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RESEARCH ARTICLE

ENHANCEMENT OF POWER SYSTEM TRANSIENT STABILITY OF A MULTIMACHINE BASED ON INTERACTIONS OF PSS WITH FACTS DEVICES

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ABSTRACT

This paper presents a study comparison of Flexible AC Transmission System (FACTS) device with Power System Stabilizer (PSS) to improve the response of transient stability of the multi-machine power system. In this paper, the Static Synchronous Compensator (STATCOM), the Static Var Compensator (SVC) and Unified Power Flow Controller (UPFC) can significantly improve the power stability, thus enhancing the overall stability of the system during the disturbance. In addition, the active power control of the power system, SVC, STATCOM and UPFC play an additional role in enhancing the stability of the terminal and thus play a vital role in controlling system stability. This research has looked at the specific performance and comparison of three devices as far as damping is concerned about system vibrations. The MATLAB software is using to study the impact of damping oscillations in a stability power system based on PSS and FACTS devices. The results showed significant improvement in transient stability when FACTS are applied by significantly reducing the time of error adjustment in the power system and effectively reducing network oscillation in contrast with when the devices are not applied.

KEYWORDS

Transient Stability, STATCOM, SVC, UPFC, Two Area System, Power System Stabilizer.

1. INTRODUCTION

Today's world is constantly growing in power generation, distribution and transmission due to population and regions. Also, at the same time required to grow the same way to meet the needs. Given the reasons for administrative, financial and green climate, new transmission lines cannot always be established to alleviate the problem of the power system stability in the over-stretched transmission line. The most important operating condition faced by electrical engineers during power transmission at high levels of temporary stability, voltage regulation, damping oscillation, etc. [1].

One of the most vital factors that carry energy at high levels is transit stability. According to literature, the temporary stability of the power system, its ability to maintain the simultaneous operation of machines appear in any small disturbance [2]. PSS is One of the solutions for damping oscillation. The PSS is connected to the generation in order to cancel negative torque oscillations that produce by Automatic Voltage Regulator (AVR) action and lead to enhance the overall performance of the power system but can't efficient for large disturbance such as three-phase faults [3].

Therefore, FACTS is a very effective solution for large disturbance (heavy load, three phase fault) to enhance transient stability which could provide reactive and active power in the transmission lines at the location of injection [4]. FACTS are qualified for controlling the network events in a very rapid mode and can be exploited to enhance the voltage, steady state, and transient stabilities of interconnected complex power system. FACTS can control different parameters of the power system such as phase angle, voltage. Reactive power support can be done with FACTS devices. Each FACTS device has different characteristics; some of them may be problematic as far as the static voltage stability is concerned. Therefore, it is important to study their behaviors in order to use them effectively. FACTS own many promising benefits, economical and technical [5].

Many researchers studied the stability problem and put their suggestions and trials to overcome instabilities by using FACTS devices in power systems. In the research work FACTS devices are introduced at different buses and voltage magnitudes of buses are plotted to look at the best location of TCSC, SVC, and UPFC [6]. The three kinds of FACTS devices are improving the voltage profile and decrease total power losses. FACTS devices in work done in seeks to improve transient stability [7]. In research the the utilization of a STATCOM with adaptive control is to enhance the transient answer of the synchronous generator via inhibiting the transients [8]. Reference The simulations were applied on IEEE 30-bus test system [9]. It studied the congestion management in deregulated power system and utilized FACTS devices in that application. It uses TCSC and UPFC.

For the work done in a previous research, Improve the stability of the power system of multi-device power and SVC is analyzed for a two area system for performance of the devices for power system stability improvement [10]. A study seeks to improve power system transient stability using FACTS devices [11]. In the analysis done in a previous study, SVC is used in a multi-area power system for improving transient stability [11]. Research study done in a study, presents the transient stability assessment of two series FACTS controllers CSC-STATCOM where it was improved transients due to faults while enhancing the Available Transfer Capacity (ATC) [12].

The UPFC is the most many sided devices in the FACTS types which can outfit an effective control of power system parameters such as transmission voltage, line impendence and phase angle. Moreover, UPFC can provide either negative or positive real and reactive power injections. So, it can improve system operation because it allows for more effective control of power flow, prevalent control system and voltage stability [13].

In this paper, to fast damping power transient system the FACTS devices with PSS have been connected as compare with connected FACTS or PSS only. Some of the methods are based on the linearized power system model. The other is based on the intricate non-linear simulation [14]. In this paper, the SVC, STATCOM and UPFC with PSS have been investigative to improve power stability.

