RESEARCH ARTICLE OPEN ACCESS

The effect of using a reactor with CFLs and LED lamps on their power quality

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ABSTRACT
Modern lighting sources like light emitting diode (LED) lamps and compact fluorescent Lamps (CFLs) have high efficiency and very low power consumption compared with traditional lighting sources like fluorescent and incandescent lamps. On the other hand, these modern lamps like any other nonlinear loads are considered a source of harmonic generation and a low power factor compared with incandescent lamp. In this paper, Total harmonic distortion of current (THDI) of various combinations of LED lamps and CFLs are experimentally evaluated and compared in different cases. Then, a reactor is connected, in series, to the same combinations of LED lamps and CFLs. Moreover, THDI and power factors of these combinations of lamps, before and after using the reactor, are compared to show the impact of using the reactor. The results show that CFLs and LED lamps produce very high level of harmonics; these harmonics decrease when using a mixed combination of LED lamps and CFLs and using the reactor improves the power quality of the lamps. Measurements were taken by Chauvin Arnoux C.A 8336 power quality analyzer.
Keywords- CFL, Harmonics, LED lamps, Power factor, Reactor.

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I. INTRODUCTION

Recently, the world has been redirected to saving energy consumption and reducing environmental pollution. Hence, lighting is considered one of the main electrical loads in electrical grid as it accounts for 20% of the global electricity demand [1]. Therefore, it was a must to replace traditional lighting sources, such as fluorescent and incandescent lamps, which highly consume energy, with modern lighting technologies like light emitting diodes (LED) lamps and compact fluorescent lamps (CFLs), which have low energy consumption, high efficiency, reliability and long lifetime compared with traditional lamps.

In spite of the several features of modern lighting sources, using a large number of them in domestic, commercial and industrial applications could cause important problems in the terms of power quality [2]. Both of LED lamps and CFLs need electronic circuits to operate them correctly and these electronic circuits have nonlinearity characteristics. These nonlinear loads are the main reason for the existence of current harmonics and voltage distortion in the AC power system. The existence of harmonics adversely affects either other loads connected to the same bus or the grid in terms of low power factor and distortion in currents [3].There are several techniques to mitigate the harmonics produced by nonlinear loads [4] - [8]; among these techniques is the use of reactors.

Compared with other techniques used to limit the harmonics, using a reactor is the simplest and has the lowest cost [9]. A reactor is an electromagnetic device that is constructed of an inductor with a ferromagnetic core. The reactor is used with both single and three-phase non-linear loads to reduce current harmonics and noise. It is also used to improve the current waveform and the power factor. The main idea of using the reactor with the loads is to increase the impedance and this means that the reactor acts as a filter between the load and the power source to prevent the flow of current at higher frequencies.

The purpose of this paper is to:

- Investigate the harmonics produced by two modern lamp technologies i.e. light emitting diode (LED) lamp and compact fluorescent lamp (CFL)
- Present a solution to reduce the current total harmonic distortion (THDI) generated by CFL and LED lamps, and improve both their current waveform shapes and their power factors.

II. EXPERIMENTAL SET:

2.1 Tests Descriptions:

To study and analyze the THDI and the power factor of lamps (both the CFL and LED), a system has been developed as shown in Fig.1. The tests were performed in two cases. In the first case, CFL and LED lamps were connected directly to the AC voltage source. In the second case, a reactor was connected, in series, to the lamps.

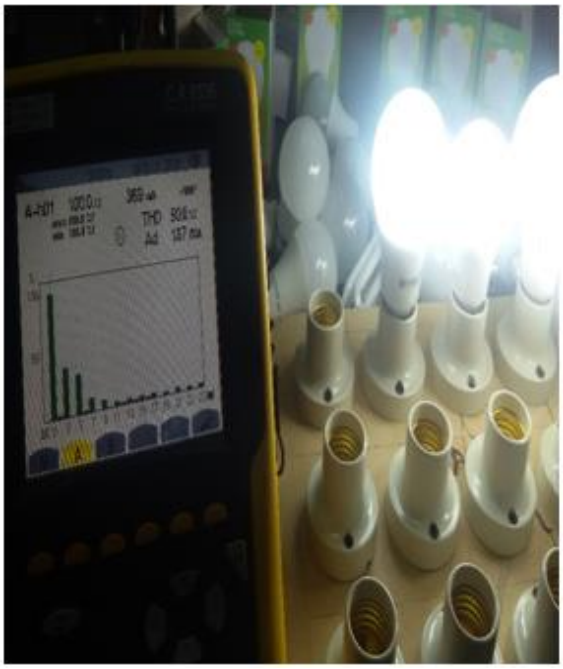

Fig.1, LED bulbs during the test.

