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Comparison between electromagnetic and electronic ballasts for fluorescent lamps in terms of power quality

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Abstract— **Conventional lighting systems with an electronic control gear significantly improve energy efficiency when comparing the energy consumed by lighting appliances equipped this auxiliary device to conventional electromagnetic ballasts. However, electronic equipments generate disturbances in the grid which diminish the quality of the electric power of the network. The objective of the present study was to compare the harmonic distortion of electromagnetic and electronic ballasts. It is concluded that electronic ballasts cause a higher perturbation in the electrical power supply.**

Index Terms— **electronic ballasts, energy efficiency, harmonic currents, total harmonic distortion.**

I. Introduction

Nowadays, it is estimated that 17% of electrical energy consumption in the world comes from artificial lighting [1]. For this reason, there is growing concern about energy saving in this area.

In Argentina, according to data from the Energy Secretary of the Ministry of Federal Planning, Public Investment and Services, 25% of the electrical energy produced is consumed by artificial lighting systems [2]. If this figure is compared to the 37% consumed by electric engines, we can say that we use almost as much energy to move things as to illuminate.

Over time, lighting technology has evolved considerably. Obsolete incandescent lamps were replaced by fluorescent lamps, and these again by energy saving bulbs and LED technology. And through this evolution it was possible to improve the energy efficiency of lighting systems.

Auxiliary electronic equipments called electronic ballasts, used in fluorescent lighting devices, substantially improve their energy efficiency since they do not incur in significant energy loss and they can be operated at high frequencies, making it also possible to eliminate visual defects [3].

Analyses performed by the Electric Power Efficiency Team at FRSN highlight its benefits. But at the same time, huge disturbances are observed, introduced in the electrical power supply by harmonic currents, which are currents of a higher frequency and a lower intensity. These currents have a high incidence in the form of wave voltage and network current. Their presence generates noise in the electrical installation and consequently produces interference in other devices. An example of the effects of these currents is the noise heard when failing to tune an AM radio station.

These disturbances introduced in the electrical power supply significantly diminish the quality of the electrical energy available in a building and they also affect the equipments to be connected. Good quality energy enables the correct operation of delicate equipment such as computers, radios, printers, LED TV equipment, and also extends their lifespan, improving energy efficiency.

It must be noted that energy efficiency should not only be considered in terms of a comparison between the amount of energy that a specific device consumes and the benefits it produces, but the quality of the energy necessary to produce the task should also be considered.

Because of their non-linear loads, harmonic distortion of electronic ballasts is greater than those of conventional electromagnetic ballasts [4].

Both electromagnetic and electronic ballasts regulate the voltage and intensity of the electric current which will be delivered to the lamp. But while in the case of the electronic ballasts this is accomplished through electronic devices, electromagnetic ballasts use a transformer and a capacitor. These electronic devices deliver a frequency output of up to 400 times the nominal frequency of the mains. This high frequency current adversely affects waveform of the mains current, whose frequency is obviously different.

II. Performance Parameters

Power factor: it is the relation between the active power (W) and the total power (VA) that the charge consumes. The closer to 1 the better:

$$FP = \frac{P}{S} = \frac{\frac{1}{T}\int_0^T vi\,dt}{\sqrt{\frac{1}{T}\int_0^T v^2 dt}\sqrt{\frac{1}{T}\int_0^T i^2 dt}}$$

Crest factor: is the ratio between the peak current that a load requires and its mean current. It is a measure of the non-linearity of electric consumption.

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Total Harmonic Distortion (THD): Total harmonic distortion is the quotient of the rms value of the harmonic component and the value of the key.

$$THD = \sqrt{\frac{I_{2,rms}^{\ 2} + I_{3,rms}^{\ 2} + ... I_{n,rms}^{\ 2}}{I_{1,rms}^{\ 2}}} \times 100$$

Being:
In, rms: power of order n, in amperes

III. EXPERIENCES WITH BALLASTS

In order to compare harmonic distortion in electromagnetic and electronic ballasts, three samples of each type were used connected to fluorescent tubes.

The 6 ballasts and the 3 tubes were assembled on a test board with connection accessories and switches, to be able to turn them on individually or up to 3 ballasts of the same type (electromagnetic or electronic) in parallel.

An alternate current generator completely independent of available electrical mains was used as energy source so as to isolate the test board from the electrical noises that other devices could introduce in the mains, thereby affecting the measurements.

To carry out the measurements, a PowerLogic PM4000 Schneider Electric network analyser was used. It is a tool that allows data collection in real time, enabling communication in various protocols and which makes it possible to export the data to a computer for further analysis.

The measurements were made on the two types of equipment: the electronic and electromagnetic ones.

Data from a single appliance, from two devices in parallel and from three devices in parallel were always taken with the same type of auxiliary equipment.

IV. MEASUREMENTS

A first summary of THD values from the measurements taken by the Network Analyzer for electronic ballasts is shown in the following table:

	Electronic ballasts		
Number of artifacts in parallel	**1**	**2**	**3**
THD	**72,03%**	**51,80%**	**48,52%**

On the other hand, for electromagnetic ballasts the following values were obtained:

	Electromagnetic ballasts		
Number of artifacts in parallel	**1**	**2**	**3**
THD	**17.26%**	**13.56%**	**13.17%**

As it can be seen, the THD of the current is significantly higher in the case of electronic ballasts than in the case of the electromagnetic ones.

In electromagnetic ballasts, harmonic distortion in the current is due to third-order harmonic. Figure 1 shows that those harmonics are in the order of 10% to 12% while the rest does not exceed 2.5%.

