Behavior of a Filter for Elimination of the 5th Harmony Caused by Components LED and Compact Lighting Lamps

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Abstract: ***The current problem in the use of lighting equipment with electronic components with low electronic compability, causes the introduction of electromagnetic disturbances to electrical equipment and systems. In addition, any electrical equipment, is a generator of electromagnetic disturbances. These cause undesirable phenomena mitigation is necessary because they are more intense with increasing voltage and current values, circuits with electronic components become increasingly sensitive and the distance between sensitive and disturbing circuits is reduced. The new technologies of LED lighting have advantages of energy saving, do not release toxic gases, do not contain harmful substances, have less energy losses and are controlled by intelligent systems. In this research, a second-order low-pass filter for the elimination of the fifth harmonic, generated by new generation lighting lamps (LED lamps and compact fluorescent lamps). A silicon controlled diode is introduced to prevent frequency rebound, allowing to have a satisfactory functioning capacity. Modeling with Matlab's Simulink is performed to obtain voltage and current waves before and after inserting the proposed filter.***

Keywords: Disturbances, Mitigation, Lighting.

1. Introduction

Harmonics are electrical voltages and currents that appear in electrical energy systems as a result of certain types of electrical charges. These are the distortion of the waveform supplied by the network, caused by “non-linear” loads, which include motor controls, computers, office equipment, compact fluorescent lamps, light dimmers, televisions and in general, most Electronic charges High harmonics increase line losses and decrease equipment life. Power systems are designed to operate at set frequencies, either 50 or 60Hz. However, certain types of charges produce currents and voltages with frequencies that are integer multiples of the fundamental frequency. These high frequencies are a form of electrical pollution known as power system harmonics. Steinmetz published a book in 1916 that devoted considerable attention to the study of harmonics in three-phase energy systems. His main concern was the currents that cause the third harmonic, caused by saturated iron in transformers and machines, and he was the first to propose delta connections to block currents that contain the third harmonic. Later, with the advent of rural electrification and telephone service, power and telephone circuits were often placed in common rights of way.

The harmonic currents produced by the transformer magnetization currents caused inductive interference with the open cable telephone systems. The interference was so severe that voice communication was impossible. This problem was studied and relieved by filtering, placing design limiters in the magnetization currents of the transformer. At present, the most common sources of harmonics are electronic power loads, such as adjustable speed units (ASD) and switching power supplies. These charges use diodes, silicon-controlled rectifiers (SCR), power transistors and other electronic switches to cut waveforms and control power or to convert from AC to DC.

Since the first AC generator was connected more than 100 years ago, electrical systems have experienced Total Harmonic Distortion. The harmonics at that time were insignificant and had no harmful effects. Very often, the operation of electrical equipment may seem normal, but under a certain combination of conditions, the impact of harmonics is improved, with harmful results [1].

Harmonics are sinusoidal voltages or currents with a frequency that is an integer multiple of the frequency of the distribution system, known as the fundamental frequency, corresponding to the Mexican Republic with a frequency of 60Hz.

Some elements known as non-linear loads such as: rectifiers, inverters, variable speed drives, ovens, computers, screens and modern lighting systems, among others, absorb periodic non-sinusoidal currents from the network.

Disturbances cause undesirable phenomena and mitigation is necessary because they are more intense as voltage and current values increase, circuits with electronic components become increasingly sensitive and the distance between sensitive circuits (victims) and disturbances (sources) are reduce [2], [3], [10], [11].

The problems caused by a low power factor in electrical systems are known, such as the regulation of voltages, improper operation of machines and increased losses, which ultimately results in a reduction of the electrical capacity and efficiency of the system. The widely used solution has been the installation of capacitor banks for reactive power compensation. Unfortunately, these banks interact with the electrical system forming RLC circuits that produce resonances, the natural frequencies of the system being a function of the inductive and capacitive components of the network. In this work, a second-order low pass filter applied to lighting is presented, because most current lighting equipment does not have an electric pollution suppressor filter, but instead they contaminate in high and low frequency, which causes consumption electric superior, also an increase in energy not consumed.

The determination of the existence of disturbances in the power supply network in electrical installations with single-phase power supply and the impact that they could generate on the operation of various equipment, in its operation and protection, due to its level of sensitivity, is increased every another day, what originates, that the creation of policies for penalties for the coming years begins.

Additionally, the distribution company has the responsibility of providing high supply quality with regard to the voltage level and its waveform [13]. Due to the complexity of the causes and problems associated with harmonics, various research groups have raised a large number of mathematical models to better understand this problem and for which definitive models have not yet been established [4].

The quality of the electricity supply has deteriorated by the distortion present in the voltages and currents. [5], [6], [12], [13].

One of the proposed solutions is to provide control of reactive potency for to prevent problems of overvoltage. Other novel idea is inject harmonics opposites in the network for compensate harmonics introduced by the consumption of power electronics. [7].

