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The Power Quality Monitoring Systems in Romanian Power Grid

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***Abstract*--Transelectrica is the Romanian Transmission System Operator (TSO) and the Metering Operator of the Wholesale Electricity Market (WEM). It is deploying a nationwide Power Quality Monitoring System (PQMS). The PQMS has been operational since October 2005.**

The paper presents preliminary measurements results obtained from PQMS. The first part of the paper provides a description of the Power Quality (PQ). According with these regulations, TSO has to monitor the PQ parameters. The second part presents the most important permanently analysis of PQ parameters, in the Points of Common Coupling (PCCs), between TSO and the Distribution Systems Operators, at 110kV and between TSO and the Eligible Customers (EC), at 220kV. The third part presents the results from the PQ temporary monitoring system, the propagation of distortions around PCCs, at high voltage levels, measured with the portable PQ instruments. The final part contains conclusions and recommendations for future development.

***Index Terms*--High Voltage, Instrument, Parameter estimation, Power Quality, Regulation, Monitoring, System**

I. Introduction

In order to achieve the goals presented in the summary, four years ago, Transelectrica performed the necessary steps.

Since 2005, dedicated CT (0.2S accuracy class) and VT (0.2 accuracy class) measuring transformers have been installed in each metering points at the interface between the participants on WEM. In the same time the PQ temporary monitoring system was achieved.

Since 2006, the first PQ permanent monitoring system has been dedicated to monitoring the interface between transmission and distribution power grids.

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Since 2007, the second PQ permanent monitoring system is dedicated to monitoring the interface between transmission and EC grids.

II. Regulations

On Romanian WEM the PQ parameters are regulated by "The Electricity Transmission Grid – Standard of performance" [1], "The Electricity Transmission Grid Technical Code" [2] and also, by "The Electricity Distribution Grid – Standard of performance" [3], "The Electricity Distribution Grid Technical Code" [4], issued by Romanian Regulatory Authority (ANRE). The PQ conditions at the interface between transmission power grid and eligible customers are regulated by the Connection Notice issued by TSO, which establishes the PQ parameters admissible limits. These regulations define the quality of service as a combination of power supply reliability, supply quality and commercial quality, between the utility and the customers. According with the regulations [1] and [2], for the PQ of the power supply in the transmission power grid, TSO has to monitor, permanently or temporarily with dedicated instruments and has to report monthly to ANRE, the following PQ parameters in the PCCs:

1. Power frequency

The nominal frequency is 50 Hz. The admissible limits for operating frequency variation are:

47.00Hz - 52.00Hz during 100 % of a year;
49.50Hz – 50.50Hz during 99.5 % of a year;
49.75Hz – 50.25Hz during 95% of a week;
49.90Hz – 50.10Hz during 90% of a week.

2. Supply voltage magnitude

for a nominal value of:

400kV, the admissible limits are inside the [380kV … 420kV];

220kV, the admissible limits are inside the [198kV … 242kV];

110kV, the admissible limits are inside the [99kV … 121kV].

3. Supply voltage harmonics

The superior admissible limit for total harmonic distortion voltage is 3%.

d. Supply voltage unbalance

Unbalance is evaluated using the method of symmetrical components and the superior admissible limit for the negative sequence component is 1%.

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III. The PQ Monitoring Systems

A. The PQ Permanent Monitoring Systems

The first PQ permanent monitoring system analysis the measurements recorded by the seven instruments type ION7650, at the interface between TSO and Distribution System Operator, voltage level of 110kV. Fixed montage solution without current probes was adopted for the installation of PQ instruments inside seven TSO's substations: Alba Iulia AT1/110kV, Brasov T1/110kV, Darste T2/110kV, Iernut AT/110kV, Fantanele AT/110kV, Gheorgheni AT1/110kV, Ungheni AT1/110kV.

