Power Quality Considerations: Measurements at a Sawmill

M. Pérez Donsión[1], F. Oliveira[2], A. Madureira[3]

[1] Department of Electrical Engineering, E.T.S.I.I., University of Vigo
Campus of Lagoas – Marcosende, 36310 Vigo, Spain
Phone:+34 986 812685, Fax:+34 986 812601, E-mail: donsion@uvigo.es

[2] Department of Electrical Engineering, E.S.T.G., Polytechnic Institute of Leiria
Morro do Leno – Alto Vieiro, Apartado 4163, 2411-901 Leiria, Portugal
Phone:+351 244 820300, Fax:+351 244 820310, E-mail: ftadeu@estg.ipleiria.pt

[3] Power Systems Unit of INESC Porto
Rua Dr. Roberto Frias, 378, 4200-465 Porto, Portugal
Phone:+351 22 2094000, Fax:+ 351 22 2094050, E-mail: agm@inescporto.pt

Abstract. The objective of this paper is to evaluate the impact of a nearby Wind Farm on Power Quality at a Sawmill or, it were be possible, the impact of the sawmill over the power system. Adequate, specialized measuring equipment made it possible to measure several quantities and assess the main Power Quality parameters with special incidence on Flicker and Harmonics levels. Take into account that the value of power quality (PQ) is decided by economic consequences of a PQ deficiency We want to evaluate also the economic aspect of a deficiency power quality and also propose solutions.

Keywords

Power Quality, Flicker, Harmonics, Wind Farms

1. Introduction

The growth in the penetration of Renewable Energies in the Power Systems has been fast during the past few years and is expected to rise even more in the near future.

Wind generation in particular has been fast growing worldwide and the issue of the impact of the connection of wind generators to the main power grid is being thoroughly analysed by experts and investigators across Europe. The main concerns are related to the irregular behaviour of the primary power source (i.e. the wind) that has a deep impact on the quality of the electrical power generated by the wind turbines.

The wind turbine shall be connected directly to the MV-network through a standard transformer with rated power at least corresponding to the apparent power of the assessed wind turbine. Considering that the flicker emission from a wind turbine is a function of the wind speed for wind turbines flicker measurements at higher wind speeds would usually give a significant longer measurement period due to the rare appearance of higher wind speeds, and are not expected to give significantly better verification of the characteristic power quality parameters of the assessed wind turbine. Then is important simulated the voltage fluctuation on a fictitious grid.

A created disturbance will be transmitted and at the same time mitigated from the "cause point" to any "effect point" situated in the same grid. Many authors stop the study of flicker generation in the common coupling point (PCC) focusing their investigations on creating methods to limit the disturbance, P_{st} acceptable.

There are factories consuming (and paying) high amount of electric energy are always a good customers and "have to be" treated as such, even more now when the market has been deregulated and electric companies have to look for places to sell the energy they can generate. This means that it can be interesting to develop a method to "share" the responsibility in flicker mitigation between the customer an the electric utility. For example it could be possible for the supply company to require some amount of flicker compensation (up to P_{st}=1,7 or P_{st}=2) at the PCC if they are able to find a place in its grid where the connection of that fluctuating load will not generate any kind of inconvenience to the normal user.

In this context, a thorough assessment of power quality from wind generators can provide valuable data and generate knowledge of the behaviour and impact of this type of generating devices. There are several technologies of measuring devices that have been developed recently. Two distinct types of measuring equipments with different characteristics were used to collect data on power quality parameters for this measuring campaign.

2. Field Measurements

As mentioned, this measurement campaign aimed at evaluating the impact on power quality of the electrical supply on a sawmill located in the proximity of the Monte Carrio Wind Farm in the region of Lalín, Pontevedra, Galicia, Spain.

The Monte Carrio Wind Farm comprises a total 37 wind turbines, each one with 850 kW, with a total of 31.45 MW of installed capacity. The company running the wind farm is Sistemas Energéticos de Lalín, S.A.

The measuring campaign took place over a total period of approximately three weeks, at three measuring sites that were carefully chosen given the nature of each one.

