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Review of Power System Stability Enhancement using Fact Controller

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Abstract – **The machine dynamics response to any impact in the system is oscillatory. In past, the size of power system is smaller; therefor the period of oscillation was not much greater than one second. Today large capacity of generator and system interconnected with the greater system inertias and relatively weaker ties results in longer period of oscillation followed by perturbation. These are the situations in which dynamic stability is concern. The enhancement of dynamic stability becomes very important for reliability and continuity of power system. Now power electronic based FACTS (Flexible AC Transmission system) devices are established to enhance the power transmitting capacity and also mitigation of oscillatory period of system at the time of fault. The case study of two area system is taken for analysis. Fault is created for observation of different parameter of machine and transmission system like rotor angle waveform, settling time, voltage of machine, active power of machine and transmission voltage. The different fault analysis says that FACTS controllers help to improve dynamic stability. Among all FACTS devices, UPFC(Unified Power Flow Controller) seen more suitable for enhancement of dynamic stability of two area and multi area system. MATLAB simulation is used to do analysis for different system.**

Keywords – **Power Systems, Power System Stability, Dynamic Stability, Flexible AC Transmission Systems (FACTS), FACTS Controllers.**

I. INTRODUCTION

At present the demand for electricity is rising phenomenally especially in developing country like India. This persistent demand is leading to operation of the power system at its limit. The need for reliable, stable and quality power is on the rise due to electric power sensitive industries like information technology, communication, electronics etc. In this scenario, meeting the electric power demand is not the only criteria but also it is the responsibility of the power system engineers to provide a stable and quality power to the consumers. These issues highlight the necessity of understanding the power system stability. In this course we will try to understand how to asses the stability of a power system, how to improve the stability and finally how to prevent system becoming unstable.

Stable operation of power system required a continuous match between energy input to the prime movers and the electrical load in the system. Continuous change is normal for an operating system. Fortunately, the changes are usually in small increments, as customer load increase or decrease. Each load increase or decrease must be accompanied by a corresponding change in input to the prime mover of the generation on the system. If mechanical input does not rapidly match the power used by the load and the system losses, system speed (frequency) and voltage will deviate from normal. Major power system has elaborate equipment and methods of sensing frequency deviations and making changes in the generation schedule to correct it. Changes in load and generation result in relative changes in the position of generator rotors that must all operate in synchronism if the power system is to remain stable. Power system stability is primarily concern with variation in rotor speed, rotor position and generator loads.

1. Basic Concepts and Definitions of Power System Stability

"Power system stability is the ability of an electric power system, for a given initial operating condition, to regain a state of operating equilibrium after being subjected to a physical disturbance, with most of the system variables bounded so that practically the entire system remains intact" [1], [2]. The disturbances mentioned in the definition could be faults, load changes, generator outages, line outages, voltage collapse or some combination of these. Power system stability can be broadly classified into rotor angle, voltage and frequency stability. Each of these three stabilities can be further classified into large disturbance or small disturbance, short term or long term.

2. Rotor angle stability

"It is the ability of the system to remain in synchronism when subjected to a disturbance". The rotor angle of a generator depends on the balance between the electromagnetic torque due to the generator electrical power output and mechanical torque due to the input mechanical power through a prime mover. Remaining in synchronism means that all the generators electromagnetic 1.2 torque is exactly equal to the mechanical torque in the opposite direction. If in a generator the balance between electromagnetic and mechanical torque is disturbed, due to disturbances in the system, then this will lead to oscillations in the rotor angle. Rotor angle stability is further classified into small disturbance angle stability and large disturbance angle stability.

