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OPTIMIZATION ANALYZE OF THE LED LIGHTING INSTALLATION FOR A QUALITY OF ELECTRICAL ENERGY

The author of this paper plans to make a measurement of quality parameters for existing and used lighting installation, made from electroluminescent diodes (LED). The measurements will be made in a few different working states of installation. Based on research will be conducted the analyze and this allow define the worst working state. In the further will be selected elements which generate the most of distortion. The research will aim to create optimal solution, that is maximal reduction of higher harmonics voltage and current level, while minimal costs of influence in lighting installation.

KEYWORDS: words: electroluminescent lighting, higher harmonics of voltage and current, LED, lighting installation, online UPS power supply, quality of electrical energy

1. INTRODUCTION

The concept of quality of electrical energy appeared relatively recently, in the 80s of the twentieth century. It is a collection of various electrical quantities (eg. voltage, frequency, harmonics, etc.) that determine is the electrical energy provided to customers retain the appropriate parameters, allowing for the correct operation of all electrical equipment [3].

Maintaining proper quality of electrical energy required to meet certain minimum requirements that have been defined and stored in the Standards and Directives. Poland has a Standard PN-EN 50160:1998 "Parameters of the voltage supply in public distribution networks" [6].

The LED technology in electrical lighting is a method of producing light using light-emitting diodes. This method based on the phenomenon of electroluminescence (returning of energy through the excited electrons as the photons of light). Light sources based on LED technology greatly affect on the quality of electrical energy in power grids. The number of LED lamps is still increasing and cause more and more noise. The work on reducing the negative impact of LED on the electricity network are becoming necessary [2].

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Bad parameters which determining the quality of electrical energy may cause incorrect work of devices which distribute electricity, starting from overheating transmission lines, through rough running motors, generators and transformers, to the total destruction of these devices.

For private customers generating higher harmonics to the energy grid causes a lot of interference in devices connected to this grid, while causes increasing consumption of electrical energy [1].

2. IMPROVING THE QUALITY OF ELECTRICAL ENERGY

Power companies must provide electrical energy to customers with the parameters defined in the Standard. Therefore in power plants, transformer stations and substations are mounted devices which control and improve the quality of electrical energy. Large customers are also required to control quality and minimize distortion introduced into the power grid. They can take care of it directly by replacing harmful elements in the electrical installations or indirectly by using the systems or devices to prevent ingress of higher harmonic voltage and current to the grid [1].

At present are using several technical solutions to improve the quality of electrical energy [3]:

a) improving the design of the equipment that emits noise – rarely used and difficult task which is not always bringing the desired effect;
b) using the passive filters, which are bent on a specific type of distortion, continuously operating only in this one purpose - the solution is often used because it allows to get quite good results with a relatively low price (good price to quality ratio);
c) using active filters, which continuously are analyzing interference in real time to reduce them - it is quite beneficial effect, allows to get satisfying results, but rather expensive, although increasingly used;
d) using active power supply, which keeps the electrical equipment always on, working in online mode, what means the device which fulfil so to say two functions, first: allow to keep power supply into devices when a sudden power failure in the electrical grid, second: at all times it is converting the voltage signal passes through the device and forming an almost undisturbed sinusoidal signal with a frequency of electrical grid (50 Hz).

3. PRE-MEASUREMENTS OF LIGHTING SYSTEM

Preliminary research allowed to determine the basic parameters of the installation and the level of potential danger. Pre-measurements were performed using a high class power quality meter FLUKE 434/PWR.

The research was conducted in the momentary mode, that means the measurement in short period of time [5].

Performed research allowed to determine the electrical parameters of electroluminescent lighting installed. The supply voltage of installation is 240 V and is slightly higher than the nominal (230 V), because the measurement were performed in the main switchboard, when most electrical equipment was turned off. The active power of installed lighting in the lobby was 720 W. The system absorb very little reactive power (73 var), so is achieved a very high power factor cos φ = 0.99. Effective current in the installation is 4.99 A [5].

From the observation of a levels of higher harmonics voltage and current it can be seen that the odd harmonics of current intensity are highly raised (Fig. 1a). It affects on the significant distortion of the current intensity. The current signal is quite different from a sinusoidal signal (Fig. 1b).

