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Transient Stability Improvement of Power System Using Static VAR Compensator

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Abstract— *Power system is that the risk of losing stability following a disturbance. Versatile ac gear mechanism (FACTS) devices square measure found to be terribly economical in an exceedingly stressing transmission network for higher utilization of its existing facilities while not sacrificing the specified stability margin. versatile AC gear mechanism (FACTS) controllers, like Static volt-ampere Compensator (SVC) and PSS uses the newest technology of power electronic switch devices in wattage transmission systems to manage voltage and power flow, associated play a very important role as a stability aid for and transient disturbances in an interconnected power systems. Shunt versatile AC gear mechanism (FACTS) devices, once placed at the mid-point of on cable, play a very important role in dominant the reactive power flow to the ability network and therefore each the system voltage fluctuation and transient stability. This study deals with the situation of a shunt FACTS device to boost transient stability in on cable with pre outlined direction of real power flow. This study investigates the consequences of Static volt-ampere Compensator (SVC) on voltage stability of an influence system. The practical structure for SVC designed with a Thyristor Controlled Reactor (TCR) and its model square measure represented. The model is predicated on representing the controller as variable electrical resistance that changes with the firing angle of the TCR.*

Keywords:—*Facts controllers, transient stability transfer reactance, transmission, distribution.*

1. INTRODUCTION

Today's ever-changing power systems produce a growing would like for flexibility, dependability, quick response and accuracy within the fields of electrical power generation, transmission, distribution and consumption. Flexible Alternating Current Transmission Systems (FACTS) area unit new devices emanating from recent innovative technologies that area unit capable of fixing voltage, point and/or electrical phenomenon at specific points in power systems. Their quick response offers a high potential for installation stability improvement except for steady-state flow management. Among the FACTS controllers, Static volt-ampere Compensator (SVC) provides quick acting dynamic reactive compensation for voltage support throughout contingency events which might otherwise depress the voltage for a big length of your time. SVC additionally dampens power swings and reduces system losses by optimized reactive power management. In previous works the effective strategies of management are enforced to regulate of SVC so as to damp power swings.

The power system these days area unit sophisticated networks with many generating stations and cargo centers being interconnected through power transmission lines. An electrical installation may be divided into four stages

(i) Generation,

(ii) Transmission

(iii) Distribution

(iv) Utilization (Load).

the fundamental structure of an influence system is as shown in Fig.1.1. it's composed of generating plants, a gear mechanism and distribution system. These subsystems area unit interconnected through transformers T1, T2 and T3

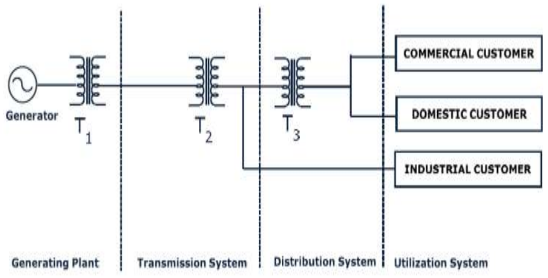

Figure 1. Typical power systems

Steady State Stability Studies

Steady state stability is that the ability of the system to develop restoring forces adequate to or bigger than the distressful force and stay in equilibrium or temporal relation when tiny and slow disturbances. Increase in load may be a reasonably disturbance. If increase in loading takes place step by step and in tiny steps and also the system withstands this modification and performs satisfactorily, then the system is alleged to be in steady state stability. Therefore the study of steady state stability is essentially involved with the determination of higher limit of machine's loading before losing temporal relation, provided the loading is accrued step by step at a slow rate. In follow, load modification might not be gradual. Further, there are also sudden disturbances owing to

(i) sudden modification of load

(ii) Shift operation

(iii) Loss of generation

(iv) Fault

Dynamic Stability Studies

Dynamic stability is that the ability of the facility system to keep up stability beneath continuous tiny disturbances additionally called small-signal stability. These tiny disturbances occur due random fluctuations in hundreds and generation levels. moreover this stability is in a position to regain temporal relation with inclusion of automatic management devices like automatic transformer (AVR) and frequency controls. this can be the extension of the steady state stability that takes a extended time to clear the disturbances [5].

