



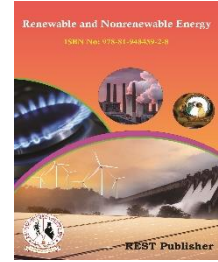
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Damping of Power System Oscillations Using Wind Power Plant

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Abstract: During the last few years' wind power has emerged as one of the most important renewable source in the power generation share. Due to stringent Grid Code requirements, wind power plants (WPPs) should provide ancillary services such as fault ride through and damping of power system oscillations to resemble conventional generation. . Through an adequate selection of electrical signal pairs, WPPs can be effectively used to provide electromechanical oscillations damping. As a consequence of increased wind power penetration levels, transmission system operators (TSOs) are concerned with system stability. Wind power plants (WPPs) are required by TSOs to meet Grid Code requirements and sometimes to behave as conventional power plants capable of providing support to the power system when requested to maintain stability. Power system stability is divided in three main groups depending on the response of the system to a fault: frequency, rotor angle and voltage stability. Wind power plants can also be effectively used to provide electromechanical oscillations damping. The physical location of the WPP plays an important role when defining the possible input and output signals for oscillation mitigation and avoids the use of Flexible Alternating Current Transmission Systems (FACTS) devices.

Keywords: wind turbines, induction generator, FACTS.

1. INTRODUCTION

A large power system has many interconnections and bulk power transmissions over long distance. Due to this their low frequency inter area oscillations which make system vulnerable to cascading failures. Many different methods have been proposed to alleviate the oscillations in the power system. For many years, power system stabilizer (PSS) has been one of the traditionally devices used to damp out the oscillations. It is reported that during some operating conditions, PSS may not mitigate the oscillations effectively; hence, other effective alternatives are required in addition to PSSs. On the other hand, the advent of flexible ac transmission system (FACTS) [6] devices has led to a new and more versatile approach to control the power system in a desired way. FACTS controllers provide a set of interesting capabilities such as power flow control, reactive power compensation, voltage regulation, damping of oscillations, and so forth. The static synchronous series compensator (SSSC) is one of the series FACTS devices based on a solid-state voltage source inverter which generates a controllable ac voltage in quadrature with the line current. By this way, the SSSC emulates as an inductive or capacitive reactance and hence controls the power flow in the transmission lines. In the literature, different methods have been proposed to design a damping controller for SSSC. For example, in authors have used the phase compensation method to develop a supplementary damping controller for SSSC. The main problem associated with these methods is that the control process is based on the liberalized machine model. The other frequently used approach is the proportional-integral (PI) controller. Although the PI controllers offer simplicity and ease of design, their performance deteriorates when the system conditions vary widely or large disturbances occur]. In this context, some new stabilizing control solutions for power system have been presented. Recently, fuzzy logic controllers (FLCs) have emerged as an efficient tool to circumvent these drawbacks. This paper addresses the study of power system oscillations damping with the help of wind power plant which are near to the load Centre. In general, to attenuate the power oscillations FACTS devices will be used but when there is wind plant near by the load centre it is advised to use it as a damping device. The oscillations may be local to a single generator or generator plant (local oscillations), or they may

involve a number of generators widely separated geographically (inter-area oscillations). These oscillations cause improper of the power system incorporating losses. Local oscillations often occur when a fast exciter is used on the generator, and to stabilize these oscillations. Wind power plants which are interconnected with the conventional power plants needs some amount of power for maintaining stability. This is because of the wind is not continuous throughout the operation of the wind power plant. When the wind is not sufficient to generate the power, the wind plant takes the power from the power system network to get rid of low wind speeds. On the other hand, when the wind is too high it delivers more amount of power to the power system.

2. CONTRIBUTION OF WPPS TO DAMP POWER SYSTEM OSCILLATIONS

WPPs comprising variable-speed wind turbines only (either based on doubly-fed induction generators or fully-rated converters) exhibits dynamics which are considerably faster than the synchronous frequency and the electromechanical dynamics found within power systems. Decoupling of WPPs from network dynamics can be achieved through the use of power converters. For these reasons, WPP models can be simplified for small-signal stability analysis. WPPs regulate the active power delivered to the grid through an adequate control of the generator-side converter. The aim is to transfer the maximum active power from the wind turbine following an optimum wind power extraction. On the other hand, reactive power regulation is achieved through the control of the grid side converter. Due to the availability of active and reactive power measurements for converter control, these could be used potentially as control signals for damping controllers. In general, either local or remote measurements could be selected as input signals for a damping controller sitting at a WPP, where electrical variables can be represented, for convenience, as phases (i.e., in terms of their magnitude and phase angle). It should be emphasized that the input output pair (or pairs) selection largely influences the performance of power oscillation

