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Enhancement of Power System Dynamic Voltage Stability With Grid Connected Wind Power Plant

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Abstract — *Wind farms influences dynamic performance in power system and so wind energy penetration in power grid has increased tremendously over the time. The wind farm performance now became a concern such as to make appropriate stability analysis and their system models. This study aids to develop stability for the power system model in which aggregated wind machines like induction machine and conventional machines like synchronous machine operate together. In the system the induction generator operating with a synchronous generator is proposed and compared with a synchronous generator model. A power system stabilizer (PSS) with induction generators is also considered to improve the voltage stability performance of the system by damping the power system oscillations.*

Keywords- *WECS, Wind power genration, grid interconnection, asynchonous generator, power system stabilizer(PSS), voltage stability*

I. INTRODUCTION

As a result of increasing environmental concern, more and more electricity is generated from renewable sources. Renewable energy can contribute to securing energy supplies and smoothen the transition to a fossil free economy. Renewable energy replaces conventional fuels in electricity generation. Renewable energy provides 19% of electricity generation worldwide. Wind power is one of the most competitive renewable technologies and, in developed countries with good wind resources, onshore wind is often competitive with fossil fuel-fired generation. Wind power generation has experienced a tremendous growth in the past decade, and has been recognize as an environmental friendly and economically competitive means of electric power generation [1]. This Paper explains the structure of WTGs, operating characteristics of WTGs, types of WTGs, interconnection of WTG with electric power systems and the impact of WTGs on performance of power system. The objectives of this research work are explained in detail.

I. A Methodology for Revelency Evaluation of Wind Generation Integration in Power System

In a present day the exponential growth of the number of wind generators, the continuous increase of the rate of power of single turbines and the particular generation condition of wind turbines makes evaluation of the compatibility of wind generators and the power systems necessary. In order to analyze wind generation compatibility in power systems four factors may be taken in account[2]

A. Electrical power system characteristics
B. Wind turbine technology
C. Grid connection requirements
D. Simulation tools

A. Electrical Power System Characteristics

The characteristic of the power system, for which the wind generation is connected to grid, influences affects highly the impact on power system stability and system power quality. Also some different parameter like voltage, Line impedance, short circuit power, are most important characteristics to limit the network capability to confess wind power generation.

Generally, the wind power generation is located in regions that have favorable wind conditions like hill station, low urbanization and a weakly developed distribution and transport power network.

B. Wind Turbine and generator Technology

Wind turbines are transforming the wind power to rotating mechanical power; it is usually at low speed and high torque. In order to convert power effectively and high speed, then necessary of use gear box .afterward convert to electrical power usually done by induction generator or synchronous generator.

From the above discussion also some setup are possible to give solution for gear less and without power electronic conversion, which power converter can be used an interface to grid.

C. Grid Connection Requirement

The foremost interconnection requirements for distributed resources can be summarized in the following three categories: general specifications, safety and protection, and power quality for all some of the general requirement is as below [2], [3]:

1. Voltage Regulation
2. Synchronization
3. Monitoring
4. Voltage Disturbances
5. Frequency Disturbances
6. Loss of Synchronism
7. Harmonics
8. Flicker

D. Simulation Tools

Once operations limits have been defined, the impact has to be analyzed by suitable simulation tools. The most complex task in this step is accurate modeling of the wind farm.

II. Power System Stability

Power system stability may be broadly defined as that property of a power system that enables it to remain in a state of operating equilibrium under normal operating conditions and to regain an acceptable state of equilibrium after being subjected to a disturbance. The complex interactions of the generating station, loads, transmission and distribution network are operating at different level. Before any complexities of power system dynamic stability has possible, at fundamental characteristic of basic system components and the factors are contributed to overall stability. The main purpose of the report is to know about all system and the how to control system component like as generator, prime movers and how to contribute to system.

Power System Stability may be depended into three main categories, depending upon magnitude of disturbances:**-**

A. Steady State Stability

Refers as ability of the power system to regain synchronism after small and slow disturbance, such as gradual power changes.

B. Transient Stability

Ability of the system to regain synchronism after a large disturbance. Due to sudden changes in application or removal of large loads, line switching operations.

