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Performance Analysis of Single and Multi machine Systems over the Infinite bus with STATCOM

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Abstract— **Transmission networks of modern power systems are becoming increasingly stressed because of growing demand and restrictions on building new lines. One of the consequences of such a stressed system is the threat of losing stability following a disturbance. Flexible ac transmission system (FACTS) devices are found to be very effective in a transmission network for better utilization of its existing facilities without sacrificing the desired stability margin. Flexible AC Transmission System (FACTS) such as Static Synchronous Compensator (STATCOM) and Static VAR Compensator (SVC), employ the latest technology of power electronic switching devices in electric power transmission systems to control voltage and power flow. A static synchronous compensator (STATCOM) is a shunt device of the flexible AC transmission systems (FACTS) family. The STATCOM regulates voltage at its terminal by controlling the amount of reactive power injected into or absorbed from power system. When system voltage is low, STATCOM generates reactive power and when system voltage is high it absorbs reactive power. In this paper performance of STATCOM is analysed over the SMIB and MMIB systems.**

Keywords- **SMIB, MMIB, STATCOM, FACTS.**

I. INTRODUCTION

Modern electric power system is facing many challenges due to day by day increasing complexity in their operation and structure. In the recent past, one of the problems that got wide attention is the power system instability. With the lack of new generation and transmission facilities and over exploitation of the existing facilities geared by increase in load demand make these types of problems more imminent in modern power systems. Demand of electrical power is continuously rising at a very high rate due to rapid industrial development [1]. To meet this demand, it is essential to raise the transmitted power along with the existing transmission facilities. The need for the power flow control in electrical power systems is thus evident. With the increased loading of transmission lines, the problem of transient stability after a major fault can become a transmission power limiting factor. To solve the problem of transient stability in the late 1980s, the Electric Power Research Institute (EPRI) introduced a new approach to solve the problem of designing and operating power systems; the proposed concept is known as Flexible AC Transmission Systems (FACTS). The two main objectives of FACTS are to increase the transmission capacity and control power flow over designated transmission routes.

FACTS are defined by the IEEE as “a power electronic based system and other static equipment that provide control of one or more AC transmission system parameters to enhance controllability and increase power transfer capability”.

“A Static synchronous compensator is a shunt-connected static VAR compensator whose capacitive or inductive output current can be controlled independent of the ac system voltage”[1].The concept of STATCOM was proposed by Gyugyi in 1976. Power Converter employed in the STATCOM mainly of two types i.e. is Voltage Source Converter and Current Source Converter. In Current source Converter direct current always has one polarity and the power reversal takes place through reversal of dc voltage polarity while In Voltage Source Converter dc voltage always has one polarity, and the power reversal takes place through reversal of dc current polarity. The power semiconductor devices used in current source converter requires bidirectional voltage blocking capability and for achieving this Characteristic an additional diode must be connected in series with a semiconductor switch which increased the system cost and its becomes costlier as compared to voltage source converter moreover Voltage source converter can operate on higher efficiency in high power applications. STATCOM is made up of a coupling transformer, a VSC and a dc energy storage device. STATCOM is capable of exchanging reactive power with the transmission line because of its small energy storage device i.e. small dc capacitor, if this dc capacitor is replaced with dc storage battery or other dc voltage source, the controller can exchange real and reactive power with the

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transmission system, extending its region of operation from two to four quadrants. A functional model of a STATCOM is shown in Figure 1 below:

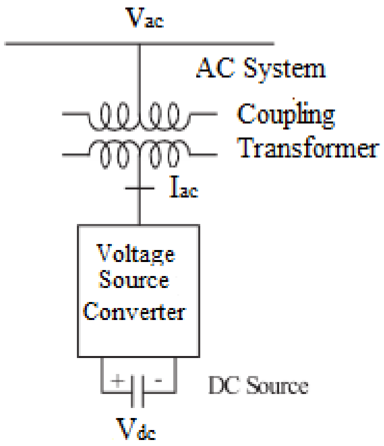

Figure 1: Basic Structure of STATCOM

II. Systems Under Test

This paper deals with single machine infinite bus system and multi machine infinite bus system. Modelling of SMIB consisting the generator, excitation system, AC network etc. A SMIB power system model as shown in Fig. 1 is used to obtain the Modified Heffron-Phillip's model parameters. This is a simplified representation of a generator is connected to the load through a transmission line. IEEE Model 1.0 is used to model the synchronous generator.

