POWER QUALITY PERMANENT MONITORING SYSTEM AT THE TRANSMISSION AND DISTRIBUTION INTERFACE

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INTRODUCTION

Transelectrica is the Romanian Transmission Company and Electrica is the Romanian Distribution Company. One of the goals of Transelectrica, the transmission and system operator, as well as Electrica, the distribution and supply operator must be maintaining the power quality indices in the common coupling points (CCPs), between the transmission and distribution system within admissible limits.

One of Transelectrica main task is to accurate measure the energy flow between participants in wholesale market of electricity in CCPs between the transmission and distribution systems. Power Quality problems are very actual and important in activities of these Companies, as we discussed in the papers presented at the previous Juko CIGRE Conference, witch was held in 2004. One of the conclusions was that the scope of monitoring is to verify the contractual requirements presented in regulations.

This paper present the next development stage for a power quality permanent monitoring system. The project was conducted by Transelectrica Sibiu Subsidiary at the interface between the transmission and the distribution system to 110kV voltage level.

First we present the main features, functionality and equipments of this system. Then we present some measurements, records and reports optained since the installation work was completed. The measurements have been done according to the IEC 61000 "Testing and measurement techniques – Power Quality Measurement Methods" for three Power Quality Indices, that were monitored and presented below. Also we present the regulations concerning the power transmitted from the transmission to the distribution system.

In the end we propose some conclusions and recommendation for extension of the present system in other area interest. The final goal of this system is to assist the dispatcher to take the necessary measures for a proper correspondence with Power Quality Indices admission limits.

Scope of the project

On the Romanian Electricity Market there are few important players: generation companies (hydro, nuclear, termo power plants), transmission company, distribution company and electricity suppliers. Transelectrica is the transmission company from Romania, that includes the Transmission Operator and the System Operator . Electrica is the Distribution Operator and the Supply Operator from Romania. Power Quality problems are very actual and important in the activities of these companies.

The power quality conditions in The Common Coupling Point (CCP) 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). In the same time, The Electricity Distribution Grid - Technical Code (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, must correspond to the following technical parameters: power frequency, the magnitude of the supply voltage in CCPs, voltage quality, regarding to voltage harmonics and supply voltage unbalance, in CCP.

One of the goals of Transelectrica, as well as Electrica, must be to maintain the power quality indices in the CCPs between the transmission and distribution system within admissible limits. Monitoring the evolution 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 measures for a proper correspondence with their admission limits.

In order to achieve those goals, during this year, the first power quality dedicated system was developed at Transelectrica Sibiu Subsidiary. This system consists of seven sites level (SL) and one central level (CL). In each site the power quality (PQ) meter is able to monitor one metering point in CCP. The communication between SL and CL uses analog modems equipments for fiber optical medium, channel of 64 kb/s digital link, with standard protocol. The PQ meter has a interface for easy data transfer on a portable computer. At the central level one server and one PC workstation are installed (figure 1).

