Advanced Research in Electrical and Electronic Engineering
p-ISSN: 2349-5804; e-ISSN: 2349-5812 Volume 4, Issue 2 April-June, 2017, pp. 43-46

http://www.krishisanskriti.org/Publication.html

Modelling of 2 Machine 5 Bus System with SVC

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Abstract—*In recent era, the management to maintain power system stability is necessary. So to manage a stable and protective function of power system must be important issue and challenging too. Generally power system is divided into three parts i.e. generation, transmission and distribution. Electric power demand is continuously increased and to maintain continue power flow is a big challenge. To create and manage desirable power reliability and quality, we have to emergence distributed resources.In this paper a new approach is taken for modelling of two machine five bus system with the help of SVC. For continuous power flow, we have to remove faults and disturbances. For fault removing, we use FACTS devices. FACTS devices are multifunctional and cheaper in cost. FACTS devices makes the power system more stable and reliable, it enhances the transmission capability in power system. In these FACTS devices, Static Var Compensation (SVC) can be used for voltage control. The main challenge in the transmission network is to maintain the voltage profile and removing the losses, which occurs in power system.*

1. INTRODUCTION

Power system is a complicated network, which contains basically three subsystem i.e. generation, distribution and transmission. It deals with the utilisation of the power and many electric components, which is connected to the system to form a power system. These electric components are generators, motors, transformers, transmission lines etc. and many other active and passive components are connected in the power system. These electric active and passive components make use ofelectric power for supply and transfer.With continuous changing environment, it must that the power system operates and deals with it. Power system is a highly nonlinear network and continuous changing environment are increasing sudden loads, disturbances, output of generators topology etc., basically disturbances are depends upon the operating conditions and many other factors. In transient disturbances, power system stability depends upon the type of disturbances. Generally two types of disturbances occur these are small disturbances and large disturbances. Small disturbances are those disturbances, which occur sudden load change and initial operating condition. Small disturbances can be easily cleared and meet the desire load demand. Large disturbances are large in nature and caused because of large disturbances.Failure of a power system can be occur because of many reasons like instability, collapse of frequency, voltage collapse and excessive load shedding and lots of other reasons. Therefore fully utilisation of the electric transmission system becomes very difficult. It's a big task to make better utilisation of the existing power system. For better use of existing transmission facilities, Flexible AC Transmission System (FACTS) controllers are used now.In these FACTS devices, Static Var Compensation (SVC) can be used for voltage control.

In AC transmission system, there are basically four type of FACT devices used. These are,

1) Shunt connected controllers
2) Series connected controller
3) Combined series-series controllers
4) Combined shunt-series controllers

2. LITERATURE REVIEW

In power system there is sudden change in load demand and it goes up and down according to the change in load demand. Soto maintain stability and quality in the power system, it's a big challenge. To maintain stability especially the transient stability in the power system a lot of studies are carried out.According Jun yang and Wei xingzheng [1], the disturbances can be removed from the output channels by the proposed method with appropriately designed disturbance compensation gain.

The main work of Static var compensator is to provide power. Main advantage of svc is that it can absorb and relisethe reactive power. Several many other FACTS devices are used to maintain synchronism and power quality in the power system. Marta Molinas, Jon Are Suul and Tore Undeland [2] presented the low voltage ride through (LVRT) capability of wind farms using squirrel cage generators can be enhanced by the use of a STATCOM, compared to the thyristor controlled static var compensator(SVC). The transient stability margin is proposed as the indicator of LVRT capability. A simplified analytical approach based on torque-slip characteristics is first proposed to quantify the effect of the STATCOM and the SVC on the transient stability margin. Results from experiments with a STATCOM and a 7.5 kW induction machine emulating a wind turbine are used to validate the suggested analytical approach.

P. Srikanth, O. Rajendra, A. Yesuraj, M. TilakK.Raja [3] presents The power system analysis and design is generally done by using power flow analysis .This analysis is carried out at the state of planning, operation, control and economic scheduling .they are useful in determining the magnitude and phase angle of load buses, and active and reactive power flows over transmission lines, and active and reactive powers that are injected at the buses. Naseer M. Yasin and Mostafa Al-eedany [4] presented Power systems are continuously subjected to various types of disturbances which in turn cause the problem of losing stability Static VAR Compensator (SVC) can control reactive power and therefore is used to improve transient stability as well as the voltage profile. Recently the generation of and transmission has been severely limited because of limited resources and environmental restrictions and power demand has increased substantially From the last two decades, the literature shows an increasing interest in this subject and system stability using FACTS controllers has been extensively investigated.