The data collected by PQ instruments are readout on request to the central level. They are stored in a common database and exported to Excel or HTML files. On central level ION Enterprise Management software configuration analyses all the PQ parameters of the transmission power grid and presents the EN 50160 statistics, taking into account the admissible limits set for high voltage, according to [1]. Statistical reports, according to [5] are automatically generated for weekly determination of cumulative probabilities 95% of power frequency, supply voltage magnitude, supply voltage unbalanced, voltage harmonics, total harmonic voltage, interharmonic voltage, long term flicker variations according standard methods and limits [1], [6], [7], [8], [9].

EN 50160 Summary Report

Meter Name: CEE.Albalulia
Start Date: 2008.aug.30 01:00
End Date: 2008.sep.27 00:00

Complete Compliance in this Summary? No

Measurement and Observation Period Compliance Table

		Power Frequency	Supply Voltage Magnitude	Flicker	Supply Voltage Dips	Short and Long Interruptions	Temporary Overvoltages	Supply Voltage Unbalance	Harmonic Voltage	Interharmonic Voltage
Observation_1	2008/Sep/06	Y	Y	Y	N	Y	N	Y	N	Y
Observation_2	2008/Sep/13	Y	Y	Y	N	Y	N	Y	N	Y
Observation_3	2008/Sep/20	Y	Y	Y	N	Y	N	Y	Y	Y
Observation_4	2008/Sep/27	Y	Y	Y	N	Y	N	Y	N	Y

EN 50160 Observation Period Report

Meter Name: CEE.Albalulia
Observation Period (End Date): 2008/Sep/27

Complete Compliance in this Period? NO

Harmonic Voltage

Phase 1

N	N1	N2	N1 Eval	N2 Eval
1008	0	57	0,00%	5,65%

Phase 2

N	N1	N2	N1 Eval	N2 Eval
1008	0	0	0,00%	0,00%

Phase 3

N	N1	N2	N1 Eval	N2 Eval
1008	0	613	0,00%	60,81%

Fig. 1. The monthly reports from the first PQ permanent monitoring system

Monthly, the reports are sent to the National Dispatch and included in the reports for the ANRE. As an example, Fig. 1 presents a part of the September 2008 report for Alba Iulia substation. Analysing the measurements from PQ temporary monitoring system, it can be seen that the harmonics level for supply voltage is outside the limits, but this was not reflected at voltage level of 220kV. The railway power stations, connected at 110kV, situated around the Alba Iulia substation, produced these perturbations, because they are supplied by transformers connected on HV between only two phases. The other PQ parameters in all substations are inside the admissible limits.

Because these PQ instruments are dedicated to PCCs for WEM, during the year 2009 they have to be upgraded for class A performance and certification, according to [6].

The second PQ permanent monitoring system analysis the measurements recorded by the fifteen instruments type ZMQ202, at the 220kV interface between TSO and EC, These EC are: COST Targoviste, the biggest plant in metallurgy industry, ALRO, the largest aluminum smelter in Central and Eastern Europe, DUCTIL Steel, Iron Plant Resita and MECHEL Campia Turzii focused on mining products, rolled steel, casting products.