The original idea was evaluate the impact of the Monte Carrio Wind Farm over a Sawmill place in the vicinity.

The measuring equipment used was a 'MEMOBOX 300 smart' units from LEM. This type of unit is capable of measuring several voltage power quality parameters.

Fig. 1.- Memobox 300 smart

Fig. 2.- Memobox 300 smart installation

Sometimes the main problem for the power quality measurement equipments connection is the seal that today the supply electric company usually put at the common coupling point of most of industrial clients.

3. Power Quality Analysis

In face of the large amount of data available, a preliminary graphical analysis was made. The several power quality parameters were then analysed separately and observed with more attention.

A. Power Quality at the Sawmill

A first measurement equipment was installed in a sawmill, where there were several significant electrical equipments (mostly motors) for sawing and preparing wood.

The table I summarizing the main power quality parameters, the measured values and the standard values (according to the EN 50160 standard Voltage characteristics of electricity supplied by public distribution systems) for the sawmill.

Harmonics present relatively small values, as can be seen in two figures of the full paper by the aggregate European THD values. Still, dominant harmonics are the usual 3^{rd}, 5^{th} and 7^{th} harmonics.

The three phases appear balanced with similar flicker values in all phases. The flicker is definitely the most delicate issue as it highly surpasses the limits set by the standard.

A deep analysis of the results provides unequivocal clues to the origin of flicker values there encountered. Flicker seems to have a "daily routine" as it starts to have significant values at about 8 a.m. every weekday morning, stops for lunch at about 1 p.m., resumes at 2 and finally decreases at about 7:30 p.m.. Weekends are clearly rest days as flicker values are comparable to night values on weekdays.

This clearly shows flicker values are strictly linked to the working hours of the sawmill.

Both short and long time flicker perceptibility measurement should be always accompanied by other disturbances capturing (sags and swells).

Then, an extraordinary set of events occurred during the measuring period, most of them consisting of voltage dips, mainly between 10% and 15% of the nominal voltage, and with durations under 20 ms.

Flicker levels are somewhat above those set by the standard. We can observe some power quality parameters that highlighting an unusually high value of flicker registered shortly after a 100% voltage dip.

4. Economic Aspects of the Power Quality

The value of power quality (PQ) is decided by economic consequences of a PQ deficiency. For example, the cost of damage caused by an outage can range from millions of euros for a small number of consumers (those with highly automated production plants) to nearly nothing for the vast majority.

The power quality problems result in high costs for industry and commercial activities, since they can lead to a decreasing in productivity and to a reduction of quality in the products or services.

We can realize the following cost classification:

Direct costs
- Damage in the equipment
- Loss of production and raw material
- Salary costs during non-productive period
- Restarting costs

Indirect costs
- Inability to accomplish deadlines

- Loss of future orders

Non-material inconvenience

- Inconveniences that cannot be expressed in money, such as not listening to the radio or watch TV

5. Electric power supply actions

The objective of an electric power system is supply electricity with a determined power quality and reliability with the minimum possible cost

The power supply companies need to invest in the satisfaction of the customer because of the specific characteristics of the market

The regulation's market impose the need of adequate power quality measurement equipment.

Today, power electronics based solutions are usual for the LV grid, and a huge worldwide market for these systems has firmly established itself. Nevertheless in MV grids, power electronics based solutions represent only a small fraction of the PQ equipment installed today. With costs falling rapidly and highly reliable, low-loss semiconductors with high frequency switching capability now available, then such solutions can be expected to increase their market in MV distribution grids.

Deregulation and the increase in power produced by distributed generation units will both have an impact on the PQ in the distribution grids.

Based upon GTO/IGBT and voltage/current sources converter technology the best-known systems for MV grids are static var compensator (SVC) for compensating reactive power with different wiring diagrams. Another one is the solid state transfer switch (SSTS), which allows the customer to switch to another feeder if a fault occurs in the connecting MV distribution grid

Another similar PQ systems are:

- STATic synchronous COMpensator (STATCOM)
- Static Synchronous Series Compensator (SSSC)
- Unified Power Flow Controller (UPFC)

While operating both inverters as a UPFC, the exchanged power at the terminals of each inverter can be imaginary as well as real.

