Compact Fluorescent Lamps Electromagnetic Compatibility Measurements and Performance Evaluation

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ABSTRACT

Compact fluorescent lamps (CFL) have multiple benefits and give a much longer lifespan when compared to incandescent or halogen bulbs. The lower power consumption is their main great advantage, the higher price being one of the most known disadvantages. Because of the internal structure, CFL have also other disadvantages not such evident, being sources of great electromagnetic fields, both radiated and conducted at the mains port. Also, the ultraviolet radiations should be considered when dealing with them, aspect not covered in this paper.

Several tests were done on different types of CFL, from different manufacturers - most of them well known, in order to determine the level of electromagnetic pollution. The electromagnetic radiated field and conducted disturbances level at the mains port were measured, in the frequency range from 80 MHz to 1 GHz and from 150 kHz to 30 MHz, respectively. The resulted values were compared against the limits provided by the CISPR 22 international standard. All measurements were done in a shielded enclosure, to avoid unwanted interferences with other EM filed sources.

INTRODUCTION

Compact fluorescent lamps (CFL) market has rapidly grown within the last years. The energy-saving CFL has a much longer lifespan, up to 15 times longer than standard incandescent bulb and consume up to 80% less power for the same amount of generated visible light.

The main issues of CFLs are the ultraviolet radiations and the electromagnetic fields generated. As specified in CISPR 15 F/399/CDV amendment [1], the principal responsible for disturbance emissions is the common mode current, which generates conducted radiations transmitted in the mains.

The conducted and radiated emissions of three different CFL types were measured using a log-periodic antenna, a Line Impedance Stabilization Network (LISN), an EMI Test Receiver and calibrated RF cables. The compact lamp and the electronic ballast modules were then independently measured, in order to establish which part of CFL is responsible for which electromagnetic disturbance. The EUT (Equipment Under Test) was placed on a 0.8 m height non-conductive turntable, at a distance of 1 m away from the receiving antenna. After we measured the emissions of both CFL modules, we placed the compact lamp in a ferrite enclosure, keeping the same test configuration as mentioned above.

CONDUCTED AND RADIATED PERTURBATIONS MEASUREMENTS

Both conducted and radiated emissions measurements were done in a semi-anechoic chamber, so the results were not affected by other radio disturbances from the surrounding environment. The conducted emissions were measured using a Line Impedance Stabilization Network (LISN), while the levels of perturbations were recorded using an EMI Test Receiver. The results obtained were then compared to CISRP 22 (EN 55022) standard limits. The three CFL used in our tests are shown in the photo below.

Figure 1. CFL tested: 13 W, 21 W and 24 W

CFL type	Description
13 W	60 W equivalent; 230-240 V; 50 Hz
21 W	100 W equivalent; 230-240 V; 50 Hz
24 W	120 W equivalent; 230-240 V; 50 Hz
	ENERGY class A

CONCLUSIONS

Developments in the field of Compact Fluorescent Lights (CFL) have neglected the unintentional release of electromagnetic energy from these devices. They use less electricity and save money, last up to 15 times longer than standard light bulbs and reduce CO2 emissions, but provide many disadvantages as well. The operation of CFL at high frequencies up to 50 kHz eliminates the flicker effect but produces high electromagnetic emissions. It has been noticed that when switched ON then OFF for several times the mains switch, all fluorescent lamps produced dangerous radiated emissions which radiate to electrical wiring and surrounding environment. The high level of CFL radiations may lead not only to signals interference but to dangerous human exposure issues as well.

A decrease of conducted disturbances may be obtained using an EMI filter in the electronic ballast circuit.

COMPACT FLUORESCENT LAMPS

The two main components of CFL are the compact lamp and the integrated ballast. The first module is a glass tube, which contains mercury vapors and is covered with a light emitting coating in the interior. In operation, a voltage is applied at the end of the tube, causing the mercury vapors to be ionized. When ionized, the vapors emit ultra violet light, converted then to visible light by the inside coating of the glass tube.

The second part of CFL is the integrated ballast. It works as a current limiter, which prevents the CFL to be damaged when the current increases (because of the negative impedance of the ionized gas from the glass tube). There are two categories of ballasts, named magnetic ballast and electronic ballast.

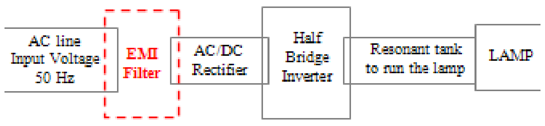

Figure 1. Electronic ballast circuit block diagram

TEST SETUP

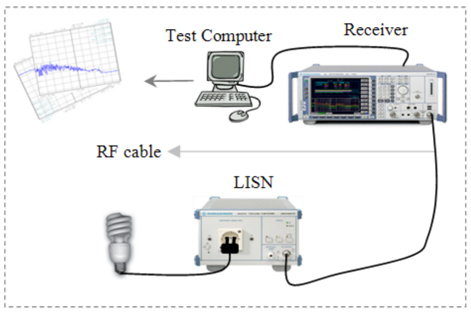

Figure 3. Test setup for CFLs conducted perturbations measurements (anechoic chamber)

