

# POWER SYSTEM STABILITY IMPROVEMENT OF MULTI MACHINE SYSTEM BY USING STATCOM

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**Abstract** - In this paper power system stability improvement of multi machine system by using STATCOM is investigated. MATLAB simulation indicates STATCOM improves transient stability of a system and compensate reactive power in steady state. Transient stability improvement of multi machine power system at different fault condition is investigated in this work. We used 9 bus western systems co-coordinating council (WSCC) multi machine power system for simulation.

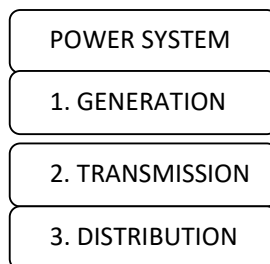
**Keywords**—STATCOM, FACTS, MATLAB/SIMULINK, POWER SYSTEM STABILITY

## I. INTRODUCTION

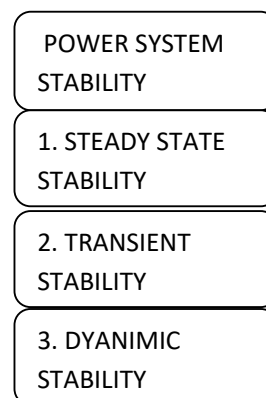
An electric power system is a network of electrical components used to supply, transfer and use electric power. An example of an electric power system is the network that supplies a region's homes and industry with power for sizeable regions, this power system is known as the grid and can be broadly divided into the generators that supply the power, the transmission system that carries the power from the generating centers to the load centers and the distribution system that feeds the power to nearby homes and industries. Smaller power systems are also found in industry, hospitals, commercial buildings and homes. A complex assemblage of equipment and circuits for generating, transmitting, transforming, and distributing electrical energy. Electricity in the large quantities required to supply electric power systems is produced in generating stations, commonly called power plants. Such generating stations, however, should be considered as conversion facilities in which the heat energy of fuel (coal, oil, gas, or uranium) or the hydraulic energy of falling water is converted to electricity.

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 that is to be taken into consideration is the stability limit of the system. The stability limit defines the maximum power permissible to flow through a particular point or a part of the system during 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.

## II. ELECTRICAL POWER SYSTEM HAVE THREE COMPONENTS



## III. POWER SYSTEM STABILITY IMPROVEMENT



#### IV. STEADY STATE STABILITY OF POWER SYSTEM

The steady state stability of a power system is defined as the ability of the system to bring itself back to its stable configuration following a small disturbance in the network (like normal load fluctuation or action of automatic voltage regulator). It can only be considered only during a very gradual and infinitesimally small power change. In case the power flow through the circuit exceeds the maximum power permissible, then there are chances that a particular machine or a group of machines will cease to operate in synchronism, and result in yet more disturbances. In such a situation, the steady state limit of the system is said to have reached. Or in other words the steady state stability limit of a system refers to the maximum amount of power that is permissible through the system without loss of its steady state stability.

#### V. TRANSIENT STABILITY OF POWER SYSTEM

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 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 of time. 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.

#### VI. DYNAMIC STABILITY OF POWER SYSTEM

Dynamic stability of a system denotes the artificial stability given to an inherently unstable system by automatic controlled means. It is generally concerned to small disturbances lasting for about 10 to 30 seconds.

#### VII. (STATCOM) STATIC SYNCHRONOUS COMPENSATOR

A static synchronous compensator (STATCOM), also known as a static synchronous condenser (STATCON), is a regulating device used on alternating current electricity transmission networks. It is based on a power electronics voltage-source converter and can act as either a source or sink of reactive AC power to an electricity network. If connected to a source of power it can also provide active AC power. It is a member of the FACTS family devices. It is inherently modular and electable

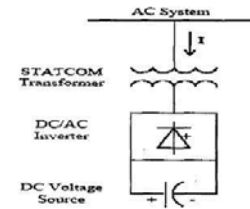


Fig-1 Basic functional model of STATCOM

#### VIII. STATCOM OPERATION

##### Basic Principle of Operation

In the case of two AC sources, which have the same frequency and are connected through a series reactance, the power flows will be:

- Active or Real Power flows from the leading source to the lagging source.
- Reactive Power flows from the higher to the lower voltage magnitude source.

Consequently, the phase angle difference between the sources decides the active power flow, while the voltage magnitude difference between the sources determines the reactive power flow. Based on this principle, a STATCOM can be used to regulate the reactive power flow by changing the output voltage of the voltage-source converter with respect to the system voltage.

##### Modes of Operation

The STATCOM can be operated in two different modes:

##### A. Voltage Regulation

- The static synchronous compensator regulates voltage at its connection point by controlling the amount of reactive power that is absorbed from or injected into the power system through a voltage-source converter.
- In steady-state operation, the voltage  $V_2$  generated by the VSC through the DC capacitor is in phase with the system voltage  $V_1$  ( $\delta=0$ ), so that only reactive power ( $Q$ ) is flowing ( $P=0$ ).