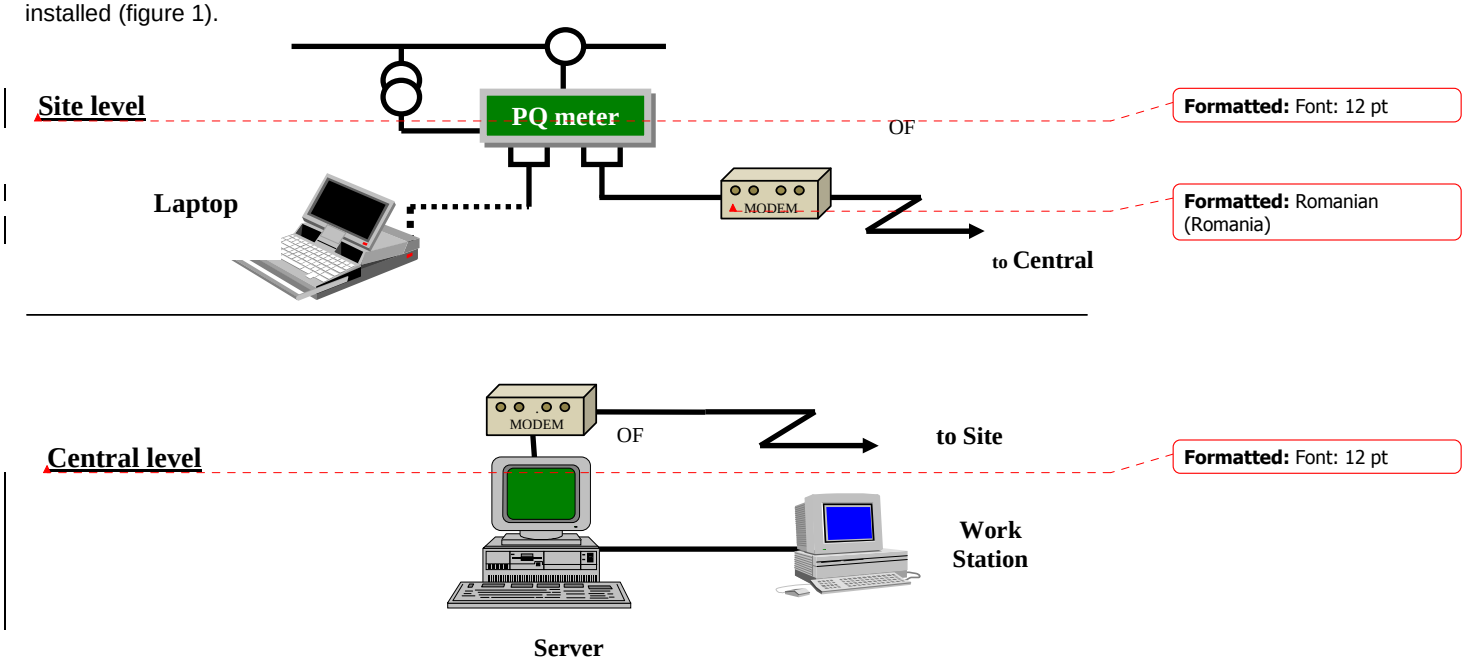
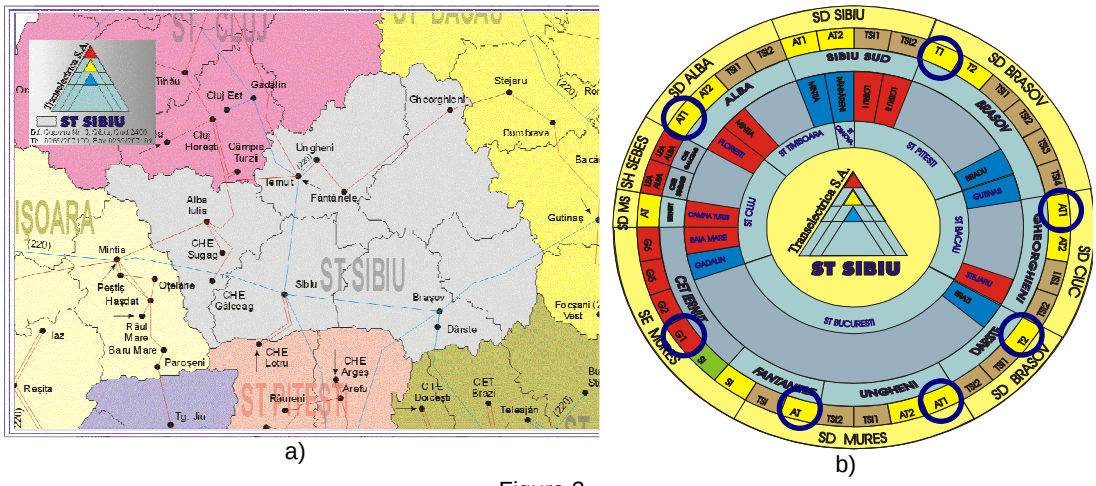


