XML Description Schema for Power Quality Data

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Abstract

The recent growth in the number of permanently installed power quality analysers has led to an increase in the amount of data requiring central processing. The information contained in the voltage and current waveforms is progressively transformed into knowledge enabling improved operation of power utilities. This power quality data chain requires a data organisation that facilitates this transformation process occurring at several locations as well as on a range of computing platforms. This paper proposes a XML schema that is both compatible with this process as well as with the standards related to power quality.

1. INTRODUCTION

While power quality (PQ) monitoring can trace its origin back to the 20's in the form of lightning strike recorders [1], it is presently developing toward permanently installed systems [2]. The last decade has been marked by rapid changes where PQ monitoring evolved from the resolution of a local power quality problem to a systematic acquisition of PQ data in electrical networks. Several driving factors are responsible for this transition: in particular regulatory requirements [3] as well as the need to improve system performance.

This system wide power quality monitoring requires an infrastructure that is distributed around a power network. Typically power quality is monitored at the substation as well as at suitably enabled revenue meters. Data is transmitted to a central database through telephone, the Internet or via a distribution automation system [4].

Data generated by the power quality instruments is progressively transformed into knowledge usable for decision-making. In addition to compulsory regulatory reporting, this source of information can also contribute to network performance assessment, benchmarking, and fault location. Ultimately, these systems could lead to the automatic evaluation of disturbances, the rapid localisation of the sources of these disturbances and also enable predictive maintenance.

As the amount of data is large, there is a need for a data structure compatible with the various steps of this data transformation. Similar to metering, the information is often generated or processed at various geographical locations as well as on a variety of processing platforms. This has led to the creation of the ASEXML (A Standard for Energy Transactions in XML) standard [5] understood by all the parties involved in the handling of metering data.

The aim of this paper is to propose a new XML schema for power quality that is suitable for both the transaction of power quality information as well as the various steps of data transformation. The power quality data chain is presented first, followed by a review of the associated standards. From this, the requirements for the schema are outlined and finally the schema itself is presented.

2. THE POWER QUALITY DATA CHAIN

As shown in figure 1, the power quality data chain originates in the electrical network and terminates in the form of knowledge for decision-making. Once in digital form, the waveforms are processed in order to extract the PQ disturbances according to IEC or IEEE standards [6-7].

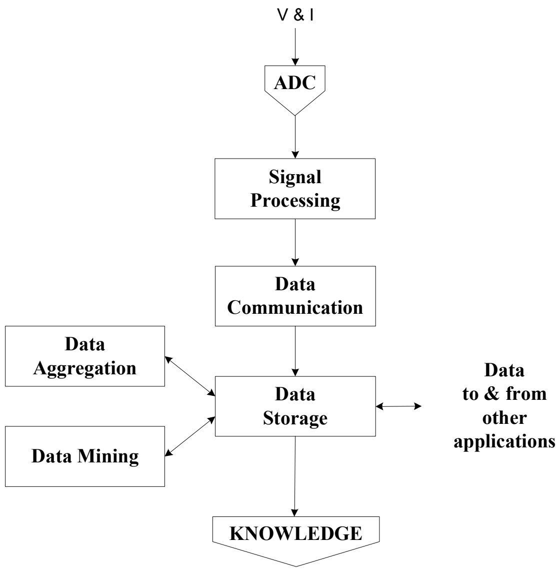


Figure 1 – The PQ data chain

The disturbances are generally stored in the memory of the instrument and are regularly downloaded to a central database via a communication channel. After storage in the database, it is necessary to reduce the amount of data into meaningful information.

Typically a three phase PQ analyser generates a data every 10 minutes (1008 per week) for all continuous disturbances. The number of these disturbances varies between 100 and about 600 depending on the instrument’s configuration. Ignoring the discrete disturbances, and given the large number of monitored sites, it is difficult to extract a clear picture of the overall power quality status of that network. This is a situation, where most utilities limit their PQ program to a simple trending of these disturbances for the sole purpose of complying with regulator’s requirements.