2. AIMS AND OBJECTIVES OF STUDY

1. Applying FACTS devices (STATCOM, UPFC and SVC) on the 6-bus system by using MATLAB/SIMULINK for voltage improving and stability on the buses.
2. Comparing the results of these FACTS devices from buses voltage magnitudes and stability points.
3. Applying proposed controller (UPFC) by using MATLAB/SIMULINK on the 6-bus system for voltage improving on the buses during heavy loads is better other types of FACTS.

3. MATERIAL AND METHODS

3.1 Problem Statement

In electrical power systems fault and disturbance discompose negative challenges. They contain energy fluctuations, oscillations, power outages, voltage inflation, voltage dimming and loss of synchronization. These conditions cause problems from instability until the breakdown in power system. The breakdown of the voltage at the fault of reactive or active energy or the inability of load dynamics leads to the recovery of energy consumption beyond the capacity of the transmission and a connected transmission network to provide the required reactive support. Moreover, the continuous demand in the grid electrical power system also a heavy load resulting in system instability. FACTS can be applied in these cases to avoid voltage breakdown and stabilizing fluctuations. These controllers have unique and unique compensation features when connected to the power system. One compensatory controller (series or shunt) such as the STATCOM control shunt, SVC shunt control and series shunt UPFC should be they were analyzed for transient stability and reactive energy control (voltage injection) because FACTS are very expensive, although they are versatile [15]. These networks improve energy networks through reactive, active and voltage control, allowing the system better transient stability and enhancing the load capacity of transmission lines over their short and long-term thermal capabilities in interconnected energy systems. Thus, the angle, voltage and impedance can be controlled, greatly improved temporary and enhanced voltage support stability. Since their compensation properties vary depending on the type and configuration, the three controllers must be simulated to illustrate the distinct compensation features of the transient stability and the power control system.

3.2 Flexible Ac Transmission System (FACTS)

FACTS are electrical electronic devices that improve the operation of the power system through control features and injection modes. FACTS Equipment development began with growing potential of electrical electronic elements. Devices for high levels of power from transformers have been provided for different levels of voltage. Comprehensive starting points are network elements that affect the interactive power of power system parameters.

Although FACTS can be quickly controlled to enhance the power system, the high cost per unit of evaluation compared to conventional equipment one of the disadvantages of power-based electronic controls [15]. The advantages of using FACTS in electrical transmission systems are to prevent power outages, increase load capacity for transmission lines, reduce voltage damping in energy system oscillation, increase power generation productivity. FACTS devices can be connected at any location in shunt, in series or in a combination. TCSC and SSCC are connected in a series while the SVC and STATCOM are associated with the shunt, on the other hand, UPFC is connected into a combination (shunt - series), combined (series – series) controller such as Interline Power Flow Controller (IPFC). The static models and concepts of the three types of FACTS devices that used in this paper are presented in the following subsections.

3.2.1 Static Var Compensator (SVC)

SVC is similar to a capacitor in use supply or absorption of interactive energy but without partial rotation. SVC is a Var of static connected to the transmission lines in any convenient location. The output is set to switch a capacitor or inductor current to control the specific variables of the power system [16,17]. It has the equivalent of an automatic voltage regulator system to identify and maintain the target voltage level. The SVC consists of a controlled reactive reactor and a condenser (or capacitor). Total SVC resistance can be controlled by controlling the thyristor launch angle. SVCs is used to enhance voltage stability to solve important problems [18]. Figure 1 illustrates the structure of the SVC. However, the SVC acts as a static capacitor or a static inductor at the maximum and minimum limited.

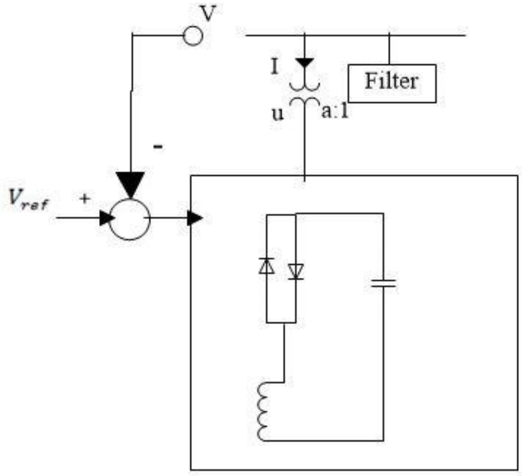


Figure 1: The basic structure of SVC

3.2.2 Static Synchronous Compensator (STATCOM)

STATCOM is a solid-state Voltage Sourced based device, which produces a controllable AC voltage, and connected in shunt to power transmission lines in a power system with quickly controllable amplitude and phase angle. The basic structure of STATCOM is shown in Figure 2. STATCOM is converted DC input voltage into AC output voltage compensation the active and reactive necessary in the power system.

