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Comparative Analysis of Voltage profile Enhancement using "FACTS" Devices.

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Abstract - As per the current situation of the power demand all over the world we would be aspect to be a great time with quality power. There is dependency over electricity of everybody becomes electrical system as much as efficient to provide us quality power every time. In Electrical system voltage profile enhancement are necessary. The countries like India with increasing demand of electric power day by day it is difficult to expand the existing transmission system due to difficulties in right of way and cost problem in transmission network expansion. So, we need power flow controllers to increasing transmission capacity and controlling power flows of power smoothly. Flexible alternating current transmission system (FACTS) controllers are capable of controlling power flows and enhancing the usable capacity of existing transmission lines. In this paper we have done the comprehensive modeling of FACTS devices for power flow study and its impact on system voltage.

Keywords - Voltage profile, SVC, STATCOM, SSSC.

I. INTRODUCTION

Daily increasing load over the electrical system becoming the challenge in front of us to provide the quality power to every customer all time. But because of different loading system and current heavy domestic machinery and also industrial system also responsible in providing imbalance in between of the generation the transmission system. Voltage stability problems normally occur in heavily stressed systems. Voltage stability not only interrupt the continuity of the working but also weaken us economically. We have a very good example of voltage stability disturbance is of India North East Power Grid Failure, in which power failure occurs as a black out and power system damaged completely for 3 days, which is only because of loss of synchronism and heavy loads over the system. Several network blackouts have been related to voltage collapses. We would also understand that this phenomenon tends to occur from lack of reactive power supports in heavily stressed conditions, which are usually triggered by system faults. The main factor causing voltage instability is the inability of the power system to meet the demand for reactive power. The reactive power is the very important part of the electrical system. Therefore, the voltage collapse problem could be treated as related to a reactive power planning problem including contingency analyses, where we gone through the analysis of suitable conditions of reactive power reserves for secure operations of power systems. Our main objective of the reactive power (VAR) planning problem is only the voltage feasibility constraints in normal and post-contingency states to provide a minimum number of new reactive power supplies to satisfy. Many works have been carried out for this subject as a research and It is necessity to include the voltage stability constraints, a few scientists have been reported concerning new formulations considering the voltage stability problem and which provides more realistic solutions for the VAR planning problem. In a new formulation and solution method are presented for the VAR planning problem including FACTS devices, taking into account the issues just mentioned. Initially we are using compensation techniques for improving power system profile as voltage profile and We are having so many techniques for compensating the power line and for reducing the losses by SSSC and STATCOM and SVC are used to keep bus voltages and to ensure the voltage stability margin. Voltage instability has been responsible for several major network accumulations. In electrical network we could understand the voltage stability is concerned with the ability of a power system to maintain acceptable voltage at all buses in the system under normal conditions and after being subjected to a disturbance.

While so many reasons are responsible for the disturbance leading to voltage collapse may be, the underlying problem is an inherent weakness in the power system. In addition to the strength of transmission network and power transfer levels, the main factors contributing to voltage disturbance are the generator reactive power/voltage controllability, loading system performance, characteristics of reactive power compensation devices, and the action of voltage controlling devices.

Initially we are using compensation techniques for improving the voltage profile over the electrical system, these are:

- Series Compensation
- Shunt Compensation

With the arrival of new techniques and new advanced electrical systems, the whole working profile and compensation techniques was changed or upgraded. With those upgraded techniques we not only use our system as per our requirement but also we are working economically.

With those new techniques could be classified as per its characteristics and importance

II. FACTS

Flexible AC Transmission Systems, called FACTS, is the latest technology in the electrical network of transmission system and well known term for higher controllability in power systems by means of power electronic devices. It has several types FACTS-devices, which have been introduced for various applications worldwide. Some new types of devices are in the stage of being introduced in practice. With the help of new development of concepts of configurations of FACTS-devices are discussed in research and literature. In most of the applications our main focus of the controllability is used to avoid cost intensive or landscape requiring extensions of power systems, for expansion like upgrades or additions of substations and power lines. FACTS-devices not only provide a better adaptation to varying operational conditions but also improve the usage of existing installations. The basic applications of FACTS-devices are:

• Power flow control,
• Increase of transmission capability,
• Voltage control,
• Reactive power compensation,
• Stability improvement,
• Power quality improvement,
• Power conditioning,
• Flicker mitigation,
• Interconnection of renewable and distributed generation and storages.

