac{dId}{dt} - \omega Li_q + V_d\ ,\quad e_d = L\frac{dIq}{dt} + \omega Li_d + V_qb\ ,\ \text{........}\qquad (2)$$

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$$e_d = |E|,\ e_q = 0$$

Since the active power (*P*) supplied from the input is directly proportional to the *d*-axis current *dI*, the d-axis reference current I_d is generated from the proportional and integral (PI)-type voltage controller for the DC-link voltage regulation. And the reactive power (*Q*) is directly proportional to the *q*-axis current I_q therefore, the reactive power equation and active power equation is shown n Equation (3) respectively.

$$P = \frac{3}{2}|E|\, i_d,\ Q = \frac{3}{2}|E|\, i_q \quad \ldots\ldots \quad (3)$$

The voltage equations shown in Equation (1) are transformed from the stationary *a-b-c* frame to the rotat- ing *d-q* frame as follows:

$$V_d = \omega L i_q + |E| + \Delta V_d,\ V_q = \omega L i_d + |E| + \Delta V_q \quad \ldots\ldots(4)$$

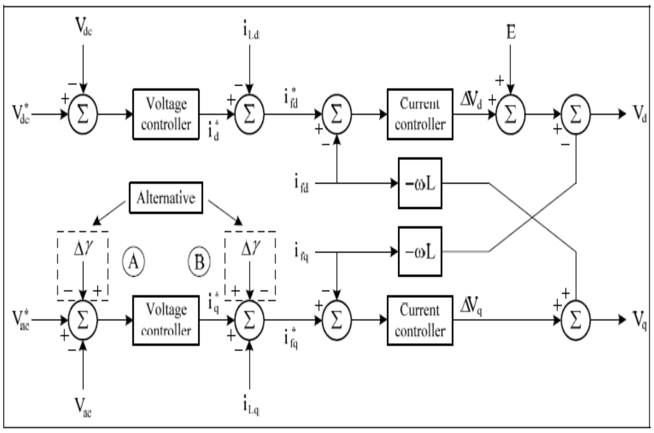

Figure 3.1: STATCOM controller model.

IV. SIMULATION & RESULT

The rectifier and the inverter which are gate-pulse based IGBT converters connected in series. The converters are interconnected through a 100-km line and 0.78H smoothing reactors as shown in Fig 5(a). The converter transformers (Wye grounded/Wye/Delta) are modeled with Three Phase Transformer (Three-Winding) blocks. The transformer tap changers are not simulated. The tap position is rather at a fixed position determined by a multiplication factor applied to the primary nominal voltage of the converter transformers (0.91 on the rectifier side,0.93 on the inverter side).

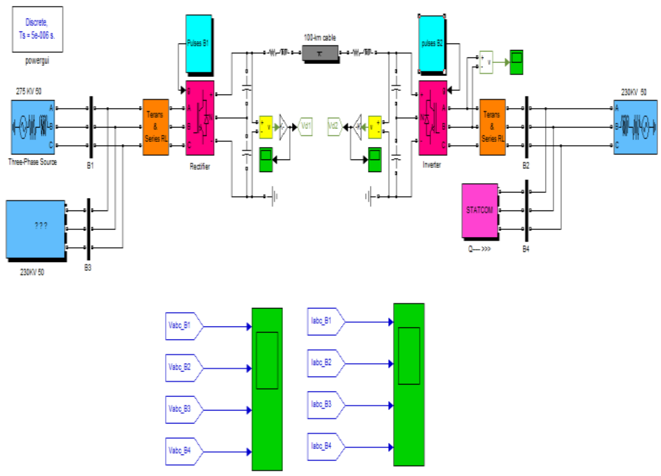

Figure 4.1: Simulink Model of HVDC with Statcom

The firing-angle control system is configured using pulse generator in series, one of which is operated as a modified HVDC bridge. The HVDC power converters with thyristor valves will be assembled in a converter bridge of twelve pulse configuration. This is accomplished by star-star connection and star-delta connection. Reduction of harmonic effects is another factor of investigation.

