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Analysis of electrical parameters of light sources used by household and municipal customers

Abstract. *This paper presents the analysis, based on measurement results, of electrical parameters of energy-saving light sources used by household and municipal customers. This paper particularly pays attention to current distortion received from the mains which has been presented in terms of several light sources equipped with electronics and of different power characteristics, made by different manufacturers. Additionally, compact fluorescent lamps accompanied in a circuit by incandescent light bulbs in a few configurations, have been researched. Finally, the paper presents the results of measurements conducted in a storey distribution board for an individual apartment in a ten-storey building.*

Streszczenie. *W publikacji przedstawiono na podstawie wyników pomiarów analizę parametrów elektrycznych energooszczędnych źródeł światła stosowanych przez odbiorców bytowo-komunalnych. Szczególną uwagę zwrócono na odkształcenie prądu pobieranego z sieci, które przedstawiono dla kilkunastu wyposażonych w układ elektroniczny źródeł światła różnych mocy, różnych producentów. Dodatkowo obiektem badań były świetlówki kompaktowe włączone w układzie z tradycyjnymi żarówkami w kilku konfiguracjach. Na koniec zaprezentowano wyniki pomiarów przeprowadzone w piętrowej tablicy rozdzielczej dla pojedynczego mieszkania w 10-cio piętrowym budynku.* ***(Analiza parametrów elektrycznych energooszczędnych źródeł światła stosowanych przez odbiorców bytowo-komunalnych)***

Key words: luminars intensity, surface of intensity distribution light reflection, total harmonic distortion, uncertainty in measurement

Słowa kluczowe: żarówka tradycyjna, energooszczędne źródła światła, współczynnik odkształceń harmonicznych

Introduction

Incandescent light bulbs have been one of the first electrical light sources commonly used. Their simple construction, low manufacturing costs and wide variety of power and rated voltage ranges made them a very popular light source used in households. Taking into consideration their very good ability to reflect light colours and other factors, such as the fact that they flash instantly on switching and they do not need any boot device nor auxiliary device, and the fact that they constitute a non-inductive load and on connecting to the AC mains they do not cause the fall of power factor, one might brand them the “perfect” light source.

Unfortunately, incandescent light bulbs, when compared to other sources of light, characterize of low luminous efficacy (from 8 to approx. 26 lm/W). It stems from the fact that most of the radiation takes place in the infrared parts of the spectrum, to which human eye does not react. Heating of the support wires and contact wires and light absorption by the bulb’s glass as well as the cap sleeve lead to loss of energy; only a few per cent of electrical power is transformed into light. In other words, bulbs are extremely uneconomical light sources.

Over the last years, one could observe raising popularity of gas-discharge light sources i.e. mainly compact fluorescent lamps, which are wrongly called “energy-saving bulbs”. There is a number of reasons underlying their popularity: firstly, inexpensive electronics, which are used during manufacturing of switchstart unit, secondly the general tendency to save electrical energy, and lastly the legal regulations, which are soon to eliminate the energy-consuming light sources – mainly the incandescent light bulbs.

Apart from compact fluorescent lamps, which are manufactured in a wide variety of powers, there are also other energy-saving light sources available on the market. LED lamps, commonly named as “LED light bulbs” and halogen lamps are among them. The first ones due to relatively high price are not frequently used in households.

All of the above, excluding halogen lamps, may be directly connected to the 230 V rated voltage power system, which feeds most of household and municipal customers. Gas-discharge lamps, among them compact fluorescent lamps, due to their nonlinear current-voltage characteristics and the voltage spike necessary to initiate the electrical breakdown, it is crucial to use a switchstart unit. Yet, LED lamps, due to specified polarization (they are able to conduct without any damage only in one direction) and low forward voltage (approx. from 1,4 V to 3,5 V) need special feeding. Firstly the feeding has to be a DC source, and secondly the voltage must be relatively lowered.

The common use of electronics in energy-saving light sources has its advantages as well as disadvantages. The positive aspects are: boosted bulb life, lowered losses which influence the increase in the luminous efficacy – a parameter that signalizes light source efficiency, reduced light source’s weight and size. However, among disadvantages one could enumerate e.g. dependency between durability and the number of switches per day (electronics does not tolerate frequent switching), low power factor, significant current distortion. From the power quality point of view, the last disadvantage seems the most serious, thus the authors of this paper mostly have focused on the issue.

Subject and scope of study

The comparative research involves three types of energy-saving light sources which are available on the market:

- integrated compact fluorescent lamps (fluorescent sources),
- LED diodes (electroluminescence sources),
- incandescent light bulb with a low voltage capsule (thermal light source).

All light sources contain E27 cap and are fed on 230 V alternating current and 50 Hz frequency.

Referring to individual light sources, voltage and current time run, current harmonic distribution, power factor, active power, reactive and apparent power values have been recorded.

General information on researched light sources (further referred to as sources) is presented in table 1. For the purpose of this paper, the researched sources have been given symbols and they have been arranged alphabetically, taking into account the criterion of manufacturer's name. Integrated compact fluorescent lamp have been determined with symbols from F1 to F16, LED "light bulbs" - E1, E2, and incandescent light bulbs have been given symbols T1, T2.