Transient Stability Studies

Transient stability is that the ability of the facility system to keep up temporal relation once subjected to a severe transient disturbance like the incidence of a fault, the sudden outage of a line or the sudden application or removal of hundreds [2][4]. The ensuing system response involves giant excursions of generator rotor angles and is influenced by the nonlinear power-angle relationship. Following such sudden disturbances within the installation, rotor angular variations, rotor speeds, and power transfer bear quick changes whose magnitudes area unit dependent upon the severity of disturbances. For an oversized disturbance, changes in angular variations is also therefore giant on cause the machine to fall out of step. this sort of instability is thought as Transient Instability. Transient stability may be a quick development, typically occurring among one second for a generator near the reason behind disturbance. the target of the transient stability study is to establish whether or not the load angle returns to a gentle worth following the clearance of the disturbance [3]. Transient stability studies area unit associated with the impact of the line faults on generator temporal relation. The transient instability development may be a in no time one and happens among one second or a fraction of it for generator near location of disturbance. During the fault, the power from near generators is reduced and also the power from remote generators remains comparatively unchanged. The resultant variations in acceleration turn out speed variations over the interval of the fault and it's vital to clear the fault as fast as doable. The fault clearing removes one or additional transmission components and weakens the system. The modifications within the gear mechanism turn out change within the generator rotor angles. If the changes area unit such the accelerated machines develop extra load, they weigh down and a replacement equilibrium position is reached. The loss of temporal relation are evident among one second of the initial disturbance.

Faults on heavily loaded lines area unit additional seemingly to cause instability than the fault on gently loaded lines as a result of they have an inclination to provide additional acceleration throughout the fault. 3 part faults turn out bigger accelerations than those involving one or 2 part conductors. Faults that aren't cleared by primary fault turn out additional angle deviations within the near generators. Also, the backup fault clearing is performed when a time delay and thus produces severe oscillations. The loss of a serious} load or a serious generating station produces significant disturbance within the system.

Factors influencing transient stability:

(i) Generator inertia

(ii) Generator loading

(iii) Generator output (power transfer) during fault-depends on fault location and fault sort

(iv) Fault clearing time

(v) Post-fault gear mechanism electrical phenomenon

(vi) Generator electrical phenomenon

(vii) Generator internal voltage magnitude-this depends on field excitation, i.e. the facility issue of the facility sent at the generator terminals

(viii) Infinite bus voltage magnitude.

Facts controllers

The IEEE Power Engineering Society (PES) Task Force of the FACTS social unit has outlined FACTS and FACTS Controller as given below [3]. versatile AC gear mechanism (FACTS): electricity transmission systems incorporating power electronic-based and different static controllers to boost controllability and increase power transfer capability. FACTS Controller an influence electronic-based system and different static instrumentation that give management of 1 or additional AC gear mechanism parameters.

It is worthy to notice the words “other static Controllers” during this definition of FACTS make sure that there may be different static Controllers that aren't supported power natural philosophy. the final image for FACTS Controller is shown in Figure. 1.2a. FACTS Controllers area unit dividedinto four classes [3]:

(i) Series FACTS Controllers

(ii) Shunt FACTS Controllers

(iii) Combined Series-Series FACTS Controllers

(iv) Combined Series-Shunt FACTS Controllers

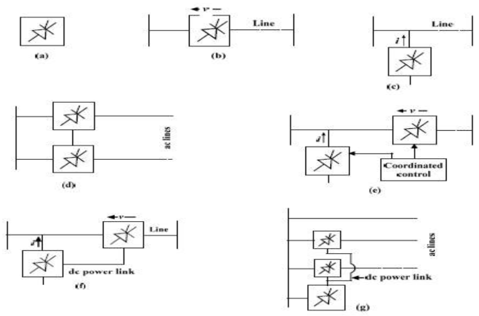

Figure 2. Basic Types of FACTS Controllers

2. METHDOLOGY

The transient stability is important issue in power system planning operation and control. For understanding transient phenomena and to improve transient stability a methodology adopt which is based on a power system stabilizers and static var compensators, consider a simple transmission system containing two hydraulic power plants. A static var compensator (SVC) and power system stabilizers (PSS) are used to improve transient stability and power oscillation damping of the system.

