Evaluation of Electromagnetic Interference Emitted from Compact Fluorescent Lamps According to CISPR-15

A. Kocakusak[1], **M. Cakır**[1,2], **S. Yalcın**[3], **S. Ozen**[1], **and S. Helhel**[1]

[1]Electrical & Electronics Engineering Department, Akdeniz University, Antalya 07058, Turkey
[2]Electrical & Electronics Engineering Department, Bayburt University, Bayburt, Turkey
[3]Electrical & Electronics Engineering Department, Suleyman Demirel University, Isparta, Turkey

Abstract— In this study, Electromagnetic interference (EMI) emitted by the compact fluorescent lamps (CFL) having biggest pie in the market has been investigated according to CISPR-15. Emissions of CFLs vary depending on trademark, since some cannot provide the requirements of CISPR-15 standards such that they act as contaminants in the electric supply system. Conducted analysis considering the limits of CISPR-15 at 150–500 kHz frequency brings out that the effect of CFL produced by Company A at 181.298 kHz is 83.94 dBμV, whereas the effect of CFL produced by Company D at 173.593 kHz frequency is 49,92 dBμV, respectively. Obtained results are out of CISPR-15 limits of 66–56 dBμV.

1. INTRODUCTION

Today, EMC has become more precise issue with the increase of high speed/high frequency electronic devices available commercially at market for daily usage. The CLF lamps were recommended in the 1970s with minimizing the control circuit to be integrated into the cap of a standard lamp [1]. Use of CFL has become widespread in structures such as shopping malls, offices, factories, hotels, houses, schools, hospitals and so on in order to provide more efficient lighting and conserve electrical energy [2]. There are many commercial brands on the market, and some producers do not obey CISPR-15 standards. This irregular production mechanism has forced scientists to focus on EMI problems induced by CFLs present in the market in recent years.

The CFLs emit harmful ultraviolet radiations and the electromagnetic disturbances' fields. According to CISPR 15 F/399/CDV [3], the principal responsible for disturbance emissions is the common mode current, which generates conducted radiations transmitted in the power supply network.

2. COMPACT FLUORESCENT LAMPS AND ELECTROMAGETICS INTERFERENCE

CFL consists of two separate components named electronic ballast and fluorescent tubes. Ignition of the lamp filaments requires high frequency sources such that those high frequency components are generated in two stages; 50/60 Hz AC to DC conversion is followed by DC to high frequency (20 kHz–40 kHz) AC conversion, and this conversion is basically known as high speed switching. This switching results in EMI emissions that need to be controlled and suppressed by using any standard methods.

2.1. Common Mode Noise and Difference Mode Noise

There are two types of noises throughout any electronics. The first type is differential mode (DM) noise conducted on the signal (VCC) line and GND line in the opposite direction to each other. Differential-mode interference causes the potential of one side of a signal transmission path to be changed with respect to another side. With this type of interference, the interference current path is wholly in the signal transmission path [4]. The second type is common mode (CM) noise conducted on all lines in the same direction. With an AC power supply line, for example, noise is conducted on both lines in the same direction. With a signal cable, noise is conducted on all the lines in the cable in the same direction. Differential mode noise is the current that results from the difference between phase and neutral voltages. Origin of differential mode is an interaction between circuit components. The noise voltage that is developed is the same in both transmission paths [4]. It is shown at Figure 1.

Voltages and currents are calculated for common mode noise as indicated in Eq. (1) and Eq. (2).

$$v_{cm} = \frac{v_p + v_n}{2} \tag{1}$$

$$i_{cm} = i_p + i_n \tag{2}$$

Voltages and currents of differential mode noise described as in Eq. (3) and Eq. (4).

$$v_{dm} = v_p - v_n \tag{3}$$

$$i_{dm} = \frac{i_p - i_n}{2} \tag{4}$$

$50\,\Omega$ loads of line impedance stabilization network (LISN) are parallel during common mode and serial during differential mode. Thus Eq. (1) and (3) produce Eq. (5), Eq. (2) and (4) produce Eq. (6) [4].

$$v_{cm} = \frac{v_p + v_n}{2} = \frac{50\,\Omega \cdot i_p + 50\,\Omega \cdot i_n}{2} = \frac{50\,\Omega}{2} \cdot (i_p + i_n) = 25\,\Omega \cdot i_{cm} \tag{5}$$

$$v_{dm} = v_p - v_n = 50\,\Omega \cdot i_p - 50\,\Omega \cdot i_n = 2 \cdot 50\,\Omega \cdot (i_p - i_n) = 100\,\Omega \cdot i_{dm} \tag{6}$$

Conducted emission is assayed by military or civil standards. If the noise exceeds the limits it will have to be separated noise components by current probes or separation methods. The importance of noise separation is underlined by literature to achieve an appropriate filter design [5–7]. Obtained noise components allow us to determine EMI filter components both for common and differential mode.