In this work, a quantitative method of linearity assessment based in the parameter of harmonica distortion total (THD) it is presented and verified experimentally. The experimental validation of method implemented showed that the method implemented is able to evaluate quantitatively the linearity of it. Moreover, it is able to determine the threshold frequency for above which the system not will show effects significant nonlinear, even for amplitudes of disturbances big. It was observed that method THD is more sensible to the nonlinear effects that the spectra themselves [8]. As the number of burdens harmonicas has increased to the long of years, ever time is more necessary to tackle the burdens generators of harmonica current (nonlinear burdens) and the second it is the way in that flow the harmonicas currents and how develop the harmonic voltages resulting [9].

2. Methodology

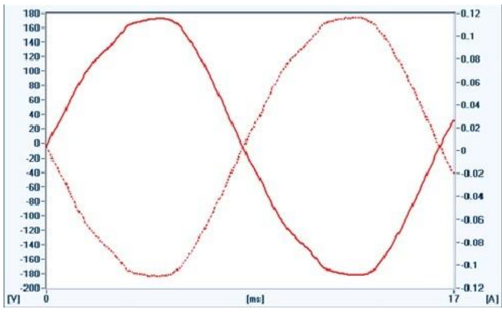
The electric variables and the distortions provoked by three lamps were obtained: one incandescent lamp, one LED and one saver lamp of 5 watts each, were determined the variables of transfer for the calculation of the components of filter and it was modeled the filter in Simulink of Matlab for to evaluate its functionality.

2.1 Obtaining electrical variables

The measurements are carried out with the application of module NI cRIO-9023, of National INstruments, with the cards of acquisition NI-9225 and NI9227, observed in figure 1.

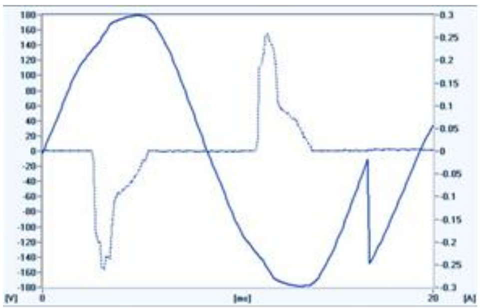
Figure 1: System used for measurement

Graphs 1, 2 and 3 presented the electrical consumption of voltage and current of the lamps, in these graphs are shown a distortion of existing current in the save lamp and the LED, compared against one nonlinear burden (incandescent lamp).

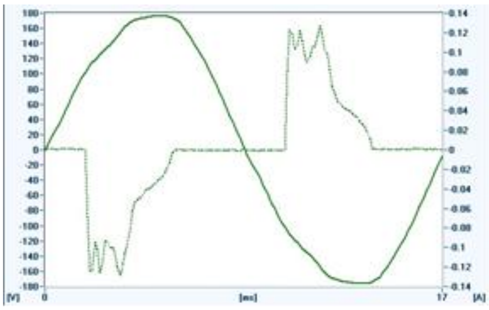


Graph 1: Voltage and current incandescent lamp

Graphic 2 shows that the harmonic distortion is bigger than in the LED lamp, so that are take as reference for carry out the electrical circuit in simulink for corresponding modeling.

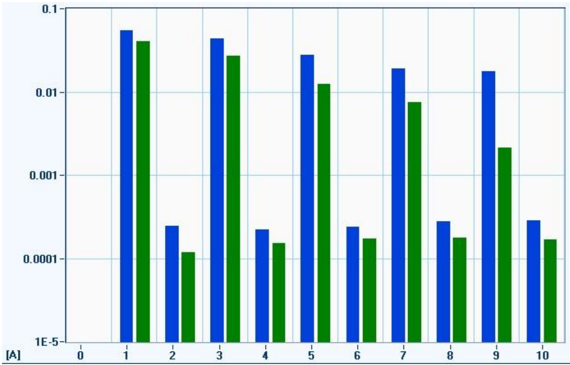


Graph 2: Voltage and current saving lamp



Graph 3: Voltage and current LED lamp

Graphic 4 shows the harmonic distortion total THD of the save lamps and LED. In this graphic are show the values of the harmonic fifth that we interested in reducing or eliminating.



Graph 4: THD of the burdens

2.2 Determination of filter variables

The transfer function, shown in equation 1, was determined for the calculation of the proposed filter in each of its components, the electronic circuit is implemented, see figure 2, this filter is an element that suppresses a certain frequency or frequency ranges of an electrical signal that passes through it, modifying its amplitude and its phase.