3. POWER FLOW OVER VIEW

The numerical analysis of power flow in an interconnected system is known as load-flow study**.** In load-flow study**,** we use one-line diagram and per-unit system and contains arious aspects related to AC power parameters, such as voltages, voltage angles, real power and reactive power. It operate in normal steady state condition. For electric power transmission system, it gives the solution of static operating condition. It is used for planning future expansion and in determining the best operation of existing systems.

There are many methods, which are used for load flow analysis. These are

1) Gauss–Seidel method
2) Fast-decoupled-load-flow method
3) Holomorphic embedding load flow method
4) Newton-Raphson method

4. POWER FLOW ANALYSIS

A bus is a node at which one or many lines, one or many loads and generators are connected. In a power system each node or bus is associated with 4 quantities, such as magnitude

of voltage, phage angle of voltage, active or true power and reactive power in load flow problem two out of these 4 quantities are specified and remaining 2 are required to be determined through the solution of equation. Depending on the quantities that have been specified, the buses are classified into 3 categories.

Buses are classified according to which two out of the four variables are specified

1) **Load bus**: No generator is connected to the bus. At this bus the real and reactive power are specified.it is desired to find out the volatage magnitude and phase angle through load flow solutions. It is required to specify only Pd and Qd at such bus as at a load bus voltage can be allowed to vary within the permissible values.
2) **Generator bus or voltage controlled bus**: Here the voltage magnitude corresponding to the generator voltage and real power Pg corresponds to its rating are specified. It is required to find out the reactive power generation Qg and phase angle of the bus voltage.
3) **Slack (swing) bus**: For the Slack Bus, it is assumed that the voltage magnitude $|V|$ and voltage phase Θ are known, whereas real and reactive powers Pg and Qg are obtained through the load flow solution.

5. NEWTON RAPSON METHOD

For solving non-linear algebraic equations, the powerful method is to use the Newton-Raphson (NR) method. There are many methods are used for solving non-linear algebraic equations like Gauss-Seidel method but the Newton-Raphson (NR) method is superior. This method gives better response than any other method and works faster than the Gauss-Seidel method. It is indeed the practical method of load flow solution of large power networks. The main drawback is the large requirement of computer memory, which can be overcome through a compact storage scheme. One of the main strengths of the Newton-Raphson method is its reliability towards convergence. Contrary to non Newton-Raphson solutions, convergence is independent of the size

of the network being solved and the number and kinds of control equipment present in the system. Hence in the proposed work Newton-Raphson method is preferred.

This method begins with initial guesses of all unknown variables (voltage magnitude and angles at Load Buses and voltage angles at Generator Buses). Next, a Taylor Series is written, with the higher order terms ignored, for each of the power balance equations included in the system of equations .

6. POWER SYSTEM TRANSIENT ENHANCEMENT THROUGH POWER ELECTRONICS

Maintaining synchronism of the interconnected synchronous generator plays an important role in ensuring the stable and uninterrupted operation of the whole power system network. This synchronism can be easily affected by various switching events in the network, which among others include faults, change of loading conditions and loss of generation are among others. The main cause for losing synchronism is due to the electrical changes at the terminals of the generators during the above mentioned events. For example, during a fault, the voltage at the terminal of a generator can drop substantially resulting in the power generation to be disrupted, which then causes the generator to accelerate out of synchronism. Sometimes upon clearance of faults, high oscillations in generator power can result in loss of synchronism.