We must take into account the distributed resources like: distributed generation (DG) and restoring technologies (that are used to provide the electric loads with ride-through capability in poor PQ environment).

Distributed Generation (DG)

- Reciprocating engines
- Microturbines
- Fuel Cells

Energy Storage (restoring technologies)

- Electrochemical batteries
- Flywheels
- Supercapacitors
- SMES
- Compressed air

A proper planned and maintained grid will avoid many PQ problems.

- High level of redundancy;
- Cleaning of insulators;
- Trimming of trees nearby power lines…

6. Conclusions

Data collected at the three measurement sites revealed not very significant levels of harmonics, all of which well within the limits set by the EN 50 160 standard.

At the sawmill the flicker levels suggest "internal causes", i.e. flicker is caused by electrical equipments at the site and not so much by the nearby wind farm. This can be observed taking into account the low flicker levels at night time.

On balance, all data collected suggest that flicker levels detected in the sawmill may have different or even combined causes. A comprehensive study of the local electrical network characteristics, as well as field measurements at the wind farm itself, may provide additional clues to the real sources of the problem.

Acknowledgement

The authors wish to thank the support from the "Ministerio de Ciencia y Tecnología", DPI2002-04416-C04-02 project and "Xunta de Galicia", PGIDIT03PXIC30308PN project.

References

[1] F. Oliveira, A. Madureira and M. Pérez Donsión "Power Quality Impact of Wind Farms on Domestic and Industrial Facilities", in ICREPQ'05, Zaragoza, March 2005.

[2] F. Oliveira, A. Madureira and M. P. Donsión, "Experimental Study of Power Quality in Wind Farms", in ICREPQ'04, Barcelona, March 2004.

[3] M. Sanz et al, "Power Quality Measurements and Analysis for Wind Turbines", in IMTC 2000, May 2000.

[4] T. Thiringer, "Power Quality Measurements Performed on a Low-Voltage Grid Equipped with Two Wind Turbines", in IEEE Transactions on Energy Conversion, Vol. 11, No 3, September 1996.

[5] T. Thiringer, T. Petru, C. Liljegren, "Power Quality Impact of a Sea Located Hybrid Wind Park", in IEEE Transactions on Energy Conversion, Vol. 16, No 2, 2001.

[6] B. Novo , J.L. de Castro y M. P. Donsión ,"An EMTP Study of Flicker Generation and Transmission in Power Systems due to the Operation of an Electric Arc Furnace", Ninth International Conference on Harmonics and Quality of Power", Orlando, Florida (USA), 2000 .

[7] A. T. de Almeida, "Power Quality Problems and New Solutions", International Conference on Renewable Energy and Power Quality (ICREPQ'03), Vigo, 2003.

Table I – Table summary for the sawmill

Parameter			Maximum value			95%-value		
	Unit	Default GWD.GWD	L1	L2	L3	L1	L2	L3
Voltage variations		230.00V						
Maximum 100% / 95%	% [Un]	+10.00/+10.00	4.85	4.68	5.28	3.30	3.72	4.22
Minimum 100% / 95%	% [Un]	-15.00/-10.00	-4.91	-4.76	-4.67	-3.30	-3.72	-4.22
Interruptions < 1%	Number of	100	6	6	6		-	
Events	Number of	100	248	425	258		-	
Harmonics								
5. Harm.	% [Un]	6.00	3.91	3.50	3.57	3.05	2.76	2.96
Flicker Plt	Plt	1.000	1.769	1.827	1.838	1.557	1.608	1.599
Unbalance	%	2.00		0.61			0.52	
Signallingvoltages	% [Un]			No				
frequency		50 Hz					99.5%-value	
Maximum 100% / 99.5%	%	+4/+1		0.20			0.20	
Minimum 100% / 99.5%	%	-6/-1		-0.20			-0.20	

