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Bang-Bang Modulated FACTS Stabilizing Controllers Based on Online Identification of Critical Modes

[1]Karam Chand Dhiman, [2]Neha Sharma
[1]*Senior Technician, PUSSGRC, Hoshiarpur and M.Tech Student GGS, Kharar*
[2]*Assistant Professor, GGS College Kharar*

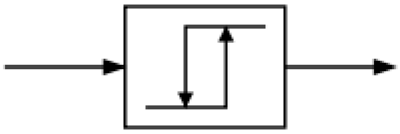
Abstract: *This paper of bang-bang modulation of FACTS signals, developed a damping control scheme for Flexible Alternating Current Transmission System (FACTS) devices. The low frequency oscillations have mainly observed in power system because of the presence of high gain of exciters, operating the system under stressed conditions and the contingencies. The proposed control strategy of stabilizing controller has been tested with SVC and PSS in MATLAB/SIMULINK. The Sim-Power toolbox is used for detailed modeling of 400 KV, 700KM line, taken as an example. With the Power System Stabilizer and FACTS controllers, better damping is achieved. The Paper studies the comparative performance of SVC (Static Var Compensator) and Power system stabilizer (PSS) for the improvement of transient stability and damping control for Long Transmission Line System. Shunt FACTS devices play an important role in improving the transient stability, increasing transmission capacity and damping low frequency oscillations. For the implementation of this proposed work the Simulink Part under Matlab software is used.*

I. INTRODUCTION

In Present time FACTS devices have become more and more popular in power systems. FACTS devices have major advantages in the transmission system such as: transmission capacity enhancement, power flow control, transient stability control, power oscillation damping, voltage stability and control. The traditional mechanical driven devices subject to wear and require maintenance but FACTS device controllers not subject to wear and require a lower maintenance [2]. The demand of electricity has been increasing day by day and a modern power system becomes a complex network of transmission lines. It is becoming increasingly important to fully utilize the existing transmission system assets due to environmental legislation, rights-of-way issues and costs of construction and deregulation policies that introduced in recent years. A number of Flexible AC Transmission System (FACTS) controllers, based on the rapid development of power electronics technology, have been proposed for better utilization of the existing transmission systems. Because of the high gain of exciters the low frequency oscillations have been mainly observed in power systems. The off-line approaches are also utilized to assess the small signal stability of the system. The models based approaches involve time extensive computations and are not suitable for real-time assessment of the system stability. Power system stabilizers (PSS) have been widely used, as supplementary controller to the generator exciters, for improving the power system damping. FACTS controllers design is however be quite more complicated than that of the PSS. A PSS controller is generally more robust than a FACTS controller and it is difficult to achieve robustness in FACTS controllers over a wide range of operating conditions. In order to have maximum controllability of oscillation modes, the best location of FACTS and the input signals are chosen. On the other hand, the residues of critical modes should not vary too much in different operating conditions, so that a low order, robust controller can be achieved. In control synthesis interactions is avoided. An ideal control loop should have minimum effect on other system's noncritical modes.

II. BASIC CONCEPT OF BANG BANG CONTROL

In control theory, a bang–bang controller (2 step or on–off controller), also known as a hysteresis controller, is a feedback controller that switches abruptly between two states. These controllers may be realized in terms of any element that provides hysteresis. They are often used to control a plant that accepts a binary input, for example a furnace that is either completely on or completely off. Most common residential thermostats are bang–bang controllers. The Heaviside step function in its discrete form is an example of a bang–bang control signal. Due to the discontinuous control signal, systems that include bang–bang controllers are variable structure systems, and bang–bang controllers are thus variable structure controllers.

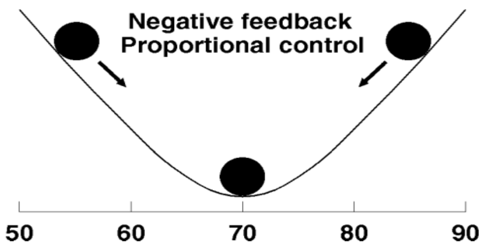


Symbol for a bang-bang control

Take an example of thermostat, regardless of whether it's wired for negative or positive feedback, applies an all or nothing form of control. When the temperature drops too low, the furnace comes on, Hell bent, to heat up the place. When it gets too hot, the air conditioners unleashed, flat out, to chill out the environs.

Engineers call this kind of control ``*bang-bang*." When it gets too cold *bang*, the furnace comes on. As soon as the temperature rises above 60°, *bang* the furnace cuts off. Too hot? *Bang*, the air conditioner starts, and so on.

Take a closer look at the inside temperature in the chart on page. See how the temperature tends to oscillate between 70 degrees and the level where the thermostat kicks in? That's the signature of bang-bang control--since nothing happens until one of the limits is hit, the temperature varies freely between them. When the system exceeds a limit, its hauled back within range, then allowed drifting again.



