PO.043

Harmonic Emission of Wind Power Plants Measurement and Assessment

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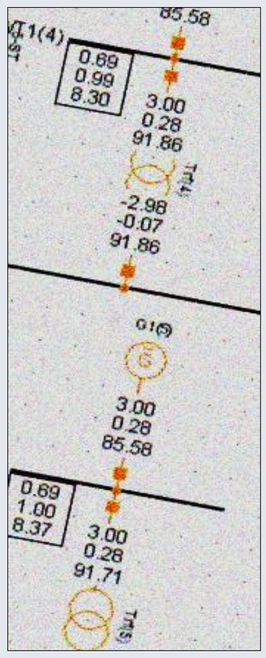
Abstract

Harmonics is a topic of special interest to study in depth due to the possible failure or damage of sensitive elements that could occur when the distortion of the voltage surpasses some limits.

The maintenance team of the international standard IEC 61400-21 [1] is making a big effort in improving the procedure for measuring and assessing the harmonic current emission of wind turbines and wind power plants connected to the grid.

Here, the evaluation of the harmonic impedance spectra is used for determining whether the connection of a new wind turbine will violate the local requirements or not.

In this paper the harmonic impedance analysis from a real wind power plant and its influence on the power system are studied by modelling the wind power plant in PowerFactory. The fulfillment of the requirements regarding harmonic emission from the wind power plant is checked here.



Objectives

The aim of this work is to calculate the harmonic emission of a wind power plant based on real measurements of the wind turbine installed and of the point of connection before the wind power plant is installed and to study how the resulting harmonic emission is affected by external influences, e.g. by the status of the wind power plant.

Restrictions

The harmonic emission of the wind turbine was measured according to IEC 61400-21 ed.2. According to that standard in the current edition, the angle of the harmonic currents is not needed to be reported.

Same situation was found when receiving the measurements of the voltage harmonics in the point of connection, angles were not declared in the IEC 61000-4-30 [2] report.

Thus, the angle of the harmonics could not be taken into account in this work.

Method

As already mentioned, besides studying voltage and current harmonic emissions from wind turbines, an assessment of harmonic impedance is necessary during harmonic filters design or it is necessary to evaluate the power quality those situations where y of the energy provided by the wind turbine.

The wind power plant has been modelled by implementing as much details as possible. The cables were characterized with direct and inverse impedances and also with zero sequence components, taking into account the sections of the cables where crossings were found, etc. The transformers were also detailed in the model and finally the reactive power compensation device.

The point of connection is modelled as a Thévenin equivalent considering the short circuit power declared. The voltage harmonics measured in the field were also implemented in the model.

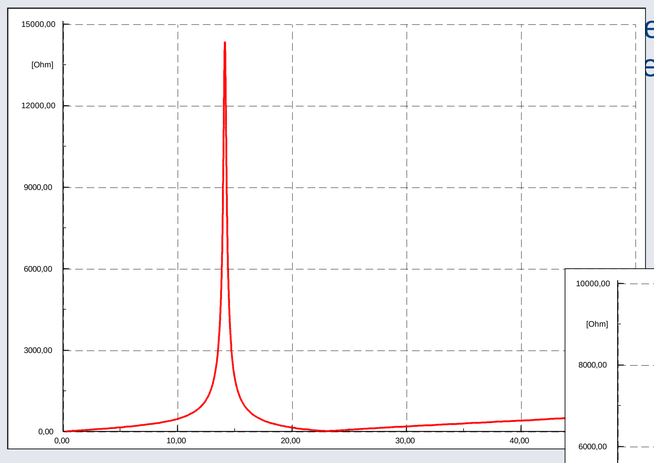
The wind turbine emission was characterized according to the measurements listed in the accredited power quality report, where the different emission of harmonics depending on the power bin was specified.

All the possible situations of the wind power plant were considered. The wind power plant was modelled for productions between 0% and 100% considering also cos_phi=1, 0.95 ind and 0.95 cap.

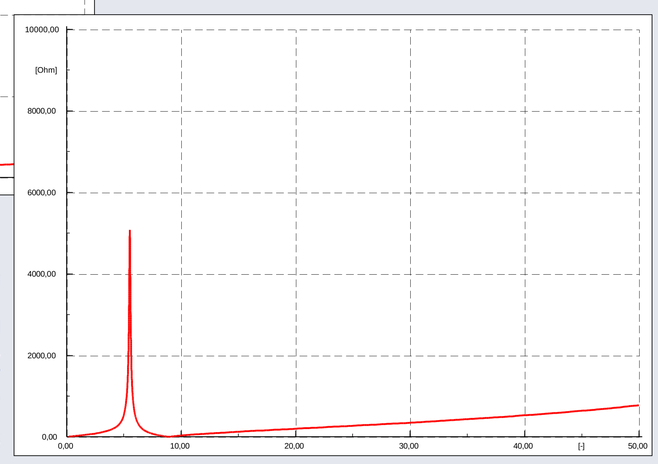
Thus, the reactive power compensation bank acted in all possible combinations

Results

After simulating all the cases, problems in the 14th and 7th were found. The frequency scan of the wind power plant shows different characteristics depending of the connection of the reactive power compensation. The resonance may change from the 14th to the 7th order, depending on the steps of the capacitors connected.



e 14th harmonic order that leads es in that frequency if harmonic



Harmonic resonance in the 7th harmonic order that leads to high values of harmonic voltages in that frequency if harmonic currents are injected by the wind turbines

Conclusions

After modelling in detail the wind power plant, the voltage harmonics have been determined considering all the cable parameters, transformers, different elements of the wind power plant and the measurements of the wind turbines and the point of connection.

High values of some voltage harmonics were found in the results. Those values only appeared when the reactive power compensation bank was connected in certain combination.

The knowledge of the harmonic impedance spectra could be useful for the assessment of the risk of failure caused by load overloading or systems resonances. It is also crucial when designing harmonic filters when the harmonic voltages are so high that the harmonic emission requirements are not fulfilled.

The harmonic resonance in those cases was excited by the current harmonic of the wind turbines or by the background voltage distortion at the point of connection. In both cases, it generates the high value of the voltage harmonic in the point of connection.

Despite of the detailed model used here, in order to increase the accuracy of this kind of studies, in the future the angle measurement must be implemented. The IEC 61400-21 will include this topic in its new revision.

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Contact

Barlovento Energy to Quality (E2Q) is an electrical laboratory member of MEASNET and accredited for measuring power quality according to IEC 61400-21 and FGW TR3 and also for testing UVRT capabilities according to the main grid codes of the world. E2Q also performs electrical studies related to grid integration of new power plants.

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