Power Quality According to EN 50160

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Abstract – **Although electricity, because of its possibility for easy conversion into other types of energy is the most used and most abundant form of energy, its features, except the frequency and amplitude of voltage is standardized too late.**

Determination of additional criteria for evaluating the quality of electricity has become necessary with the increasing of the use of electric consumers with nonlinear character. Such electrical devices and equipment, on one hand they need quality voltage for their operation, on the other hand inject many disturbances that negatively affect the characteristics of voltage which is connected. These are a kind of customer whose work is mainly based on microprocessor and logic circuits and particularly is important to be exposed to less interruption at work because they can cause major economic damage. With the increasing of the number of nonlinear consumers it is also increased the interest for power quality in recent decades.

Keywords – **Distribution network, electric power quality, European norm EN 50160, network performance analyser.**

I. INTRODUCTION

Electrical energy is a product and, like any other product, should satisfy the proper quality requirements. If electrical equipment is to operate correctly, it requires electrical energy to be supplied at a voltage that is within a specified range around the rated value. A significant part of the equipment in use today, especially electronic and computer devices requires good power quality (PQ). However, the same equipment often causes distortion of the voltage supply in the installation, because of its non-linear characteristics, i.e. it draws a non-sinusoidal current with a sinusoidal supply voltage. Thus, maintaining satisfactory PQ is a joint responsibility for the supplier and the electricity user. The responsibilities of the suppliers and the consumers of electricity are defined by internationally accepted electrical standards. In our area the most suitable standard for power supplying in distribution networks is the European standard EN 50160.

This paper presents the results of measuring the PQ at several points in DN using auxiliary sophisticated network analyzer.

II. POWER QUALITY

A. Term of PQ

Different ways of understanding what PQ is are present worldwide, including Macedonia. For example, power suppliers equalize the concept of power quality with supply reliability (continuity in delivery), defining the system as 99.98 percent reliable. Manufacturers of electrical equipment can define electrical energy as being quality if their equipment functions properly. Of course, such approach is subjective and open to criticism. But, however, the most reasonable, and in any case there must be a priority, the definition behind which stands the user of electricity, its consumer. The PQ analysis generally includes the following voltage parameters: power frequency, supply voltage variations, rapid voltage changes (and flicker), supply voltage dips, short interruptions, long interruptions, temporary over voltages, supply voltage unbalance, harmonic voltage, mains signalling voltage.

B. Standard EN 50160

EN 50160 gives the main voltage parameters and their permissible deviation ranges at the customer's point of common coupling in public low voltage (LV) and medium voltage (MV) electricity distribution systems, under normal operating conditions.

Supporting the requirement to define voltage characteristics in terms of frequency, magnitude, waveform and symmetry, EN 50160 provided definitions and in some cases measurement methods and compliance levels for 12 characteristics of the supply voltage:

TABLE I
EN 50160 COMPLIANCE LIMITS

No	Parameter	Supply voltage characteristics according to EN 50160
1	Power frequency	LV, MV: mean value of fundamental measured over 10 s ±1% (49.5 - 50.5 Hz) for 99.5% of week -6%/+4% (47- 52 Hz) for 100% of week
2	Voltage magnitude variations	LV, MV: ±10% for 95% of week, mean 10 minutes rms values
3	Rapid voltage changes	LV: 5% normal 10% infrequently Plt ≤ 1 for 95% of week MV: 4% normal 6% infrequently Plt ≤ 1 for 95% of week (formula 1)
4	Supply voltage dips	Majority: duration <1s, depth <60%. Locally limited dips caused by load switching on: LV: 10 - 50%, MV: 10 - 15%
5	Short interruptions of supply voltage	LV, MV: (up to 3 minutes) few tens - few hundreds/year.Duration 70% of them < 1 s
6	Long interruption of supply voltage	LV, MV: (longer than 3 minutes) <10 - 50/year
7	Temporary, power frequency overvoltages	LV: <1.5 kV rms MV: 1.7 Uc (solid or impedance earth) 2.0 Uc (unearthed or resonan earth)
8	Transient overvoltages	LV: generally < 6kV, occasionally higher; rise time: ms - μs. MV: not defined
9	Supply voltage unbalance	LV, MV: up to 2% for 95% of week, mean 10 minutes rms values, up to 3% in some locations
10	Harmonic voltage	95% of the time in 1 week, THD <8% (Table 2, formula 2)

