Petr KREJCI[1], Pavel SANTARIUS[1], Radovan HAJOVSKY[1], Richard VELICKA[1], Radim CUMPELIK[2]

VSB – Technical University of Ostrava, Czech Republic (1), CEZ, a.s., Czech Republic (2)

PQ Monitoring in Selected Networks of Czech Republic

***Abstract**. In the paper, the results of the complex monitoring of selected PQ parameters during 12 years will be summarized together with the comparison of the changes of parameters after three years on all voltage levels (HV, MV and LV) in the power company CEZ in the North Moravia Region. In addition the results of annual continual monitoring for one selected locality on MV level will be presented in the paper.*

Streszczenie.** W artykule przedstawiono wyniki kompleksowej, trwającej 12 lat, obserwacji wybranych parametrów jakości energii elektrycznej oraz porównanie zmian podstawowych parametrów po 3 latach w sieciach o różnych poziomach napięć (WN, SN i nn) w przedsiębiorstwie energetycznym CEZ w rejonie Północnych Moraw **(Monitorowane jakości energii w wybranych sieciach w Republice Czeskiej).

Keywords: Power quality, harmonics, flicker, unbalance.
Słowa kluczowe: Jakość energii, harmoniczne, fluktuacja napięcia, asymetria.

Introduction

The electrical power quality is assessed by the CSN EN 50 160 standard via 13 parameters of voltage. Extensive use of appliances with non-linear characteristics in LV distribution networks (appliances such as TVs, computers, copy machines, compact lights, etc.) is substantially deteriorating to quality parameters of electrical energy supplied.

In the former regional power company SME, a.s. (currently member of the CEZ group) in the Czech republic, there was, in 1997, a complex monitoring of selected parameters of voltage quality initiated for distribution networks of this company. Step by step, individual supply nods 110 kV for all 6 supply areas of the company were measured. The whole cycle is rendered in 3-year cycles, so, as of 2010, the fifth measurement cycle is being rendered (with 1 year time-out in 2009). So, that is how, step by step, information on changes in periods of three years is being measured.

The method of power quality evaluation

In the power company CEZ (in the North Moravia Fig. 1) the monitoring of a number of selected parameters of the quality of electrical energy (harmonics, flicker, unbalance) is being done in cooperation with research laboratories of the Department of Measurement and Control and Department of Electrical Power Engineering, Faculty of Electrical Engineering and Computer Science, VSB - Technical University of Ostrava.

Fig. 1. The North Moravia Region, the Czech Republic

Monitoring of the power quality was gradually done in individual parts of the company. The measuring was done in a complex way within the HV, MV and LV distribution. The program of complex quality of electrical energy evaluation was done in 59 LV distribution transformer station. The composition of consumption in the LV network was similar in all measured localizations – i.e. a mix of family houses and blocks of flats and small services.

In accordance with the Standard CSN EN 50 160, the measuring and evaluation of the power quality of single points was done in one week intervals, while the parameters of quality were evaluated for 10 minute intervals in the course of measuring. The measurement is separated to 6 stages. As individual parts of the company have 8-10 feeding nodes 110 kV, the monitoring was organized in half-year cycles, thus the whole program lasted for 3 years.

In single feeder points they evaluate measured data in all phases and on all voltage levels:

- Selected voltage harmonics (3., 5., 7., 9., 11.)
- Flicker
- Unbalance

The trends of changes of the selected parameters

As it was stated, the monitoring of the quality parameters was started in 1997 in all feeding points and was done during three years. In 2002 the second cycle of monitoring was completed in the same sites, therefore it is possible to evaluate the trends of change during three years. In 2005 the third cycle and in 2008 the fourth cycle of monitoring was completed and in 2010 the fifth cycle of monitoring was started after 1 year time-out in 2009.

In the Table 1 the changes of the selected quality parameters are summarized (selected harmonics, flicker and unbalance) during the first 3 years in the LV, MV and HV network. In the Table 2 and Table 3 the changes of the selected quality parameters are summarized during the second and the last 3 years. Ref. [1]

Table 1. Trends of changes of the selected quality parameters between 1st and 2nd cycle (in years 1997-2002)

	LV	MV	HV
3rd harmonic (%)	0,056	0,056	0,183
5th harmonic (%)	0,157	0,335	0,065
7th harmonic (%)	0,095	0,111	0,040
9th harmonic (%)	0,006	-0,018	-0,050
11th harmonic (%)	0,015	0,016	-0,001
Pst (-)	0,157	0,135	0,113
Plt (-)	0,118	0,077	0,131
Unbalance (%)	0,088	0,135	-0,017

Table 2. Trends of changes of the selected quality parameters between 2nd and 3rd cycle (in years 2000-2005)

