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Improvement of Power System Stability Using Static Var Compansator with Controller

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Abstract— **This paper presents some new & different types of SVC controller & compare their performance for different types of faults during transient conditions to improve the the stability of multi-machine large scale power system. This paper contributes to the improvement of transient stability of multi-machines power system by using different types of SVC controllers i.e. P.O.D, P.I, P.I.D & generic controllers. The system response was simulated and evaluated during single and three phase line to line faults applied to the terminals. Phasor simulation results, due to single and three-phase faults under different loading conditions were performed to demonstrate the robustness and effectiveness of the developed controller in terms of fast response and less settling time. This work is presented to improve the voltage stability by using SVC without and with different types of controller & compare their performance to enhance the stability of power system. Simulation results show that, If no controllers are applied in SVC, then the rating of SVC becomes very large, system stability times becomes large, On the other hand, If controllers are used then small rating SVC can improve system stability within very smallest possible time. So, SVC with controllers can improve power system stability effectively.**

Keywords—***SVC, Automatic voltage regulator (AVR), P.I, P.O.D, P.I.D, Generic controller, MATLAB Simulink***.

I. INTRODUCTION

Stability augmentation is very important for large scale power system. An understanding of system stability, therefore, requires a large knowledge both of the mathematical modelling of the problems and of the numerical techniques[1]. In most cases, the model consists of a set of nonlinear algebraic or differential equations depending upon the type of studies to be performed[2]. Damping of generator oscillations were investigated using a Proportional Integrated Derivative (P.I.D) Static VAR Controller[3]. The P.I.D Controller is a simple and most widely used for control schemes in industrial process control.

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Traditionally, fixed or mechanically switched shunt and series capacitors, reactors and synchronous generators were being used to enhance same types of stability augmentation[2]. However, there are some restrictions as to the use of these conventional devices[6]. For many reasons desired performance was being unable to achieve effectively. A static VAR compensator (SVC) is an electrical device for providing fast-acting reactive power compensation on high voltage transmission networks and it can contribute to improve the voltages profile in the transient state and therefore, it can improve the quality performances of the electric services[6]. A SVC can be controlled externally by designing P.I, P.I.D, P.O.D & generic controller which can improve voltage stability of a large scale power system. The dynamic nature of the SVC lies in the use of thyristor devices (i.e. GTO, IGCT)[4].Therefore, This paper presents thyristor based SVC with different types of controllers to improve the performance of a power system.

II. CONTROL CONCEPT OF SVC

SVC is a controlled shunt susceptance (B) which inject reactive power (Q_{net}) into thereby increasing the bus voltage back to its net desired voltage level. The SVC based control system is shown in Fig.1.[2] .The output B of this control block diagram feeds into the pulse generator controller that generates the required thyristor firing signal for the light-triggered TCR. Therefore, the magnitude of reactive power injected into the system, Q_{net}, is controlled by the magnitude of $-Q_{ind}$ reactive power absorbed by the TCR. If bus voltage increases, the SVC will inject less (or TCR will absorb more) reactive power, and the result will be to achieve the desired bus voltage.

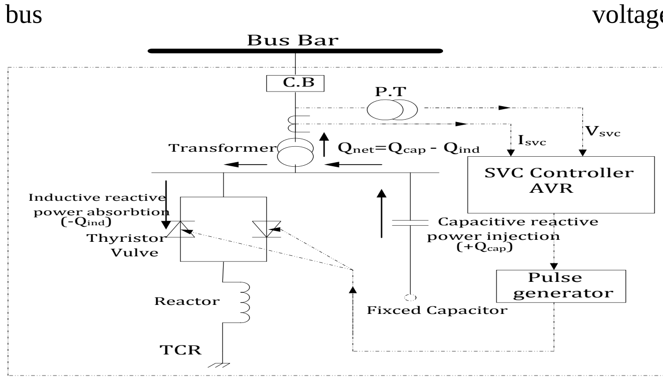

Fig.1 SVC based control system

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III. Power System Model

This example described in this section illustrates modelling of a simple transmission system containing 2- hydraulic power plants. SVC has been used to improve transient stability and power system oscillations damping. The phasor simulation method can be used. A single line diagram represents a simple 500 kV transmission system is shown in Fig.2.