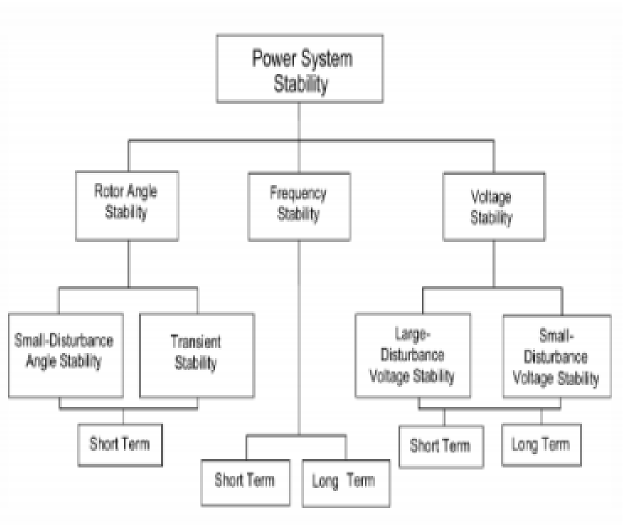


Fig. 1.Classification of power system stability.

3. Small-disturbance or small-signal angle stability

"It is the ability of the system to remain in synchronism when subjected to small disturbances". If a disturbance is small enough so that the nonlinear power system can be approximated by a linear system, then the study of rotor angle stability of that particular system is called as small-disturbance angle stability analysis. Small disturbances can be small load changes like switching on or off of small loads, line tripping, small generators tripping etc. Due to small disturbances there can be two types of instability: non-oscillatory instability and oscillatory instability. In non-oscillatory instability the rotor angle of a generator keeps on increasing due to a small disturbance and in case of oscillatory instability the rotor angle oscillates with increasing magnitude.

4. Large-disturbance or transient angle stability

"It is the ability of the system to remain in synchronism when subjected to large disturbances". Large disturbances can be faults, switching on or off of large loads, large generators tripping etc. When a power system is subjected to large disturbance, it will lead to large excursions of generator rotor angles. Since there are large rotor angle changes the power system cannot be approximated by a linear representation like in the case of small-disturbance stability. The time domain of interest in case of large-disturbance as well as small-disturbance angle stability is any where between 0.1- 10 s. Due to this reason small and large-disturbance angle stability are considered to be short term phenomenon. It has to be noted here that though in some literature "dynamic stability" is used in place of transient stability, according to IEEE task force committee report [2], only transient stability has to be used.

5. Voltage stability

"It is the ability of the system to maintain steady state voltages at all the system buses when subjected to a disturbance. If the disturbance is large then it is called as large-disturbance voltage stability and if the disturbance is small it is called as small-disturbance voltage stability". Unlike angle stability, voltage stability can also be a long term phenomenon. In case voltage fluctuations occur due to fast acting devices like induction motors, power electronic drive, HVDC etc then the time frame for understanding the stability is in the range of 10-20 s and hence can be treated as short term phenomenon. On the other hand if voltage variations are due to slow change in load, over loading of lines, generators hitting reactive power limits, tap changing transformers etc then time frame for voltage stability can stretch from 1 minute to several minutes. The main difference between voltage stability and angle stability is that voltage stability depends on the balance of reactive power demand and generation in the system where as the angle stability mainly depends on the balance between real power generation and demand.

6. Frequency stability

"It refers to the ability of a power system to maintain steady frequency following a severe disturbance between generation and load". It depends on the ability to restore equilibrium between system generation and load, with minimum loss of load. Frequency instability may lead to sustained frequency swings leading to tripping of generating units or loads. During frequency excursions, the characteristic times of the processes and devices that are activated will range from fraction of seconds like under frequency control to several minutes, corresponding to the response of devices such as prime mover and hence frequency stability may be a short-term phenomenon or a long-term phenomenon. Though, stability is classified into rotor angle, voltage and frequency stability they need not be independent isolated events. A voltage collapse at a bus can lead to large excursions in rotor angle and frequency. Similarly, large frequency deviations can lead to large changes in voltage magnitude. Each component of the power system i.e. prime mover, generator rotor, generator stator, transformers, transmission lines, load, controlling devices and protection systems should be mathematically represented to assess the rotor angle, voltage and frequency stability through appropriate analysis tools. In fact entire power system can be represented by a set of Differential Algebraic Equations (DAE) through which system stability can be analyzed. In the next few Chapters we will be concentrating on power system components modeling for stability analysis.