	LV	MV	HV
3rd harmonic (%)	-0,016	-0,026	0,089
5th harmonic (%)	0,204	0,181	0,106
7th harmonic (%)	0,204	0,193	0,073
9th harmonic (%)	0,026	-0,009	-0,012
11th harmonic (%)	0,075	0,036	0,001
Pst (-)	-0,034	-0,093	-0,024
Plt (-)	-0,005	-0,079	-0,080
Unbalance (%)	0,043	-0,052	0,169

Table 3. Trends of changes of the selected quality parameters between 3rd and 4th cycle (in years 2003-2008)

	LV	MV	HV
3rd harmonic (%)	-0,004	-0,019	-0,067
5th harmonic (%)	-0,334	-0,303	-0,082
7th harmonic (%)	-0,017	-0,022	-0,004
9th harmonic (%)	0,010	-0,006	-0,002
11th harmonic (%)	0,024	0,021	0,022
Pst (-)	0,008	0,048	0,050
Plt (-)	-0,022	0,022	0,050
Unbalance (%)	-0,066	-0,058	-0,176

Evaluation of the trends of development of the selected quality parameters

As for harmonics, the results are relatively positive, the values of individual harmonic components are significantly below the values of compatible levels, changes after 3 years are minimal. As for unbalance, the changes are also quite small.

As for flicker, in years 1997-2002 the situation was worse, the increase of P_{st} and P_{lt} parameters was relatively low in relation to the level 1,0 (10-16%), but in relation to the real values the increase was significantly higher (around 40%). But in years 2000 – 2005 there was stabilization or even decrease of flicker parameters.

The fourth cycle of measurement indicates rather stagnation of quality parameters. On the Figure 2 and on the Figure 3 there are shown 95% values of 5th harmonic and flicker of 4 cycles of measurements in the LV distribution and values of 5th harmonic and flicker in LV, MV and HV networks in the fifth cycle of monitoring. Ref. [2]

