POWER QUALITY INDICATOR MANAGEMENT SYSTEM – SIMPLIFIED AND AUTOMATIC MONITORING PROTOTYPE IMPLEMENTATION AT CPFL

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ABSTRACT

This work presents the procedure of the Power Quality Indicator Management System, a simplified and automatic monitoring system implemented at CPFL. This process is based on a device developed after 3 years of research, within CPFL R&D program, called RIQEE - Electric Power Quality Indicators Recorder, and it was customized for this project by Reason Tecnologia, especially assisting the simplicity, low cost, processing, robustness and the reliability.

In this System the phenomena of the quality of energy as non conformity (Flicker Pst, Flicker Plt, Voltage Harmonic Distortion, Current Harmonic Distortion, Voltage Unbalance and Current Unbalance) they are summarized with 95% of probability (proposed Brazilian standard). The events of Sag and Swell are summarized by their remaining voltage and duration. The system offers an easy procedure for analysis of the disturbance, because the most data are already processed in the device and then it is send to mainframe, avoiding great volumes of data to be transmitted and analyzed.

The results obtained by the PQ Manager System implemented by Expertise Engenharia at CPFL, is presented at this work, shows that the project provides a high degree of visibility.

INTRODUCTION

With the great technology evolution seen last decades allowed a significant development at electrical utility clients (mainly at commercial and industrial sectors). The brand new technology incorporated the most advanced electronics devices. These new devices came to control industrial and commercial process using modern power electronics.

These devices contributed significantly to several sectors to compete with high quality products. Therefore, with all this new technology, came new problems related to the power quality.

These problems are connected to new type of loads that increasing in distribution system. They are called non-linear loads and they produce disturbance in the electrical system and cause lost productions. And the disturbances are responsible for non conformity of energy supplying. They can cause big losses to the utility as well as for customers. For the last 20 years more emphatically, all electrical society researched about power quality phenomena and its implications, measurements and limits definition. We had a good progress in all this area; but the power quality monitoring involves a huge amount of data processing and storing cost.

In Brazil, especially CPFL had monitored our PQ index and it results a big data bank. So the CPFL decided to fix a limit for each phenomenon or disturbance. Because, it had concluded that the most part of Common Coupling Point (CCP), information wasn't necessary. So within our R&D program, we developed a power quality device called "RIQEE – Power Quality Index Recorder". Basically, it monitories several PQ phenomena during all day and after 24 hour monitoring, it stops recording and begins PQ processing and sends the results and Sag/Swell events to company mainframe by mobile phone or intranet.

So, the PQ engineer may supervise PQ indexes and can take over if any troubles. And also can anticipate the trouble, analysing historical data.

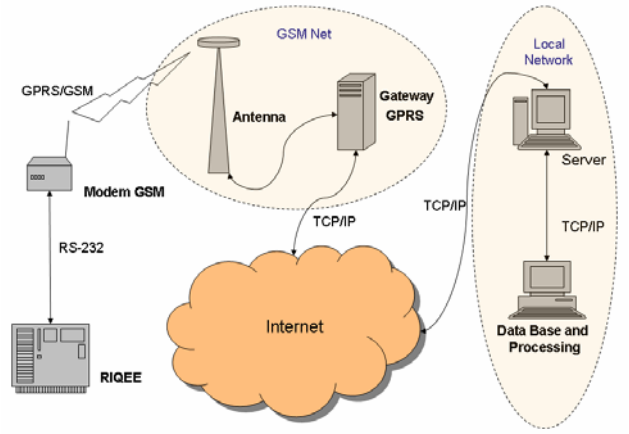

Figure 1 – Power Quality Manager System Architecture

The system implemented in the CPFL will be presented

subdivided in four blocks: Signal Acquisition, Data Processing, Data Transmission and Manager System. *Figure 1* illustrates the Power Quality System Architecture, from the signal acquisition in field to the data base.
The results obtained by the PQ Manager System implemented by Expertise at CPFL, that will be presented at this work, shows that the project provides a high degree of visibility of the electrical distribution system, being evident and documented the correlation of phenomena in different points from the electric system. That reinforces that PQ, in an utility , cannot just be treated in a punctual way , but yes in a systemic way, making interface with internal sections (planning, maintenance, juridical, etc) and external (great customers, agency regulatory, etc). Therefore, the PQ problems will be detected previously and the solution will be directed.
The results compiled during the year of 2005 will be presented in tabular way and the results will be analysed according to Brazilian normalizations.