The conversion of that power quality data to usable knowledge is achieved through data mining and data aggregation. This is the focus of current research which holds great promises. The techniques typically used are: expert systems, neural networks and machine learning. An example of research on data aggregation is the PQ triangle developed at the University of Wollongong [8-10].

The concept of the PQ triangle shown in Figure 2 is based on time and space compression where data is reduced to a much simpler set of numbers as summarised in Section 4.2

The usage of this power quality data can be further enhanced when integrated with data generated by other functions within a utility. This integration is central to improved operations and is the objective of an IEC working group (See 3.3).

3. CURRENT STANDARDS

Over the years, standards aimed at streamlining the exchange and processing power quality have emerged. However they have often been limited to one aspect only. The following sub-sections summarise a few of the standards relevant to the power quality data chain. Figure 3 shows their respective relevance in the PQ data chain.

3.1. IEC 61000-4-30 Power quality standard

This standard intends to standardise the processing of the raw data at the output of the ADCs by defining how each power quality disturbance should be measured and interpreted. The aim is to ensure consistent results between instruments.

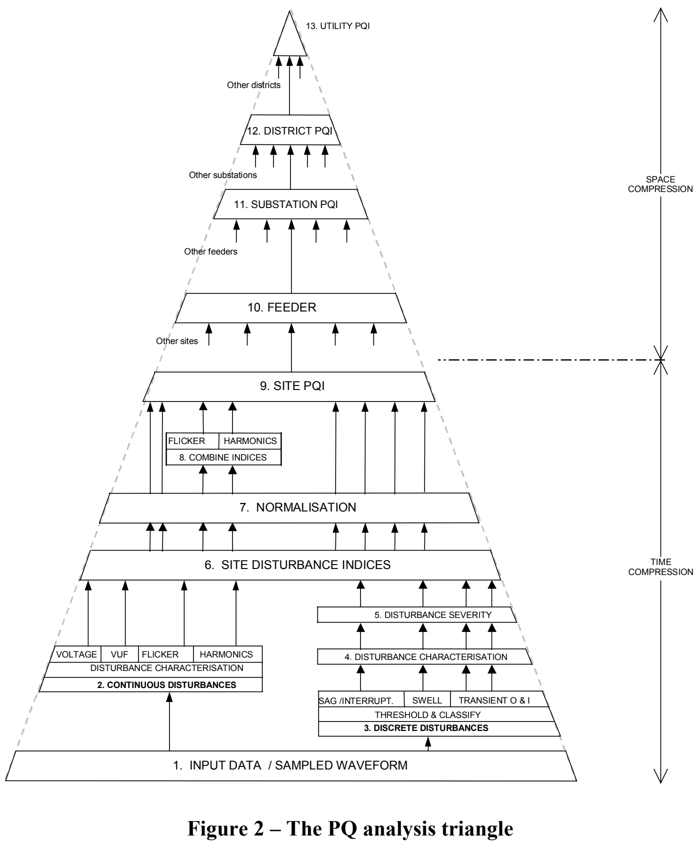


Figure 2 – The PQ analysis triangle

While still in draft form at the time of writing, this standard is already followed by several European manufacturers of power quality recorders. However, as this standard is paralleled with the efforts of the IEEE 1159 standards it is likely that differences in techniques will emerge.

3.2 IEEE 1159.3 PQDIF standard

This IEEE draft standard [11] is an attempt to standardise the exchange of power quality data in a vendor independent fashion. This standard encompasses both power quality monitoring and simulation equipment and aims for a single unified exchange data structure. At the time of writing this was the only standard with this objective.

As this standard is linked mostly with the transmission of data, great effort has been made to minimise the size of the files. A binary format has been chosen; this can be further compressed by the use of the public domain zlib compression library. This standard also offers flexibility with regards to the "payload" which can vary greatly from one instrument to another. Its structure is based on linked lists data structure whose records can be tailored to the specific data available by the use of tags defined by the standard itself. These tags also facilitate the search and extraction of data from these files. Despite the fact that this standard has been developed in isolation of IEC 61000-4-30 it is believed to be compatible.

