Reactive Power Compensation and Load Balancing of Multi Area Power System by SVC and Active Filter

P Suguna Ratnamala, G Rasmitha

Abstract**:** ***The Power System Stabilizer (PSS) is a control gadget which guarantees greatest power exchange along the lines and the steadiness of the power framework improvement. The PSS has been broadly used to moist electromechanical motions happen in power frameworks and which are because of unsettling influence. In the event that no satisfactory damping is accessible, the motions will expand prompting insecurity. The Static Var Compensator (SVC) is additionally used to enhance dependability in the framework due to its job in lessening the responsive power in the electrical transmission lines. This paper displays a use of (SVC) in electrical transmission lines and PSS in two zones, two generator test control framework. Utilizing Matlab programming to structure and executes control framework and concentrate the impact of damping motions in strength control framework after proposed blames in transmission lines of research demonstrate that utilized (PSS-conventional and multiband) types and programmed voltage controller (AVR)***

Index Terms**:** ***SVC, STATCOM, Reactive Power Compensation***

I. INTRODUCTION

The increasing complexness of power systems encompasses a massive impact on its stability by manufacturing differing types of disturbances. the foremost common kinds of disturbances ar voltage and current unbalances, voltage swings, transients and harmonics [1]. Voltage swings and current unbalances ar serious issues in power systems. the consequences of those kinds of instability lead to damages to generators and protection devices. These issues are mitigated with the employment of strategies and devices that ar unendingly evolving as is that the case of the Static volt-ampere Compensator (SVC). There ar completely different causes for voltage and current swings and unbalances. in an exceedinglyll|one amongst|one in every of} the sources for such unbalances in a 3-phase system is asymmetries within the lengths of the conductors and it's solved by transposing the conductors. However, the larger contribution to unbalances return from unbalanced hundreds. Unbalanced currents from unbalanced hundreds ar tougher to handle and also the leading issues ar considerably additional harmful to an influence system. Those issues embrace further power losses and negative sequence currents that harm rotating machines, bar of full line's capability usage, voltage spatial property, negative impact in power natural philosophy, and generation of current harmonics [2]. within the case of voltage swings, the causes are often swings in rotor, variations of a distribution system, electrical device tap-changers, and shift of reactive elements [3].

Methods to mitigate voltage swings and current unbalances in use currently ar completely different from those of the past. Originally, separate devices were accustomed attain management of voltage and to produce reactive power for current reconciliation or power issue correction. one in all the well-known technologies to handle compensation of reactive power is that the synchronous compensator, that may be a electric motor running on no load and solely supply reactive current so as to manage voltage. though the machine itself is strong and capable of handling overcurrent, its dynamic response is slow and its value is high, and thanks to its rotating elements, maintenance necessities ar expensive . differently to compensate reactive power may be a automatically switched bank of capacitors however these also are too slow. associate degree recent technique for dominant power generation embrace the automated Generation management (AGC) that consists of observance the distinction between the demand and also the generated power employing a speed governor and different signals to come up with feedback and judge if the rotary engine desires additional or less steam/water to drive the torsion of the ability generator. Another device for voltage management is that the Tap-Changer management, that works as a electrical device with completely different settings which will be adjusted on-line or offline looking on the kind to regulate voltage and consequently power flow. additionally, a Phase-Shifting electrical device are often used for power flow management. These comparatively "old" devices are often adjusted to regulate the flow of power in terms of section, magnitude or each [4]. a number of the disadvantages of those recent systems embrace their restricted vary, restricted controllability, their speed of operation, that is usually slow, and that they gift wear and maintenance issues. Newer technologies to handle voltage management and reactive power compensation have appeared as a consequence of latest developments within the semiconductor sector within the last 2 or 3 decades. These arrangements that mix power natural philosophy and power systems ar referred to as versatile AC Transmission Systems (FACTS).

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What makes FACTS a motivating choice is that these devices will handle over one issue at a time. for example, they will each management voltage and balance load victimisation one controller. additionally, the latency is way quicker compared to recent strategies and since they use less moving elements their wear decreases [3]. FACTS devices are often divided in 2 types; initial and second generation. initial generation embrace the Static volt-ampere Compensator and its subsystems, thyristor-controlled Series electrical condenser (TCSC) and Thyristor-Controlled section Shifter (TCPS). The second generation includes Static Synchronous Compensator (StatCom), Static Synchronous Series Compensator (SSSC), Unified Power Flow Controller (UPFC) and Interline Power Flow Controller (IPFC)[5].