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11	Interharmonic voltage	LV, MV: under consideration
12	Mains signaling voltage	9% - 100 Hz; 1% - 100 kHz, 99% of the time in 1 day

$$P_{it} = \sqrt[3]{\sum_{i=1}^{12} \frac{P_{sti}^3}{12}} \quad (1)$$

$$THD = \sqrt{\sum_{h=2}^{40} (U_h)^2} \quad (2)$$

TABLE II
VALUES OF INDIVIDUAL HARMONIC VOLTAGES AT THE SUPPLY TERMINALS FOR ORDERS UP TO 25, GIVEN IN PERCENT OF UN

Odd harmonics				Even harmonics	
Not multiples of 3		Multiples of 3		Not multiples of 3	
Order *h*	Relative voltage (%)	Order *h*	Relative voltage (%)	Order *h*	Relative voltage (%)
5	6,0%	5	6,0%	5	6,0%
7	5,0%	7	5,0%	7	5,0%
11	3,5%	11	3,5%	11	3,5%
13	3,0%	13	3,0%	13	3,0%
17	2,0%	17	2,0%	17	2,0%
19	1,5%	19	1,5%	19	1,5%
23	1,5%	23	1,5%	23	1,5%
25	1,5%	25	1,5%	25	1,5%

III. SYSTEM ANALYZER OMNI-QUANT

The OMNI-QUANT mobile is preferably used as portable device in changing locations. Four voltage and current measuring inputs each one allows power measurements, fault analyses and recording functions along with the evaluation of the voltage quality.

Complete scanning and calculation of the following values:

- Phase voltage (L-N) and phase-to-phase voltage (L-L)
- Star point voltage and symmetry L1...L3
- Frequency (identical for all channels)
- Current, total current L1...L3, total current L1...L3 + N
- Power (P, Q, S, power factor, distorted reactive power)
- Power of the fundamental (active power, reactive power, apparent power, cos)
- L1...L3 total of the above power variables
- Harmonics 1...50th order
- Intern harmonic of U and I up to 2.5 kHz
- Ripple control level
- Distortion factor (THD) of V and A.

IV. EXAMPLES OF MEASURING THE PQ ACCORDING TO EN 50150

A. Measuring

Practical measurement of power quality using measuring device OMNI-QUANT was made in several times in different points in distribution system.

The first measuring was performed in the period from 01.11.2011 to 01.12.2011 at 20 kV voltage level of the TS Polog 110/20 kV / kV. It is important to note that this is completely automatic TS with automatic voltage regulation and integrated device for continuous control of power quality.

Next measurement is performed in the period from 20.01.2011 to 28.01.2011 at 0,4 kV voltage level. Measurements were performed simultaneously at supply terminal of one consumer and at the LV level of TS Crniliste 20/0,4 which supplies this consumer.

B. Showing the results

After finishing the process of measurement, data is transferred to the PS. Then, by using special software package the summary results of measurements are obtained according to standard EN 50160. Because of the size of the number of the data it is not possible to display all the data and charts provided from measurements. It will be shown only those who are most interesting and most important for this paper.

In the graphical results presented in additional in this paper, the limit values according to standard EN50160 are marked by violet color.

Line voltage variations at 20 kV voltage level of TS Polog are given in the first picture. It can be noticed that the line voltages variations throughout the period were within the allowable limits according EN 50160.

On the second and the third picture are given the results for short interruptions of supply voltage and values of flicker severity and total harmonic distortion factor at 20 kV level of TS Polog 110/20 kV/kV.

It can be seen that on 10.11.2011 the THD is more than 7.5 % (very close to 8%) and there is deviation of flicker severity (Plt>1) about several hours in 26.11.2011, but still the values of these parameters also vary within the allowable limits according to EN 50160.

