POWER QUALITY MONITORING SYSTEM AT THE TRANSMISSION AND DISTRIBUTION INTERFACE

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ABSTRACT

First part of this paper contains the standards, the technical and commercial regulations regarding Power Quality (PQ), issued by the Romanian Regulatory Authority. We present them according to transmission and distribution system objectives and customer's positions. The PQ indices can be part of contractual requirements and must be monitored with dedicated PQ meters.

The second part of this paper presents the main features, functionality and equipments of the first PQ permanent monitoring system in Transelectrica. We locate this system in the WEB presentation for Transelectrica Sibiu geographical map and energy transfer boundary witch contains all the partners and exchange points grouped according to substation sites and voltage levels .We also present methods, measurements, records with complete analysis of PQ indices during seven months for the national dispatcher centres.

The third part of this paper presents a PQ mobile monitoring system, consisting of portable PQ meters used to analyse the propagation of distortions around the common coupling points (CCPs). We present the locations, methods, measurements and the results obtained, during six weeks.

The fourth part of this paper presents the main features of the future permanent monitoring system which will be implemented by Transelectrica at eligible consumers.

The final part contains conclusions and recommendations for future development. PQ has an important effect regarding network economic efficiency and represents a defining parameter for performance network evaluation.

The final goal of this system is to assist the dispatcher in taking the necessary actions for a proper correspondence with PQ indices admissible limits.

INTRODUCTION

On Electricity Market there are important players: generation companies (hydro, nuclear, thermo power plants), transmission company, distribution company and electricity suppliers. Transelectrica is the Romanian Transmission, System Operator and at the same time, the Metering Operator of the wholesale electricity market. PQ aspects are very actual and important in this company activity at interface with Electrica, the Distribution and supply Operator. Both Transelectrica and Electrica have the common goal of maintaining the PQ indices in the 110kV CCPs, between the transmission and distribution system, within admissible limits.

The PQ conditions in CCPs between transmission system and distribution system are regulated by The Electricity Transmission Grid - Technical Code (ETGTC) issued by Romanian Electricity and Heat Regulatory Authority (ANRE) [1]. At the same time, The Electricity Distribution Grid - Technical Code and Performance Standard (EDGTC), issued by ANRE is in force for distribution system [2].

According to ETGTC, the power transmitted from the transmission system to the distribution system, in CCPs must correspond on the following technical parameters: power frequency, supply voltage quality, regarding to: voltage magnitude, harmonic voltage and voltage unbalance.

The PQ conditions in CCPs between transmission system and eligible consumers are regulated by the Contract of Eligible Consumers. In this regulation are established PQ indices admissible limits.

The monitoring of power quality indices at the interface between the transmission and the distribution system is used to verify the contractual requirements presented in regulations and allows the different levels of dispatcher to take the necessary actions to keep them in their admissible limits. At the same time PQ has an important effect regarding network economic efficiency and represents a defining parameter for performance network evaluation.

In order to achieve those goals, during last year, Transelectrica developed:

A) The first **POWER QUALITY PERMANENT MONITORING SYSTEM** for transmission and distribution interface, at 110kV voltage level, in Transelectrica Sibiu Subsidiary. It consists of seven PQ meters, installed at site level, in seven substations and one central level. In each site, the PQ meter is able to complete monitor one metering point, in CCP. The communication between site level and central level uses analogue modems and optical fibber medium. At the central level one server and one PC workstation are installed.

B) The **POWER QUALITY MOBILE MONITORING SYSTEM** for in depth analyse of 110kV supply nodes for very important customers, at 400/220/110kV voltage levels, in Transelectrica Bacau and Constanta Subsidiaries. It consists of five portable PQ meters, installed in 15 metering points, some of this are CCPs, located in three substations and one laptop. The PQ meter has an Ethernet interface to allow easy data transfer on the laptop, with a dedicated software.

PQ PERMANENT MONITORING SYSTEM

For Sibiu Subsidiary the exchange partners can be easily located using the geographical map (figure 1) and the energy transfer boundary (figure 2). The last contains all the partners and all the CCPs between subsidiary and other entities, grouped according to substations site and voltage levels. CCPs are very important to determine the quantity of electric energy received from, or delivered to other participants, in the wholesale electricity market. Locations of installed power quality meters are indicated using a blue circle.