Here, MATLAB/SIMULINK program is used as the simulation tool. The firing angles are always maintained at almost constant or as low as possible so that the voltage control can be carried out. Three level IGBT bridges are the best way to control the DC voltage. Other bridges or convertors are not preferable of series due to the increase in harmonic content. The control of power can be achieved by two ways i.e., by controlling the current or by controlling the voltage. It is crucial to maintain the voltage in the DC link constant and only adjust the current to minimize the power loss. The rectifier station is responsible for current control and inverter is used to regulate the DC voltage. Firing angle at rectifier station and extinction angle at inverter station are varied to examine the system performance and the characteristics of the HVDC system. The voltage and current waveform are shown in figure. The output is get with STATCOM in HVDC network system.

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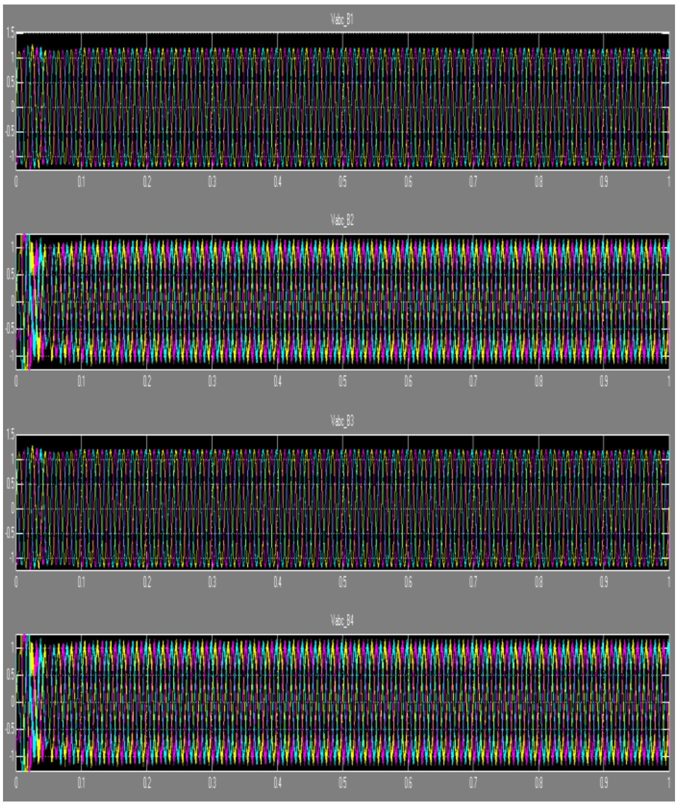

Figure 4.2: waveform of voltages in all bus system with STATCOM in HVDC system

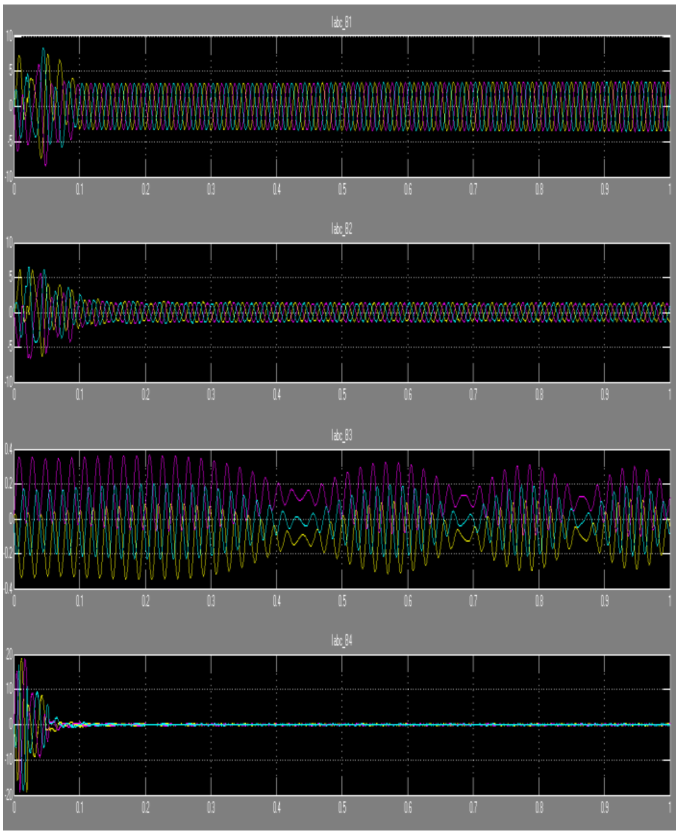

Figure 4.3: waveform of currents in all bus system with STATCOM in HVDC system

After the examiner of HVDC system with STATCOM. The Statcom is disconnected to Statcom. Without Statcom, the performance become reduces of HVDC network, which is shown in figure 4.4 and 4.5.