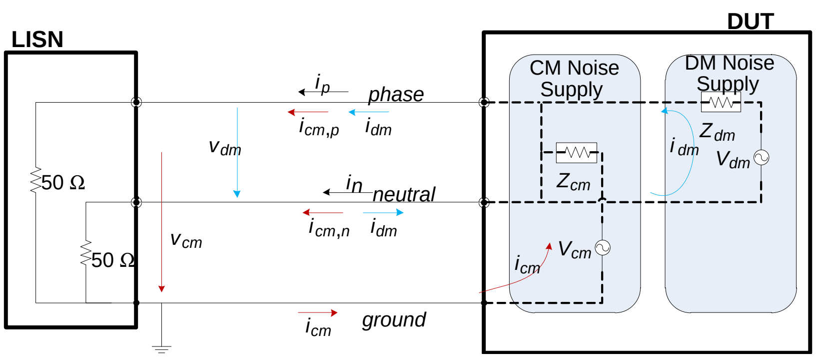

Figure 1: Common mode noise and difference mode noise.

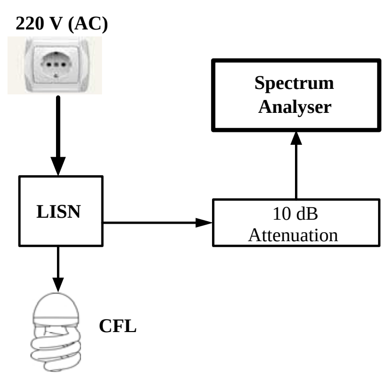

Figure 2: Measurement method of CFL

Table 1: The CISPR-15 limits.

Frequency Range (kHz)	**Method**	
	Quasi-peak (dBµV)	**Average (dBµV)**
9–50	110	-
50–150	90–80	-
150–500	66–56	56–46
500–5,000	56	46
5,000–30,000	60	50

3. CONDUCTED INTERFERENCE MEASUREMENTS

Conducted emission (CE) measurements were hold at 3m standard anechoic chamber at EMC Pre-Compliance Test Laboratory at Akdeniz University Industrial Based Microwave Research and Application Center (EMUMAM) [8]. The conducted interferences were measured using a Line Impedance Stabilization Network (LISN), while the levels of perturbations were recorded using an spectrum analyzer. Then the results were compared to CISRP 15 standard limits. Table 1 indicates the CISPR-15 standards' limits, and Figure 2 demonstrates the layout for CFL caused measurements.

4. RESULTS AND CONCLUSIONS

Some trademarks were observed that they are producing noises above the CISPR-15 values in the network, and measured values and limit values are presented in Table 2. Brand A predicts 83.94 dB µV at 181,298 kHz which is about 18 dB above the permitted limit, Brand B predicts 79.67 dB µV at 165 kHz which is about 14 dB above the limit and Brand C predicts 80.75 dB µV at 168,5 kHz about 15 dB above the limit. However, Brand D predicts almost 50 dB µV at 173,5 kHz which is about 6 dB below the limit. There is only one brand presents below CISPR-15 limits. Due to commercial and economic concerns, it looks that some companies having about 60% total market share are not obey EMC limits of CISPR 15.

Table 2: Measurement results.

Brand	**Power (W)**	**Frequency (kHz)**	**Measured (dBµV)**	**Limit (dBµV)**
A	22	181,298	83,94	66–56
B	20	164,908	79,67	66–56
C	18	168,528	80,75	66–56
D	20	173,593	49,92	66–56

Governments should increase the number of controls to save network, network components and connected devices for harmonics. Those controls will also regulate the market for standard products.

ACKNOWLEDGMENT

This study was supported by Akdeniz University Scientific Research Supporting Unit (BAP), and measurements were carried out at EMC Pre-Compliance Test Laboratory at Akdeniz University Industrial Based Microwave Research and Application Center (EMUMAM) [8] granted by State Planning Organization (2007K120530-DPT).

REFERENCES

1. Letertre, T., A. Azoulay, A. Destrez, F. Gaudaire, and C. Martinsons, "Characterization of compact fluorescent lights RF emissions in the perspective of human exposure," *EMC'09*, 22S3-3, Kyoto, 2009.
2. Ferreira, P. I. L., G. Fontgalland, G. F. Aragao, A. R. Z. Nascimento, R. C. S. Freire, and S. E. Barbin, "Conducted interference reduction from compact fluorescents lamps," *2010 Asia-Pacific International Symposium on Electromagnetic Compatibility*, Beijing, China, Apr. 12–16, 2010.
3. Istok, R., "Relation between disturbance radiation of CFL and resonant frequency of power supply cable," *Advances in Electrical and Computer Engineering*, Vol. 7, No. 1, 23–25, 2007, ISSN: 1582-7445, e-ISSN: 1844-7600.
4. Bockelman, D. E. and W. R. Eisenstadt, "Combined differential and common-mode scattering parameters: Theory and simulation," *IEEE Transactions on Microwave Theory and Techniques*, Vol. 43, No. 7, Jul. 1995.
5. Guo, T., D.-Y. Chen, and F.-C. Lee, "Separation of the common mode and differential mode conducted EMI noise," *IEEE Transactions on Power Electronics*, Vol. 11, No. 3, 480–488, 1996.
6. Paul, C. R., "A comparison of the contributions of common-mode and differential-mode currents in radiated emissions," *IEEE Transactions on Electromagnetic Compatibility*, Vol. 31, No. 2, 0018–9375, 1989.

7. Chiado-Caponet, M. and F. Profumo, "Devices for the separation of the common and differential mode noise: Design and realization," *IEEE APEC' 02*, 100–105, Dallas, USA, 2012.
8. http://emumuam.akdeniz.edu.tr/tr.