II. PROJECT OBJECTIVE

The objective of this paper is to investigate the power system stability analysis and improvement by Flexible AC Transmission System (FACTS) controllers. Here at first we have analysis a demo network with stable and unstable condition.

A stable power system network may be unstable at any moment due to external fault, if the fault is cleared but it will effect the transmission line voltage as well it also effect the connecting generators also. as a result the generator output stability is changed so line voltage is differ from its stability limit and make the system unbalance and unstable.

As a result huge amount power loss occurred in the line. So in this paper we have studied a normal power system and make it abnormal in fault is cleared but transmission line voltage has been changed (decrease) improve it by FACTS controller device and more improve it by using two FACTS controller device then voltage level is improved tremendiously.

Networkis analysis again improve by STATCOM Controller. We have also analysis the alternator output curve and make this also more stable by analysis in Mat lab simulation.

III. PROJECT MOTIVATION

1. At first effect of different FACTS controller mainly SVC and STATCOM on transient stability is analyzed in a demo power network.
2. Comparison between effect of SVC and STATCOM on two machine system is carried out with and without controller.
3. Transient stability in two fault condition – three phase to ground fault and line to line fault is studied and analyze the different curves of transient stability with different parametric condition with respect to time and how they are vary with respect to time and get the idea of transient stability and get how the system is different from the actual curve of respective parameter.
4. Understanding modeling requirements of power system equipment for different studies
5. Understanding causes of instability and methods of analysis and enhancement of different power system small and large disturbance rotor angle stability phenomena.
6. Understanding different methods and techniques of power system stability controls and their limitations.

IV.LITERATURE REVIEW

Mr. B. T. Ramakrishna Rao*, P. Chanti, N. Lavanya, S. chandraSekhar**, Y. Mohan kumar“ Power System Stability Enhancement Using Fact Devices”** The development of the modern power system has led to an increasing complexity in the study of power systems, and also presents new challenges to power system stability, and in particular, to the aspects of transient stability and small-signal stability. So Power system engineers are currently facing challenges to increase the power transfer capabilities of existing transmission system. This is where the Flexible AC Transmission Systems (FACTS) technology comes into effect with relatively low investment, compared to new transmission or generation facilities. Flexible AC transmission system (FACTS) devices use power electronics components to maintain controllability and capability of electrical power system. The paper aims towards the performance of UPFC is compared with other FACTS devices such as Static Synchronous Series Compensator (SSSC), Thyristor Controlled Series Capacitor (TCSC), and Static Var Compensator (SVC) respectively. The simulation results demonstrate the effectiveness of the UPFC on transient stability of the system.

Naveen Singh, PiyushAgnihotri “Power system stability improvement using facts Devices” Due to limited resources and environmental restrictions, the power generation and transmission has been severely limited even though the power demand has increased substantially in the last two decades. The consequence being some of the transmission lines are heavily loaded and the system stability becomes a power transfer limiting factor. To solve various power system steady state control problems, FACTS (Flexible ac transmission system) controllers have been used. Flexible and dynamic control of power systems are allowed through Flexible AC transmission system or FACTS. The investigation of FACTS devices for the enhancement of system stability has been done. To improve the operation of electrical power system by utilizing FACTS devices is the main aim of this paper. This paper also discussed the performance comparison of different FACTS controllers. Reviews and summaries of some of the utility experience and semiconductor technology development have also been taken into consideration.in this paper, the discussion of applications of FACTS to power system studies has also been done.