As it was mentioned above that this is completely automatic TS with automatic voltage regulation and integrated device for continuous control of power quality and this significantly affects to the values of all measured parameters to moving in approved limits.

In Fig. 4 and Fig. 5 are presented the results from measurement of PQ at 0.4 kV voltage level of TS Crniliste. Similar as in the previous example (TC Polog) most of the parameters are moving within the limits according to the standard EN 50160. From the shown parameters, the flicker severity, the total harmonic distortion factor and the supply voltage unbalance did not deviate from the allowable limits prescribed by EN 50160 over the entire period. With the exception on 23.01.2011 when it has a deviation of phase voltages above the limits for several hours.

In contrast to the values measured at 0.4 kV level of TS Crniliste, the values measured in the same period at supply terminal of one consumer supplied by TS Crniliste, significantly differ. In fact, with the exception of the total harmonic distortion factor, which moves within the allowable limits, the other parameters significantly deviate outside the limits. The results from this measurement are presented in Fig. 6 and Fig. 7.

V. CONCLUSION

Today's electronic loads are susceptible to transients, sags, swells, harmonics, momentary interruptions, and other disturbances that historically were not cause for concern. For sensitive loads, the quality of electric service has become as important as its reliability. Power quality is a new phenomenon. Events such as voltage sags, impulses, harmonics, and phase imbalance are now power quality concerns. Power quality problems have a huge economic impact. As a result, any discussion of power system reliability must also include power quality.

The main document dealing with requirements concerning the supplier's side is standard EN 50160, which characterizes voltage parameters of electrical energy in public distribution systems.

In this paper were presented several measurements of PQ using modern network analyzer OMNI-QUANT. By using a special software package the summary results of measurements are obtained according to standard EN 50160.

From the first measurement can be seen that measured values fully satisfy the limits prescribed in EN 50160. This PQ is due to the fact that this is completely automatic TS, with automatic voltage regulation and integrated device for continuous control of power quality.

Serious deviations from the limits according to EN 50160 are detected during measuring the PQ at supply terminal of one consumer supplied by TS Crniliste. LV lines with great length and TS with outdated equipment are the reason of such results for the PQ. Hence, the investments in distribution systems are necessary to achieve satisfactory results for the PQ.

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VI. ADDITION

Fig. 1. Voltage magnitude variations at 20 kV level of TS Polog 110/20 kV/kV

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Evaluation period:  from  06.11.2011 | 13:12:43.202   to  26.11.2011 | 04:00:23.481
Limits: c:\haagews\damon\en50160(230).lim

OQ  Polog ETR1-20kV      Events total: 6
    0.0000 sec <= Dur < 60.000 sec     :   Num(evtUlow) =    6
    60.000 sec <= Dur < 180.00 sec     :   Num(evtUlow) =    0
    180.00 sec <= Dur < +Inf sec       :   Num(evtUlow) =    0
                 Tot                   :   Num(evtUlow) =    6

OQ  Polog ETR1-20kV      Events total: 11
                 Tot                   :   Num(evtUrel) =   11
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Fig. 2. Statistical report for short interruptions of supply voltage in the observed period

