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Power quality information system based on data energy metering integration and analysis

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SUMMARY

The quality of electrical power is an important issue for electrical companies. Power quality requirements adopted by the electrical utilities to assure economical and satisfactory service of customers are based on different international standards for instance IEC, IEEE and ANSI. In order to measure, detect and register power quality events, electronic meters have been developed and introduced in the market. Several electrical utilities use these types of meters to monitor power quality in your transmission and distribution grids. In most cases, the meters are from different manufacturers with own communication protocols; hence is necessary use different computational applications to obtain information from each meter. In this work, a power quality information system based on data energy metering integration and analysis is described. The information system integrates data from diverse brands of electronic meters that possess power quality information in homologated data bases. Power quality data are acquired automatically via Ethernet by the information system based on proprietary protocols of each meter. This information is analyzed and displayed in a graphical user interface established upon international standards. The information system presented is a unique platform, located in regional servers and in a national server, which provides not only the flexibility, security and robustness for managing power quality information coming from different meters, but also contributes to systematize power quality data, electric load profiles, and power transformers loads.

KEYWORDS

SIACEN, POWER QUALITY, CBEMA, SAG, SWELL.

1. INTRODUCTION

The smart grid concept includes the generation, transmission and distribution areas of electrical utilities, in order to make more efficient the electricity supply to end user. A Smart grid has the ability to transport electricity from the suppliers to the consumers, using bidirectional technology to control end user needs. With this, is possible save energy, reduce costs and use the energy more efficiently; helping to reduce CO2 emissions and global warming.

The development of renewable energies in the energy landscape has changed significantly the energy flows in the grid, end-users now not only consume energy, but they also provide electricity through the same grid. Therefore, now the energy flow is bidirectional.

A good electric service is characterized by its continuity and acceptable power quality. Hence in recent years, electrical utilities have focused their attention to the problems related to power quality, particularly with large customers and those they use in their production processes or control systems and microprocessor based equipment with high levels of sensitivity to disturbances that are generated in an electric grid.

In order to attend above mentioned, is necessary to monitoring the grid to know how many disturbances have occurred, your duration and amplitude. To obtain this information, special meters must be used and a computer system to analyze the disturbances registered by each meter.

Nowadays, there are various energy meters with ability to record and store information from the power quality disturbances like saw, swell, voltage interruptions and harmonic distortion, among others. In his case, the only problem is the different types of meter brands with their own communication protocols and their particular formats to store the data.

With the purpose to unify the data formats, Transmission Department of Mexican utility established develop a system to read different data bases from power quality meters and create a unique data base with the same structure and data formats, regardless brand of the meter.

2. POWER QUALITY

Power quality term describes disturbances in an electric circuit, like variation in voltage magnitude, transient voltages and current, harmonic content in the waveforms for AC power, among others. These disturbances sometimes may cause damage to electrical equipments connected to power lines.

Events or disturbances occurring in a power grid are identified as:

Transient: Refers to sudden but significant deviations from normal voltage or current levels. Transients typically last from 200 milliseconds to half a second (figure 1). Transients are typically caused by lightning, electrostatic discharges, load switching or faulty wiring.

Transients can erase or alter computer data, resulting in difficult-to-detect computational errors. In extreme cases, transients can destroy electronic circuitry and damage electrical equipment.

Sag (dip): Describe a decrease to between 0.1 and 0.9 pu in rms voltage or current at the power frequency for durations of 0.5 cycles to 1 minute.

Swell: An increase to between 1.1 pu and 1.8 pu in rms voltage or current at the power frequency durations from 0.5 to 1 minute.

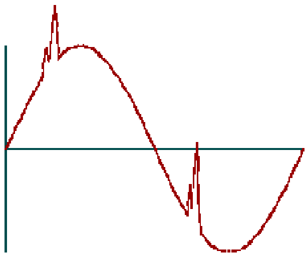


Figure 1 Example of voltage transients.