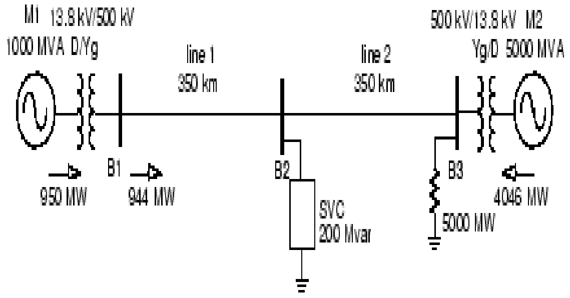

Figure 3. System Model

A 1000 MW hydraulic generation plant (M1) is connected to a load center through a long 500 kV, 700 km transmission line. The load center is modeled by a 5000 MW resistive load. The load is fed by the remote 1000 MVA plant and a local generation of 5000 MVA (plant M2).A load flow has been performed on this system with plant M1 generating 950 MW so that plant M2 produces 4046 MW. The line carries 944 MW which is close to its surge impedance loading (SIL = 977 MW). To maintain system stability after faults, the transmission line is shunt compensated at its center by a 200 Mvar static var compensator (SVC). The SVC does not have a power oscillation damping (POD) unit. The two machines are equipped with a hydraulic turbine and governor (HTG), excitation system, and power system stabilizer (PSS).

Transient Stability of a Power System with SVC and PSS

In this work modeling of a simple transmission system containing two hydraulic power plants. A static var compensator (SVC) and power system stabilizers (PSS) are used to improve transient stability and power oscillation damping of the system.

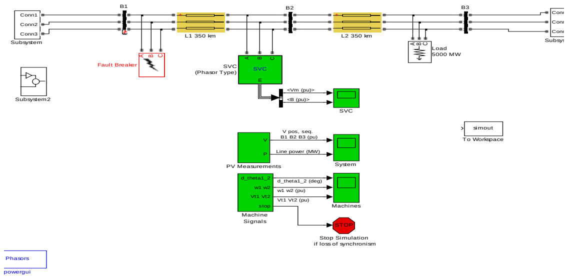

Figure 4. MATLAB Model

Case –I

When pss are not in service and fault duration is 0.1 sec.

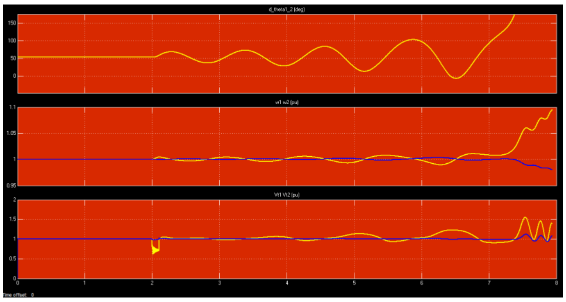

Figure 5. Magnitude of dθ1, dθ2(deg), w1, w2(pu) Vt1, Vt2(pu) when pss are not in service and fault duration is 0.1 sec

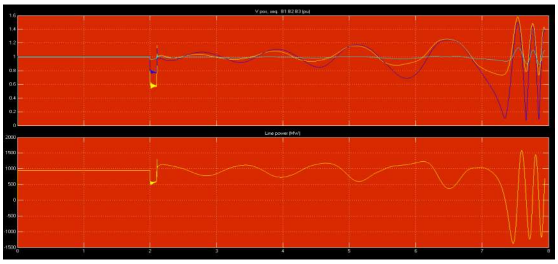

Figure 6. Magnitude of V pos seq B1, B2, B3(pu) when pss are not in service and fault duration is 0.1 sec

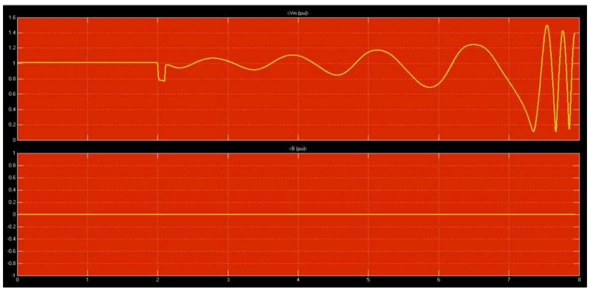

Figure 7. Magnitude of Vm(pu), B(pu) when pss are not in service and fault duration is 0.1 sec

Case-II

When generic pss are in service and fault duration is 0.1 sec.

