Evaluation of power system Oscillation with the use of Phasor Measurement Technology (PMU) and its Damping with use of Power System Stabilizer (PSS)

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***Abstract* - To get the maximum advantages of a power system and to transfer the maximum power transfer high frequency oscillation are required. Thus low frequency oscillation are disadvantages to the goals of maximum power transfer and optimal power system security. A solution to this problem is the more use of power system stabilizer (PSS) to the automatic voltage regulator (AVR) on the generator in power system. The damping provided on the generator stabilizer and reduces the inhibiting effects of the oscillation. Thus, this paper is a note on the use of synchronous phasor measurement as input signals for two area power system. Thus, this paper work contains brief note on dealing with designing of wide area power system stabilizer to damp inter area mode of oscillation using wide area signals. Many effects have been made to damp oscillation by use of control attach upon wide area measurement (WAMS) many problems to be solved also.**

***Keywords*- Low frequency oscillations(LFO), power system stabilizers (PSS), phasor measurements unit (PMU), Wide Area Measurement (WAMS)**

I. INTRODUCTION

Few earlier power system has stability problems which contain self made power system oscillations at low frequencies. These low frequency oscillations (LFOs) are related to the small signal stability of a power system. As power system begin to be work out close to their stability limits, the fault of a synchronizing torque among the generator was realized as a primary cause of system instability. To iner area the steady system stabilizer AVR's are very helpful but transient stability became a problem for power system operators. The sum of secondary controller into the control loop, with the intro to PSS to AVRs on the generators manage to decrease the inhibiting effect of low frequency oscillation.

The AVR and PSS are added in associated machine for measurement of like as generator speed, phase angle of the rotor and voltage of the particular bus. From above, by using AVRs and PSSs control action and their feedback control is efficient for local and control mode oscillation, but maybe it is not possible or efficient for inter area oscillation in power system the event of transient stability, FACTs device control, with including state estimation in its control action. As achieved from SMPS.

In this paper describe the synchronous phasor measurement into the generator control loop in from of input to a PSS installed in a two area four machine test system. Include poorly damped inter area oscillation these system done using MATLAB program.

II. POWER SYSTEM STABILIZER

(A) Overview of the Excitation System of the Synchronous Generator

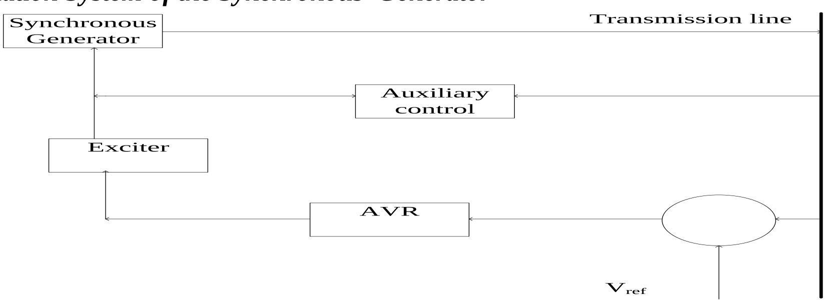


Figure 2.1: Schematic of the excitation system

We had given a historical overview on the excitation system of the synchronous generator. After that we move on to give the schematic diagram of the excitation system that we shall basically we use in these project to design the power system stabilizer.

The first step in original excitation system was the introduction of the amplifier in the feedback path to amplify the error signal and creation the system fast acting. More and extra complex excitation systems are being developed to make the system as fixed as possible due to increase in size of the units and interconnected systems, With the introduction of solid-state rectifiers, ac exciters are recently in frequent use. Automatic voltage regulators (AVR), Power System stabilizers (PSS), and filters are equal of the A modern excitation system components which help in fixing the system and maintaining nearly constant terminal voltage. On the basic of complexity and operating conditions these components can be analog or digital.

To maintain a constant voltage and to decrease swings because of transient rotor angle instability are the final aim of the excitation system. The excitation voltage comes transmitter the transmission line itself. And the AC voltage is first change into DC voltage by rectifier units and is fed to the excitation system via its components like the AVR, PSS etc.

(B) Power System Stabilizer (PSS)

(I) In PSS the Issues of Stability

The excitation system regulates the generated voltage and it also helps in given direction the system voltage. Through excitation control automatic voltage regulators (AVR) are found best suitable for the regulation of generated voltage. Large use of AVR has negative effect on the dynamic stability or steady state stability of the power system. such as low frequencies oscillation (typically in the range of 0.2 to 3 Hz) continued in the power system for a large time and sometimes affect the power transfer capabilities of the system.

The power system stabilizers (PSS) were developed to help in damping of oscillations by modulation of excitation system increase stability to the system. The basic operation of PSS is to apply a signal to the excitation system that creates by damping torque in phase nearby the rotor oscillations.

