

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.

compact fluorescent lamp, electromagnetic compatibility, electronic ballast, anechoic chamber, common mode current

I. 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.

II. 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.

The first type of the ballast provides minimum functions for operation of CFL and is not as efficient as the electronic ballast, which operates at high frequencies up to 50 kHz. The electronic ballast is more complex than the magnetic ballast and it typically contains a voltage fed half-bridge quasi resonant circuit, a current fed half-bridge resonant circuit or a push-pull resonant circuit [2].

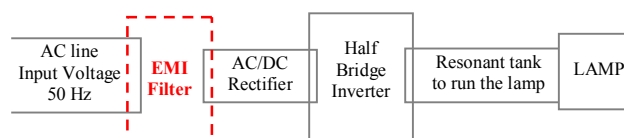


Figure 1. Electronic ballast circuit block diagram

The electronic ballast operates at a higher frequency than the mains, therefore EMI are transmitted in the mains network [2]. Since a power factor correction circuit (PFC) is required, high power ballasts can incorporate active power factor correction circuits, but the high frequency operation and the inverter stage causes more conducted and radiated noise.

In response to the electromagnetic noise generation and for interference with other systems prevention, an EMI filter in the electronic ballast circuit is required [3-8].

III. 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 [9] (EN 55022) standard limits. The three CFL used in our tests are shown in the photo below.



Figure 2. CFL tested: 13 W, 21 W and 24 W

TABLE I. COMPACT FLUORESCENT BULBS

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
<i>CE Mark, Energy class A</i>	

The experimental results are detailed in section V.

IV. TEST SETUP

In this section, all test configurations used in our experiments are described in detail.

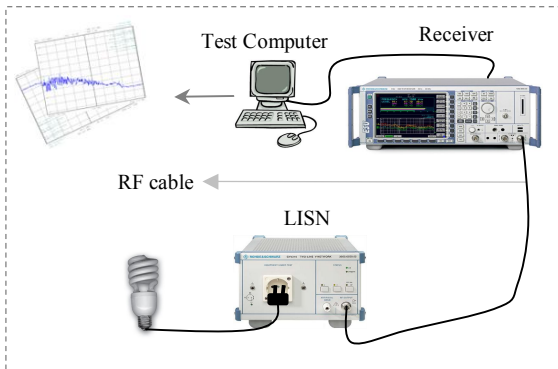


Figure 3. Test setup for CFLs conducted perturbations measurements (anechoic chamber)

For the first set of measurements, the compact fluorescent lamp was connected to LISN (figure 3), while the conducted

perturbations were recorded using the EMI Test Receiver (in spectrum analyzer mode).

For radiated emissions testing, the CFL was placed on a 0.8 m height non-conductive table at 1 m distance away from the receiving antenna (figure 4).

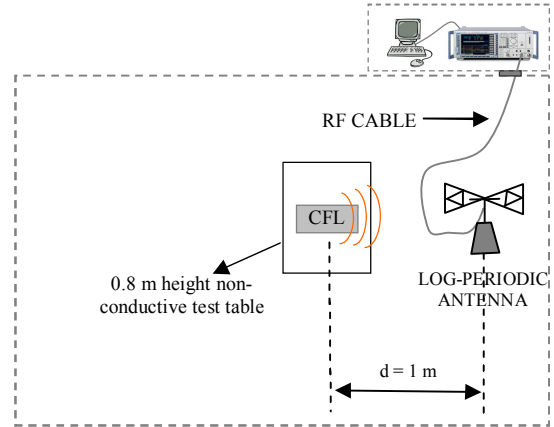


Figure 4. Test setup for CFLs radiated emissions measurements (semi-anechoic chamber)

In the second part of this work, the main CFL modules of a 21 W compact fluorescent bulb were separated and connected via AWG 24 twisted pair wires (figure 5).

