IMPROVEMENT OF POWER SYSTEM STABILITY IN ELECTRICAL SYSTEM USING FACTS DEVICE AND POWER OSCILLATION DAMPING (POD) CONTROLLER

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ABSTRACT*:*

The uncommon peak demand in power system causes heavily loaded lines which results into voltage instability. This Voltage Instability is caused due to the absence of sufficient Reactive Power, Which in turn causes failure of the System. In this Simulation a FACTS Device with Power Oscillation Damping Controller have been used in Multi Machine System Integrated with Renewable energy. The Flexible AC Transmission System delivers a compensating voltage with an inductive or a capacitive range so as to Improve Voltage Stability of the System. Power Oscillation Damping (POD) Controller is used to examine its Performance when Unsymmetrical and symmetrical Faults were produced in the System along with Oscillations from the Power produced from Electrical Sources. In the result, the Performance of the system, Bus parameters and Machine Parameters are compared between a system with and without POD controller.

Keywords—Power Oscillation Damping Controller, Voltage Instability, Real and Reactive Power Compensation

INTRODUCTION

The connection of AC electrical power grids have been facing technical challenges ranging from regulation of frequency and transient stability. These challenges have gained higher interest on one hand due to theincorporation of power electronic converters in the transmissionlinks and on the other hand, due to the integration of weak, ratherthan strong power systems. In a weak system a small disturbance can cause large deviations in the voltage and other variables in thenetwork. The short circuit level at a bus is commonly used as a measure of the system strength at that particular point. Technically, a weak AC system could be evaluated following several considerations: low ratio of inductance over resistance, high impedance and low inertia. Examples of weak networks include isolated micro grids with renewable energy.

A. Modelling of the Power System

Synchronization is the procedure which coordinates the speed and frequency of a generator or other source to a running system. There are five conditions that must be met before the synchronization procedure happens. The system to be synchronized must have accordance with line voltage, frequency, phase sequence, phase point, and waveform to that of the Generator that is used as the main source. Development of the generator and its associations with the system settles the waveform and phase sequence. Amid establishment of a generator, cautious checks are made to guarantee the generator terminals and all control wirings are right so that the request of phases (phase sequence) coordinates the system. The voltage, frequency and phase point must be controlled each time a generator is to be associated with a system.

B. Modelling of SSSC

In this paper, an examination concerning the utilization of SSSC based power swaying damping controller to improve the transient stability of a multi-machine control systems is introduced. For assessment of viability and strength of composed controllers, the execution was tried on multi-machine system subjected to unbalance faults and system parameter varieties. Simulation results are completed in MATLAB/SIMULINK condition for multi-machine control system to examine the impacts of SSSC on transient stability execution and damping of energy swings of the system. Simulation comes about demonstrate the fine execution of the proposed SSSC controller in damping the basic modes without altogether falling apart the damping qualities of different modes in multi-machine control system.

Late advancement of energy electronic gadgets presents the utilization of Flexible AC Transmission Systems (FACTS) controllers in power systems. Power controllers have capacity of controlling the system condition in a quick way and this special component of FACTS can be altered to enhance the stability of a power system. The clarification about the FACTS controllers are very much reported in the writing. For expanding the power stream capacity of the transmission lines another approach named Flexible A.C Transmission system has been presented in most recent couple of years. This new innovation has propelled control hardware based controller. The target of the transmission lines is to meet the necessity of utility while keeping up the power system security and unwavering quality. Presently all the power system equipments of the Grid are interconnected. Because of inaccessibility to take care of the power demand causes the variety in power systems parameter, for example, voltage profile facilitate which exasperate the stability of the system.

For eliminating the electromechanical oscillations power systems stabilizers are used up to some extent. Power electronics based FACTS controllers damp out the oscillations with high speed and thus enhances the stability of the system. FACTS technology is a modern power electronics based application utilized at important locations of transmission line for controlling and adjusting the parameters of the transmission line for enhancing the power flow capability.

