Review of Power System Transient Stability

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Abstract— This paper presents review of various techniques used for enhancement of power system stability. Various FACTS devices including UPFC, TCSC, SSSC, TCBR, FCL which are used for enhancing transient stability in power system are reviewed in this paper. Survey up to 2013 is done and the information collected in this paper is sufficient for finding out relevant references in the field of power system stability.

Keywords : *FACTS, transient stability,* UPFC, TCSC, SSSC ,TCBR, FCL.

I. INTRODUCTION

With the increasing demand of electric power, power systems should be exploited near stability margins. In these conditions, transient stability problems become more serious. When a power system is subjected to a large disturbance, control actions need to be taken to limit the extent of the disturbance. Various methods have been taken to improve the transient stability of power systems, such as high-speed exiting, steam turbine fast-valving and dynamic braking. The wide usage of FACTS controllers is another method that helps to enhance power system transient stability. FACTS are system comprised of static equipment's which are used for the AC transmission of electrical energy. Concept of FACTS was first defined by N.G. Hingorani in 1988.

Various FACTS device which helps in enhancing power system stability are reviewed in this paper:-

Unified Power Flow Controller (UPFC) is used to control the power flow in the transmission systems by controlling the impedance, voltage magnitude and phase angle. TCSC can be utilized in the power system transient stability enhancement, power system oscillation damping, the SSR mitigation and load flow control. SSSC is used in controlling active and reactive as well as damping power system oscillations in transient mode. FCL is used for fault current limiting, transient stability enhancement and reduction of torsional oscillations and TCBR is used for fast control of generator disturbances.

Power system stability is the ability of the system to regain its original state after being subjected to disturbances. Power system stability is considered as the main problem for the secure system. Power system stability is defined as the ability of the system to maintain equilibrium during normal operating conditions and regain the equilibrium after being subjected to disturbance. In power system stability the restoring forces are equal or greater than the disturbing forces.

Instability in the system can be classified into many ways depending upon system configuration and operating modes. The stability problem is main in synchronous operation and as power system rely on synchronous machines for generation so their stability is important to maintain synchronism.

The electrical power system is an interconnected system which includes thousands of electric elements.

Advantages of interconnected power system

- It provides us large amount of power and increases the reliability.
- It helps in reduction of machine size that is required for peak load and spinning reserve.
- It provides economical power to consumers.

This paper presents review of various techniques used for enhancement of power system stability. Various FACTS devices including UPFC, SSSC, TCBR, FCL which are used for enhancing transient stability in power system are reviewed in this paper. Survey up to 2013 is done and the information collected in this paper is sufficient for finding out relevant references in the field of power system stability.

II. LITERATURE REVIEW

Chi-Shan Yu, this paper explains the improvement of the optimal aim strategy (OAS) for the design of a thyristor controlled series compensator controller has been proposed to enhance the inter-area transient stability of interconnected power systems. Due to some problems created in applying conventional OAS to the power system transient stability control and some solutions have been proposed to improve the conventional OAS and the analytic design procedures also have been proposed to achieve the desired performance. In this addition for multimachine inter-area transient stability OAS control; the reduced order model has been proposed to design the improved OAS command. Shaping of the reduced order model involves the real-time measurements which are available from phasor measurement units (PMUs). Finally, some simulation studies are employed to test the controller.

Souza, C.L, this technique aims to analyze the transient stability of electrical power systems including the influence of induction generators driven by prime movers whose primary fuel is the industrial wastes of sugar cane alcohol plants. In a steady state these machines work with the synchronous generators attending part of the active power demand (cogeneration) and during disturbances they also act to improve the system transient stability. Used an existing transient stability program; some simulations are run to compare the performance of a typical electrical system with and without the presence of induction generators.

P. Kumkratug and M. H. Haque, in this paper SSSC has been applied to different power system studies to improve the system performance . There has been some work done to utilize the characteristics of the SSSC to enhance power system stability. Wang investigated the damping control function of an SSSC installed in power systems. The linearized model of the SSSC integrated into power systems was established and methods to design the SSSC damping

controller were proposed. Kumkratug and Haque demonstrated the capability of the SSSC to control the line flow and to improve the power system stability. A control strategy of an SSSC to enlarge the stability region has been derived using the direct method. The effectiveness of the SSSC to extend the critical clearing time has been confirmed though simulation results on a single machine infinite bus system.

Prof. Ahmed A. Hossam-Eldin Prof. Hesham Elrefaie Eng. Gaballah Kfvlobamed (2006) presented a paper in which study and investigation is done on how UPFC affects the transmission system having series voltage and shunt current injection. UPFC provides better results than other devices and its advantages are also discussed. Various features of UPFC are discussed and some of them include improvement of the system characteristics, power factor , control of voltage and power flow thus providing the best transient and dynamic stability. UPFC is also used for improving the transient stability in power system. Simulation is done for various loads and system voltages.