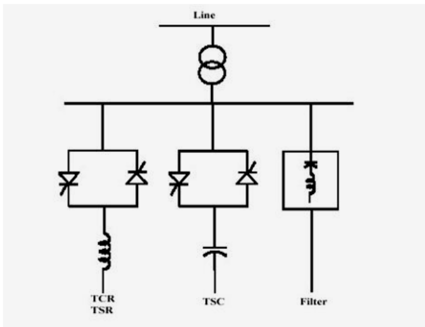
Bang-bang control keeps the temperature pretty much within the range from 60 to 80, but it allows the temperature to vary freely between the limits. Suppose instead of just switching the furnace and air conditioner on and off, we coupled the temperature reading to the gas valve on the furnace: the further the temperature falls below 70, the more heat the furnace generates. Likewise, as soon as the temperature rises above 70, the air conditioner starts, but we rig it to generate more and more cooling as the temperature rises.

Bang-Bang Control in Power System

Bang Bang Control in power system of Lightly Damped Systems is also favorable. The advantage of the bang-bang controller for lightly damped systems is its simplicity and its robustness. The control signal is piecewise constant with an initial step change that causes the system output to reach the desired value at the first peak of its response.

III. SHUNT FACTS DEVICE 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). This is a general term for a Thyristor Controlled Reactor (TCR) or Thyristor Switched Reactor (TSR) and/or Thyristor Switched Capacitor (TSC). The term, "SVC" has been used for shunt connected compensators, which are based on thyristors without gate turn-off capability. It includes separate equipment for leading and lagging vars; the thyristor –controlled or thyristor – switched reactor for absorbing reactive power and thyristor – switched capacitor for supplying the reactive power.



Static Var Compensator

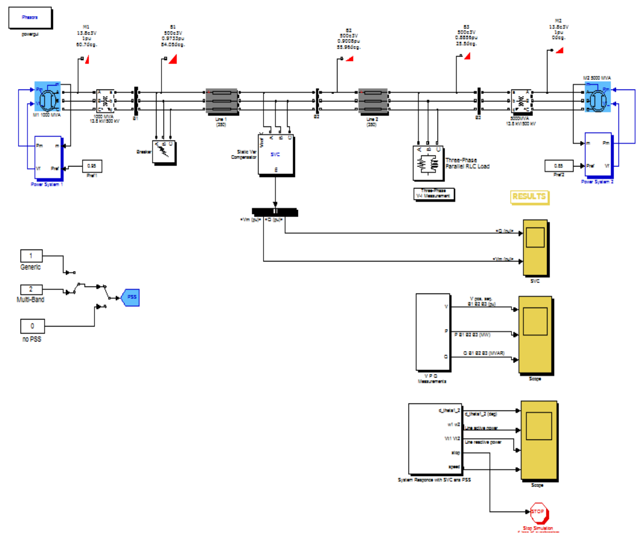
The SVC can be seen as a dynamic source of reactive current having sub-cycle reaction time. Using the thyristor valve as fast switches, capacitor banks can be switched in and out. This arrangement of switching capacitors and controlling reactors provides regular control of the reactive current output between two extremes dictated by component rating selection. Electrical loads both generate and absorb reactive power. Since the transmitted load varies significantly from one hour to another, the reactive power equilibrium in a grid varies as well. The result can be undesirable voltage amplitude variations, a voltage depression, or even a voltage collapse.

IV. POWER SYSTEM STABILIZERS PSS

The **Power System Stabilizer** (PSS) is a supplementary excitation controller used to damp generator electro-mechanical oscillations in order to protect the shaft line and stabilize the grid. It also damps generator rotor angle swings, which are of greater range in frequencies in **power system**.
The PSS is a feedback controller, which is a part of the control system for a synchronous generator. PSS provides an additional signal that is added to the input summing point.
The PSS main function is to damp generator rotor oscillations in the range from 0.1 to 2.5 Hz approximately, which according to [11], are oscillations due to electromechanical dynamics and are called electromechanical oscillations.
By adding the stabilizing signal the PSS is expected to produce an electric torque component that counteracts the mechanical dynamics. The produced electric torque component should be in phase with the deviations of the generator rotor speed in order to be able to damp the oscillations.

V. SYSTEM MODELLING AND SIMULATION

An accurate network model is required To get perfect and exact simulation results. SIMULINK/Power System Block set (PSB) is used to create power system model for simulation. With the new updated versions of MATLAB/SIMULINK, the model development of power system components is required for perfection. Due to the fast development of new technologies, which improve the power transfer efficiency and the optimum utilization of System capability, power electronic equipment like SVC, PSS and so on may be widely used in power systems in the future. Thus, the selection and the setting of parameters of power system and FACT devices should be calculated, evaluated and tested thoroughly. SIMULINK includes variant basic power components, which can be used alone or in combination use to finish all kinds of power system network simulations. It is very easy to create power system in SIMULINK environment, which allows users to build a model by simple "click and drag'' procedures. Because all of the electrical parts of the simulation interact with the SIMLLINK'S modeling library, it is not just possible to easily draw the power system network, but also to include its interactions with every electrical component.
To show the transient stability improvement by SVC in a two area power system, a model of two area system is designed in MATLAB. In this model a 1000 MVA power plant-1 is connected with another 5000 MVA power plant-2 through a 700 km transmission line. Both the plants are supplying the power to the load connected at BUS. Simulation is performed for 12 sec.and a three phase fault is applied from 5.0 sec to 5.1 sec in each case. A stop block is used to stop the simulation when the angle difference becomes 3*360 degree.



