

Compact fluorescent lamps, LED lamps and harmonic distortion

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Abstract. The aim of this paper is to evaluate the harmonic distortion in the current waveform of Compact Fluorescent Lamps (CFL) and Lamps Lighting Emitting Diode (LED). For this, we analysed the power factor, voltage waveform, current waveform, total harmonic distortion (THD) and active power consumed.

1. Introduction

Compact fluorescent lamps were originally developed aiming the replacement of incandescent lamps. They have similar operating principle of the tube fluorescent lamps, but their dimensions are pretty reduced.

They have modern and compact design, high efficiency, long life (up to 20 times greater than that of ordinary incandescent lamp), light beams distribution diversity and a variation of products able to meet the most different applications: commercial, industrial or residential.

In Brazil, the use of this type of lamp is widely encouraged and intensified during the 2002 energy shortage.

Currently when thinking about innovation and energy efficiency in lighting people think in the Led lamps. Notes the desire of many people to make use of this technology, but there is still much lack of knowledge about its advantages and disadvantages. Led lamps as modernization of incandescent, halogen and fluorescent tube lamps are products increasingly found in the market.

Seduced by the idea of a long life, high luminous efficiency, no ultraviolet radiation, infrared and harmful metals such as mercury, more and more people want to use the LEDs as a light source.

Some care, however, must be observed when specifying or purchasing Led lamps for modernization of electrical installations. Currently, there are a variety of products on the market and we do not have in place any regulation or recommendation for the use of equipment that adopt this technology.

Concerning energy efficiency, it is evident the superiority of LED lamps when compared to incandescent and compact fluorescent lamps. However, when observing the effects of Compact Fluorescent lamps and LED lamps on the power quality of the system in which they are used, there is a certain commitment due to the emergence of unwanted distortion in the network.

These distortions are composed of multiple frequencies or sub-multiple of the fundamental frequency (60 Hz) and are known as harmonics.



2. Harmonic Distortion and Harmonics

Given a periodic signal with a frequency f , as the fundamental frequency, it is denominated the harmonic component of this signal, a periodic waveform with a frequency multiple (integer) of the fundamental frequency. [1]

Figure 1 illustrates this concept. The waveform of larger amplitude and lower frequency is the fundamental waveform and the waveform with smaller amplitude and higher frequency represents a harmonic component.

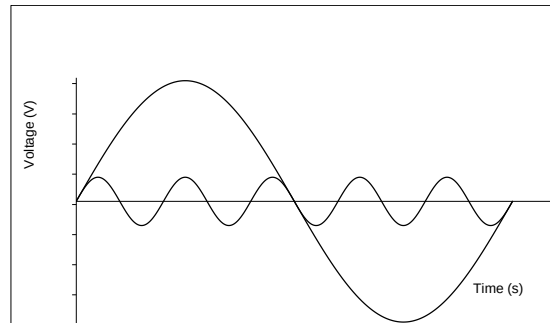


Figure 1. Periodic fundamental waveform and its harmonic component.

Figure 2 shows the signal resulting from the sum of the two waveforms. This signal represents the distortion caused by the presence of harmonics. Note that, the final waveform is no longer perfectly sinusoidal.

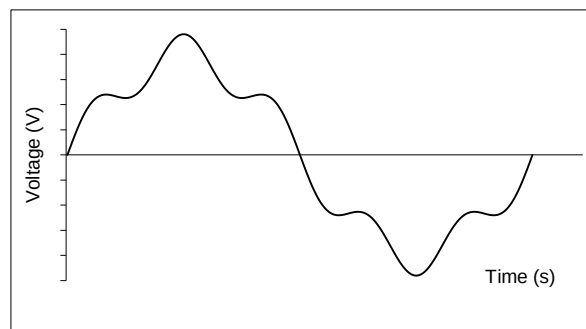


Figure 2. Periodic signal distorted by a harmonic component.

The harmonic waveforms occur continuously, should not be confused with signals that have few cycles or short durations.

To characterize the content of harmonics in practice, the distortion factor d or THD (Total Harmonic Distortion) is used, which is defined as the equation 2.1 (for example, current (I)):

$$d = \left(\frac{\sum_{k=2}^{\infty} I_k^2}{I_1^2} \right)^{1/2} \quad (2.1)$$

i.e., the square root of the ratio of the quadratic sum of all harmonic divided by the rms value of the squared fundamental waveform.

3. Methodology

To measure power, two digital multimeters from Agilent 3458A [3] are used synchronously. Applying the method of digital sampling, a multimeter measures the voltage signal while the other multimeter measures the current signal on the voltage drop across a shunt [2]. The algorithm developed to analyse non-sinusoidal waveforms partially applies the discrete integration method and Discrete Fourier Transform (DFT) [1]. To perform the evaluations in the LED and CFL lamps were used the equipment shown in figure 3.

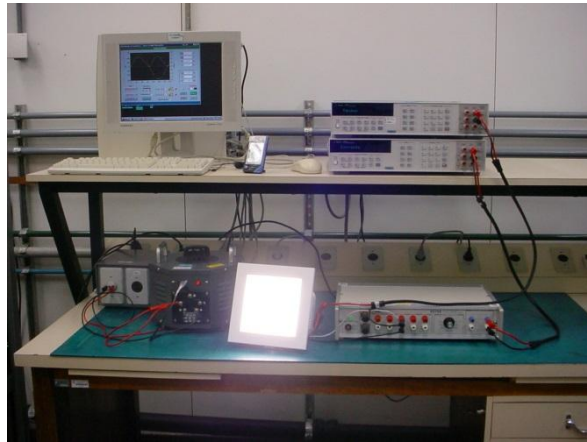


Figure 3. System used in the measurement of LED and CFL lamps.