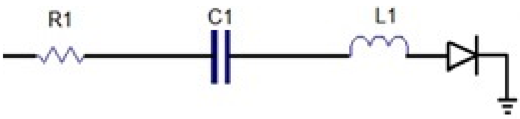


Figure 2: Proposed filter

The transfer function for this filter is:

$$H(jw) = H_0 \frac{2\zeta\left(j\frac{w}{w_0}\right)}{1+2\zeta\left(j\frac{w}{w_0}\right)+\left(j\frac{w}{w_0}\right)^2} \qquad (1)$$

$H(jw)$ Degree Polynomial $m \leq 2$

$$2\zeta = \frac{1}{Q}$$

Q Factor quality of filter
W System frequency (Hz)
w_0 Resonance frequency (Hz)

The parameters of the function characteristic comes are given by:

$$H_0 = \frac{R_L}{R_1 + R_L} \qquad (2)$$

$$w_0 = \frac{1}{\sqrt{LC}} \qquad (3)$$

$$Q = \frac{1}{2\zeta} = \sqrt{\frac{L}{C}}\left(\frac{1}{R_1 + R_L}\right) \qquad (4)$$

R_1 Resistance (Ω)
R_L Inductive reactance $= X_L (\Omega)$
ζ Cushioning coefficient

For the calculation of the cycles:

$$W_H = w_0\left(\sqrt{\zeta^2 + 1} + \zeta\right) \qquad (5)$$

$$W_L = w_0\left(\sqrt{\zeta^2 + 1} - \zeta\right) \qquad (6)$$

$$Z = \sqrt{R^2 + (X_L - X_C)^2} \qquad (7)$$

X_L Inductive reactance (Ω)
X_C Capacitive reactance (Ω)
w Throbbing $= 2\pi f$

$$X_L = w * L \qquad (8)$$

$$X_C = \frac{10^6}{w * c} \qquad (9)$$

The values for each filter component are shown in the table 1, the components are applied to a power of 10W.

Table 1: Values of the filter components

R	39Ω
C	$38\mu F$
L	$1\mu H$

The characteristics of the diode MR754: Voltage Reverse Repetitive Vrrm maximum: 400V, Direct Current t If (AV): 6A, VF maximum: 1V, Ifsm maximum: 400A Temperature operating maximum: 150°C.

2.3 Modeling computational

The modeling computational is carried out for a power of 5W and an electronic circuit of a saving lamp, shown in the figure 3, for be this, which distort most measurement to the current. The values measures of the harmonics in the simulation shown an important distortion, which cause a loss of energy.

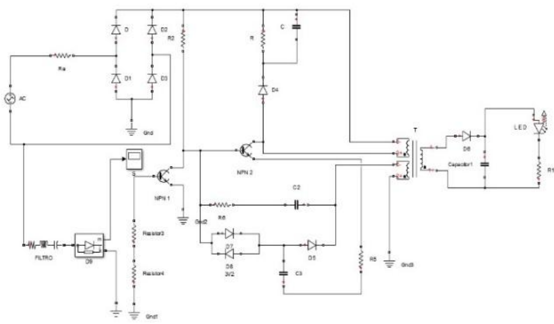
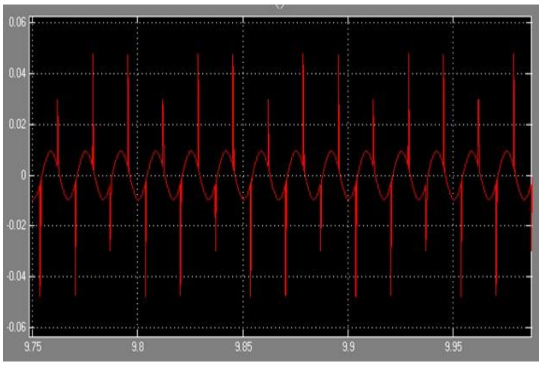


Figure 3: Diagram of a saving lamp

Watched in the graph 5 the harmonic distortion caused for the electronic components.

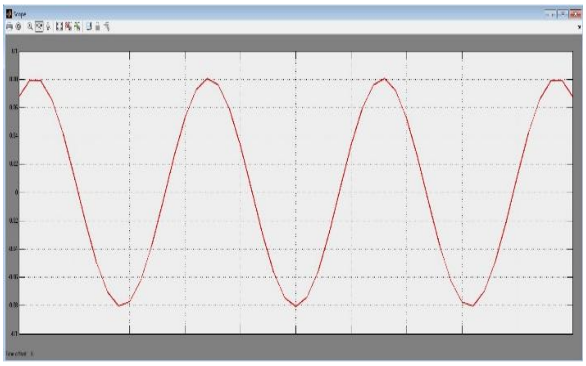


Graph 5: Harmonic distortion of current

3. Results

The comparison of the electric variables of the three lamp allows to realize an analysis deeper, establishing the functionality of each a of the lamps, to determinate the values of each a of the components of the filter for the elimination of the 5th harmonic.

With the application of the filter in computational modeling is achieved correct the harmonic distortion giving to result the current wave showing in the graph 6, where it is observed a homogeneity of the current curve.


Graph 6: Correction of the harmonic distortion of the current

4. Conclusions

The constant technological advances allow us to count with new illumination devices much more efficient.
However these devices have the peculiarity of contaminating the systems of feeding (Line-Neutral), with harmonics as shown in development of this investigation, causing loss of energy, premature aging of components and drivers. In this research the results are shown to the simulation part of a filter. This filter is capable of attenuate 12dB/eighth outside of the step band.

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