PROBLEMS WITH WIND POWER PLANTS INSTALATIONS

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ABSTRACT

In the latest years, number of wind power plants arose in our surroundings. This is closely confederate with requirement on power quality offered to the consumers, because a lots of problems, especially flicker and produced output power fluctuating, appear with their connection to the electric network grid. In this paper are described basic troubles of wind power plants installation and roughly their evaluation mentioned.

1 INTRODUCTION

Wind power plants bring us absolutely pure and renewable source of electric power. At the same time, with increasing sensitivity of the consumers equipment, appear a frequently discussed issue of power quality and impact flicker emission from wind turbines on the electric network grid. Not only dynamic voltage fluctuating (flicker) became primary purpose of many studies and observations, but also changes of steady state voltage level, harmonics current injection and influence by switching operations on grid. These problems, which affect not only power quality, but also cost of integration wind turbines into network grid, are the main inconvenience and aim of this paper.

2 MAIN COMPLAINTS AND THEIR ASSESMENT

2.1 INFLUENCE OF FLICKER LEVEL

On the present it is the biggest hardness, which is jointed with wind turbines installation. Voltage fluctuation contribution from wind turbines (also called flicker) to the grid, where wind turbines are connected, depend on many factors and conditions. Mostly is flicker level dependent on the voltage fluctuation, their frequency, and the shape of the waveform. Voltage fluctuation is caused due some notable phenomenon i.e. tower shadow and wind shear effect. The construction of tower of wind turbine plant evoke resistance to the wind flow, which is expressed as reduce the aerodynamic torque on the blades of rotor. It is shown on Fig.1 [1,3]. The wind flow is affected in both streams, but the tower shadow effect is more important for the wind turbines having their blades downwind of the tower.

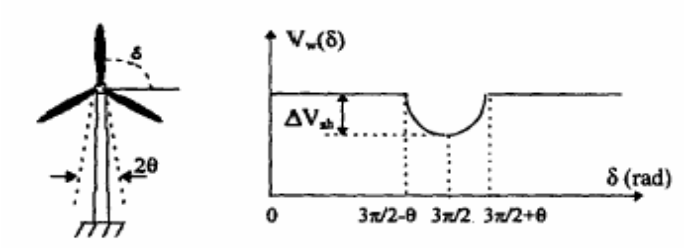

Fig. 1: *The tower shadow effect [1]*

The wind shear phenomenon signifies the change of horizontal wind speed component along the area swept by the blades. This events produce on each blade torque fluctuation, which must be take into account and have to be added to main torque produced by mean wind speed. So torque produced by each blade T_i can be expressed as $T_i=T_{st}+T_g+T_y$, where T_{st} are torque fluctuation produced by tower shadow and wind shear, T_g is the torque produced by mechanical loads such as gravity action on each blade, and T_y is the torque due to yaw misalignment [3]. Reason of power (i.e. voltage) fluctuation are just these torque fluctuation as were described in [1] and [3].

The next influence, that increases flicker emission in power plants installation, is turbulence intensity of the wind. It has been found, that flicker emission at 16 % turbulence intensity is twice as high compared to a turbulence intensity of 8 %.

The grid parameters should quite moderate flicker contribution from wind turbine. So one the important factor for connection of wind turbine is the grid strength, ratio between grid short-circuit capacity and rating power of wind turbine. In the [5] is in detail resolved results of practical measurements in wind park Alsvik. From this conclusions arise, that with the grid strength increase flicker emission produced by wind turbines are reduced. The X/R-ratio, called grid impedance angle, is also an important factor for flicker emission. For instance, it was demonstrated, that flicker emission for an X/R-ratio of 0.5 is ten times higher compared to an X/R-ratio of 2 [5]. Generally it is known, that with increase wind speed also increase the flicker emission value produced by wind turbine. That is related to the fact of the wind higher turbulence intensity.

There are two basic types of wind turbines. The firs one, which is designed only for one rating wind speed so-called constant wind speed wind turbine (CS). The other one is equipped by power electronics converter (AC/DC/AC) if case of need also compensation capacitors. This variable speed wind turbine (VS) should be operating in different wind conditions. Confrontation these two types of wind turbines in viewpoint of flicker level contribution is in detail reported in [1] and [2]. The graphs on Fig.2 unambiguously determine contribution of power electronic converter. It is apparent the greatly reduced variability of the wind turbine output power, that also markedly modify produced flicker level.

On more thing has influence on production of flicker emission and it is just “pollution” comming from the grid, which affecting wind turbine. Not only wind turbines are sources of flicker, but also equipment of consumers connected to the same point of common coupling (PCC). This problematic was solved in papers [4] and [5]. From many measurements and observations has been found a large incidence from the grid on wind turbine by grid voltage dips. At the moment of this dip (shortly 10 % voltage dip), the output power of wind turbine moves from 0 to 75 % of rated one in a fraction of a second. This variations are express as a damped oscilation, which goes on a frequency of 8 Hz. This power oscilation contributes

strongly to the flicker value, because the flicker algorithm is as most sensitive to 9 Hz voltage fluctuating [5].