The calculations of the voltage and current rms values and active power are made by applying the discrete integration method. For the reactive power (Q) are shown two of the most important definitions reported in the literature: QB according to the Budeanu definition and QF according to the Frize definition [4]. The accuracy of the developed methodology is $\pm 0.01\%$.

4. Exemplification

The lamps evaluated had active power similar characteristic.

Table 1 shows the results of the interest measurements. figures 4 to 7 show the behaviour of lamps 1 and 2.

Table 1. Measurements of LED lamps and CFL.

Quantity	LED	CFL
	Lamp 1	Lamp 2
Voltage	220.07 V	127.99 V
Current	0.083 A	0.17 A
Active Power	17.30 W	16.98 W
Power factor	0.95	0.79
THD(current)	22.6 %	61.6%

Figures 4 and 6 show the program Harmonic Analyser control panel, with the results of the analysis of LED lamps and CFL.

For better visualization of the harmonics the panel presents also their spectra. As can be seen in figures 5 and 7, in these cases the odd harmonics of the currents are dominant. The table in the right of each screen shows the results of powers analysis.

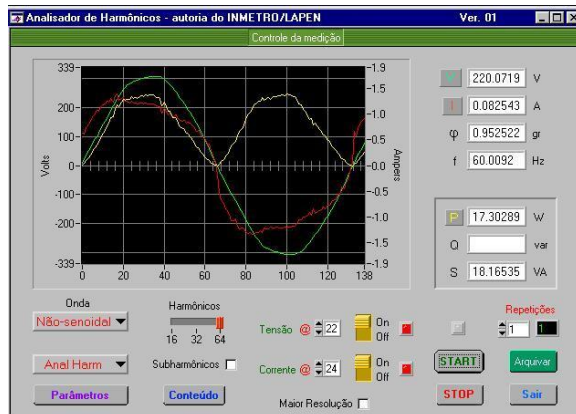


Figure 4. Lamp 1 Behavior

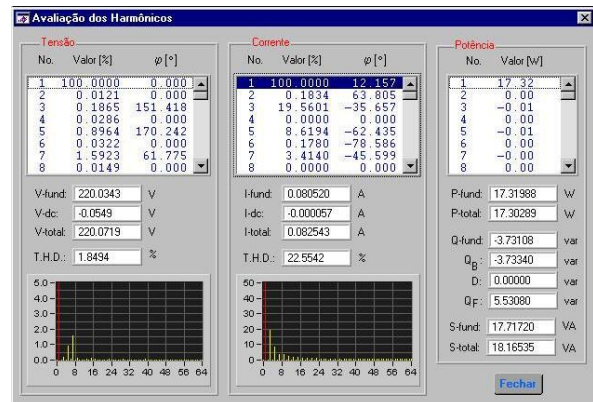


Figure 5. Lamp 1 Harmonic Components

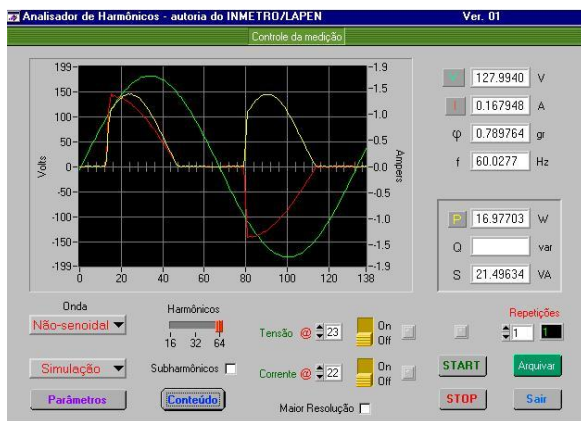


Figure 6. Lamp 2 Behavior

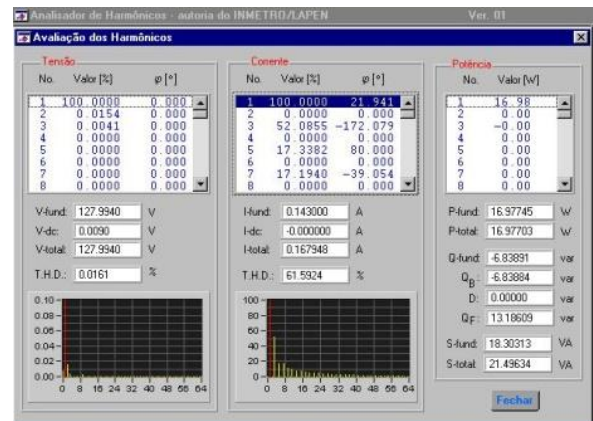


Figure 7. Lamp 2 Harmonic Components

5. Conclusion

This paper presented an evaluation of harmonic distortion caused by LED and CFL lamps and verified that these lamps cause significant harmonic distortion in the current circuit, since their waveforms have the highest harmonic waveform with respect to the voltage supplied.

It is concluded that, even with high harmonic distortion in LED and CFL lamps, is not observed the same behavior of compact fluorescent lamps in relation to the power factor [5].

6. References

- [1] Oppenheim A V and Schafer W R 1989 *Discrete-Time Signal Processing*, pp 514-640, Englewood Cliffs (New Jersey 07632).
- [2] Franco A M R, Debatin R M, Toth E 2008 *A Power Measurement System Under Non-Sinusoidal Loads*. 6th IMEKO TC4 Symposium and 13th Workshop on ADC Modelling and Testing (Florence).
- [3] Agilent 1994 *HP3458A Multimeter. Operating, programming and Configuration Manual*.
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- [5] Franco A M R, Tóth E, Debatin R M 2002, *Influência dos harmônicos na medição da potência*, V International Congress of Electrical Metrology (Rio de Janeiro).