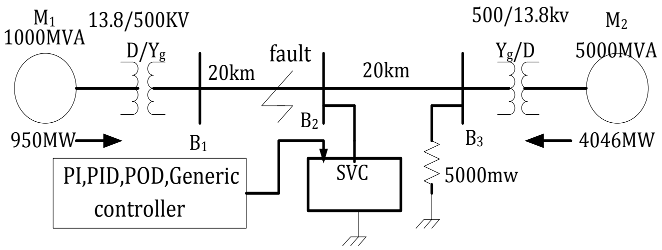

Fig.2 Single line diagram of 2-machine power system with different types of SVC controller

A 1000 MW hydraulic generation plant (M1) is connected to a load centre through a long 500 kV, 40km transmission line. A 5000 MW of resistive load is modeled as the load centre. The remote 1000 MVA plant and a local generation of 5000 MVA (plant M2) feed the load. 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 centre by a 200 MVAR Static VAR Compensator (SVC). The SVC does not have any controller unit. Machine & SVC parameters has been taken from [5]

speed deviation goes on higher value & after clearing the fault at 0.2s machines speed deviation or oscillation is damped out gradually & dω becomes stable at 4.2s [Fig.3(d)].

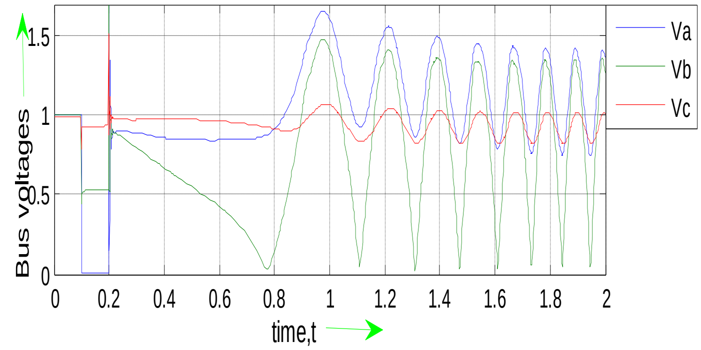

Fig.3(a) Bus voltage in p.u. at faulted condition (without SVC)

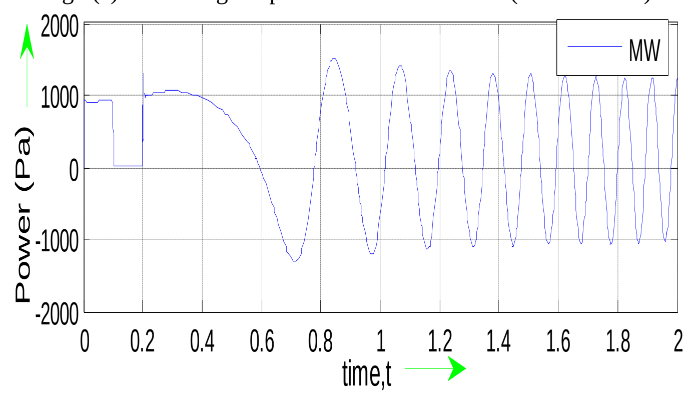

Fig.3(b) Bus power in MW at faulted condition (without SVC)

