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FACTS DEVICES FOR CONTROLLINGTHE POWER FLOW IN TRANSMISSION SECTOR

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ABSTRACT

The flexible AC transmission system (FACTS) in a power system play a vital role in improving the power system performance, both the static and dynamic, where improving the stability, reducing the losses and the cost of generation, also enhancing the system loading capability with rerouting the power flow in the network. In order to reach the above goals, these devices must be located optimally.In any power system, unexpected outages of lines or transformers occur due to faults or other disturbances. These events, referred to as contingencies, may cause significant overloading of transmission lines or transformers, which in turn may lead. Flexible AC Transmission System (FACTS) controllers provide new facilities, both in steady state power flow control and dynamic stability control. Static VAR controllers control only one of three important parameters (voltage, impedance, phase angle) determining the power flow in the AC power system viz. the amplitude of voltage at selected terminals of transmission line.

Keywords: FACTS, Optimal Power Flow, Interior Point Method, Sensitivity of system loading factor, N-1 contingency criterion

1. Introduction

The power demand in the recent year has been increased substantially while the expansion of power generation & transmission have been severely limited due to environmental restriction & resources, as an effect some transmission lines heavily loaded.Overloading may also due to transfer of chap power from generator bus to load bus ,this lead to the introduction of FACTS such as Static VAR Compensator(SVC).This device control the power flow in the network and reduce the flow heavily loaded line there by resulting in an increase load ability low system losses improved stability of the network and reduced cost production. The OPF solution gives the optimal settings of all controllable variables for a static power system loading condition. A number of mathematical programming based techniques have been proposed to solve the OPF problems. Thyristor Controlled Series Capacitor (TCSC) is a variable impedance type FACTS device and is connected in series with the transmission line to increase the power transfer capability, improve transient stability, and reduce transmission losses. Optimal power flow (OPF) is an operating condition in which the power flow in an electrical system occurs optimally. It is a power flow problem in which certain controllable variables are adjusted to minimize an objective function such as cost of active power generation or the transmission loss, while satisfying operating constraints.

The type of control that an optimal power flow must be able to satisfied are active and reactive power injections, generator voltages, transformer tap ratios and phase shift angles. The optimal power flow is problem seeks to find an optimal profile of active and reactive power generations along with voltage magnitudes in such a manner as to minimize the total operating cost of a power system, while satisfying network security constraints. The main purpose of OPF to schedule power system controls to optimize an objective function while satisfying a set of non-linear equality, and inequality constraints. Mathematically, the OPF problem can be formulated as a constrained non-linear optimization problem. Different solution approaches have been proposed to solve OPF problems. A new N-R method have solved optimal power flow problem incorporating FACTS devices using Newton's method, leading to highly robust iterative solutions. But it has been noted that the OPF problem with series compensation may be a non- convex problem, which will lead the classical method to be stuck into local minimum. Voltage control: Applications to optimize bus voltage values. These studies take into account the stability of power system voltages from the maximum and minimum admissible values. Transmission line overloads reduction: Applications to reduce the overload of a specific transmission line.

This paper is organized as follows: following the introduction in section, basic concept and problem formulation are described in section II. Then in section III, FACTS devices are explain. In section IV, Optimal power flow using SVC in section has revised. In section V, the conclusion is constructed[1].

2. BASIC CONCEPTS AND PROBLEM FORMULATION

N-R METHOD:- The most widely used method for solving simultaneous nonlinear algebraic equations is the Newton Raphson method (NR). Newton's method is found to be more efficient and practical. The number of iterations required to obtain a solution is independent of the system size, but more functional evaluations are required at every iteration. Since in the power flow problem real power and voltage magnitude are specified for the voltage-controlled buses, the power flow equation is formulated in polar form. This equation can be rewritten in admittance matrix as

$$I_i=\sum_{j=1}^{n} Y_{ij} V_j$$

In the above equation, j includes bus i . Expressing this equation in polar form, we have