Mohammed Abido “Power system stability enhancement using FACTS controllers: A review”In recent years, power demand has increased substantially while the expansion of power generation and transmission has been severely limited due to limited resources and environmental restrictions. As a consequence, some transmission lines are heavily loaded and the system stability becomes a power transfer-limiting factor. Flexible AC transmission systems (FACTS) controllers have been mainly used for solving various power system steady state control problems. However, recent studies reveal that FACTS controllers could be employed to enhance power system stability in addition to their main function of power flow control. The literature shows an increasing interest in this subject for the last two decades, where the enhancement of system stability using FACTS controllers has been extensively investigated. This paper presents a comprehensive review on the research and developments in the power system stability enhancement using FACTS damping controllers. Several technical issues related to FACTS installations have been highlighted and performance comparison of different FACTS controllers has been discussed. In addition, some of the utility experience, real-world installations, and semiconductor technology development have been reviewed and summarized. Applications of FACTS to other power system studies have also been discussed. About two hundred twenty seven research publications have been classified and appended for a quick reference.

Arun Kumar ; G. Priya"Power system stability enhancement using FACTS controllers" This paper presents a comprehensive review on enhancement of power system stability such as rotor angle stability, 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 this paper 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 that this survey article will be very much 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.

Suparna Pal, "A Power System Transient Stability Analysis And Improvement By Facts Controllers" - Today's Power system is a complex network; power generation usually does not situate near the load center. So meet the growing power demand, it is better to give more interest in utilization of available power system capacities of existing generation and power transmission network, instead of building new transmission lines and expanding substations. On the other hand, power flows in some of the transmission lines are overloaded, causing the deterioration of voltage profiles and decreasing system stability and security due to short circuit or any other external fault. In addition, existing traditional transmission facilities, in most cases, are not designed to handle or control this complex and highly interconnected power systems. This overall situation requires improving the traditional transmission methods and practices, and the creation of new concepts, which would allow the use of existing generation and transmission lines up to their full capabilities without reduction in system stability and security. This paper is highlighting this concept and analysis of a complex network and this approach can be applied in complex power system network.

Alok Kumar Mohanty*, Amar Kumar Barik* "Power System Stability Improvement Using FACTS Devices" In the last two decades, power demand has increased substantially while the expansion of power generation and transmission has been severely limited due to limited resources and environmental restrictions. As a consequence, some transmission lines are heavily loaded and the system stability becomes a power transfer-limiting factor. Flexible AC transmission systems (FACTS) controllers have been mainly used for solving various power system steady state control problems. Flexible AC transmission systems or FACTS are devices which allow the flexible and dynamic control of power systems. Enhancement of system stability using FACTS controllers has been investigated. This paper is aimed towards the benefits of utilizing FACTS devices with the purpose of improving the operation of an electrical power system. Performance comparison of different FACTS controllers has been discussed. In addition, some of the utility experience and semiconductor technology development have been reviewed and summarized. Applications of FACTS to power system studies have also been discussed.

Panda, Sidhartha "Power System Stability Improvement With Facts Controllers" This thesis mainly contributes in the area of application of various Flexible AC Transmission Systems (FACTS) controllers for power system stability improvement ensuring secure and stable operation of the power system. In this context, modern heuristic optimization techniques are employed to design the FACTS-based controllers and also to find the optimal location of FACTS controllers. In recent years, one of the most promising research field has been "Heuristics from Nature", an area utilizing analogies with nature or social systems. Among these heuristic techniques, Genetic Algorithm (GA), Particle Swarm Optimization (PSO), and GA-based multiobjective optimization techniques appeared as promising algorithms for handling the optimization problems. In the present study, an attempt has been made to explore the application of these modern heuristic optimization techniques to improve the stability of a power system installed with FACTS controllers. The main objectives ofthe proposed research work are; 1. Application and comparison of modern heuristic optimization techniques in FACTS-based controller design. 2. Development of MATLAB/SIMULINK models for power systems with both FACTS controllers andpower system stabilizer andtheir coordinated design. 3. Determination of optimal location ofFACTS controllers. 4. Investigations on power system stability improvement using FACTS controllers and further extended to distribution networks embedded with wind energy. Optimization techniques such as Particle Swarm Optimization (PSO) and Genetic Algorithm (GA) are inspired by nature, and have proved themselves to be effective solutions to optimization problems.