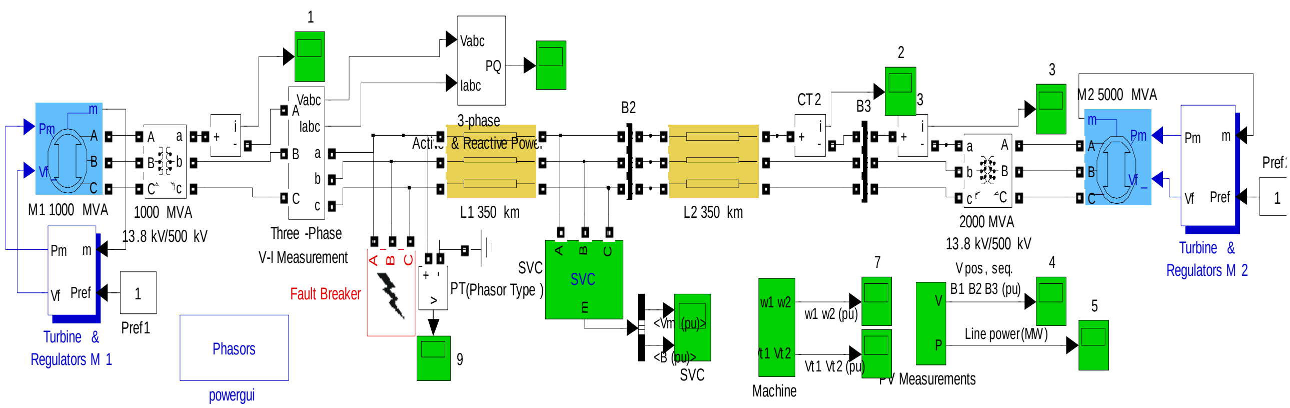

Fig.3 Complete simulink model (without SVC controller)

IV. Simulation Results(SVC Without Controller)

Two types of faults has been considered: A. Single line to ground fault & B. Line-Line faults.

A. Single line to ground fault:

Suppose 1-line to ground fault occurred at 0.1s & cleared at 0.2s (3-phase 4-cycle fault).Without SVC, the system voltage & power becomes unstable [Fig. 3(a) & 3(b)].But, If SVC is used but without any controller then although initial voltage damping was 5%, but after t=3.8s,the system voltage damping becomes 0.01% and system is stable[Fig.3(c)] & at 0.1s the

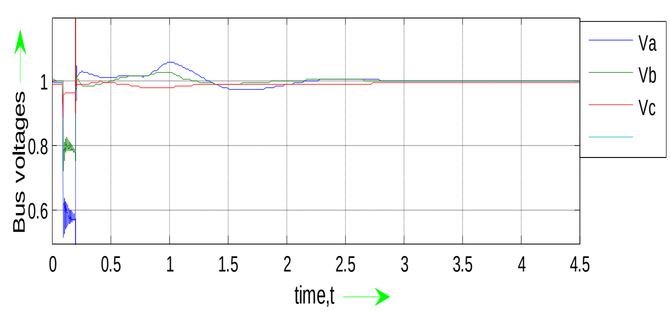

Fig.3(c) Output of SVC (V_m) in p.u for 1-phase fault (with SVC)

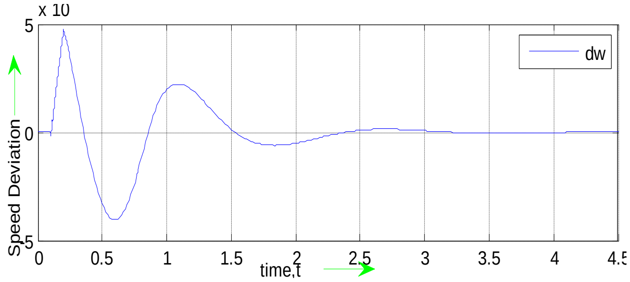

Fig.3(d) Machines speed oscillations for 1-phase fault

B. Line –Line fault:

During 3-phase L-L faults, If no SVC is applied then system becomes unstable But when SVC is applied then oscillation is damped out & at t=5s system voltage becomes stable &final damping becomes 0.01%,as shown in Fig.3(e).

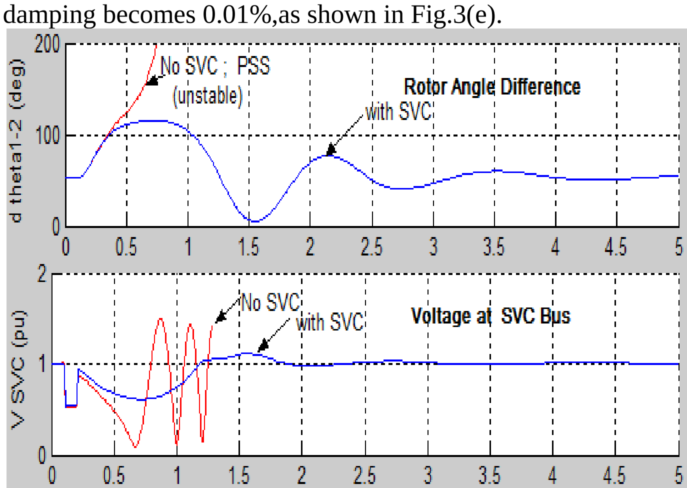

Fig.3(e) d-theta1-2 & V_m for L –L faults

V. SVC MODEL WITH P.I CONTROLLER

The power system network with SVC proportional Integral (P.I.) controller is shown in Fig.4. The angular speed deviation dω & mechanical power deviation P_m has been taken as an input parameter. When any faults occurred in the network, then both machines angular speed dω, mechanical power P_m & bus voltages will be changed & oscillated. If SVC with P.I. controller [Fig.4] is used then every network parameters become stable.

