Transient Stability Enhancement Of Bangladesh East West Interconnected System Using Static VAR Compensator (SVC)

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Abstract

This paper describes the transient stability studies of the East-West interconnected System (EWIS) of Bangladesh Power System (BPS) using Static VAR Compensator (SVC). With the enhancement of power transfer, transient stability is main issue for reliable operation. The assessment of a transient stability is an extremely intricate and highly non-linear problem for large scale interconnected power system. To mitigate this problem, a considerable research with an SVC controller has been evident in the industry. Static VAR Compensator (SVC) is a shunt connected FACTS devices, and plays an important role as a stability support for dynamic and transient disturbances in power system. In this work the modelling of SVC for transient stability enhancement is studied and tested in the East-West interconnected System (EWIS) of Bangladesh Power System (BPS) network.

Keywords:

Transient stability, Static VAR Compensator (SVC), Bangladesh Power System (BPS), East-West interconnected System (EWIS), East-West interconnector (EWI).

1. INTRODUCTION

Transient stability is the ability of a power system to maintain synchronism when subjected to a severe disturbance [1]. An interconnected power system is a complex network comprising of numerous generators, transmission lines, variety of loads and transformers. As a consequence of increasing power demand, some transmission lines are more loaded than was planned when they were constructed. With the increased loading of long transmission lines, the problem of transient stability after a severe disturbance can become a transmission limiting factor [2-3]. The Static VAR Compensator (SVC) with its dynamic action can provide damping and improve overall power system stability [4]. Selection of input signal is important to SVC damping controller to aid power-swing damping. Use of current magnitude and active power enables substantial damping to be attained, with a positive contribution for all operating conditions [5]. SVC becomes more efficient for controlling power swings at higher levels of power transfer and it can damp inter-area modes along with local modes of oscillations [6]. This paper investigates potential benefit of SVC application in EWIS of BPS network. On the basis of the actual topology of the BPS network, approximate model of EWIS system has been developed. Two SVCs are connected at the Ishurdi and Sirajganj buses of EWIS. Simulation results show positive effect of SVC on damping of electromechanical oscillations.

The paper is organised as follows: Section 2 presents modelling of EWIS from actual BPS network configuration. In Section 3, SVC basic structure and its controller are presented. Brief descriptions of simulation tool and simulation results are presented in Section 4 and Section 5 respectively. Conclusion of this work is given in Section 6. Finally, References of this work is given in Section 7.

2. SYSTEM MODELLING

Power system in Bangladesh consists of two main regions, namely Eastern Grid and Western Grid, which are geographically divided by the combined flow of rivers Jamuna, Padma and Meghna. Until March 2009, there was only one interconnection between eastern and western grid that was Ghorasal to Ishurdi (1st EWI) 230 kV line. After this another 230 kV line has been constructed between Ashuganj to Sirajganj (2nd EWI) to enhance power transmission capability from eastern to western grid. At the same time power handling capability of the western grid was enhanced by extending 230 kV tapped from sirajganj to Barapukuria and sirajganj to Khulna. Natore to Bogra line creates mesh configuration at the middle part of the western grid as shown in Figure 1.