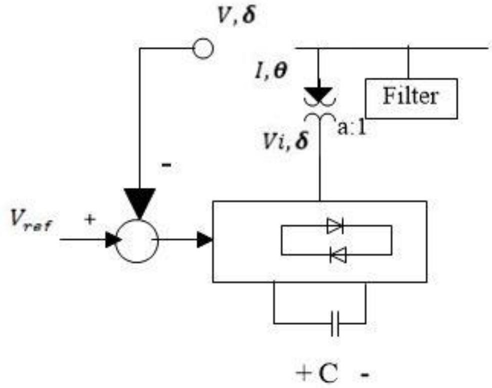


Figure 2: General schematic of STATCOM

3.2.3 Unified Power Flow Controller (UPFC)

The UPFC is a many-sided controller in the FACTS concept. It has the ability to set three control parameters: bus voltage, transmission line reactor, and the phase angle between two buses, either simultaneously or independently. It has two source voltage converters (VSCs), and a string conversion adapter, which is connected to each. Other with a common DC junction capacitor which provides a bidirectional flow of real power between the connected series and straight-moving. The UPFC model can be integrated into energy flow equations by including the impedance of the transformer adapters in the carrier entry matrix and adding the UPFC injection powers on specific buses. Schematic diagram connecting two buses. The basic structure of UPFC is shown in Figure 3.

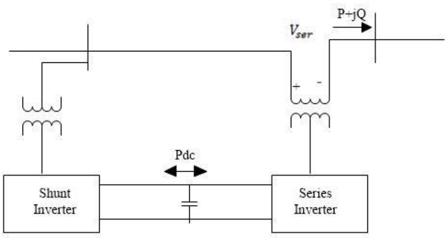


Figure 3: General schematic of UPFC

4. INTER-AREA POWER SYSTEM

In this paper, a study of a two-area, six bus and the four-machines system have been implemented. The system studies trainset stability as shown in Figure 4. The system has 2-area connected by transmission line between 2 and bus 3. 2-generators, have G1, G2 1000MVA and G3, G4 3000MVA. Also, a central loads are applied at bus four and five. The locations of FACTS devices have connected at the mid-point of the transmission line to give maximum efficiency.

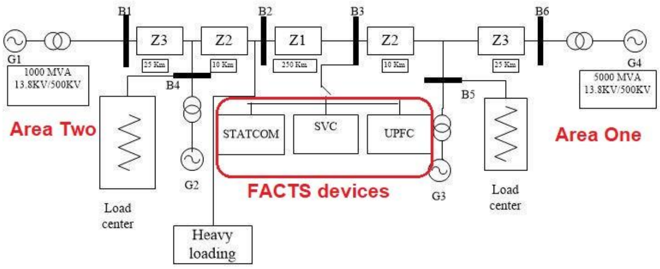


Figure 4: Four machine two-areas power system

5. FEATURES OF PSS AND FACTS CONTROLLERS

5.1 Function and Structure Of PSS

The PSS works through the excitation system of generation units. The PSS is an additional component for damping speed changes proportionate torque. It consists of a transfer function consisting of a clean out block, two lead-lag blocks. The lead-lag time constants are specified by the method. The lead-lag blocks supply the appropriate phase-lead characteristic to compensate the phase-lag between the input and torque [19,20]. The structure of the PSS controller as shown in Figure 5.

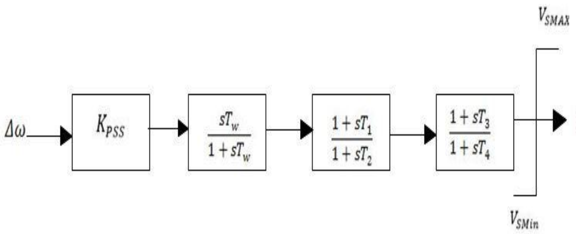


Figure 5: PSS controller

5.2 Function and Structure Of FACTS

In general, the series FACTS controller schematic, as shown in Figure 6. There are types of FACTS, SVC, STATCOM and UPFC [21]. The position of FACTS important in distribution grid to remain the stability of power system for large disturbances.

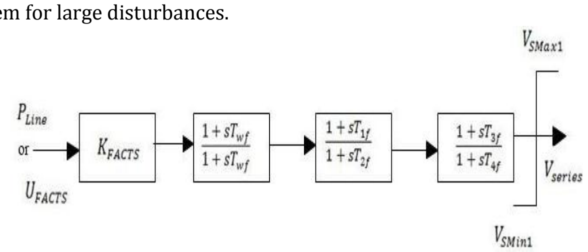
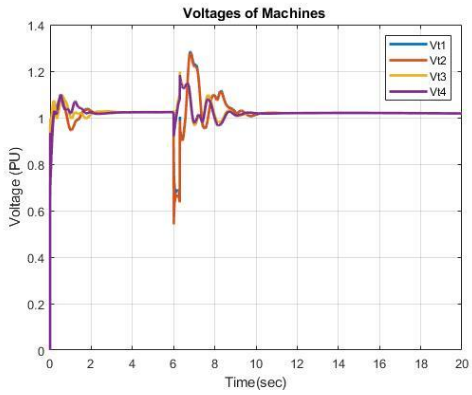


