Proper Mixture of CFL as an Energy Efficient Lighting System Without Violating Harmonics Limits

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Introduction

Technology development causes large electricity demand in both industries and residents. The smart wayto meet the electricity demand is by introducing energy saving techniques. Most of the countries experiencing peak electricity demand in the evening and early night period. One of the main reasons for this is inefficient lighting loads, such as filament lamps. Compact Fluorescent Lamp (CFL) is one of the accepted efficient lighting loads available in the market. CFLs provide the same intensity of light as incandescent bulbs, but use about 75% less energy as well as less heat. Also, they last up to ten times longer than a standard incandescent bulb [1, 2].

CFLs create harmonics on the supply system because of the control system limiting the plasma current, which produces light. These harmonic currents are then injected into the distribution system. Most electrical appliances have been designed work with linear voltage and current waveforms. Therefore excessive nonlinear loads can cause serious problems such as overheating conductor, transformers and capacitor failures as well as malfunction of electronic equipment. The magnitudes of harmonics generated by the CFLs vary based on the manufacturing technologies. Using the Fourier series, a distorted periodic wave shape can be represented by its fundamental and harmonics frequencies sine waveforms.Harmonic component can be expressed as a percentage of the fundamental and it is known as the Total Harmonic Distortion (THD),

$$THD = \frac{\sum_{h=2}^{\infty}(I_h)^2}{I_1} 100\% \qquad (1)$$

Where I_h – h^{th} harmonic component and I_1 – fundamental current component Harmonic distortion level is depended on the type of CFL and distribution parameters. CFL can cause current distortion and that can result voltage distortion as well [2, 3]. Hence the use of CFL is appreciated with low distorted current to use within the acceptable limit for harmonics.The target of this paper is to study the amount of penetration can go with the CFL without violating the IEEE - 519 harmonic standards.

Methodology

To emphasize the study not being influenced by the vendor, six varieties of CFL bulbs were chosen namely A, B, C, D, E and F. The study consisted of two parts, thus testing of different CFL bulbs for the harmonics contents in the current wave. Then the luminosity test was carried out to compare luminosity level. All the necessary steps were taken to meet higher precision.

Harmonic test

Figure 1(Left) shows the test set up used to find out the harmonics.Digital oscilloscope (DL 1640) was used to take the measurements.Harmonic contents were extracted by importing the measured data to EMTDC/PSCAD simulation package. Table I summarises the interested harmonic contents up to 11^{th} harmonics. Figure 1 (Right) shows the EMTDC/PSCAD simulation diagram

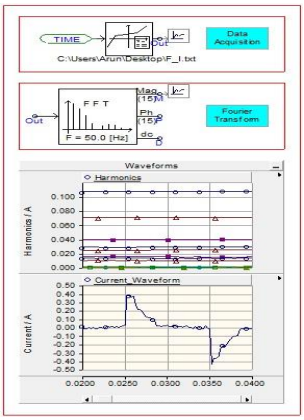

Figure 1: Experimental set up (Left), EMTDC/PSCAD simulation results (Right)

Table I: Harmonic contents

Harmonic current / (A)	Bulbs						
	Filament Lamp	CFL					
		A	B	C	D	E	F
1st	0.2772	0.1012	0.0977	0.1201	0.1023	0.1038	0.1080
5th	0.0040	0.0403	0.0383	0.0450	0.0368	0.0140	0.0399
7th	0.0020	0.0282	0.0284	0.0328	0.0279	0.0089	0.0285
11th	0.0006	0.0178	0.0175	0.0177	0.0151	0.0092	0.0159

Luminosity Test

To figure out the luminosity of the bulbs, a LUX meter was used. Figure 2 shows the experimental setup and results are tabulated in table II.

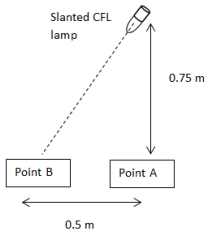

Figure 2. LUX Meter (Left), Measured Points (Right)

Table II: LUX levels

Bulb	Luminosity /(LUMENS / SQ.FT)	
	Laboratory Test	
	A	B
A	0.3	0.4
B	1.0	0.8
C	1.0	0.8
D	0.8	0.5
E	0.3	0.4
F	0.3	0.4

To find out the number of CFLs can be used to replace filament lamps, a specimen calculation was done based on the measured parameters. Eq. 1 was used to calculate THD. This study resulted that to satisfy the limitations for harmonic currents (where THD must be kept below 5% according to IEEE 519) out of 6 filament lamps, 5 can be replaced with CFLs. This concludes the harmonic constrained on replacing CFLs.

Conclusion

The experimental study confirmed that CFL has tremendous performance when compared with conventional lighting loads. Further the study resulted that the payback period of using CFL is less than 6 months. The study on harmonic effects resulted that out of every six filament bulbs, five can be replaced with CFL without exceeding the limitation imposed by IEEE 519 harmonic standards.

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