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FACT Devices in Power System Stability

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Abstract
Stability is one of the major concerns related to power system. The instability causes the fluctuations in different parameters of power system but the voltage and frequency are most importantly considered because may cause great damage and even cause complete shutdown of power system. This paper presents brief overview of different types of instabilities in power system and the techniques used to overcome it. The paper also compares the applicability of different techniques on the basis of performance.

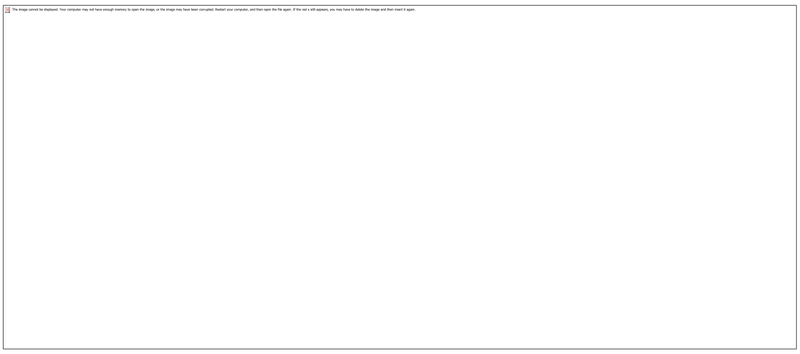
Keywords: power system stability, FACT devices, static VAR compensator, static synchronous compensator

I. Introduction

The stability of the power system is defined as "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 practically the entire system remains intact" [1]. According to above definition it is clear that if system fails to get operating equilibrium then it will be called instable. There are many kind of instabilities exists in the modern power systems (such as voltage, frequency etc.) and accordingly the different stabilization methods are used. The stabilization processes basically works by compensation of the causing the instability in past this is done by connecting and disconnecting the capacitor, inductors or combination of both after that synchronous condenser, saturated reactor, thyristor controlled reactor, fixed capacitor thyristor controlled reactor, thyristor switched capacitor were used; but in present days this is performed by more advanced devices like STATCOM, VSC, TCSC etc. these devices evolves the intelligent controlling and fast switching power devices like MOSFET and IGBT the capability of fast switching makes them feasible for providing precise and smooth controlling. The intelligent controlling is performed by the complex calculations which are done by either analog circuits or microprocessors. Although analog devices performed well but in recent past developments in the semiconductor technology makes the digital controllers as first choice because of their capabilities and lower cost.

II. Types of Instabilities in Power System

The classification to be introduced here is based on the physical mechanism being the main driving force in the development of the associated instability.



Blockdiagram of power system stability

Power System Stability (PSS) problems may be classified as:

- Angle Stability
- Voltage Stability
- Frequency (Mid- and Long-Term) Stability Each category can be divided to:

- Small-Signal (Dynamic) Stability: Determines if system remains in synchronism following a small disturbance (e.g., small load and/or generation variations).
- Transient Stability: Determines if system remains in synchronism following a major disturbance (e.g., transmission fault, sudden load change, loss of generation, line switching). The transient stability can further be divided into two classes.
- First-Swing Stability: for 1st second after a system fault (simple generator model & no control model).
- Multi Swing Stability: system analysis over long period of time (more sophisticated machine model)[2]

2.1.Rotor angle stability

The rotor angle stability problem involves the study of the electromechanical oscillations inherent in power systems. A fundamental factor in this problem is the manner in which the power outputs of synchronous machines vary as their rotor angles change. The mechanism by which interconnected synchronous machines maintain synchronism with one another is through restoring forces, which act whenever there are forces tending to accelerate or decelerate one or more machines with respect to other machines. Under steady-state conditions, there is equilibrium between the input mechanical torque and the output electrical torque of each machine, and the speed remains constant. If the system is perturbed, this equilibrium is upset, resulting in acceleration or deceleration of the rotors of the machines according to the laws of motion of a rotating body. If one generator temporarily runs faster than another, the angular position of its rotor relative to that of the slower machine will advance. The resulting angular difference transfers part of the load from the slow machine to the fast machine, depending on the power angle relationship. This tends to reduce the speed difference and hence the angular separation

2.2 Voltage Stability

With regards to receptive power adjust the circumstance isn't as clear and basic as concerning dynamic power. There is dependably a harmony among "delivered" and "devoured" receptive power in each hub of a system. This is in certainty an immediate result of Kirchoff's first present law. When one discusses unevenness in this setting we imply that the infused responsive power is such, typically too little, that the voltage in the hub can't be kept to worthy qualities. (At low load the infused responsive power could be high bringing about a too high voltage, conceivably higher than the gear may be intended for. When we discuss unevenness for this situation we along these lines imply that the infused responsive power contrasts from the coveted infused receptive power, expected to keep the coveted voltage. In the event that this lopsidedness gets too high, the voltages surpass the adequate range.