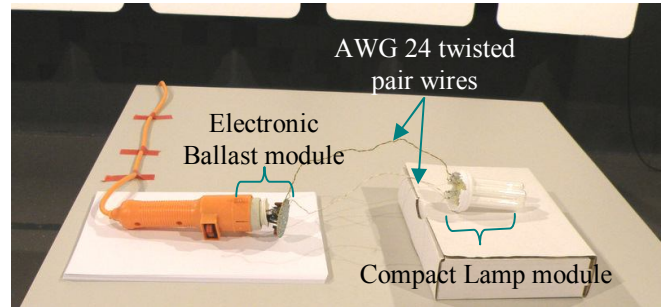


Figure 5. CFL measurements (experimental test setup)

The compact lamp module was then introduced in a ferrite enclosure and the radiated emissions were measured using the same test setup as described in figure 4. This configuration was chosen in order to determine which part of compact fluorescent bulb is responsible for which radiated emission.

V. EXPERIMENTAL RESULTS

The CISPRS22 [9] standard limits for conducted perturbations and radiated emissions are listed below.

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])		

TABLE III. RADIATED EMISSIONS LIMITS

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

In figure 6 we have a screen capture taken from EMI Test Receiver during the conducted emissions measurements (test setup according to figure 3). As it is also apparent from the screen captures above, several conducted perturbations are introduced in the power network supply. We have the conducted emissions levels recorded via EMI Test Receiver when the CFL was turned ON for 5 seconds, then switched OFF. We repeated this action for 10 times.

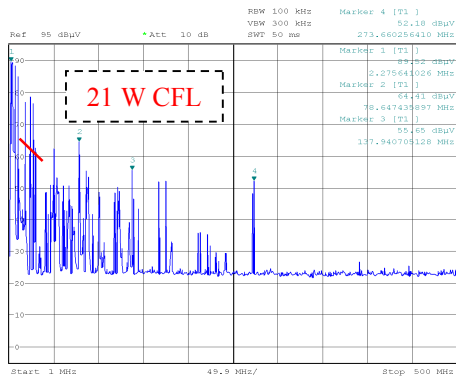


Figure 6. Conducted disturbances measurements in the frequency band of 1 MHz - 500 MHz (21 W CFL)

In normal operation (turned ON for 5 minutes and then switched OFF: figure 7), the compact fluorescent lamp continues to emit, but the level of perturbations is much lower. A maximum electromagnetic radiations level is recorded only when the CFL is switched ON.

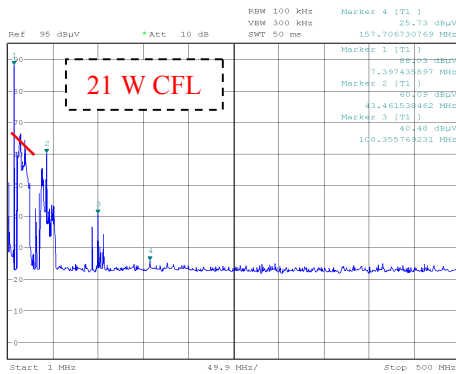


Figure 7. Conducted disturbances measurements - normal operation of CFL (turned ON for 5 minutes)

In figure 8, the 21 W CFL was switched ON for 5 seconds and then turned OFF, repeating this action for 10 times. As it is also apparent from the screen capture, more radiated

electromagnetic perturbations occurred.

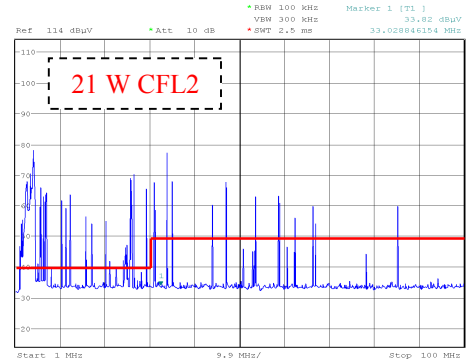


Figure 8. Radiated emissions measurements (CFL2 = 21 W) frequency band 1 MHz to 100 MHz