$$I_i=\sum_{j=1}^{n} Y_{ij} V_j < \theta_{ij} + \delta_j$$

The complex power at bus i is

$$P_i + jQ_i=V_i^* I_i$$

Separating the real and imaginary parts

$$P_i=\sum_{j=1}^{n} Y_i V_j \; Y_{ij} \cos(\theta_{ij} - \delta_i + \delta_j)$$

$$Q_i=-\sum_{j=1}^{n} Y_i V_j \; Y_{ij} \sin(\theta_{ij} - \delta_i + \delta_j)$$

$$\begin{bmatrix} \Delta P \\ \Delta Q \end{bmatrix}=\begin{bmatrix} J1 & J2 \\ J3 & J4 \end{bmatrix}\begin{bmatrix} \Delta\delta \\ \Delta V \end{bmatrix}$$

By running the load flow analysis using NR-method we can fine the Power flows in individual lines and loss[3].

3.FACTS DEVICES

The flexible Ac transmission system (FACTS) controllers can play an important role in the power system security enhancement. FACTS devices can regulate the active and reactive power control as well as adaptive to voltage-magnitude control simultaneously because of their flexibility and fast control characteristics. Controlling the power flows in the network, under normal and abnormal conditions of the network,can help to reduce flows in heavily loaded lines and reduce system power loss. FACTS Controllers are classified as following

1. Series controllers such as Thyristor Controlled Series Capacitor (TCSC), Thyristor Controlled Phase Angle Regulators (TCPAR or TCPST), and Static Synchronous Series Compensator (SSSC).
2. Shunt controllers such as Static Var Compensator (SVC), and Static Synchronous Compensator(STATCOM).
3. Combined series-series controllers and Combined series-shunt controllers such as Interline Power Flow Controller (IPFC), Unified Power Flow Controller (UPFC).

THYRISTOR BASED FACTS CONTROLLER

The thyristor based family uses capacitor and reactor banks with fast solid-state switches in traditional shunt or series circuit arrangements. The thyristor switches control the on and off periods of the fixed capacitor and reactor banks and hence realize a variable reactive impedance. Except for losses, they cannot exchange real power with the system. Important thyristor based FACTS controllers are:-

(i) Static Var Compensator (SVC).
(ii) Thyristor-Controlled Series Capacitor (TCSC).

(i) STATIC VAR COMPENSATOR (SVC)

SVC is a shunt connected controller. SVC at a bus is capable of controlling the corresponding bus voltage magnitude during steady state model. It main function is to regulate the voltage at a given bus by controlling its equivalent reactance. It can exchange reactive power only with the connected bus. In EHV transmission line, when the voltage fall in the bus, capacitive vars are injected and when bus voltage become higher, inductive vars are supplied to lower the bus voltage. In conventional methods of shunt compensation, shunt reactors are connected during low loads, and shunt capacitors are connected during heavy loads or low lagging power factor loads. It is largely transient-free, capacitor bank switching and very first operating capability and maintenance is simple. Voltage drops as capacitors in reactive capability is the same degradation.

(ii)Thyristor Controlled Series Capacitor (TCSC)

TCSC is a series connected controller. Its major purpose is the increase in steady state power transfer. During steady state, TCSC can be considered as a static reactance .The controllable reactance is directly used as the control variable in the power flow equations Conventional series capacitor is modified by adding the thyristor controlled reactor. A controlled reactor in parallel with series capacitor, enables a continuous and rapidly varying compensator system.