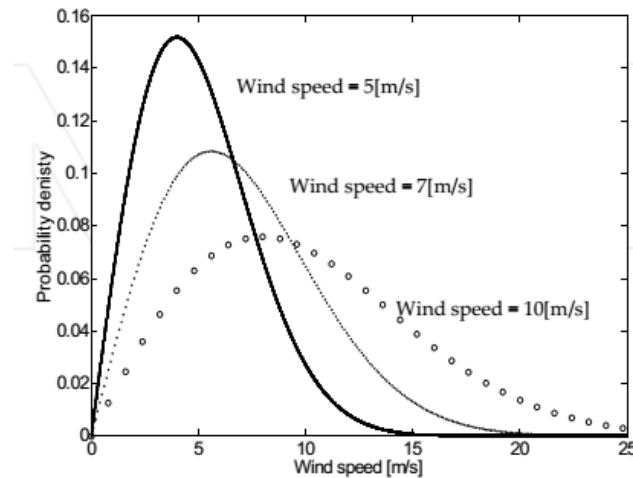


FIGURE 1. Wind probability density distribution

Critical for the case of WPPs, since they can be located far away from the synchronous generators where electromechanical oscillations originate. If power oscillation damping is provided by WPPs, the system inputs (or control signals) could be the active (P_{wt}) and the reactive power (Q_{wt}) delivered by the WPP. Conversely, the outputs (or measured signals) could be defined as the voltage magnitude (V_{wt}) and the voltage phase angle (θ_{wt}) at the point of connection of the WPP. The availability of these signal measurements provides different control alternatives, including both SISO and MIMO control schemes. For instance, if a SISO controller is considered.

3. CASE STUDY

A wind farm does not operate all the time so backup capacity is needed when it does not and differences between forecast and actual production have to be balanced. Balancing and backup comes at a cost, as does building new infrastructure. These facts apply to wind energy just as they apply to other power producing technologies that we integrate into the electricity grids. But for reasons that are difficult to grasp, balancing and backup of wind energy is generally perceived to be problematic whereas balancing and backup for other technologies seems as easy as breathing. Certainly, most of the mainstream media does not find it interesting to report the complexities of balancing a constant supply of nuclear power or inflexible coal-fired power against the demand from millions of consumers, with their constantly changing and unpredictable demands for power.

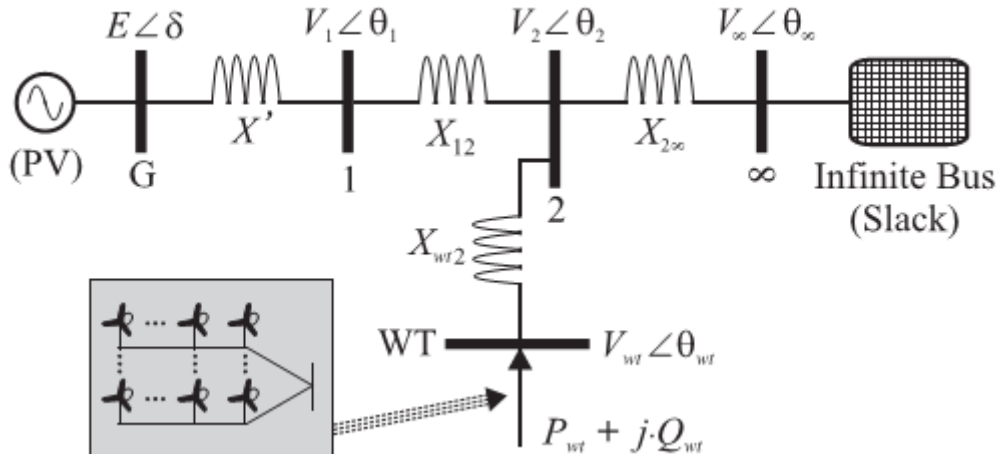


FIGURE 2. interconnection of wind and conventional power plant.

The control signals or system inputs are frequency, voltage, active power and reactive power. The reactive power is directly related to the voltage and the active power is directly related to the frequency of the rotor. Any change in the rotor speed and voltage on the bus will adversely affect power and reactive power of the wind power plants. The swept area of the wind turbine can be calculated from the turbine length of the rotor blade using the equation for the area of a circle. The change in wind speed is more common in the wind plant and the change in voltage on the bus of WPP is less pronounced. So confine our study to only active power which will directly relate to wind speeds. So the damping of oscillations means active power damping. This project study was done at Pawan Wind Energy Services which gets its generators and maintaining equipment from Bharath Heavy Electricals Limited. The plant has 16 individual generators and each having 250KW rating. The overall plant capacity is 4MW.