Figure 1

For Sibiu Subsidiary the exchange partners can be easily located using geographical map (figure 2a), and energy transfer boundary (figure 2b) witch contains all the partners, all exchange points between subsidiary and other entities grouped according to substations site and voltage levels. Locations of installed power quality meters are indicated with a blue colored circle.



a)

b)

Figure 2

System main features, functionality and equipments

The project consists of seven PQ meters, the corresponding communication devices installed in the field, and the Central System located at the headquarters of Sibiu Subsidiary. The measurements have been done according to the IEC 61000-4-30 “Testing and measurement techniques – Power Quality Measurement Methods”.
Field locations are presented in table 1:

Nr.	Substation	Bay
1	Alba Iulia 220/110/20kV	110kV power autotransformer AT1
2	Brasov 400/110/6kV	110kV power transformer T1
3	Darste 400/110/6kV	110kV power transformer T2
4	Fantanele 220/110/20kV	110kV power autotransformer AT1
5	Gheorgheni 220/110/20kV	110kV power autotransformer AT1
6	Iernut 400/220/110kV	110kV power autotransformer AT1
7	Ungheni 220/110/20kV	110kV power autotransformer AT1

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

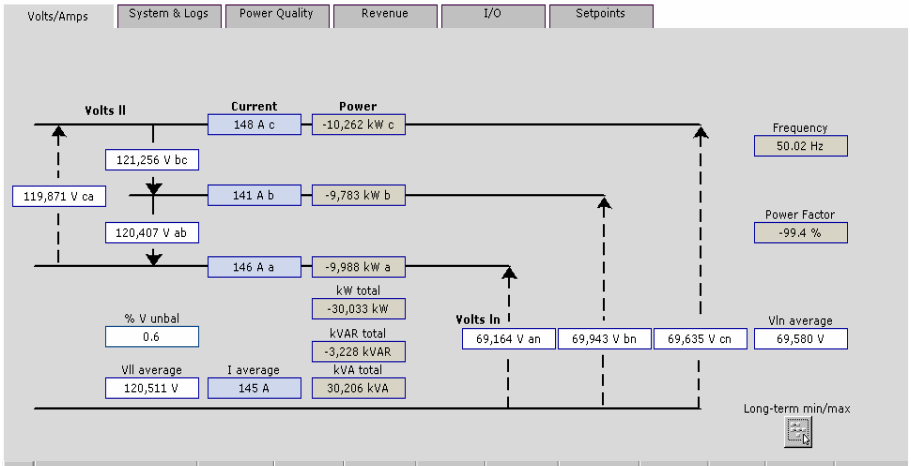
The equipment used for this project is a ION7650 from Power Measurements and has the functionality of a three phases static power quality meter, disturbance analyzer and data logger in a single instrument for trouble shooting, load profiling, supply monitoring, safety and ease of use.

It has the possibility to measure and record with real time clock the values of phase voltage, frequency, current, power for 3 phase system and individual for each phase, power factor, the vectors diagram and active, reactive, apparent energy. The equipment records the min, max, average values, and detect and measure 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 admission limit for 110kV level.
1. Power frequency. The admission limits are defined in EU interconnecting systems conventions.
2. Voltage magnitude value. The admission limits are inside the [99kV … 121kV] interval.