3.3 IEC 61968 Interface architecture

While being currently developed by the WG14 (working Group 14) of the IEC TC57 (Technical Committee 57), the objective of this series of standards is to enable the enterprise application integration (EIA) as well as the business-to-business integration (B2B) [12-13]. At the core of this standard is an interface architecture that permits the integration of disparate applications implemented in a variety of platforms. These applications are [12]:

- Network operation
- Network expansion planning
- Customer inquiry
- Meter reading and control
- Operational planning & optimization
- Maintenance & construction
- Records & asset management
- Utility business systems

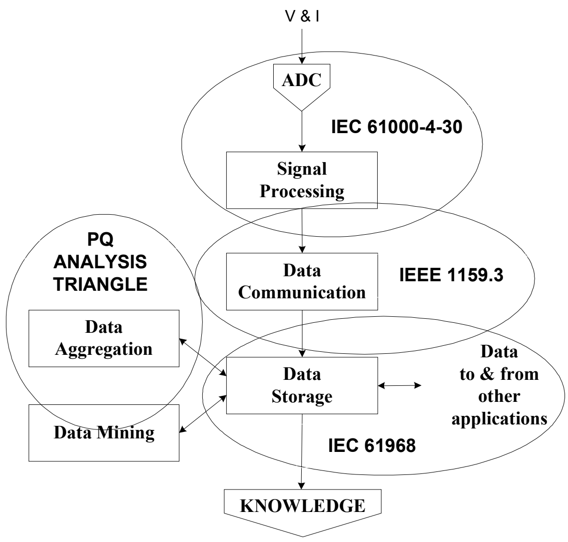


Figure 3 – Relevance of standards in the PQ data chain

The coupling of these various applications reduces the need for data duplication which exist in isolated applications. This would lead to increased efficiency, lower costs as and improving consistency among applications.

The essence of IEC 61968 resides in the definition of a common semantic understandable by all applications. For two applications to share information requires a shared vocabulary in the form of XML metadata as well as a set of rules for specifying values such as semantic information (e.g. word definition) and typing information (e.g. strings).

4. XML SCHEMA FOR PQ DATA

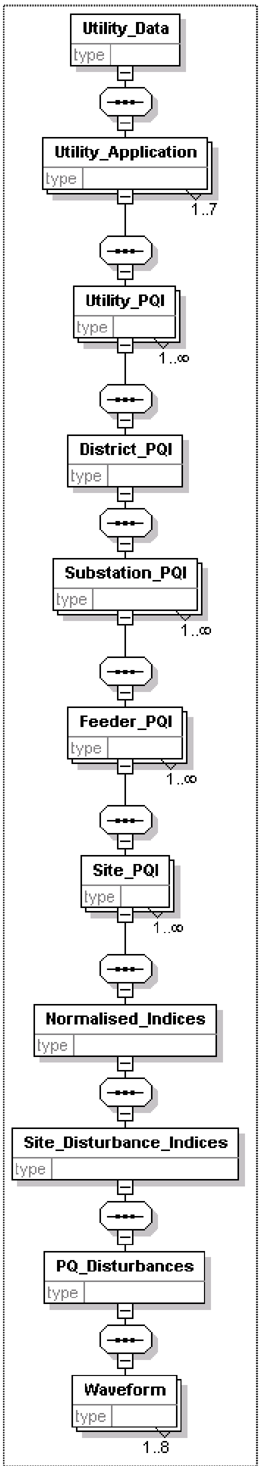
4.1 Requirements

As seen in the previous sections, power quality is moving toward an integrated system of data. As such, the organisation of the PQ data must reflect this. Additionally, these levels may be processed at various locations and also by different organisations using a variety of computing platforms. This leads to the following requirements:

- A layered data structure reflecting the various phases in the PQ data chain as well as the PQ Triangle
- The various level must have a link to the previous level (traceability)
- The description must be independent of a given computing platform

4.2 Schema for PQ data

This section presents the highest level of the PQ schema. At this present time the aim is to propose the usage of XML schema as it allows the fulfilment of all the above requirements. The implementation details would be beyond the scope of this paper.