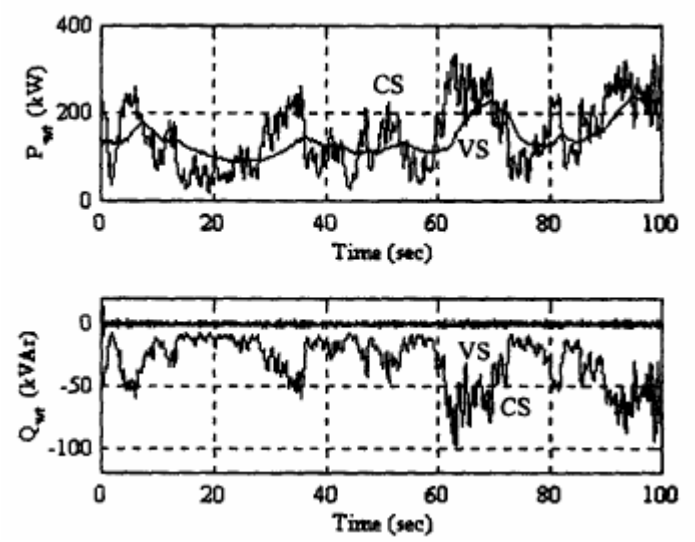

Fig. 2: *Difference between output power of variable and constant speed wind turbines [1]*

2.2 HARMONICS CURRENT INJECTION

This problem is jointed especially with wind turbines equipped by thyristor inverters. In these cases has been measured emission of harmonics current above the recommended standarts. Harmonics currents originate on grounds of nonlinear take-off of some appliances. Such electric demand should be periodical, but in the most cases it isn't sinusoidal (on fig. 3 is take-off from electric controlled rectifier and corresponding production of overtones).

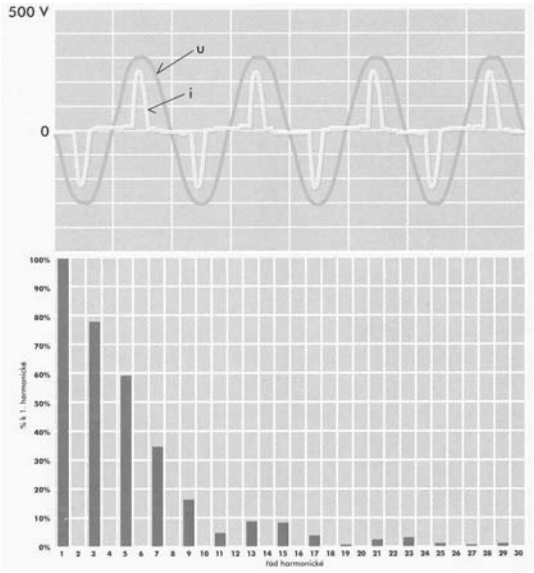

Fig. 3: *Nonlinear take-off and corresponding production of overtones [6]*

As a consequence are harmonics current running from nonlinear appliances to the grid, where cause higher voltage decrease, major loading of isolation and reducing their life service. Of course, this is not only issue of wind turbines, but solution of this trouble will help to easier integrate variable speed wind turbine into the elektric network grid.

2.3 DISTURBANCES DUE SWITCHING ACTIONS

Operations of wind turbines also have some influence on the grid, where are connected. To this actions belongs especially connecting turbine generator and switching capacitor. During the first action can high currents by the turbine generator cause a voltage dip. This is one of important factors, that limits the wind turbine installation to a specific grid.

Switching capacitors implicate origin of high-frequency currents and corresponding voltage transient in connected grid. This can be problem only in case, when some sensitive equipment is connected to the same bus bar (low). Both these mentioned switching actions involve high flicker impact. The flicker values due to switching actions has different limits compared to the flicker impact originating from continous turbine operating,so switched capacitors banks cannot be used for a dynamic reactive power control [3].

3 CONCLUSION

Dilemma of wind turbines is present very actual and also important, because growing press of integrate renewables sources into electric network grid. Many studies and observations were made about problems caused by wind turbine. This paper should be helpful to easier orientation in problematics wind turbines, because is here recapitulate the main complaints and inconveniences of their connection to the grid. Simultaneously is here some simplified evaluation mentioned with references to specific literature.

REFERENCES

[1] Papadopoulos, M. P., et al.: Investigation of the flicker emission by grid connected wind turbines, Athens, NTUA, 1998

[2] Boulaxis, N. G., Papathanassiou, S.A., Papadopoulos, M.P.: Wind turbine effect on the voltage profile of distribution networks, Athens, NTUA, 2001

[3] Moreno, C. V., Duarte, A. D., Garcia, J. U.: Propagation of flicker in electric power networks due to wind energy conversation systems, Madrid, 2002

[4] Marei, M. I., et al.: A flexible wind energy scheme for voltage compensation and flicker mitigation, University of Waterloo, Ontario, 2003

[5] Thiringer, T., Petru, T., Lundberg, S.: Flicker contribution from wind turbine installations, Göteborg, 2004

[6] Dán, A., et al.: Kvalita dodávané elektrické energie v sítích nízkého napětí, Budapest, HCPC, 2001

[7] Rychetník, Janoušek, Pavelka: Větrné motory a elektrárny, Praha, ČVUT, 1997