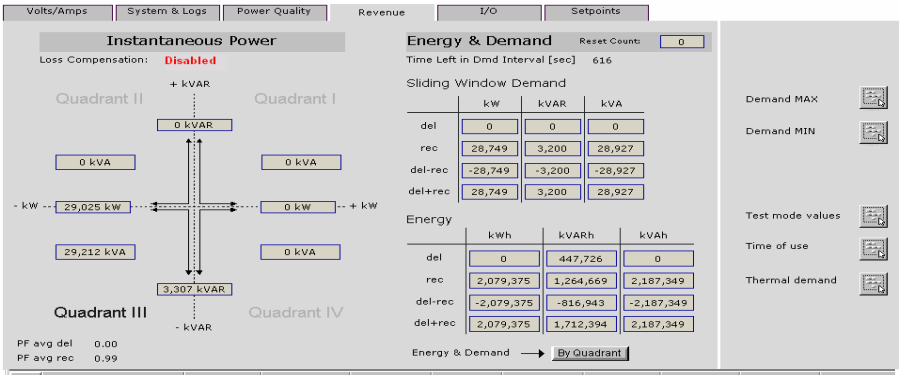
3. Total harmonic distortion voltage. The superior admission limit is 3%.
4. Voltage unbalance. Unbalance is calculated in using also the symmetrical components. The superior admission limit for negative phase sequence voltage magnitude is 1%.
According with (3) measurements of this PQ parameters are in class A performance.

Some available measurements are presented in figure 3 and 4 (snapshots of real-time measurements).



	timestamp	Vll avg mean	Vll ab mean	Vll bc mean	Vll ca mean	V unbal mean	Vll avg high	Vll ab high	Vll bc high	Vll ca high	V unbal high
67	05/14/2006 04:45:00.000 PM	122,206.922	122,016.016	123,001.875	121,602.789	0.641	122,450.039	122,301.43	123,225.8	121,890.367	0.873
68	05/14/2006 04:30:00.000 PM	122,057.57	121,843.148	122,921.547	121,407.945	0.699	122,372.719	122,241.086	123,254.6	121,789.25	0.926
69	05/14/2006 04:15:00.000 PM	122,095.07	121,908.57	122,925.227	121,451.586	0.67	122,394.516	122,202.836	123,164.9	121,815.719	0.847
70	05/14/2006 04:00:00.000 PM	121,859.297	121,646.93	122,659.398	121,271.539	0.645	122,388.086	122,205.063	123,200.8	121,840.078	0.757
71	05/14/2006 03:45:00.000 PM	121,594.016	121,334.531	122,442.992	121,004.477	0.688	122,134.969	121,891.039	122,951.9	121,561.875	0.866
72	05/14/2006 03:30:00.000 PM	121,826.773	121,559.539	122,853.469	121,067.305	0.837	122,174.25	121,927.969	123,150.6	121,456.945	1.044
73	05/14/2006 03:15:00.000 PM	121,826.727	121,573.672	122,865.961	121,040.359	0.844	122,223.523	122,017.586	123,160.1	121,494.891	1.051
74	05/14/2006 03:00:00.000 PM	121,871.422	121,663.094	122,753.336	121,197.727	0.715	122,264.945	122,072.398	123,133.9	121,631.367	0.897
75	05/14/2006 02:45:00.000 PM	122,042.656	121,843.914	122,876.281	121,407.789	0.674	122,317.523	122,131.805	123,152.6	121,688.039	0.871
76	05/14/2006 02:30:00.000 PM	122,084.391	121,932.836	122,802.727	121,517.617	0.577	122,365.875	122,255.414	123,054.4	121,858.719	0.703
77	05/14/2006 02:15:00.000 PM	122,012.688	121,856.773	122,744.875	121,436.555	0.589	122,256.305	122,163.445	123,002.2	121,717.758	0.714
78	05/14/2006 02:00:00.000 PM	121,795.117	121,654.898	122,462.508	121,267.797	0.537	122,084.016	121,966.227	122,709.8	121,691.844	0.68
79	05/14/2006 01:45:00.000 PM	121,808.492	121,696.977	122,432.977	121,295.469	0.501	122,081.43	121,991.125	122,703.2	121,611.891	0.609