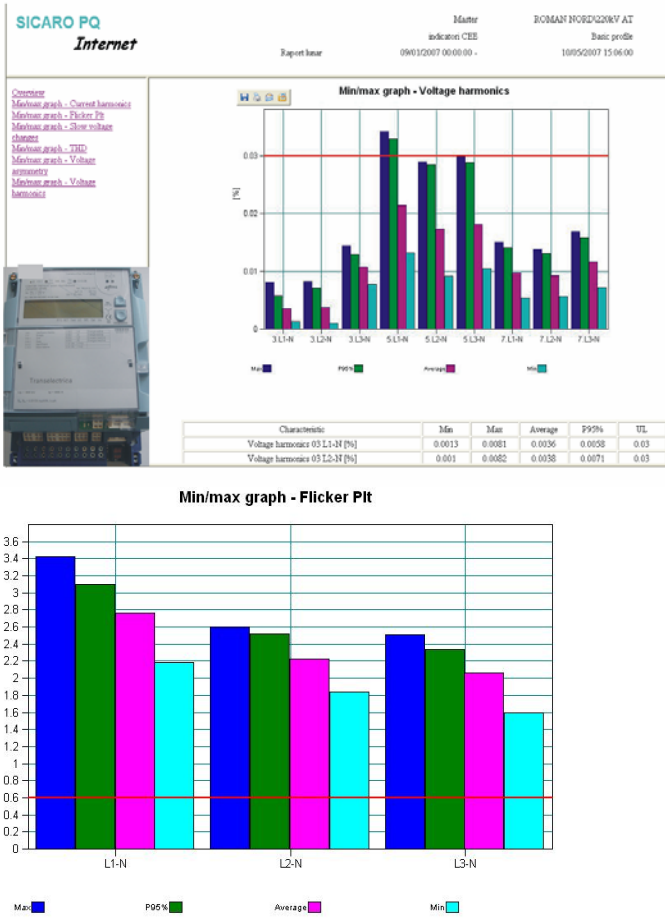

Fig. 2. The monthly reports from the second PQ permanent monitoring system

Fixed montage solution without current probes was adopted for the installation of PQ instruments. inside eight

Transelectrica's substations: Otelarie 220kV, Resita 220kV, Iaz 220kV, Slatina 220kV, Targoviste 220kV, Campia Turzii 220kV, Roman Nord 220kV, Tulcea Vest 400kV.

According to [7] the admissible HV limits for long term flicker Plt is 0,6 and for short term flicker is 0,8. Analysing the results of the permanent monitoring during last year for each EC supplied at HV one may observe that the PQ parameters for flicker are outside the limits, as presented in Fig. 2 for COST Targoviste (value 95% Plt=3). Also the total harmonic distortion (THD) parameter for voltage and current is outside the admissible limits in every measuring point from the EC, according with [8], as in Fig. 2 for COST Targoviste. Usually, the voltage harmonics outside the limits are the odd ranks between the 3rd and the 19th harmonic. The duty of EC is to install the specific equipments/installations to reduce the voltage/current harmonics and flicker distortions.

A model for statistical yearly reports of the record of outages, under/over voltage with selectable thresholds, voltage dip table with duration and depth, from the first and second PQ permanent monitoring systems, is presented in Fig. 3.

overvoltage	U_R			U_S			U_T		
	Δt <1s	1s≤Δt <1 min	1min≤ Δt	Δt <1s	min	1min≤ Δt	Δt <1s	min	1min≤ Δt
110%Uc < U < 120%Uc	0	0	3	0	2	9	0	0	10
120%Uc ≤ U < 140%Uc	0	0	0	0	0	0	0	0	0
140%Uc ≤ U < 160%Uc	0	0	0	0	0	0	0	0	0
	U_R			U_S			U_T		
dips	< 100ms	< 500ms	< 1s	< 100ms	< 500ms	< 1s	< 100ms	< 500ms	< 1s
10%Uc < ΔU < 15%Uc	0	0	0	0	0	0	1	0	0
15%Uc ≤ ΔU < 30%Uc	0	0	0	1	0	0	0	0	0
30%Uc ≤ ΔU < 60%Uc	0	0	0	0	2	0	0	0	0
60%Uc ≤ ΔU < 99%Uc	0	0	0	0	0	0	0	0	0

Fig. 3. The yearly reports from the PQ permanent monitoring system

B. The PQ Temporary Monitoring Systems

The PQ temporary monitoring system consists of five portable PQ instruments, type TOPAS 1000, which are installed in the PCCs, between transmission and distribution power grids. The scope of this monitoring system is to analyse the electromagnetic chain of propagation the disturbances, from distribution to transmission power grids.