The characteristics of generator are given below:

Rotor:

Diameter	: 2m
No of blades	: 3
Rotor speed range	: 4 rpm to 12 rpm
Rotational direction	: clock wise
Orientation	: upwind
Speed regulation	: pitch control
Aero dynamic brakes	: full feathering
Yaw rate	: 0.5degrees/sec

Wind speeds:

Cut in wind speed	: 4 m/s
Rated wind speed	: 10 m/s
Cut-off wind speed	: 20m/s
Survival wind speed	: 25 m/s

Electrical parameters:

Rated voltage	: 440 volts (3-phase)
Rated power	: 250 KW

The stability of the wind plant is mainly affected by the intermittent wind speeds. When there no adequate amount of wind speed to generate the power the wind plant has to take power from nearby power system network. So wind plant not only supplying power to the power system network but also gets power from it for maintaining stability caused by wind intermittent. The power generation and consumption of wind plant for the year 2014-15 is listed below on the monthly basis. The net power generated is also listed.

TABLE 1.

	Power Generated (MWH)	Power Consumed(KWH)	Net Power dispatched from plant (MWH)
May	400	40	360
June	600	90	510
July	550	66	484
August	320	22	294
September	200	9	191
October	150	11.7	138
November	130	9.1	120.9
December	320	44.8	275.2
JAN	360	57.6	30.24
FEB	270	35.1	23.49
MAR	240	12	2.28
APR	280	25.2	2.548
TOTAL	3820	422.5	3397.5

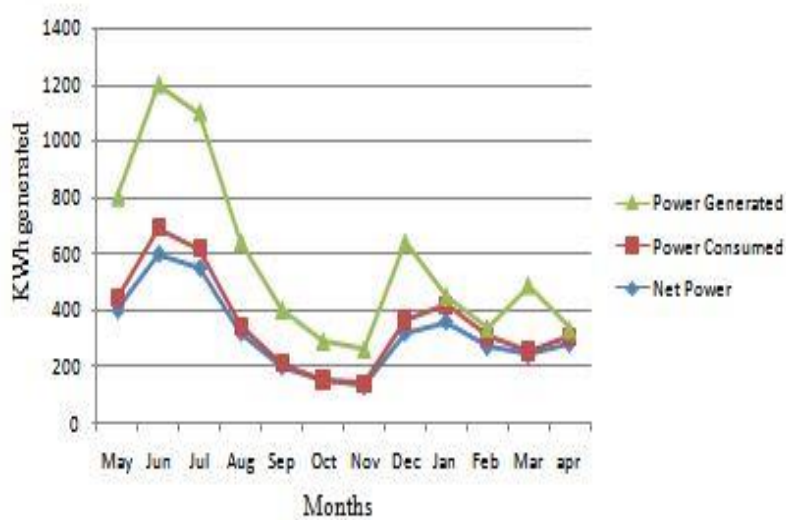


FIGURE 3. Graph of Annual power generation vs. months

For the year 2014-15 the wind plant has the following power generation levels

- Power generation = 38, 20,000 units
- Power consumption = 4, 22,500 units
- Net power generation = 33, 97,500 units

4. CONCLUSION

When the electrical load is nearby any wind power plant it is desirable to use the wind power plant for maintaining the system stable. Since the wind power plant can be used not only supplying power to the load but also for damping of its oscillations when the load is under varying conditions i.e. lightly loaded or heavily loaded conditions. When the power system is subjected to varying load conditions i.e. lightly loaded and heavily loaded conditions, the entire system starts oscillating, this because there is an imbalance between generation and consumption of active and reactive powers. Generally, these imbalances in powers can be damped out by FACTS devices. This situation can be handled by the wind plant by supplying power to the load and when heavily loaded condition and it takes the power from the load when lightly loaded condition. So there is no necessary to use these FACTS devices when win power plant is nearby power system network. From this study it is concluded that the use of FACTS devices can be avoided by the wind power plant for damping of power system oscillations. Generally, the electrical energy generated by the wind power plant will be sold at a particular tariff to the local distribution companies. The wind intermittent causes reduction in electricity generated and the tariff imposed on the wind plant for consuming electrical energy is minimised because the wind plant

will be used for damping of load oscillations and avoids the use of FACTS devices.

REFERENCES

- [1] Kaplana Sinha¹ Pawan C Tapre², Enhancement of power system stability using PSS in wind farm distribution generation IJETAE journal.
- [2] Rosella Sadikovic¹ Petr Korba² Goran Andersson³ application of FACTS devices for damping of power system oscillations IEEE transactions.
- [3] Ravindra Sangu¹, Veera Reddy.V.C², Sivanagaraju.S Damping of power system oscillations by SSSC equipped with a hybrid damping controller.IJAREEIE journal
- [4] surekha manoj¹ puttaswamy palahalli srinivasaia² Improvement of power quality of grid integrated wind distributed generation by STATCOM. IJEAT journal.
- [5] Ahmed G. Abo-Khalil¹Impacts of Wind Farms on Power System Stability
- [6] Bindeshwar Singh¹Introduction to FACTS Controllers in Wind Power Farms. IJRER journal.