Efficient Inter-area Power Oscillation Controller for Two Area Four Machine System Using Multiband Power System Stabilizer

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Abstract— Most of Power systems are steadily increasing with ever higher capacity. All individual systems are interconnected to each other. The Modern power systems have transformed into the system of very large size. With growing generation capacity, different areas in power system are added with very large inertia. As a consequence in large interconnected power systems, low frequency oscillations have large importance. Low frequency oscillations include local area modes and inter-area modes. Inter-area modes of oscillations may be caused by the either high gain exciters or heavy power transfer across weak tie line. The occurrence of the inter-area oscillations depends on various reasons such as weak ties between interconnected areas, voltage level, transmitted power and load. At time, the oscillations may continue to grow causing the instability of the power system. lots of power system stabilizers have been developed by the researchers in the past few years, but the area is still open for the efficient power stabilizer development which can efficiently able to handle the power oscillations without increasing the system controller system complexity. This paper deals with the development and implementation of a multiband power system stabilizer (MB-PSS) for the efficient power oscillation damping in two area four machine transmission system. The implementation of the proposed work is with the Simulink of MATLAB 2012(b). This paper also presents a complete comparative analysis of Inter- area power oscillation damping capabilities of proposed multiband power system stabilizer (MB-PSS) and conventional PID power system stabilizer (PID-PSS). The obtained results shows that the Inter-area power oscillation damping capability of proposed multiband power system stabilizer (MB-PSS) is much higher than the PID-PSS. In addition the damping time required by proposed MB-PSS is 50% less as compare to PID-PSS.

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Keywords—PID Controller, Power System Stabilizer (PSS), Multi area machine system, Power oscillation Damping, MB-PSS, PID-PSS.

1. INTRODUCTION

Many power systems will complex non-linear systems, that are often subjected to some what low frequency oscillations. The useful application in power system stabilizers to improving stability especially dynamic stability of power systems and damping out the low frequency oscillations due to problems and disturbances has received much attention recently. Power system is a highly nonlinear system and it is very difficult for obtaining correct mathematical model for the system. For adaptive self-tuning and variable structure with artificial neural network based PSS, fuzzy logic based PSS, have been proposed to provide optimum damping to the system oscillations which under wide value of variations in all operating conditions and all system parameters. Oscillation like low frequency oscillation problems that are very difficult to solve because power systems that are very large, complex with geographically distributed. Therefore, it is necessary for utilize most efficient optimization all methods for taking full of advantages in simplifying the problem and their implementation [1-5].

From this view, many succeeded and powerful optimization methods and algorithms have been employed in formulating and solving this problem. These days swarm intelligence has become more and more attractive for the researchers, who work in the relevant research field. It can be classified as one of the branches in evolutionary computing. Swarm intelligence can be defined as a measure for introducing the collective behavior of social insect colonies or other animal groups to develop algorithms or various distributed problem-solving devices. Generally, the algorithms in swarm intelligence are used to solve various optimization problems. Many swarm intelligence algorithms for solving problems of optimization have proposed such as the Cat Swarm Optimization (CSO), the Parallel Cat Swarm Optimization (PCSO), the Artificial Bee Colony (ABC), the Particle Swarm Optimization (PSO), the Fast

Particle Swarm Optimization (FPSO), and the Ant Colony Optimization (ACO). Moreover, several applications of optimization algorithms based on computational intelligence or swarm intelligence one after another [6-9].

Artificial Bee Colony (ABC) algorithm based particular intelligent behavior of the system. In addition, the accuracy and efficiency of ABC are compared with Differential Evolution (DE), PSO and the Evolutionary Algorithm (EA) for numeric problems at multi-dimensions. On observing the operation and structure of the ABC algorithm, we notice that the operation of agent, e.g. the artificial bee, can only move straight to one of sources which are discovered by employed. Nevertheless, this characteristic which may narrow down the zones of which all bees can explore and may that become a drawback of ABC.

This work deals that development and implementation of a multiband power system stabilizer for the efficient power and their oscillation damping in that two area four machine transmission systems.

Aim of this work is to analyze the power stabilization capability of proposed multiband power system stabilizer as compared to conventional PID power system stabilizer for interred power oscillation damping of two areas with four machine transmission line systems.

2. Four Machines Two Area Test System

Here two fully symmetrical areas linked to each other with two tie 230KV lines of 220Km length as shown in given Fig.1. It was specifically designed to study low frequency electromechanical oscillations all in large interconnected power systems. Despite its small size, so here it mimics very closely so the behavior of typical system in actual operation. Each area is has two identical round rotor generators rated 20 KV/900 MVA. The synchronous machines contains identical parameters leaving the inertias which are H = 6.5s in area 1 and H is = 6.175s in area 2. Thermal plants that having identical speed regulators are which further assumed at all locations, in addition to fast static exciter with a 200 gain. The load is represented as constant impedance and spilt between the areas.

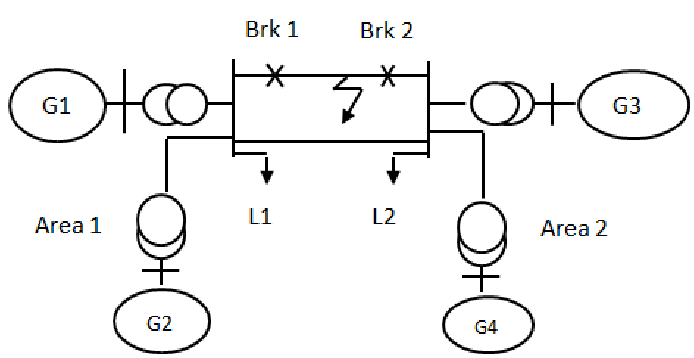

Fig -1: Two Area Four-Machine power system for Stability Analysis

Now the actual simulation model implemented for analysis of the PID-PSS and proposed MB-PSS for Inter-area power oscillation stability is shown in fig.2. Fig.3. Shows the internal structure of area-1 of the implemented power study testing system and fig. 4. Depicts the Internal configurations of Turbine and regular consisting the conventional PID-PSS and proposed MB-PSS.