(II) Considerations in PSS Design

At that the effect of power system transient stability to damp out oscillations by using PSS Method. PSS damps oscillations by regulating generator field voltage it solution in swing of VAR output. The resultant profit margin of Volt/VAR swing should be acceptable to prefer by PSS gain. The limits to modified to be minimized while ensuring the oscillation of damping action of PSS for all system incident. PSS is needs to be possible by interaction with other controls which may be part of the excitation system or external system like as FACTS, HVDC, TCSC, SVC. The input to PSS in LFO by high frequency turbine generator oscillations which should be obtain by PSS design.

III. PHASOR MEASUREMENT UNIT (PMU)

(A) Introduction of PMU

Indian power system is spreading at fast speed to meet the growing requirement. It is important to grow a system dependable and protective. The most complex engineering machines in the modem power grid. Everyone the components must be work on dependable, 24 hours a day, seven days a week, to power our homes and businesses. Positions are grid in continually changing. Electricity change in requirement necessitate instantaneous changes in electricity construction. As per Indian electricity grid code every State/DISCOM is responsible for maintaining its load generation balance. Frequency is approve to vary under specified band.

Flexibility in frequency led to above drawl, under drawl, over generation and under generation by the utilities leading to overloading of lines and come up and dip of voltages in the grid. The extreme penetration of renewable generation suitable its unpredictability, variability and intermittency will even. Appearance challenges in operation of the grid. Under such complexities, carrying out security assessment on actual time basis and responding to contingencies are reviler for maintaining credibility and stability of the grid.

New later advances in measurement, communications and analytic technology have produced a order of new options. In particular, Phasor Measurement Unit (PMU) have come to the fore as a means to address not just immediate reliability concerns but also operations point like enhancing transfer capability in actual time.

(B) History of PMU

Since 1980s (Taylor, 2006) by Bonneville Power Administration (BPA) in the first introduced of Wide Area Measurement System (WAMS). This was resulted from this fact that the Western System Coordinating Council (WSCC) faced a critical deficiency of dynamic information throughout the 1980s.

After 1988,the invention of phasor measurement units (PMU) by Dr.Arun G.Phadke and Dr. James S. Thorp at Virginia Tech, Steinmetz's technique of phasor calculation.

The calculation of actual time phasor measurements that are synchronized to an absolute time reference provided by the Global Positioning System (GPS). It is also called as Wide Area Monitoring/Measurement System (WAMS).

Since 1990 result of this, a common plan to address this problem was formed (Cai et al., 2005). Therefore, the Western Interconnection of the North America power system was the first test-bed for WAMS implementation.

Since 1994, phasor measurement units (PMU) have been used in WAMS and they have provided synchrophasor measurements. Synchrophasor measurements may contribute ago functions or may introduce some new WAMS functions, which are never secured previously by conventional measurements. When synchrophasor measurements are used as data resources of a WAMS, such a WAMS will be called PMU based WAMS.

The benefit of synchronizing measurements by digital relays using time pulses from GPS satellites became clearly evident for getting a good snapshot of the happenings in the system. A major retention in commercial implementation of PMU's in early times was that there was an incomplete deployment of GPS satellites. Due to this, one would not expect a satellite to be present at each location all the time.

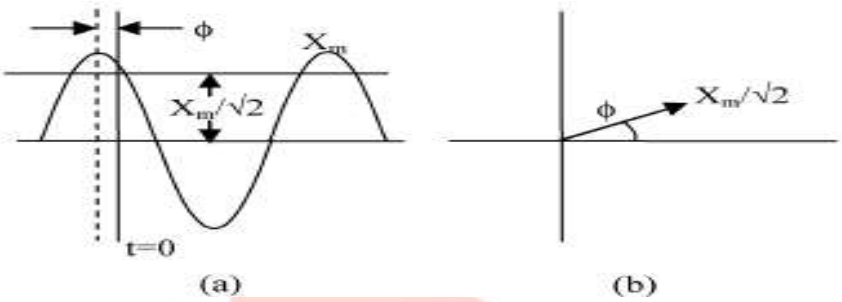
Thus, the GPS receivers were very expensive because of the need to keep the time accurately up to the next satellite came into view. Today this problem has been overcome because the satellite system is complete leading to a large drop in the prices of GPS receivers which can now be purchase for a few hundred dollars.

(C) Definition of PMU

"Phasor measurement unit (PMU) device is measure the electric waves on an electricity grid, using common time source for synchronization. Time synchronization is allows synchronized real-time measurement of multiple remote measurement points on the grid." PMU measurements are used in power systems and high speed and low cost communication systems to worked based on a layer model, are also well-established in power systems.

A PMU at substation measures voltage and current Phasor with microsecond accurate time- tagging of the measurement. PMU computes power transmitter the measurement (MW/MVAR) and frequency. Measurement are reported at rate of 10-60 sample per second.

PMU measures the system was magnitude of voltage and phase angle of a particular location at a rate of multiple samples per second. This data is time stamped through a common reference and transmitted to the Phase Data Concentrator (PDC) installed at a nodal point, through high speed communication medium.