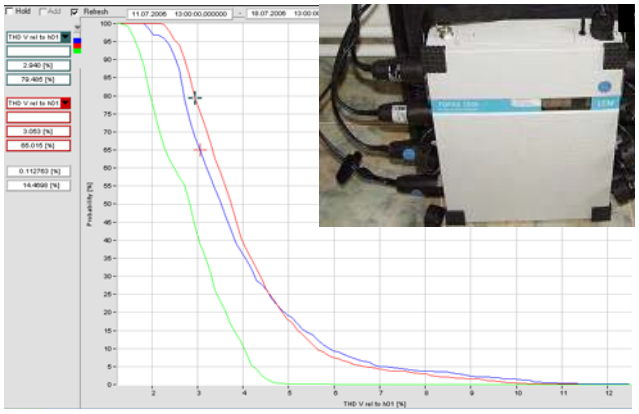

Fig. 4. The analysis from the PQ temporary monitoring system

For the customers like metallurgy processing plants, railway power stations, supplied at voltage levels of 110kV the perturbations generated by their technological processes are conducted in the transmission power grid.

According to the program of PQ monitoring, during one year, the PQ instruments are installed in over than 25 metering points, located inside the more than four TSO's substations. In each substation PQ parameters are recorded over a minimum interval of two weeks. With this type of dedicated PQ instrument the data acquired in the field can be used for special PQ analyses, including for example voltage variations over time, harmonic spectrum or the probability curve, as in Fig. 4.

Statistical reports that meet the requirements of [5], for admissible limits according to [1] are automatically generated for weekly analyse of cumulative probabilities 95% and 100% of 'True RMS' power frequency, supply voltage magnitude, supply voltage unbalanced, total harmonic voltage, interharmonic voltage, flicker. Monthly the reports are sent to the National Dispatch and included in the reports towards ANRE.

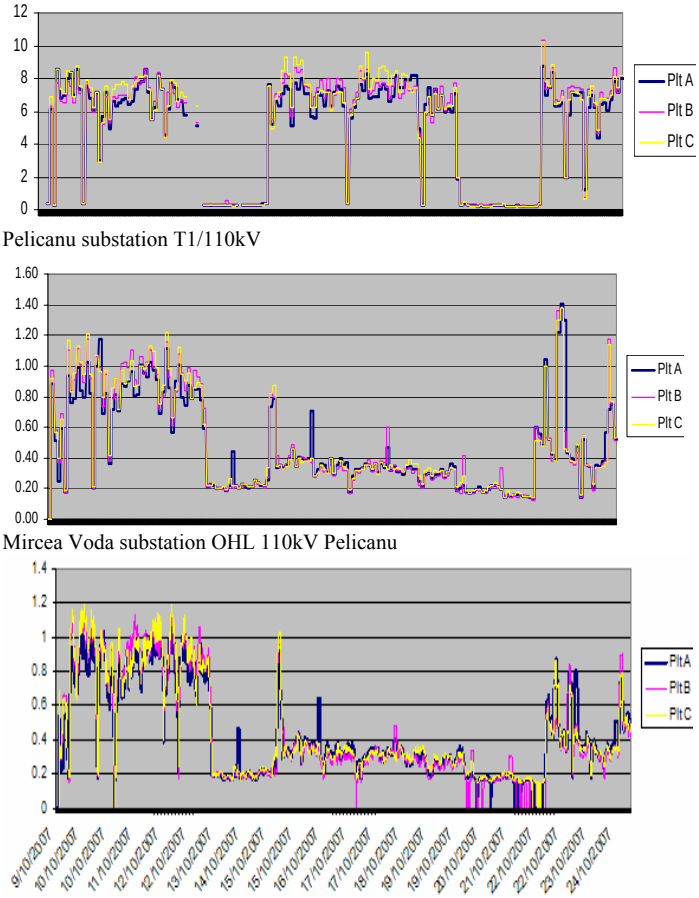

Fig. 5. Long term flicker variations

The study [10] has been contracted to analyse the causes and the effects of the distortions identified in Pelicanu substation. The measurements took place in the following substations: Pelicanu 400/110kV, Saint Gobain 110kV, Mircea Vodă 110kV, Călăraşi 110kV and Bucureşti-Sud 400/220/110kV, using 16 PQ instruments. Values outside the limits have been recorded for long term flicker, short term

flicker, supply voltage total harmonic distortions and supply voltage negative unbalance, according to [7], [8] and [9]. The measurements in Pelicanu 400/110kV substation were performed during three weeks in normal network configuration and in particular configuration, in order to identify the source of the perturbations.