2.2 Equipment:

The performed system of the study consists of the following components:

1. An AC power source.
2. A 150Wreactor.
3. A set of bulbs from various brands both CFL and LED that are used in residential and commercial applications and are available in the Egyptian market as shown in Table1.
4. A Chauvin Arnoux (C.A.) 8336 power quality analyzer.
5. A laptop and a power analyzer transfer (PAT) software to configure the power quality analyzer and export the measurement data.

Table 1 – Technical data for tested CFLs and LED bulbs

Trade name	Type of bulb	Power [W]	Lumens [lm]
Philips	CFL	23	1350
Lumina	CFL	26	1040
Rouka	CFL	26	1040
Philips	LED	10	1055
Canyon	LED	9	900
El-Sewedy	LED	12	1150
Venus	LED	11.5	1200
Mega	LED	12	1200
G.P	LED	9	540

The tested bulbs were divided into three combinations that are almost equal in power consumption as follows:

1) A combination of five different brands of LED lamps.
2) A combination of three different brands of CFLs.
3) A combination of four different brands of LED lamps and a CFL.

III. RESULTS AND ANALYSIS

3.1 Current total harmonic distortion

In this section the THDI of the three combinations of lamps is measured by (C.A.) 8336 power quality analyzer.

The x axis of the following figures (Fig. 2. – Fig. 7.) represents the harmonic order while they axis represents the harmonic level magnitude as a percentage of the fundamental frequency.

3.1.1 Case I: Connecting the lamps directly to the AC source

In this case, the lamps are directly connected to the AC source. Three combinations of lamps are connected as the following:

3.1.1.1 CFLs combination

The total current harmonic of three CFLs can be seen as shown in Fig.2.

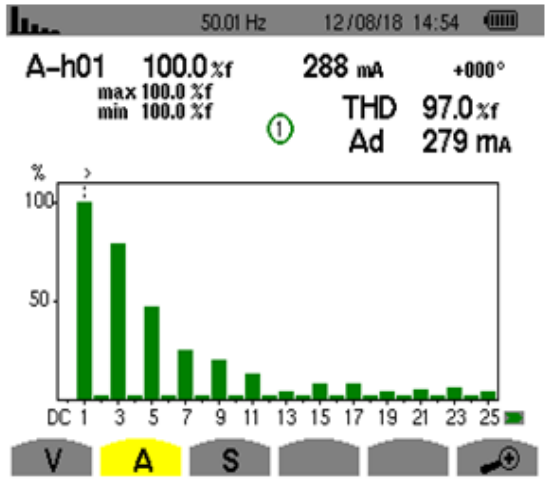

Fig.2, Total current harmonic distortion of three CFLs

3.1.1.2 LED bulbs combination

The total current harmonic of 5 LED lamps can be seen as shown in Fig.3.

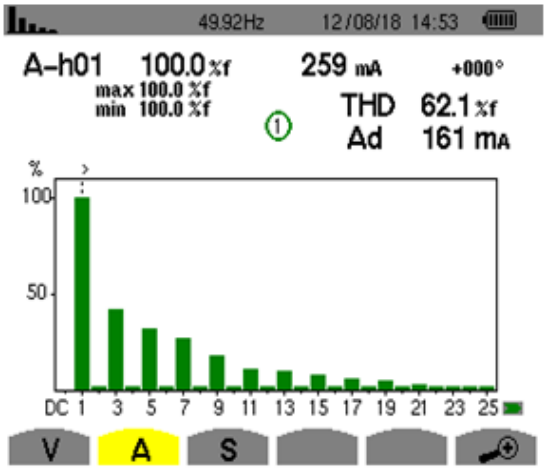

Fig.3, Total current harmonic distortion of five LED lamps

3.1.1.3 CFL & LED bulbs combination

The total current harmonic of 4 LED lamps and a CFL can be seen as shown in Fig. 4.