Figure 3



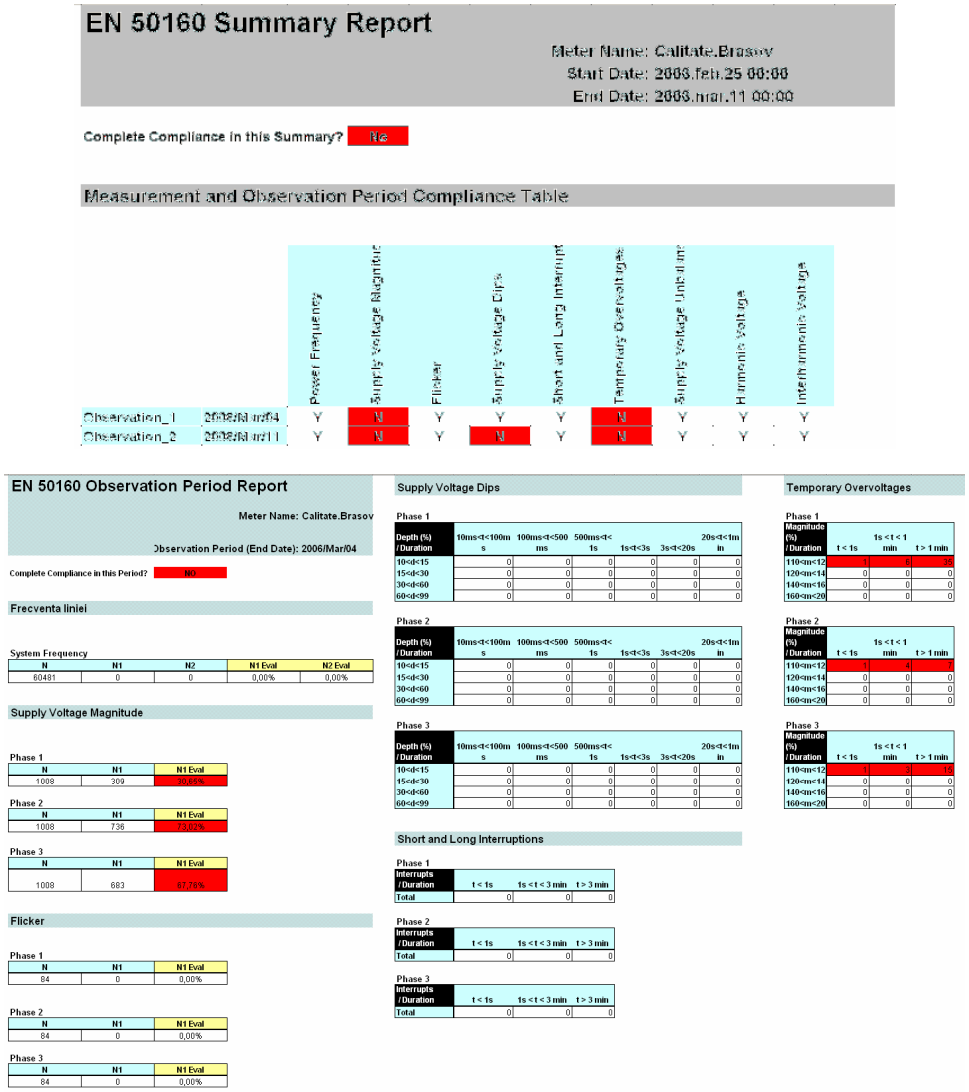
	timestamp	kW tot mean	kVAR tot mean	kVA tot mean	kW tot high	kVAR tot high	kVA tot high	kW tot low	kVAR tot low	kVA tot low
100	05/15/2006 03:15:00.000	-19,548.514	683.908	19,561.223	-18,880.082	1,095.77	20,184.5	-20,184.334	82.165	18,901.445
101	05/15/2006 03:00:00.000	-20,345.119	126.753	20,346.711	-19,459.984	639.565	20,861.881	-20,860.625	-269.491	19,464.354
102	05/15/2006 02:45:00.000	-20,845.277	-187.56	20,847.607	-19,990.209	411.619	21,820.053	-21,791.816	-1,123.275	19,994.445
103	05/15/2006 02:30:00.000	-20,156.09	344.649	20,160.564	-19,247.404	987.121	20,905.441	-20,904.52	-196.236	19,272.701
104	05/15/2006 02:15:00.000	-19,348.709	765.712	19,364.922	-18,612.803	1,126.992	20,229.596	-20,227.938	244.993	18,643.467
105	05/15/2006 02:00:00.000	-19,199.85	775.219	19,215.91	-18,728.908	1,141.582	19,861.707	-19,852.365	466.999	18,746.875