Figure 6: FACTS controller

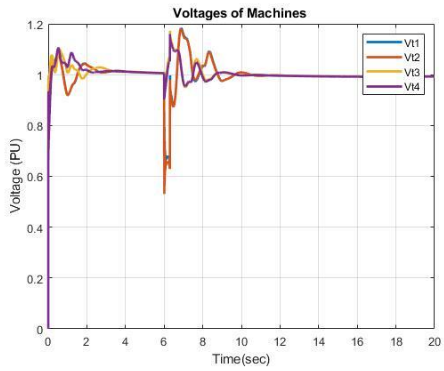
6. SIMULATION RESULT

6.1 Distribution Network With STATCOM

The STATCOM is associated shunt at the mid-point with a rating of ± 1000 MVA at G1, G2 and ± 3000MVA at G3, G4. The system during heavy load (5000MW), a three-phase heavy load in time 6 sec and the clearing time were taken 6.3 sec after initiation of the heavy load. The damping to the steady-state operating condition of three-phase heavy load oscillations is significantly enhanced by STATCOM FACTS device with two types of PSS. The effect of the system with STATCOM as observed in Figures7, 8,9 and 10. The STATCOM with PSS damps the oscillations at a time of about 8 seconds as shown in Figure 7. It's observed in Figure 7(a), the PSS MB with STATCOM is better than PSS generic in damping oscillation in the terminal voltage of generators as compared with Figure 7(b). In Figure 8, The damping of fault oscillations to a steady state operating condition is significantly achieved faster with STATCOM FACTS device in the load angles of generators G1-4, G2-4 and G3-4. Figure 9 that terminal voltage of buses, show 2 cases (a) and(b). As case (a) shown, the voltage stability is improved with PSS MB more than PSS generic as compared with the case (b). As shown in Figure 10, the speed of machines G1, G2, G3 and G4.

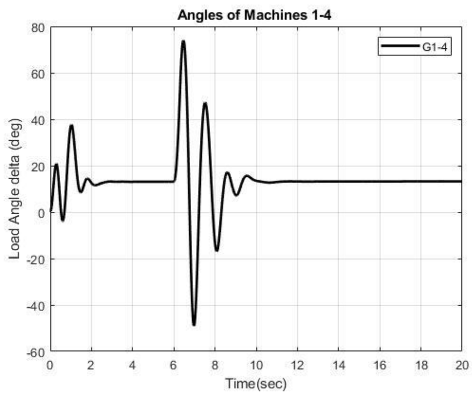


(a)



(b)

Figure 7: Variations voltages of the generators with STATCOM in the terminal with (a) PSS MB, (b) PSS generic



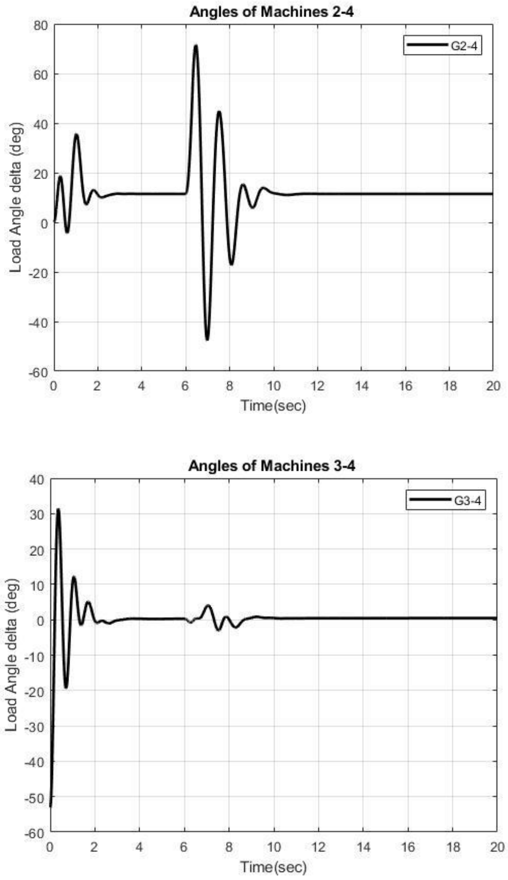
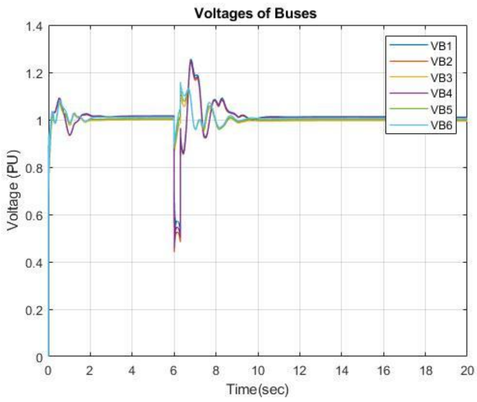
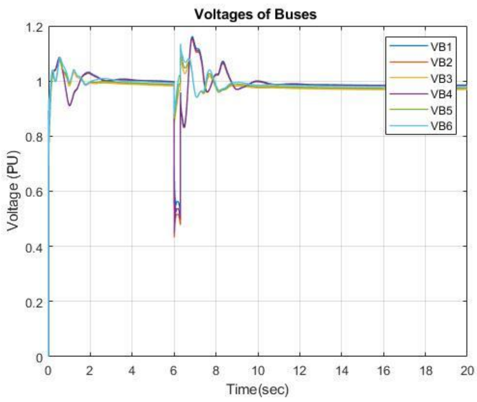