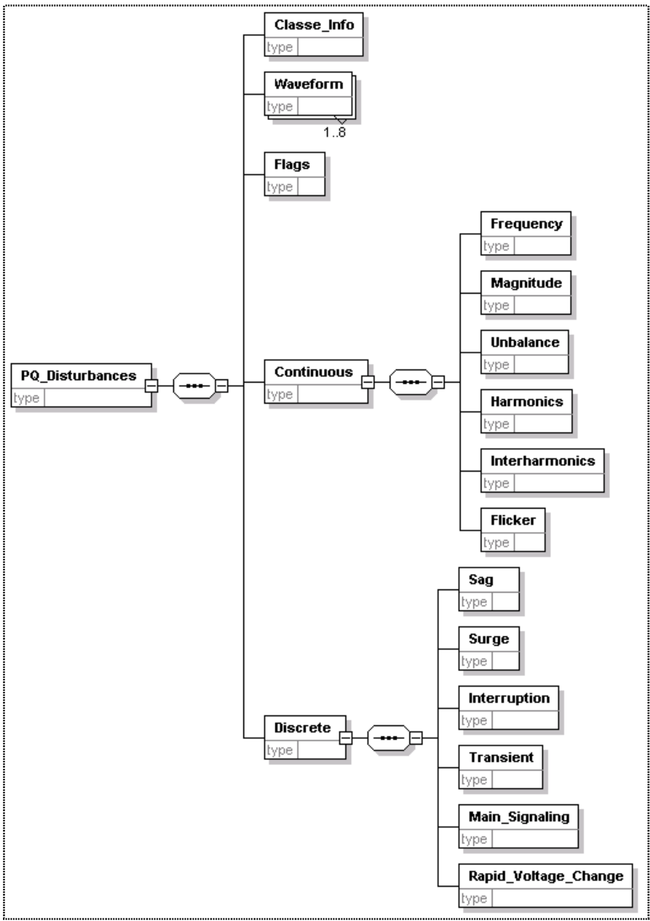


Figure 5 – PQ Disturbances

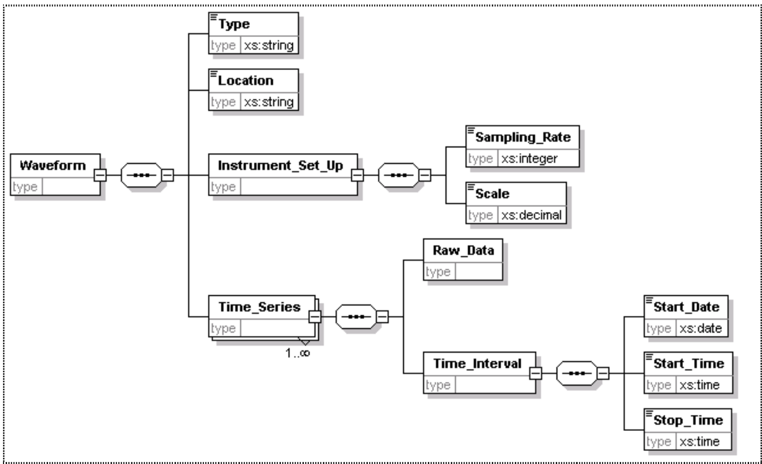


Figure 4 – Skeleton of PQ Schema

Figure 6 – Waveform details

Figure 4 shows the skeleton of the XML schema where each block represents a level in the PQ data chain. Starting at the bottom with voltage and current waveforms it is ending with the IEC 61968 utility enterprise application integration. The various "Utility_Application" are of the realm of the various sections of the standard while the ones below are those of the PQ triangle. However, at this time it is not known which of the IEC 61968 sections will deal with power quality.