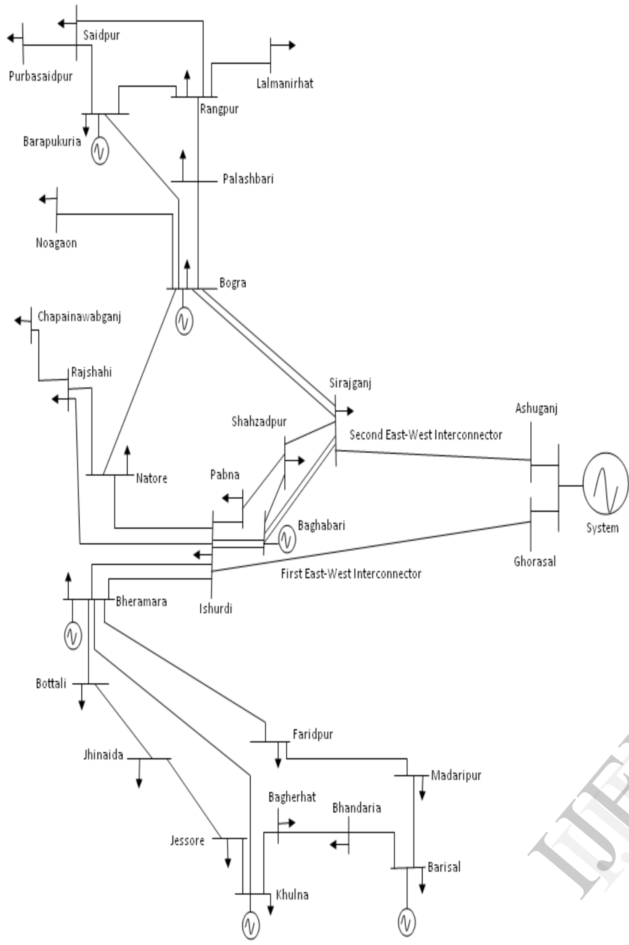

Figure 1: East West Interconnected System (EWIS)

3. STATIC VAR COMPENSATOR

A. SVC Basic Structure

SVC is the shunt compensation device whose main function is to regulate voltage at a chosen bus by controlling the reactive power injection. SVC increases steady state power transmission limit and hence enhances the transient stability of the system [7]. The basic SVC structure consists of a Thyristor Controlled Reactor (TCR) module and a Fixed Capacitor (FC) connected in parallel as shown in Figure 2. This fixed capacitor and TCR branch act together to produced desired susceptance.

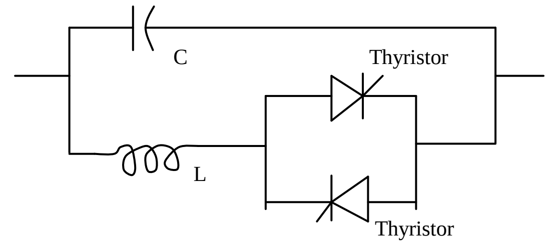

Figure 2: SVC basic structure

B. SVC Stability Loop

To control bus voltage, SVC involves voltage control loop which is composed of voltage regulator, firing circuit, and voltage magnitude transducer [5] as shown in Figure 3. The primary control function is performed by voltage regulator. Depending on the desired susceptance value firing circuit is initiated to convert this numerical value of susceptance to thyristor conduction angle. Power swing damping controller produces modulation signal VMOD depending on the different locally measurable input signals like bus voltage magnitude, active power, reactive power, current magnitude etc. This modulation signal VMOD is added with reference voltage VREF and output of voltage magnitude transducer is subtracted from this summation to produce error signal.

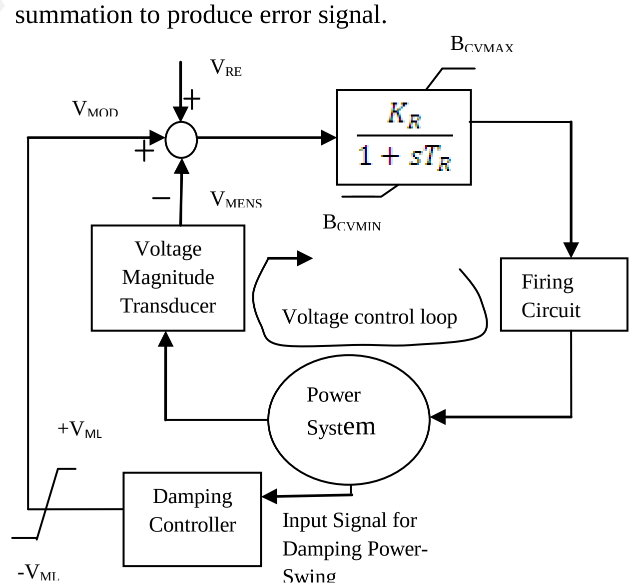

Figure 3: SVC control structure for stability analysis

C. SVC Damping Controller

Power swing damping controller, used in this work is shown in Figure 4 as proposed in [5]. To avoid controller response to dc offset of input signal, washout filter is used. Dynamic compensator consists lag-lead block which provides dynamic compensation upon occurrence of severe disturbance. Finally output of the lead-lag block is passed through first order lag to produce desired modulation signal (VMOD).