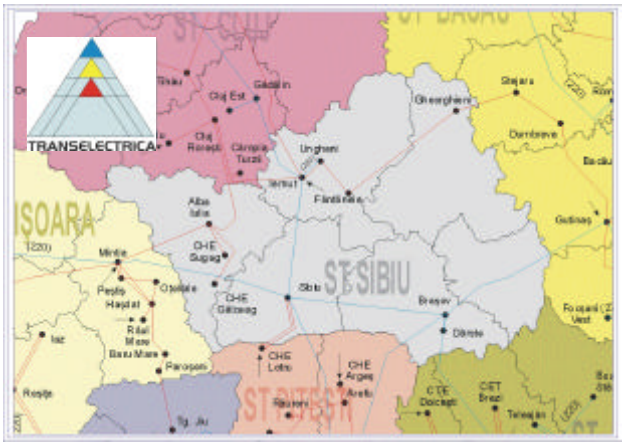

Figure 1. Map of transmission network for Sibiu Subsidiary

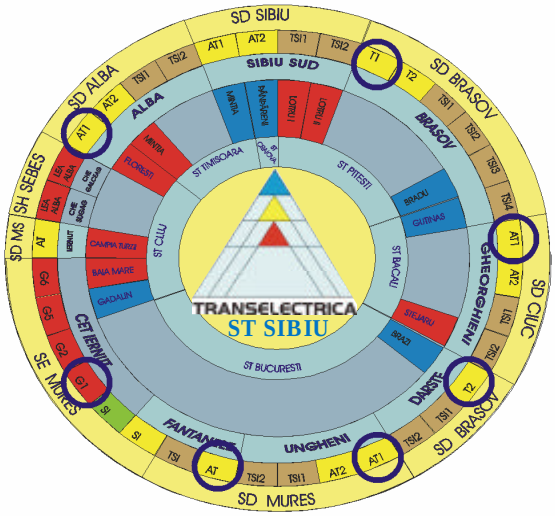

Figure 2. Energy transfer boundary for Sibiu Subsidiary

The system consists of seven PQ meters, type ION7650 manufactured by Power Measurement[5], installed in seven substations, the corresponding communication devices and the server installed at the headquarters of Sibiu Subsidiary are presented in figure 3. The communication between levels uses analogue modems, equipments for optical fibber medium, channel of 64kb/s digital link and standard protocols.

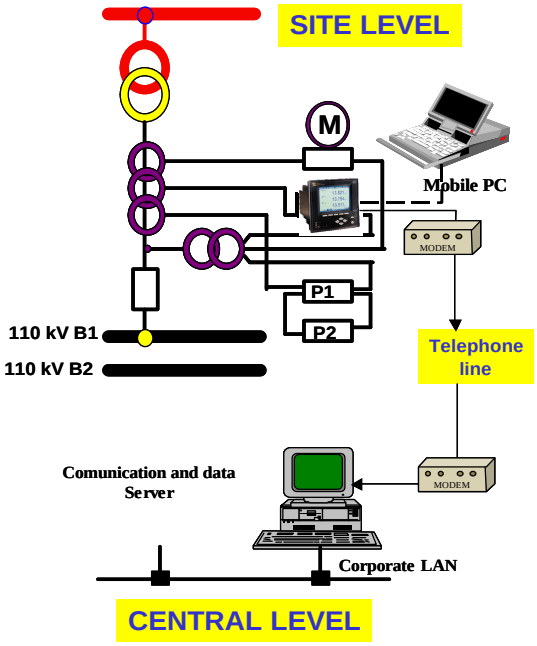

Figure 3. PQ system architecture

The measurements have been done according to the IEC 61000-4-30 "Testing and measurement techniques – Power Quality Measurement Methods", on each phase for voltage and currents.

Fixed montage solution without current probes was adopted for the installation of PQ meters in all seven locations,. This means that the PQ meters are using 4 input currents and 4 input voltages becoming part of the secondary circuits of measurement current and voltage transformers,.

The equipment used for this system has the functionality of a three phases static power quality meter, disturbance analyzer and data logger in a single instrument for trouble shooting, load profiling, supply monitoring, and for safety and ease of use.

It has the possibility to measure and record in real time the values of phase voltage, frequency, current, power of 3 phases system and individual power of each phase, power factor, the vectors diagram and active, reactive, apparent energy. The equipment records the min, max, average values, and detects and measures dips, surges, flicker and interruptions.

According with ETGTC and EDGTC regulations four common PQ parameters must be observed. This PQ system analyses the data according to the ETGTC admissible limit for 110kV level.

1. Power frequency. - The admissible limits are defined in EU interconnecting systems conventions.
2. Voltage magnitude value - the admissible limits are inside the [99kV … 121kV] interval.
3. Total harmonic distortion voltage - the superior admissible limit is 3%.
4. Voltage unbalance - unbalance is calculated in using also the symmetrical components; the superior admissible limit

for negative phase sequence voltage magnitude is 1%.
Supplementary, short and long time flicker variations are recorded according standard methods and limits.
The PQ meter has a built in memory for data logging and capturing, capable to store all 'True RMS' measurements recorded at very short integration time (3 sec) and short integration time (10 min.) over one week (7 days). The data collected by PQ meters data are transmitted to the CL on request and stored in a common database.
Statistical reports required by standards are automatically generated for weekly determination of cumulative probabilities, 95% and 99% of 'True RMS' supply voltage magnitude, power frequency, total harmonic voltage and supply voltage unbalanced. By default, ION Enterprise Management software configuration measures the supply voltage and presents EN 50160 statistics according to [3] (figure 4).