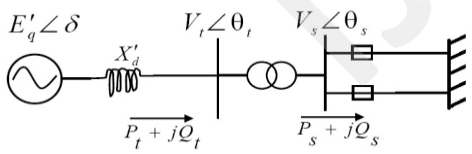

Figure 2: Single Machine Infinite Bus System

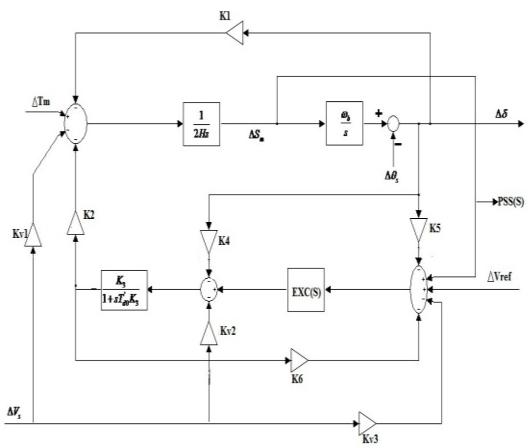

Figure 3: Phillip Heffron Model of SMIB

For the study of single machine infinite bus system a Heffron Phillips model can be obtained by linearizing the system equations around an operating condition. The obtained hefffron model is as in figure 2.

The MMIB system is kundur's four machine two area test system as shown below:

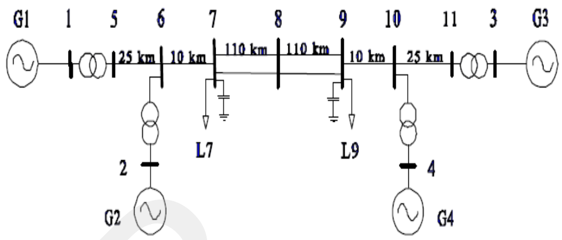

Figure 4: Kundur's four machine two area test system

The system contains eleven buses and two areas, connected by a weak tie between bus 7 and 9. Totally two loads are applied to the system at bus 7 and 9. Two shunt capacitors are also connected to bus 7 and 9 as shown in the figure below. The system has the fundamental frequency 60 Hz.

The system comprises two similar areas connected by a weak tie. Each area consists of two generators, each having a rating of 900 MVA and 20 kV.

The left half of the system is identified as area 1 and the right half is identified as area 2. The test system consists of two fully symmetrical areas linked together by two 230 kV lines of 220 km length. This system is specifically designed to study low frequency electromechanical oscillations J in large interconnected power systems. Three electromechanical modes of oscillation are presented in this system; two intra-area modes, one in each area, and one inter-area low frequency mode. Despite its small size, it mimics very closely the behaviour of typical systems in actual operation. Each area is equipped with two identical round rotor generators rated 20kV/900MVA.

III. Modelling and Simulation

Model for test of SMIB and MMIB systems are developed using MATLAB/SIMULINK R2009b. Heffron Phillip model is developed for Single

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machine infinite bus system. Parameters are as follows:

K1 = 0.5320, K2 = 0.7858, K3 = 0.4494, K4 = 1.0184, K5 = -0.0597, K6 = 0.5746, KA = 20, M=7.

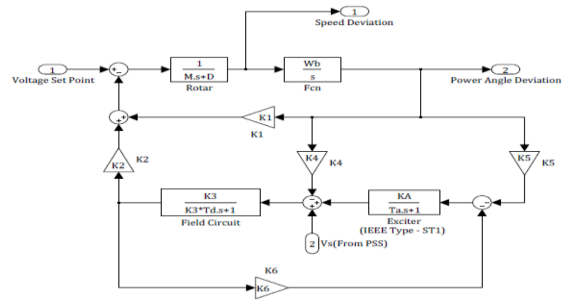

Figure5: Heffor Phillips model for SMIB

Model for multi machine system is developed in SIMULINK as described by parameter in section II showing below:

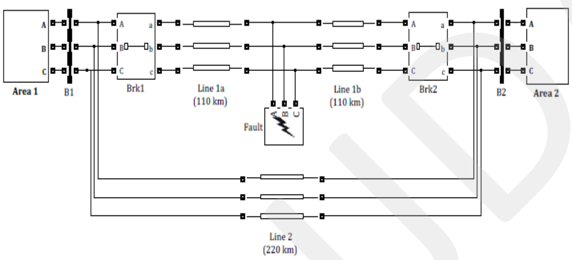

Figure 6: Kundur's four machine system

Both system are simulated under the fault condition first and then STATCOM is installed in both systems as shown below:

