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Review of Power System Transient Stability Enhancement by using Various Types of PSS & FACT's Devices

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ABSTRACT: This paper describes the performance of study and comparison of various FATCS devices and their effect on power system stability enhancement. In a current scenario power demand increases and widely expanded in the power generation and transmission and distribution system sector. But to maintain the stability and steady state operation of power system causing from disturbance or oscillation, faults and suddenly changing of the load, voltage instability, voltage sag, disturbance in frequency, stability is the most important factor regarding to power system. Due to instability, different problems come forward in power system such as fluctuation in voltage and frequency, which may cause damage or failure of power system. Flexible AC Transmission System (FACTS) devices are used to solve the problems of modern power system generation and transmission system which leads in improvement and development of performance of the power system. A static var compensator (SVC) and power system stabilizers (PSS) are used to improve transient stability and power oscillation damping of the system. Various types of FACTS devices consist of Distribution Static Synchronous Compensator (D-STATCOM), Thyristor Controlled Series Compensator (TCSC), Static Series Synchronous Compensator (SSSC), Static VAR Compensator (SVC), Unified Power Flow Controller (UPFC), Thyristor Controlled Series Reactor (TSSR), Thyristor Controlled Voltage Reactor (TCVR), Interline Power Flow Controller (IPFC) and another more devices.

KEYWORDS: FACTS, transient stability, D-STATCOM, SVC, PSS UPFC, TCSC, SSSC.

I.INTRODUCTION

Modern electric power system is facing many problems day by day growing in complex network and their operation and structure. In the power system, instability of the problems are arised vary frequently. There are number of stability issues that limit the transmission capability in transient stability, dynamic stability, steady state stability, frequency collapse, voltage collapse.

The opportunities arise through the ability of FACTS controllers to control the interrelated parameters that govern the operation of transmission systems including series impedance, shunt impedance, current, voltage, phase angle, and the damping of oscillations at various frequencies below the rated frequency.

FACTS devices have increased controllability and improved power transfer capability. The FACTS devices consist of three groups, dependent on their switching technology: mechanically switched (such as phase shifting transformers), thyristor switched using semiconductor device, while some types of FACTS, such as the phase shifting transformer and the static VAR compensator are already well known and used in power systems. New developments in power electronics and control have extended the application range of FACTS [6]. The devices are used in transmission system to control and utilize the flexibility and system performance. To obtain this, the FACTS devices control the main parameters namely voltage, phase angle and impedance, which are affecting ac power transmission system.

The power system stabilizer (PSS) is mainly connected with electromechanical oscillation and improves the power system stability with the help of its additional excitation system. For maintaining the consistent generation and transmission of electric energy, the electric power systems become larger and larger, which covers a area and include all transmission lines, synchronous generators, loads and variety of controllers in more economical way. Power system

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stability can be improved by using dynamic controllers as excitation systems, power system stabilizers and FACTS devices, controlled islanding and HVDC [4].

II. LITRETURE REVIEW

1. "Omar Mohammed Benaissa, Samir Hadjeri, Sid Ahmed Zidi" (2016): It presents an application of (SVC) in electrical transmission lines and PSS in two areas, two generator test power system. Using Matlab software to design and implements control system and study the effect of damping oscillations in stability power system after proposed faults in transmission lines of research model that used (PSS-generic and multiband) types and automatic voltage regulator (AVR).
2. "Khoshnaw Khalid Hama Saleh, Ergun Ercelebi" (2015): It compares a power system stabilizer (PSS) and static Var compensator (SVC) to improve damping oscillation and enhance transient stability. The effectiveness of a PSS connected to the exciter and/or governor in damping electromechanical oscillations of isolated synchronous generator was tested. The SVC device is a member of the shunt FACTS (flexible alternating current transmission system) family, utilized in power transmission systems. The designed model was tested with a multi-machine system consisting of four machines six bus, using MATLAB/SIMULINK software. The results obtained indicate that SVC solutions are better than PSS.
3. "Mahesh K. Mishra, Student Member, IEEE, Arindam Ghosh, Senior Member, IEEE, and Avinash Joshi"(2013) : the operating principles of a distribution static compensator (DSTATCOM) that is used to maintain the voltage of a distribution bus. A three-phase, four-wire distribution system is assumed in this study. A three-phase bridge inverter circuit that is supplied by two neutral-clamped dc storage capacitors realizes the DSTATCOM. Three filter capacitors, one for each phase, are connected in parallel with the DSTATCOM to eliminate high-frequency switching components.
4. "Vinay M. Awasthi Senior Member, IEEE and Mrs. V. A. Huchche Senior Member, IEEE" (2016): The D-STATCOM, based on voltage source converter, which injects the reactive power in distribution line. The output voltage of D-STATCOM is made leading to that of system voltage for the purpose of controlling VAR generation. Implementation of D-STATCOM by using PI controller is carried out in MATLAB/ Simulink.
5. "Weerakorn Ongsakul and Peerapol Jirapon" (2005) : Four types of FACTS devices are included: thyristor-controlled series capacitor (TCSC), thyristor-controlled phase shifter (TCPS), unified power flow controller (UPFC), and static var compensator (SVC). Test results on IEEE 30-bus system indicate that optimally placed OPF with FACTS devices by EP could enhance the TTC value far more than OPF without FACTS devices.