Traditionally, these problems were often resolved by implementation of complex control systems for the generator such as the automatic voltage regulator (AVR), power system stabiliser(PSS) and speed turbine governor. However, with the expansion of power system networks through non-conventional generating sources and increasing loads, the response at the terminal of the generators can be very erratic when faced with a disturbance due to a weak link in the network. Engineers have sought alternative solutions to improve the stability of the network in light of the restricted capability of the generator's controllers due to their limited rating and flexibility. The advent of high rating fast control power electronics technology has given rise to the possibility of enhancing the stability of a power system network, externally of the generators. At transmission level, these new power electronics controllers are termed Flexible AC Transmission System (FACTS) devices, while at low rating, they are known as custom power devices. The main objectives of introducing these controllers into power systems are to increase the power transfer capability and to provide control of power flow over a designated transmission or distribution network . These controllers achieve their objective by providing continuous control over a wide range of power system parameters, which include voltage magnitude, phase angle, active and reactive power flow, and the network impedance.

7. STATIC VAR COMPENSATOR (SVC)

According to definition of IEEE PES Task Force of FACTS Working Group:

Static VAr Compensator (SVC): A shunt-connected static var generator or absorber whose output is adjusted to exchange capacitive or inductive current so as to maintain or control specific parameters of the electrical power system (typically bus voltage).

SVC provides fast acting reactive power on high voltage transmission network. It is a set of electric devices. In SVC, there are no moving part like other rotating devices. It is a device, which matches automated impedance and brings the system near to the unity power factor.

SVC has includes separate equipment for leading and lagging vars i.e. thyristor –controlled or thyristor – switched reactor.

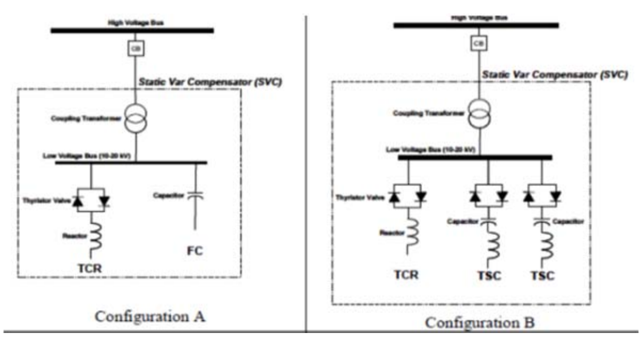

Fig. 1: SVC configuration

There are basically two conditions where we connect svc in the system.

- For regulating transmission voltage
- For improvement of power factor of the system and connected near to the large industrial areas.

Generally SVC is used to regulated grid voltage in the transmission applications. thyristor controlled reactors are used when the reactive load is capacitive, where asThyristor switched capacitor is used when the reactive load is inductive.

8. THE SINGLE LINE DIAGRAM OF FIVE BUS NETWORK

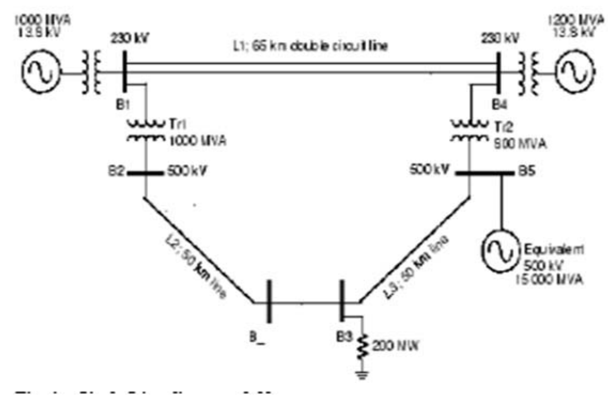

Fig. 2: Single line diagram of five bus system

For study we have considered the five bus system as shown in Fig. 2.1, which is a seven line, two generator and three load bus. In this system two synchronous machine is connected in north and south side and a three phase fault is occurs in the system.

The network, shown in Fig.4.is the single line diagram of a5-bus system connected to grid under investigation. Model 1.The system, connected in a loop configuration, consists of five buses (B1 to B5) interconnected through transmission lines (L1, L2, L3) and two 500 kV/230 kV transformer banks Tr1 and Tr2.Line L1 is used as double circuit line to increase the power transfer capacity by lowering the inductance of line. Two power plants located on the 230-kV system generate a total of 2200 MW which is transmittedto a 500-kV 15000-MVA equivalent and to a 200-MW load connected at bus B3. A speed regulator, an excitation system as well as a power system stabilizer (PSS) is included plantmodels. In normal operation, most of the 1200-MW generation capacity of power plant 2 is exported to the 500-kVequivalent through three 400-MVA transformers connectedbetween buses B4 and B5.