P. Sivachandran, T. Hariharan and R. Pushpavathy "Improvement of Power System Stability using D-

Facts Controllers: A Review" As the power demand has been increasing rapidly, power generation and transmission are being affected due to limited resources, environmental restrictions and other losses. Transient stability control plays a vital role in maintaining the steady state operation of power system in the event of huge disturbance, faults and any extinction of power generation. Flexible AC Transmission System (FACTS) controllers were mainly used for solving various power system control problems. This paper presents the study of various FACTS devices and their effects on power system for stability enhancement.

ChagantyVeeraVenkataPavani, "Power System Stability Improvement FACTS Devices" In the most recent two decades, control request has expanded significantly while the development of force era and transmission has been seriously constrained because of restricted assets and ecological confinements. As an outcome, some transmission lines are vigorously stacked and the framework strength turns into a power exchange restricting component. Adaptable AC transmission frameworks (FACTS) controllers have been principally utilized for settling different power framework unfaltering state control issues. Adaptable AC transmission frameworks or FACTS are gadgets which permit the adaptable and element control of force frameworks. Improvement of framework security utilizing FACTS controllers has been explored. This paper is pointed towards the advantages of using FACTS gadgets with the reason for enhancing the operation of an electrical power framework. Execution examination of various FACTS controllers has been talked about. Furthermore, a portion of the utility experience and semiconductor innovation advancement have been checked on and compressed. Uses of FACTS to power framework considers have additionally been talked about.

Mohamed EL-Shimy"Power System Stability - A technical report and a short course"Power system stability denotes the ability of an electric power system, for a given initial operating condition, to regain a state of operating equilibrium after being subjected to a physical disturbance, with most system variables bounded so that system integrity is preserved. The integrity of the system is preserved when practically the entire power system remains intact with no tripping of generators or loads, except for those disconnected by isolation of the faulted elements or intentionally tripped to preserve the continuity of operation of the rest of the system. Stability is a condition of equilibrium between opposing forces; instability results when a disturbance leads to a sustained imbalance between the opposing forces. Due to the high dimensionality and complexity of stability problems, it is essential to make simplifying assumptions and to analyze specific types of problems using the right degree of detail of system representation. The power system is a highly nonlinear system that operates in a constantly changing environment; loads, generator outputs, topology, and key operating parameters change continually. When subjected to a transient disturbance, the stability of the system depends on the nature of the disturbance as well as the initial operating condition. The disturbance may be small or large. Small disturbances in the form of load changes occur continually, and the system adjusts to the changing conditions. The system must be able to operate satisfactorily under these conditions and successfully meet the load demand. It must also be able to survive numerous disturbances of a severe nature, such as a short circuit on a transmission line or loss of a large generator. Following a transient disturbance, if the power system is stable, it will reach a new equilibrium state with practically the entire system intact; the actions of automatic controls and possibly human operators will eventually restore the system to a normal state. On the other hand, if the system is unstable, it will result in a runaway or a run-down situation; for example, a progressive increase in angular separation of generator rotors, or a progressive decrease in bus voltages.

K. Revathi1 , B. Viswanath "Performance Analysis of Facts Controllers for Transient Stability Enhancement of Four Machine Two Area Test System" In this paper an investigation has been performed for the upgradation of transient stability limit in four machine two area test system using different FACTS Controllers. Flexible AC transmission systems (FACTS) controllers have been mainly used for solving various power system steady state control problems. However, latest studies reveal that the FACTS controllers could be employed to enhance power system stability in addition to their main function of power flow control. Modelling and simulation of Static Synchronous Series Compensator (SSSC), Static synchronous compensator (STATCOM) and Unified Power Flow Controller (UPFC) for power system stability enhancement and improvement of power transfer capability have been presented in this paper. The performance of unified power flow controller (UPFC) for the upgradation of transient stability limit has been investigated along with other FACTS devices such as static synchronous compensator (STATCOM) and static synchronous series compensator (SSSC) respectively. The paper establishes the superiority of UPFC over STATCOM & SSSC.

