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Optimal Location Analysis Of STATCOM In Multimachine

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Abstract:- *In this paper, we have taken a multi-machine power system to demonstrate the features and scope of a Simulink-based model for transient stability analysis. The stability of power systems has been and continues to be of major concern in system operation. multi-machine power system is designed using SIMULINK (a software tool associated with MATLAB). Multi-machine power system with turbine and governing system is modeled. Modeling is done for the system with statcom.*

1. INTRODUCTION:-

FACTS technology opens up new opportunities for controlling power and enhancing the usable capacity of past, as well as present and upgraded future lines. The possibility is that current through a line can be controlled at a reasonable cost enables a large potential of increasing the capacity of existing lines with larger conductors, and use of the FACTS Controllers is to enable corresponding power to flow through such lines under normal and contingency conditions. These opportunities arise through the ability of FACTS Controllers to control the interrelated parameters that govern the operation of transmission systems including series impedance, shunt impedance, current, voltage, phase angle, and the damping of oscillations at various frequencies below the rated frequency.

The FACTS technology is not a single high power Controller, but rather it is a collection of Controllers, which can be applied individually or in coordination with others to control one or more of the interrelated system parameters. When implemented on a large-scale basis, FACTS technologies deliver the following benefits.

- **Rapidly Implemented Installations**: FACTS projects are installed at existing substations and avoid the taking of public or private lands. They can be completed in less than 12 to 18 months—a substantially shorter timeframe than the process required for constructing new transmission lines.
- **Increased System Capacity**: FACTS provide increased capacity on the existing electrical transmission system infrastructure by allowing maximum operational efficiency of existing transmission lines.
- **Reliability to enhance System** : FACTS strengthen the operational integrity of transmission networks, allowing greater voltage stability and power flow control, which leads to enhanced system reliability and security.
- **Controllability to Improve System**: FACTS allow improved system controllability by building “intelligence” into the transmission network via the ability to instantaneously respond to system disturbances and gridlock constraints and to enable redirection of power flows.

- **Fiscally Sound Investments:** FACTS are less expensive solutions to upgrading transmission system infrastructure as compared to conventional solutions such as the construction of new transmission lines. Strategic implementation of FACTS on a nationwide basis could reduce transmission system infrastructure expenditures by an estimated 30% overall. FACTS also provide transmission owners greater opportunity to realize profits through more efficient operation of existing networks.

FACTS technologies can essentially be defined as highly engineered power-electronics-based systems, integrating the control and operation of advanced powersemiconductor-based converters (or valves) with software-based information and control systems, which produce a compensated response to the transmission network that is interconnected via conventional switchgear and transformation equipment. FACTS technologies provide dynamic control and compensation of voltage and power flow and can be designed to coordinate the control of other transmission compensation devices, such as capacitors, reactors, and transformer tap changers, in order to establish greater overall system operation improvements. In effect, FACTS "builds intelligence" into the grid by providing this type of enhanced system performance, optimization, and control.

Flexible AC Transmission Systems, called FACTS, also got a name in the recent years a well known term for higher controllability in power systems by means of power electronic devices. Several FACTS-devices have been introduced for various applications worldwide. A number of new types of devices are introduced in practice in this stage.

FACTS devices are capable of controlling the network condition in a very fast manner and this unique feature of FACTS devices can be exploited to improve the transient stability of a system. Reactive power compensation is an important issue in electrical power systems and shunt FACTS devices play an important role in controlling the reactive power flow to the power network and hence the system voltage fluctuations and transient stability . SVC and STATCOM are members of FACTS family that are connected in shunt with the system. Even though the primary purpose of shunt FACTS devices is to support bus voltage by injecting (or absorbing) reactive power, they also improve the transient stability by increasing (decreasing) the power transfer capability when the machine angle increases (decreases), which is achieved by operating the shunt FACTS devices in capacitive.

2. BASIC TYPES OF FACTS CONTROLLERS

In general, FACTS Controllers can be divided into four categories:

- Series Controllers
- Shunt Controllers
- Combined series-series Controllers
- Combined series-shunt Controllers

2.1 SeriesControllers: The series Controller could be a variable impedance, such as capacitor, reactor, etc., or a power electronics based variable source of main frequency, sub synchronous and harmonic frequencies (or a combination) to serve the desired need. All the series Controllers inject voltage in series with line. Even a variable impedance is multiplied by the current flow through it, represents an injected series voltage in the line. As long as the voltage is in phase quadrature with the line current, the variable reactive power is being supplied or consumed by the series controller. Any other means of phase relationship will involve handling of real power as well.