In contrast, electronic ballasts have a much more varied current harmonic content. Figure 2 shows that the 11th, 13th, and 15th harmonics have greater relevance than the rest. However, the third order harmonics also have important values.

It is interesting to mention a phenomenon of attenuation in electronic ballasts in parallel [5]. When connecting two or more devices in parallel, THD value is reduced with respect to a single device. The attenuation is due to the cancellation of some harmonics when connecting non-linear loads in parallel. The effect is more significant for harmonics of high orders than for the lower order. This is not, obviously, so perceptibly for electromagnetic ballasts, since they do not generate harmonics of higher orders.

Below, there are graphs of the harmonic content for both types of equipment. It should be noted that although the network analyzer can display information up to harmonic of order 255, in this analysis only harmonics of order up to 15 are shown.

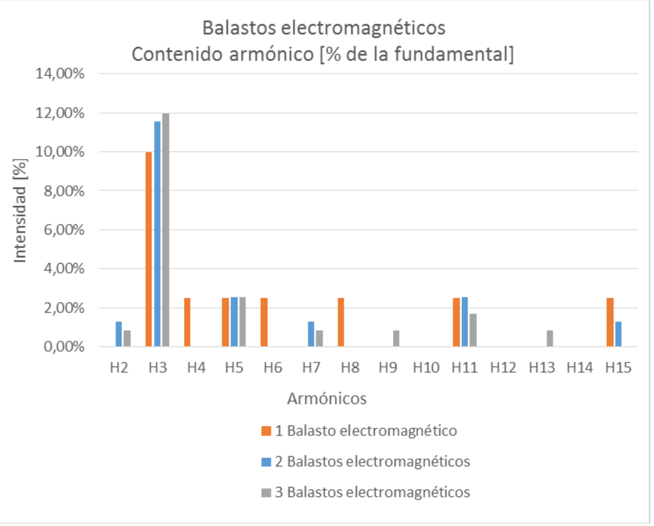

Figure 1. Harmonic content of fluorescent devices associated with electromagnetic ballasts, as a percentage of the fundamental wave.

As mentioned in a previous paragraph, in electromagnetic ballasts there are not disturbance in high harmonics and, as shown in Figure 1, the third-order harmonic predominates.

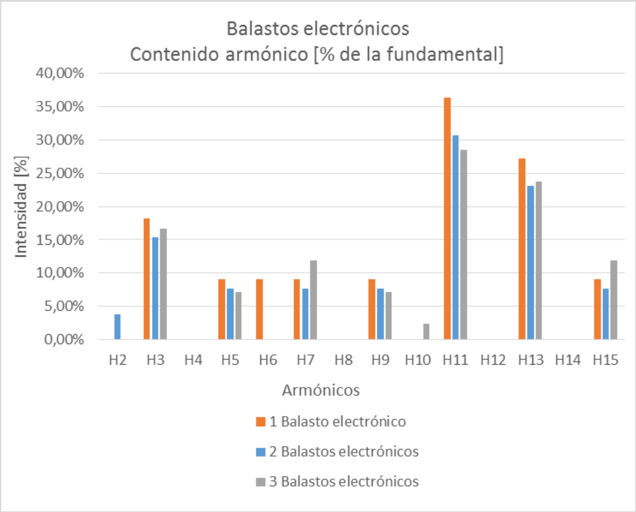

Figure 2. Harmonic content of fluorescent devices associated with electronic ballasts, as a percentage of the fundamental wave.

After analysing the figures and values of THD, it can be concluded that electronic ballasts produce greater disturbance in the electrical power supply, since the resulting waveform is much less similar to a sine wave than it could be with other types of devices.

It should be highlighted that the 11th, 13th and 15th harmonics have a high influence in the final value of THD in electronic equipments. Disruptions in the electrical networks are significant because of its high frequencies.

V. CONCLUSIONS

Although electronic ballasts have advantages, such as increased performance, elimination of “flicker" or strobe effect, increase of bulb lifespan, it is important to mention that one of its main disadvantage is the generation of harmonics of a higher-order than the wave of fundamental current, as every equipment or non-linear circuit current.

These harmonic currents have a negative impact on the mains supply since they distort the current of the same wave form.

As a direct consequence, this disturbance negatively affects the quality of the energy available in the electrical network. Besides, the design of these networks should also be taken into account, since, for example in the neutral conductor, as it is well known, odd multiple harmonics of third harmonic are added to it causing these conductors to overheat.

Therefore, it is important to consider the effects caused by the use of electronic ballasts in fluorescent lighting systems.

REFERENCES

[1] Pablo G. Paisan, “Etiquetado de Eficiencia Energética”, Instituto de Normalización y Certificación IRAM, 2003.
[2] IAE, “Sector Energético República Argentina, Anuario 1998”, Instituto Argentino de la República Argentina “General Mosconi”.
[3] CADIME, “Balastos electrónicos”, Revista Avance Eléctrico Cámara Argentina de Distribuidores de Materiales Eléctricos, edición 140/14, abril 2011.
[4] J. A. Suárez, G. F. Di Mauro, D. Anaut y C. Agüero, “Análisis de la distorsión armónica y los efectos de atenuación y diversidad en áreas residenciales”, IEEE Latin America Transactions, Vol. 3, No. 5, Diciembre 2005
[5] G. Lemieux, "Power System Harmonic Resonance - A Documented Case," IEEE Transactions on Industry Applications, vol. 26, NO. 3, pp. 483-488, May./June, 1990.