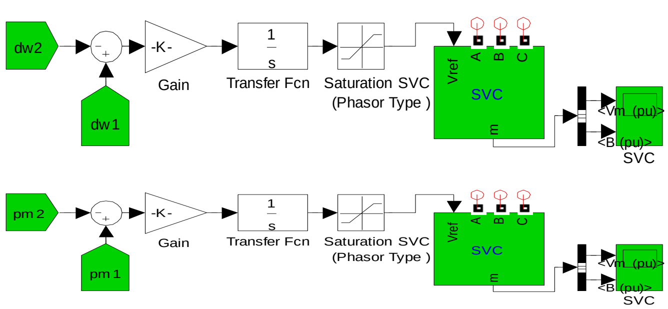

Fig. 4 Simulink diagram of SVC with P.I. controller

VI. SIMULATION RESULTS(SVC WITH P.I CONTROLLER)

Two types of faults has been considered: A Single line to ground fault & B. Line-Line faults.

A. Single line to ground fault:

During 1-phase faults, after clearing the faults ,the system voltage becomes stable within 3s with 0% damping [Fig. 4(a)] & both machines speed deviation becomes stable within 3.5s [Fig.4(b)]

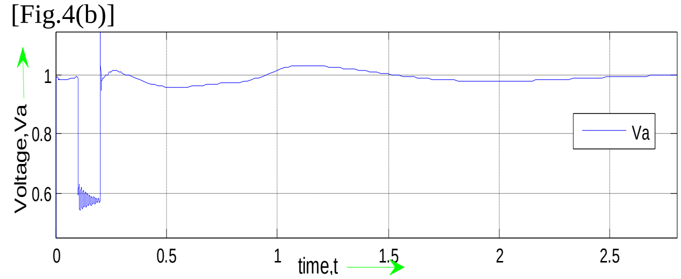

Fig.4(a) Bus voltage (in p.u.) for 1-phase fault

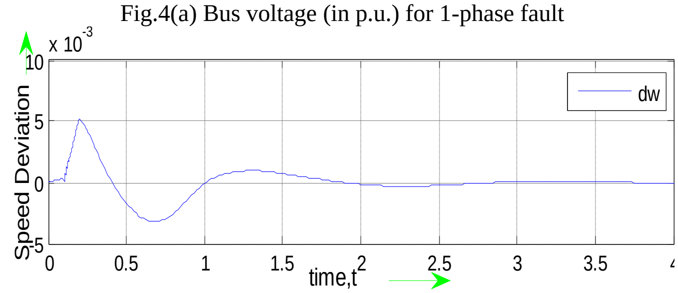

Fig.4(b) Machines speed oscillations for 1-phase fault

B. Line-Line fault:

During L-L faults, if SVC with P.I controller is used then the system voltage becomes stable within 3s with 0% damping [Fig. 4(c)] & machines speed deviation or oscillations becomes stable at 4.5s [Fig.4(d)].