METHODOLOGY

This power quality indicator management system is called *SGQP – Sistema de Gestão da Qualidade da Potência* can be better explained with examples from our prototype implementation. CPFL with partners developed, design and manufactured 34 samples of RIQEE. They were installed at our substations to monitor our power quality indexes without spending much time, neither, money to analysis.

Signal Acquisition

The RIQEE can be connected directly to a low voltage outlet, this is especially interesting point to monitor flicker disturbance or it can be used to measure voltage and current signals are acquired from potential transformer (PT) and from current transformer (CT). There are equipments installed at low voltage as 220127 volts; 11.9 kV, 25.0 kV, and 69.0 kV and in 138.0 kV in the CPFL system.

Data Processing

In this System the phenomena of the quality of energy (Flicker Pst, Flicker Plt, Voltage Harmonic Distortion, Current Harmonic Distortion, Voltage Unbalance and Current Unbalance) are summarized daily by a statistical value in which 95% of the samples are below this value. These samples are Integrated each 10 minutes, except for Flicker Plt samples that are Integrated each 2 hours. The events of Sag and Swell are summarized by remaining voltage and duration. In other words, the system propitiates an easy analysis of the data, because the data are already processed, they are "cut information" for the Analysis of PQ.
The device for data acquisition and processing is presented at *figure 2*. This is only first model, now we updated the device and some criteria of data processing.

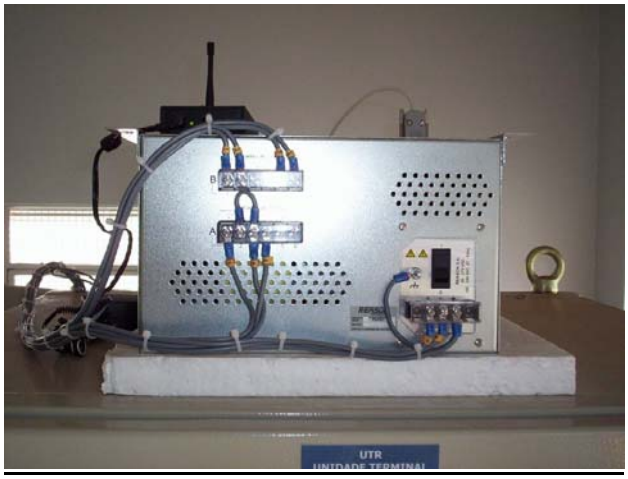

Figure 2 – prototype of the RIQEE, used for tests (it was made 34 units to field test)

Data Transmission

After 24 hours of measuring (normally just after mid night), the device process all measurement data, to consolidate indicators. Then the indicators is sent to the CPFL mainframe. The Modem hardwired to the recorder makes a connection GPRS with the server that feeds the Date Base. The methodology of compacting of the data makes possible that each measurement point uses 5 Kbytes to transmit the data, decreasing the system communication cost.

Manager System

The Manager System is responsible for the insertion of the data in the Date Base, making the reading of the archives sent by several RIQEEs and inserting the information in a base SQL Server.
The consults also are carried through by the Manager System. The information can be visualized in table form, graphical form, as exemplified in *Figure 3*, and through reports.