Pradeepkumar S. Mahapure1 , A. R. Soman "Transient Stability Improvement using FACTS Devices" FACTS devices used in electrical systems form one of the important aspects of power electronics revolution that are taking place in electrical areas. Use of several Technological FACTS devices in Electrical power system is because of advanced researches in power electronics. This revolution in power electronics is happening and different applications in electronic system will tend to expand and increase day by day. Almost unique and ideal quality and properties of FACTS controllers that is possible to implement so to improve transient and overall stability of Electrical network, as when using these controllers it allows to have control on network conditions by giving quick response in less time by control on reactive energy which will further result in enhancement of electric energy. Stability in System and operation in electrical power systems during huge disturbances and faults can be obtained by maintaining Transient stability as Transient stability control plays important role in control of power system parameters. By employing UPFC in network it plays an important role as it acts as effective FACTS (Flexible AC Transmission System) equipment.

It is possible to obtain control on the true or real, reactive energy flowing along network through changing accordingly series and shunt values, and when FACTS devices are attached with On Site Generation (ONG) or Decentralised energy by connecting it using DC link to obtain control on disturbances created during or by faults results in improvement of overall stability of a electrical network. To show different capabilities of UPFC study of collection of overall performance characteristics is presented. Different FACTS controllers can be used are Static Synchronous Series Compensator (SSSC), Thyristor Controlled Series Capacitor (TCSC), and Static VAR Compensator (SVC) respectively are compared with UPFC and performance of UPFC against other FACTS controller is checked.

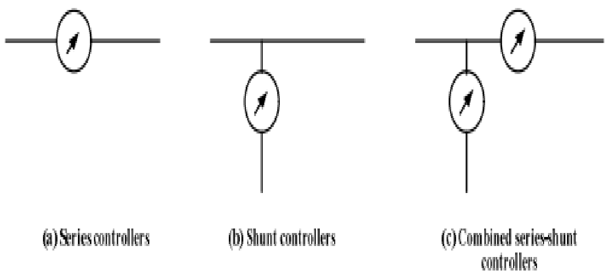
V. METHODS OF FACT CONTROLLLERS

1. Facts Controllers:

Flexible AC Transmission System (FACTS) is defined by an IEEE Working Group as: "Alternating current transmission systems incorporating power electronic-based and other static Controllers to enhance controllability and increase power transfer capability." The significance of the power electronics and other static Controllers is that they have high-speed response and there is no limit to the number of operations.

Like a transistor leads to a wide variety of processors, power devices such as Thyristor, GTO, and IGBT lead to a variety of FACTS Controllers as well as HVDC converters. These Controllers can dynamically line voltage, active and reactive power flow, and control line impedance. They can absorb or supply reactive power and with storage they can supply and absorb active power as well. Figure 1 show, that there are three types of FACTS Controllers, all with high speed control.

- As injection of voltage in series with the line;
- As injection of current in shunt and the
- A combination of voltage injection in series and current injection in shunt. These Controllers will of course have constraint according to the specific type of Controller, its characteristics and rating.



(a) Series controllers (b) Shunt controllers (c) Combined series-shunt controllers

Fig.(5.1). Type of Facts Controller.

2. Objectives of FACTS controllers:

The main objectives of FACTS controllers are the following:

- Regulation of power flows in prescribed transmission routes.
- Secure loading of transmission lines nearer to their thermal limits.
- Prevention of cascading outages by contributing to emergency control.
- Damping of oscillations that can threaten security or limit the usable line capacity.