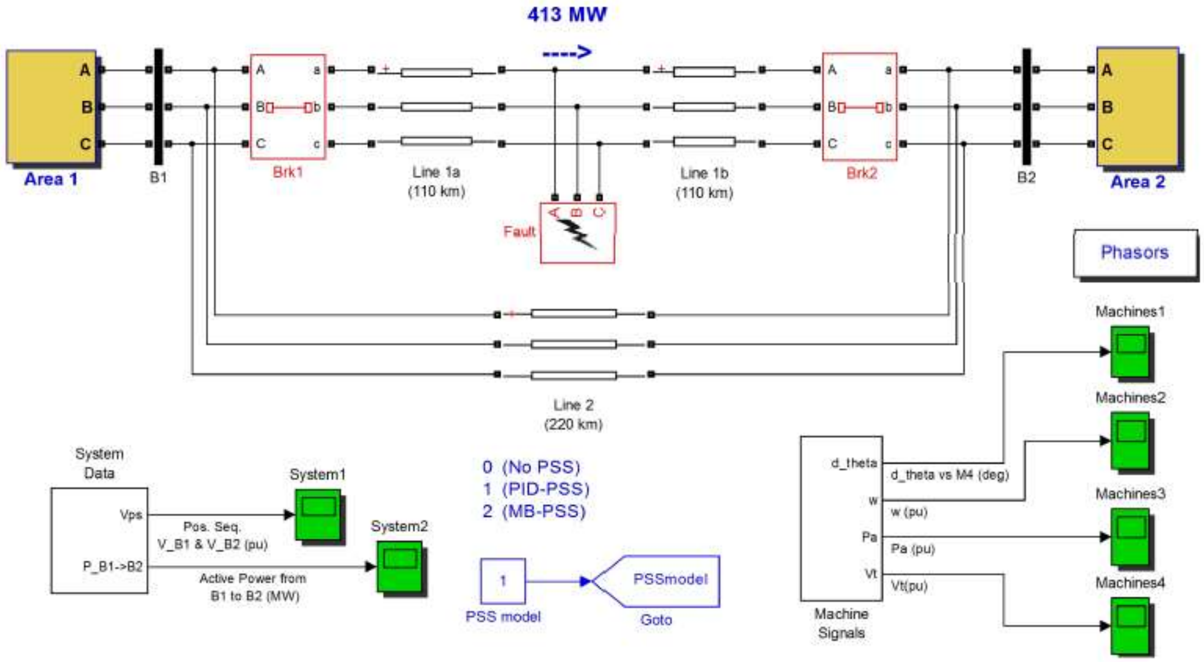

Fig - 2: Actual simulation model implemented with PID-PSS and proposed MB-PSS for Inter-area power oscillation stability Analysis.

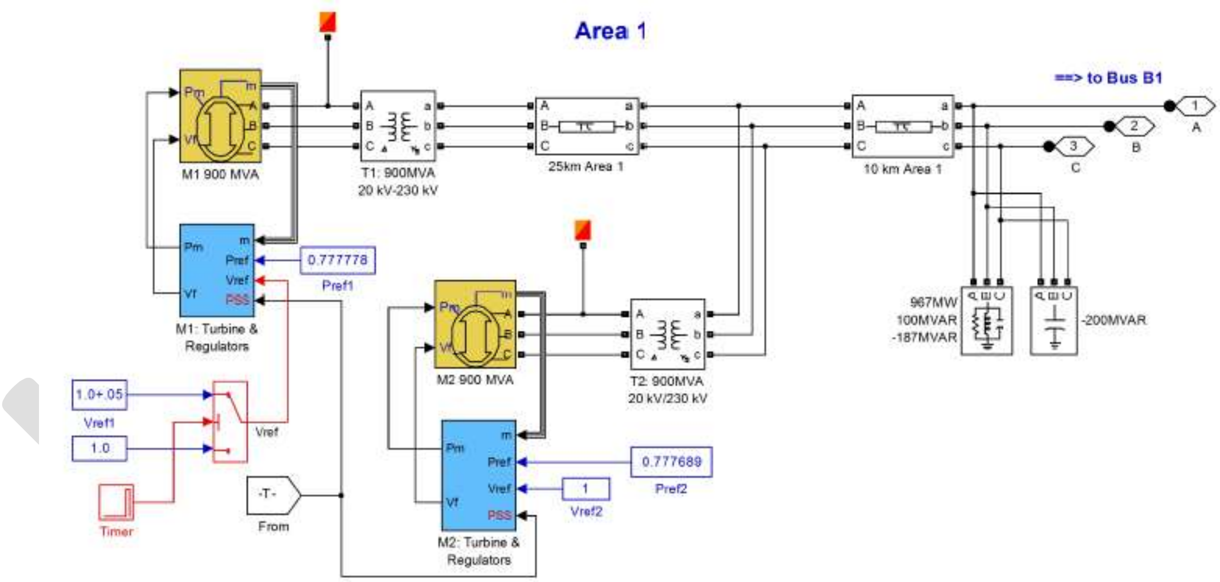

Fig-3: Internal configuration of area 1(subsystem)