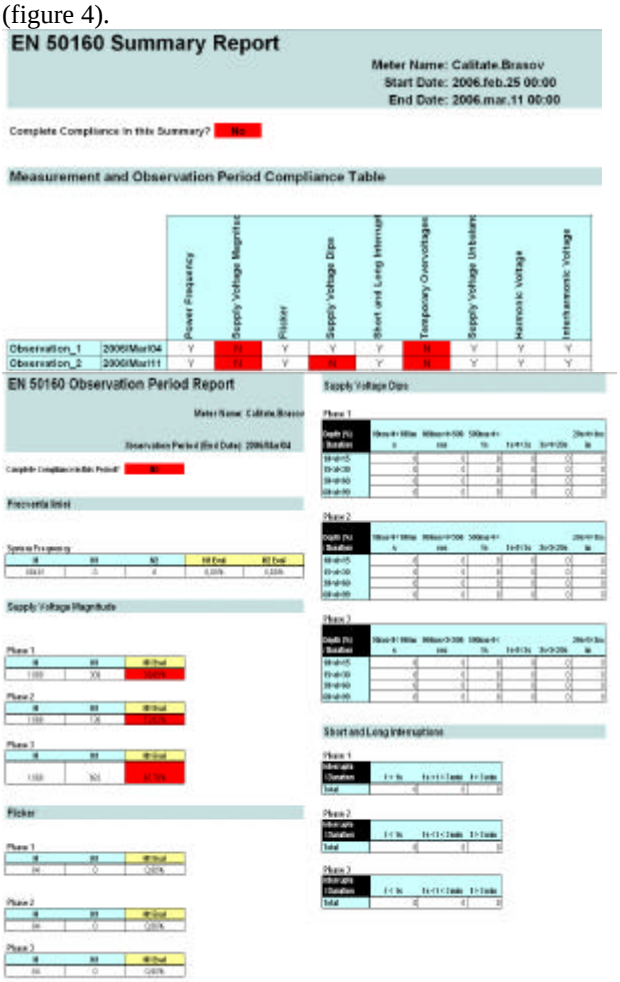

Figure 4 Standard EN50160 report

Results for a seven month study period for all locations are presented in Table 1. Recorded values outside the admissible limits of 95% value over one week are indicated in red.

substation	power frequency	supply voltage magnitude	harmonic voltage	supply voltage unbalance	flicker
Alba Iulia AT1/110kV	Y	N	N	Y	Y
Brasov T1/110kV	Y	N	N	N	Y
Darste T2/110kV	Y	N	Y	N	Y
Fantanele AT/110kV	Y	N	Y	Y	Y
Gheorgheni AT1/110kV	Y	N	Y	Y	Y
Iernut AT/110kV	Y	N	Y	Y	Y
Ungheni AT1/110kV	Y	N	N	Y	Y

Table 1. Results for a five month study period

PQ MOBILE MONITORING SYSTEM

The PQ temporary monitoring system consists of five portable PQ meters, type TOPAS 1000 manufactured by LEM Austria [6] and one laptop. This equipment is a dedicated PQ analyser, according with EN 50160-1999.
The scope of this project was to monitor the most important customers supplied by 110kV overhead lines, for study the distortions propagation to higher voltage levels on 400/220kV trough auto-transformers.
For this purpose the PQ meters were installed in 15 metering points, located in three transmission substations: Roman Nord, Tulcea Vest and Smardan.
In each substation data were recorded over a two week period and then downloaded off-line on a laptop using Ethernet port.
For each location recorded data were analysed using 95% over one week limit value statistical method.
Five PQ meters were used in Roman North substation to monitor one 220/110kV autotransformer, two steel processing plants 110kV overhead supply lines and two railroad power stations 110kV overhead supply lines.
The disturbances outside the admissible limits detected in Roman Nord substation included over voltages, flicker and harmonics distortion voltage THD-U up to 6.37%. The worst situation is illustrated in figure 5.

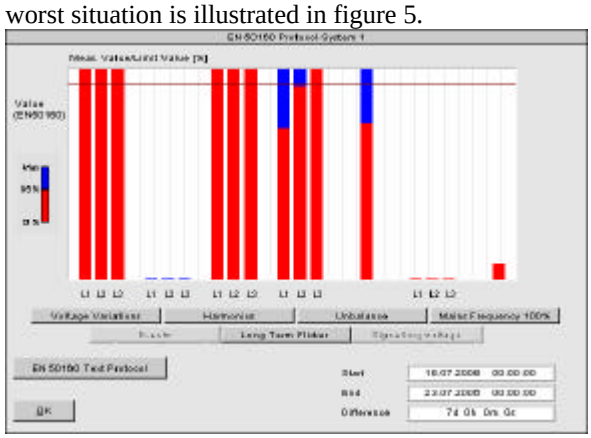

Figure 5. EN50160 report for railroad power station 110kV Razboieni

As seen in figure 6, voltage harmonics and flicker caused by industrial customers are transferred to higher voltages.