C. Dynamic Stability

Denotes the artificial stability given to an inherently unstable system by automatic control devices. Dynamic stability is concerned with small disturbances lasting for times of the order of 10 to 30 seconds with the inclusion of automatic control devices. Voltage stability can represent by long term phenomenon. In term of voltage fluctuations occur due to fast acting devices like as induction motors, power electronic drive, HVDC then the time for understanding the stability is in the range of 10-20 s and hence this can be treated as short term phenomenon. Can be treated as short term phenomenon.

III. Power System stabilizer

In 1960's the power system generations were being operated with continuously voltage regulators only. When the system become large interconnected to each other then the low frequency power oscillation occur in power system. so to maintain the stability in interconnected system power system stabilizer is introduce with the excitation system which help for the excitation of continuous operation of power system. The power system stabilizer has advantages likes less costs, edibility and the implementation is easier in the power system. In power system generally the power system stabilizer are design on the basic of the linear control system theory. So these type of power system stabilizer are known as the conventional power system stabilizer (CPSS) in the power system to enhance the damping oscillations.**[4]**

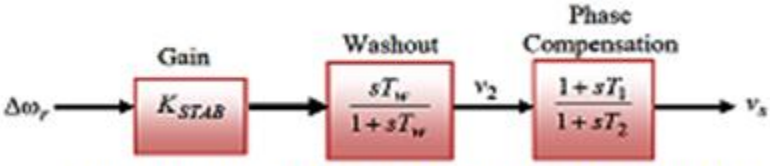


Fig. Structure of PSS (description of fig in detail)

(1) Gain:
It provides the amount of damping in PSS. Its gain sets at maximum damping of oscillatory modes. In practical high gain value not be good and create very high amplification in input in PSS. In general gain value should be set according to get satisfy results in damping without affecting the stability limits.

(2) Washout Circuit:
It eliminates the steady state bias in the output of PSS. It only respond to transient variation on the input signals only and not to the dc offsets of signals. Its act as high pass filter and pass all frequency of its interest.

(3) Lead-Lag Compensator:
Its gives phase lead-lag compensation between the exciter inputs and generator electrical torque. It's used for the multiple stage of lead-lag compensator use in practical requirements to provide for the compensation to the system.

(4) Limiter:
It's used for the limiting between generator terminal voltages which fluctuating during the transients conditions. The contribution of PSS if lager then terminal voltage of generator faces more fluctuation in system. So the aim is to select the output of PSS which allows the maximum forcing capability of stabilizer. The value of the limiters is between the 0.1 to 0.2 per units, but the minimum limits is -0.05p.u and -0.1 p.u.

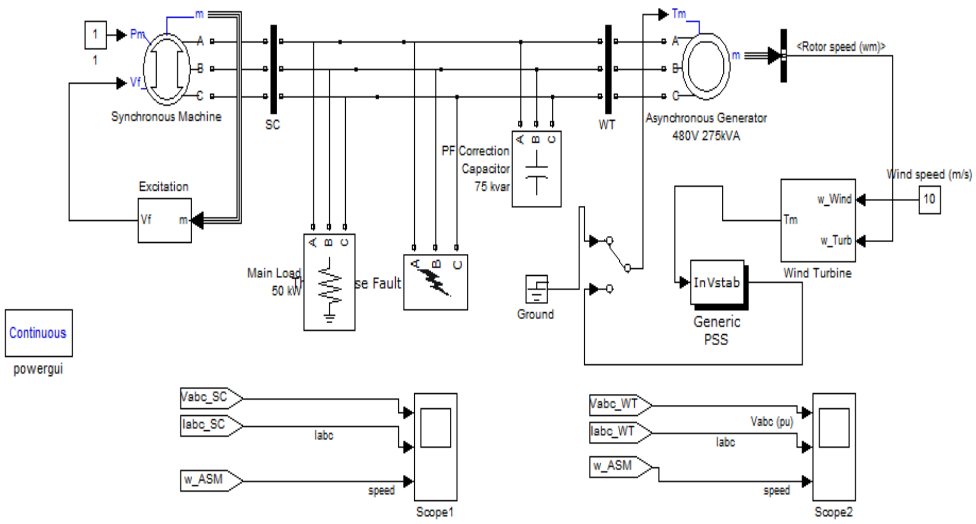
(5) Input of PSS:
The Power system stabilizer inputs signals shaft speed, frequency, change in load angle, change in electrical power etc are possible to use as input .However from practical point of view the following three types of input signals are most commonly used.
_ Rotor Speed Deviation (delta ώ)
_ Frequency Deviation (delta f)
_ Electrical Power Deviation (delta P)

IV. SIMULATION WORK & RESULT

Simulation model of Asynchronous Generator connected to grid synchronous generator through grid. This model developed by using SIMULINK MATLAB. The Simulation work has been performed for this wind turbine system at with and Without Fault condition. Asynchronous generator voltage is 3-phase, 415 V (rms), 50 Hz & Synchronous generator 480V supply Capacity of 300kVA. Load is connected between the two source is around 50kW. Also with this fig.(1) for Simulink Diagram of wind power connected with the grid. & fig.(2) for Waveform of Wind Power plant without PSS and fig.(3) for Wind Power Plant with PSS.