Sinusoidal signal Phasor representation

Figure 3.1 Phasor representation of a sinusoidal signal

(D) Block diagram of PMU

1. Anti-aliasing Filter

Anti aliasing Filtering a signal by sampling to remove components of that signal whose frequency is equal to or greater than the nyquist frequency and not removed, these signal components as a lower frequency component. Then Sampling frequency must be greater than the maximum frequency of the signal to be sampled. If lower sampling rates are used then original signal's information may not be completely recoverable from the sampled signal and they may appear as aliases.

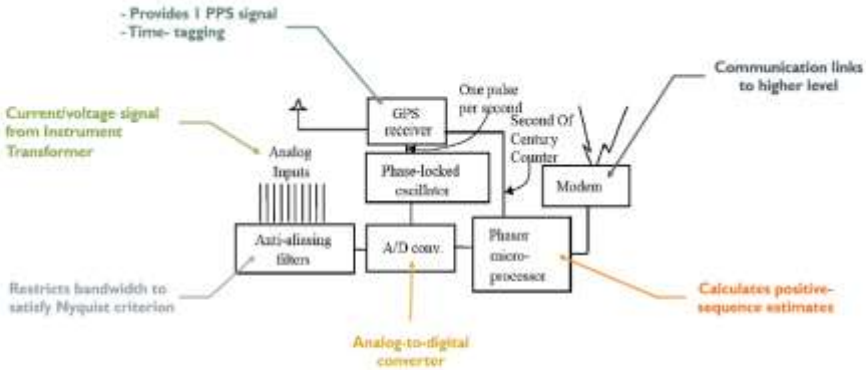


Figure 3.2 Block diagram of Phasor Measurement Unit (PMU)

2. A/D converter

The Analog to digital converter digitizes the analog signal, from the AAF (Anti Aliasing Filter),at sampling instants defined by the sampling time signals from PLO. These digitized samples are then fed to the phasor microprocessor.

3. GPS (Global Positioning System)

Global positioning system is a satellite based navigation system information about place and time irrespective of weather conditions. It consists of a network of 24 satellites orbiting in 6 geo visible from any point on the earth surface.

Synchronization is achieved by using GPS technology which contain:

- 24 satellite in 6 orbital planes
- Orbit time: 12 hours
- Signals: Position, Velocity and Time
- Visibility: 5 to 8 satellite from any place at any time

• 100 nanoseconds Time accuracy the original signal's information may

4. Phase locked oscillator

Usually in PMU, the pulse signals from the satellite are phase locked with the sampling clock. This job is a accomplished by phase lock oscillator. Analyzed in PLO divides is the phase locked oscillator system. Number of pulses are required into GPS signal from one pulse per second for sampling. These systems is 12 per cycle of fundamental frequency. The pulse number within one second interval is identified by the GPS time tag for sampling.

5. Phasor Microprocessor

It is programmed to calculate the positive sequence components from the digitized sampled data by using algorithm which is usually Discrete Fourier Transform (DFT) as described in. This calculated phasor is time-tagged. All the measured data are transmitted to the remote location through a proper communication channel using modems.

6. Phasor Data Concentrator (PDC)

Runs on normal desktop PC and collects data from multiple PMUs in PDC software application. Dedicated by Server application designed to accept several PMU data and analyze the data depending on application requirement.

(E) Comparison between SCADA and PMU

Attribute	***SCADA***	***PMU***
Measurement	Analog	Digital
Resolution	2-4 samples per sec	Up to 60 samples per sec
Observability	Steady state	Dynamic/ Transient
Monitoring	Local	Wide Area
Phase Angle Measurement	No	Yes
Time Synchronization	No	Yes
Measured Quantity	Magnitude MW & MVAR	Magnitude MW & MVAR Phase from common - reference, Angle difference

Table 3.1 comparison between SCADA and PMU

IV. SIMULATION AND RESULT ANALYSIS

SIMULATION

(A) MAIN SYSTEM

Simulation of the system is done using MATLAB Program as shown in Figure.