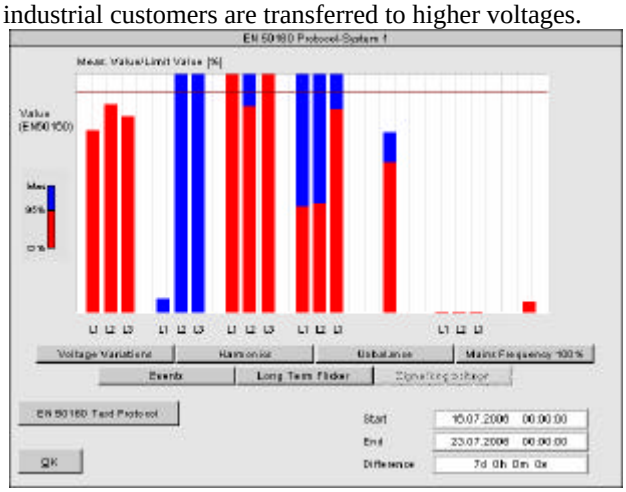

Figure6. EN50160 report on 220kV autotransformer in Roman North substation.

In Smardan substation 7 metering points have been monitored for a two weeks period. The value of 1,21% of the negative unbalance at shipyard 110kV overhead supply line was the only one outside the limits.
In Tulcea Vest substation 3 metering points have been monitored, but no distortion outside the limits was detected. Data acquired in the field can be used for a various type of reports including voltage variations over time and harmonic spectrum (figure 7) or active/reactive power load profiles and flicker variations over monitored period (figure 8).

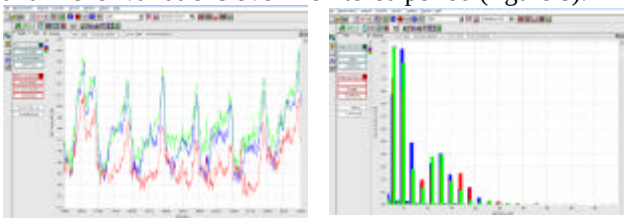

Figure 7 Harmonic voltage distortions.

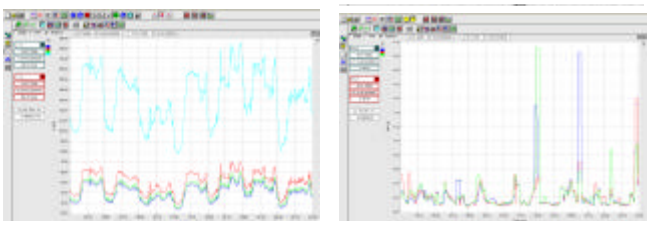

Figure 8 Power active, reactive abrupt changes, voltage fluctuations, Flicker variation

The number of Romanian eligible consumers increased last year, with the implementation of the liberalized wholesale energy market. During this year Transelectrica will implement a permanent monitoring system at the interface of 220kV transmission grid with eligible consumers. This system consists of 16 metering points in 9 substations, a central station at OMEPA- Metering Operator and a work station at the National Dispatch. The equipments are high precisions meters ZMQ with PQ recorder module manufactured by Landis Gyr from Switzerland. Data acquisition are analysed with Simeas Q PAR-Manager and Sicaro PQ from Siemens Germany. The data transmission will be done using OF medium.

CONCLUSIONS

The actual revising of the ETGTC, EDGTC and Performance Standard and their correlation according to the objectives in distribution and transmission system is necessary. This way the Power Quality Indices will create a correlation suppliers and the final user on one hand, and between the transmission system and the distribution system on the other hand in CCPs.
In present the statistic reports from permanent monitoring system are monthly sent to the national dispatcher. The final goal of this system is to assist the dispatcher in taking the necessary action to keep the PQ parameters in admissible limits. Further we propose future developments such as integrating the reports generated by the system in a WEB based database which will provide access to different users via internet browsers.
Short term monitoring of PQ in CCP determines the perturbations level and if a permanent monitoring system is required in that location. Information gathered by such systems will help to identify measures to be taken for network optimization, loses reduction and customer satisfaction.
The future permanent monitoring system will be very useful to verify the contractual requirements presented in the regulations. Special attention is required for customers connected at high voltage (steel and aluminium processing plants). Perturbations generated by their technological processes are transmitted over transmission network and affect power quality for other customers located at great distance about the PCC.

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