Monitoring of the Electric Energy Quality in the Electricity Supply

Tzancho B. Tzanev[1], Svetlana G. Tzvetkova[2] and Valentin G. Kolev[3]

***Abstract* –Ensuring and supporting of the electric energy quality is a basic duty of the electric supplying companies. The consumers have every right to require and to get qualitative electric energy. But they should to have obligations, with their consumers and their work regimes, not to worsen the indexes of electric energy quality in the electric supplying systems.**

Results from monitoring of the electric energy quality in distribution installation low voltage on kiosk switchgear supplying administrative building are given in the paper.

***Keywords* – monitoring, electric energy, quality, low voltage, distribution installation**

I. INTRODUCTION

In the last years is observed a tendency of growing numbers and capacity of the consumers that make worse the electric energy quality, but also these that demand great requirements to the quality.

The combination of such characteristics of the supplying system, in which the consumers of electric energy can execute functions deposited in them, is defined by the general term *electric energy quality* [1]. Often the concept of electric energy quality is used to describe the specific characteristics of the supply voltage. The electric energy quality has two basic components – continuity and voltage level.

In 1999, the European organization for standardization in the electromagnetic field approved European standard EN 50160 *"Voltage characteristics of electricity supplied by public distribution systems"*, which reflects the theoretical level, level of the measuring techniques and exploitation practice in the electric energy quality field during the past years. Since March 2006 this standard was introduced as Bulgarian standard BSS EN 50160 and completely replaced BSS 10694-80.

The standard BSS EN 50160 includes the following basic indexes of electric energy quality [2]: frequency deviation; voltage deviation; fast voltage fluctuations; flicker; unbalance; harmonics; interharmonics; voltage dips; transient overvoltages; short-time and long-time interruptions.

[1]Tzancho B. Tzanev is with the Faculty of Electrical Engineering, Technical University - Sofia, Kliment Ohridski 8, 1000 Sofia, Bulgaria, E-mail: ttzanev@tu-sofia.bg

[2]Svetlana G. Tzvetkova is with the Faculty of Electrical Engineering, Technical University - Sofia, Kliment Ohridski 8, 1000 Sofia, Bulgaria, E-mail: stzvet@tu-sofia.bg

[3]Valentin G. Kolev is with the Faculty of Electrical Engineering, Technical University - Sofia, Kliment Ohridski 8, 1000 Sofia, Bulgaria, E-mail: vkolev@tu-sofia.bg

The norms of electric power quality indexes for low and medium voltage electric distribution networks are given in Table I according to BSS EN 50160 [2, 3].

The electric energy quality in the electricity supply system is formed in jointly operation of various electrical installations and equipment, which influence in different way on electric energy indexes. This necessitates audit and estimation of the energy installations in details and introducing of contemporary systems for monitoring and control of the electric energy quality in the exploitation. In this way energy efficient exploitation of the electrical installations will be ensured.

Results from monitoring of the electric energy quality in distribution installation low voltage on kiosk switchgear supplying administrative building are given in the paper.

II. MONITORING OF THE ELECTRIC ENERGY QUALITY IN DISTRIBUTION INSTALLATION LOW VOLTAGE

To be done a complex assessment of the electric energy quality and its influence on the electrical installations operation in given industrial enterprise or administrative building is necessary to be made investigations in different points of the electric supplying system.

Determination of the electric energy quality indexes and theirs influence on the electrical installations operation may be done in the following ways:

- Theoretical – this is possible only if we know all data for electrical installation elements. The method is very labour-consuming and inaccurate;
- By simulation of computer model – this also is possible only if we know all data for electrical installation elements. This method is used very often. It is more accurate in comparison with the theoretical method;
- By measurements with special instruments.

Monitoring of the electric energy quality indexes could be made by using of contemporary fixed or portable measuring instruments. The basic principles in which the measuring instruments have to respond are the following [4]:

- To measure the electric energy quality indexes according to BSS EN 50160;
- To have high accuracy and possibility for data registration in real time;
- To have self-contained power supply;
- To allow data transfer by modem, optical port or computer;
- To have software that allow data processing according to BSS EN 50160;
- To allow the time for averaging of the measured values to be given by the operator;

TABLE I
NORMS OF THE TO ELECTRIC ENERGY QUALITY INDEXES FOR LOW AND MEDIUM VOLTAGE ELECTRICAL DISTRIBUTION NETWORKS ACCORDING TO BSS EN 50160