Here in Fig.3 & Fig 4 we can see that the Voltage Clearing Time has been improved. Using the Power System Stabilizer the fault clearing time can be improved. Here we have used one turbine connected to grid; elsewhere we can connect number of wind turbine (Wind Farm) to improve the dynamic stability of the system. In the fault location block in this system we done all three phase faulted so system became the dynamically disturb for a large time. Here we use the Power System Stabilizer for the improvement of Stability. Also we could be used FACTs device like SVC and STATCOM to improve the voltage stability inject the reactive power in the system. For the result refer the following table:

SR. NO.	**Asynchronous Machine With & Without PSS**			
	status	***fault time***	***fault clearing***	***machine speed***
1.	Without PSS	1-2 s	2.8 s	1.2 to 1.5 p.u.
2.	With PSS	1-2 s	2.2 s	0 to 0.8 p.u.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Excitation
SC
WT
Asynchronous Generator
480V 275kVA
PF Correction
Capacitor
75 kvar
Main Load
50 kW
Wind speed (m/s)
Wind Turbine
Generic
PSS
Ground
Continuous
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Scope1
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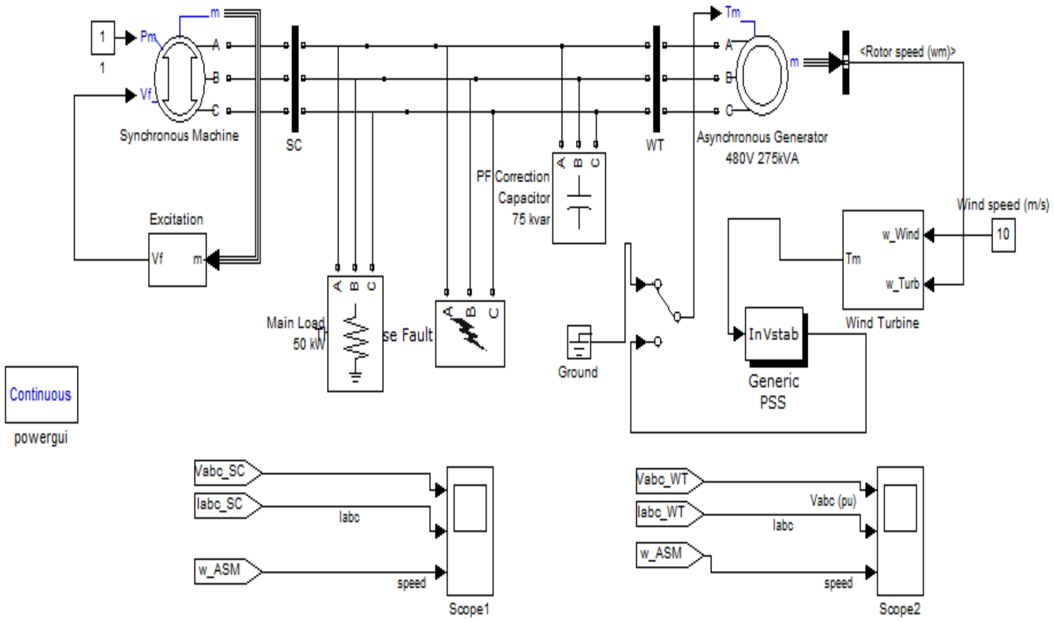
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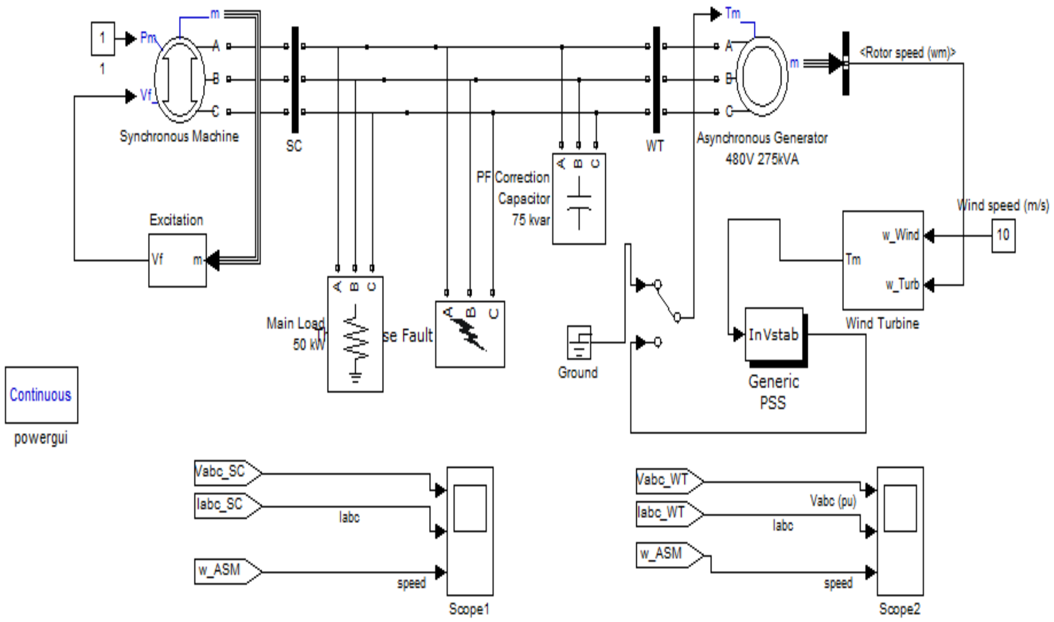
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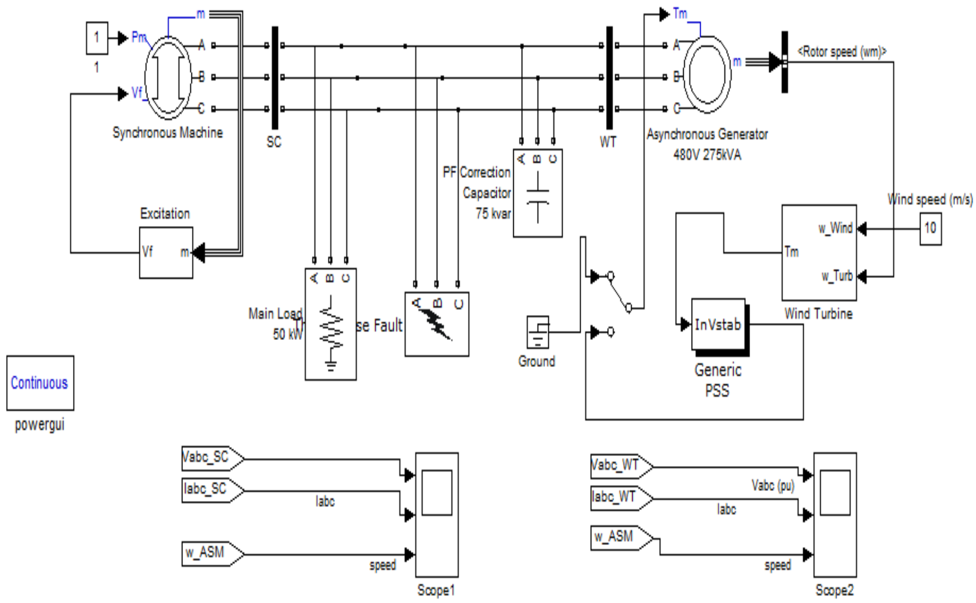
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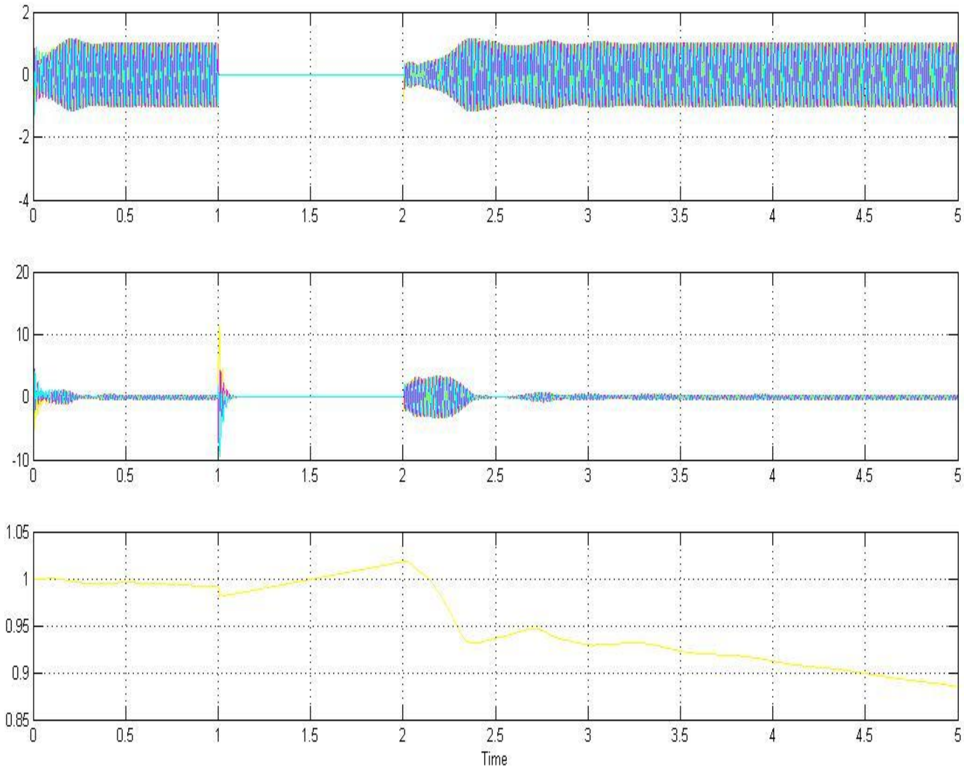

