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Improvement of Power System Stability using STATCOM

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Abstract: Power system stability plays a key role in ensuring the stable operation of power system. FACTS devices are often used for the stabilization of the power system during the occurrence of large disturbances and faults. A fault condition within the line will cause disturbance to the prevailing system. One of the examples of FACTS devices is STATCOM. This device is useful to mitigate the voltage fluctuations like voltage swells and sags. This paper gives an overview of power system stability and about STATCOM, its operation and applications.
Keywords: Power system stability and STATCOM.

I. INTRODUCTION

The power system is regularly being subjected to changes or disturbances of varied forms such as faults, load changes, connection/disconnection of generators etc. Because the power network is an advanced electro-mechanical system, these events cause oscillations within the speed and angles of machines and in power flows through the lines. Stability analysis is that study of the response of the system to those changes and is employed to see if the system is going to be stable when given a disturbance. For proper operation of the system, it's essential to make sure that after the occurrence of any disturbance, the system settles all the way down to a stable condition.

Power system stability, majorly includes Steady state stability and Transient stability analysis.

Steady state stability is about the study of system's response after the occurrence of small disturbances in the system which last for longer time duration.

Transient stability cares with the flexibility of the system to take care of synchronicity once subjected to severe perturbations. It involves the study of the system following a serious disturbance. The transient stability of the system is a crucial consideration in the development of power systems. The target of the transient stability study is to determine whether or not the load angle returns to a gradual worth following the clearance of the disturbance.

II. POWER SYSTEM STABILITY

Power system stability is that the ability of an electrical power system, for a given initial operative condition, to regain a state of operative equilibrium when being subjected to a physical disturbance, with most of the system variables finite in order that much the whole system remains intact.

In other words, it is the ability to remain in operative equilibrium. Angle stability explains about the ability to take care of synchronicity. Voltage stability explains about the ability to take care of steady acceptable voltage.

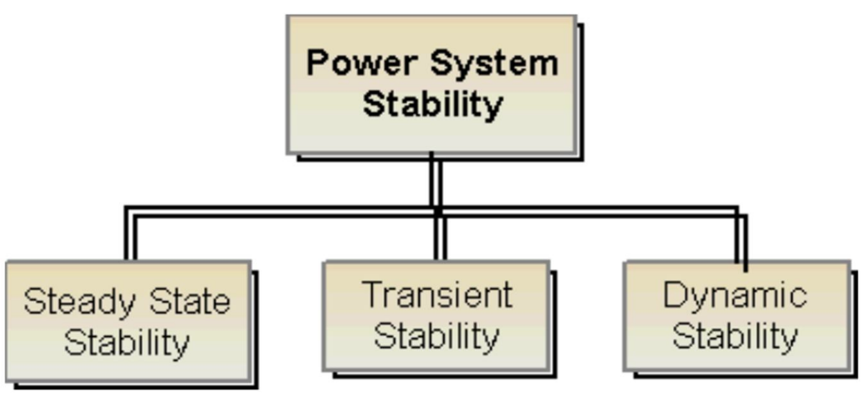

Figure 1: Types of power system stability

Types of power system stability

1) *Steady-state Stability:* It denotes the flexibility of the system to regain its stability when slow and little disturbance that happens because of gradual power changes.
2) *Transient Stability:* It is about the study of the flexibility of power system to come to its stable operating conditions after the occurrence of a large disturbance for short span of time. During conditions like sudden connection or removal of large loads, line faults, etc., transient analysis comes into picture.
3) *Dynamic Stability:* It denotes the soundness of a system to achieve its stable condition when a really tiny disturbance occurs. It's referred to as tiny signal stability. These small disturbances which occur on the system produce oscillations in the system. If these oscillations do not acquire more than particular amplitude and also if they die out quickly, then the system is said to be dynamically stable. If these oscillations grow continuously in amplitude, then the system is said to be dynamically unstable.