As per the all above applications the practical requirements, needs and benefits have to be considered carefully to justify the investment into a complex new device. Figure 2.1 shows the basic idea of FACTS for transmission systems. Basically the usage of lines for active power transmission should be ideally stand the standards or up to the thermal limits. Flexible AC Transmission Systems, called FACTS, is in the power system since few years and well-known term for higher controllability in power systems by means of power electronic devices. The power electronic allows very fast reaction times down to far below one second. There is complete structured overview on FACTS-devices in detail is given. These devices are located to their different fields of applications. There is little bit try can introduce you about the FACTS-devices and can also be found in the abstract with the main focus on basic technology, modeling and control.

Flexible AC Transmission Systems can be defined 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.”

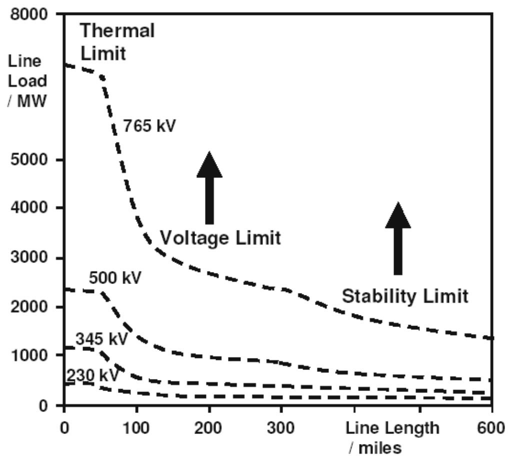

Fig.2.1- Operational Limits of transmission lines for different voltage levels.

The FACTS-devices contains more advanced technology of voltage source converters based with the control system, today mainly on Insulated Gate Bipolar Transistors (IGBT) or Insulated Gate Commutated Thyristors (IGCT). Voltage Source Converters is capable to control voltage in magnitude and phase due to a pulse width modulation of the IGBTs or IGCTs. High modulation frequencies would be allow to get low harmonics in the output signal and which also compensate disturbances coming from the network. The disadvantage is that the losses are increasing with an increasing switching frequency. Therefore special designs of the converters are required to compensate this. In each column the elements can be structured according to their connection to the power system. The shunt devices are primarily for reactive power compensation and therefore voltage control.

For getting smoother operation in comparison to the mechanically switched operation/compensation we have to use the SVC which provides more precise control. It not only improves the stability of the network but also it can be adapted instantaneously to new situations. Now we use the STATCOM for improving the power quality against even dips and flickers of the power system. The series devices having its impedance plays very important role in providing batter stability and power flow as compensating reactive power. These devices are installed on platforms in series to the line.

FACTS-Devices and Applications mainly for stability improvement and damping of inter-area oscillations, but it has as well as certain influence on the power flow. The SSSC is a device which has so far not been built on transmission level because Series Compensation and TCSC are more than enough as per the system needs and fulfilling all the today's requirements more cost efficient.

Series applications of Voltage Source Converters have been implemented for power quality applications on distribution level for instance to secure factory in feeds. These devices are called Dynamic Voltage Restorer (DVR) or Static Voltage Restorer (SVR). More and more important devices as a part of FACTS devices with the growing importance are getting the FACTS-devices in shunt and series configuration. These devices are used for not only power flow controllability but also the higher volatility of power flows due to the energy market activities requires a more flexible usage of the transmission capacity. Power flow control devices shift power flows from overloaded parts of the power system to areas with free transmission capability.