The progression from one level to the next one is done by data processing of the lower level data. Figure 6 shows some of the details of the lowest level while Figure 5 shows how the raw data is reorganised once processed according to IEC 61000-4-30. At the next level of processing is the transformation of these disturbances into indices. In summary, the schema is nothing more than a progressive abstraction of waveforms to information.

Starting from the lower level shown in Figure 6, any waveform captured at a given measurement point is first combined with "housekeeping" information such as: type (voltage, current, phase), the location of the point of measure, as well as the instrument configuration. The waveform itself is most likely made up of several time series captured at different intervals. Thus a time stamp is added to each record of raw data.

In the next level up, shown in Figure 5, the transformed waveforms are now organised into a structure designed around disturbances classification. First they are separated into their respective class (continuous or discrete) then combined with their associated information which is not shown in the diagram. In addition to the disturbances, general information is also included: measurement class (A or B), flagging [6] as well as a link to the original waveform. This is the key to the ability of navigating up and down the complete PQ data chain thus maintaining traceability.

The next three levels shown in Figure 4 are the processes leading to a single figure of merit that summarise the power quality of a given site. From this level, space compression [8] begins to reduce the data from an ever-increasing number of sites into a single number. Once computed, each disturbance is in the form of a data series which needs to be converted to a single number as described in [14]. This number is primarily used to determine the compliance of the given disturbance. This is then followed by the normalisation of all the disturbance indices that have been previously computed into a number scaled between 0 and 1 representing respectively no disturbance present and 1 the highest acceptable value. In this system, any number above 1 indicates excess in the disturbance level. In the final stage all these numbers are then combined into a single figure of merit summarising that site [9].

5. CONCLUSION

This paper outlined a possible implementation of a XML schema for power quality data that integrates the various existing standards along the PQ data chain. This will bring the benefits of XML to the handling of PQ data. Among them are: the ease of sharing data, the independence to computing platforms as well as simplifying web transmissions of PQ data. While still in embryonic form, this schema requires detailed implementation. A task best suited to an industry wide working group similar to the one responsible for ASEXML.

6. REFERENCES

[1] A. McEachern, "Roles of intelligent systems in power quality monitoring: past, present and future", IEEE Power Engineering Society Summer Meeting, July 2001

[2] M. McGranaghan, "Trend in power quality monitoring", IEEE Power Engineering Review, October 2001, p3-9

[3] "Electricity distribution code", Office of the Regulator-General, Victoria, January 2001

[4] A. Mäkinen et al., "Power quality monitoring as integrated with distribution automation", Proceedings of the 2001 International Conference on Electricity Distribution (CIRED), June 2001, p2.54

[5] The Combined Gas & Electricity IT working group, "White paper Part B – Technical", Version 0.3, October 200

[6] IEC-61000-4-30, "Testing and measurement techniques - Power quality measurement methods", draft issue July 2001

[7] IEEE std 1159-1995, "IEEE Recommended practice for monitoring electric power quality", November 1995

[8] V.J. Gosbell, B.S.P. Perera, H.M.S.C. Herath, "New framework for utility power quality data analysis", Proceeding of the AUPEC 2001 conference, September 2001, p577-582

[9] V.J. Gosbell, B.S.P. Perera, H.M.S.C. Herath, "Unified Power Quality Index (UPQI) for continuous disturbances", accepted for ICHQP02, Brazil, October 2002

[10] V.J. Gosbell, D. Robinson, B.S.P Perera, "The analysis of utility voltage sag data", accepted for IPQC02, Singapore, October 2002

[11] IEEE P1159.3 Draft 8, "Recommended practice for the transfer of power quality data", February 2002

[12] G. Robinson, "Key standards for utility enterprise application integration (EIA)", GITA 2002, Enterprise Application Seminar

[13] G. Robinson, "Model driven integration (MDI) for electric utilities", GITA 2002, Enterprise Application Seminar.

[14] EN 50160: 2000, "Voltage characteristics of electricity supplied by public distribution systems", February 2000