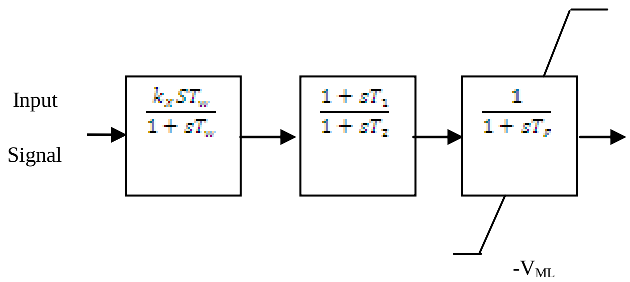

Figure 4: SVC damping controller

Typical acceptable damping ratio of oscillatory modes has been stated in the literature as 3% to 5% [8]. Eigenvalue analysis shows that some of critical modes in EWIS have damping ratio lower than the acceptable range. Dynamic action of SVC can improve the damping ratio of these critical modes. Using line active power flow as input to damping controller, controllability and observability analyses on these critical modes have been performed. Product of controllability and observability gives residue [9, 10]. Supplement of residue phase angle and frequency of critical modes can be used to calculate lag-lead time constants of the damping controller [9].

4. SIMULATION TOOL

Power System Toolbox (PST) is MATLAB based tool that can be used for dynamic analysis of AC/DC/FACTS power systems. This tool was first developed by Prof. J. H. Chow of Rensselaer Polytechnic Institute, New York, USA and was further developed by Graham Rogers of Cherry Tree Scientific Software, Ontario, Canada. PST provides models of machines and control systems for performing transient simulation of power system, and for building state variable models for small signal analysis and for damping controller design. The tool contains several driver program files for performing load flow, eigenvalue, and transient analysis. The most attractive feature of PST is that it is open source, so user can expand or modify PST program code to meet special modeling or simulation requirements. Detailed information about this tool is presented in [11].

5. SIMULATION RESULT

Improvement in transient stability with shunt compensation than that of without compensation has been observed in EWIS. A three phase fault is applied in a load bus near the Ishurdi bus in the western grid during time domain simulation. System variables such as tie-lines active power flow, faulted bus voltage, and machine speed deviation of the nearest unit from the faulted bus have been plotted in a 20 sec. snap-shot.

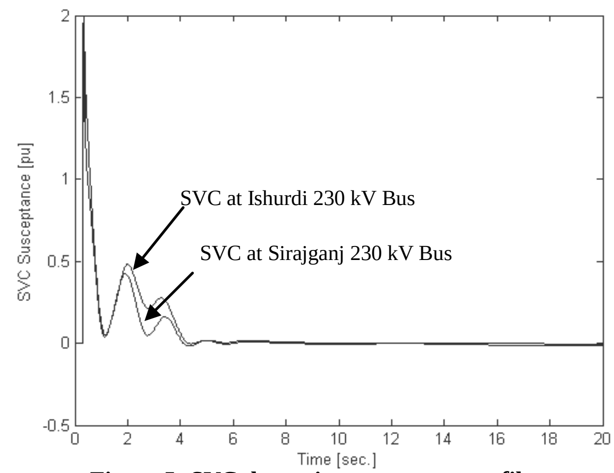

Figure 5: SVC dynamic susceptance profile

Dynamic action of SVC controller is shown in Figure.5 with active power as input signal to the controller. Figure 5 demonstrates that maximum level of shunt compensation is provided by the SVC in the post fault scenario. Just after fault application, percentage compensation jumps up to its maximum level and then gradually decreases. Figure 6 shows that power oscillation of the Ghorasal-Ishurdi (1st EWI) and Ashuganj-Sirjganj (2nd EWI) is well damped with SVC than without SVC.