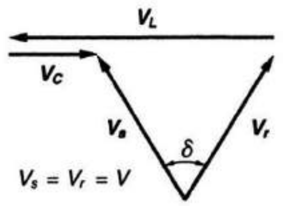

Fig. 1. Phasor Diagram of SSSC

The utility interactive inverters not only conditions the power output of the PV arrays but ensures that the PV system output is fully synchronized with the utility power. A solar PV panel produces DC electrical power, which is different from AC power that received from electrical grid supply. The DC generated by the PV panels is converted into AC power by the inverter (exactly the same high quality AC current delivered to your site by the utility-provided power grid). Output from the inverter is connected to existing distribution panel which feeds the rest of the site.

C. *Control Range and VA rating*

The SSSC can give capacitive or inductive compensating voltage autonomous of the line current up to its predetermined current rating. Thus, in voltage compensation mode the SSSC can maintain the rated capacitive or inductive compensating voltage in the face of changing line current theoretically in the total operating range of zero to Iqmax. (The practical minimum line current is that at which the SSSC can even now retain enough real power from the line to recharge its losses.) The VA rating of the SSSC (solid-state converter and coupling transformer) is just the result of the greatest line current (at which compensation is as yet sought) and the most extreme arrangement repaying voltage: VA = Imax*Vqmax. In impedance compensation mode, the SSSC is established to maintain the maximum rated capacitive or compensating reactance at any line current up to the rated maximum, the corresponding loss versus line current characteristic. Note that in practical applications, as indicated previously for variable impedance type compensators, I max may be separately defined for the rated maximum steady-state line current and for a specified short duration overcurrent. The basic VA rating of the major power components of the SSSC must be rated for these currents and for the relevant maximum voltages. It is seen that an SSSC of 1.0 p.u. VA rating covers a control range corresponding to 2.0 p.u. compensating vars, that is, the control range is continuous from -1.0 p.u. (capacitive) vars to +1.0 p.u. (inductive) vars. In many practical applications, only capacitive series line compensation is required. In these applications.

DESIGN OF POD CONTROLLER

D. *Architechture of POD Controller*

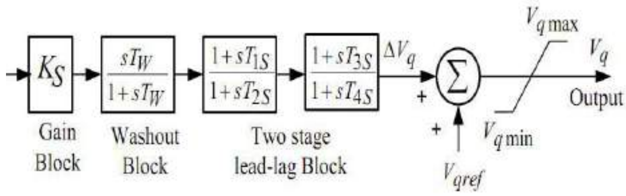

Fig. 2. Block Diagram of POD Controller

One of the structures used in this paper to modulate the SSSC injected voltage is the lead-lag structure. This structure consists of gain block, a washout block and two stage lead-lag block. The two phase lead-lag block gives suitable phase-lead attributes to make up for the phase lag amongst input and the output signals. The washout block behaves as a high pass filter to allow signals associated with oscillations to pass as it is. The inputs to the POD controller are the bus voltage at Bus no.2 and the current flowing in Line 1.The Power Oscillation Damping Controller takes input as Vabc, Iabc& it converts it as power.

During the off time when no errors has happened then switch stays open. Yet, when fault happened then switch ends up plainly shut and subsequent to filtering or damp out oscillation, it will likewise give an error signal and at long last two error signal has been included and this is Vqref.