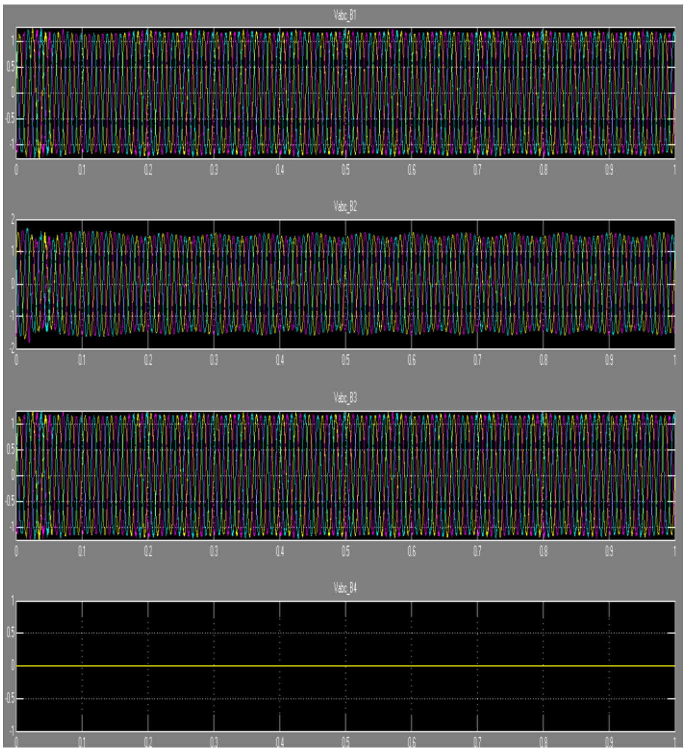

Figure 4.4: waveform of voltages in all bus system without STATCOM in HVDC system

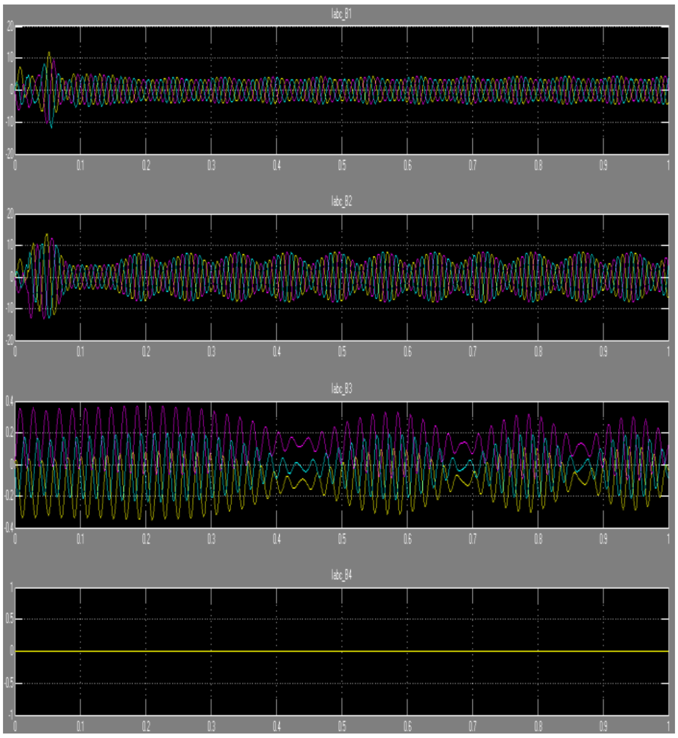

Figure 4.5: waveform of currents in all bus system with STATCOM in HVDC system

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V. Conclusion

In this paper we have analyzed voltage and current profile for different cases in HVDC line with and without STATCOM at time 1.1 seconds. Also considered the effect of power swing on transmission line components such as transformers etc. by using Matlab. This paper describes about the widespread of this project which has enlisted all aspects for High voltage direct current (HVDC) transmission. Good HVDC design begins with a thorough understanding of the basic concepts, their, and operation and control of HVDC system. There are many bases for operation and control before acting on them, but for High voltage direct current (HVDC) transmission there are many constraints. Hence it is required to test the systems for different condition, and checking the system for limit violations by using features of Power Flow.

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