II. Reactive Power Supply Using Static Var Compensator

One of the approaches to give the fundamental responsive power is by utilizing settled capacitors and inductors, in any case; these are settled at an esteem and can't give dynamic remuneration, except if they can be turned on and off quickly, which is commonly impractical with mechanical exchanging. In this area a prologue to SVC is given just as a short outline of StatComs. These gadgets are "genuine static reciprocals of the turning synchronous condenser" [6] likewise they are quick and don't contain moving parts.

The Static Var Compensator (SVC) is a framework that includes the two reactors and capacitors and with the assistance of intensity hardware it gives or assimilates receptive power in a persistent shape. SVCs comprise of one or a gathering of gadgets with various capacities and qualities. Be that as it may, including SVCs in a framework prompts symphonious flows in the framework. These sounds are an aftereffect of controlling the thyristor controlled reactor at various points. Typically, for symmetrical terminating plots for both positive and negative cycles just odd music are created.

So as to utilize SVCs to give receptive power in a three stage framework, unique courses of action ought to be made. There can be more than one topology for SVCs in a three stage framework relying upon the necessities. SVCs can give driving and slacking VARs (+Q and - Q) as abridged in Table 1-1.

The characterization of SVCs is as per the following:

Thyristor Controlled Reactor (TCR) – It is the most vital component in a SVC framework, this is on the grounds that it gives the adaptability of changing the susceptance of SVC in a consistent way. It gives reactance just that can be controlled as a susceptance that goes from – B to zero.

Settled Capacitor (FC) - It gives a settled estimation of susceptance that is dependably +B hence giving positive receptive power (+Q). This capacitor(s) can be picked to likewise go about as a channel, which is normally the situation.

Thyristor Switched Capacitor (TSC) - The thyristor exchanged capacitor associates banks of capacitors into the framework discrety (in steps). These means can be picked to be of equivalent size or binarily whichever works best for the required reason. It gives capacitance just a susceptance that is zero or B or N times B with N as number of capacitors associated in parallel.

Static Var Compensator (SVC) System. We can have a SVC framework with a blend of no less than a TCR in parallel with a TSC, FC or different mixes.

Table 1-1 Reactive power compensation range of the SVC Family

	Continuous +Q	Continuous -Q	Discrete +Q
Thyristor Controlled Reactor (TCR)		X	
Fixed Capacitor (FC)			X
Thyristor Switched Capacitor (TSC)			X
Combination of (TCR) + (TSC or FC)	X	X	

III. Applications of SVC in Power Systems

As a result of its receptive power supply capacity, the SVC has different utilizations; it tends to be utilized as a methods for power factor remedy (PFC), voltage control and load adjusting. A powerful factor redress is important to have an effective transmission of intensity. Higher power factor implies more power will be transmitted, making the transmission line proficient and in this manner sparing cash. Voltage control is utilized to keep up a consistent reference voltage at different purposes of the power framework. Normally the control utilized is a shut circle corresponding vital subsidiary (PID) controller. In the event that each stage in the 3-stage air conditioning framework has an alternate load the air conditioner side flows will never again be adjusted, and the uneven voltage drops in the system impedances will prompt unequal voltages too. Load adjusting is accomplished by the SVC utilizing Steinmetz's strategy [9] . Load adjusting infers that there is a decrease or end of negative succession flows in the symmetrical components[10]. Maintaining a strategic distance from negative succession flows ensures control framework gadgets, for example, pivoting machines.

The primary utilizations of the SVC are quickly depicted beneath.

Voltage Flickering. Voltage glinting is described by ceaseless little fast variances in the voltage supply. This is commonly seen at the association purpose of a bend heater and the primary air conditioning framework. SVCs are to a great extent utilized in this industry since they can fix gleaming just as load adjusting which is another basic issue of a curve heater. Power Factor Correction. A perfect electrical framework transmits absolutely dynamic power, which happens when the edge of individual stages among voltage and flow is zero. Along these lines by giving the right responsive power factor to the framework, a SVC can convey the power factor more like one.

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Load Balancing. It was appeared by Steinmetz that an uneven three stage framework can be made adjusted by including simply receptive components. Along these lines, by having a SVC in each stage, we can figure the measure of responsive power required in each stage and subsequently balance the framework.