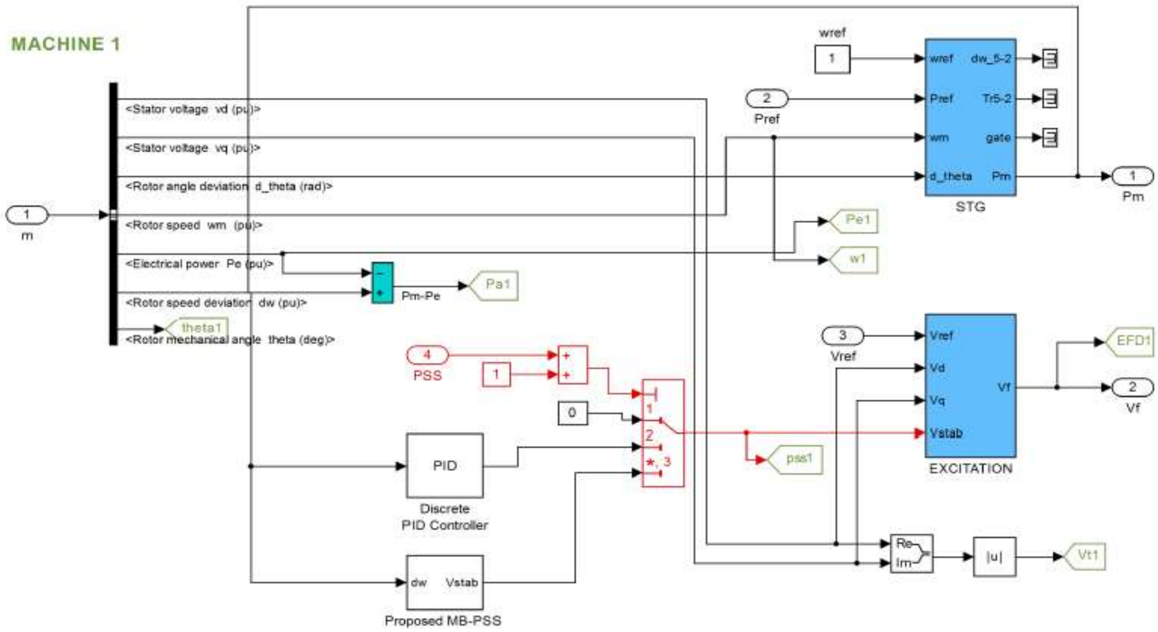

Fig-3: Internal configuration of Turbine and regulator With PID-PSS and proposed MB-PSS.

3. Proposed Multiband power system stabilizer (MBPSS)

The main features of the MB-PSS model (IEEE PSS4B) are given in fig.4 and fig.5. As for conventional PSS, the MB-PSS has three main functions, first , the transducers, another , the lead-lag compensation and the limiters. Two speed deviation transducers are necessary to feed the three band structure used as lead-lag compensation. Four adjustable limiters are given, one for each band and one for total PSS output.

The low band is looking of very slow oscillating phenomena such as common modes resulted on isolated system. Hydro-Quebec system is the best example with its 0.05 Hz global mode. The intermediate band is needed for inter-area modes usually found in the range of 0.2 to 1.0 Hz. The high band is working with local modes, either plant or inter-machines, with a typical frequency range of 0.8 to 4.0 Hz.

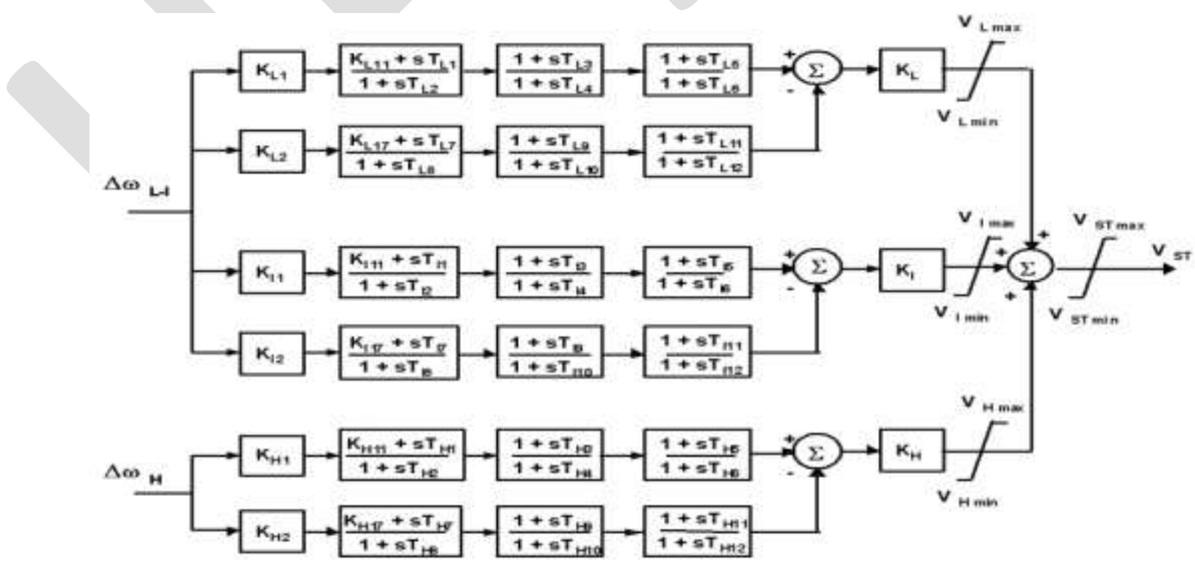

Fig-4: IEEE PSS4B model of the MB-PSS

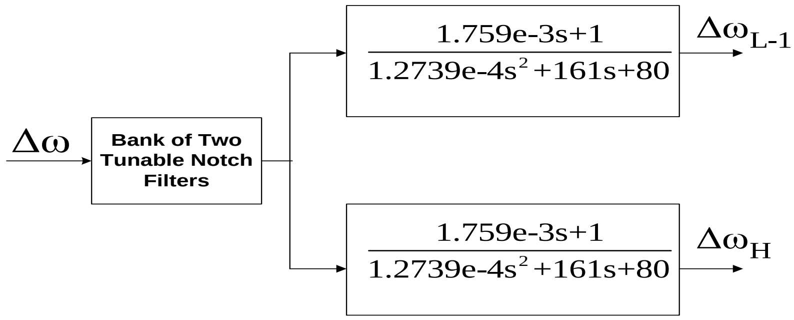

Fig-5: MB-PSS Speed Deviation Transducers

Lead-lag compensation bands are based on differential filters that may be used in several ways. Fig.6 zooms on the high hand to illustrate its characteristics.