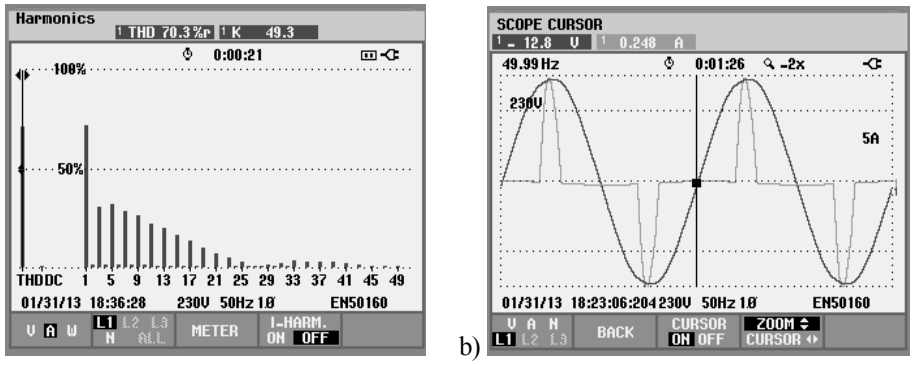

Fig. 1. Current distortion: a) the levels of higher harmonics, b) the current waveform

4. DETAILED MEASUREMENTS OF LIGHTING SYSTEM

The whole process of conducting of detailed research was very similar to preliminary research. Only one difference was to performed more measurements at different times of day and night. Additionally, to observe the changes taking place in the lighting installation, was made measurements in the tracking mode of quantity of the power quality in 6-hour periods.

The main purpose of any measurements was to determine the levels of higher harmonics of voltage and current intensity. Behind the measurements in different points of time was also conducted the observation of every higher harmonics in a long period of time.

In addition to tracking higher harmonics of voltage and current were also observed changes of other electrical quantities in a long period of time. These were mainly: voltage, current intensity (Fig. 2), frequency, active power, reactive power, apparent power and power factor [4].

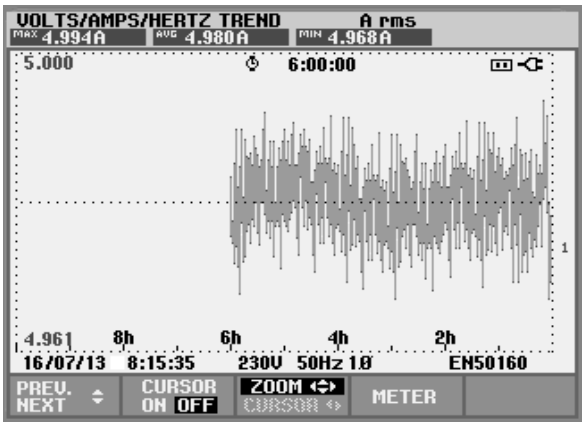

Fig. 2. The trend of RMS current intensity in 6 hours - tracking mode (screenshot from meter)

5. THE ANALYZE OF MEASUREMENTS OF ELECTRICAL INSTALLATION

After processing the data stored in memory of the meter FLUKE 434/PWR drawn graphs harmonic content of voltage and current. The analysis was performed for three different working states of lighting installation:

a) full load of lighting installation - all light sources and power supplies are enabled in the rated load (Fig. 3),
b) only power supplies working - light sources are disabled at the secondary side of power supplies, power supplies are turned on (Fig. 4),
c) disabled lighting installation – light sources and power supplies are disconnected from the electrical grid, the grid parameters were measured at the connection point of the lighting installation.

In bar charts are presented the individual harmonics up to the 50th in the values of effective current. To receive the percentage content of the of higher harmonics should be taken the value of the first harmonic (50 Hz) as 100% and the proportional determine the higher harmonics.

After summing up the basic harmonic and all higher harmonics (up to 50th) in the Fourier series is achieved current waveform in time presented on Fig. 5. The waveform does not have the shape of sinusoid, and it is very distorted [4, 5].

In the Standard PN-EN 61000-3-2:1997 "Electromagnetic Compatibility. Acceptable levels. Limits for harmonics current emissions (equipment input current $\leq$ 16 A" specified ambiguously defined levels of harmonic current, while these values are oversized. Nevertheless part of the harmonics current in the tested installation is approaching the limits of normative levels [7].