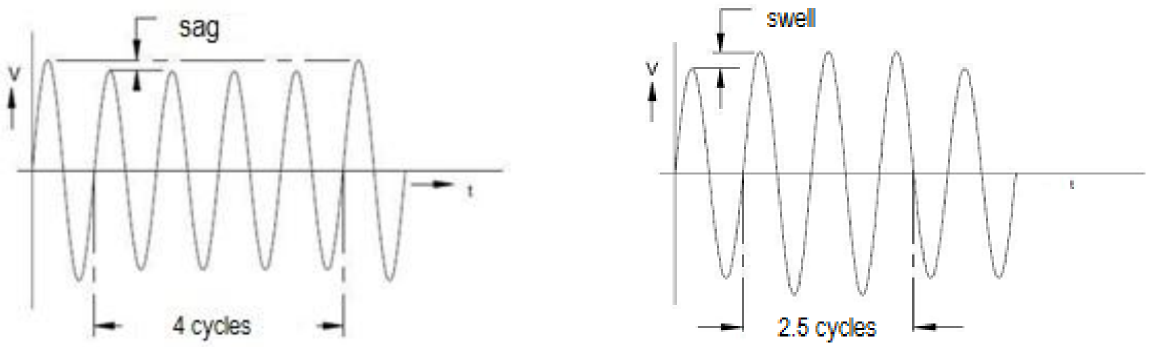


Figure 2 Examples of voltage sag and swell

Interruptions: This event occurs when voltage levels drop to zero. Interruptions are classified as momentary, temporary, or long-term. Momentary interruptions occur when service is interrupted, but then is automatically restored in less than two seconds.

Temporary interruptions occur when service is interrupted for more than two seconds, but is automatically restored in less than 2 minutes. Long-term interruptions last longer than two minutes and may require field work to restore service

Harmonic distortion: Distortion occurs when harmonic frequencies are added to the 60 Hertz (60Hz) voltage or current waveform, making the usually smooth wave appear jagged or distorted. Distortion can be caused by solid state devices such as rectifiers, adjustable speed controls, fluorescent lights, and even computers themselves.

At high levels, distortion can cause computers to malfunctions and cause motors, transformers, and wires to heat up excessively. Distortion is probably the most complicated and least understood of all power disturbances.

Flicker: This event can be defined as small amplitude changes in voltage levels occurring at frequencies less than 25 Hertz (25Hz). Flicker is caused by large, rapidly fluctuating loads such as arc furnaces and electric welders.

Flicker is rarely harmful to electronic equipment, but is more of a nuisance because it causes annoying, noticeable changes in lighting levels.

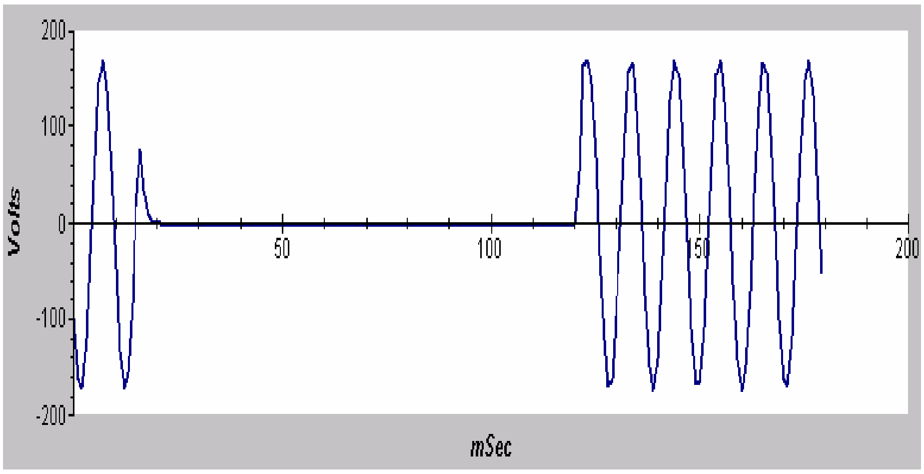


Figure 3 Example of momentary interruption

3. ANÁLISIS DE CALIDAD DE LA ENERGIA.

Actually, international standards like IEEE P1195/D5, IEC 61000-4-11, IEEE 446-1995, IEEE 1100-1999, SEMI F47-0200, SEMI F42-0600 e ITIC (CBEMA), establish limits allowed for disturbances present in a grid and the appropriate procedures to assess their damages. CBEMA curve and SARFI graphic are two methods to represent graphically power quality events.