4. POWER FLOW USING STATIC VAR COMPENSATOR(SVC)

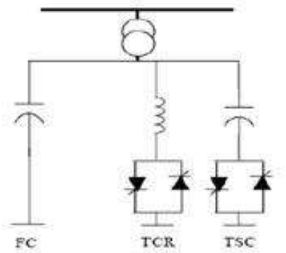

Figure 1: SVC Configuration

The power demand, in the recent years, has increased substantially while the expansion of power generation and transmission has been severely limited due to environmental restrictions and limited resources. As an effect, some transmission lines are heavily loaded and the system stability and voltage becomes a limiting factor for power transfer. Flexible AC transmission systems (FACTS) controllers have been mainly used for solving various power system steady state control problems. However, studies reveal that FACTS controllers could be employed to enhance voltage profile in the network in addition to their function of power flow control in the network. This paper presents how static var compensator (SVC) can be utilized to control transmission system dynamic performance for system disturbance and effectively regulate system voltage. Static var compensator (SVC) is basically a shunt connected static var generator whose output is adjusted to exchange capacitive or inductive current so as to maintain or control specific power variables, typically, the control variable is the system bus voltage. Voltage control and the increase in system load ability are the main applications of SVC in this paper. Firstly, to design a controller for SVC devices on a transmission line, a single machine infinite bus (SMIB) is modeled. A state space model is developed in the MATLAB/SIMULINK to show the improvement in the dynamic performance of the system[2].

Flexible AC transmission systems (FACTS) have gained a great interest during the last few years, due to recent advances in power electronics. FACTS devices have been mainly used for solving various power system steady state control problems such as voltage regulation, power flow control, and transfer capability enhancement. As supplementary functions, damping the inter-area modes and enhancing power system stability using FACTS controllers have been extensively studied and investigated. The increase in the loading of the transmission lines sometimes can lead to voltage collapse due to the shortage of reactive power delivered at the load centers.This is due to the increased consumption of reactive power in the transmission network and the characteristics of the network.Various FACTS controllers like SVC, STATCOM, IPFC, UPFC etc are used today in electrical power network depending upon its application. The main focus of this paper is the application of static var compensator

(SVC) to solve voltage regulation and improve system dynamic performance. SVC is a thyristor based controller that provides rapid voltage control[2].

A. History and Background of SVCs

Static var compensators, regarded as the first FACTS controllers, have been used in North American transmission systems since late 1977 in western Nebraska . The aforementioned transmission SVC device was installed to provide “automatic, continuous voltage control.”Since then, there are a lot of transmission SVCs commissioned around the world, and many transmission SVCs applied in North America. The term “transmission system SVC” is used because SVCs are also applied at the distribution level to compensate for local voltage fluctuation problems due to industrial load operation. The heart of the SVC is an ac power semi-conductor switch commonly known as the “thyristor valve” that is used in principle to replace mechanical switches to achieve rapid repetitive, and in some cases continuous control of the effective shunt susceptance at a specific location in a transmission system by a set of inductors and capacitors . For example, the fixed capacitor (FC) in parallel with a thyristor-controlled reactor (TCR), the valve continuously and “smoothly” controls the reactor to achieve a “net susceptance” that is varied to maintain the transmission system voltage to a desired value or range.

The overall steady-state characteristics of the SVC are described in the form of a volt-current(VI) curve, as illustrated in the following sections. An automatic voltage regulator with a transfer function of [K * 1/(1+sTp)] is often used. References provides an excellent application-oriented and often referenced book by Dr. Hingorani and Dr. Gyugyi that “emphasizes physical explanations of the principles involved in FACTS applications.

B. Voltage Control using SVC

References provide in-depth and comprehensive explanations and application examples associated with voltage stability and system stability and control. These references discuss how and when SVC application can:-

(1) Effectively improve voltage control and dynamic performance

(2) A cost-effective solution

The influence on voltage control capabilities of reactive compensation devices such as mechanically-switched capacitors (MSC), SVC, voltage-source converters (STATCOM), and thyristor controlled series capacitors (TCSC) are compared in. This paper compares the ability of the aforementioned devices to influence the transient voltage stability of a transmission system, and their ability to maintain security under contingency conditions. SVC with “smooth” control can solve transient voltage stability and regulation problems that cannot be solved by MSCs due to the limitations of switching speed and switching frequency of MSC. However, MSC can be economically used together with SVCs to provide a static var system for voltage control. The mentioned references also discuss how reactive compensation such as SVC is often applied in or around load centers (with remote generation) where the system connecting the load center to the generation source can become relatively weak under certain contingency conditions leading to voltage control or collapse problems. The results of an electric utility survey on the practices that utilities use for transmission operational planning studies with respect to voltage limits and reactive margins to ensure adequate system security and reliability. This report outlines the general process that utilities use to determine system voltage limits and reactive power margins required to prevent voltage collapse (for example) for different system conditions such as peak and light loading, and contingency outages of transmission lines or generators[2].