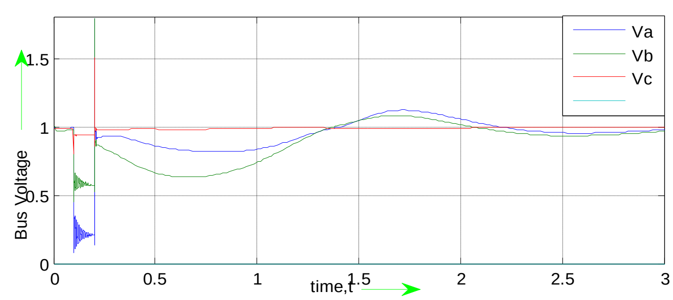

Fig.4(c) Bus voltage (in p.u.) for L –L faults

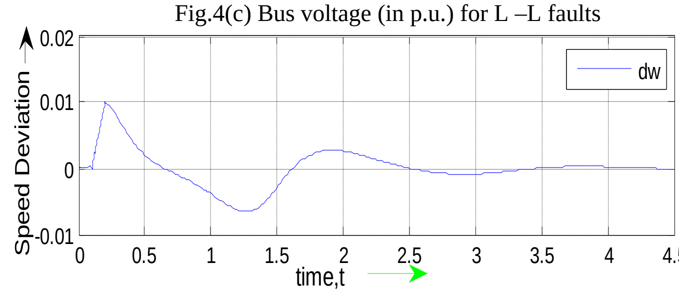

Fig.4(d) Machines speed oscillations for L-L phase fault

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VII. SVC Model with P.I.D Controller

Proportional Integral Derivative (P.I.D) controller is one of the most power full controller which takes input as same as PI controller. The SVC with P.I.D controller simulink model is shown in Fig.5

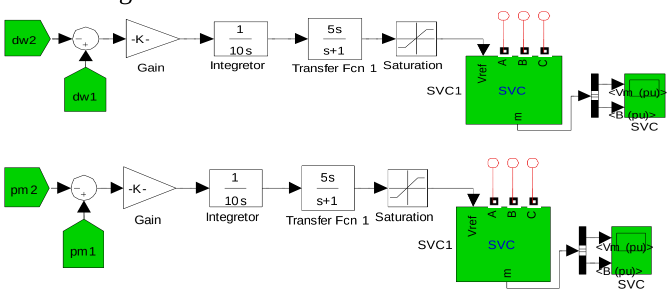

Fig.5 Simulink model of SVC with P.I.D controller

VIII. Simulation Results(SVC With P.I.D Controller)

Two types of faults has been considered: A Single line to ground fault & B. Line-Line faults.

A. Single line to ground fault:

During Single line to ground fault, if SVC with P.I.D controller is used then the system voltage becomes stable within 2.5s with 0% damping[Fig. 5(a)] & Machines speed deviation becomes stable within 3s which is shown in Fig.5(b).

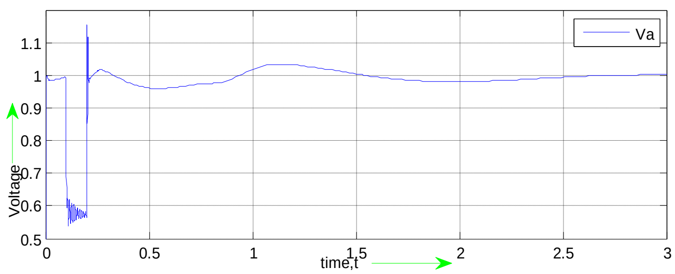

Fig.5(a) Bus voltage (in p.u.) for 1-phase faults

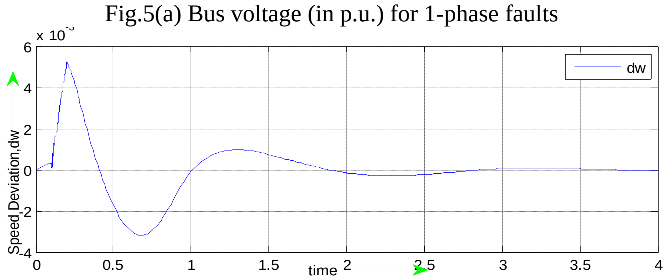

Fig.5(b) Machines speed oscillations for 1- phase fault

B. Line-Line faults.

During L-L faults, if SVC with P.I.D controller is used then the system voltage becomes stable within 2.5s with 0% damping [Fig.5(c)] & Machines speed deviation becomes stable within 3.5s which is shown in Fig.5(d).