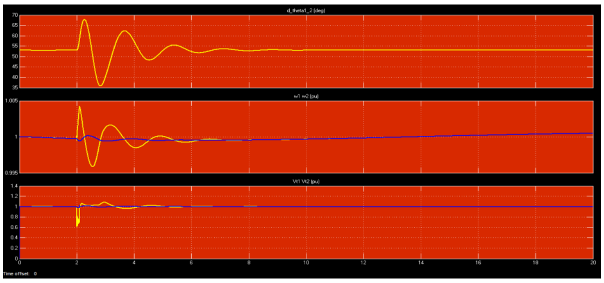

Figure 8. Magnitude of dθ1, dθ2(deg), w1, w2(pu) Vt1, Vt2(pu) when generic pss are in service and fault duration is 0.1 sec.

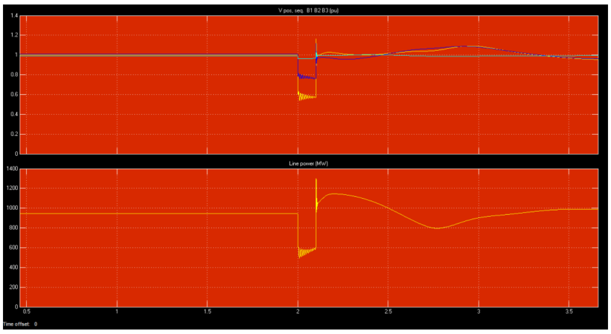

Figure 9. Magnitude of V pos seq B1, B2, B3(pu), Line Power (MW) when generic pss are in service and fault duration is 0.1 sec

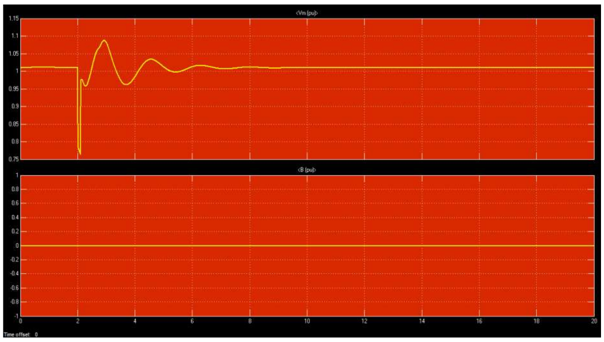

Figure 10. Magnitude of Vm(pu), B(pu) when generic pss are in service and fault duration is 0.1 sec

Case-III

When multiband pss are in service and single phase fault is created for 0.1 sec.

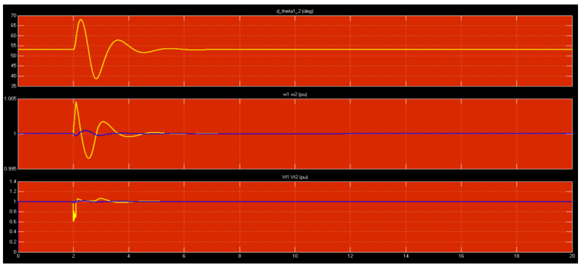

Figure 11. Magnitude of dθ1, dθ2(deg), w1, w2(pu) Vt1, Vt2(pu) when multiband pss are in service and single phase fault is created for 0.1 sec.

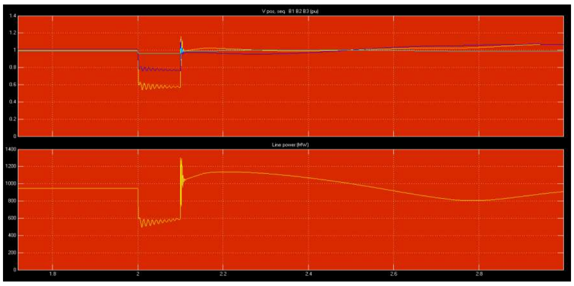

Figure 12. Magnitude of V pos seq B1, B2, B3(pu), Line Power (MW) when multiband pss are in service and single phase fault is created for 0.1 sec.