Figure 8: Variation in differences load angles of the generator with STATCOM

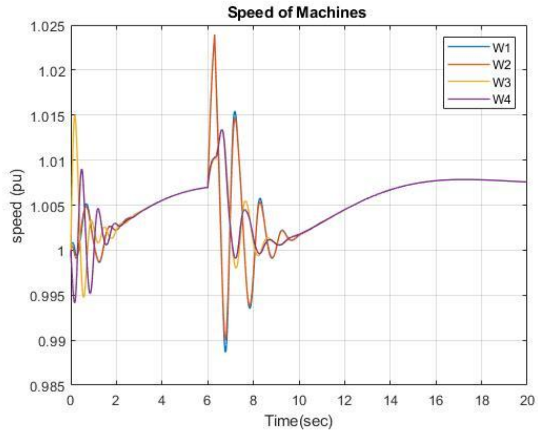


(a)

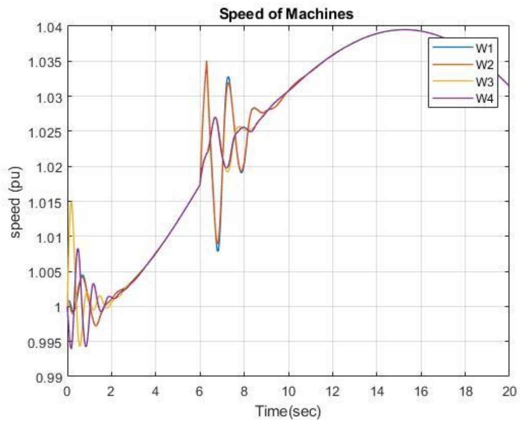


(b)

Figure 9: Variation of terminal voltages at all buses with STATCOM with (a) PSS MB, (b) PSS generic



(a)

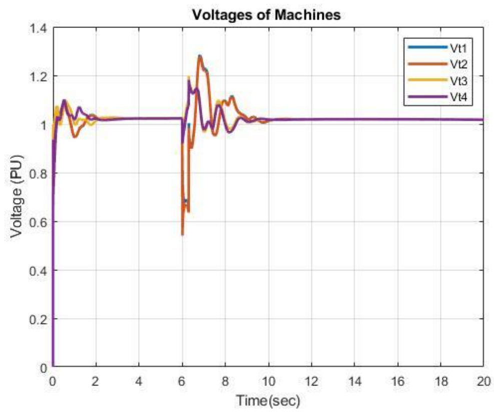


(b)

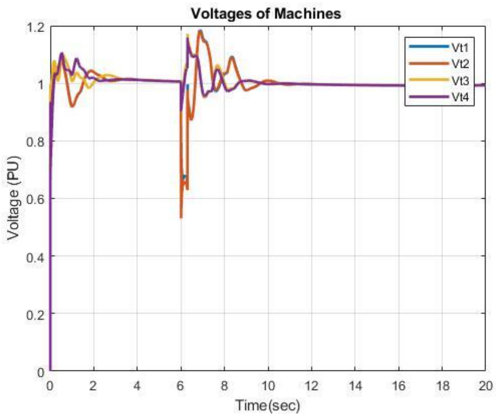
Figure 10: Variation of speed at a generation with STATCOM with (a) PSS MB, (b) PSS generic

6.2 Distribution Network With SVC

The Simulink diagram based on SVC with PSS has been implemented in this section. The distribution network with a rating of ± 1000 MVA at G1, G2 and ± 3000MVA at G3, G4. This heavy load applied at time period 6sec and eliminated at 6.3 sec. In Figure 11 its show the terminal voltage of generators units. Its observed the damping to steady-state operating condition of three-phase heavy load oscillations is significantly enhanced with PSS MB more than PSS generic as compared Fig 11 (a) with (b). Figure 12 illustrate the difference rotor angle behaviour for four synchronous generators, the load angles of generators G1-4, G2-4 and G3-4. The terminal voltage of the bases can show in Figure 13 (a); the response of the voltage stability is increase with PSS MB type better than PSS generic type in (b). it is the speed of the system for PSS MB type in (a) get better from PSS Generic type in (b) in Figure 14.