Characterization	Low voltage networks	Medium voltage networks
Frequency	49,5-50,5 Hz (for 99,5% from 1 year period) or 47-52 Hz (whole year)	49,5-50,5 Hz (за 99,5% from 1 year period) or 47-52 Hz (whole year)
Voltage deviation	U_H ±10% (for every period from one week, 95% from the average effective voltage value per 10 min); U_H +10/-15% (for every period from 1 week, all average effective voltage values per 10 min)	U_H ±10% (for every period from one week, 95% from the average effective voltage value per 10 min)
Fast voltage fluctuations	Less than 5%Uн; fluctuations up to 10%U_H with short duration may advent few times per day in some conditions. Flicker: $P_{lt} \leq 1$ (for 95% from period from 1 week)	Less than 4%U_H; fluctuations up to 6%U_H with short duration may advent few times per day in some conditions. Flicker: $P_{lt} \leq 1$ (for 95% from period from 1 week)
Voltage unbalance	95% from the average effective voltage value with back sequence per 10 min must be in limits from 0 to 2%U_H from the right sequence for every period of 1 week. In some power network areas may have values up to 3%U_H	95% from the average effective voltage value with back sequence per 10 min must be in limits from 0 to 2%U_H from the right sequence for every period of 1 week. In some power network areas may have values up to 3%U_H
Harmonics	95% on the average effective voltage value of each harmonic formation of voltage per 10 min for every period of one week must be: $U_3 \leq 5\%$, $U_5 \leq 6\%$, $U_7 \leq 5\%$, $U_{11} \leq 3.5\%$, $U_{13} \leq 3\%$; Total harmonic distortion ≤ 8%	95% on the average effective voltage value of each harmonic formation of voltage per 10 min for every period of one week must be: $U_3 \leq 5\%$, $U_5 \leq 6\%$, $U_7 \leq 5\%$, $U_{11} \leq 3.5\%$, $U_{13} \leq 3\%$; Total harmonic distortion ≤ 8%
Voltage dip	Expected number may be from few scores to one thousand per one-year period.	Expected number may to be from few scores to one thousand for a year period.
Short-time interruptions	Values: from a few scores to several hundred	Values: from a few scores to several hundred
Long-time interruptions	Values: (interrupting over 3 min) annual frequency from 10 to 50, depending on area	Values: (interrupting over 3 min) annual frequency from 10 to 50, depending on area

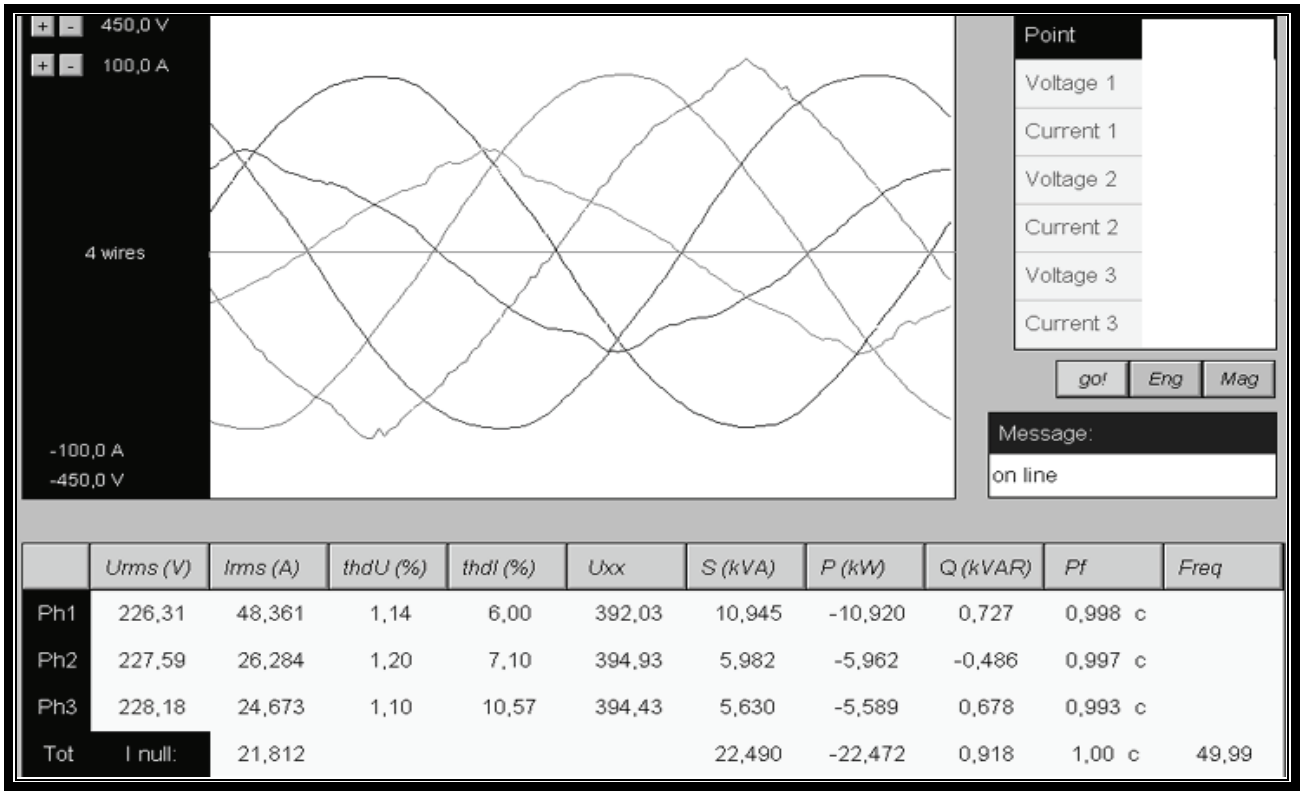
- The software have to work under WINDOWS 9X, XP, 2000 and to allow data collection, statistical data processing, data representing by graphics and tables;
- To be convenient for transport and maintenance;
- To respond to all safety requirements;
- To have acceptable price.