VI. CASE STUDY WITH AND WITHOUT CONNECTING THE SVC

When models are all the three cases of different loads, simulated without SVC then it is observed from Figure 1 respectively that large transients occur in rotor angle difference of machines, in line voltage, in line active power and in line reactive power. With SVC, there is marked reduction in rotor angle difference in all the three case as is evident from Figure 2, Figure 3 respectively. Line voltages, line active powers and line reactive powers at buses 1, 2, 3 are shown in Figure 1-3, for different load cases respectively.

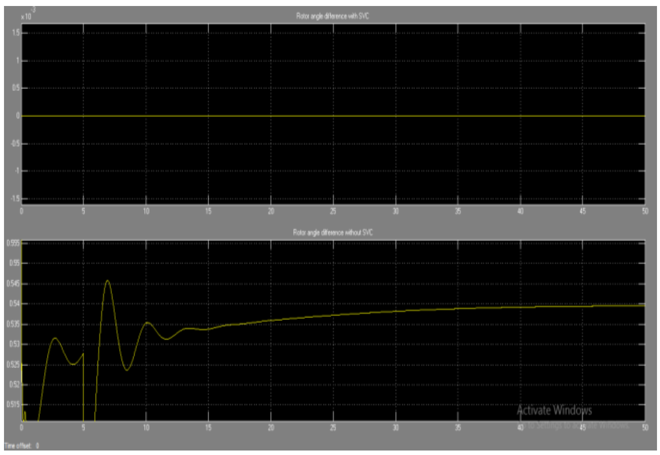


Fig 1: Rotor angle difference without SVC

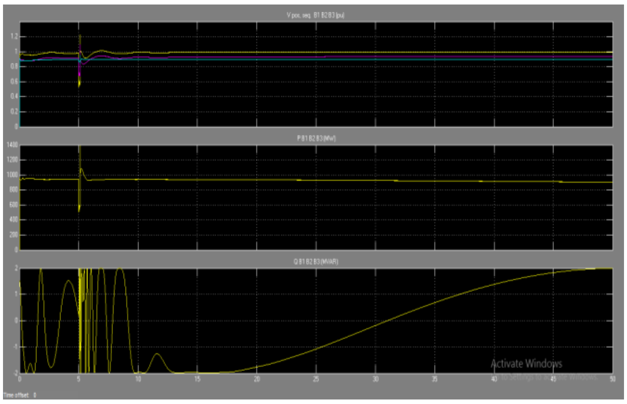


Fig 2: Line voltages at bus 1, 2, 3 (p.u) with SVC

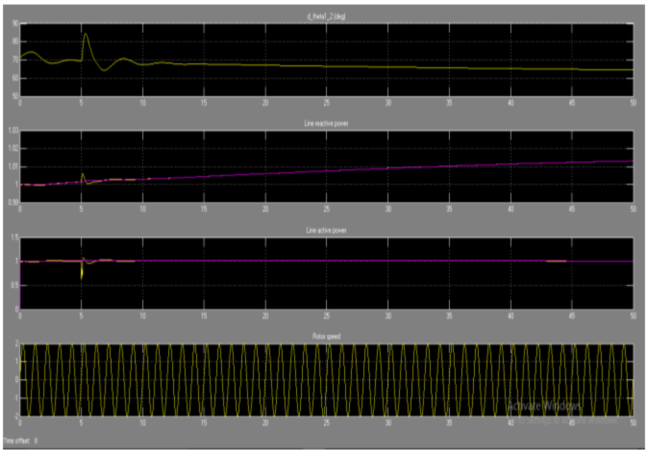


Fig 3: Line active power at bus 1, 2, 3 (MW) with SVC

VII. CONCLUSION

This paper proposed a model for power system stabilizer (PSS - generic & multiband) types and Static Var Compensator (SVC) to Damp out oscillations and also improves transient stability. The basic structure of (PSS) is operating under typical control generator while the basic structure of (SVC) is operating under typical bus voltage control. The proposed controller is used (PSS) & (SVC) under abnormal system conditions.

FUTURE WORK

In this simulation L-L-G fault is taken in future the results are compare for different faults. The simulation can be done with other FACT devices and also Zone protection in transmission line can be studied with various types of relays using SVC and PSS.

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