The implementation of the above objectives requires the development of high power compensators and controllers. The technology needed for this is high power electronics with realtime operating control. The realization of such an overall system optimization control can be considered as an additional objective of FACTS controllers [1].FACTS offers solutions to overcome constraints on useable transmission capacity. These constraints may be due to:Dynamic conditions of :

Transient and Dynamic Stability

- Sub-synchronous Oscillations
- Dynamic Over Voltages and Under Voltages
- Voltage Collapse

Steady State conditions of :

1. Undesirable Power Flow
2. Excess Reactive Power Flows
3. Steady State Voltage
4. Thermal Limits

3. Transient Stability:

Transient stability of a power system refers to the ability of the system to reach a stable condition following a large disturbance in the network condition. In all cases related to large changes in the system like sudden application or removal of the load, switching operations, line faults or loss due to excitation the transient stability of the system comes into play. It in fact deals in the ability of the system to retain synchronism following a disturbance sustaining for a reasonably long period. And the maximum power that is permissible to flow through the network without loss of stability following a sustained period of disturbance is referred to as the transient stability of the system. Going beyond that maximum permissible value for power flow, the system would temporarily be rendered as unstable.

In power plants, several synchronous generators are connected to the bus having the same frequency and phase sequence as the generators. Therefore, for a stable operation, we have to synchronize the bus with the generators over the entire duration of generation and transmission. For this reason, the power system stability is also referred to as synchronous stability and is defined as the ability of the system to return to synchronism after having undergone some disturbance due to switching on and off of load or due to line transience. To understand, stability well, another factor needs to be considered, and that is the stability limit of the system. The stability limit defines the maximum power permissible to flow through a particular part of the system for which it is subjected to line disturbances or faulty flow of power. Having understood these terminologies related to power system stability let us now look into the different types of stability.

The power system stability or synchronous stability of a power system can be of several types depending upon the nature of the disturbance, and for successful analysis, it can be classified into the following three types as shown below:

4. Control of Power System:

- **Generation, Transmission and Distribution**

The creation, transmission and utilization of electrical power can be separated into three areas in any power system which traditionally determined the way in which electric utility companies had been organized.

- Generation
- Transmission
- Distribution

5. Power System Constraints

As the introduction specifies, transmission systems are being pushed closer to their stability and thermal limits whereas, the complete focus is headed towards the quality of power delivered to be greater than ever. The transmission system’s limitations can take many forms and power transfer between areas or within a single area or region may be involved along with the following characteristics:

- Steady state power transfer limit
- Voltage stability limit
- Dynamic voltage limit
- Transient stability limit
- Power system oscillation damping limit
- Inadvertent loop flow limit
- Thermal limit
- Short circuit current limit
- Others

One or more of these system level problems may be incorporated in each transmission bottleneck or regional constraint. By thorough system engineering analysis, these problems can be solved in the most cost effective and coordinated manner.

6. Controllability of Power System

Power-angle curve is shown, which is considered to illustrate that the power system only has certain variables that can beimpacted by control. Despite of being a steady state curve and the implementation of FACTS is primarily for dynamic issues, thisillustration demonstrates that there are three main variables that can be directly controlled to impact the performance of power system. They are:

- Voltage
- Angle
- Impedance

7. Benefits of control of power system

Once the identification of power system constraints is done and identification of viable solution option is done through system studies, the benefits of added power system control must be determined. The benefits are offered by the following list:

- Increased loading and more effective use of transmission corridors
- Added power flow control
- Improved power system stability
- Increased system security
- Increased system reliability
- Added flexibility in starting new generation
- Elimination or deferral of the need of new transmission lines

VI. CONCLUSION

In power plants, several synchronous generators are connected to the bus having the same frequency and phase sequence as the generators. Therefore, for a stable operation, we have to synchronize the bus with the generators over the entire duration of generation and transmission. For this reason, the power system stability is also referred to as synchronous stability and is defined as the ability of the system to return to synchronism after having undergone some disturbance due to switching on and off of load or due to line transience. To understand, stability well, another factor needs to be considered, and that is the stability limit of the system. The stability limit defines the maximum power permissible to flow through a particular part of the system for which it is subjected to line disturbances or faulty flow of power. Having understood these terminologies related to power system stability let us now look into the different types of stability.