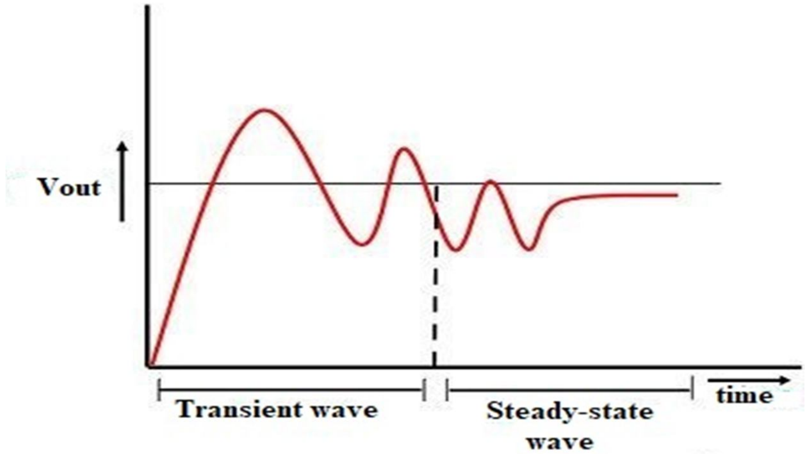

Figure 2: Graph showing transient and steady state voltage variations upon occurrence of a fault

The transient and steady-state behaviour of voltage in power system upon occurrence of a fault is shown in figure (2).

III. STATCOM

STATCOM or Static Synchronous Compensator is a power device which uses force commutated devices like IGBT, GTO etc. to manage the reactive power flow through an influence network and thereby increasing the soundness of power network.

STATCOM is a shunt device i.e. it's connected in parallel with the load. It's a member of the versatile AC transmission of devices. The term Synchronous in STATCOM means that it will either absorb or generate reactive power in synchronization with the demand to stabilize the voltage of the power network.

STATCOM is a rapidly used device for grasping or giving the reactive current and thereby controlling the voltage. The technology is based on voltage source converter in a multi-level configuration. The comfortable and rapid response of the STATCOM is helpful for managing voltage within the stability limits during network faults and to analyze the short term voltage stability. Also the STATCOM can provide power factor correction, reactive power control, and damping of low-frequency power oscillations, active harmonic filtering, flicker mitigation and power quality improvements.

Usually a STATCOM is installed to support electrical networks that have a poor power factor and often poor voltage regulation. The most common use of STATCOM is for voltage stability. A STATCOM is a voltage source converter (VSC) based device, with the voltage source behind a reactor. The voltage source is created from a DC capacitor and therefore a STATCOM has very little active power capability. However, its active power capability can be increased if a suitable energy storage device is connected across the DC capacitor. The STATCOM is generally a shunt connected device and used for the control of reactive power. Some of the areas where the STATCOM is used as follows:

1) Voltage support and control
2) Voltage fluctuation and flicker mitigation
3) Unsymmetrical load balancing.
4) Power factor correction.
5) Active harmonics cancellation.
6) Improve transient stability of the power system.

A. Construction of STATCOM

1) STATCOM Consists of the following Components

a) A Voltage Supply Convertor, VSC: The voltage source converter is employed to convert the DC input voltage to an AC output voltage. It is generally a multi-level inverter.

b) DC electrical Condenser: DC electrical condenser is employed to produce constant DC voltage to the voltage supplied converter, VSC.

c) Inductive Electrical Phenomenon: An electrical device is connected between the output of VSC and power system. Electrical device essentially acts as a coupling medium. For this purpose a coupling transformer is used. Additionally, transformer neutralizes harmonics contained within the square waves created by VSC.

d) Harmonic Filter: Harmonic Filter attenuates the harmonics and rest other high frequency parts due to VSC.

A simplified diagram of STATCOM is shown in figure below.