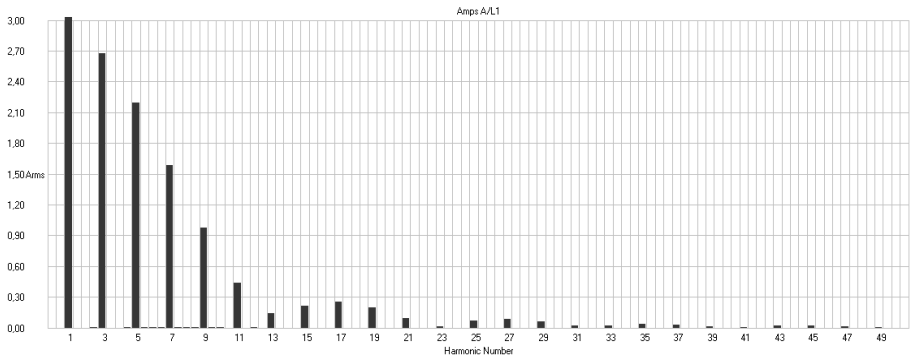

Fig. 3. Full load work - all light sources and power supplies enabled, higher harmonics of current intensity before modernization

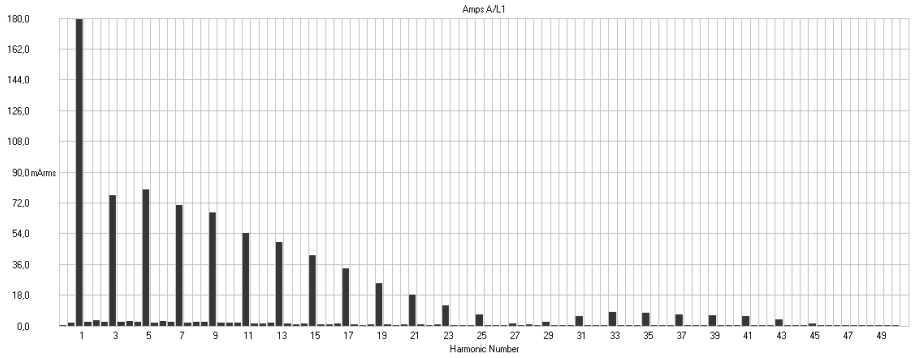

Fig. 4. Idle work - enabled power supplies, disconnect the light source, higher harmonics of current intensity before modernization

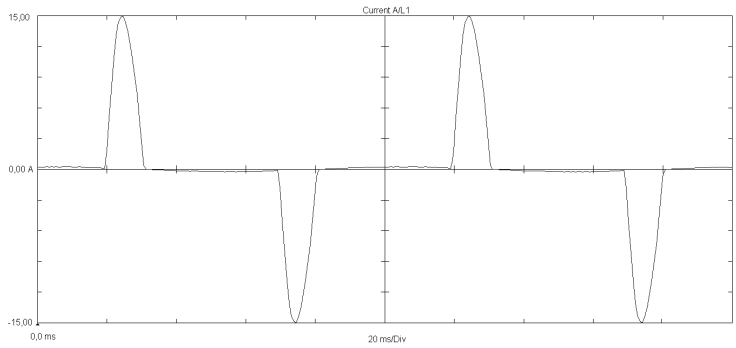

Fig. 5. Waveform of current in lighting installation before modernization

6. IMPROVEMENT THE PARAMETERS OF POWER QUALITY IN TESTED LIGHTING INSTALLATION

Tested lighting installation was simulated numerically and optimized to improve the power quality, and at the same time the lowest cost of interfering on the installation are achieved. Three possible solutions were checked:

a) regulators of higher harmonics of voltage and current - the most expensive solution because it would be necessary to use separate systems for each higher harmonic, and there are too many higher harmonics in the tested installation,
b) capacitor batteries - the cheapest solution, but not giving satisfactory results in the case of reduction the levels of higher harmonics of voltage and current,
c) UPS Online power supplies - the best solution, these power supplies are cheaper than regulators of higher harmonics and at the same time they adjust voltage and current harmonics better than capacitors.