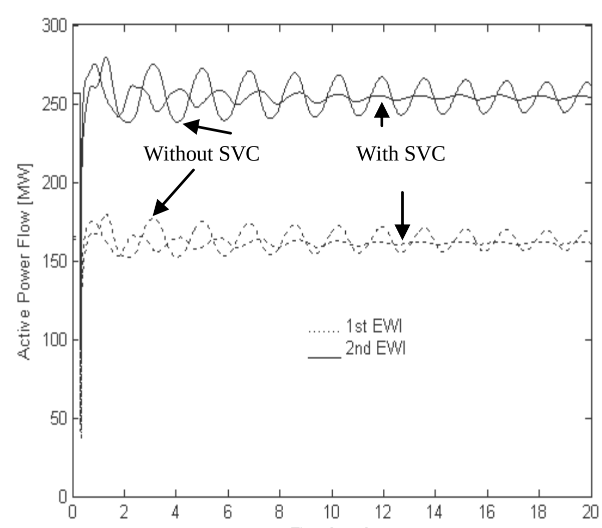

Figure 6: Active Power flow through EWIs

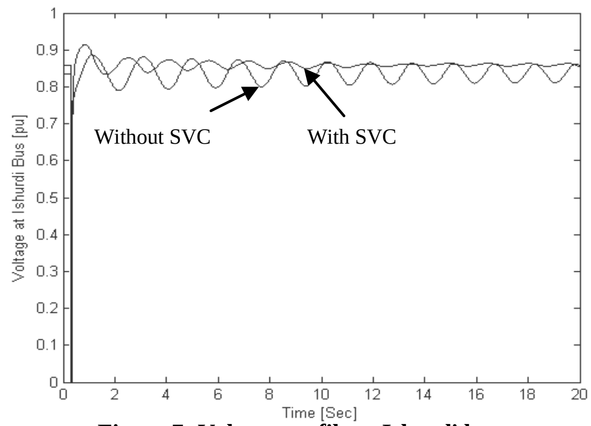

Figure 7: Voltage profile at Ishurdi bus

Voltage profile at Ishurdi bus and machine speed deviation of Baghabari unit have been plotted in Figure 7 and Figure 8 respectively to show transient performance improvement with SVC. Voltage profile is more flattened with SVC as shown in Figure 7.

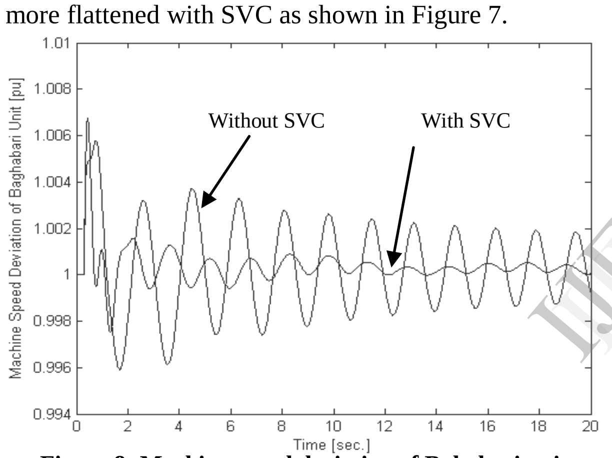

Figure 8: Machine speed deviation of Bahabari unit

6. CONCLUSION

Transient stability enhancement East-West interconnected System (EWIS) of Bangladesh Power System (BPS) has been studied in this work by means of SVC. Controllability and observability analyses on critical modes have been performed to tune SVC damping controller parameters. Two 200 MVAR SVCs are connected at Ishurdi and Sirajganj 230 kV buses. A three phase disturbance has been applied in a load bus near the Ishurdi bus. Time domain simulation shows the positive effect of SVC on the transient performance of the system. Oscillation of bus voltage, line active power flow and machine speed is well damped with SVC.

7. REFERENCES

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