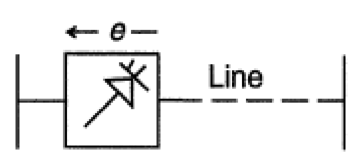

Fig 2.1 Series Controllers:

2.2 Shunt Controllers*:* As in the case of series Controllers, the shunt Controllers may be variable impedance, variable source, or a combination of above these. All the shunt Controllers inject current into the system at the point of connection. Even a variable shunt impedance is also being connected to the line voltage causes a variable current flow and hence represents injection of current into the line. As long as them injected current is in phase quadrature with the line voltage, the variable reactive power is basically supplied or consumed by the shunt controller. Any other means of phase relationship will involve handling of real power as well.

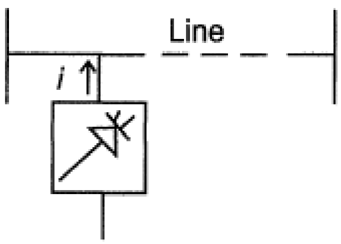

Fig 2.2 Shunt Controllers

2.3 Combined series-series Controllers*:* This could be a combination of separate series controllers, which are being controlled in a proper manner, in a transmission system of multiline. Or it could be a unified Controller, in which series Controllers provide reactive compensation for each line but also transfer real power among the lines via the power link.

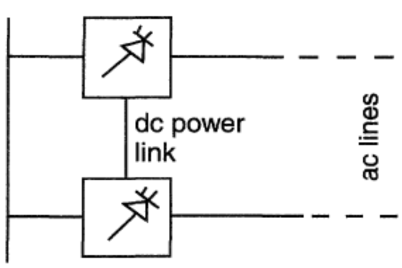

Fig2.3Combined series-series Controllers

2.4 Combined series-shunt Controllers*:* This could be a combination of separate shunt and series Controllers, which are controlled in a proper manner, or a Unified Power Flow Controller with series and shunt elements. Combined shunt and series Controllers inject current into the system with the shunt part of the Controller and voltage in series in the line with the series part of the Controller. However, when the shunt and series Controllers are unified there can be a real power exchange between the series and shunt Controllers via the power link.

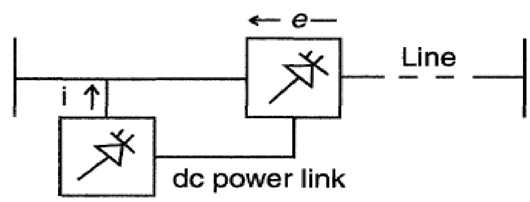

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Fig 2.4 Combined series-shunt Controllers

3. STATIC SYNCHRONOUS COMPENSATOR (STATCOM)

STATCOMs are GTO (gate turn-off type thyristor) based SVC's. Compared with conventional SVC's they don't require large inductive and capacitive components to provide inductive or capacitive reactive power to high voltage transmission systems. This results in smaller land requirements. An additional advantage is that the higher reactive output at low system voltages where a STATCOM can be considered as a current source independent from the system voltage. STATCOMs have been in operation for approximately 5 years.

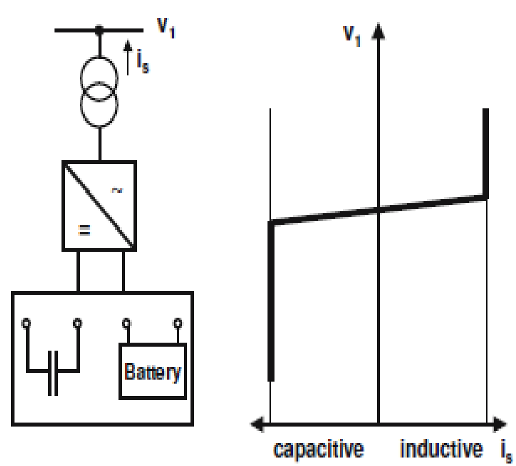


Fig 3.1 Structure of Statcom

In the distributed energy sector the usage of Voltage Source Converters for grid interconnection is commonly used today. The next step in STATCOM development is the combination with energy storages on the DC side. The performance for power quality and balanced network operation can be improved much more with the combination of active and reactive power.

3.1 Multimachine machine system modeling using statcom:-

The popular Western System Coordinated Council (WSCC) 3-machines 9-bus practical power system is a widely used one and found very frequently in the relevant literature shows a 3-machines 9-bus WSCC system. Here the loads have been assumed to be represented by constant impedance model.