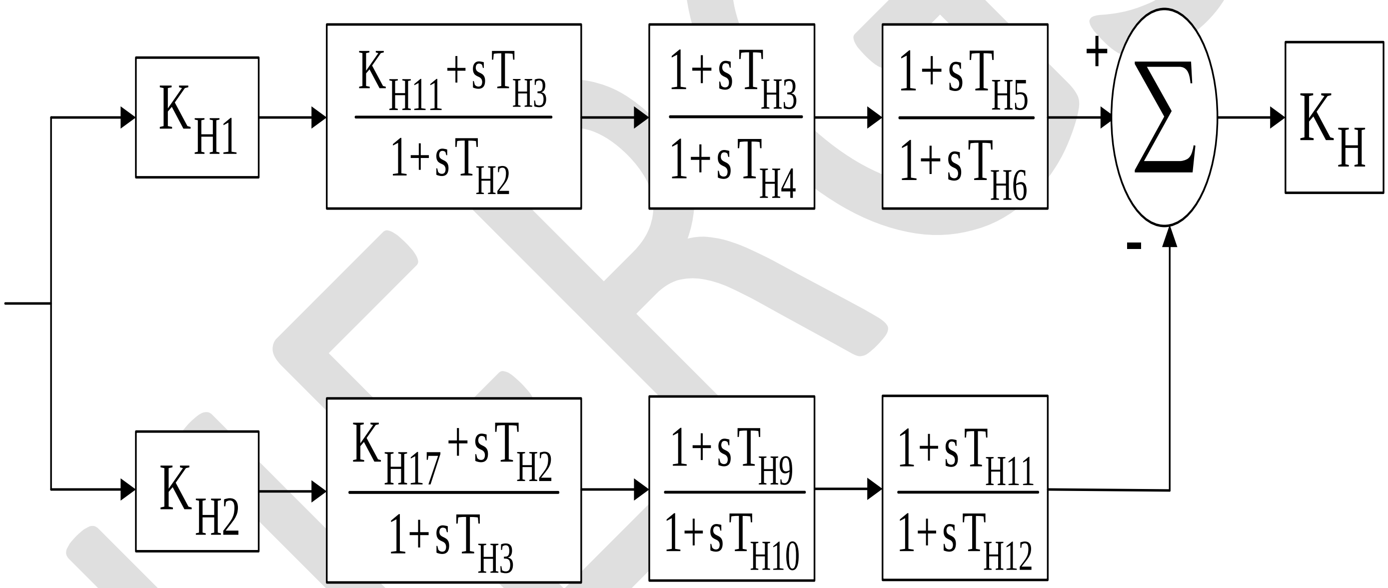

Fig-6: The high band differential filter

4. Simulation Results

The performance of the PID-PSS and proposed MB-PSS was evaluated by applying a large disturbance caused by three-phase fault applied at the middle of one tie line at 0.2 sec. and cleared after 0.133 sec by opening the breakers, with one tie-line the system can reach a stable operating point in steady state. The Parameters of PID-PSS used in test generators are given in Table 1. Each generator parameters are based on data in Table 2.

Table -1: Parameter of PID controller

Parameter	Kp	Kl	Kd
G1	30	10	0.001
G2	10.50	0.67	0.45
G3	10.50	0.67	0.45
G4	10.50	0.67	0.45

Table -2: Parameters of the generator

Parameter	Generator
X_d	1.8
X_d'	0.3
X_d''	0.25
X_q	1.7
X_q'	0.55
X_q''	0.25
X_t	0.2
T_{do}	8
T_{do}'	0.03
T_q	0.4
T_q'	0.05

To investigate the Inter-area power oscillation damping performance of PID-PSS and proposed MB-PSS with two-area four-machine test system, the three phases to ground fault was considered in the simulation studies. A three-phase fault of 0.4sec duration is simulated at line-1. Fig. 7, Shows the performance of test system response of without power system stabilizer (PSS).

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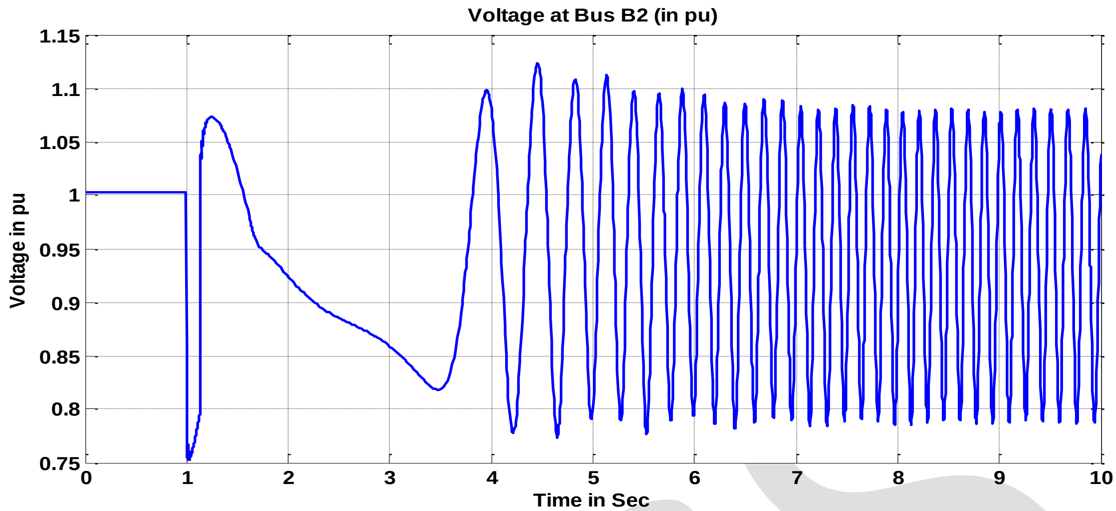

Fig-7(a): Voltage at Bus_1 without PSS.