The power system stability or synchronous stability of a power system can be of several types depending upon the nature of the disturbance, and for successful analysis, it can be classified into the following three types as shown below:

- Steady state stability.

- Transient stability.
- Dynamic stability.

REFERENCES

[1]. N.G. Hingorani (2011). “Understanding of FACT concept technology of flexible ac transmission system”, IEEE Power Engineering IEEE press, Wiley India.

[2]. L. Gyugyi. (1988). “Power Electronics in electric utilities: Static VAR Compensator”, Processing of IEEE, Vol.7, No.4, pp.483-494.

[3]. N. Hingorani, L. Gyugyi, (2000). “Understanding FACT concept technology of flexible AC transmission system”, IEEE Press, Newyork.

[4]. NagarjunDonipalaet. al. (2014). “An Adaptive Power System Stability Enhancement using Static Synchronous Series Compensator (SSSC)”, Int. Journal of Engineering Research and Applications, ISSN:2248-9622, Vol.4, No.1, pp.261-265.

[5]. B.M. Naveen Kumar Reddy, HimaniGoyal. (2013). “Power System Stability Enhancement using Static Synchronous Series Compensator (SSSC)”, International Journal of Modern Engineering Research (IJMER), Vol.3, Issue.4, pp.2530-2536.

[6]. H. Taheri, S. Shahabi, Sh. Taheri and A. Gholami (2009). "Application of Synchronous Static Series Compensator (SSSC) on Enhancement of Voltage Stability and Power Oscillation Damping", IEEE Transactions on Power System, pp.533-539.

[7]. Abido M. A. (2009). "Power System Stability Enhancement Using Facts Controllers: A Review", The Arabian Journal for Science and Engineering, Vol.34, pp.153-172.

[8]. B.N. Singh, A. Chandra, K.AI-Haddad and B. Singh (1999). "Performance of sliding- mode and fuzzy controllers for a static synchronous series compensator", IEEE proceedings, Vol.146, No.2, pp.200-206.

[9]. G. N. Pillai, A. Ghosh, A. Joshi, (2000). “Torsional interaction studies on a series compensator based on solid-state synchronous voltage source”, Industrial Technology 2000, Proceedings of IEEE International Conference on, Vol.2, pp.179-184, 19-22.

[10]. Sen K.K, (1998). “SSSC-Static Synchronous Series Compensator: Theory, Modeling and Publications”, IEEE Trans. Power Delivery, Vol.13, No.1, pp.241-246.

[11]. A. H. Norouzi, A. M. Sharaf, (2005). “Two control schemes to enhance the dynamic performance of the STATCOM and SSSC”, IEEE Trans. Power Delivery, Vol.20, No.1.

[12]. J. H. Kim, K. C. Kim, E. K. P. Chong, (1994). “Fuzzy precompensated PID controllers”, IEEE Trans. Control Syst. Technology, Vol.2, No.4.

[13]. R. Mihalic, I. Papic, (1998). “Static synchronous series compensator-a mean for dynamic power flow control in electric power systems”, Electrical Power System Research, Vol.45, No.1, pp.65-72.

[14]. L. Sunil Kumar, Arindam Gosh, (1999). “Static synchronous series compensator-Design, Control and Application”, Electrical Power System Research, Vol.49, No.2, pp.139-148.

[15]. A. M .Kulkarni, K. R. Padiyar, (1999). “Damping of power swings using series FACTS controllers”, International Journal of Electrical Power and Energy Systems, Vol.21, No.7, pp.475-495.