The experience show that the determination of the electric energy quality indexes by measurement with special instruments is most accurate and most fast method.

For the aim, an investigation of the electric energy quality in distribution installation low voltage is done. It is supplied from kiosk switchgear 1000 kVA, 20/0,4 kV. The distribution installation supplies administrative building in which the electric energy consumers are mainly electrical heaters for heating (about 90%) and computers (about 10%).

The measurements were done by special instrument for analysis of the electric energy quality indexes *Power Quality Analiser MI2192* production of company *Metrel*. The instrument allows measuring of all electrical quantities and indexes of electric energy quality according to BSS EN 50160. They are following [4]:

- Phase values of voltage (U_{rms});
- Values of the line voltage (U_{xx});
- Frequency;
- Phase values of current (I_{rms});
- Value of current in the neutral conductor (I_{null});
- Total value of current;
- Active power (P);
- Reactive power (Q);
- Apparent power (S);
- Power factor (Pf);
- Total values of active, reactive and apparent power for Ph1 ... Ph3;
- Total value of the power factor;
- Active energy (consumption/ generate);
- Reactive energy (inductive/capacitive);
- Voltage and current harmonics (up to 63th harmonic);
- Voltage and current interharmonics;
- Voltage and current Total Harmonic Distortion;
- Voltage deviation;
- Flicker;
- Determination of the voltage dips and peaks;
- Determination of the voltage interruptions;
- Determination of transient processes;
- Level of pulsations;
- Unbalance.



	Urms (V)	Irms (A)	thdU (%)	thdI (%)	Uxx	S (kVA)	P (kW)	Q (kVAR)	Pf	Freq
Ph1	226,31	48,361	1,14	6,00	392,03	10,945	-10,920	0,727	0,998 c	
Ph2	227,59	26,284	1,20	7,10	394,93	5,982	-5,962	-0,486	0,997 c	
Ph3	228,18	24,673	1,10	10,57	394,43	5,630	-5,589	0,678	0,993 c	
Tot	I null:	21,812				22,490	-22,472	0,918	1,00 c	49,99

Fig. 1 Currents and voltages in the three phases and table with data for the basic electrical quantities that characterized the load and voltage in distribution installation low voltage on kiosk switchgear 1000 kVA, 20/0,4 kV supplying administrative building

Power Quality Analyzer MI2192 is used in 3-phase networks with or without neutral conductor. It has voltage and current inputs. The current clamps with different sensibility could be turn to the current inputs. The data are measured and recorded in 2048 KB SRAM memory. The measuring and recording data are accessible for reading by the communication port RS232 by software working under WINDOWS. The rate of data transfer is 2400-57600 bit/sec.

The graphics of the currents and voltages in the three phases and the table with data for the basic electrical quantities that characterized the load and voltage in distribution installation low voltage are given on fig. 1. It looks that the load is ohmic load and quite small capacitance is due to the pulse electric supplying blocks of the computers and monitors that is appeared ohmic-capacitive load.

The maximum voltage deviation is +3,9%. It is less than the norm from +10%. The frequency deviation is -0,01 Hz. Therefore, the voltage deviation and frequency deviation are in the admissible norms.

The voltage unbalance is insignificant – around 0,8%. It is less than the norm from 2%. The load of the phases is very unequal. Most loaded is phase 1. Phases 2 and 3 are rather lighter loaded. Current unbalance is 49%. Therefore, redistribution of the loads in the phases must be done.

It is necessary to draw attention that the voltage fluctuations and frequency fluctuations are in very smaller borders from 1% per 1 sec. For this reason we could not speak for any fluctuations of these two indexes. This is due to the fact that investigated distribution installation supply only two lifts and there are not other more powerful installations with fast changeable operating mode.

From the graphics given on fig. 1 is look that the voltage sinusoid is better than current sinusoid.