Yuning Chen, M.E. El-Hawary, in this paper a new braking resistor approach using the equal area criterion (EAC) is used to improve the transient stability of power systems. The conventional and a fuzzy logic controller have been developed and compared. This proposed approach was tested on a single machine system and on the WSCC multimachine test system. The simulation results indicate that the proposed approach provides a simple and effective method for the transient stability improvement.

Sidhartha Panda Ramnarayan N. Patel, in this paper the used of Shunt Flexible AC Transmission System (FACTS) devices can be placed at the mid-point of a long transmission lineand they give a important role in controlling the reactive power flow to the power network and hence both the system voltage fluctuations and transient stability. In this paper deals with the location of a shunt FACTS device to improve transient stability in a long transmission line with predefined direction of real power flow. This validity of the mid-point location of shunt FACTS devices is verified with different shunt FACTS devices, namely static var compensator (SVC) and static synchronous compensator (STATCOM) in a long transmission line by using the actual line model. It is observed that the FACTS devices when placed slightly off-centre towards sending-end and give better performance in improving transient stability and the location depends on the amount of local/through load.

KA Folly, Member, IEEE, B. S. Limbo, this paper discusses the experience of the authors in using Matlab Power System Toolbox for the transient stability studies of an AC/DC Interconnection power system. This modified two-area power system model with HVDC Link is used in the investigation. It shown that the AC line became weaker (as compared to the DC line); the transient stability of the interconnected AC/DC system is negatively affected. The use of power system stabilizer (PSS) was critical in maintaining the stability of the system.

Mansour A. Mohamed George G. Karady Ali M. Yousef, this paper discusses the proposes of transient angle stability agents to enhance power system stability. The transient angle stability agents divided into two strategy agents. This first strategy agent is a prediction agent that will predict power system instability. The prediction agent's output the second strategy agent which is a control agent is automatically calculating the amount of active power reduction that can

stabilize the system and initiating a control action. The new proposed strategies are applied to a realistic power system, the IEEE 50- generator system. The results show that the proposed technique can be used on-line for power system instability prediction and control.

Prechanon Kumkratug, in this paper investigation is done for problem for controlling and modulating power flow in transmission line using static synchronous series comprensator (SSSC). One of the major interests of power utilities is the improvement of power system transient stability behavior. Static Synchronous Series Compensator (SSSC) is a power electronic based device is used for capability of controlling the power flow through a line. The study of the SSSC to improve transient stability of power system. SSSC is represented by variable voltage injection with associate transformer leakage reactance and the voltage source. These series voltage injection model of SSSC is modeled into power flow equation and thus it is used to determine its control strategy. We can study the uses machine speed deviation to control it. These swing curves of the three phase faulted power system without and with a SSSC is tested and compared in various cases. The swing curve of system without a SSSC gets increases monotonically and thus the system can be considered as unstable whereas the swing curves of system with a SSSC can be considered as stable. SSSC can improve transient stability of power system.

Dr. Tarlochan kaur and Sandeep kakran, in this paper to improve the transient stability of long transmission line system by using SVC. In the present time power systems are being operated nearer to their stability limits due to economic and environmental reasons. The maintaining a stable and secure operation of a power system is a very important and challenging issue. Transient stability has given much attention by power system researches and planners in recent years and being regarded as one of major sources of power system insecurity. Shunt FACTS device an important role in improving the transient stability and increasing transmission capacity and damping low frequency oscillations. In this paper to describes the shunt FACTS device SVC is used in a two area power system for improving the transient stability. MATLAB software is used.

Kumar, Arun, this paper presents a comprehensive review on enhancement of power system stability such as rotor angle and frequency stability and voltage stability by using different FACTS controllers such as TCSC; SVC; SSSC; STATCOM; UPFC; IPFC in an integrated power system networks. Also the presents the current status of the research and developments in the field of the power system stability such as rotor angle stability, frequency stability and voltage stability enhancement by using different FACTS controllers in an integrated power system networks. Authors strongly believe the useful to the researchers for finding out the relevant references in the field of enhancement of power system stability by using different FACTS controllers in an integrated power system network.