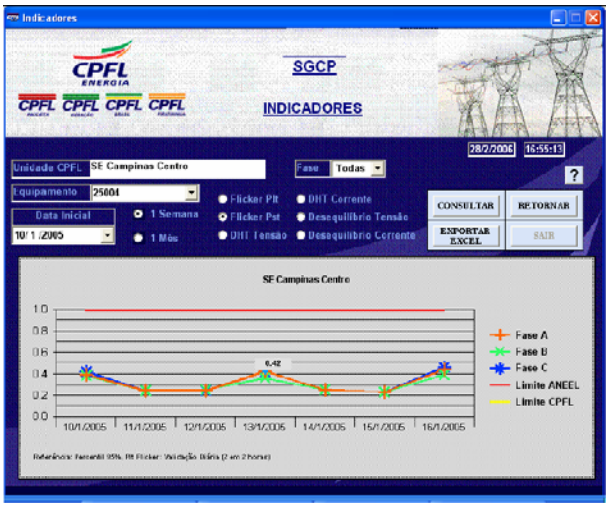

Figure 3 – Power Quality Indicator Management System (example Flicker of substation Campinas Centro for one week monitoring).

The cadastre of equipment and points of measurement is also managed by the system.

RESULTS

All the presented values to follow had been registered for Power Quality Manager System and correspond to statistical level 95% of the daily samples
In Table 1 we have the maximum values, minimum and average values of 12 CPFL's substations during the year of 2005.

Table 1 – Resumo dos resultados de 12 SE's

	PST(pu)	DHTV(%)	KV(%)	DHTI(%)	KI(%)
SE	Min - Max / Med	Min - Max / Med	Min - Max / Med	Min - Max / Med	Min - Max / Med
Americana	0,2 - 1,2 / 0,8	1,0 - 6,0 / 2,0	0,15 - 5,5 / 0,3	2,0 - 30,0 / 5,0	1,0 - 7,5 / 2,0
Andorinha	0,3 - 0,8 / 0,5	2,8 - 5,0 / 3,5	0,1 - 0,6 / 0,25	6,0 - 18,0 / 12,0	2,0 - 11,0 / 4,0
Campinas Centro	0,2 - 1,8 / 0,5	2,0 - 5,0 / 3,0	0,25 - 0,6 / 0,4	3,5 - 16,0 / 6,0	2,0 - 13,0 / 4,0
Colonial	0,15 - 1,2 / 0,4	1,5 - 6,3 / 2,0	0,15 - 0,7 / 0,3	2,0 - 22,0 / 4,0	1,5 - 7,0 / 2,8
Ipê	0,15 - 1,2 / 0,7	1,0 - 4,5 / 2,0	0,15 - 0,4 / 0,3	2,0 - 23,0 / 5,0	1,2 - 3,6 / 1,8
Morumbi	0,15 - 0,7 / 0,4	1,0 - 5,2 / 2,5	0,35 - 0,7 / 0,45	1,0 - 17,0 / 5,0	2,5 - 14,0 / 4,0
Nova Aparecida	0,15 - 1,0 / 0,6	1,3 - 3,0 / 2,0	0,8 - 1,5 / 1,1	2,0 - 11,0 / 4,0	4,0 - 12,5 / 6,0
Nova Veneza	0,2 - 1,05 / 0,8	1,0 - 5,5 / 1,5	0,5 - 0,9 / 0,65	2,0 - 25,0 / 3,0	1,8 - 6,0 / 2,5
Orquídea	0,2 - 2,0 / 0,9	1,1 – 3,0 / 1,6	0,25 - 0,9 / 0,6	4,0 - 11,0 / 8,0	2,0 - 12,5 / 5,0
Piracicaba	0,4 - 7,0 / 1,6	2,0 - 11,0 / 3,0	0,2 - 1,1 / 0,3	-	-
Quilombo	0,2 - 0,9 / 0,6	1,5 - 3,8 / 2,5	0,35 - 0,9 / 0,6	2,0 - 1,01 / 4,0	3,0 - 13,0 / 5,0
Souzas	0,15 - 1,3 / 0,4	1,0 - 4,5 / 2,5	0,15 - 0,8 / 0,25	2,5 - 18,0 / 4,0	1,5 - 11,0 / 2,5