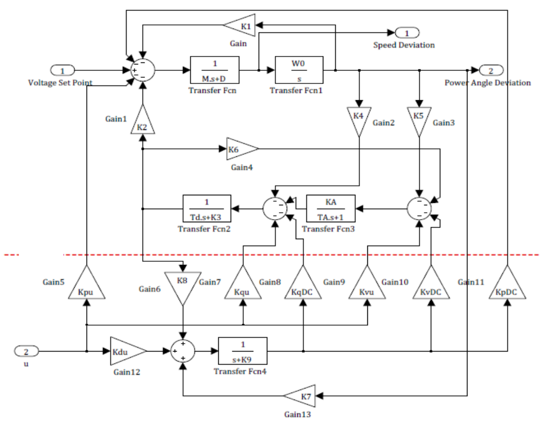

Figure 7: SMIB with STATCOM

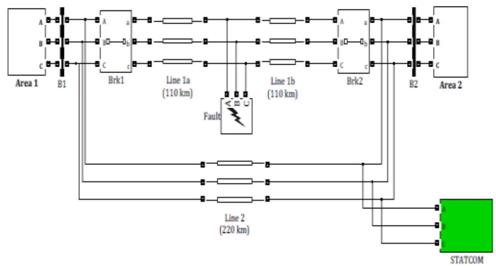

Figure 8: MMIB System with STATCOM

IV. RESULTS

Both the system are simulated under the fault condition with and without controller. Figures below showing the speed deviation for all configuration stated above.Figure 10 showing speed deviation under the fault condition in SMIB without STATCOM, Figure 11 showing speed deviation under the fault condition in SMIB with STATCOM, Figure 12 showing speed deviation under the fault condition in MMIB without STATCOM, Figure 13 showing speed deviation under the fault condition in MMIB without STATCOM.

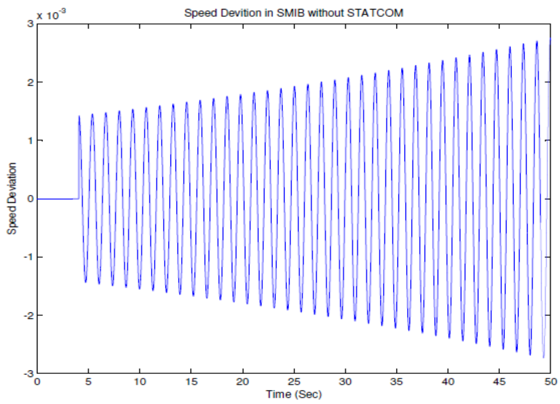

Figure 9: Speed Deviation in SMIB without STATCOM

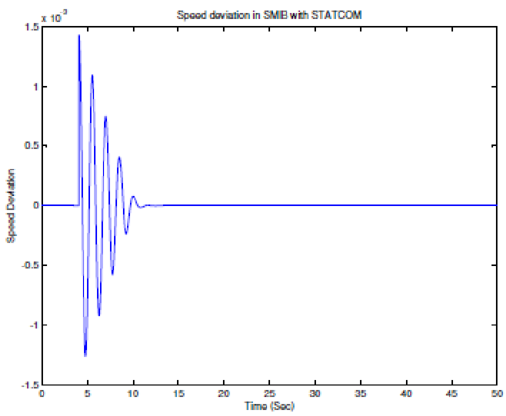

Figure 10: Speed Deviation in SMIB with STATCOM

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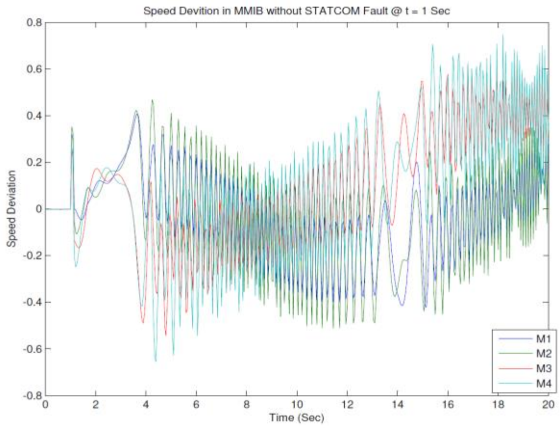

Figure 11: Speed Deviation in MMIB without STATCOM

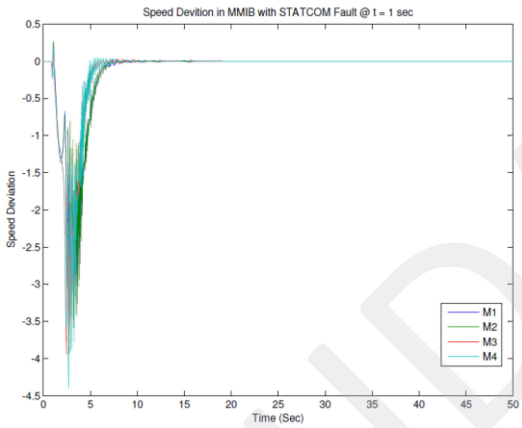

Figure 12: Speed Deviation in MMIB with STATCOM

IV. CONCLUSIONS

In this paper, dynamic behaviour of single and multi-machine system installed with STATCOM is investigated under 3-phase fault. Proposed work is implemented using MATLAB/SIMULINK. Results showing the impact of STATCOM over the SMIB and MMIB system. The STATCOM is used to control power flow of power system by injecting appropriate reactive power during dynamic state. Computer simulation results show that STATCOM not only considerably improves transient stability but also compensates the reactive power in steady state. Therefore STATCOM can increase reliability and capability of AC transmission system.

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