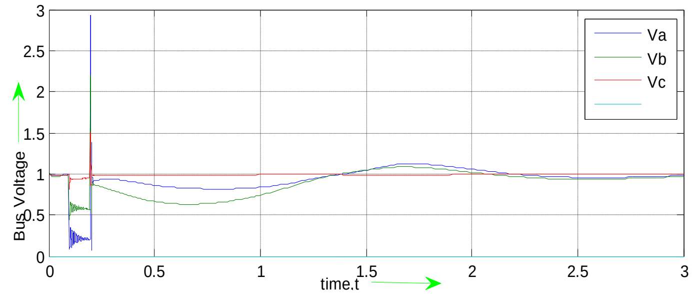

Fig. 5(c) Bus voltage (in p.u.) for L –L faults

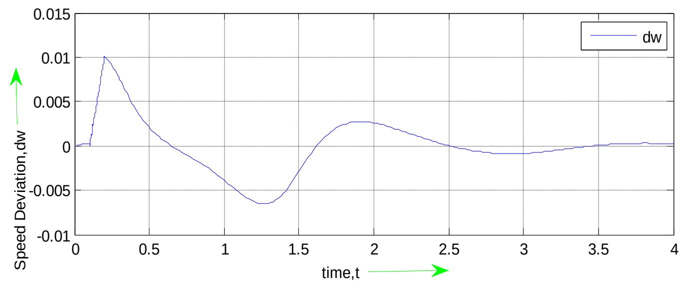

Fig.5(d) Machines speed oscillations for L-L phase fault

IX. SVC Model with P.O.D Controller

Power Oscillation Damping (P.O.D) is a controller which externally injects V_{qref} to the SVC. The P.O.D controller consists of active power measurement system, a general gain, a low-pass filter, a washout high-pass filter, a lead compensator, and an output limiter. All values of the P.O.D controller has been taken from [5].

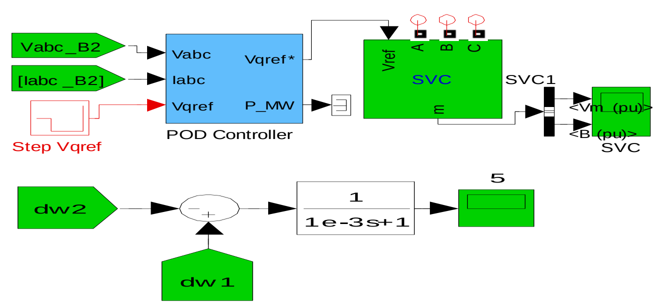

Fig.6 Simulink model of SVC with P.O.D controller

X. Simulation Results(SVC With P.O.D Controller)

Two types of faults has been considered: A. Single line to ground fault & B. Line –Line faults.

A. Single line to ground fault:

During Single line to ground fault, if P.O.D is used as SVC controller then, the system becomes stable within 2s with 0.01% damping [Fig. 6(a)] & Machines speed deviation becomes stable within 3s [Fig.6(b)].

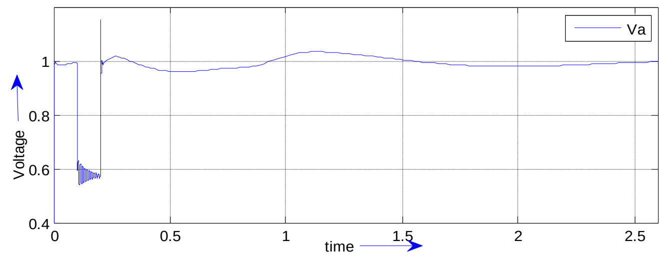

Fig.6(a) Bus voltage(B_1) in p.u. for 1-phase fault

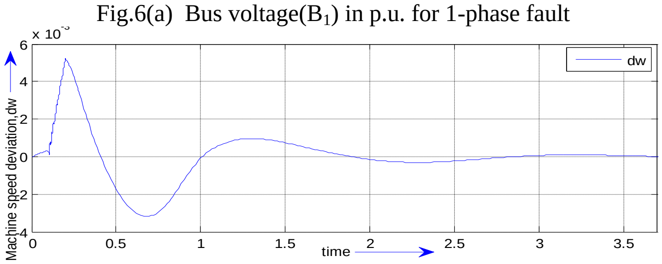

Fig.6(b) Machines speed oscillations for 1- phase fault

B. Line-Line fault:

During L-L faults, Although initial damping was higher then 1-phase fault, If P.O.D is used as SVC controller then the system becomes stable within 1.5s with 0.04% damping [Fig. 6(c)] & Machines speed deviation becomes stable within 2.5s with 0.04% damping [Fig.6(d)].