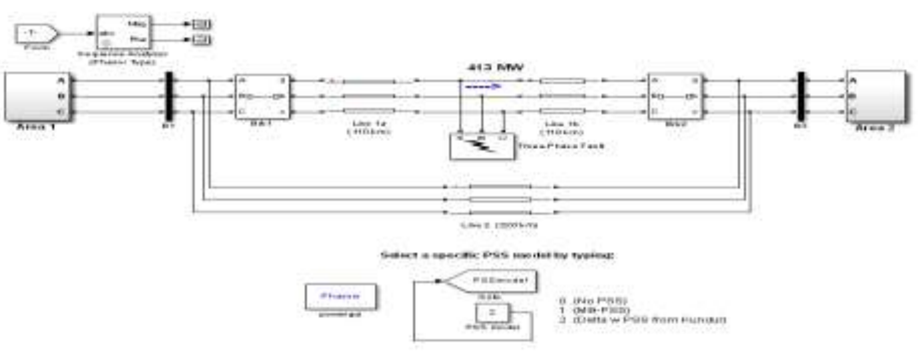


Figure 4.1 Two Area – Four Machine System

SUB SYSTEM : AREA 1

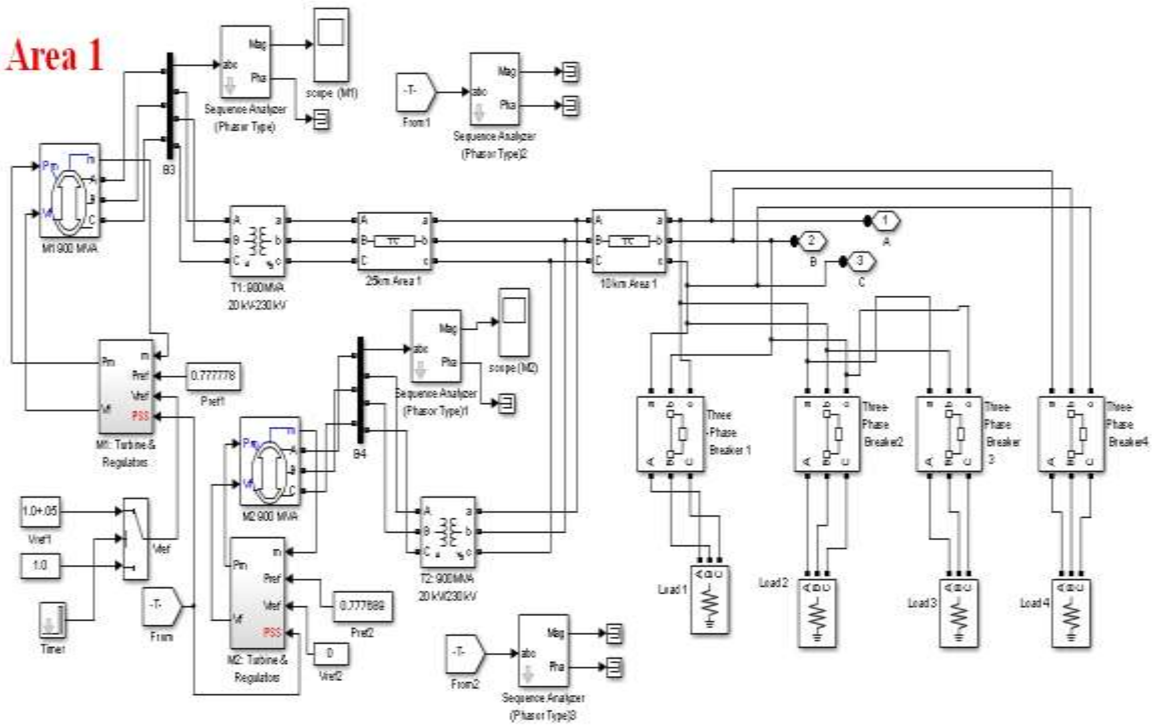


Figure 4.2 Area 1 Sub System

RESULTS

(B) Case Studies : AREA – 1

Case No.	**Detail of cases**
Case 1	All Load with 100 MW in Without PSS, Multi Band – PSS, Delta w PSS
Case 2	Increasing by 100 MW load in Without PSS, Multi Band – PSS, Delta w PSS
Case 3	Increasing by 200 MW load in Without PSS, Multi Band – PSS, Delta w PSS
Case 4	Increasing by 500 MW load in Without PSS, Multi Band – PSS, Delta w PSS

Table 4.1 Varies Case studies

(C) varies load in time duration

LOAD	**Starting Value**	**Initial Value**		
	CASE 1	**CASE 2**	**CASE 3**	**CASE 4**
1	100	100	300	800
2	100	200	400	900
3	100	300	500	1000
4	100	400	600	1100

Table 4.2. Area 1 connected varies load in time duration

CASE – 1 All Load are 100 MW

MACHINE – 1 in AREA 1:

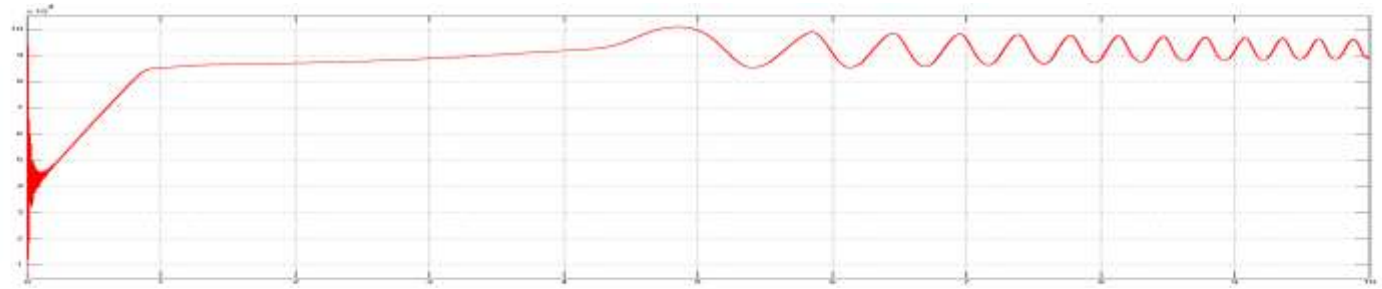


Figure 4.3 Without PSS in Machine 1

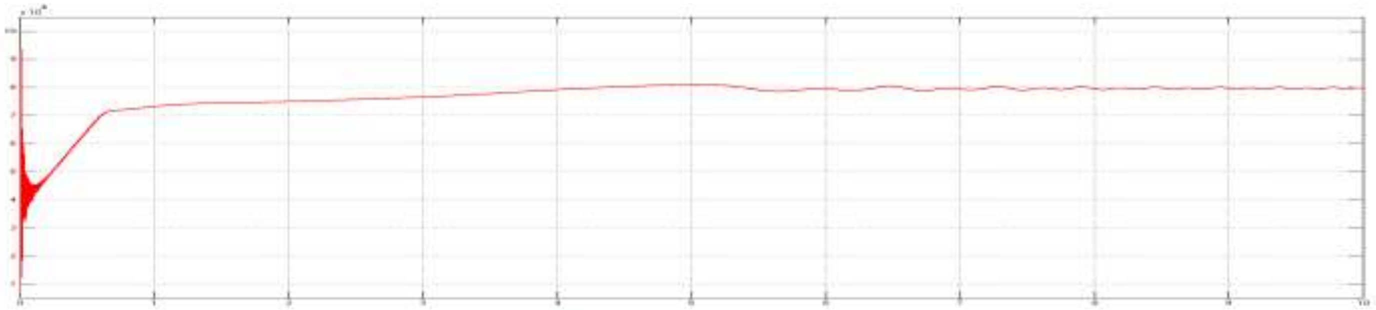


Figure 4.4 MB - PSS in Machine 1

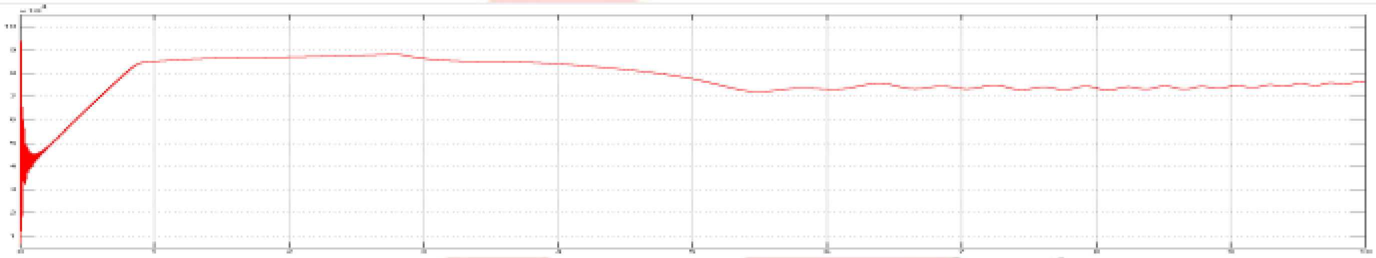


Figure 4.5 Delta w PSS in Machine 1

CASE 2 Increasing by 100 MW load

MACHINE – 1 in AREA 1:

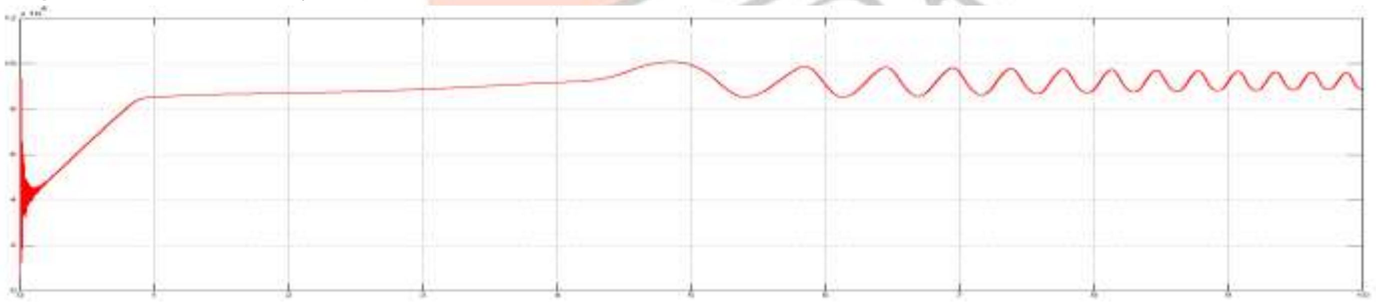


Figure 4.9 Without pss in Machine – 1

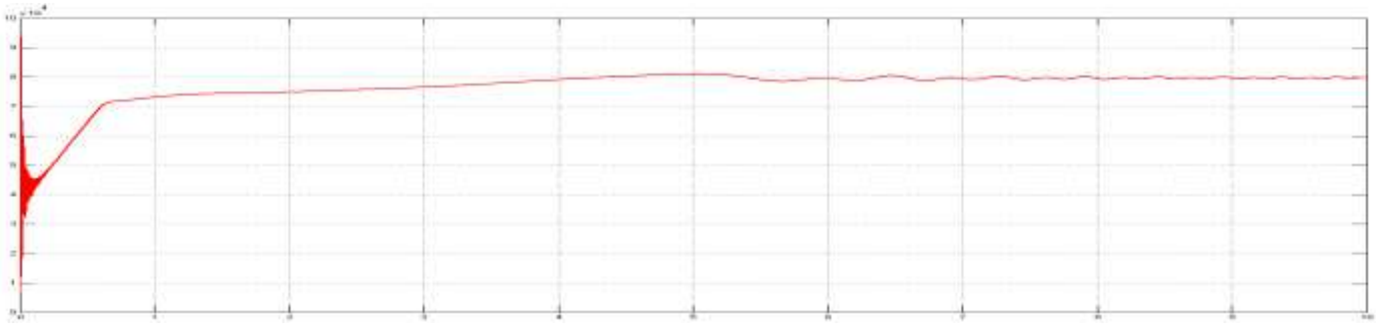


Figure 4.10 MB - PSS in Machine – 1

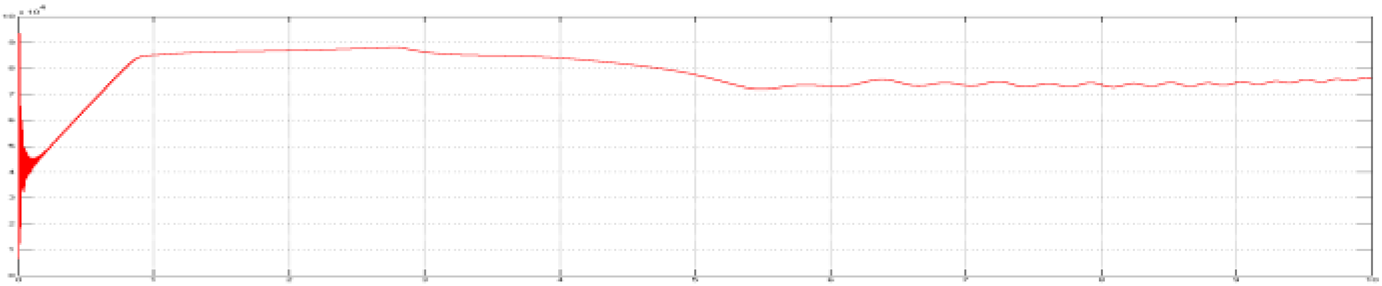


Figure 4.11 Delta w PSS in Machine - 1

CASE 3 Increasing by 200 MW load

MACHINE – 1 in AREA 1:

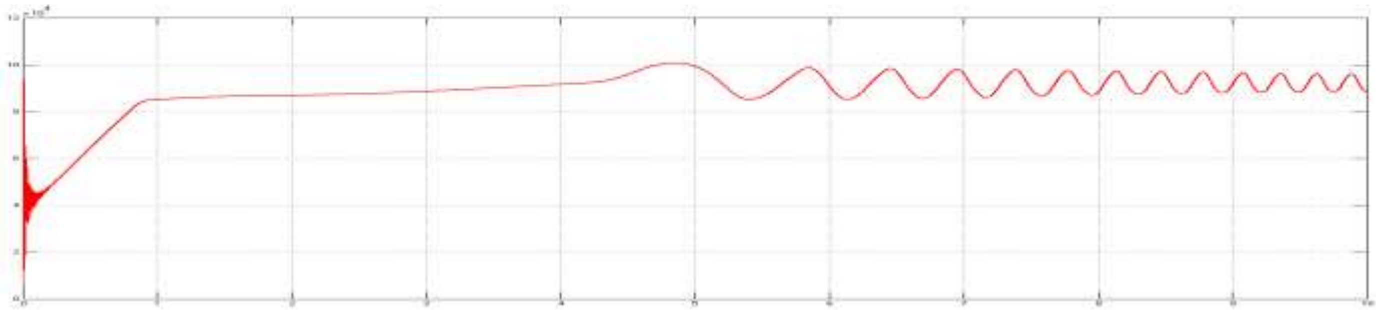


Figure 4.15 Without pss in Machine – 1

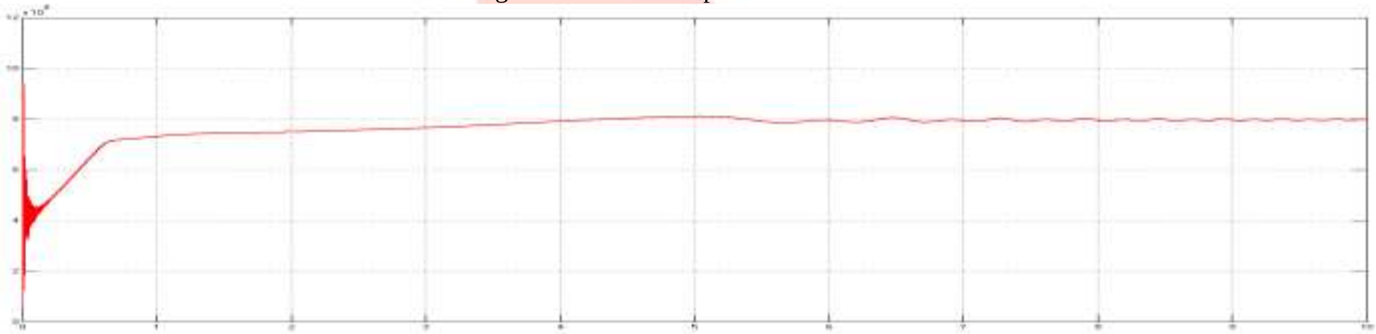


Figure 4.16 MB - PSS in Machine – 1

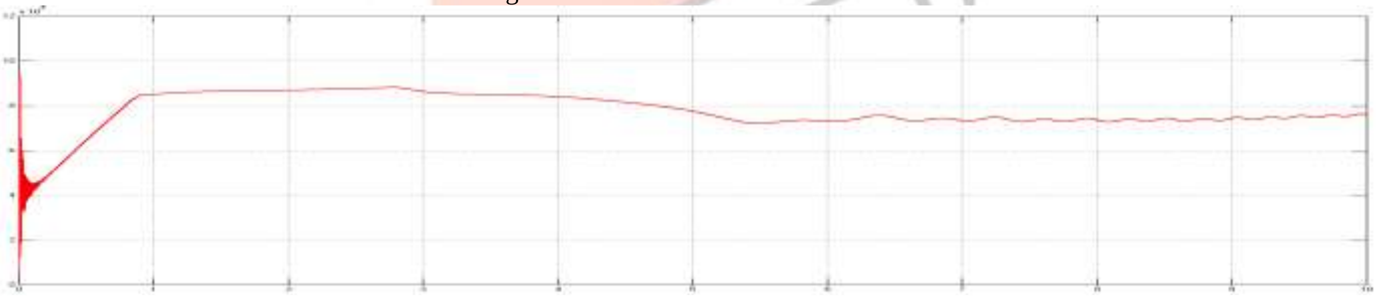


Figure 4.17 Delta w PSS in Machine – 1

Case – 4 Increasing by 500 MW load

MACHINE – 1 in AREA 1:

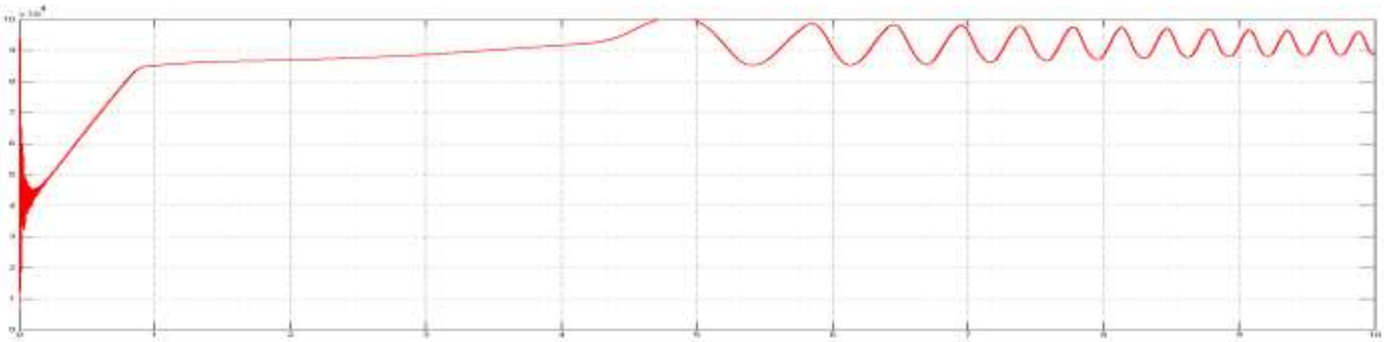


Figure 4.21 Without pss in Machine – 1

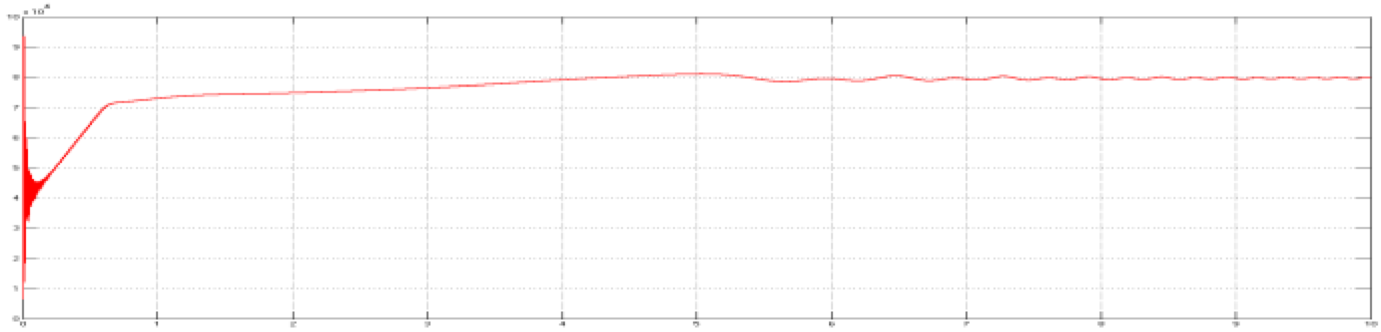


Figure 4.22 MB – PSS in Machine – 1

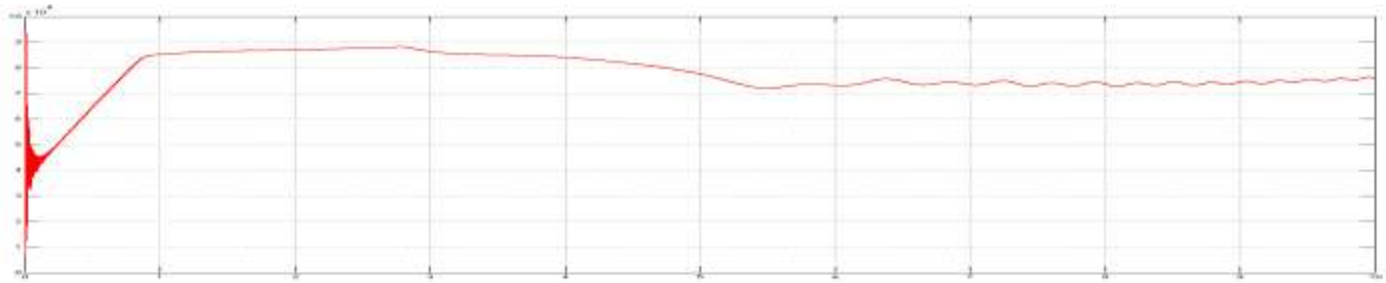


Figure 4.23 Delta w PSS in Machine – 1

CONCLUSION

- By designing of the two area method in MATLAB tool box conclusion results in different condition is define following table;

No	Methods	Conclusion
1	Without PSS	Oscillation damping is Less
2	MB PSS	Oscillation damping is high compare to without PSS method
3	Delta w PSS	Oscillation damping is high compare to MB PSS method

- Now, conclude that MB PSS is better to Delta w PSS in damp out to oscillation.
- Wide area measurement is possible with the -implementation of phasor measurement unit.

APPENDIX

LFO - Low frequency oscillations
PSS - Power System Stabilizers
PMU - Phasor Measurement Unit
WAMS - Wide Area Measurement System
WPSS - Wide-Area Power System Stabilizers
AVR - Automatic Voltage Regulators
SPMs - Synchronized phasor measurements
FACTS - Flexible Alternating Current Transmission
HVDC - High Voltage Direct Current
SVC - Static Var Compensator
TCSC - Thyrister Controlled Series Capacitor
WSCC - Western System Coordinating Council
GPS - Global Position System
PDC - Phase Data Concentrator
AAF - Anti Aliasing Filter
SCADA - Supervisor Control And Data Acquisition

GPS - Global Position System
DFT - Discrete Fourier Transform
ADC - Analog to Digital

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REFERANCES

[1] Prabha Kundur, " Power System Stability and Control", McGraw Hill, Inc. New York.
[2] Richard G. Farmer, "Power System Dynamics and Stability", Boca Raton: CRC Press LLC, 2001
[3] A.G. Phadke and J.S. Thorp, "Synchronized Phasor Measurements and Their Applications", spinger
[4] S.R. Bhide , Digital Power System Protection, PHI publication.
[5] "Analysis of Power System Oscillations for Developing Synchrophasor Data Applications", by Luigi Vanfretti, Joe H. Chow, IEEE Transaction 2010.
[6] "Real-Time Phasor Mensurement for Low Frequency Oscillation in Power System" by Yutian Liu, Chi Xiao, Yuanyuan Sun; IEEE Transaction 2005.
[7] "Synchronized Phasor Measurements and Their Applications " by A.G. Phadke , J.S. Thorp,Jaime De La Ree ,IEEE Transaction 2010.
[8] "Identification Of Low Frequency Oscillations In Power System" by S. Avdakovic, A. Nuhanovic, M. Kusljugic, E. Becirovic, IEEE Conferenace 2010.
[9] "Applications of phasor measurement units (PMUs) in electric power system networks incorporated with FACTS controllers" by International Journal of Engineering, Science and Technology, IEEE Transaction 2011.
[10] "Monitoring and Control of Power System Oscillations using FACTS/HVDC and Wide area Phasor Measurements" by http : //www.cigre.org, 2012.
[11] "Synchrophasors : Definition, Measurement, and Application" by Mark Adamiak, William Premerlani , Dr. Bogdan Kasztenny , IEEE Conference.
[12] M. Klein, G.J. Rogers, P. Kundur, "A Fundamental Study of Inter AreaOscillations in Power System" IEEE Transactions on Power System, Vol.6, No.3, Aug 1991.