3.1 CBEMA curve.

The method most frequently used to characterize data related to power quality in electrical circuits is use graphics to indicate duration and magnitude of each disturbance in an XY plane; the X axis corresponds to the duration and the Y axis to the amplitude of the perturbation.

According to the method mentioned above, the "Computer Business Equipment Manufacturers Association" developed the CBEMA curve to define the tolerance of data-processing equipment to voltage variations considering the duration and magnitude of voltage variations. The CBEMA curve was adapted from IEEE Standard 446 (Recommended Practice for Emergency and Standby Power Systems for Industrial and Commercial Applications - Orange Book), which is typically used in the analysis of power quality monitoring results.

The CBEMA curve is a susceptibility profile with the abscissa (horizontal axis) representing the duration of the event, while the ordinate (vertical axis) indicates the percent of voltage applied to the power circuit. In the center of the plot is the so called acceptable area. Voltage values above the envelope are supposed to cause malfunctions such as insulation failure, over excitation and overvoltage trip. On the other hand, voltages below the envelope are assumed to cause the load to drop out due to lack of energy. In other words, the concept is that if the supply voltage stays within the acceptable power area then the sensitive equipment will operate well. However, if such an event persists for a longer time, then the sensitive equipment might fail

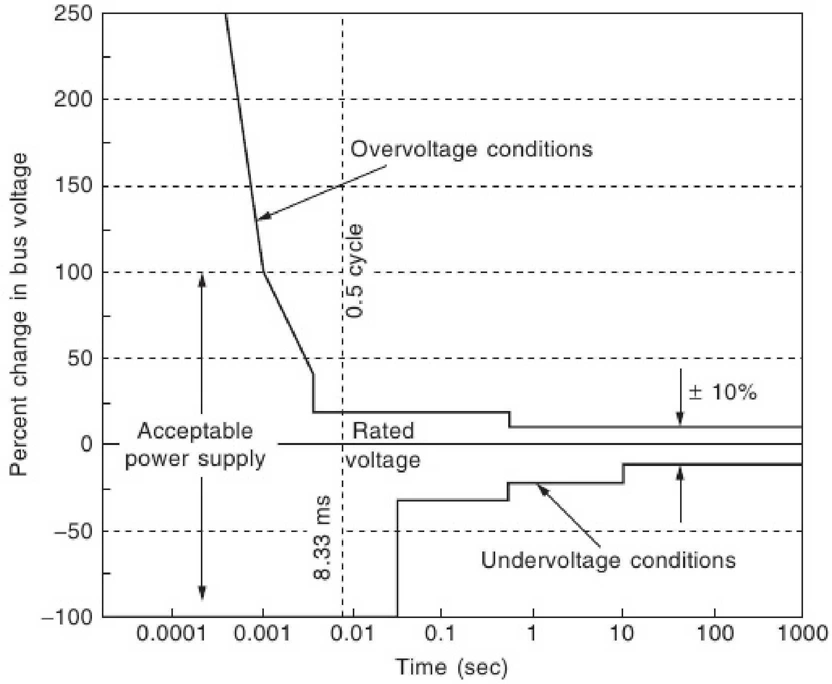


Figure 4 CBEMA curve.

3.2 SARFI

The SARFI is table o graphs that allow analyze the number of events (mainly sags) occurred in a given area, in a certain period of time and their degree of involvement, considering their duration and percentage of voltage variation, for which, the table indicates areas where the sags are classified as high, medium or low impact for devices connected to the grid.

<table>
<tr><th rowspan="2">Voltage variation (v)</th><th colspan="3">Duration (msec)</th></tr>
<tr><th>20<= t <150</th><th>150<= t <600</th><th>600<= t < 3000</th></tr>
<tr><td>90% >= V >85%</td><td colspan="3" rowspan="1">Y</td></tr>
<tr><td>85% >= V >80%</td><td colspan="2">Y</td><td rowspan="2">Z1</td></tr>
<tr><td>80% >= V >70%</td><td>Y</td><td rowspan="3">S</td></tr>
<tr><td>70% >= V >60%</td><td>X1</td><td rowspan="3">Z2</td></tr>
<tr><td>60% >= V >40%</td><td>X2</td></tr>
<tr><td>40% >= V >=0%</td><td colspan="2">T</td></tr>
<tr><td colspan="4">Events out durations limits:</td></tr>
<tr><td colspan="4">Events out amplitud variations:</td></tr>
<tr><td colspan="4">Events out range:</td></tr>
<tr><td colspan="4">Total Events:</td></tr>
</table>

Figure 5 SARFI graph.