The best solution in simulations was tested on the actual installation. In the switchboard was connected UPS online power supply with power up to 1 kW between lighting installation and switchboard. Then measured and analyzed the results of measurement of higher harmonics voltage and current intensity.

On the Fig. 6 and Fig. 7 was presented a graphic view the content of higher harmonics of current after the modernization of lighting installation.

From the comparison results before and after modernization of lighting installation it is evident that higher harmonics content has been reduced by about 70%. It is a very good result. In the installation are dominating odd harmonics. The value of the basic harmonic (50 Hz) was increased. After summing up all the harmonics in the Fourier series is achieved current waveform close to a sinusoid (fig. 8). Consequently, the current effective value is higher [4, 5].

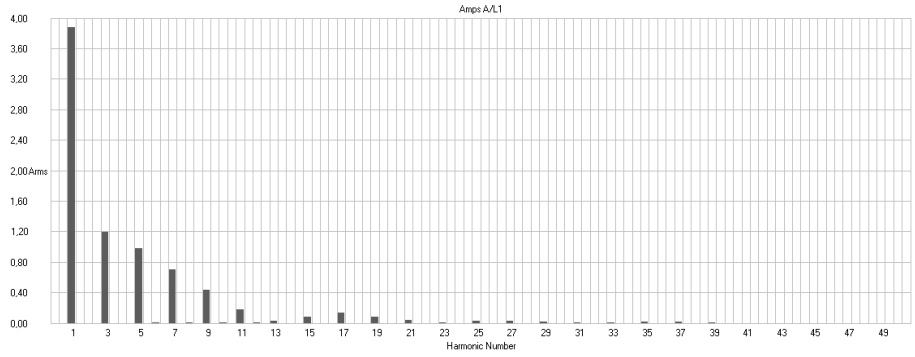

Fig. 6. Full load work - all light sources and power supplies enabled, higher harmonics of current intensity after modernization

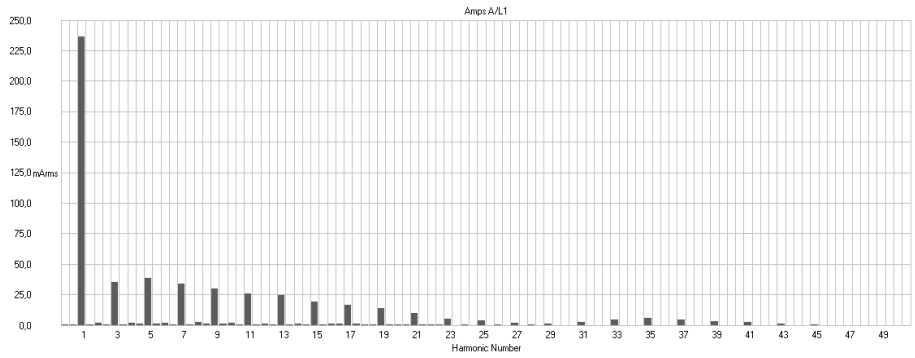

Fig. 7. The idle work - enabled power supplies, disconnect the light source, higher harmonics of current intensity after modernization

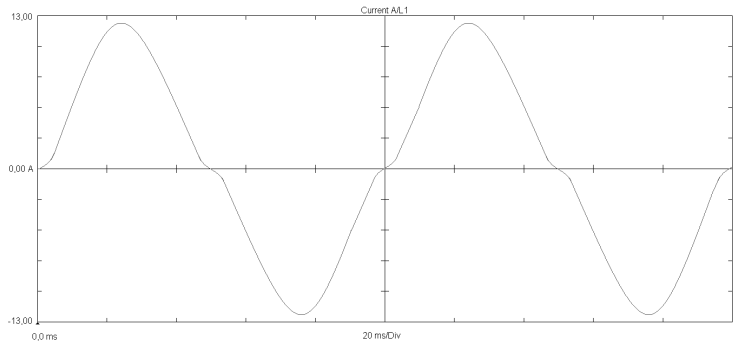

Fig. 8. Waveform of current in lighting installation after modernization

6. CONCLUSION

From the comparison above it shows, that the undertaken work have produced the desired effect. As a result it was reduced the content of higher harmonics of current in the lighting system of lobby in an office building. Comparing the values of higher harmonics of current intensity before the research with values after the research was achieved nearly 70-percent improvement.

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