Gundala srinivasa rao, in this paper to improve transient stability by using Fuzzy controlled TCSC. When power system is subjected to sudden changes in load levels. The important concept of the stability to which determines the stable operation of power system. In the rotor angle stability is taken as index but the concept of transient stability which is the function of operating condition and disturbances deals with the ability of the system to remain intact after being subjected to abnormal deviations. The system is said to be synchronously stable (i.e., retain

synchronism) for a given fault if the system variables settle down to some steady-state values with time after the fault is removed.
In this paper, in order to improve the Transient Stability margin further series FACTS device has been implemented. In a fuzzy controlled Thyristor Controlled Series Compensation (TCSC) device has beend used here and the result highlight the effectiveness of the application of a TCSC improving the transient stability of a power system.
In this paper also used of trajectory sensitivit analysis (TSA) to measure the transient stability condition of the system. TCSC is modeled by a variable capacitor the value of which chande with the firing angle. TSA can be used in the design of the controller. The location of the TCSC controller for different fault conditions can also be identified with the help of TSA. The advantage of the use of TCSC with a fuzzy controller over fixed capacitor operation.

Carlo Cecati and Hamed Latafat, to study the transient stability of a two machine infinite bus system when affected by large disturbances by comparison of time domain approach versus transient energy function. Then decentralized nonlinear controller is embedded within the power system and simulation results show that the transient stability has been greatly enhanced. Based on existing transient energy function of uncontrolled power system the controlled power system has been represented as a forced Hamiltonian system. The Lyapunov function is suitable for transient stability analysis of this controlled power system has been used for stability. Simulations in different operating points show the enhancement of transient stability of power system with controller in both time domain approach and energy function method.

B .M. Naveen kumar Reddy, Mr. G. V. Rajashekar, Dr. Himani Goyal In this paper is done by controlling and modulating power flow in transmission line using Static Synchronous Series Compensator (SSSC). Here, PWM techniques controlled for SSSC, are conducted and control circuits are presented. In this paper SSSC is used to investigate effect of it in controlling active and reactive powers as well as damping power oscillations in the transient mode. SSSC equipped with source of energy in the DC link and can supply or absorb the reactive and active power to or from the line. Simulations are done in MATLAB/simulink environment. Two machine system is used in this paper along with SSSC for controlling power flow in the line and achieving the desired value for active and reactive power, also damping oscillations appropriately. It has been explained in the paper that SSSC applications will be extended in future to investigate the problems related to the various modes of power oscillation in the power systems.

Satvinder Singh, Atma Ram, Nitin Goel, Pawan Kumar published a paper in which significant area of research is improvement of transient stability. In this paper to studies of the comparative performance of SVC (Static Var Compensator) and UPFC (Unified Power Flow Controller) for the improvement of transient stability of multi-machine system. The UPFC is more effective FACTS (Flexible AC Transmission System) device for controlling active and reactive power flow in a transmission line and power oscillation damping by controlling its series and shunt parameter. Simulation is carried out in MATLAB/Simulink environment for multi-machine system to analyses effects of SVC and UPFC on transient stability system. The performance of UPFC is compared with SVC. The simulation results demonstrate the effective and robustness of the proposed UPFC for transient stability improvement of the system.

Surinder Chauhan, Vikram Chopra, Shakti Singh in this paper by using a static synchronous compensator is one of the FACTS devices used to improve the transient stability of the power system. In this paper the fuzzy logic controller is also designed. The inputs of the fuzzy logic are the alternator speed i.e. ω and the output is the firing angle α of the voltage source converter. The proposed controller is tested on two machine system using Matlab Simulink. The Results compared with conventional PI STATCOM Controller.

Manish kumarsaini, Nareshkumaryadav, Naveen mehra published a paper in which the applications of UPFC for optimal flow of power and reduction of losses is demonstrated. In this paper to describes the multi machine power system example to demonstrate the features and scope of graphical simulink environment of general purpose of MATLAB software.

Unified Power Flow Controller (UPFC) is used to control the power flow in the transmission systems by controlling the impedance, magnitude and phase angle. The advantage of controller in terms of static and dynamic operation of the power system. It is new challenges in power electronics and power system design. It consists of two voltage source inverter (VSI); where one converter is connected in parallel to the transmission line while the other is in series with the transmission line. The designing of a single phase UPFC using Matlab and Simulink software and constructing a lab scale model of the UPFC along with transient stability of multi-machine power system.

UPFC provides better results than other devices and its advantages are also discussed. Various features of UPFC are discussed and some of them include improvement of the system characteristics, power factor , control of voltage and power flow thus providing the best transient and dynamic stability. Simulation is done for various loads and system voltages.

III. DISCUSSIONS BASED ON SURVEY

Flexible alternating current transmission system (FACTS) gave up new ways for controlling the power flow and increasing the usable capacity of transmission lines. It is concluded that by reviewing various papers, among FACTS devices, Thyristor Controlled Braking Resistor (TCBR) and fault current limiter (FCL) strategies are considered to be the most simple and easy way to implement it for stability analysis.

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