1. When system voltage is high, the STATCOM will absorb reactive power (inductive behavior)
  2. When system voltage is low, the STATCOM will generate and inject reactive power into the system (capacitive).
- Subsequently, the amount of reactive power flow is given by the equation:
  - $Q = [V_1(V_1 - V_2)] / X$

##### B. Var Control

- In this mode, the STATCOM reactive power output is kept constant independent of other system parameter

### IX. SIMULATION

This Western system coordinated council (WSCC) 3-machine 9-bus practical power system widely used in simulation of power system modeling

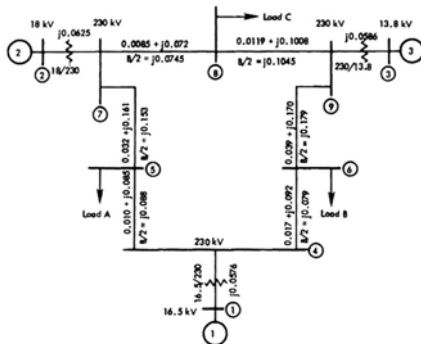


Fig-2 3-machine 9-bus WSCC model

- This WSCC 3 Machines, 9 Bus Test Case (known as P.M Anderson 9 Bus) represents a simple approximation of the Western System Coordinating Council (WSCC) to an equivalent system with nine buses and three generators.
- This test case consists of 9 buses, 3 generators, 3 two-winding power transformers, 6 lines and 3 loads.
- The base KV levels are 13.8 kV, 16.5 kV, 18 kV, and 230 kV. The line complex powers are around hundreds of MVA each. As a test case, the WSCC 9-bus case is easy to control, as it has few voltage control devices.

### X. RESULT

#### CASE-1

The MATLAB/simulink model of 3-machine 9-bus WSCC system with three phase fault between bus 4 and bus 5 without STATCOM .the variation of relative angular position of generators with time is analyzed .

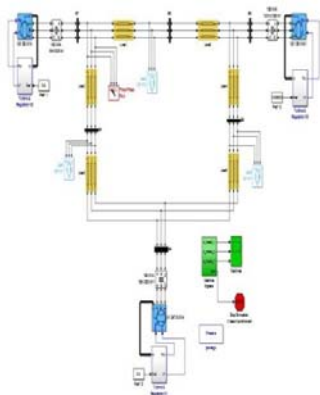


Fig-3 3-machine 9- bus system with 3-phase fault with STATCOM

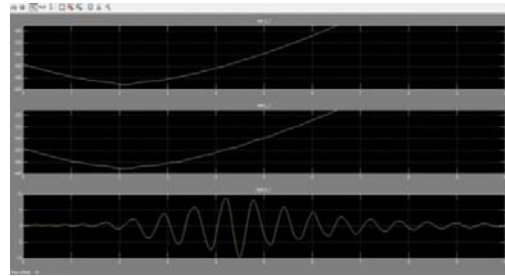


Fig-4 Variation of relative angular positions for delta2\_1, delta3\_2 and delta3\_1 (without STATCOM)

#### CASE -2

The MATLAB/simulink model of 3-machine 9-bus WSCC system with three phase fault between bus 4 and bus 5 with STATCOM.placed between bus 4 and bus 5 .the variation of relative angular position with respect to time is been analysed

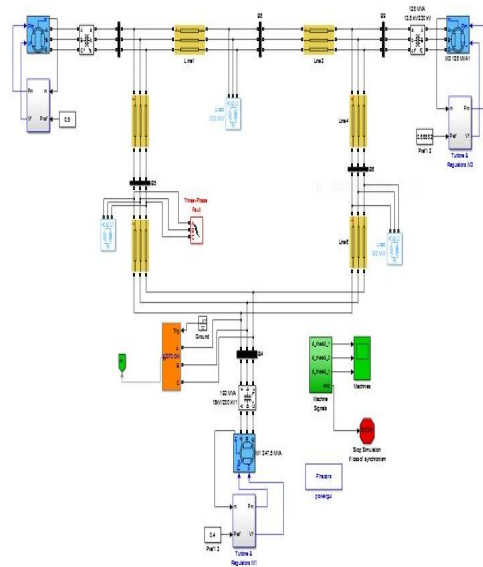


Fig-5 3-machine 9- bus system with 3-phase fault with STATCOM

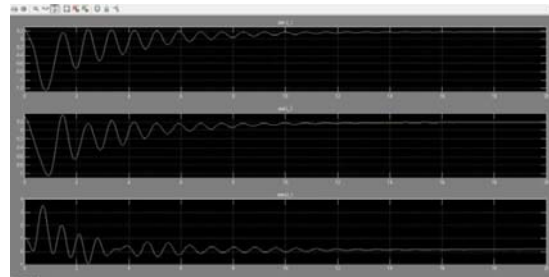


Fig-6 variation of relative angular positions for delta2\_1, delta3\_2 and delta3\_1 (with STATCOM)  
 Note- total time taken for simulation is 20 sec.



## XI. CONCLUSION

Power system stability improvement of multi machine system at various fault condition is examine in this paper. When three phase fault occur between bus 4 and bus 5 then system becomes instable and large instability occur in system. By using STATCOM at same location between bus 4 and bus 5. thus system became stable very fast and reliable and at Mid point position of STATCOM in system shows best result as compared to other position. the simulation is done by using MATLAB/simulink software with time taken 20sec. This simulation work can also be extended for multiple faults system and complex multi- machine power systems.

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