Modern LED sources and harmonic pollution, which they caused

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Abstract
In recent years, there was increased use of advanced light sources with electronic control gear (LED Sources). This inevitably affects the generation of harmonic pollution in the power grids for lighting.
The report presents a study of harmonic pollution in power grids for lighting. The aim of the study was to analyze the impact of modern LED sources on the quality of energy in lighting power grids.
There are examined the impact of Retrofit LED lamps, produced by different manufacturers, on the harmonic pollution in power grids. There are shown the basic results of this study.
Keywords: Harmonics from LED, LED, Harmonic pollution.

INTRODUCTION

In recent years, LED light sources are increasingly used. Along with their undisputed advantages (good energy efficiency, long service life, etc.) some disadvantages are also reported. The main disadvantage, in terms of energy supply systems, is that they are semiconductor devices powered with DC voltage. To ensure adequate supply conditions of LED sources, electronic drivers are mainly used for the power supply, which essentially are pulse power supplying devices. The use of these devices usually results in the generation of harmonic distortion components that return to the power supply network and cause a harmonic "pollution" [1, 2].

The **purpose of this paper** is to investigate the harmonic "pollution" in the electrical power networks for lighting caused by the use of LED light sources.

BODY PART

An energy system does not operate in a clean sinusoidal state under non-linear loads. The effect of harmonics should be taken into account. In the case when harmonics exist in the power supply system, the instantaneous voltage and current values can be shown as:

$$x(t) = \sum_{h=1}^{M} X_h . \sin\left(w_h t + \alpha_h\right) \quad , \tag{1}$$

where h is the number of harmonics, M means the highest harmonic, and accordingly X_h, w_h and α_h are the amplitudes of the signal (voltage or current), the frequency and the phase angle in the 3rd harmonic.
The total active power can be shown as a sum of components associated with the main and other harmonics

$$P = P_1 + P_h \quad , \tag{2}$$

where P1 is known as the main active power, since it is linked to the main harmonic (h = 1);
Ph - includes the sum of all harmonic components of (h≥2) and it is indicated as an active harmonic power.

SUBJECT OF THE STUDY

In conducting the study of harmonic pollution in power grids for lighting caused by the modern LED sources, LED lamps of the 10 leading companies on the Bulgarian market are used. Examined lamps have got different housings, different color temperature, different power and different purpose. Names of companies are intentionally not mentioned. Principal types of models of LED lamps subject to the study are:
- Retrofit LED lamps (replacing the classic incandescent lamps) – Fig. 1;
- LED light sources, Downlight – Fig. 2;
- LED light sources replacing halogen incandescent lamps with G9 socket, MR16, etc. – Fig. 3;
- LED light sources replacing fluorescent lamps – Fig. 4.

Figure 1. Retrofit LED lamp

Figure 2. LED lamp, Downlight

Figure 3. LED lamp with G9 socket

Figure 4. LED tube lamp, replacing fluorescent lamp

STUDY RESULTS

Measurement of electrical technical qualities is performed by using a LEM ANALYST 3Q analyzer. The analyzer give the possiblity to measure all electrical quantities relating to the electrical energy quality in the power supply network. During the study, the requirements of the electrical energy quality standard were followed. Every light source was subject to an independent study.
Summary data from the Study are shown in Table 1.

Table № 1
Study Results from the different types of LED light sources.

Type of LED source	P, W	S, VA	cos φ	PF	Q_B, VAR	THD U, %	THD I, %
LED A60 BULB SKU-4378 VT-2007 Cool White 6000K	5	10	0,545	0,470	-6	1,7	61,0
LED A60 BULB SKU-4376 VT-2007 Warm White 2700K	5	11	0,520	0,448	-7	1,7	61,6
LED SPOTLIGHT VT-1878 Nature White 4500K	4	9	0,839	0,456	-2	1,6	99,9
LED SPOTLIGHT VT-1878 Warm White 3000K	4	8	0,834	0,505	-2	1,6	99,9
LED G9 LAMP VT-1849 Warm White 3000K	3	7	0,933	0,429	1	1,7	99,9
GLASS TUBE VT-6272 SMD Cool White 6000K	9	17	0,907	0,504	-3	1,9	99,9
LED LAMP PREMIUM Warm White 2700K	7	15	0,942	0,462	-2	1,7	99,8
LED LAMP PREMIUM Neutral White 4200K	7	15	0,940	0,450	-2	2,6	99,8

Table № 1 (continued)
Study Results from the different types of LED light sources.

Denomination, type of LED source	P, W	S, VA	cos φ	PF	Q_B, VAR	THD U, %	THD I, %
LED SPOTLIGHT SMD2835 Warm White 2700K	5	12	0,924	0,453	-2	1,6	99,9
LED SPOTLIGHT SMD2835 Neutral White 4200K	5	12	0,928	0,444	-1	1,5	99,9
LED G9 Warm White 2700K	2	5	0,333	0,307	-4	2,6	55,1
LED T8 TUBE SMD2835 Cool White 6000K	8	9	0,952	0,930	-2	1,8	19,6
LED bulb Warm White 2700K	6	8	0,870	0,730	-2	2,5	57,1
Core Pro LED bulb Warm White 2700K	8	17	0,954	0,495	-2	1,9	99,8
LED SPOTLIGHT Warm White 2700K	3	7	0,500	0,407	-4	2,4	65,7
LED G9 Warm White 2700K	1	5	0,301	0,280	-3	1,8	55,1
Core Pro LED T8 TUBE Cool White 6000K	8	8	0,969	0,917	-1	1,9	22,6

Following the comparison of the resulted data, it is noticeable that a high deviation of power factor (PF) and cosφ is mainly observed in low-budget LED sources, which in turn results into reactive power increase. As seen, in most cases, the power indicated by the manufacturer of the light source is usually more than twice higher compared to the actual power. Also, in most cases, the value of parameters characterizing the harmonic pollution under THD I current is very high.

CONCLUSION

Based on the Study of harmonic pollution in electrical net for lighting caused by the modern LED sources, the following conclusions can be drawn:

1. Study of harmonic pollution in the power networks caused by LED lighting sources is carried out by means of the Electrical Energy Quality Analyzer;
2. Most parameters of low-cost LED sources are deteriorated – PF, cos φ, THD I, etc.;
3. Deteriorated performance parameters in turn results an increase the energy consumption of the LED source and serious harmonic pollution of the electrical power net, especially when are using large number of lamps.

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