European Association for the Development of Renewable Energies, Environment and Power Quality (EA4EPQ)	International Conference on Renewable Energies and Power Quality (ICREPQ'11) Las Palmas de Gran Canaria (Spain), 13th to 15th April, 2010

Reliability and Predictions of Power Supplied by Wind Power Plants

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Abstract. The paper deals with the reliability analysis of electrical power supplies from renewable sources. It focuses primarily on wind power stations which provide variable, stochastic power supply to the distribution and transmission network. Results from application of wind power plant power flow measurement methodology are shown in this paper. We apply measurement methodology to two wind power plants in different localities and we analyze measured values. In the last part is a description of the prediction model developed at the Technical University of Ostrava

Key words

Wind power plants, power measurement, prediction model.

1. Introduction

Reliability of supply of electric power from renewable resources is important with respect to operators and electric power distribution and super grids.
Any unstable and stochastic supply of electric power results in higher requirements for controls backup volumes and the continuously increasing installed output of RES (Renewable Energy Resources) present a risk to the electric power networks.

Prediction of output from renewable resources then plays a specific role both from the prospective of operators of electric power distribution networks and super grids as well the operators of wind power plants. There are currently several prediction models in place, varying by different levels of prediction accuracy. The Technical University of Ostrava is concerned with development of the wind power plant simulator – Wind Power Forecast – which uses the output curve, wind speed and wind direction to predict the output volume for a specific wind power plant.

2. Reliability of Supply from Renewable Power Resources

Reliability is generally defined as an essential characteristic of a certain object comprising its ability to perform specific functions while maintaining the determined operation indicators within set limits and with adherence to timescales in compliance with defined technical conditions.
The reliability of supply of power from renewable power resources can be divided into two categories:

- Renewable power resources with the ability to ensure stable and continuous supply of power. This category might as well include the biomass, which allows for long-term accumulation (storage).
- Renewable resources with variable and stochastic nature of power supply. This category includes wind and solar power plants.

The reliability of power supply represents the ability of the transformation chain to supply the product of such quality as needed at a specific time, or even throughout a certain time period, and required by a specific appliance and it can be generally expressed as follows [1]:

$$R_{W,T} = \frac{W_{d,T}}{W_{est,T}} \quad (1)$$

where $W_{d,T}$ power actually supplied over the time period T
$W_{est,T}$ expected supply of power over the time period T

The reliability of power supply at the resource depends on the option for output prediction. Especially wind or solar power plants are resources with difficult output prediction options. These resources are associated with low probability output prediction based on monitoring and forecast of weather conditions.

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Effects of non-zero phase harmonics on inductions machines and coupled mechanical loads

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Abstract. The presence and effect of harmonics in power systems is widely known, but some of its effects are still only partially studied and addressed in existing works. Traditionally, power system harmonics were nearly always not phase-shifted from the fundamental sine wave, and therefore the effect of the phase was not considered. This paper will address the influence of such harmonic content, with non-zero phase, in the behaviour of an induction machine and its mechanical load, namely in mechanical vibrations produced and speed stability. While mechanical vibrations are intrinsically present on rotating machines, both electrical and mechanical parameters can have a strong influence in their severity. This being a broad topic of research, this paper intends to show a preliminary approach destined to validate some of the starting points set for the development of further work.

Key words

Rotating machinery, power system harmonics, phase harmonics, mechanical

1. Introduction

It is well known that most electric motors, namely induction machines, are designed to operate in the linear portion of the hysteresis curve, and therefore the machine working parameters selected and the magnetic materials used are so calculated.

This, combined with the high time constants (in comparison with electric systems) of mechanical systems should also mean that higher frequency signals, such as those generated when the machine is driven by a variable speed drive, or fed with a harmonically rich network voltage, would produce little or no mechanical effects, due to the fact they would rest in the saturation part of the hysteresis curve.

However, it is well known, and stated by many authors, including the authors of this paper, that under conditions such as harmonics and PWM-modulation waves, mechanical aspects such as vibration and speed stability are affected. On the other hand, most studies address harmonic levels considering only each harmonic order in magnitude, but neglecting the effect that the phase of harmonic component has on the resulting voltage and current waveforms, and consequently on the behaviour of the electric machine and the coupled load.

This, of course, has much to do with the fact that traditionally voltage harmonics were mainly generated by non-linear loads and unloaded power transformers, which meant harmonics with non-zero phase were rare.

However, nowadays, considering the combined effect of the profusion of numerous non-linear loads, the decrease of linear loads, and the growing importance of power quality disturbances introduced by distributed generation, non-zero phase harmonics are becoming more present in power systems.

The main mathematical tool used to study a periodic signal, providing it as an infinite sum of sine waves, the Fourier transform, works with complex numbers, and this, of course, is not a mere curiosity – though most of the times, only the modulus is considered, the phase of the complex number provides the angle distance between the fundamental component, and each harmonic component.

In this paper, the issue of non-zero phase harmonics in the voltage wave feeding an induction motor, and its effects, will be addressed, mainly based on experimental trials conducted using a trial bench, a programmable power source and adequate measurement and acquisition equipment. The main ideas and conclusions will be presented, highlighting that phase, as well as magnitude,