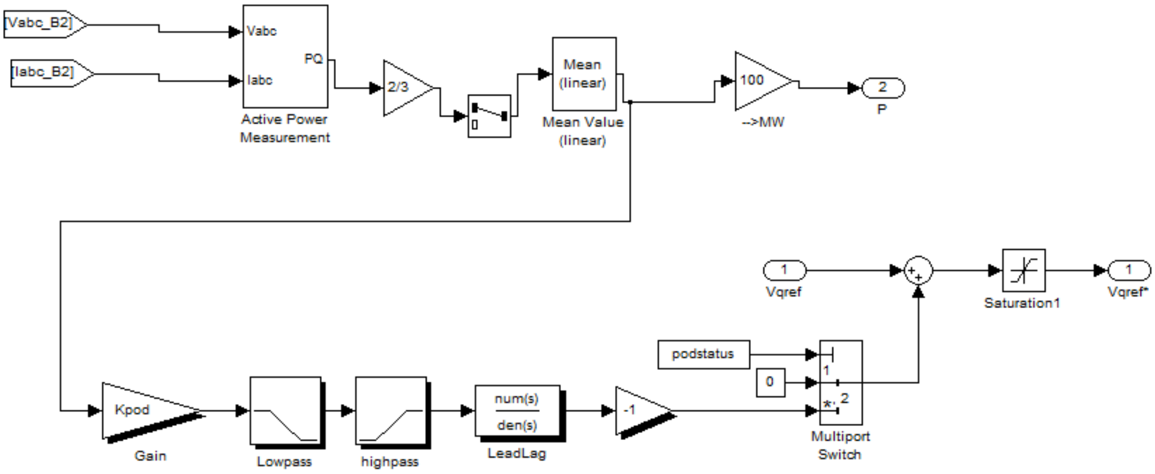

Fig. 3. MATLAB Modelling of POD Controller

MATLAB MODEL OF SSSC WITH POD CONTROLLER

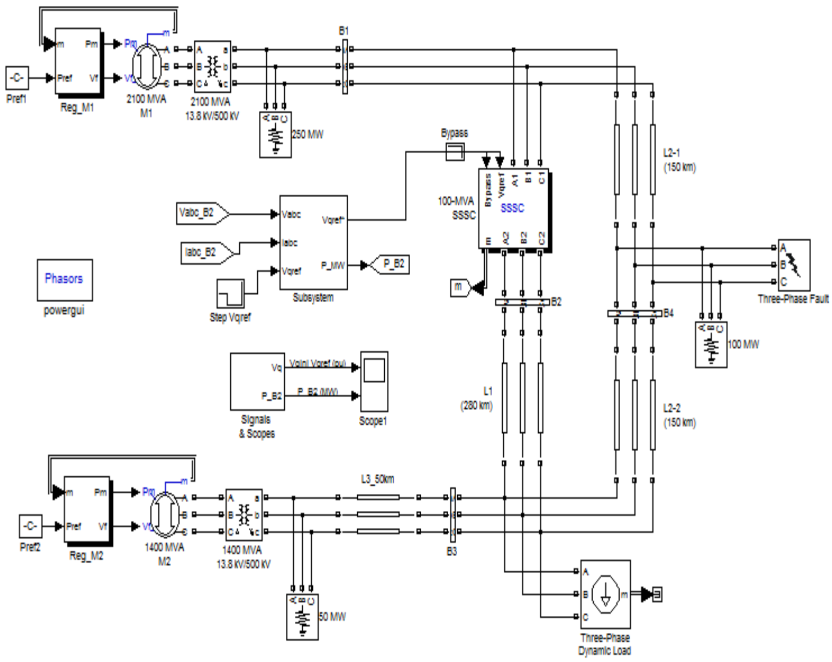

Fig. 4. MATLAB Modelling of SSSC with POD Controller

The Comparison between the power system with and without POD Controller is given below

TABLE I ACTIVE AND REACTIVE POWER WITHOUT POD

Bus No	Current	Voltage (pu)	Reactive Power	Active Power
1	13.51	1.007	-3.768	20.06
2	6.701	1.007	-1.82	9.959
3	9.881	1.002	-0.4871	14.84
4	5.566	1.015	-0.5898	8.452

The SSSC injects a voltage of variable magnitude in quadrature with the line current, thereby emulating an inductive or capacitive reactance. This emulated variable reactance in series with the line can then influence the transmitted electric power.

E. Dynamic Response of POD Controller:

The dynamic response of the model is first verified. The "Step Vqref" block (the red timer block connected to the "Vqref" input of the POD Controller), should be programmed to modify the reference voltage Vqref as follows: Initially Vqref is set to 0 pu; at t=2 s, Vqref is set to -0.08 pu (SSSC inductive); then at t=6 s, Vqref is set to 0.08 pu (SSSC capacitive). The POD Controller block is set as such the POD status parameter is "off". This will disable the POD controller. Also, make sure that the fault breaker will not operate during the simulation. After Initialization of the Controller, the first graph displays the Active, Reactive Power signal along with the Power injected by the SSSC in BUS 2. The second graph displays the active power flow and reactive power (P_B2) on line L1, measured at all buses. We can see that the SSSC controller takes after the reference signal Vqref. Depending on the injected voltage, the power flow on line varies from 575 to 750 MW. In a genuine system the reference signal Vqref would ordinarily be changed more progressively keeping in mind the end goal to stay away from the oscillation we see on the transmitted power (P_B2 signal).