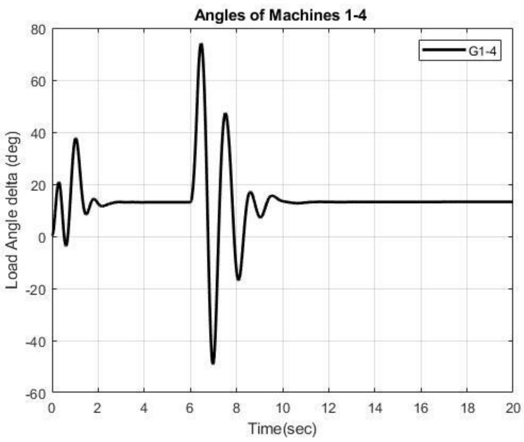


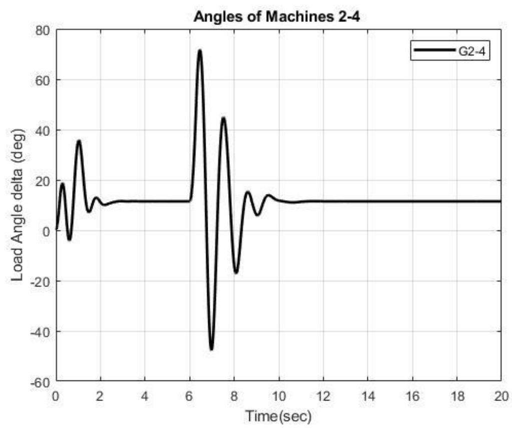
(a)



(b)

Figure 11: Variations voltages of the generators with SVC in the terminal with (a) PSS MB, (b) PSS generic





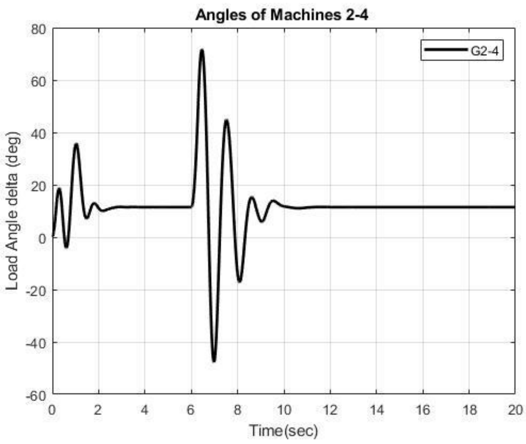
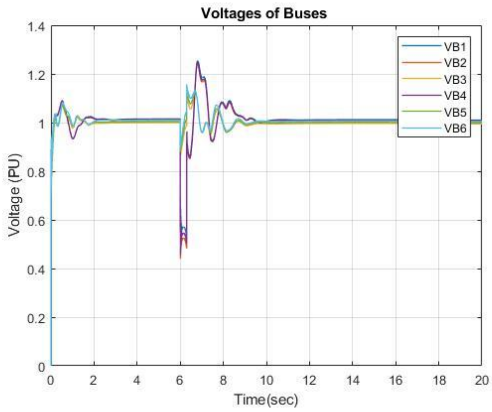
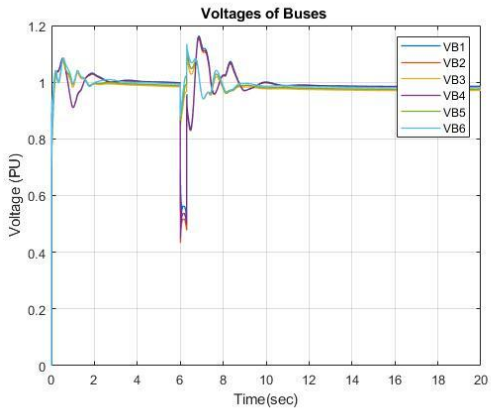