Voltage Regulation. Customarily, SVC is utilized for voltage control. The SVC can be utilized to keep the voltage seen by the source at a decided voltage reference.

A standout amongst the most essential FACTS gadgets is the SVC in light of its dependability, cost viability and in general industry demonstrated limits. SVC frameworks can be utilized in mix with more current innovations so as to dodge overdesign. A few businesses like to utilize very much created and tried "new advancements" since it lessens the danger of calamitous malfunctions[11]. Notwithstanding, despite the fact that SVCs have been around for quite a while, there is an absence of appropriate testbeds for scholarly use.

IV. Reactive Power from Static VAR Compensators

Reactive Power

The flow of power in an electrical system can be represented by a phasor diagram with active and reactive components of power as shown in Figure [4]. It can be seen by the diagram that the total power phasor can be adjusted in both magnitude and phase by adjusting the lagging and leading reactive powers.

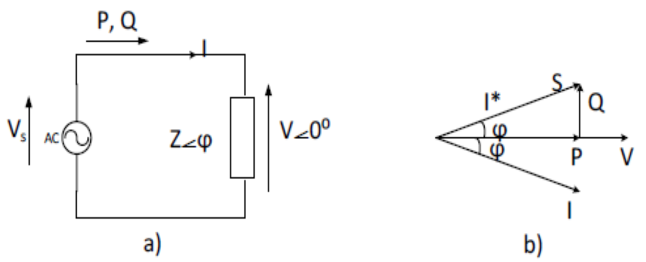


Fig 1: Power transfer in ac system. a) Power system b) Phasor representation.

The complex power is written in the form

$$S = \bar{V} \cdot \bar{I}^* = P + jQ = VIcos\theta + jVI\, sin\theta$$

$$PF = \cos(\theta)$$

The SVC (with TCR and TSC components) is fit for giving both driving and slacking receptive forces, in this way it can control the complete complex power in a framework up to a specific rating. This element is extremely valuable when managing unsettling influences to the electric framework that require dynamic responsive power. Research has appeared during the time the distinctive employments of the SVC. The diverse parts of a SVC give distinctive qualities in various types of receptive power. This controllability of responsive power is the thing that makes SVCs extremely unique and valuable.

Thyristor Controlled Reactor (TCR)

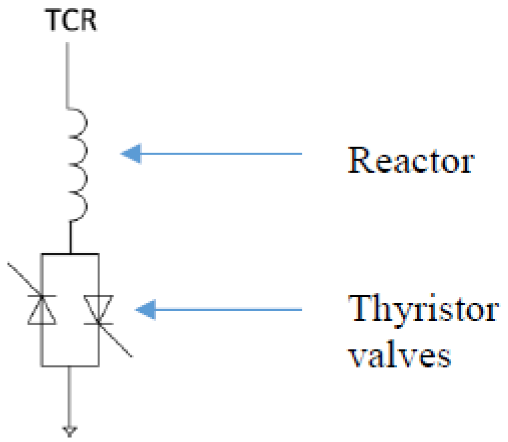
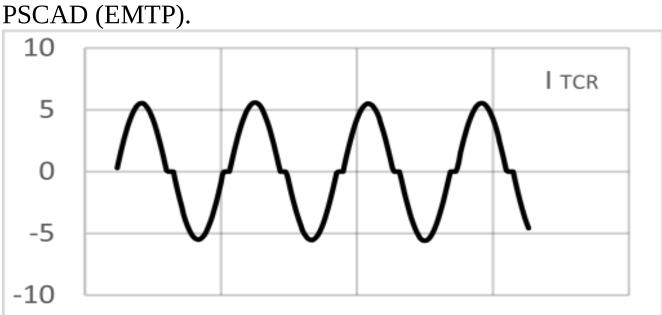
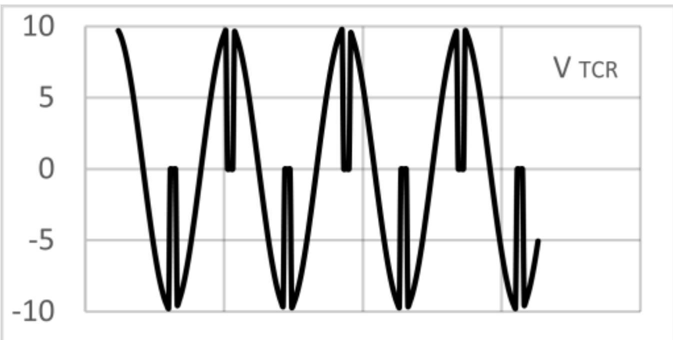


Fig 2: Thyristor Controller Reactor (TCR).