TABLE II. ACTIVE AND REACTIVE POWER WITH POD CONTROLLER:

Bus No	Current	Voltage (pu)	Reactive Power	Active Power
1	13.55	1	-4.743	19.99
2	7.65	0.9945	-1.82	11.25
3	9.887	1	-0.2449	14.82
4	4.65	1	-0.2401	7.094

SIMULATION RESULTS:

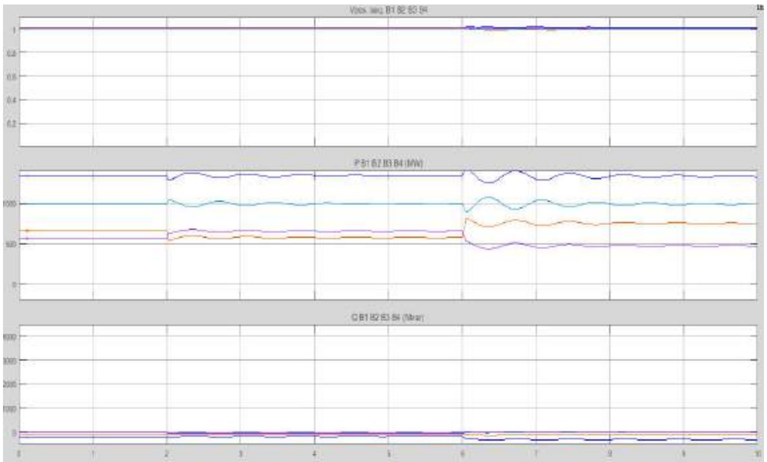

Fig. 9. Voltage, Active and Reactive Power in all buses

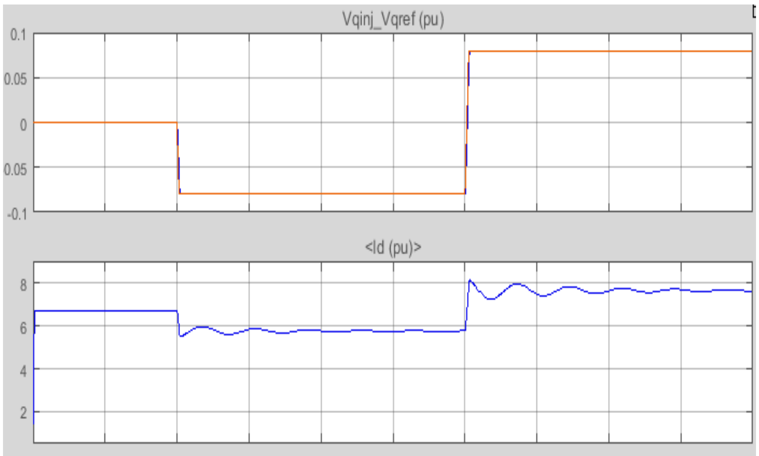

Fig. 10. Voltage change due to Reactive Power Injected and Change in current Waveform

CONCLUSION

SSSC execution against voltage stability were considered in multi machine system in both condition. The estimation of all the bus voltages were observed to be above per unit esteem which demonstrates the voltage instability in the system without SSSC. In the wake of associating the SSSC in arrangement with transmission lines all the bus voltages progresses toward becoming per unit as SSSC infuses quick changing voltage in the transmission line. Consequently enhancing the voltage stability of the system. In second case, to check the execution of POD against disturbance, unsymmetrical faults were connected at Bus 4. MATLAB/SIMULINK model were worked to concentrate the execution of POD controller in the wake of actualizing it in the system. From the outcomes, it is presumed that the utilization of POD in the system causes fast damping of system oscillations when contrasted with system without POD.

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