Figure 12: Variation in differences load angles of the generator with SVC

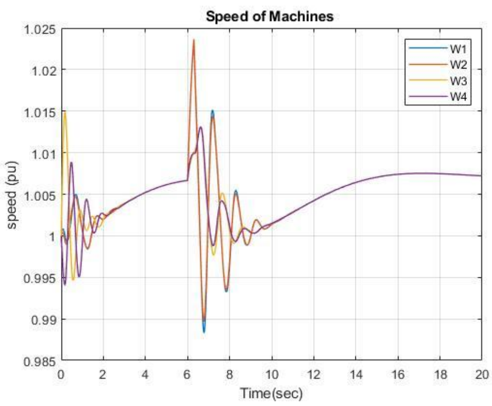


(a)



(b)

Figure 13: Variation of terminal voltages at all buses with SVC with (a) PSS MB, (b) PSS generic



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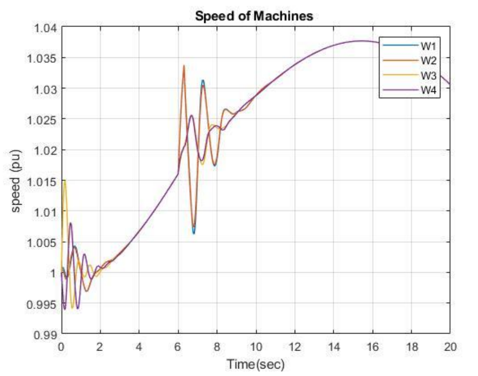
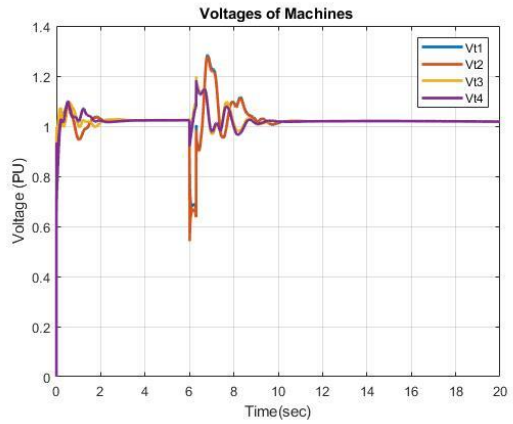


(b)

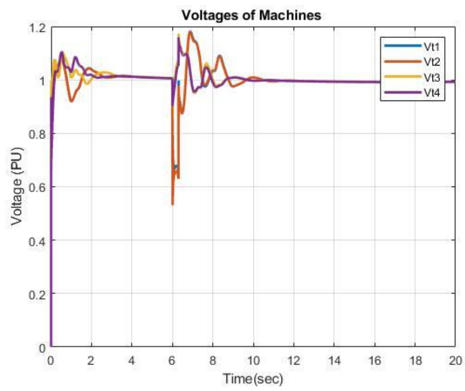
Figure 14: Variation of speed at a generation with SVC with (a) PSS MB, (b) PSS generic

6.3 Distribution Network With UPFC

The Simulink diagram based on UPFC with PSS has been implemented, UPFC has been placed at mid-point is in series with the tie line with a rating of ±1000 MVA at G1, G2 and ±3000 MVA atG3, G4. To study the system during heavy load, a three-phase heavy load entered in time 6 sec and the clearing time was taken 6.3 sec after initiation of the heavy load. The terminal voltage of generators under a steady-state conditions as shown in Figure 15. Its observed the oscillations are improved significantly by placing independent UPFC FACTS device. From Figure 16, it is deducing the oscillations in generators load angles G1-4, G2-4 and G3-4 and the transient stability are improving. Figure 17 (a) show the voltage of buses is more stable than the Figure 17 (b) and the reason is to use PSS MB type reduces the damping oscillation better than use PSS generic type. Figure 18 (a) and (b) show the speed of the system in G1, G2, G3 and G4, as seen in this Figure 18 (a) successfully stability by using MB from generic in Figure 18 (b).

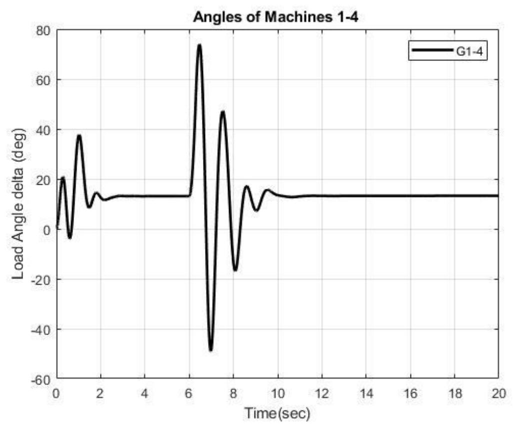


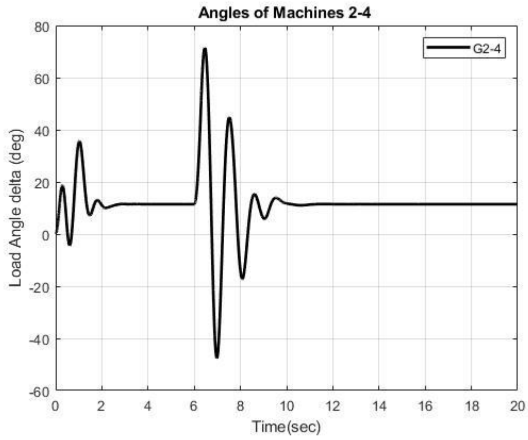
(a)