A standout amongst the most essential gadgets in the Static Var Compensator (SVC) is the Thyristor Controlled Reactor (TCR) represented in Figure 3.2 in view of the capacity to constantly control its reactance. The reactance in the TCR is managed by controlling the current through the reactor.

The thyristor conducts current when it is on (when it is terminated) and quits directing when the leading current achieves zero. The correct minute when the thyristor is determined to concerning the voltage stage is known as the "terminating edge". In the TCR topology, the current through the inductor is constantly symmetrical regarding the voltage zero intersection as saw in Figure 3.3. This is on the grounds that the current is relative to the necessary of the voltage as demonstrated in condition 3.4. Figure 3.3 demonstrates the current and voltages over a TCR with various terminating points acquired from SVC recreations in PSCAD (EMTP).





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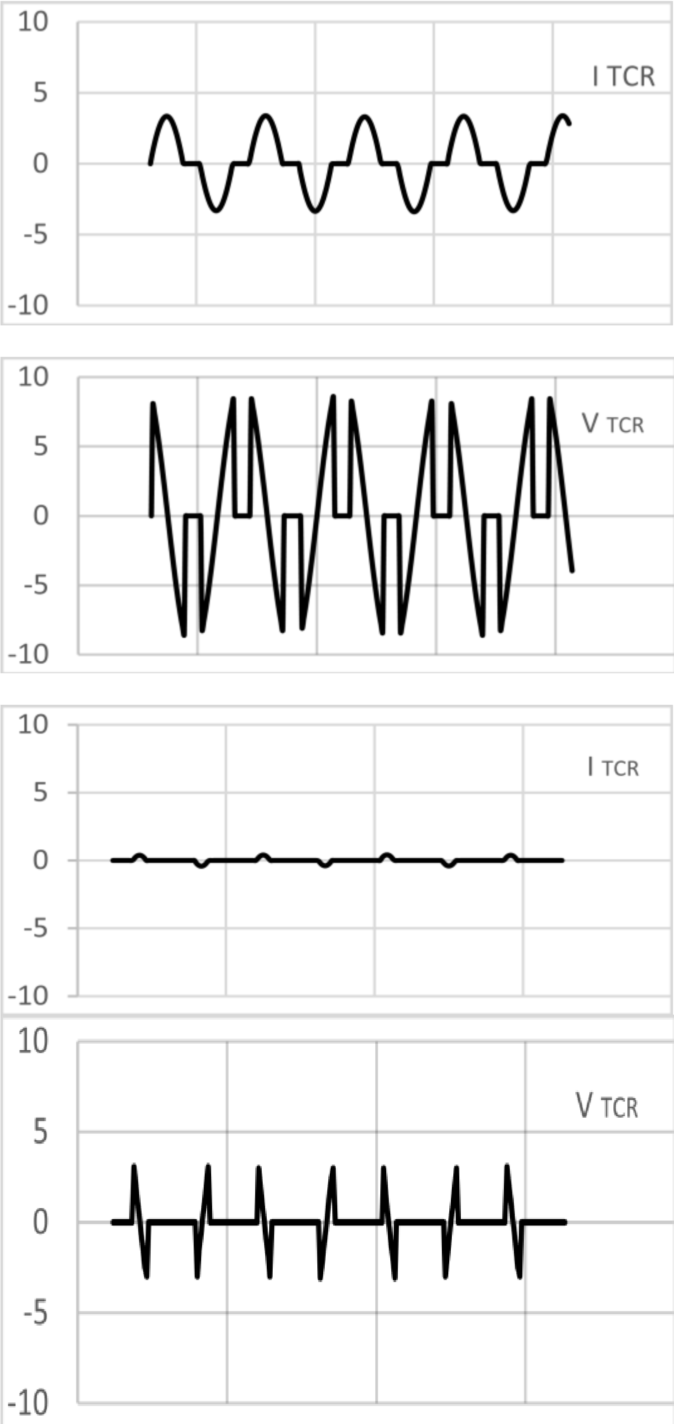

Fig 3: Current and voltage through the inductor for firing angles (α=100^0, 120^0, 160^0).