III. FACTS DEVICES

FACTS devices are capable of controlling the network condition in a very fast manner by reactive power management and this unique feature of FACTS devices can be exploited to improve the transient stability of a system. Transient stability control plays a significant role in ensuring the stable operation of power systems in the event of large disturbances and faults. FACTS controllers are used for the dynamic control of voltage, impedance and phase angle of high voltage AC transmission lines. The basic principles of the following FACTS controllers, which are used in the two-area power system under study, are discussed briefly.

A. Static Var Compensator (Svc):-

Static VAR Compensator (SVC) is a first generation FACTS device that can control voltage at the required bus thereby improving the voltage profile of the system. The primary task of an SVC is to maintain the voltage at a particular bus by means of reactive power compensation. The SVC uses conventional thyristors to achieve fast control of shunt-connected capacitors and reactors. The configuration of the SVC is shown in Fig.1.Which basically consists of a fixed capacitor (C) and a thyristor controlled reactor (L). The firing angle control of the thyristor banks determines the equivalent shunt admittance presented to the power system. , SVC is composed of a controllable shunt reactor and shunt capacitor(s). Total susceptance of SVC can be controlled by controlling the firing angle of thyristors. However, the SVC acts like fixed capacitor or fixed inductor at the maximum and minimum limits.

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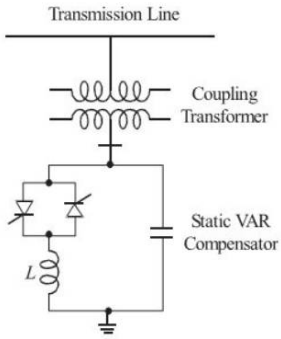

Fig:1 SVC connected to a transmission line.

B. Static Synchronous Compensator (STATCOM)

In the transmission systems, STATCOM provides voltage support to buses by modulating bus voltages during dynamic disturbances in order to provide better transient characteristics, improve the transient stability margins and to damp out the system oscillations due to these disturbances. The STATCOM is based on the solid state synchronous voltage source which generates a balanced set of three sinusoidal voltages at the fundamental frequency with rapidly controllable amplitude and phase angle. The configuration of a STATCOM is shown in Fig.2. Basically it consists of a voltage source converter (VSC), a coupling transformer and a dc capacitor. Control of reactive current and hence the susceptance presented to power system is possible by variation of the magnitude of output voltage with respect to bus voltage and thus operating the STATCOM in inductive region or capacitive region.

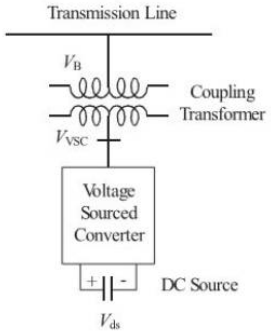

Fig: 2 STATCOM connected to a transmission line.

C. Thyristor Controlled Series Capacitor (TCSC)

TCSC is one of the most important and best known FACTS devices, which has been in use for many years to increase the power transfer as well as to enhance system stability. The main circuit of a TCSC is shown in Fig. 3.The TCSC consists of three main components: capacitor bank C, bypass inductor L & bidirectional thyristors SCR1 and SCR2.

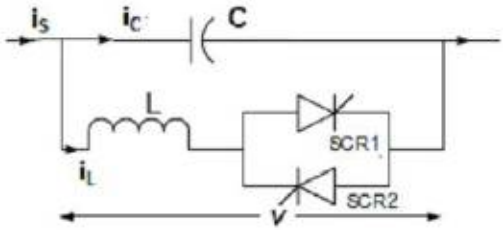

Fig: 3 TCSC connected to a transmission line

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The firing angles of the thyristors are controlled to adjust the TCSC reactance in accordance with a system control algorithm, normally in response to some system parameter variations. According to the variation of the thyristors firing angle or conduction angle, this process can be modeled as a fast switch between corresponding reactance's offered to the power system.