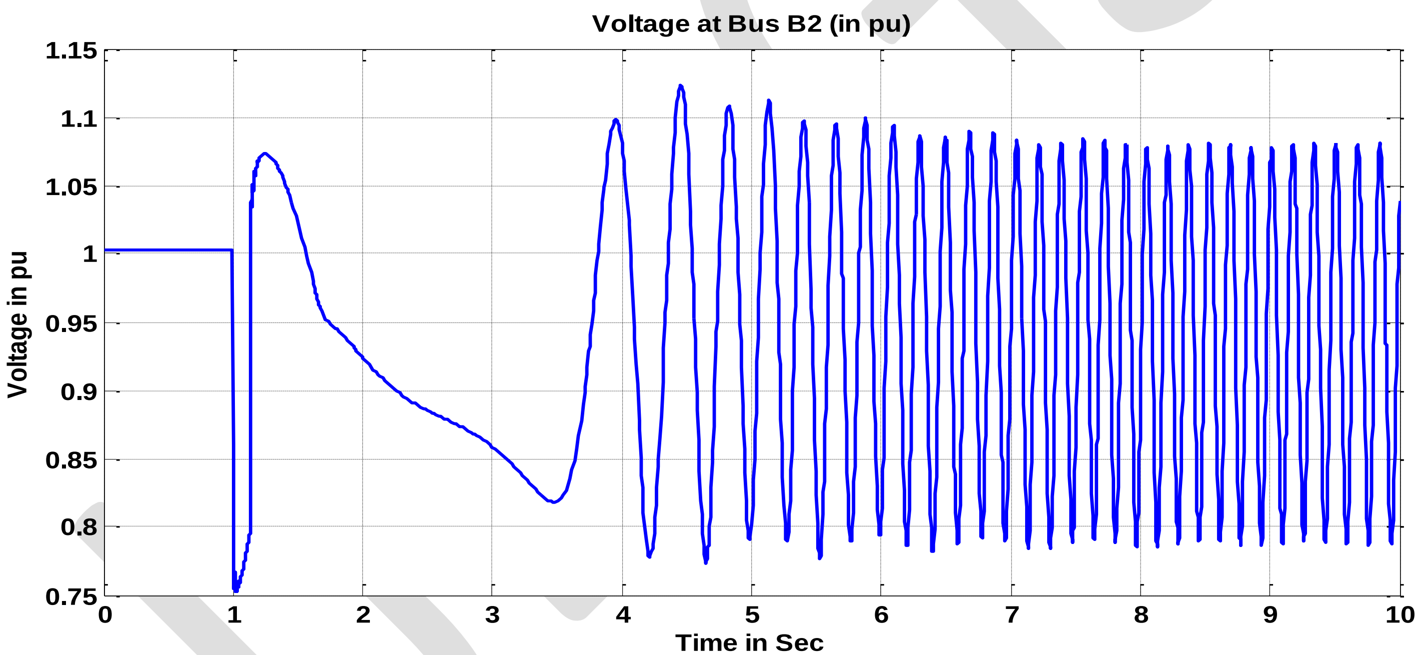

Fig-7(b): Voltage at Bus_2 without PSS.

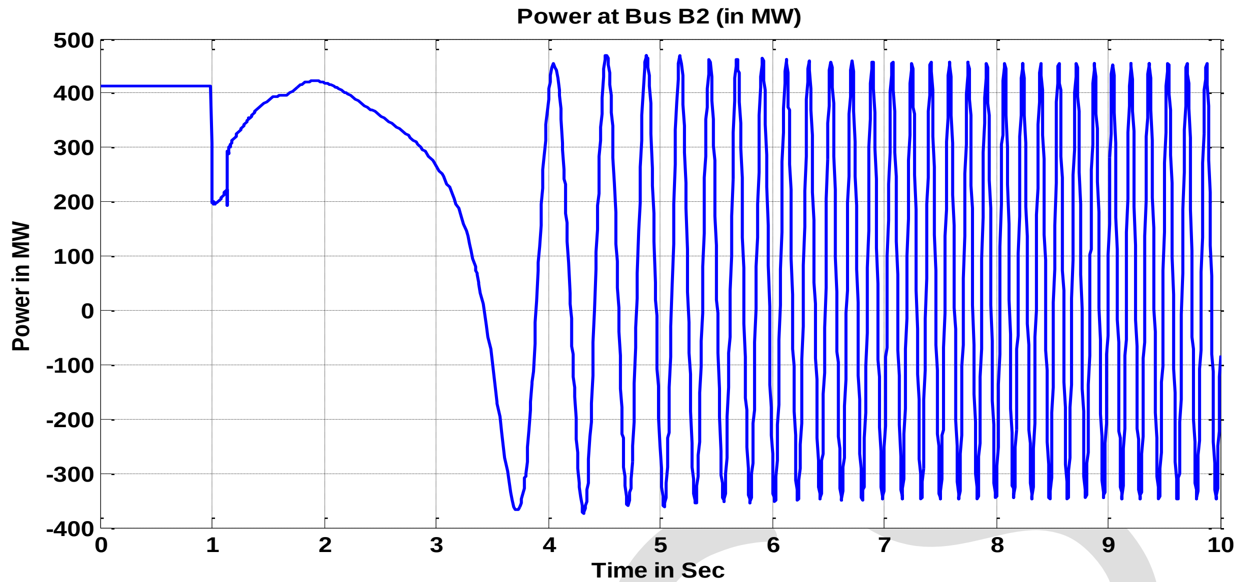

Fig-7(c): Power at Bus_2 without PSS

Now Fig.8. Presents the results of the examined power system with the same three phase fault under PID PSS