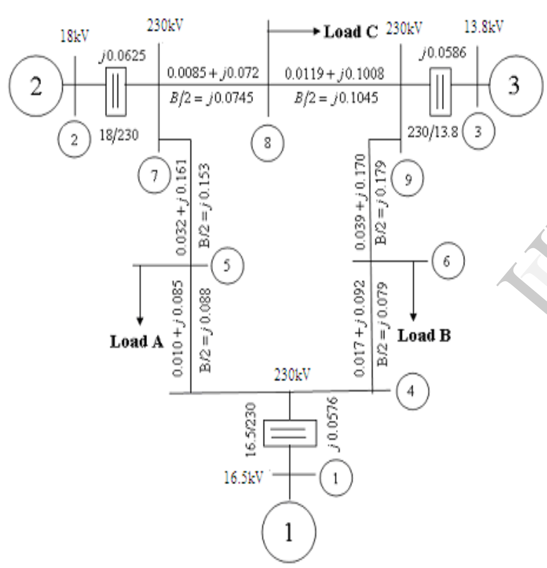
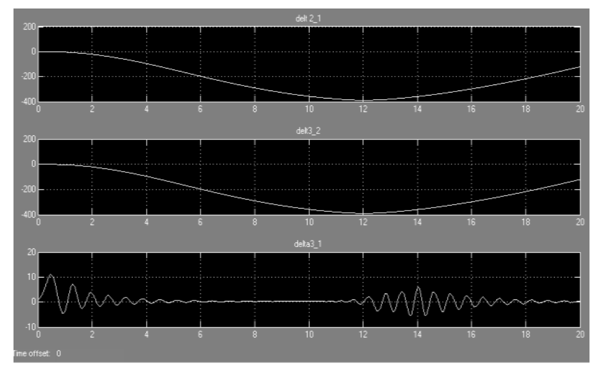


Fig. 3.2 3-Machines 9-bus WSCC system

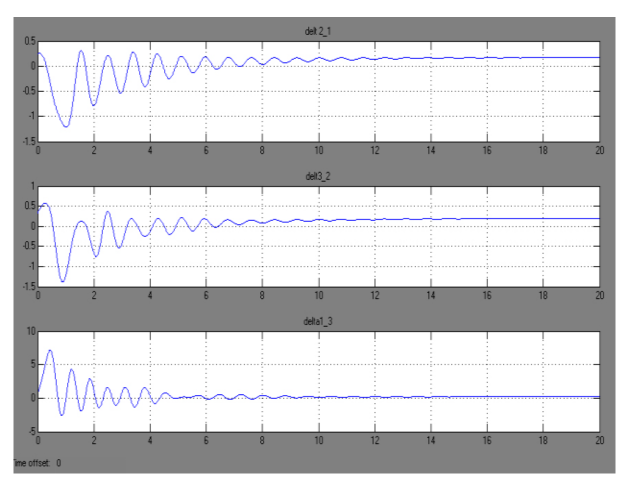
The system frequency is 60 Hz and the system has been simulated with a classical model for the generators. The disturbance initiating the transient is a three-phase fault occurring near bus 7 at the end of line 9–7.The fault is cleared by opening line 9–7. The system, while small, is large enough to be nontrivial and thus permits the illustration of a number of stability concepts and results.

4. SIMULATION STUDIES:-

Case 1- MATLAB/Simulink model of multi-machine (3-machine 9-bus) WSCC system, is incorporated with a three-phase fault .
And without STATCOM For transient Stability studies, the variation of relative angular positions of the generators with time has been analysed



Case 2- MATLAB/Simulink model shows the variation of relative angular positions with time for 3-machine 9-bus WSCC system with STATCOM controller placed in the middle of bus 7 and bus 9 and three phase fault taking place between bus 7 and bus 9. The total simulation time taken is 20 sec



The location of STATCOM has been varied to study the optimum location of STATCOM in case of a fault in a system and the time taken to attain stability for three relative angular positions delt2_1, delt3_2 and delt1_3, for different locations of STATCOM when a three-phase fault occurred between bus 9 and bus 7.

5. CONCLUSION:-

STATCOM controller injects current in shunt with the line that changes the reactive power which in turn affects the rotor angle and brings back the system into synchronism.The best optimum location of STATCOM can be obtained. when the three-phase fault is occuring between bus 7 and bus 9, STATCOM finds its best location in the mid point of the same line i.e between bus 7 and bus 9. The simulation of single-machine infinite-bus (SMIB) system and multi-machine (3-machine 9-bus) WSCC system with STATCOM FACTS controller has been done using MATLAB/Simulink (7.5 version) software. This simulation can also be extended for Multiple faults system and Complex multi-machine systems.

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