Considering the standards above mentioned and the CBEMA curve and SARFI graphic, Transmission Department of Mexican utility defined the L0000-70 Guide, "Power Quality. Characteristics and limits of disturbances in electrical energy parameters", which aims is determine the power quality taking into account the characteristics and limits of disturbance of the energy supplied by operational processes of the electrical utility (generation, transmission and distribution).

4. System description

Power Transmission Department of Mexican utility has approximately 1500 electronic meters with capacity to detect and record events related to power quality, as well as measurement the energy in periods of 5, 10 or 15 minutes to create load profiles. These meters are installed in transmission substations and they are interconnected to control centers through an Ethernet network that integrates to electric company intranet. Meters installed in each substation are of different models belonging to three different brands. Therefore, each of these brands has its own communication protocol and a particular way of representing the data generated, therefore it requires particular software to link with each meter and gets the information recorded. This reading software obtains information from each meter to store it in a particular database. In other words, meter reading software of same brand requires its own database.

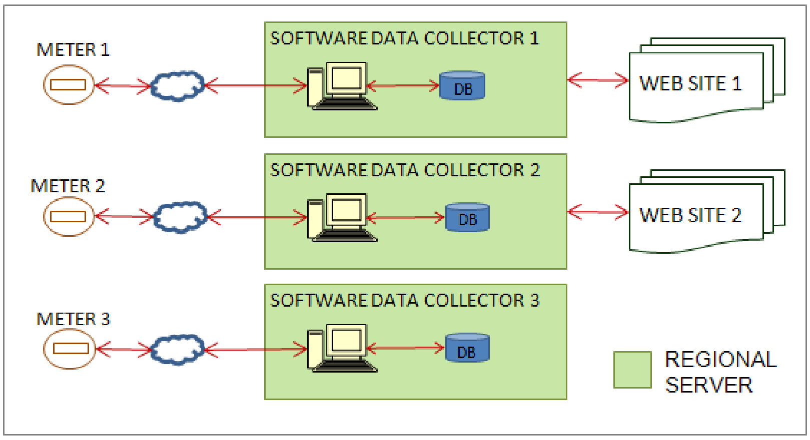


Figure 6 Original scheme to read meters.

In order to analyze in an easier way power quality data recorded for each meter, was raised to develop a system whereby different utility areas can query and analyze the disturbances detected in the transmission circuits, regardless of brand meter that recorded them.

Based on the above, firstly it was determined to create a unique database containing all the information relating to events of power quality (sag, swells, interruptions short time, harmonic distortion, flicker, etc.) and load profiles of kVARh and kWh, obtained from the proprietary databases for each meter trademark.

Next step was defining the system structure taking into account the following considerations:

1. Each meter must be read by your proprietary software.
2. Three different meter brands will be considerate.
3. The information read will be stored into your corresponding database (proprietary database).
4. Each database will be accessed by a software collector to extract power quality data and energy load profiles.
5. Every Transmission Regional Department must have your own data collector running in a dedicated server. Hence, nine data collector will be running simultaneously.
6. One central server will be installed at the main offices of the utility. This server store all the information collected by regional data collectors.