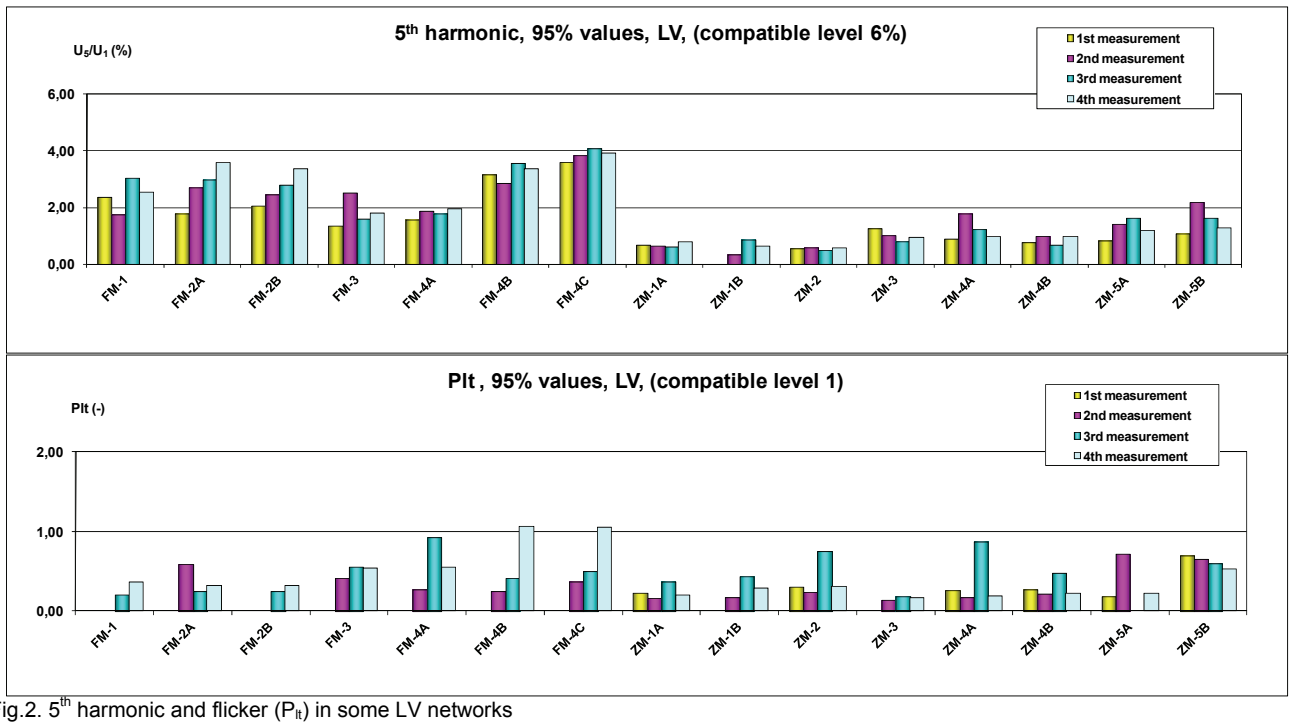

Fig.2. 5th harmonic and flicker (P_{lt}) in some LV networks

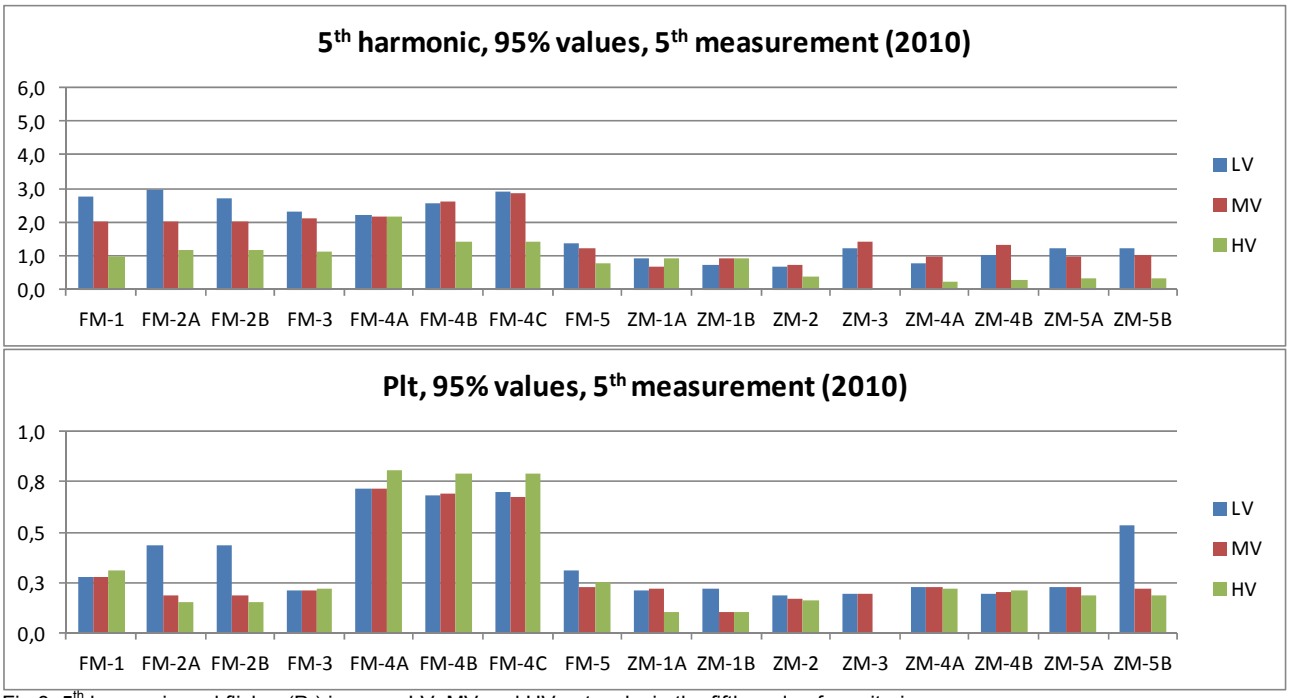

Fig.3. 5th harmonic and flicker (P_{lt}) in some LV, MV and HV networks in the fifth cycle of monitoring

Quality parameters monitoring at all times

As of 2001, there are analyzers QWave (manufactured by LEM) fitted to distribution points of 110 kV so as it is possible to register as much information on individual parameters of voltage quality and events in the distribution system, as possible. QWave Power measures, simultaneously, all voltage quality parameters and compares it with the limit values according to the CSN EN50160 standard, and furthermore, it also renders the current analysis. QWave Light is a simplified version, evaluating only current for its all guaranteed and indicative parameters.

The rules for operation of distribution networks (DN) contain Annex 3 (Quality of electrical power in the distribution system, manners of determination and evaluation). Based on these rules, there must be quality analyzer of the electrical power supply fitted at all times, as of January 1, 2006, for all HV supply terminals, and as of January 1, 2007, for all supplies from DN 110 kV. The data acquired by these analyzers are being continuously processed and archived. Ref. [2]

On the Figure 4 you can see the illustration of the continuously monitoring power quality parameters at the selected place OS-8 MV distribution network. On the diagram there are also placed the results acquired by the cyclic monitoring at the same place as it was described in the previous part of the contribution. For example, you can see that the values of flicker acquired by the cyclic monitoring makes approximately one quarter of the maximal value acquired by the yearly monitoring.