D. Unified Power Flow Controller (UPFC)

Among the available FACTS devices, the Unified Power Flow Controller (UPFC) is the most versatile one that can be used to enhance steady state stability, dynamic stability and transient stability. The basic configuration of a UPFC is shown in Fig. 4. The UPFC is capable of both supplying and absorbing real power and reactive power and it consists of two ac/dc converters. One of the two converters is connected in series with the transmission line through a series transformer and the other in parallel with the line through a shunt transformer. The dc side of the two converters is connected through a common capacitor, which provides dc voltage for the converter operation. The power balance between the series and shunt converters is a prerequisite to maintain a constant voltage across the dc capacitor. As the series branch of the UPFC injects a voltage of variable magnitude and phase angle, it can exchange real power with the transmission line and thus improves the power flow capability of the line as well as its transient stability limit.

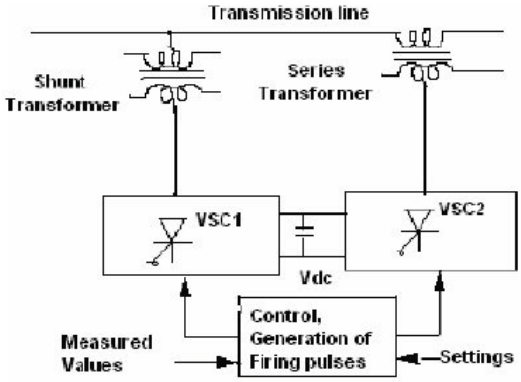

Fig: 4 UPFC connected to a transmission line

E. Static Synchronous Series Compensator (SSSC):-

SSSC is connected in series with a power system. It has a voltage source converter serially connected to a transmission line through a transformer. It can be considered as asynchronous voltage source as it can inject an almost sinusoidal voltage of variable and controllable amplitude and phase angle, in series with a transmission line. The injected voltage is almost in quadrature with the line current. A small part of the injected voltage that is in phase with the line current provides the losses in inverter. Most of the injected voltage, which is in quadrature with the line current, provides the effect of inserting an inductive or capacitive reactance in series with the transmission line. The variable reactance influences the electric power flow in the transmission line. The basic configuration of a SSSC is shown in Fig. 5.

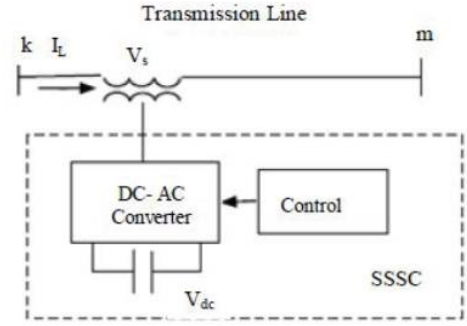

Fig: 5 SSSC connected to transmission line

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F. Two Area Power System Model:-

Consider a two area power system (Area-1 & Area-2) with series and shunt FACTS devices, connected by a single circuit long transmission line as shown in fig. 1 and fig. 2 respectively. Fig. 6 Two area power system with series FACTS device Here, the series FACTS devices such as UPFC (combination of STATCOM and SSSC), SSSC, and TCSC are equipped between bus-2 and bus-3. The direction of real power flow is from Area-1 to Area-2. Fig. 7 Two-area power system with shunt FACTS devices Here, the shunt FACTS devices such as STATCOM, SVC are equipped at bus-2. The direction of real power flow is from Area-1 to Area-2.

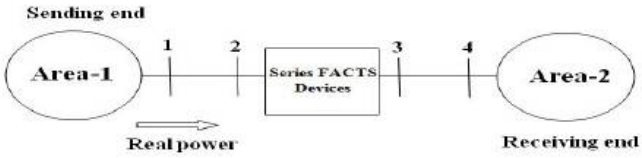

Fig: 6 Two-area power system with series FACTS device

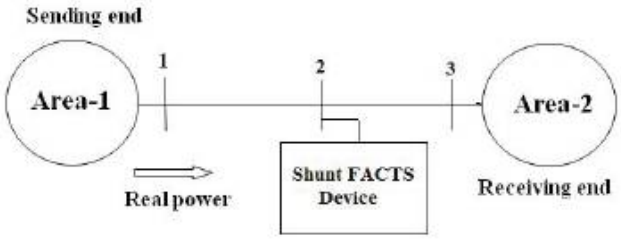

Fig: 7 Two-area power system with shunt FACTS devices

IV. CONCLUSION

FACTS are powerful devices to improve the voltage profile and power system enhancement. In this paper, comparison of different FACTS devices with respect System Stability Enhancement is carried out and gives an idea about the FACT devices. This paper concludes that in order to provide faster responses over a wide range of power system operation and improve the power system stability by using FACTS devices with PSS and to provide the optimal power flow power networks. The FACTS are economically and efficiently operation in transmission and generation system's and due application of FACTS devices to prevent the uninterrupted power supply provide to generation, transmission and distribution system. The power system stabilizer means using external excitation (AVR) controller also prevent upset output power of generation system causing various reasons.

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