The equations for the TCR current are as follows [4]:

$$L\frac{di}{dt} - v_s(t) = 0$$

L is the inductance. By integrating above equation

$$i(t) = \frac{1}{L}\int v_s(t)dt + C$$

Where C is the constant of integration

Alternatively,

$$i(t) = \frac{V}{\omega L}\cos\omega t + C$$

For the boundary condition, i(ωt = α) = 0,

$$i(t) = \frac{V}{\omega L}(\cos\alpha - \cos\omega t)$$

Where α is the firing angle

It is evident by observing the waves in Figure 3.3 that the resulting current contains harmonics and their magnitude depends on the firing angle. Thus, it means that the firing angle influences two things; the fundamental component of the current and the level of harmonics injected.

Thyristor Switched Capacitor (TSC)

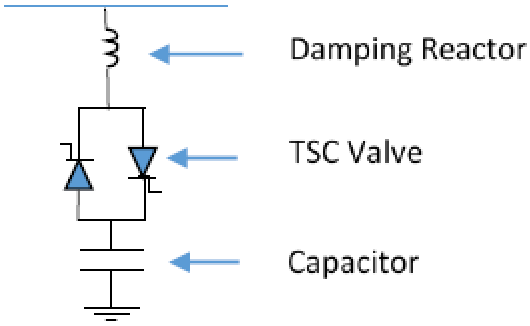

Fig 4: Thyristor Switched Capacitor (TSC).

In this arrangement, one or more capacitors are discretely connected using thyristors with a firing pulse that is always on or off. A damping reactor can be used in order to avoid large influx currents, The damping reactor can be carefully chosen in order to be used also as a filter [12].

Switching on and off capacitors using thyristors is a process that requires caution to avoid undesired behavior. In order to avoid transients, capacitor banks are switched on when their voltage and the system's voltage reach a minimum difference. Consequently, the maximum time delay is half a cycle for turning on capacitors. In addition, inrush currents and resonances with the system are avoided by including a damping reactor in series with the capacitor as shown in Figure 3.6. Another aspect to take into account when turning on a capacitor is the amplification factor (Equation 3.10) and the resonant circuit it creates with the inductor [12].

Amplification factor:

$$B_{TSC} = \frac{B_C n^2}{n^2 - 1}$$

Sometimes the capacitors can be switched in/out with a mechanical switch, in this case the arrangement is known as Mechanically Switched Capacitor (MSC).

The Complete SVC System

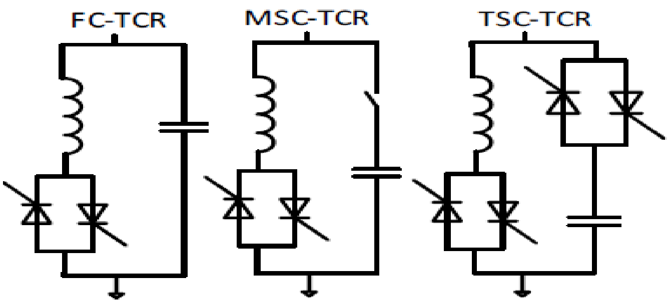

Fig 5: Figure SVC systems.

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In order to achieve a range of reactive power, which can go from negative to positive, a combination of reactors and capacitors is required with such combinations shown in Figure 3.7 [4]. This includes the FC-TCR, MSC-TCR, and TCR-TSC. The total susceptance of the system is the sum of the parallel connections of each subsystem. Since the capacitors are turned on in discrete values the total susceptance will be controlled by the TCR. If the FC is used in parallel with a TCR the total susceptance is BSVC=BC+BTCR. When there is more than one TSC there must be an overlap area between switching capacitors on and off to avoid excessive switching [12]. Figure 3.8 shows the susceptance Bsvc of the system with respect to the BTCR.

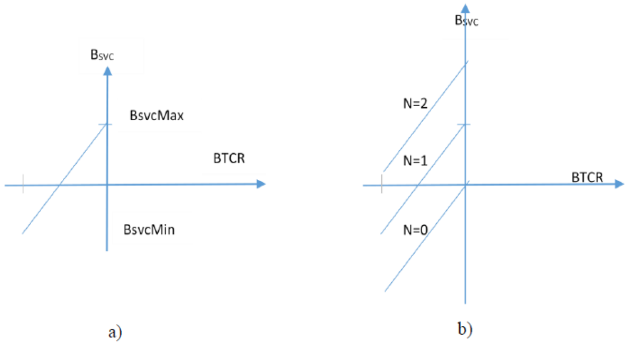

Fig 6: Reach of SVC systems. a) TCR-FC, b) TCR-TSC.