Fig.(2) Waveform of Wind Power plant Without PSS

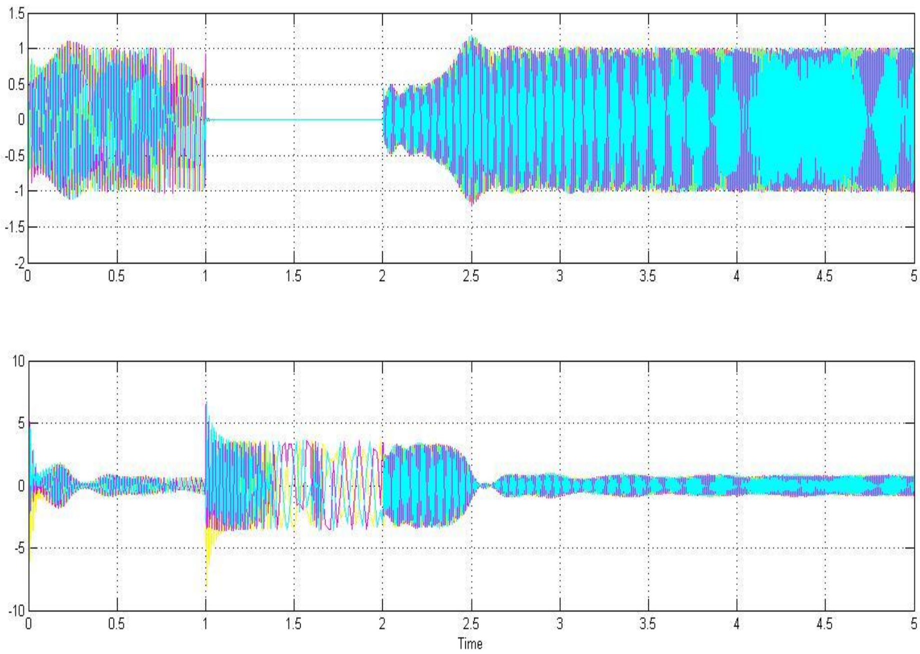

Fig.(3) Waveform of Wind Power plant With PSS

V. CONCLUSION

Wind power integration system with Power System Stabilizer has damping effect, can reduce oscillation of rotor angle difference and improve the voltage stability. It also observed that from the dynamic stability result of the combine model of induction generator and synchronous generator is reliable and produces the quite effective result. Power system stabilizer linked with the wind generator (induction generator) is considered to improve the stability performance of the system by damping the power system oscillation.

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