Table 1. General information on researched light sources

Manufactu-rer	*U* [V]	*I* [mA]	*P* [W]	*Φ* [lm]	*Energy Class*	*Source symbol*
Fluorescent sources						
ANS	230	X	55	3000	A	F1
APOLLO	230	61	15	365	B	F2
GE	220-240	X	15	850	A	F3
GOVENA	220-240	X	20	1300	A	F4
HELIOS	220-240	134	20	1140	A	F5
OSRAM	220-240	X	14	900	A	F6
PHILIPS	220-240	100	14	820	A	F7
PILA	230-240	90	14	760	A	F8
POLUX	230	130	14	X	A	F9
POLUX	230	200	23	1600	A	F10
POLUX	230	X	30	1900	A	F11
POLUX	230	190	40	2678	A	F12
POLUX	230	290	60	4298	A	F13
POLUX	230	X	85	6390	A	F14
YHC	220-240	105	15	880	A	F15
SYLVANIA	220-240	100	15	830	A	F16
Electroluminescent sources						
OSRAM	100-240	X	2	X	A	E1
POLUX	85-265	X	3	210	A	E2
Thermal light sources						
PHILIPS	230	brak	20	370	B	T1
OSRAM	230		60	710	E	T2
X – no info on the packaging or plastic cap of the source						

Additionally, conventional 60 W incandescence light bulbs have been tested; they were accompanied in a circuit by compact fluorescent lamps manufactured by a randomly selected producer. In order to observe the influence of the number of cooperating sources on the degree of current distortion, it was necessary to consider a few cases, which are presented in table 2. All sources were connected in a parallel unit and powered from one circuit (fig. 1).

Table 2. Different cooperation units of conventional incandescent bulbs and integrated compact fluorescent lamps

	Source T2 (incandescent bulb)	Source F15 (fluorescent lamp)
Variant 1. (W1)	1 pcs	3 pcs
Variant 2. (W2)	2 pcs	3 pcs
Variant 3. (W3)	3 pcs	3 pcs
Variant 4. (W4)	3 pcs	2 pcs
Variant 5. (W5)	3 pcs	1 pcs

Devices which are used in households (i.e. computer, LDC TVs, and also compact fluorescent lamps) constitute harmonic sources. In principle, each of the electrical loads, when considered separately, has low rated current, thus the fraction of harmonic source will be slight. However, taking into account the fact that most of the loads may be used simultaneously, their influence on the power mains cannot be ignored. Therefore, it would be worthwhile to make measurements e.g. at the grid connection of the household building and the obtained values of individual harmonic voltage should be referred to requirements contained in the standards [3]. Due to the fact that it is difficult to get access to such grids (special permits are necessary), the measurements have been made in one apartment in a ten-storey building. The power analyzer's current circuit was connected through a fuse holder which was just behind the internal power supply line which runs through individual storeys of the construction. In terms of the operating devices in the examined apartment, two cases have been specified. The first case (P1) involved 7 integrated compact fluorescent lamps, an LCD TV, and an iron. The second case (P2) involved 8 compact fluorescent lamps and 4 halogen lamps.

Measuring system

Laboratory tests have been conducted on a system which structure is presented in fig. 1.

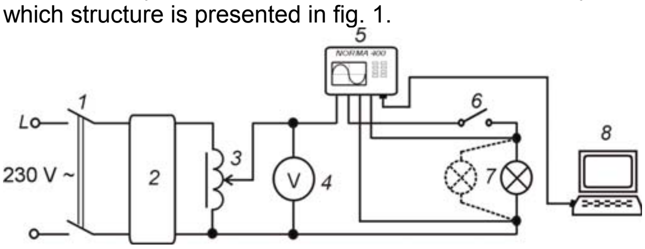

Fig. 1. Diagram presenting measuring system used to define the electrical parameters of researched light sources: *1*, *6* – power switches, *2* – voltage regulator, *3* – autotransformer, *4* – digital voltmeter, *5* – analyzer, *7* – researched light source(s), *8* – PC

Electric power is supplied to voltage regulator (2) through a switch (1). Voltage regulator provides constant rms voltage with accuracy to 0,1%. With the help of autotransformer (3), a value of 230V is set. The value is verified by the voltmeter (4). On closing the switch (6), the researched light source(s) (7) turn on. Power analyzer Norma 4000 manufactured by Fluke (5) was used to record voltage and current time run. Measuring instrument was connected to the PC (8) by RS−232C, a serial communication connector. Communication between the PC and the analyzer is bidirectional i.e. the device transmits data but it can also be controlled by the computer. On finishing measurements, all collected values can be conveyed to the PC and saved on a hard drive. Software on which the meter operates, allows to save the data in a text format accepted by any broadsheet.

Due to distortion of current which is supplied from the mains to the power analyzer and laptop's power supply, the elements used to record electrical parameters of the researched light sources in the measuring system, it was necessary to feed them on a separate circuit.

Measurement results

Electrical parameters of individual sources were recorded after approx. 30 minutes of their operation. However, prior to the test and in compliance with the standards' recommendations [2], the sources had been aged for 100 hours on rated voltage power supply. All light sources during the measurements were placed vertically -with their cap down. Ambient temperature in the laboratory where the tests were carried out was 25°C ± 1°C (the room was air-conditioned).

Measurement results for every of the analyzed sources (excluding conventional incandescent light bulb - source T2) are presented in a form of graphs fig. 2-6 as well as in table 3. Time run of several light sources which were switched on simultaneously - in different configurations (presented in table 2.) are shown in fig. 7 and 8.

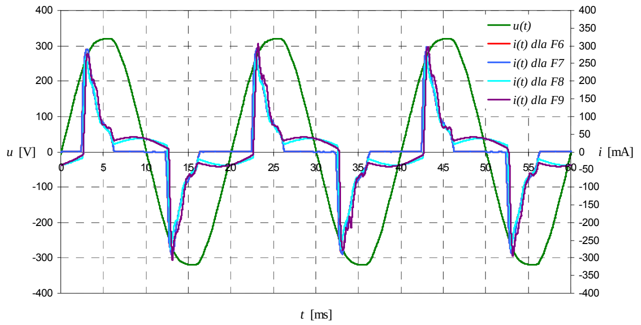

Fig. 2. Voltage and current time run of light sources over 14 W