POWER QUALITY MEASUREMENT AND ANALYSIS USING HIGHER-ORDER STATISTICS

UNDERSTANDING HOS CONTRIBUTION ON THE SMART(ER) GRID

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Preface

The so-called digital energy networks are gathering numerous elements that have emerged from different branches of Engineering and Science. Concepts such as Internet of Things (IoT), Big Data, Smart Cities, Smart Grid and Industry 4.0 all converge together with the goal of working more efficiently, and this fact inevitably leads to Power Quality (PQ) assurance. Apart from its economic losses, a bad PQ implies serious risks for machines and consequently for people. Many researchers are endeavouring to develop new analysis techniques, instruments, measurement methods and new indices and norms that match and fulfil requirements regarding the current operation of the electrical network. This book offers a compilation of the recent advances in this field. The chapters range from computing issues to technological implementations, going through event detection strategies and new indices and measurement methods that contribute significantly to the advance of PQ analysis. Experiments have been developed within the frames of research units and projects and deal with real data from industry and public buildings. Human beings have an unavoidable commitment to sustainability, which implies adapting PQ monitoring techniques to our dynamic world, defining a digital and smart concept of quality for electricity.

PQ analysis is evolving continuously, mainly due to the incessant growth and development of the smart grid (SG) and the incipient Industry 4.0, which demands quick and accurate tracking of the electrical power dynamics. Much effort has been put on two main issues. First, numerous distributed energy resources and loads provoke highly fluctuating demands that alter the ideal power delivery conditions, introducing at the same time new types of electrical disturbances. For this reason, permanent monitoring is needed in order to track this a priori unpredictable behaviour. Second and consequently, the huge amount of data (Big Data) generated by the measurement equipment during a measurement campaign is usually difficult to manage due to different causes, such as complex structures and communication

protocols that hinder accessibility to storage units, and the limited possibilities of monitoring equipment, based on regulations that do not reflect the current network operation.

The introduction of new indicators in PQ is one of the main subjects of discussion in the CIRED/CIGRÉ working group; however, it is necessary to solve future challenges from new perspectives. Indeed, this book proposes to spread the use of PQ indices based on HOS from event detection up to cycle-to-cycle continuous monitoring, taking advantage of their most simple calculations in order to detect the effect of multiple loads acting/working together on a node for a specific length of time.

Chapter 1 introduces the State of the Art in the power quality field and will help researchers to bridge the gap between traditional methods and those applications that use HOS analysis.

Chapters 2–5 propose different and experimental approaches that have been used to validate HOS applications in monitoring the power system.

Table A summarizes the monitoring objectives that would be accomplished using HOS as part of the results of this book and according to the

Table A HOS approach related to different applications.

Monitoring objective	Variables	Sampling rate	Data averaging window	Reference
Compliance verification-connections agreements/premium power contracts	Voltage sags or voltage swells	5 Hz	As specified in the contract	Chapter 3
Performance analysis	Steady-state voltage Voltage sags and swells Highest or lowest RMS voltage per 1 (or 10 min) Fundamental frequency deviations	5 Hz	10 min averaging window 1 min averaging window	Chapter 3
Site characterization		20 kHz		Tables Chapter 4 Chapter 5
Troubleshooting	Disturbance depending on the nature of the problem being investigated			Chapter 3 Chapter 4

topics proposed in the Guideline for Selection of Monitoring Parameters. Compared with other simpler methods, such as RMS measurements, HOS are not sensitive to noise. In Chapter 3, the authors demonstrated that HOS can help to detect fundamental frequency changes in the bi-dimensional plane and Chapter 4 introduces techniques in the frequency domain, such as spectral kurtosis.

Overall, here the authors summarize the last 10 years of power quality research based on HOS techniques that would be incorporated in future PQ measurement campaigns, in order to accomplish the monitoring challenges of the next generation of advanced metering infrastructure in terms of compression, as well as reporting PQ efficiently.

This book gathers new advances in techniques and procedures to describe, measure and visualize the behaviour of the electrical supply, from physical instruments to statistical signal processing (SSP) techniques and new indexes for PQ that try to go beyond traditional norms and standards. The authors are recognized experts in the field, committed to a main goal: to provide new instrumental and analytical tools to help mitigate the serious consequences of a bad PQ in our digitized society, and thus enhancing energy efficiency for a more sustainable development.

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During this research, a National Patent directly aligned with the method was proposed. ES2711204 Procedimiento y Sistema de Análisis de Calidad de la Energía e Índice de Claidad 2S2PQ, Caracterización de la Señal en un Punto Del Suministro Eléctrico.

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