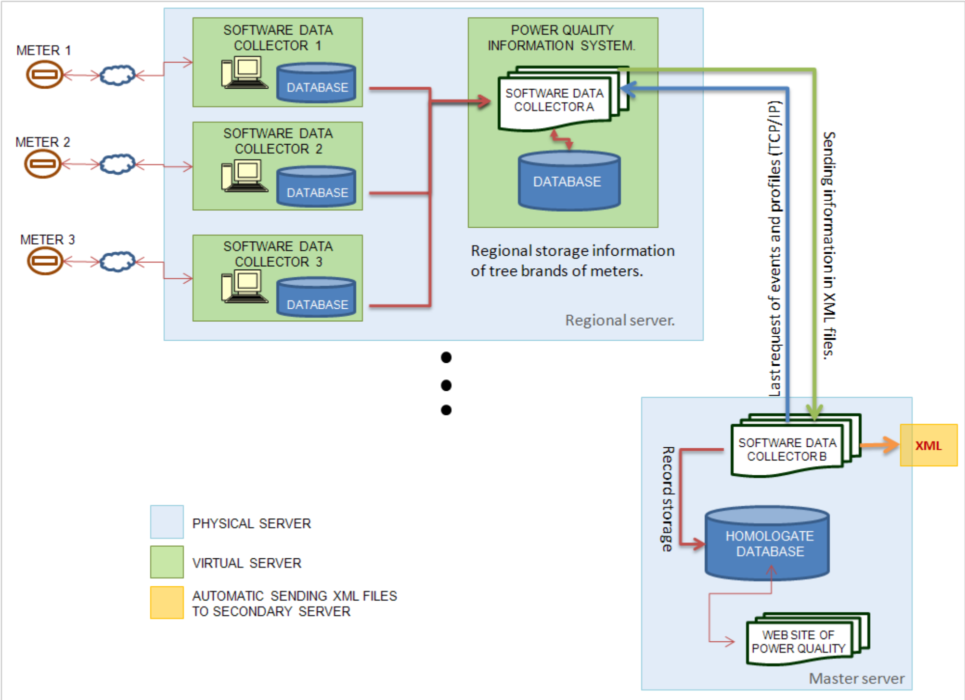


Figure 7 System scheme proposed.

The system developed was named "Interactive System for analysis of power quality" “SIACEN” (for its acronym in Spanish). SIACEN system is integrated by two main elements, first one the collector (SIACEN-Recolector), this application is installed in every regional server, and their main functions is obtaining data from every proprietary database and store them in a homologated database. The information stored in each regional database is sending it to the central database by request of the main server.

The SAICEN-Web Site application is the second one element of SIACEN system. This application resides in central server and could be executed from any regional server, as well as from main server. Web Site includes functions to process, show and analyze power quality information stored in its homologated database. The user can generate reports or see the events detected and registered by one o several meters. Also, SIACEN-Web Site automatically sends every week, power quality information to other utility system in order to share and compare similar information generated for Distribution and Generation areas of Mexican utility.

The information stored in homologated database, could be deployed in CBEMA curve or SARFI table (see figures 8 and 9) or in a power quality indicators table (see figure 10).

Caída de la tensión V	Duración t (ms)		
	20<= t <150	150<= t <600	600<= t < 3000
90% >= V >85%	0	0	0
85% >= V >80%		0	0
80% >= V >70%		0	
70% >= V >60%	0		0
60% >= V >40%	0		
40% >= V >=0%	0		
Eventos fuera de duración: 2			
Eventos fuera de magnitud: 0			
Eventos fuera de rango: 0			
Total de eventos: 2			

Figure 8 SARFI table show by SIACEN Web Site.