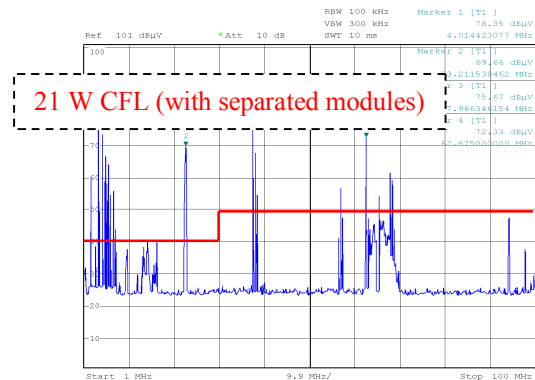


Figure 9. Radiated emissions measurements (21 W CFL (with separated modules)) frequency band 1 MHz to 100 MHz

The maximum levels recorded in the frequency band of 1 MHz - 100 MHz are listed in table IV.

TABLE IV. CFL 21 W - RADIATED EMISSIONS LEVELS

MARKER	freq.	LEVEL recorded	CISPR22 limit*
1	4.01 MHz	78.35 dBuV/m	40 dBuV (50 dBuV)
2	23.21 MHz	69.66 dBuV/m	40 dBuV (50 dBuV)
3	37.96 MHz	75.67 dBuV/m	40 dBuV (50 dBuV)
4	62.87 MHz	72.33 dBuV/m	40 dBuV (50 dBuV)

* only for informative purpose

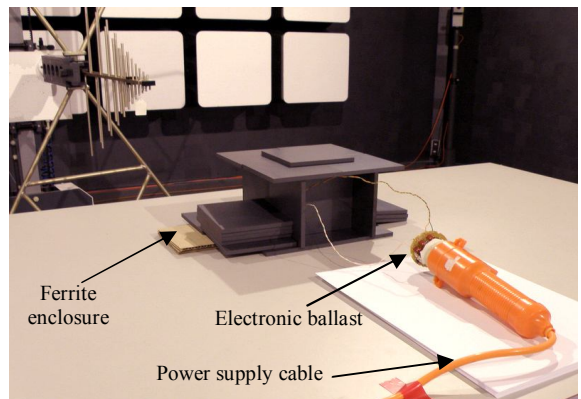


Figure 10. Radiated emissions measurements (shielded compact lamp module)

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 10). 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).

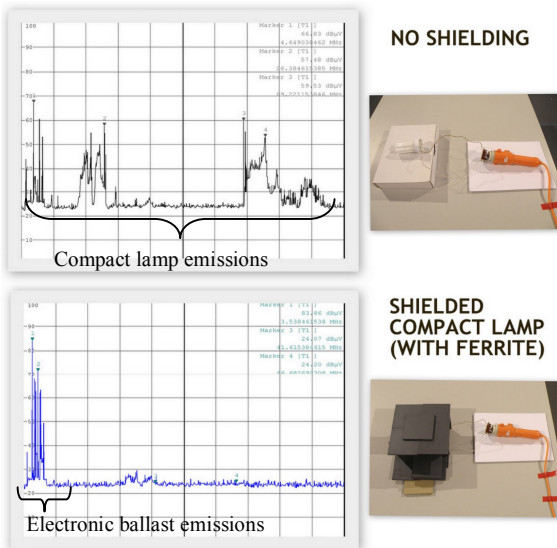


Figure 11. Comparative radiated emissions measurements

Based on the results obtained, we can conclude that the compact lamp module acts as an antenna and radiates electromagnetic waves in the frequency range of 10 MHz - 100 MHz. On the other hand, the high frequency operation of the electronic ballast circuit generates conducted noise in the power supply network and radiated emissions in the 1 MHz - 10 MHz frequency band.

VI. CONCLUSIONS

Within the last few years, the new 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 lots of disadvantages as well.

The operation of CFL at high frequencies up to 50 kHz eliminates the flicker effect (also known as the disturbing 50/60 Hz cycle mains hum) 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.

Several radiated and conducted emissions measurements on different CFLs were made in order to point out the high level of compact fluorescent lights perturbations. A decrease of conducted disturbances may be obtained using an EMI filter in the electronic ballast circuit.

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