Power Quality Data Analytics

Maike Luiken
Director, Bluewater Technology Access Centre, Lambton College

Monitoring of grid elements, collection of data and analyzing it in real-time and off-line are critical for the modern grid. The needs are many, including: grid operations, system performance optimization, predictive maintenance and system planning.

It is standard practice to collect and analyze data for electrical disturbances that would affect Power Quality (PQ), focusing on the harmful effect of the electrical disturbance to enable mitigation. But what if that data could also be used to identify concerns with the system itself?

In July 2013 Wilson Xu made a Presentation at the PES General Meeting in Vancouver reporting unexpected results of his research efforts in the study of all types of electrical disturbances that affect PQ. Dr. Xu and his team found that PQ monitors, due to their general nature are widely used and also used to meet other monitoring needs. They learned that the data has been used to solve issues beyond PQ, like feeder capacitor status monitoring and feeder fault anticipation.

Analyzing the PQ monitoring data -- particular waveform-level data --can yield information beyond the direct electrical disturbance information; the condition of the system and its equipment can also be revealed. So although electrical disturbances affecting Power Quality have negative impact on the grid performance, power engineers are beginning to be able to take advantage of these disturbances to diagnose the system condition for purposes such as fault location/detection and predictive maintenance. Disturbance analysis expertise has led to the capability to locate the disturbance source location and synchronization of measured data. This work has become accepted as a new field of research: Power Quality Data Analytics (PQDA) – the science of extracting knowledge through the examination of raw electrical disturbance data.

Applications of PQDA include:

1. Distribution Feeder Fault Anticipator. Unusual V&I waveforms are analyzed to determine if a potential fault could occur in a feeder. This capability started from a PQ disturbance monitoring project by US-EPRI; fault anticipation is claimed as a key feature of the smart grid.

2. Fault location

3. Home appliance monitoring. Each appliance is represented in a composite waveform – as monitored at the meter - as a component. The target is to profile major appliances in a home relying on unique harmonic signatures from each appliance (North American homes have about 10 to 20 appliances each). Success of this research will create even “smarter” meters. The anticipated benefits of home appliance monitoring are

   - The electricity bill is split to appliance level
   - Power cost per use of an appliance is known
   - Energy efficiency claims can be verified
   - Energy use of similar appliances can be compared
   - The replacement of appliances can be simulated
   - Malfunctioning or unusual functioning of an appliance, as in drawing more power than expected, can be flagged

4. Load parameter estimation

5. Electricity theft

A key element to the success of PQDA is the development of harmonic signatures for the various individual grid system elements.

Looking at the big picture of monitoring activities in today’s grids there are four major monitoring networks in current power systems:

SCADA network: 60Hz magnitude data; For load flow, state estimation & other applications.

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PMU network: 60Hz magnitude & phase data; killer applications have yet to be identified

PQ network: Waveform & transients data; for PQ monitoring and, in the future, for PDA/PQDA

AMI network: Interval E, P, V & I data; for billing purpose and demand monitoring

The PQ monitoring network provides a unique set of data with a significant amount of information on the performance of a network and its elements. It is the best candidate to collect and provide waveform-level data. It is just a matter of time before large-scale waveform-level data will be made available to utility companies. The goal of power disturbance analytics is knowledge extraction and to create killer applications based on such data.

To summarize, electrical power disturbances can provide information quite useful to utilities with applications beyond traditional PQ activities. At present, the PQ monitoring network is the most general platform to provide the data needed for significant knowledge extraction, and will likely emerge as a powerful platform for power system monitoring, in parallel with SCADA, WAMS and AMI.

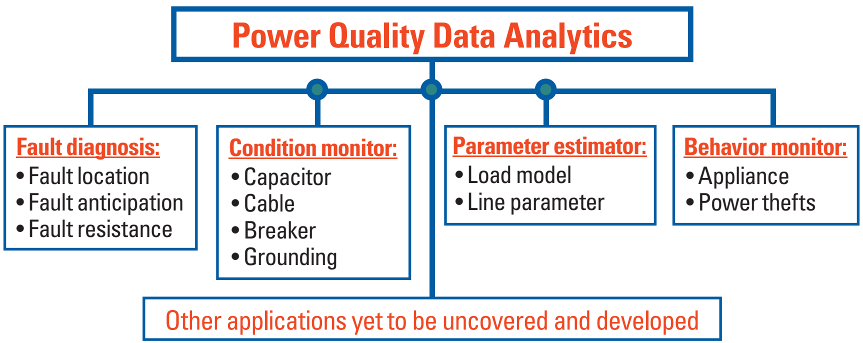

Fig. 1 Overview of Power Quality Data Analytics

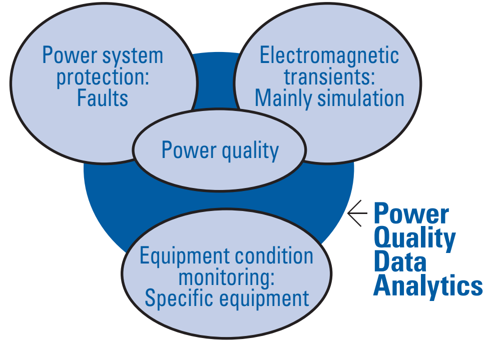

Fig. 2 Various fields contributing to Power Quality Data Analytics

For those interested in finding out more about research in this area, there are two proposed IEEE standards addressing these issues: P1836 and P1837; there is also a working group: PES PQDA WG ■

This article prepared with material from Wilsun Xu, University of Alberta.