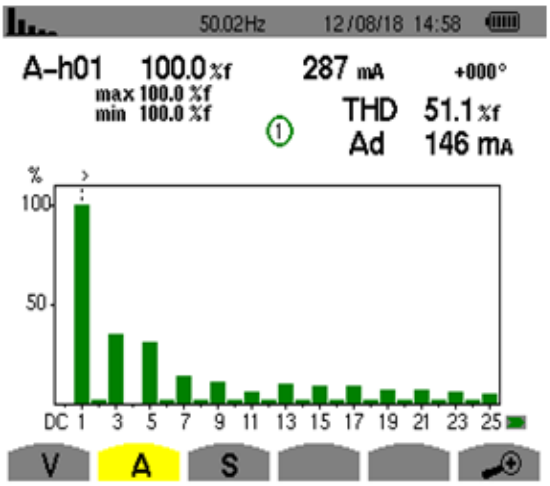

Fig.4, Total current harmonic distortion of four LED lamps and a CFL

From the figures (2 - 4), it can be noted that:

1) THDI generated by a combination of CFLs is 97.0% as shown in Fig.2.
2) THDI of LED lamps is62.1% as shown in Fig.3.
3) THDI of a combination of LED lamps and one CFL is 51.1% as shown in Fig.4.

3.1.2 Case II: Connecting a reactor ,in series, to lamps:

In this case, a reactor is connected in series to the lamps.

3.1.2.1 Connecting the reactor to CFLs combination:

The total current harmonic of three CFLs connected, in series, to the reactor can be seen as shown in Fig.5.

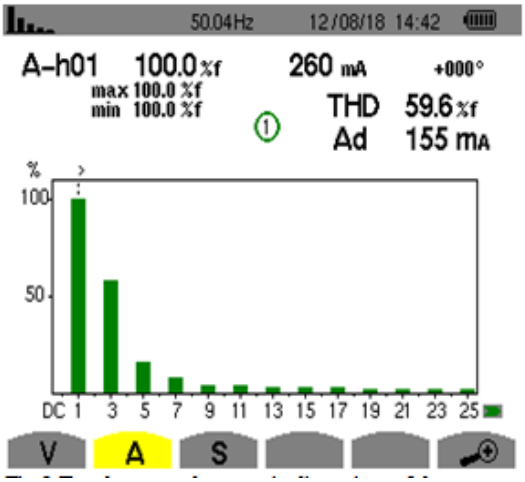

Fig.5, Total current harmonic distortion of three CFLs after using the reactor

3.1.2.2 Connecting the reactor to LED bulbs combination:

The total current harmonic of five LED lamps connected, in series, to the reactor can be seen in Fig.6.

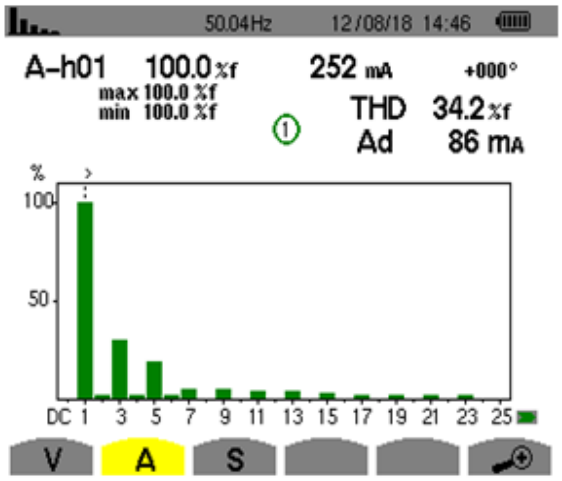

Fig.6, Total current harmonic distortion of five LED lamps after using the reactor

3.1.2.3 Connecting the reactor to CFL & LED bulbs Combination

The total current harmonic of four LED lamps and one CFL connected, in series, to the reactor can be seen in Fig.7.