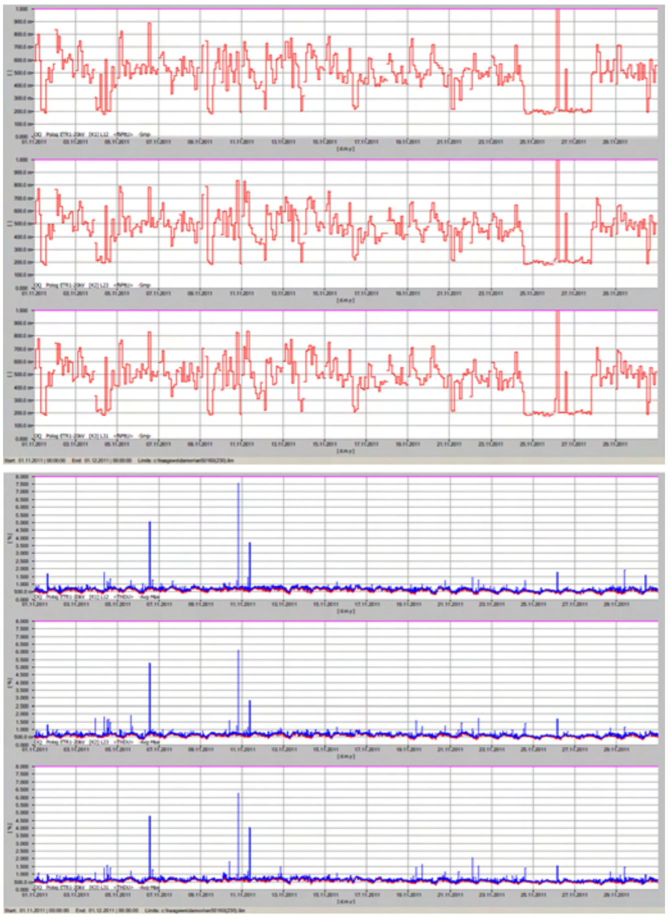

Fig. 3. Flicker severity and total harmonic distortion factor at 20 kV level of TS Polog 110/20 kV/kV

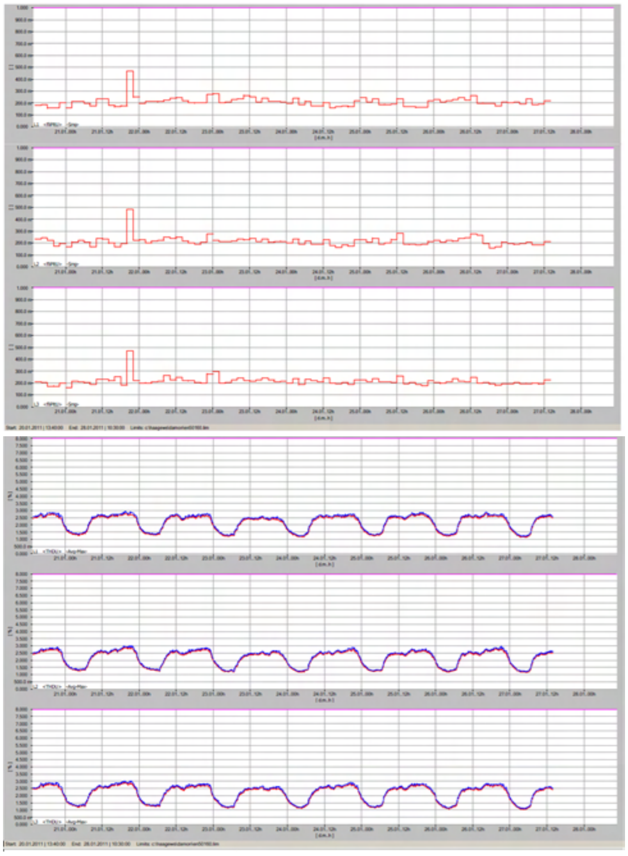

Fig. 4. Flicker severity and total harmonic distortion factor at 0,4 kV level of TS Crniliste 20/0,4 kV/kV