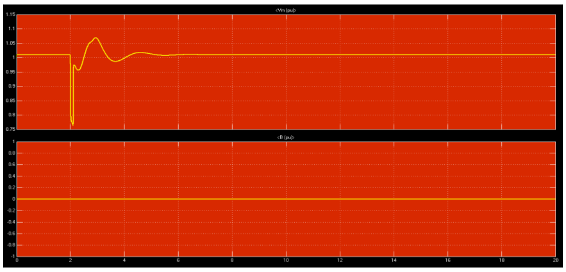

Figure 13. Magnitude of Vm(pu), B(pu) when multiband pss are in service and single phase fault is created for 0.1 sec.

Case-IV

When only SVC is in service and three phase fault is created for 0.1 sec.

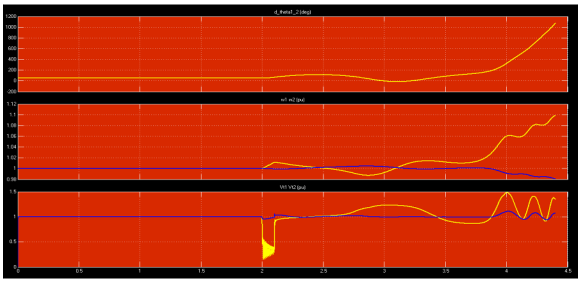

Figure 14. Magnitude of dθ1, dθ2(deg), w1, w2(pu) Vt1, Vt2(pu) when SVC is in service and three phase fault is created for 0.1 sec.

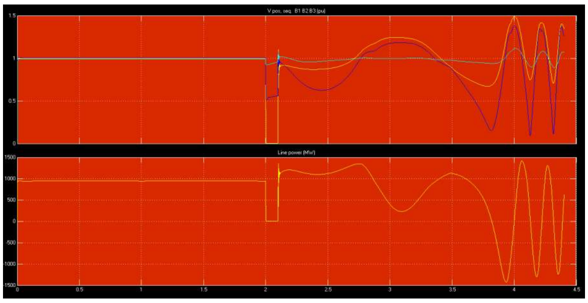

Figure 15. Magnitude of V pos seq B1, B2, B3(pu), Line Power (MW) when SVC is in service and three phase fault is created for 0.1 sec.

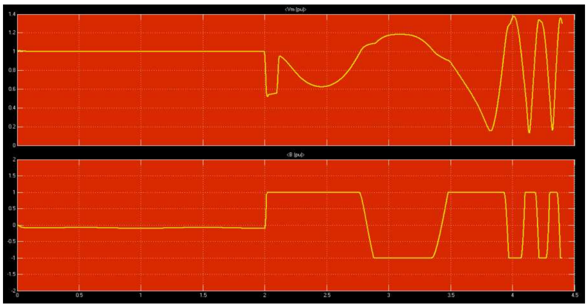

Figure 16. Magnitude of Vm(pu), B(pu) when SVC is in service and three phase fault is created for 0.1 sec.

Case-V

When SVC and pss is in service and three phase fault is created for 0.1 sec.

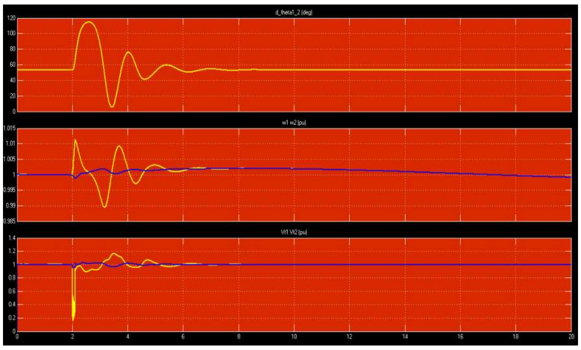

Figure 17. Magnitude of dθ1, dθ2(deg), w1, w2(pu) Vt1, Vt2(pu) when SVC and pss is in service and three phase fault is created for 0.1 sec.