V. Simulation Results

This work outlines demonstrating of a straightforward transmission framework containing two water driven power plants. A Static Var Compensator (SVC) and Power System Stabilizers (PSS), they are utilized to enhance transient strength and power wavering damping of the framework. So as to demonstrate this exhibitions what's more, watch the effect of PSS and SVC on the power framework soundness a solitary stage to ground blame and a three-stage blame have been connected on the main area of the line (L1)

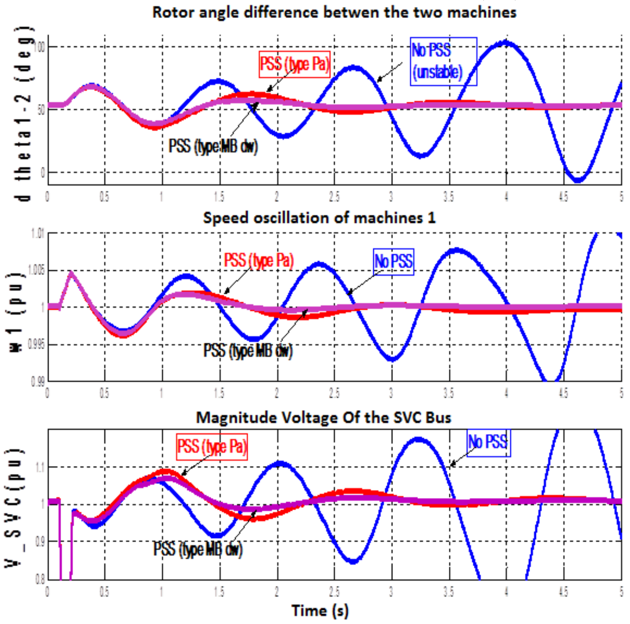

Fig 7: Impact of stability for 1-phase fault (without SVC).

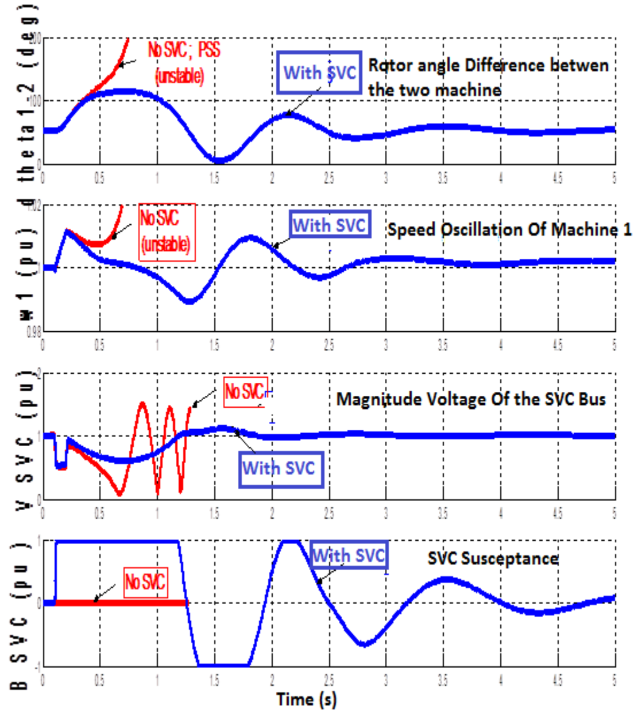

Fig 8: Impact of the SVC for 3-phase fault.

VI. Conclusion

The work depicted in this paper delineates displaying of a basic transmission framework containing two water powered power plants. A static Var compensator (SVC) and power framework stabilizers (PSS - nonexclusive and multiband types) are utilized to enhance transient solidness and power wavering damping of the framework. The outcomes portray that a framework has been grown effectively for the dependability of homeless people in a bi-machine transmission framework with PSS and SVC. The essential structure of (PSS) is working under average control generator while the essential structure of (SVC) is working under run of the mill transport voltage control. The proposed controller is utilized (PSS) and (SVC) under unusual framework conditions.

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