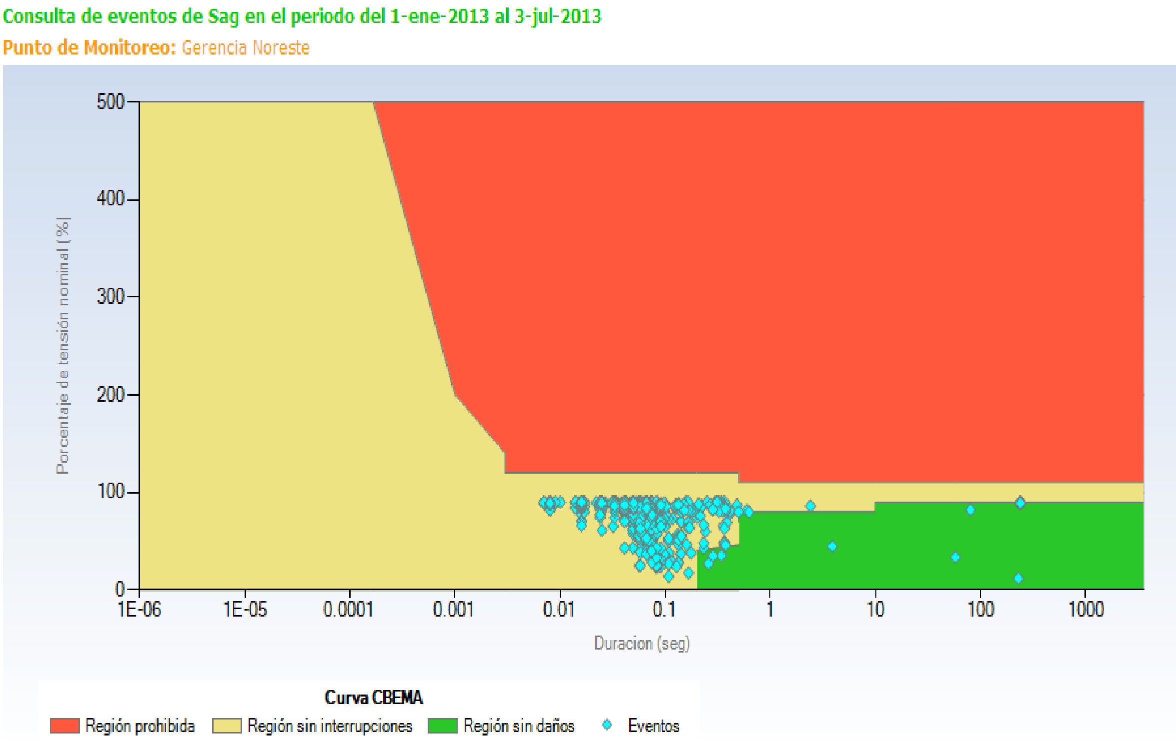
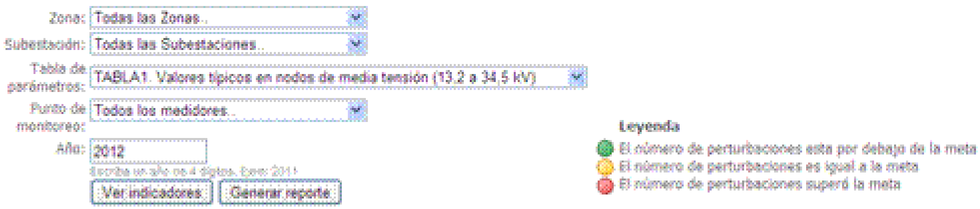


Figure 9 CBEMA curve generated by SIACEN-Web Site.



Fenómeno por evento	Tipo	Magnitud (pu)	Duración	Cliente (cantidad)	Periodo de evaluación	Contribución de Eventos por proceso: G	T: Meta	T: Real	C	D
Interrupción	Momentánea	0,1	1 ciclo - 3 s	26	Anual	0	6	1	NA	10
	Temporal	0,1	3 s - 1 min	50	Anual	4	10	1	1	15
	Sostenida	0	1min	18	Anual	2	4	6	1	4
Sag	Instantáneo	0,1 - 0,9	1 - 30 ciclos	148	Anual	0	8	194	NA	70
	Momentáneo	0,1 - 0,9	30 ciclos -3 s	66	Anual	0	6	1	NA	30
	Temporal	0,1 - 0,9	3 s - 1min	28	Anual	3	2	0	NA	10
Swell	Instantáneo	1,1 - 1,8	1 - 30 ciclos	104	Anual	0	4	0	NA	50
	Momentáneo	1,1 - 1,4	30 ciclos -3 s	22	Anual	0	2	0	NA	10
	Temporal	1,1 - 1,2	3 s - 1min	24	Anual	5	2	0	NA	5

Figure 10 Power quality events indicators.

1. CONCLUSIONS

The SIACEN System has allowed the transmission area of electrical utility to have a tool capable of bringing the information related to power quality of about 1500 meters of three different manufacturers, these meters are installed in transmission substations located in several cities from Mexico. The system also has allowed monitoring goals that includes the L-000070 guide, which refers to the amount of permissible disturbances of power quality parameters by electrical process or by levels voltage.

The SAICEN System being used by the nine Transmission regional offices and exist plans to expand your application in other areas like Generation.

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