	timestamp	PF lag mean	PF lead mean	Freq mean	PF lag high	PF lead high	Freq high	PF lag low	PF lead low	Freq low
100	05/15/2006 03:15:00.000 AM		99.935	50		99.999	50.021		99.84	49.976
101	05/15/2006 03:00:00.000 AM		99.988	49.993	100	100	50.015	99.992	99.946	49.967
102	05/15/2006 02:45:00.000 AM		99.998	50.018	100	100	50.039	99.867	99.979	49.991
103	05/15/2006 02:30:00.000 AM		99.985	50.023	100	100	50.054	99.996	99.869	50.003
104	05/15/2006 02:15:00.000 AM		99.916	50.018		99.993	50.039		99.818	49.992
105	05/15/2006 02:00:00.000 AM		99.916	50.001		99.971	50.044		99.818	49.968
106	05/15/2006 01:45:00.000 AM		99.934	50.028	100	100	50.056	99.992	99.818	49.992
107	05/15/2006 01:30:00.000 AM		99.985	50.011	100	99.999	50.034	100	99.891	49.991

Figure 4

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% for 'True RMS' voltage magnitude, frequency, total harmonic distortion voltage and unbalanced voltage. ION meter have a default configuration that measures the supply voltage and presents EN 50160 statistics according to a set of guidelines defined by Eurelectric (UNIPEDE).



EN 50160 Summary Report

Meter Name: Calitate.Brasov
Start Date: 2006.feb.25 00:00
End Date: 2006.mar.11 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 Interrupt	Temporary Overvoltages	Supply Voltage Unbalance	Harmonic Voltage	Interharmonic Voltage
Observation_1	2006/Mar/04	Y	N	Y	Y	Y	N	Y	Y	Y
Observation_2	2006/Mar/11	Y	N	Y	N	Y	N	Y	Y	Y

EN 50160 Observation Period Report

Meter Name: Calitate.Brasov
Observation Period (End Date): 2006/Mar/04
Complete Compliance in this Period? NO

Frecventa liniei

System Frequency

N	N1	N2	N1 Eval	N2 Eval
60481	0	0	0,00%	0,00%

Supply Voltage Magnitude

Phase 1

N	N1	N1 Eval
1008	309	30,65%

Phase 2

N	N1	N1 Eval
1008	736	73,02%

Phase 3

N	N1	N1 Eval
1008	683	67,76%

Flicker

Phase 1

N	N1	N1 Eval
84	0	0,00%

Phase 2

N	N1	N1 Eval
84	0	0,00%

Phase 3

N	N1	N1 Eval
84	0	0,00%

Supply Voltage Dips

Phase 1

Depth (%) / Duration	10ms<t<100m s	100ms<t<500 ms	500ms<t< 1s	1s<t<3s	3s<t<20s	20s<t<1m in
10<d<15	0	0	0	0	0	0
15<d<30	0	0	0	0	0	0
30<d<60	0	0	0	0	0	0
60<d<99	0	0	0	0	0	0

