TECHNICAL PAPER

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SMALL SIGNAL STABILITY ANALYSIS OF POWER SYSTEM WITH WIND GENERATION USING OPTIMIZED WIND PSS

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Abstract- This paper primarily focuses on Small Signal Stability Analysis of power system integrated with Wind Generation. Power System Stabilizer (PSS) is used with Wind Generation to investigate its effectiveness in damping out Local Area (Plant Mode) Oscillations. The effects are analyzed on 9-Bus Test System using established modeling and simulation techniques. Using SMIB based generator model, AVR lag and Oscillation Frequency are evaluated. Based on these calculations, Wind PSS is then modeled and introduced to provide the necessary damping thereby enhancing the system performance. The Local Area speed variations are used as the Reference Signal for Wind PSS to analyze its performance under Small Disturbances. Results validate the effectiveness of Wind PSS in damping the local area oscillations thereby enhancing small signal stability.

Index Terms – Small Signal Stability, Power System Stabilizer (PSS), Heffron-Phillips Model , Local Area Oscillations, Inter Area Oscillations.

I. INTRODUCTION

NERGY is the controlling variable for progress in modern world. The global demand for energy is increasing at a much higher rate owing to the rapidly developing world. The environmental constraints being the greatest challenge have compelled the utilities to meet this demand by increasing reliance on renewable energy sources. Renewable Distributed Generators (RDG) based power systems provide a good framework for incorporating the unconventional energy sources into the power system as it enhances system security and reliability.

The Modern Power Systems are dominated by High Integration of Wind Generation that is conventionally based on Induction Generators. The High Penetration of Wind Generation affects the dynamics of power system in multiple ways. The Wind Generators are less stiffly coupled to the power system than Synchronous Generators. However, an important benefit of Wind Generators is the inherent damping characteristics against oscillations due to the fact that the Torque of Induction Generators is proportional to the Speed Deviation or Slip[2].

In this paper, the effects of Integrated Wind Generation on Small Signal Performance of Power System are analyzed. Wind Power System Stabilizers (PSS) are modeled and implemented to study the effects on Local Modes and Inter

II. SMALL SIGNAL STABILITY

Generally, power systems are always liable to small disturbances resulting from minor load changes to changes in mechanical inputs of system generators. Under these small disturbances the power system state variables follow transient oscillations with frequencies known as Eigen Frequencies or Modes of Oscillation. These modes of oscillation generally results from electromechanical interactions in generators and exciter-field voltage-current responses. The study of such transient effects is called as Small Signal Analysis.

The ability of the power system to maintain synchronism after subjected to small variations in load or generation is termed as Small Signal Stability. The nature of system response depends on a number of factors; however, the excitation controls are of primary concern. Generally, the instability may be caused due to lack of sufficient damping torque, thereby, resulting in rotor oscillations of increasing amplitude.

In practical power systems, the issue of small signal stability is associated with insufficient damping of oscillations. Generally, the following Modes of Oscillations are analyzed:

- Local Modes i.e. associated to the oscillations of Power Station with respect to the rest of the Power System [1].
- Inter Area Modes i.e. associated to the oscillations of Independent Groups of Power Units with respect to each other. The Groups of Power Units are located in different parts of the Power System and connected by weak ties [1].

III. POWER SYSTEM STABILIZERS

Power System Stabilizer is a device employed to quickly dampen the generator electromechanical oscillations. When a disturbance occurs, the generator speed and power will vary according to the swing equation about their steady state operating point:

$$\frac{2H}{\omega_o}\frac{d^2\delta}{dt^2} = T_m - T_e$$

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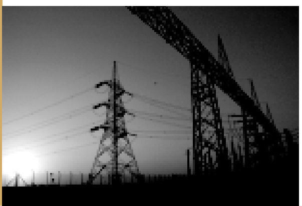
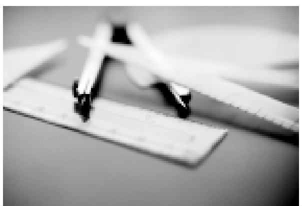


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