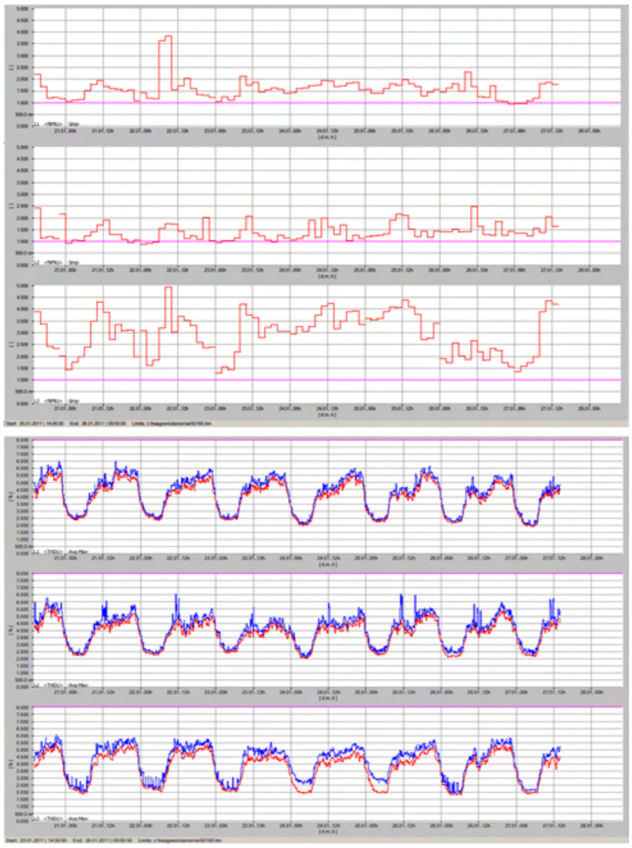

Fig. 6. Flicker severity and total harmonic distortion factor at supply terminal of one consumer supplied by TS Crniliste

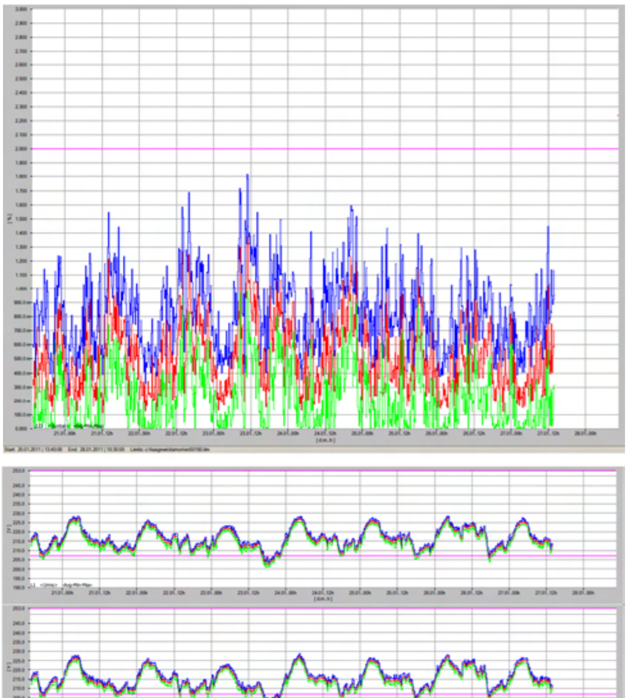

Fig. 5. Supply voltage unbalance and voltage magnitude variations at o,4 kV level of TS Crniliste 20/0,4 kV/kV

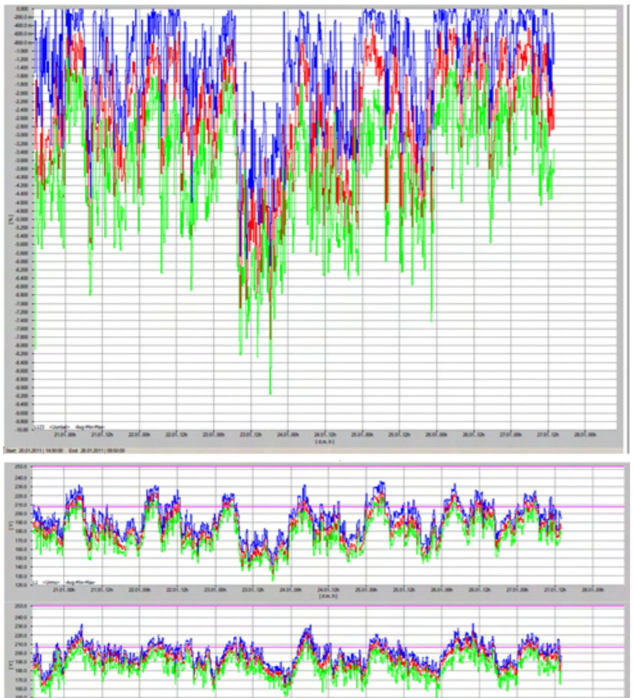

Fig. 7. Supply voltage unbalance and voltage magnitude variations at supply terminal of one consumer supplied by TS Crniliste