5. CONCLUSIONS

A steady state mathematical model for the SVC and TCSC was proposed. The proposed model can easily be incorporated in existing programs. The capability of SVC and TCSC in optimal power flow applications was demonstrated and compared with losses of a SVC and TCSC. It was shown that FACTS Devices can be controlled in a power system to satisfy the objectives simultaneously: Regulating power flow through a transmission line, minimization of power losses without generation rescheduling.

6. REFERENCES

[1] M.Karthik, P.Arul, "Optimal Power Flow Control Using FACTS Devices", International Journal of Emerging Science and Engineering (IJESE) ISSN: 2319–6378, Volume-1, Issue-12, October 2013.
[2] M Asrar Ur Rahman1 and M Sabah ul Islam2,Electrical Engineering Department, K.F.U.P.M, Dhahran, Kingdom of Saudi Arabia. Corresponding Author: M Sabah ul Islam, Dept. of Electrical Engineering, JNTU-H, Hyderabad-INDIA, "Voltage Control and Dynamic Performance of Power Transmission Using Static VAR Compensator", International Journal of Interdisciplinary and Multidisciplinary Studies (IJIMS), 2014, Vol 1, No.4, 141-151.
[3] Mr.P.S.Chindhi1, Prof .H.T.Jadhav2, Mr.V.S.Patil3, "A Comprehensive Survey for Optimal Location and Coordinated Control Techniques for FACTS Controllers in Power System Environments and Applications",IOSR Journal of Electronics and communication Engineering (IOSR-JECE) ISSN: 2278-2834, ISBN: 2278-8735, PP: 05-11
[4] M. A. Abido, System Stability Enhancement using FACTS Controllers The Arabian journal for science and engineering.(2009) .
[5] Daniel J. Sullivan, Improvement in voltage control and dynamic performance of power transmission systems using Static var Compensator(SVC) University of Pittsburgh,2006.
[6] Md M. Biswas, KamolK.Das, Voltage level improving by using Static VAR Compensator Bangladesh university of engineering and technology (BUET),Bangladesh.
[7] Ravi kumarsahu and nitinsaxena, Dynamic performance of power transmission system improvement using static VAR Compensator, International general of electrical,electronic and computer engineering (2013**)**.
[8]Avneesh Kumar Vishwakarma,DhaneshwariSahu, Efficient voltage regulation in three phase AC transmission lines using static VAR compensator, International journal of advanced research in electrical, electronics and instrumentation engineering.(2013).
[9] D. Murali, Dr. Rajaram, Active and reactive power flow control using FACTS devices, International Journal of computer applications (0975- 8887) Volume 9- No. 8, November – 2010.
[10] Alok Kumar Mohanty, Amar Kumar Barik, Power system stability improvement using FACTS devices, International journal of modern engineering research (IJMER), Volume1, issue 2, pp-666-672, ISSN:2249-6645.
[11] A .S. Siddiqui, Tanmoi Deb, Voltage stability enhancement through static VAR compensator, International journal of scientific and engineering research, Volume 4, Issue 2, February 2013., ISSN 2229-5518.
[12] Mr. P.S. Chindhi, Prof. H.T. Jadhav, Mr. V. S. Patil, A comprehensive survey for optimal location and coordinated control techniques for FACTS controllers in power system environments and applications, IOSR Journal of electronics and communication engineering, ISSN: 2278-2834, ISBN:2278- 8735, PP: 05-11.
[13] M. Karthik, P. Arul, Optimal power flow control using FACTS devices, International journal of emerging science and engineering (IJESE), ISSN:2319-6378, Volume-1, Issue – 12, October 2013.
[14] Alok Kumar Mohanty, Amar Kumar Barik, Power system stability improvement using FACTS devices, International journal of modern engineering research (IJMER), Volume1, issue 2, pp-666-672, ISSN:2249-6645.