(b)

Figure 15: Variations voltages of the generators with UPFC in the terminal with (a) PSS MB, (b) PSS generic





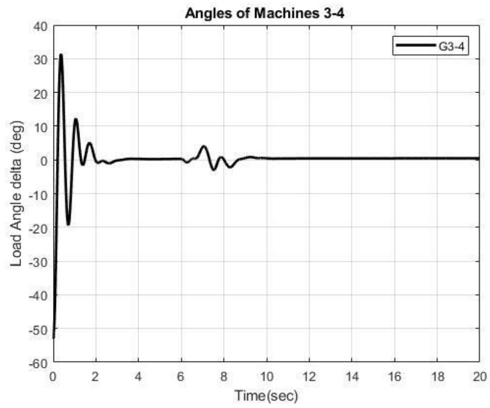
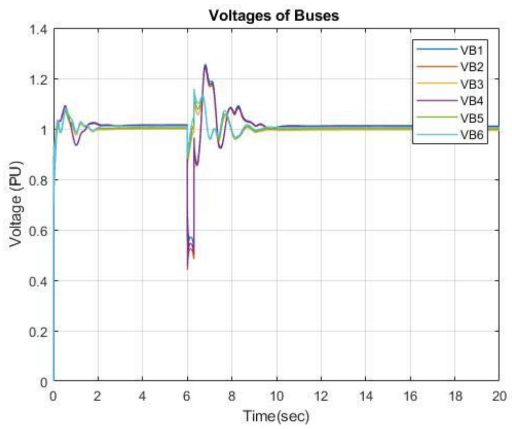
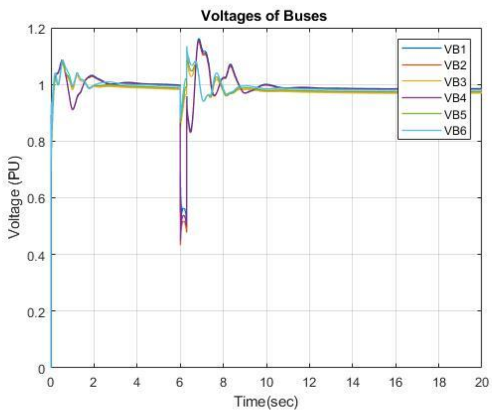


Figure 16: Variation in differences load angles of the generator with UPFC

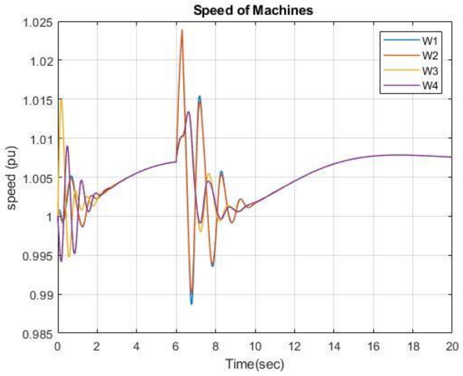


(a)



(b)

Figure 17: Variation of terminal voltages at all buses with UPFC with (a) PSS MB, (b) PSS generic



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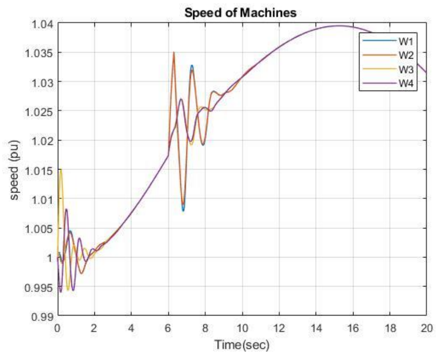

(b)

Figure 18: Variation of speed at a generation with UPFC with (a) PSS MB, (b) PSS generic

7. CONCLUSIONS

In this paper, present a studied the modelling of PSS with FACTS to improve the transient stability of power system of the multimachine with a three-phase heavy load. The proposed system contains tow-area four-machine power system with three types of FACTS devices which connected at mid-point the transmission lines to achieve a steady state operating condition after disturbances. The STATCOM and SVC simulation results show the similar oscillations properties of the studied variables but UPFC has better damping characteristics for the interactive energy response and an enhancement in rotor angle and voltage stability at steady state.

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