Max value above limit value

95% (99.5%) - value above limit value

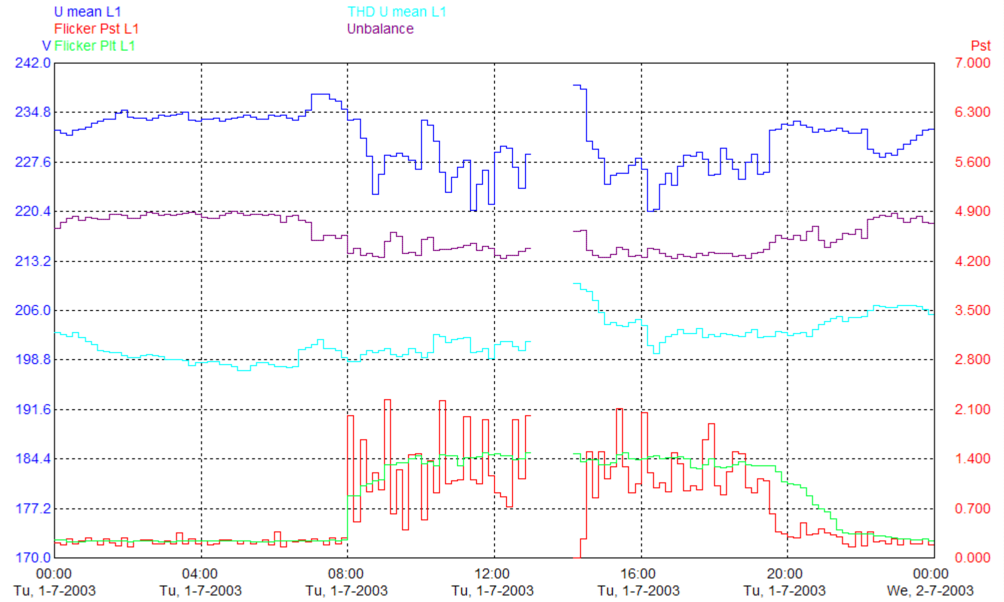

Fig. 3. Several power quality parameters measured at the sawmill over 1 day

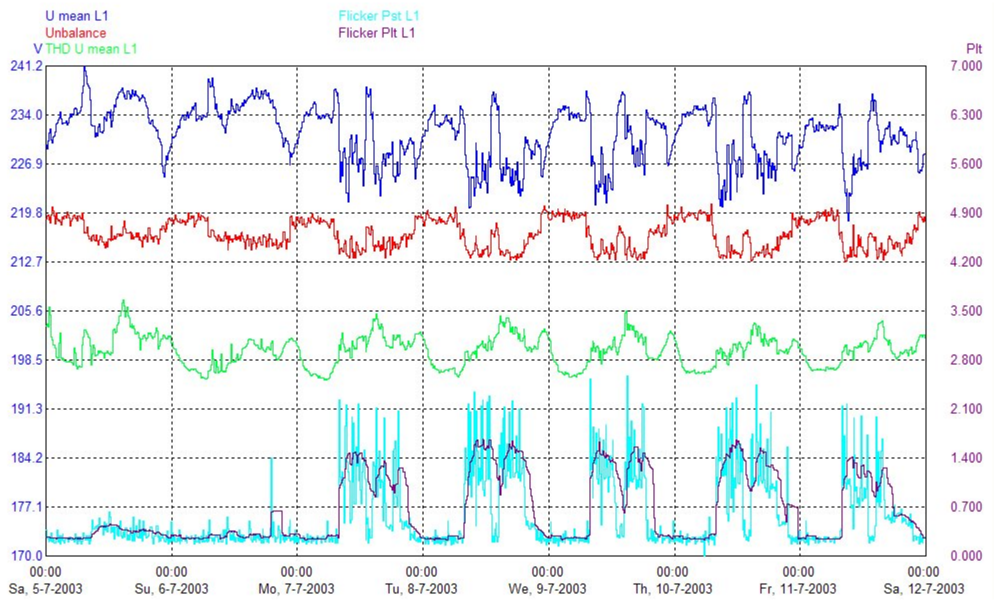

Fig. 4. Several power quality parameters measured at the sawmill over 1 week