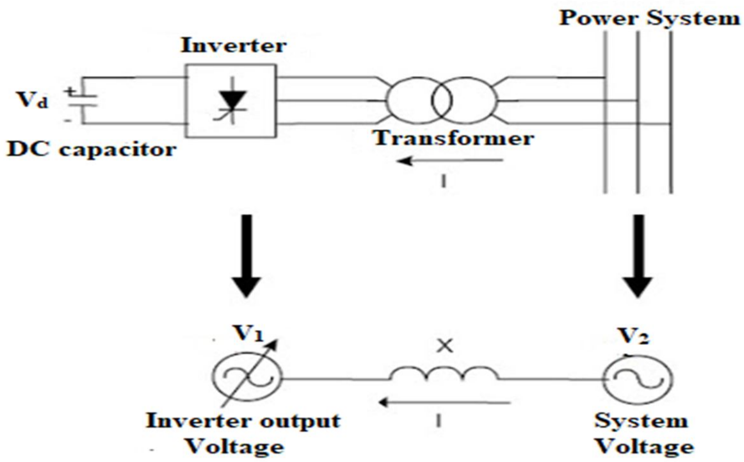

Figure 3: Simplified diagram of STATCOM

2) STATCOM's Operating Principle

Taking two sources V1 and V2 are connected through a resistance Z = Ra + j X as shown in figure below.

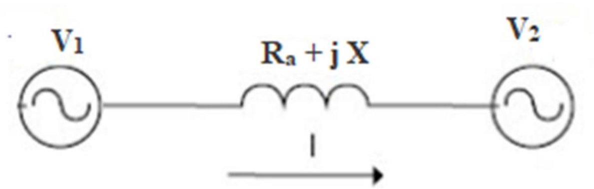

Figure 4: Circuit explaining working principle of STATCOM

If Ra is assumed to be zero, then the reactive power flow is given by, Q= [V2 /X] [V1Cosδ- V2].

Now, if the angle between V1 and V2 ie., δ is zero, the flow of active power becomes zero and the flow of reactive power depends on (V1 – V2). Therefore for flow of reactive power there are 2 prospects.

a) If the magnitude of V1 is larger than V2, then reactive power will be flowing from supply V1 to V2.

b) If the magnitude of V2 is larger than V1, then reactive power will be flowing from supply V2 to V1.

This principle is employed in STATCOM for reactive power management.

As seen from the figure 3, supply V1 represents the output voltage of the STATCOM. During a case in which reactive power demand is increased within the power system, STATCOM will increase its output voltage V1 while maintaining the phase difference between V1 and V2 to zero. As V1 > V2, reactive power will be flowing from the STATCOM to the power system. Therefore STATCOM provides reactive power and acts as reactive power generator. Again, if the voltage of power system increases because of load throw off, STATCOM can cut back its output voltage V1 and so can absorb reactive power to stabilize the voltage to traditional worth. This operative mode of STATCOM is named Voltage Regulation Mode.

As we have seen that a typical STATCOM configuration consists of multi-level VSC supported IGBTs, section reactors and transformer. It's shunt-connected to the grid. The reactive current is provided or absorbed by manufacturing a controlled internal voltage wave. Most STATCOMs out there within the market nowadays operate as grid following converters. The voltage wave is adjusted with relevance to its affiliated grid voltage. In general, the STATCOMs operate as AC current controlled device, though the management of the output current is achieved via the regulation of the STATCOM internal voltage (behind the section reactor) in amplitude, whereas the angle is ninety degrees with relevance the grid affiliation point voltage. If the STATCOM voltage amplitude is beyond the system voltage amplitude reactive power is provided to the grid. The quantity of reactive current depends on the electrical device contact electrical phenomenon and also the voltage distinction and is restricted to the thermal limits of the IGBTs. During stable operation, i.e. the system voltage is inside sure limits, each voltage amplitude is equal and no reactive power is changed with the grid. A longtime management is that if the grid voltage is on top of the brink worth, STATCOM management can decrease the amplitude of the STATCOM voltage wave, creating the STATCOM act as associate inductive component and absorb reactive power from the grid. Once the grid voltage is below the brink worth, the magnitude of the voltage wave is multiplied, creating the STATCOM act as a source of reactive power and provide reactive current to the grid.

IV. CONCLUSION

STATCOM is a shunt connected FACTS device which acts as a controlled reactive power source or sink. The desired level of generation or absorption of reactive power is provided by the help of electronic processing of voltage and current waveforms in VSC. The fast response of STATCOM makes it convenient for maintaining voltage at the time of network faults, thereby helping the power system to maintain its stability. In addition, STATCOMs also help in enhancing voltage stability, reactive power control and power quality.