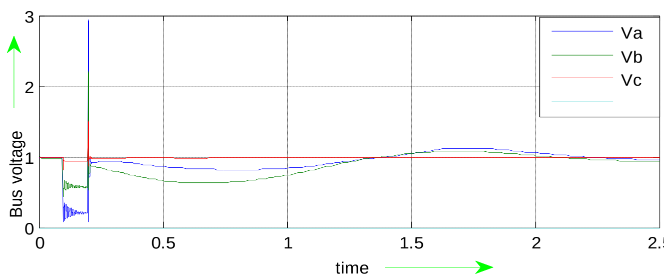

Fig. 6(c) Bus voltage(B_1 B_2 B_3) in p.u. for L-L faults.

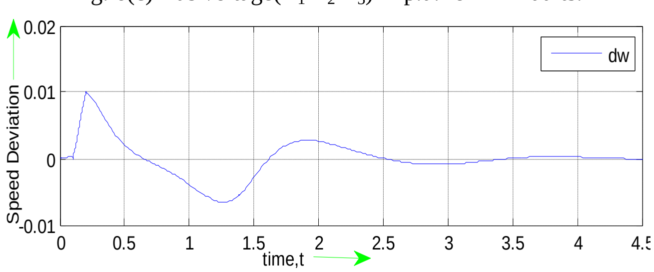

Fig.6(d) Machines speed oscillations for L-L faults

VII. SVC Model with Generic Controller

The block diagram of generic SVC controller is shown in fig.7

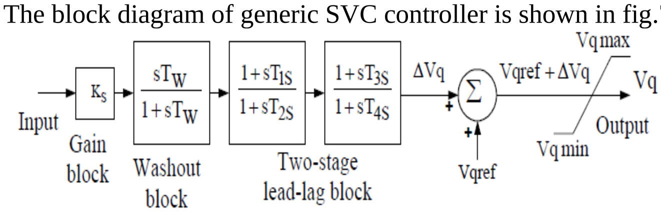

Fig.7 Generic SVC controller block diagram

The input of this controller is also same as above. T_w=10,T_2=T_4=0.3 has been taken as constant & gain,K,T_1 & T_3 can be selected by properly trial & error methods. For this network, the optimum value was, K=65.49,T_1=0.5527 & T_3=0.2563.

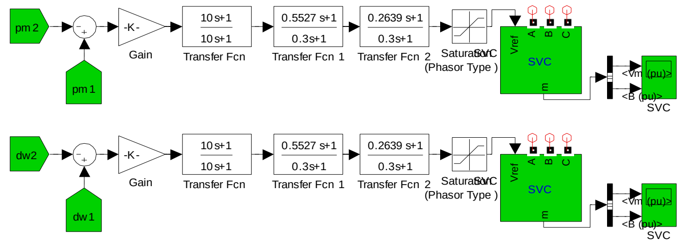

Fig.8 Simulink model of generic SVC controller

XI. Simulation Results

Two types of faults has been considered: A. Single line to ground fault & B. Line-Line faults.

A. Single line to ground fault:

During Single line to ground fault If SVC with generic controller is used then the system voltage becomes stable within 1.5s with 0.01% damping [Fig.8(a)] & Machines speed deviation becomes stable within 2s with 0.03% damping [Fig.8(b)].