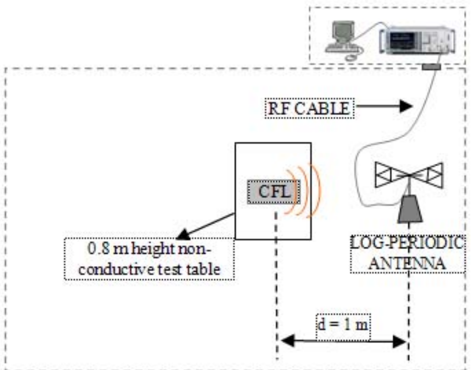

Figure 4. Test setup for CFLs radiated emissions measurements (semi-anechoic chamber)

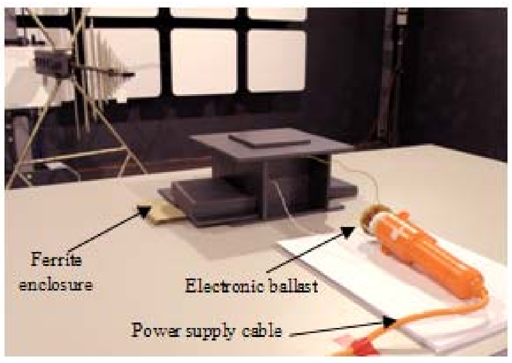

Figure 10. Radiated emissions measurements (shielded compact lamp module)

CONDUCTED DISTURBANCES

TABLE II. CONDUCTED DISTURBANCES LIMITS

FREQUENCY (MHz)	CISPR22 LIMITS [3] (dBuV) quasipeak	
0.15 … 0.5	66 to 56 dBuV	EUT Class B
0.5 … 5 MHz	56 dBuV	
5 … 30 MHz	60 dBuV	
Conducted Disturbances (CISPR22, cap. 6 [9])		

Experimental results

TABLE IV. CFL 21 W - CONDUCTED EMISSIONS LEVELS

MARKER freq.	LEVEL recorded	CISPR22 limit*
4.01 MHz	78.35 dBuV	40 dBuV (50 dBuV)
23.21 MHz	69.66 dBuV	40 dBuV (50 dBuV)
37.96 MHz	75.67 dBuV	40 dBuV (50 dBuV)
62.87 MHz	72.33 dBuV	40 dBuV (50 dBuV)

* *only for informative purpose*

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RADIATED EMISSIONS

TABLE III. RADIATED EMISSIONS LIMITS

FREQUENCY (MHz)	CISPR22 LIMITS [dB(uV/m)] quasipeak	
30 … 230 MHz	40 dBuV	EUT Class B (3 m distance)
230 … 1000 MHz	47 dBuV	
30 … 230 MHz	50 dBuV	EUT Class A (3 m distance)
230 … 1000 MHz	57 dBuV	

Experimental results

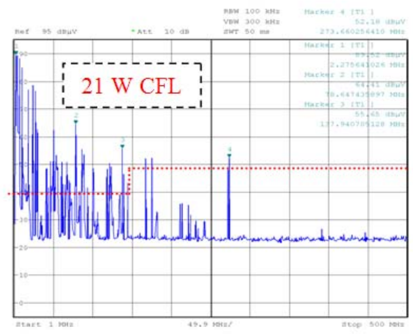

Figure 6. Radiated disturbances measurements in the frequency band of 1 MHz - 500 MHz (21 W CFL)

In order to determine which part of CFL is responsible for those electromagnetic radiations producing, we placed the compact lamp module in a special ferrite enclosure, keeping the same test configuration (figure 11). It has been noticed that the most of radiated emissions from the frequency band of 10 MHz - 100 MHz disappeared. At frequencies up to 1 GHz, the ferrite materials act as an absorber for the electromagnetic waves, while at frequencies above 1 GHz ferrite may reflect EM waves [10-12]. Anyway, the ferrite enclosure constructed suppresses the compact bulb emissions, so that only the electronic ballast radiations were recorded - from 1 MHz to 100 MHz (figure 11).

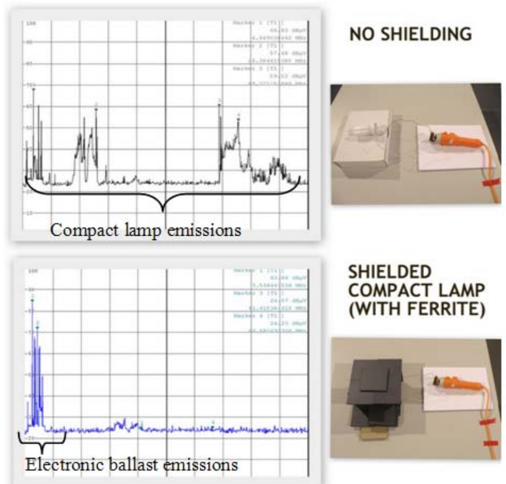

Figure 11. Comparative radiated emissions measurements

SUMMARY

1. Several commercially available CFLs were measured. All of them had the CE mark applied and are Class A Energy saving.
2. Conducted disturbances and Radiated emissions were measured in a controlled environment (semi-anechoic chamber). Both measurement sets of data indicate perturbing signals generated by the CFLs are larger than the limit imposed by CISPR 22 for IT class equipments.
3. Supplementary tests were made in order to determine the cause of the emissions. We identified the electronic ballast as the cause for the radiated emissions and conducted disturbances.
4. More work has to be done in order to future modify the ballast and insert EMI filters for the CFLs to comply with standards.

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