Phase 2

Depth (%) / Duration	10ms<t<100m s	100ms<t<500 ms	500ms<t< 1s	1s<t<3s	3s<t<20s	20s<t<1m in
10<d<15	0	0	0	0	0	0
15<d<30	0	0	0	0	0	0
30<d<60	0	0	0	0	0	0
60<d<99	0	0	0	0	0	0

Phase 3

Depth (%) / Duration	10ms<t<100m s	100ms<t<500 ms	500ms<t< 1s	1s<t<3s	3s<t<20s	20s<t<1m in
10<d<15	0	0	0	0	0	0
15<d<30	0	0	0	0	0	0
30<d<60	0	0	0	0	0	0
60<d<99	0	0	0	0	0	0

Short and Long Interruptions

Phase 1

Interrupts / Duration	t < 1s	1s < t < 3 min	t > 3 min
Total	0	0	0

Phase 2

Interrupts / Duration	t < 1s	1s < t < 3 min	t > 3 min
Total	0	0	0

Phase 3

Interrupts / Duration	t < 1s	1s < t < 3 min	t > 3 min
Total	0	0	0

Temporary Overvoltages

Phase 1

Magnitude (%) / Duration	t < 1s	1s < t < 1 min	t > 1 min
110<m<120	1	8	38
120<m<140	0	0	0
140<m<160	0	0	0
160<m<200	0	0	0

Phase 2

Magnitude (%) / Duration	t < 1s	1s < t < 1 min	t > 1 min
110<m<120	1	4	7
120<m<140	0	0	0
140<m<160	0	0	0
160<m<200	0	0	0

Phase 3

Magnitude (%) / Duration	t < 1s	1s < t < 1 min	t > 1 min
110<m<120	1	3	16
120<m<140	0	0	0
140<m<160	0	0	0
160<m<200	0	0	0

Figure 5

The data can be used also in the management of active, reactive energy to determine the proper tariffs and loads profile (figure 6) :

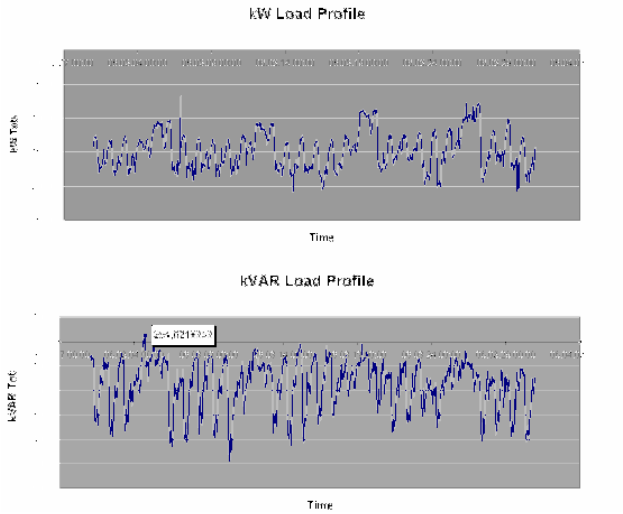


Figure 6

CONCLUSIONS :

In present the statistic reports are monthly sent to the national dispatcher. Until now the PQ parameters are conform admission limits in normal operation. The final goal of this system is to assist the dispatcher to take the necessary measures for a proper correspondence with PQ parameters admission limits.

PQ meters have a Ethernet port. At the SL present telephone cable link between PQ meter (analog modem-telephone circuits) and FO repartition panel will be replaced with communication over Ethernet network. 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.

For extension of the present system in other area interest, Transelectrica OMEPA subsidiary is developing a project for a power quality system dedicated to 16 consumers connected to the transport grid, at 220kV. In this project two CL are mentioned, one for OMEPA and one for national dispatcher.

The revising of the ETGTC, EDGTC and Performance Standard and their correlation according to the objectives in distribution and transmission system is necessary. On this way the Power Quality Indices will be correlated starting from the CCPs between supplier to the end userone one hand, and than in CCPs between the transmission system and the distribution system on the other hand

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