The measurements concluded that the deviation of PQ parameters for transmission power grid and for the other customers 110/20kV are caused by the plant in metallurgy industry supplied at a voltage level of 110kV Pelicanu. TSO issued a new Connection Notice enforcing the consumer to install the Static VAR Compensator, in order to keep the flicker parameters, as in Fig. 5, inside the admissible limits, otherwise it should be disconnected from the power supply. Following the needed corrective actions, TSO will include this customer in the existing PQ permanent monitoring system.

IV. Conclusions

Romanian energetic prescriptions regarding PQ need to be updated according to the international PQ standards, including also the flicker parameters. PQ permanent monitoring systems create a necessary statistical database for development of PQ regulation and the ascertainment of contractual conditions.

The purpose of this monitoring is to help the National Dispatch to make the correct decisions in order to keep the indicators inside the imposed limits. The data obtained from the PQ monitoring systems are needed to report monthly the PQ indicators from power transmission grid to ANRE.

When the PQ parameters do not fit into the admissible limits is necessary to extend the measurements on areas of influence, using portable PQ instruments. Sometimes its need to be followed up by dedicated studies which will identify the causes and the solutions that will limit the recurrence of perturbation and keep them in the allowed limits. The Network Operator has the obligation to specify in the legal document the duty of the Customer to keep the PQ parameters inside the admissible limits.

On the WEM, the monitoring of the PQ parameters requires the use of class A performance PQ instruments, according with [6], together with a good knowledge of the measurement uncertainty, calculation formulas and the implemented measurement, aggregation and ascertainment methods.

PQMS is a very powerful source of data, but only if the persons who are using it are aware of its possibilities. For this reason it is very important to educate people who are in charge of such a system. The dedicated training classes Leonardo Power Quality Initiative Vocational Education System are forming a large number of PQ experts starting with 1st level experts in 2006-2007 and continuing with 2nd level experts in 2008-2009.

PQ has an important effect in the network economic efficiency and represents a defining parameter in the evaluation of the network performances. The goal of this integrated system is to assist the dispatcher in taking the necessary action to keep the PQ parameters in admissible limits, adopt the configuration for single line diagram, or the connection of different voltage tap of autotransformer. With Transelectrica investment during the year 2009 a software platform will be developed to integrate these systems.

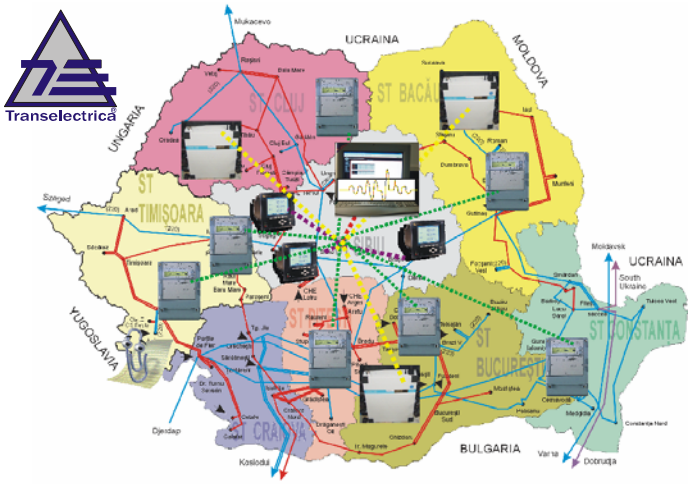

Fig. 6. The future of the PQ monitoring systems

The future developments such as integration of the reports generated by the PQ monitoring systems will provide access for different users, like National Dispatch, Transelectrica's Subsidiaries, Customers via internet browsers, as in Fig. 6.

The results of PQ monitoring systems presented above are used to verify the customer's compliance with contractual agreement, to monitor the performance evolution of a network during long periods, to compare different networks evolution during the same period. Hereby we propose to extend the permanent PQ monitoring by implementing new systems that will optimize the power grid operating mode, reduce the energy technical looses and increase the customer satisfaction.

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VI. BIOGRAPHIES

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