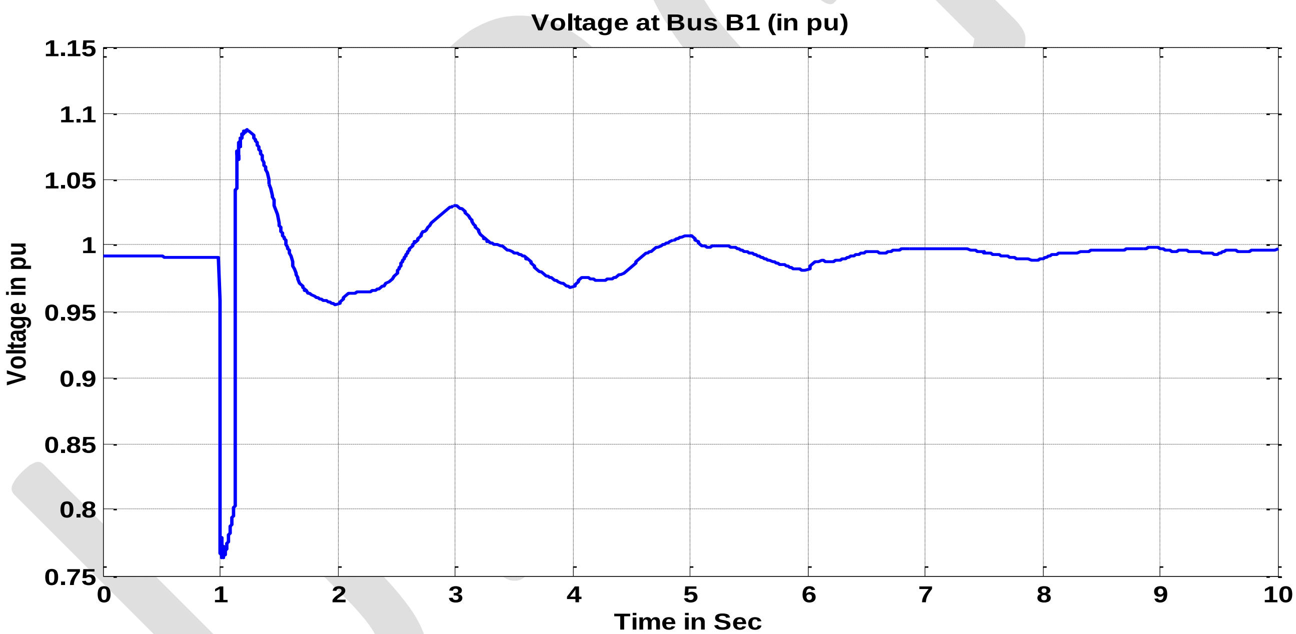

Fig-8(a): Voltage at Bus_1 with PID-PSS.

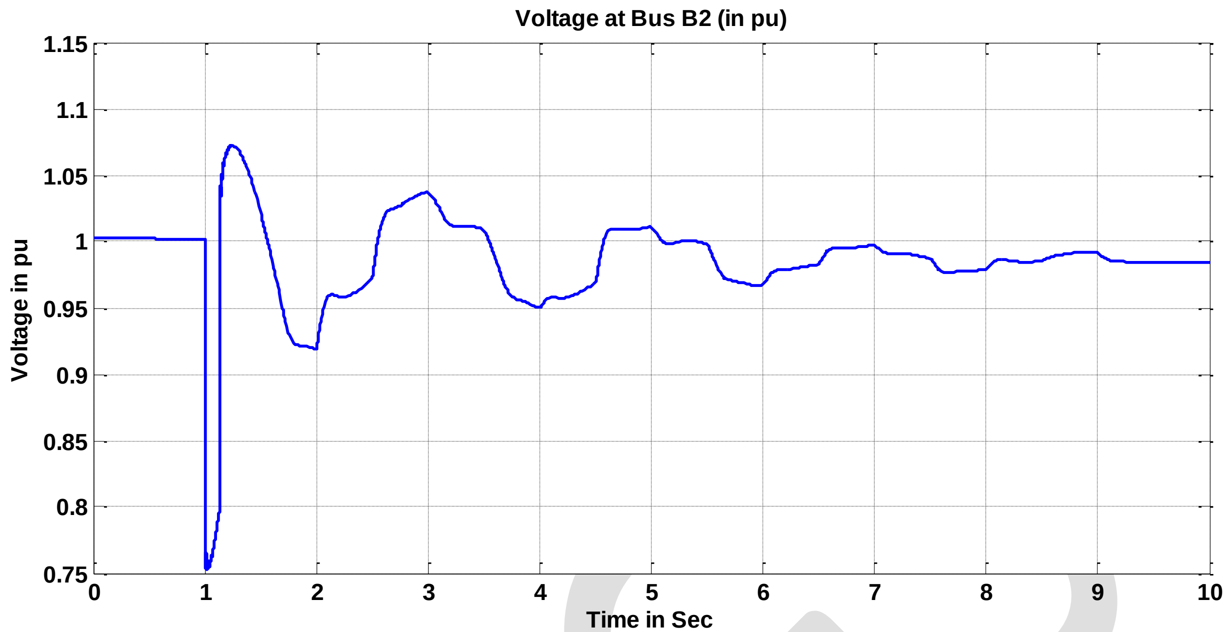

Fig-8(b): Voltage at Bus_2 with PID-PSS.