Phase Shifting Transformers (PST) are the most common device in this sector. Because of their limitation is the low control speed together with a high wearing and maintenance for frequent operation. As an alternative with full and fast controllability the Unified Power Flow Controller (UPFC) is known since several years mainly in the literature and but as well in some test installations. The UPFC provides power flow control together with independent voltage control. The high cost is the main disadvantage of this device due to the complex system setup. The relevance of this device is given especially for studies and research to figure out the requirements and benefits for a new FACTS-installation. We could get more and more devices from the UPFC if their capability is sufficient for a given situation.

Derived from the UPFC there are even more complex devices called Interline Power Flow Controller (IPFC) and Generalized Unified Power Flow Controller (GUPFC) which provide power flow controllability in more than one line starting from the same substation. Between the UPFC and the PST there was a gap for a device with dynamic power flow capability but with a simpler setup than the UPFC. The Dynamic Power Flow Controller (DFC) was introduced recently to fill this gap. The combination of a small PST with Thyristor switched capacitors and inductances provide the dynamic controllability over parts of the control range.

HVDC Back-to-Back controls power flow adequately and the power systems allow power flow controllability while additionally decoupling the frequency of both sides. While in the HVDC Back-to-
Back system the active power could be controlled by the Thyristors only and the version with Voltage Source Converters allows additionally a full independent controllability of reactive power on both sides. Only those devices can ideally improves voltage control and stability together with the dynamic power flow control. For getting same functionality sure HVDC with Thyristor or Voltage Source Converters together with lines or cables provide the can be seen as very long FACTS-devices.

POWER ELECTRONICS

FACTS-devices are usually introduced as a new technology, but it was usually in operation since long with hundreds of installations worldwide, especially of SVC since early 1970s with a total installed power of 90.000 MVAr, show the acceptance of this kind of technology. Table 1 shows the estimated number of worldwide installed FACTS devices and the estimated total installed power. Even the newer developments like STATCOM or TCSC show a quick growth rate in India also with their specific application areas.