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9. MODELLING OF SVC

A problem has been taken of two machine model consisting of five bus model for analysis of transients stability using MATLAB Simulation. To see the effect of the SVC in the system to stabilize the voltage wave form when the system subjected to three phase fault, a two machine system system is developed with five buses as shown in fig.

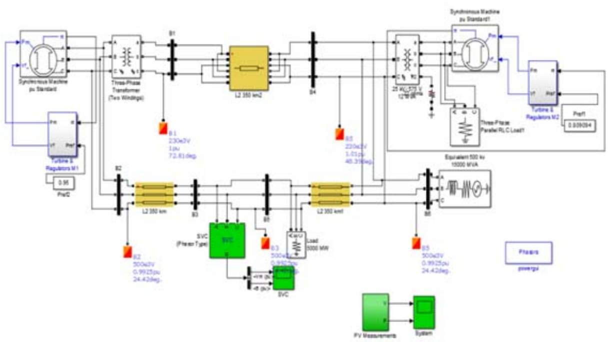

Fig. 3: simulation model of 2 machine 5 bus system

10. SIMULATION RESULT

A three-phase fault is simulated in one of the lines of the five-bus system i.e. three phase to earthfault. The simulation is done in three phases. To start with, the pre-fault system is run for a small time. Then a symmetrical fault is applied at one end of a line. Simulation of the faulted condition continues until the line is disconnected from the buses at both of the ends of the faulted line after a fault clearing time tcl s. Then the post-fault system is simulated for a longer time (say,10 s) to observe the nature of the transients. We start with tcl = 0.1 s (which is six cycles for a 60-

Hz system) and then tcl =.15s.

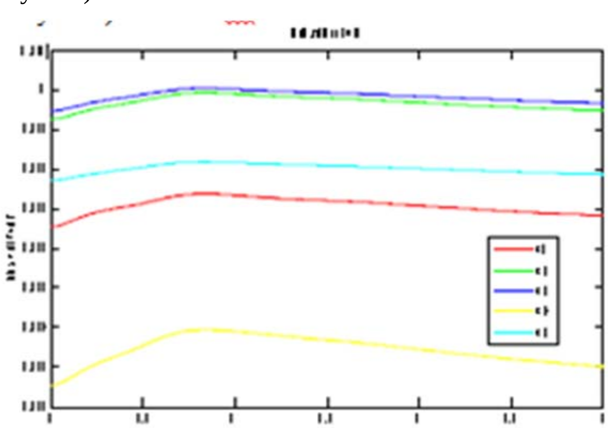

Fig. 4: Voltage profile of 2 machine 5 bus system without SVC

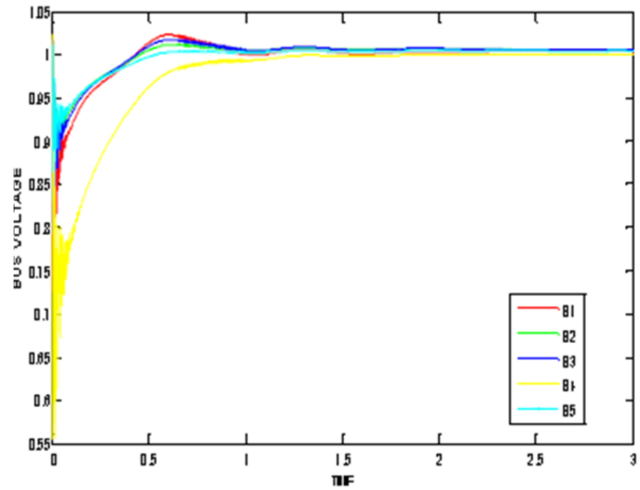

Fig. 5: voltage profile of 2 machine 5 bus system with SVC

In these two fig, here is the Simulink result of the voltage profile of two machine five bus system with and without SVC.

11. CONCLUSION

This paper represents the basics of power flow analysis with the help of svc which is connect between the two machines and five bus system. Simulink result shows the voltage profile of two machine five bus system with and without SVC.

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