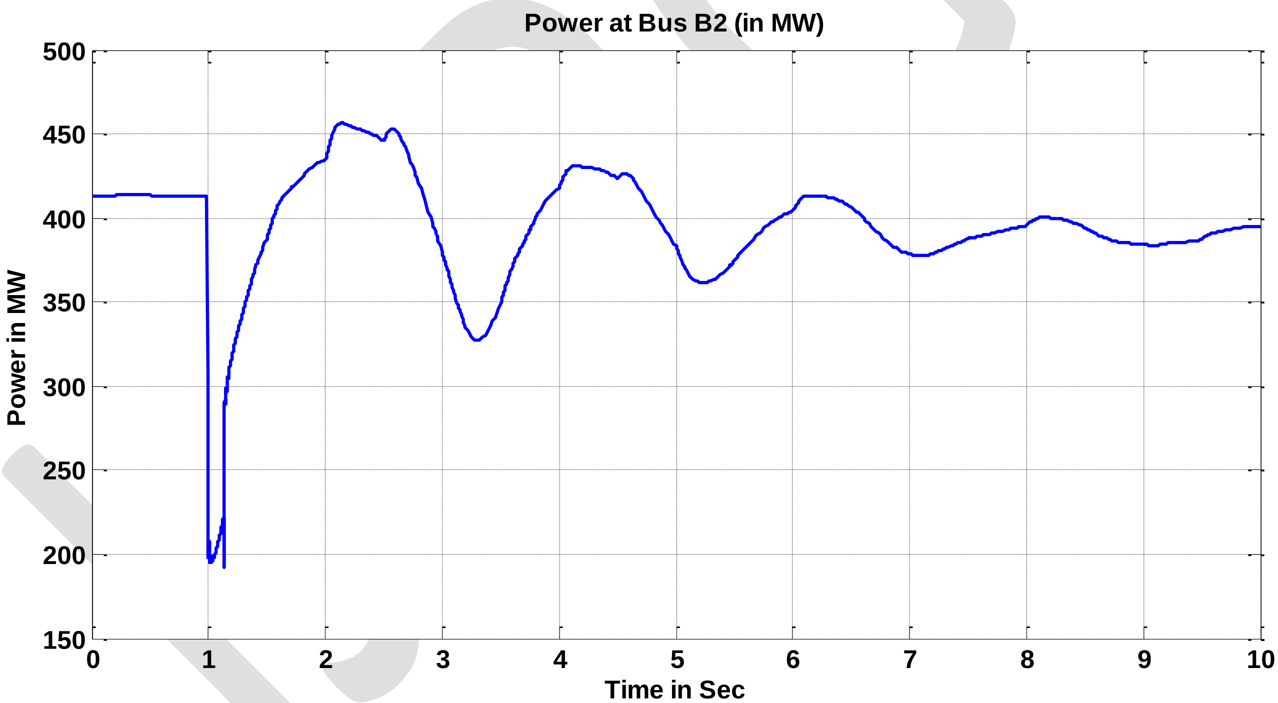

Fig-8(c): Power at Bus_2 with PID-PSS.

Now Fig. 9 presents the results of the examined power system with the same three phase fault under proposed MB-PSS.

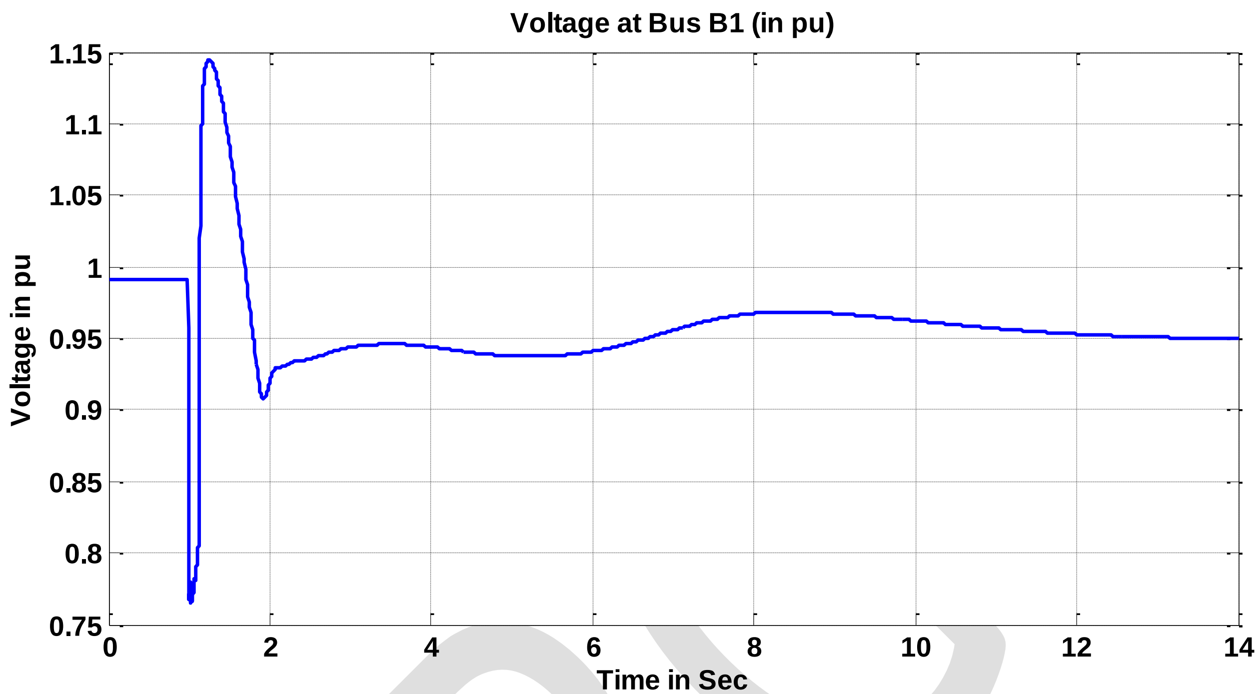

Fig-9(a): Voltage at Bus_1 with proposed MB-PSS.