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III. MATLAB SIMULINK MODEL

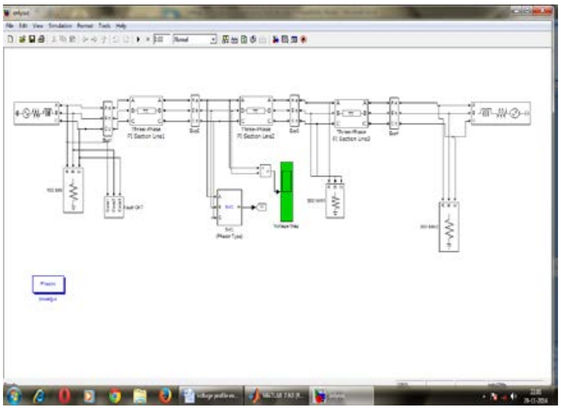

Fig. 3.1 - MATLAB Simulink Model of SVC

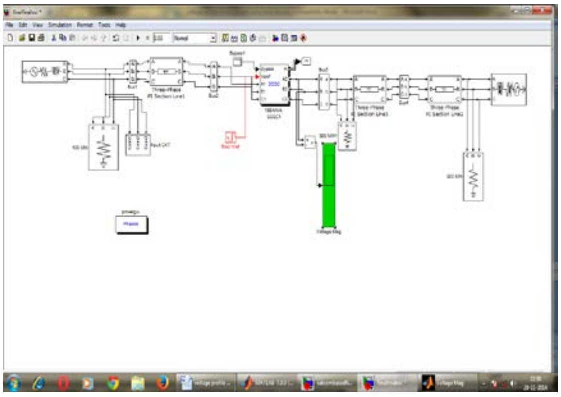

Fig. 3.2 - MATLAB Simulink Model of SSSC System

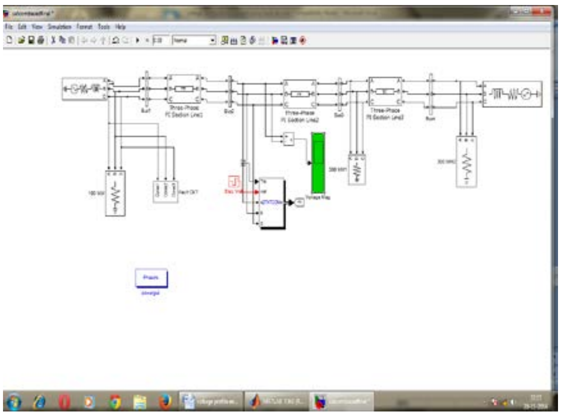

Fig. 3.3 - MATLAB Simulink Model of STATCOM

IV. RESULTS

Fig. 4.1 - Voltage profile without fault SVC System

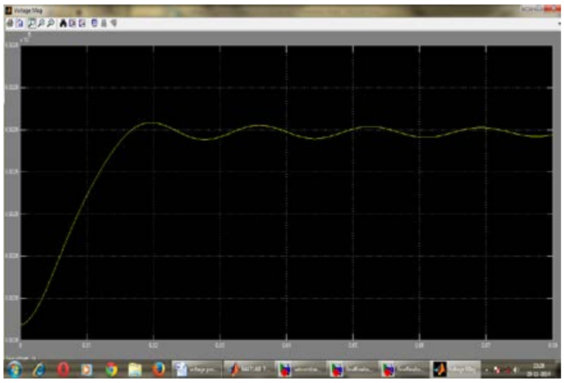

Fig.4.2 - Voltage profile without fault SSSC System

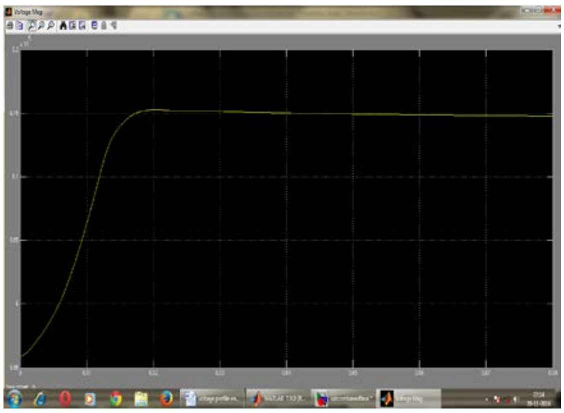

Fig. 4.3 - Voltage profile without fault STATCOM System

Issue	STATCOM	SVC	SSSC
V/I characteristic	good under voltage performance Current source	good overvoltage performance Impedance	good under voltage performance Voltage source
Control range	Symmetrical otherwise Hybrid solutions	freely adjustable to any range by TCR/TSR /TSC branches	Symmetrical
Modularity	Same converter usable for various applications (STATCOM, UPFC, CSC, B2B etc) Redundancy no degraded mode	TCR/TSR/TSC branches used in SVC and TCSC/TPSC Redundancy Degraded mode operation	Same converter usable for various applications UPFC, SSSC configurations are used in the CSC
Response time	1 to 2 cycle	2 to 3 cycle	3 to 4 cycle
Transient behavior	Self protecting at critical system Faults	Available before, during and after critical system conditions	Self protecting at critical system Faults
Space requirements	40 to 50 %	100 %	60 to 70 %
Availability	96 to 98 %	> 99 %	90 to 92 %

V. CONCLUSIONS

This paper explains not only various voltage stability problems but also the FACTS controllers that are used to degrade the voltage stability problems. The standard FACTS controller for a particular type of problem is also given. We could easily understand by the simulation results as how the FACTS devices improve the Voltage quality. The simulation work is done with the help of Static Var Compensator (SVC) and Static Synchronous Compensator (STATCOM) Static Synchronous Series Compensator (SSSC).

SVC, STATCOM and SSSC are providing much better power quality under variation of source voltage and when the system suffers from the bad conditions like over loading, surge etc for the disturbance of the system. The paper includes the simulation results of the SVC, STATCOM and SSSC only. We could reach up to the future scenario about the exact assumption and analysis of the devices performance, which is not only helps us in selection of the right device but also saves our time.

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