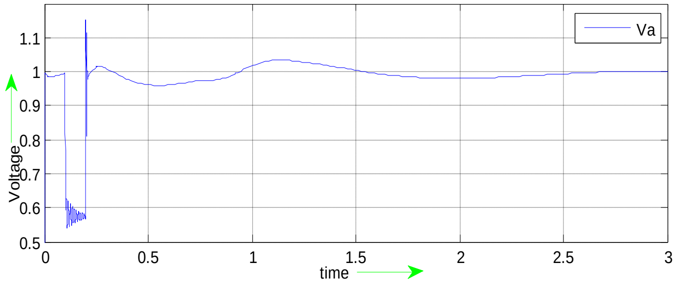

Fig.8(a) Bus voltage(B_1) in p.u. for 1-Ø fault

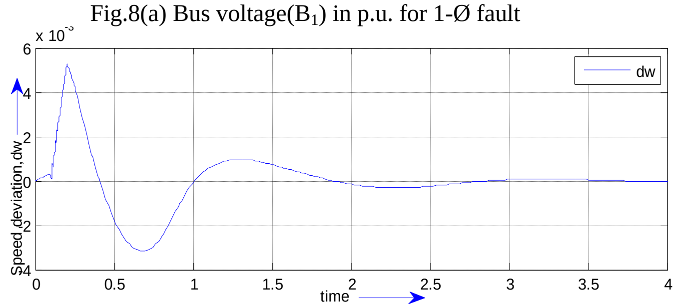

Fig.8(b) Machines speed oscillations for 1- phase fault

B. Line-Line fault:

During L-L faults, If SVC with generic controller is used then the system becomes stable within 1.4s with 0% damping [Fig.8(c)] & Machines speed deviation becomes stable within 2.5s with 0.02% damping [Fig.8(d)].

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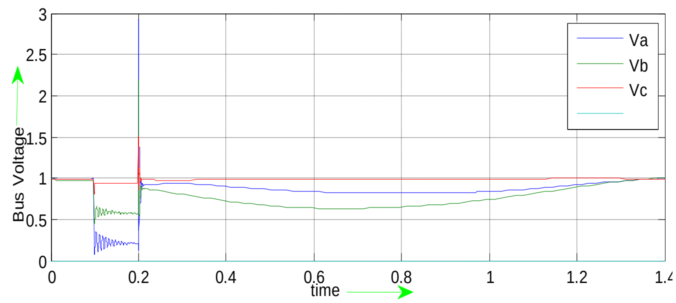

Fig.8(c) Bus voltage(B_1 B_2 B_3) in p.u. for L-L fault

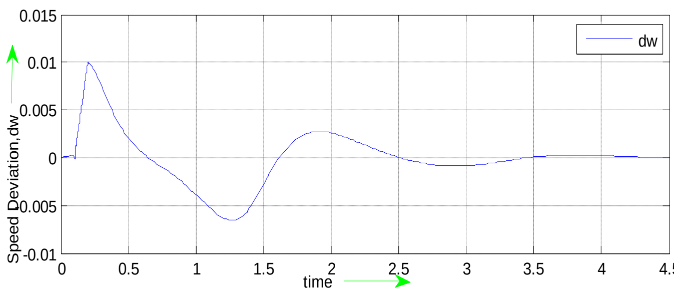

Fig.8(d) Machines speed oscillations for L-L faults

XII. Performance Comparison

The performance of different types of SVC controller taking same 500KV transmission line are summarized below:

TABLE I

Performance comperison among proposed controllers

		1-Ph fault		L-L faults		
Controllers	**SVC Rating**	**Volt**	**dω**	**Volt**	**dω**	**Damping**
Without	200 MVA	3.8s	4.2s	5s	5s	5%~0%
P.I.	100 MVA	3 s	3.5s	3s	4.5s	0%
P.I.D	50 MVA	2.5 s	3s	2.5s	3.5s	0%
P.O.D	30 MVA	2s	3s	2s	2.5s	0.01%
Generic	30 MVA	1.5s	2s	1.4s	2.5s	0.001%

VIII. Conclusion

In this paper, the voltage level of two machines power system has been improved by using SVC with different types of controller for Single line to ground fault & Line-Line faults by Phasor simulation method. Same 500KV transmission line has been simulated & observed the transient response for different types of SVC controller. Above all, SVC with Generic controller are highly efficient for voltage stability for both steady state & dynamic conditions because of having shorter voltage stability time & machine oscillation becomes damped out within very shortest time compared to other controllers. In this paper, all controller parameter has been selected by trial & error methods normally, but those parameters can be selected by FSO, Neural network or Genetic algorithm techniques. Those controllers special advantages is that it can be used any robust multi-machine power system network with very easily & cheaply. In this paper, only machines angular speed deviation(dω) & Mechanical power(pm) has been taken as input parameters of those controllers. But when any fault occurred, then voltage, current, power, mechanical power(pm),machines angular speed deviation(dω) everything will change. So, future work should be taken all of the above parameters as input parameters of those controllers & controller parameters can be tuned with any newly deigned algorithm.

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Biographies

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