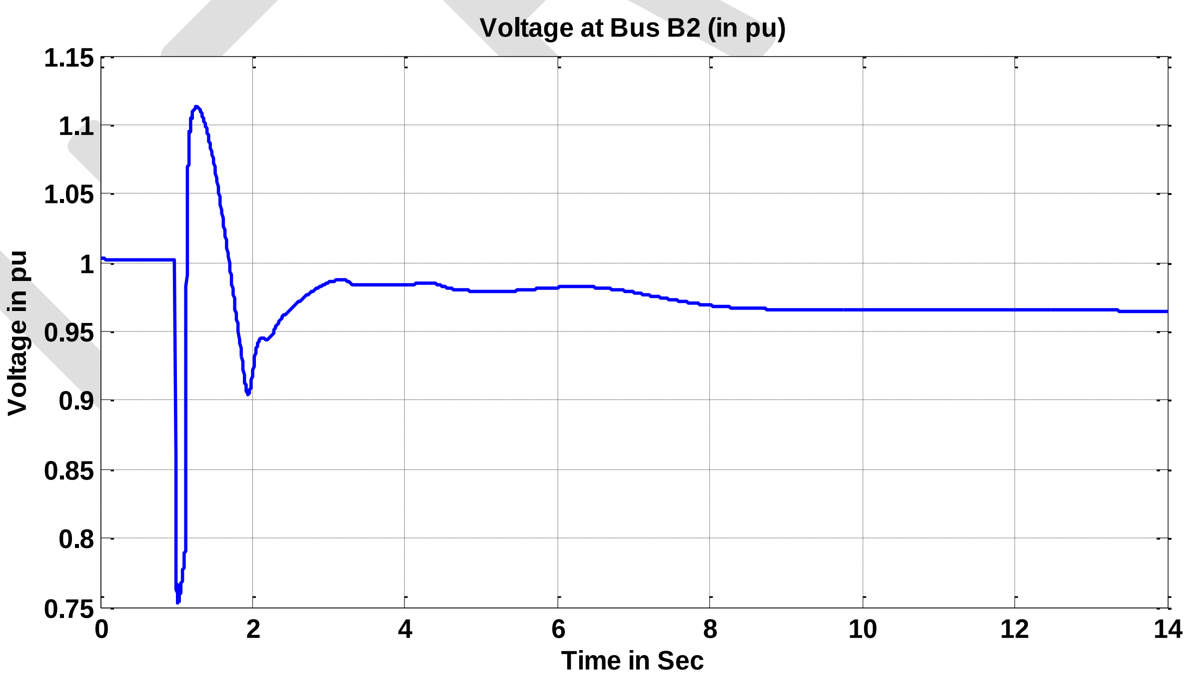

Fig-9(c): Power at Bus_2 with PID-PSS.

Finally fig.10, Shows the comparative Inter-area power oscillation damping performance of test system without power system stabilizer (PSS), with PID-PSS and with proposed MB-PSS.

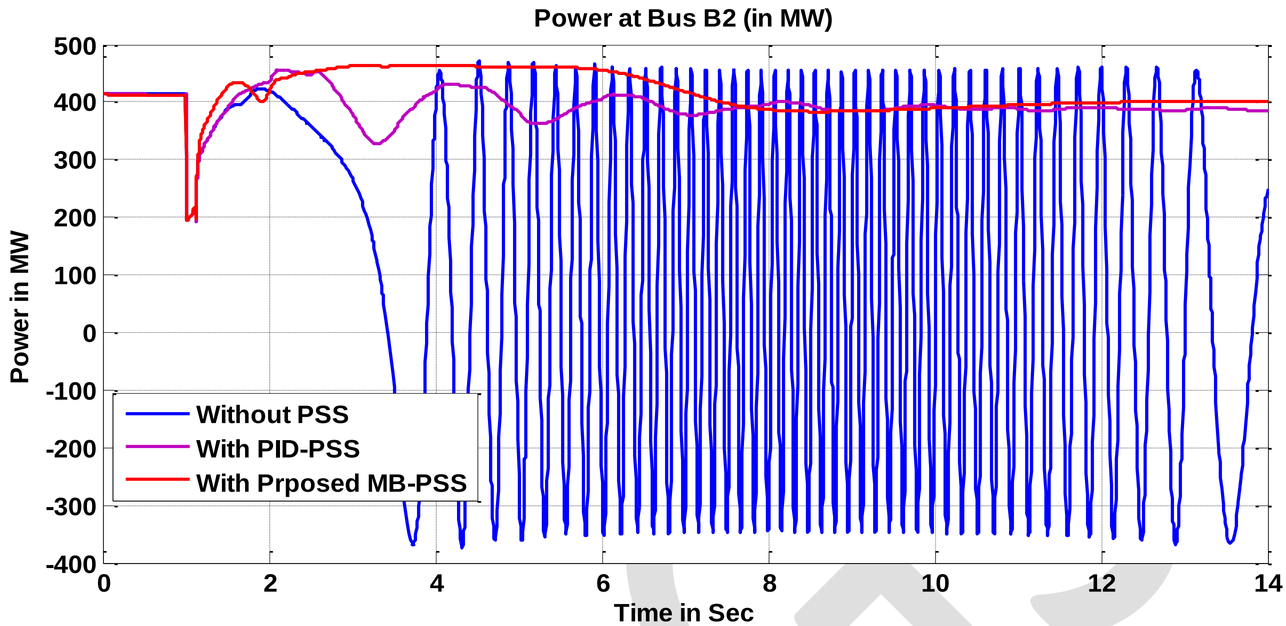

Fig-10: comparative Inter-area power oscillation damping performance.

5. CONCLUSION

Here a complete performance analysis that are two area four machine transmission lines power oscillation damping with which proposed MB-PSS, PID-PSS and without any PSS. After the simulation of this testing system without PSS, it is found that the power transfer between sending and receiving end, Here highly suffers with large oscillation. In addition to this the useful part with this simulation is that the system without PSS is not able to damp the power oscillation that even after 14 sec in this simulation. On the other side with the PID-PSS at the same system response which is quite acceptable, but here the response is still suffering from oscillations and that needs further improvement to all efficiently damp the oscillations. To overcome this problem this paper proposed a novel which multiband power system stabilizer. This result of Inter area power oscillation damping using proposed MB-PSS clearly indicates the high efficiency of proposed and PSS as compare to conventional PID-PSS. In addition with this the results also indicates that, the proposed model of MB-PSS takes only few seconds 10 sec to completely damp the Interarea power oscillations and whereas PID-PSS takes even more like greater than 14 sec to control the power supply oscillations.

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