2.3 Frequency Stability

Frequency stability refers to the ability of a power system to maintain steady frequency following a severe system upset resulting in a significant imbalance between generation and load. It depends on the ability to maintain/restore equilibrium between system generation and load, with minimum unintentional loss of load. In stability that may result occurs in the form of sustained frequency swings leading to tripping of generating units and/or loads. Severe system upsets generally result in large excursions of frequency, power flows, voltage, and other system variables, thereby invoking the actions of processes, controls, and protections that are not modeled in conventional transient stability or voltage stability studies. These processes may be very slow, such as boiler dynamics, or only triggered for extreme system conditions, such as volts/Hertz protection tripping generators. In large interconnected power systems, this type of situation is most commonly associated with conditions following splitting of systems into islands. Stability in this case is a question of whether or not each island will reach a state of operating equilibrium with minimal unintentional loss of load. It is determined by the overall response of the island as evidenced by its mean frequency, rather than relative motion of machines. Generally, frequency stability problems are associated with inadequacies in equipment responses, poor coordination of control and protection equipment, or insufficient generation reserve.

III. Device utilized for Enhancement of the Stability of Power System

The ordinary control gadgets like synchronous condenser, immersed reactor, thyristor controlled reactor, settled capacitor thyristor controlled reactor, thyristor exchanged capacitor having less framework security restrict, less improvement of framework damping, less voltage gleam control when contrasted with rising realities gadgets like TCSC, STATCOM and UPFC. This Section explores just FACT gadgets for framework solidness.[3]

3.1. Static VAR Compensator (SVC)

Static VAR systems are applied by utilities in transmission applications for several purposes. The primary purpose is usually for rapid control of voltage at weak points in a network. Installations may be at the midpoint of transmission interconnections or at the line ends. Static VAR Compensators are shunt connected static generator whose outputs are varied so as to control voltage of the electric power systems. The SVC is connected to a coupling transformer that is connected directly to the ac bus whose voltage is to be regulated.[4]

Typically, an SVC comprises one or more banks of fixed or switched shunt capacitors or reactors, of which at least one bank is switched by thyristors. Elements which may be used to make an SVC typically include:

- Thyristor controlled reactor (TCR), where the reactor may be air- or iron-cored.
- Thyristor switched capacitor (TSC).
- Harmonic filter(s).

3.2 Thyristor Controlled Series Compensator (TCSC)

TCSC is one of the most important and best known FACTS devices, which has been in use for many years to increase line power transfer as well as to enhance system stability. The main circuit of a TCSC is shown in Figure. The TCSC consists of three main components: capacitor bank C, bypass inductor L and bidirectional thyristors SCR_1 (T1) and SCR_2 (T2). The firing angles of the thyristors are controlled to adjust the TCSC reactance in accordance with a system control algorithm, normally in response to some system parameter variations. According to the variation of the thyristor firing angle or conduction angle, this process can be modeled as a fast switch between corresponding reactance offered to the power system.[5]

3.3 Static Compensator (STATCOM)

It is a device connected in derivation, basically composed of a coupling transformer, that serves of link between the electrical power system (EPS) and the voltage synchronous controller (VSC), that generates the voltage wave comparing it to the one of the electric system to realize the exchange of reactive power the STATCOM adjusts at each moment the inverse voltage so that the current injected in the network is in quadrature to the network voltage, in these conditions P=0 and Q=0.

The STATCOM uses a VSC interfaced in shunt to a transmission line. In most cases the DC voltage support for the VSC will be provided by the DC capacitor of relatively small energy storage capability hence, in steady state operation, active power exchanged with the line has to be maintained at zero.With the active power constraint imposed, the control of the STATCOM is reduced to one degree of freedom, which is used to control the amount of reactive power exchanged with the line. Accordingly, a STATCOM is operated as a functional equivalent of a static VAR compensator; it provides faster control than an SVC and improved control.[6]

IV. Conclusion

The paper talked about the different sorts of precariousness issues associated with control framework it additionally examined the FACT gadgets, their working, Structure and position in control framework. At long last an examination tablet is introduced for correlation of the execution of FACT gadgets for various framework conditions.. At long last it very well may be said that the paper gives a non scientific clarification and a reasonable correlation of various FACT.

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