Flicker - Pst95%

According to recommendations of the ANEEL, the maximum limit for low and average tension, acceptable only as precarious condition, is PstD95%=2pu (daily index). In normal conditions the limit is PstD95%=1pu.
Among the 12 substation monitored, only Piracicaba accused a preoccupying level of Pst. The average value of PstD95%, throughout 2005, surpassed the maximum limit of 2pu. The root cause is the operation of voltage arc ovens of siderurgical industry, installed next the Piracicaba. Steps had been taken in December of 2005 transferring the feeding of this industrial installation to another substation, with bigger level of short circuit. This measure in fact revealed efficient, decreasing this daily PST95% next to 1pu. With this improving measure in middle December, the average level of Piracicaba, Orquídea substation, suffered a small raise from the Pst95% level, that passed from 0.7 average to 1.05pu. Similar behavior also was observed in Americana substation that passed from an average of 0.7 to 1.0pu. In others substations the level of flicker was not preoccupying, rarely passing 0.8pu.

Total Harmonic Distortion - Voltage - $THD_{V95\%}$

According to recommendations of the ANEEL (Electrical Energy National Agency), the maximum acceptable limit for total distortion of the tension is $THD_{V95\%}$=6.0%. This maximum limit was observed in 3 substations: Americana (6.0%), Colonial (6.3%) and Piracicaba (11.0%). However, all these cases have been outcome and may have been caused by some anomaly of the distribution system. The average levels of $THD_{V95\%}$ in this substation had been well below of 6.0% (2.0%, 2.0% and 3.0%, respectively).

Voltage Unbalance - K_V-95%

According to recommendations of the ANEEL, the acceptable maximum Voltage Unbalance limit of K_V-95%=2%. This limit was not reached in any substations, and the biggest average was 1,1%, registered in Nova Aparecida substation. This substations had a monotonic growth, from 0,8% to 1,4%. This atypical behavior suggests that it is gradually increasing the unbalance level of loads attended by this substation.

Total Harmonic Distortion - Current – $THD_{I95\%}$

The biggest average value observed was $THD_{I95\%}$=12% in Andorinha substation. Capacitors manufacturer worries when the level of harmonic in its equipment passes 10% due the risks of damages for excessive losses and overheating. Therefore this could be a limit to be signaled prevention measures.
Although, the value exceeded only at Andorinha substation. Maximum values above 10% had been observed in the 12 substations, reaching 30% in Americana substation and 25% in Nova Veneza, which constitutes important industrial centers. The engineer responsible for this particular substation now can take over about current harmonic distortion. Looking for the client with a big non linear load or it can be caused by harmonic resonance. In both case the RIQEE helps to save time and money spending.

Current Unbalance $K_{I-95\%}$

The limit of current unbalance could serve for orientation to balance loads when this value was exceeded. An additional complication is that the presence of harmonic current also causes unbalance, and this type of unbalance is not repaired balancing the phases but reducing the harmonic content. The biggest average value of K_I was observed in Nova Aparecida (6%). The maximum values had been in the band between 10% and monitored 14% in seven of the 12 substations.

CONCLUSION

The results generated for the Power Quality Indicator Management System make possible a better understanding regarding the quality phenomena and the diffusion of concepts in diverse sectors of the company and, mainly, assists the taking of decision in the relationship with great customers, in the system planning, the maintenance and assets management. The consolidation of a historical base characterizes the electrical system of the CPFL regarding the PQ, and makes possible a systemic vision of the electrical distribution system, anticipate emergency actions and bases the internal processes to assure the Quality of the Energy Supply. And another very important contribution is many engineers, who weren't familiarized with power quality problems are now can consult PQ level at his local substations, so can be prepared for new energy trends and mandatory regularizations.

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