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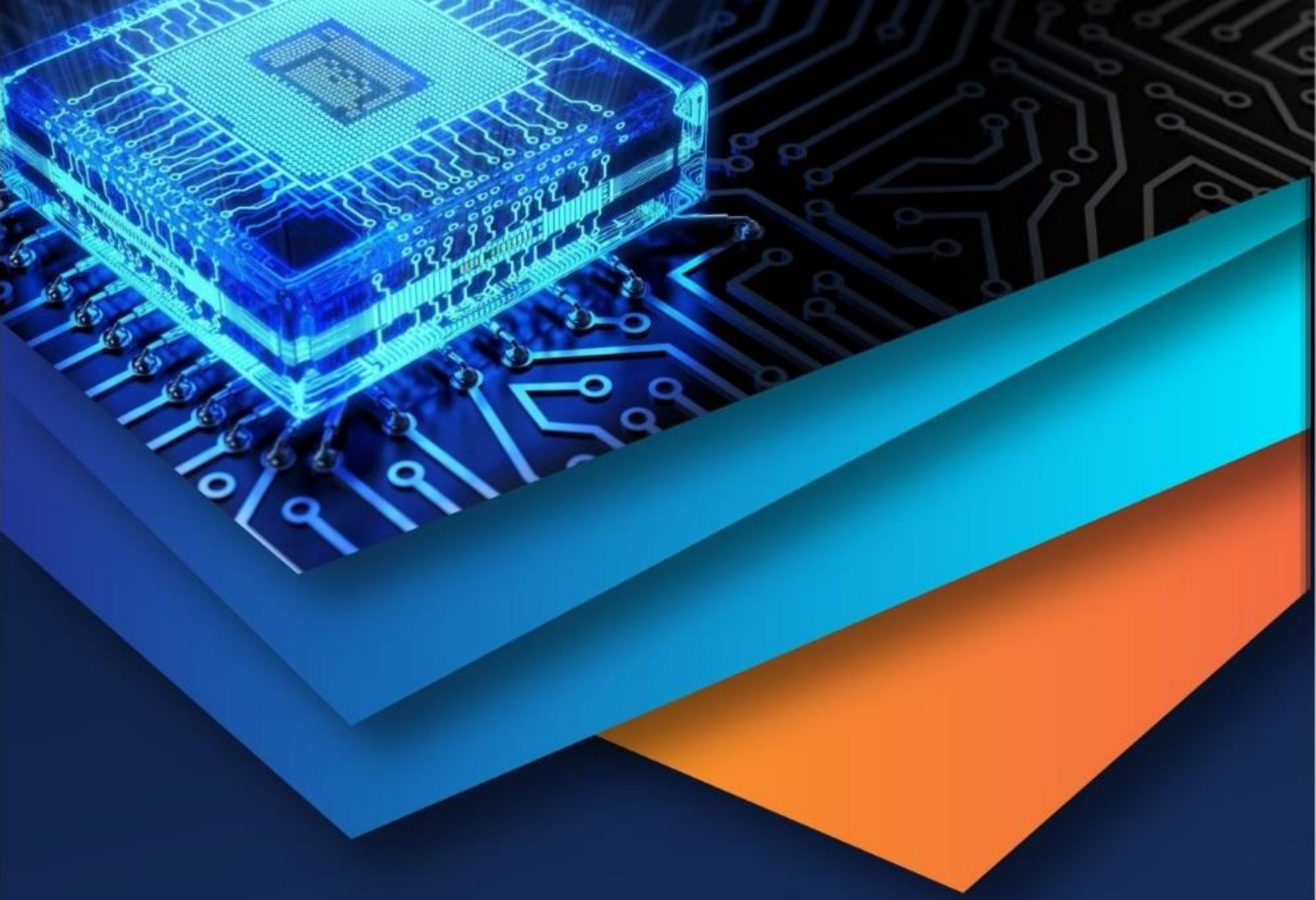

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