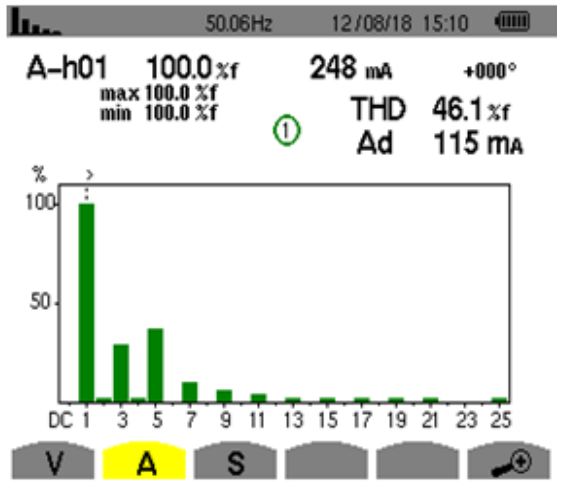

Fig.**7,** Total current harmonic distortion of four LED lamps and a CFL after using a reactor

From the previous figures, it can be noted that by using the reactor, in series, to the same combinations of lamps, there are changes in the THDI value of lamps. The following figure (Fig.8.) shows a comparison between the current total harmonic distortions before and after using the reactor.

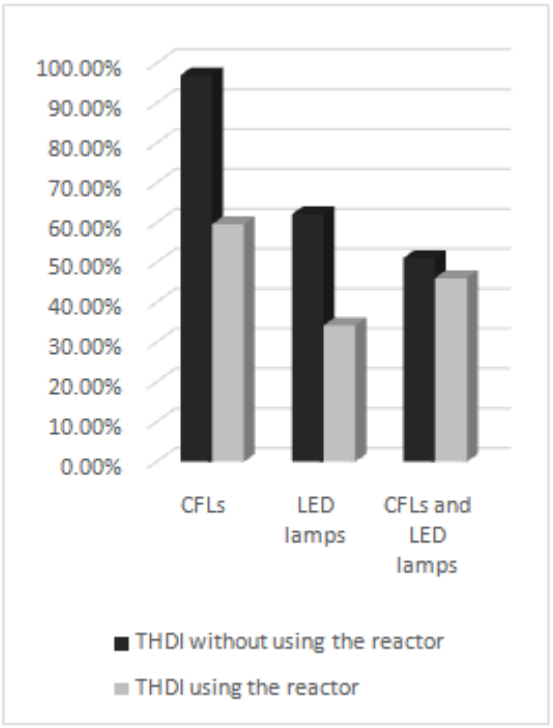

Fig.8, THDI comparison before and after using the reactor

From the results, it can be noted that THDI after using the reactor is reduced by 37.4% in case of CFLs, 27.9% in case of LED lamps, and 5% for a combination of CFLs and LED lamps.

3.2 Power factor

Table 2 shows the measured power factor values of the three combinations of lamps before and after using the reactor.

Table 2 - The measured power factor values before and after using the reactor.

Combinations	**Power factor**	
	Before the reactor	**After the reactor**
CFLs	0.646	0.807
LED lamps	0.821	0.931
CFLs and LED lamps	0.783	0.841

As shown in Table 2, the power factor values are improved after using the reactor with all the combinations of lamps.

IV. CONCLUSION:

Several experimental results of THDI for combinations of CFLs and LED lamps are presented in this paper. CFLs and LED bulbs from different brands were tested. The results show that CFLs generate higher level of current harmonics than do LED lamps and it is noted that using a combination of both CFLs and LED lamps reduces the value of harmonic generation. Moreover, a reactor was used, in series, with the same combinations of lamps and the tests were conducted again to show the reactor's effect on THDI and PF of the lamps. It is also found that using the reactor improves the power factor and reduces the total current distortion of CFLs and LED lamps. The shapes of the current waveforms of the lamps combinations are also improved after using the reactor. In order to improve the power quality, it is preferred to use a reactor with the groups of CFLs and LED lamps.

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