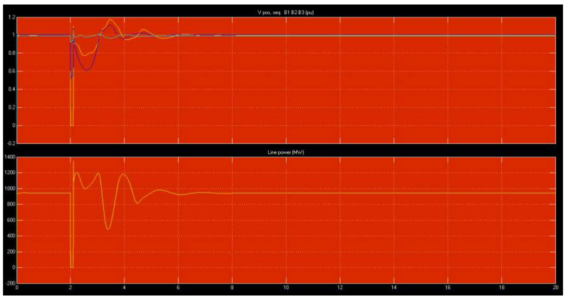

Figure 18. Magnitude of V pos seq B1, B2, B3(pu), Line Power (MW) when SVC and pss is in service and three phase fault is created for 0.1 sec.

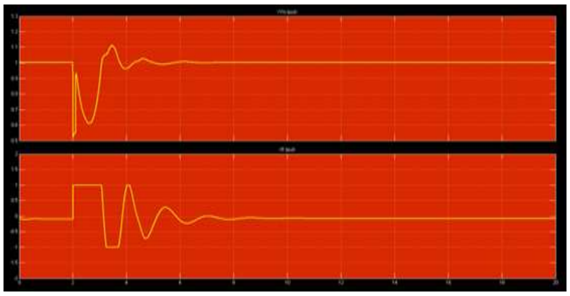

Figure 19. Magnitude of Vm(pu), B(pu) when SVC and pss is in service and three phase fault is created for 0.1 sec.

Case-VI

When SVC and multiband PSS is in service and three phase fault is created for 0.1 sec.

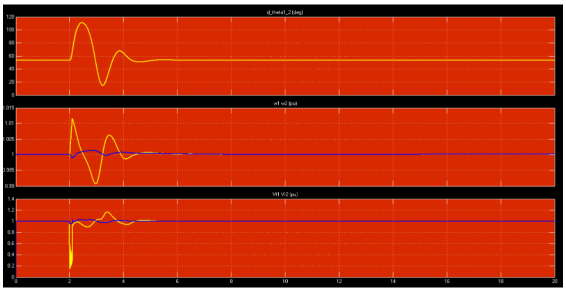

Figure 20. Magnitude of dθ1, dθ2(deg), w1, w2(pu) Vt1, Vt2(pu) When SVC and multiband PSS is in service and three phase fault is created for 0.1 sec.

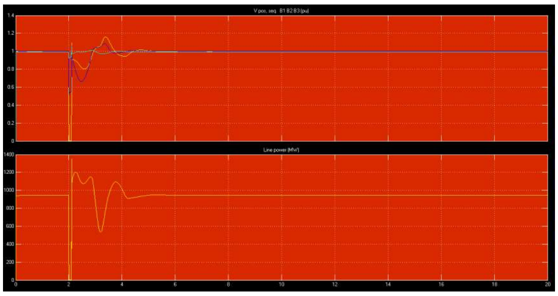

Figure 21. Magnitude of V pos seq B1, B2, B3(pu), Line Power (MW) when SVC and multiband PSS is in service and three phase fault is created for 0.1 sec.

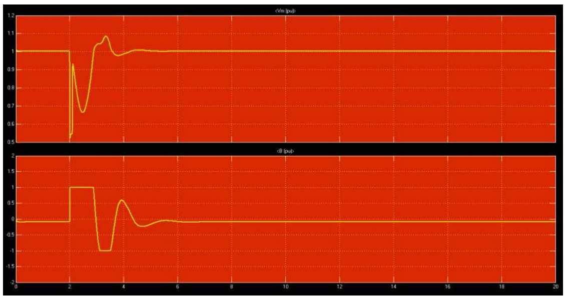

Figure 22. Magnitude of Vm(pu), B(pu) when SVC and multiband PSS is in service and three phase fault is created for 0.1 sec.

3. CONCLUSION

Each generator operates at the same synchronous speed and frequency of 50 hertz while a delicate balance between the input mechanical power and output electrical power is maintained. Whenever generation is less than the actual consumer load, the system frequency falls. On the other hand, whenever the generation is more than the actual load, the system frequency rise. The generators are also interconnected with each other and with the loads they supply via high voltage transmission line.

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