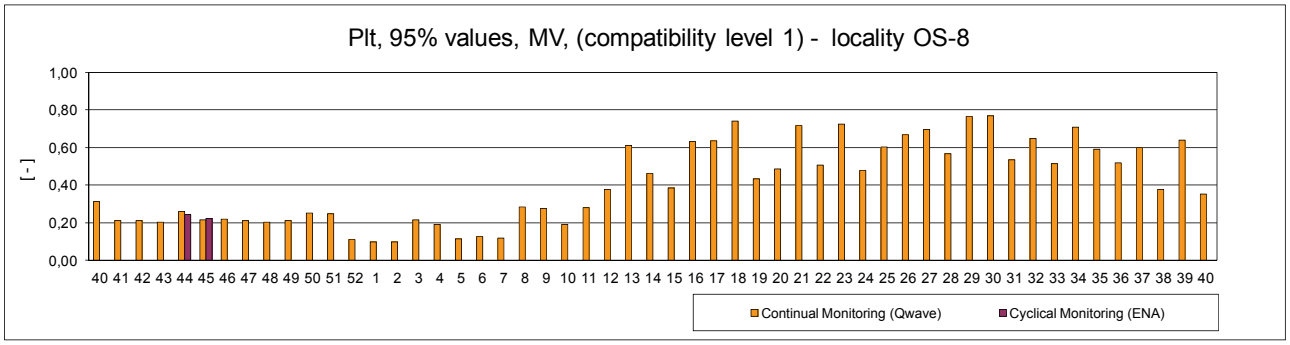

Fig.4. Flicker (P_{lt}) in MV network OS-8

Use of intelligent electrometers for monitoring of quality parameters

Characteristic parameters of voltage within low and high voltage networks are introduced in the standard ČSN EN 50160. The revised normative ČSN EN 50160 further defines parameters for very-high voltage networks.

Current intelligent electrometers usually provide data that is not in compliance with the normative mentioned above, but they afford relevant data for energy companies usable in operation.

As for usage in operation of distribution, the most crucial issues are long-term monitoring of voltage deviations and their evaluation in compliance with standard ČSN EN 50160. Further important values are overvoltage, falls and short-time blackouts typically with 1s sample period (thus quite not in accordance with ČSN EN 50160). Yet this data can give a power company relevant information, because events longer than 1 second still report about the conditions of distribution network and during the changes (usually rising) they indicate the error states. Unfortunately, these data are recorded as events, but the number or logged events are limited and set low.

Harmonics and THD, even evaluated until low frequencies only (till 10^{th} or 25^{th} harmonic multiple), can provide relevant information. For example, when the third harmonic element rises, it can indicate the problem of power transformer. A significant rise of any harmonic or THD indicates the problem with resonances in distribution network.

Conclusions

In the paper above there are summarized the results of a long-term monitoring of the selected power quality parameters of the distribution networks together with the evaluation of the trends of change in the three years periods and results of continual monitoring PQ in selected MV distribution network.

The biggest changes were registered for flicker, in years 1997-2002 the situation was worse, the increase of P_{st} and P_{lt} parameters was relatively low in relation to the level 1,0 (10-16%), but in relation to the real values the increase was significantly higher (around 40%). But in years 2000 – 2005 there was stabilization or even decrease of flicker parameters.

The results from continuously monitoring of power quality parameters manifest that the measured values can differ during the year and therefore the continuously monitoring is well-founded.

Current intelligent electrometers usually provide data that is not in compliance with the normative mentioned above, but they afford relevant data for energy companies usable in operation.

Acknowledgment

This contribution was supported by the Czech Science Foundation (No. GA ČR 102/09/1842).

REFERENCES

[1] Santarius P., Krejci P., Spacil D., Vasenka P. Power Quality Problems in Regional Distribution Networks in the Czech Republic. Conference “EPQU 2007”, Barcelona, Spain

[2] Santarius P., Krejci P., Chmelikova Z., Ciganek J. Long-term Monitoring of Power Quality Parameters in Regional Distribution Networks in the Czech Republic. Conference “ICHQP 2008”, Wollongong, Australia

***Authors**:*

Doc. Ing. Petr Krejci, Ph.D., petr.krejci@vsb.cz
Prof. Ing. Pavel Santarius, CSc., pavel.santarius@vsb.cz
Ing. Radovan Hajovsky, Ph.D., radovan.hajovsky@vsb.cz
Ing. Richard Velicka, Ph.D., richard.velicka@vsb.cz
Ing. Radim Cumpelik, radim.cumpelik@cez.cz
VSB – Technical University of Ostrava
17. listopadu 15, 708 33 Ostrava – Poruba, Czech Republic