The voltage and current harmonics for each phase are shown on fig. 2. The odd harmonics predominate. For the voltage this are 3, 5 and 11 harmonics. Their values are very lower than the admissible values given in Table I. Predominate 3, 5, 7 and 9 current harmonics. The maximum value have third current harmonic - 3,25% per phase 1, 4,5% per phase 2 and 7% per phase 3. The magnitude of 3, 5, 7 and 9 current harmonics according to IEC 61000-3-4 is respectively 23%, 11%, 9% and 5% [5]. Hence, the magnitudes of the measured current harmonics are lower than admissible values.

The voltage total harmonic distortion is 1,14% per phase 1, 1,20% per phase 2 and 1,10% per phase 3. These values of the voltage total harmonic distortion are far under the admissible value from 8% for low voltage networks given in Table I.

The current total harmonic distortion is 6,00% per phase 1, 7,10% per phase 2 and 10,57% per phase 3. These values of the current total harmonic distortion are less than the admissible value from 25% [5].

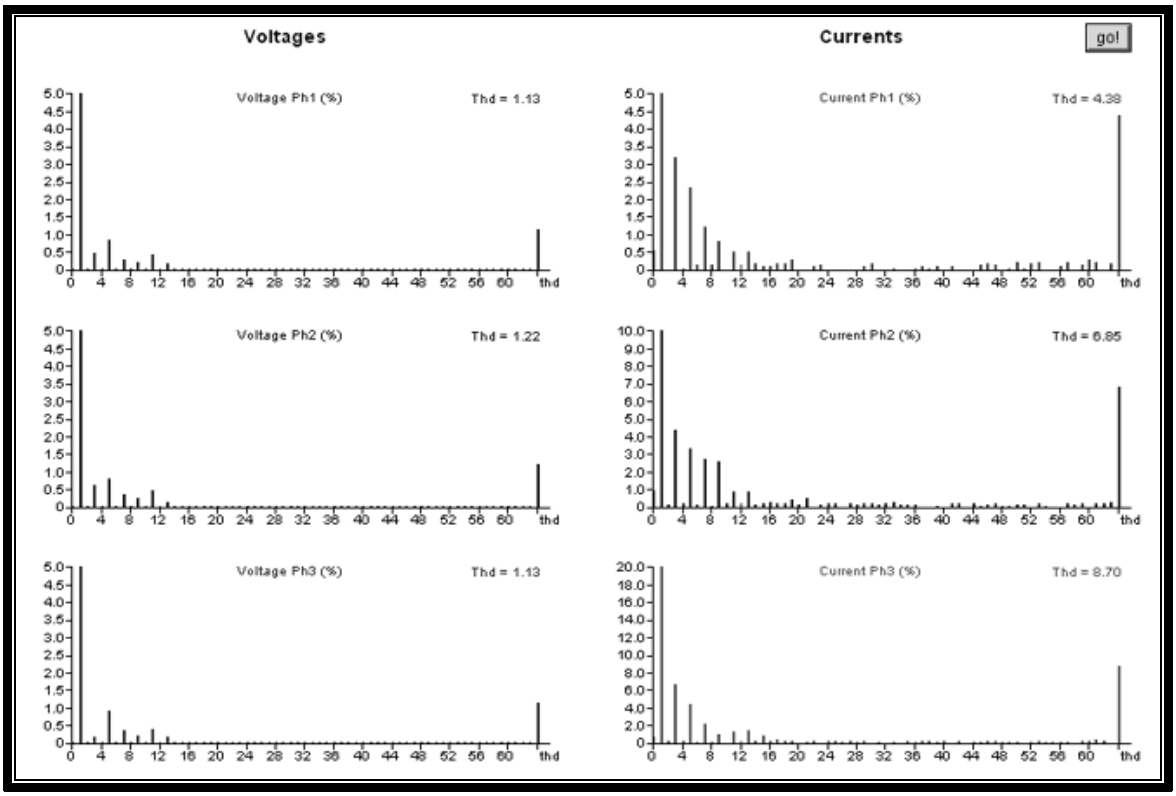


Fig. 2 Voltage and current harmonics measured in distribution installation low voltage on kiosk switchgear 1000 kVA, 20/0,4 kV supplying administrative building

IV. CONCLUSION

Ensuring and supporting electric energy quality is a basic duty of the electric supplying companies. On the other hand, the consumers have right to require and receive qualitative electric energy. But they should to have obligations, with their consumers and their work regimes, not to worsen the indexes of electric energy quality in electric supplying systems.

The measurements in the distribution installation low voltage on kiosk switchgear 1000 kVA, 20/0,4 kV supplying administrative building that were done, show that measured electric energy quality indexes are in the norms. The electric energy could not influence negative on the normal operation of the consumers.

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