# Relation Between Disturbance Radiation of CFL and Resonant Frequency of Power Supply Cable

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***Abstract*—This paper may be divided in two parts. The first part presents the role of common mode current in radiated disturbance emission, and this determine which part of CFL is responsible for common mode current producing. The second part of the paper presents the connection between the radiated disturbance emission of the CFL and the resonant frequency of the power supply cable.**

***Index Terms*—Common mode current, power supply cable, resonant frequency, GTEM cell, electronic ballast, CFL**

## I. Introduction

In conformity with CISPR/F/399/CDV amendment proposal for CISPR 15 standard the compact lamps should be measured in the 30 MHz – 300 MHz frequency band. In this frequency band, the principal responsible for disturbance emissions is the common mode current, which is produced by compact lamp and is emitted in power supply network through power supply cable. The common mode current appears on both lines of supply cable and flows in the same direction, in-phase and with equal amplitudes. Because they have the same direction, they cannot eliminate each other, and generate an electromagnetic field through the supply cable. To reduce the disturbances produced by the lamp it is necessary to know which part of the compact lamp is responsible for producing the disturbances; whether the power supply cable has any influence in emission of these disturbances and how does this manifest itself. Because in this case we have to talk about three distinct parts which are produced and transported/radiated the disturbance signal:

- Compact lamp
- Electronic ballast
- Supply cable

The actuality of the subject is given by the next modification of CISPR 15 standard. The information about disturbances emissions produced by compact lamps in 30 MHz – 300 MHz frequency band are limited

## II. Compact Fluorescent Lamp (CFL)

A typical compact fluorescent lamp is constructed of a glass arc tube which contains two electrodes, a coating of powdered phosphor covering the interior of the tube, and small amounts of mercury. When energized, the electrodes produce a large potential between which the free electrons initiate an arc. The arc generates some visible radiation which in turn excites the phosphor coating causing it to emit light. A compact fluorescent lamp has negative resistance characteristics in that the voltage applied to the fluorescent lamp following the discharge operation is reduced in inverse proportion to an increase in the amount of current flowing through the fluorescent lamp. Therefore, a ballast used for such a fluorescent lamp must serve to supply high voltage required for a turning on of the compact fluorescent lamp while controlling the amount of current flowing through the fluorescent lamp, following the turning on, thereby maintaining a desired brightness. Figure 1 shows the circuit diagram of typical high frequency electronic ballasts.

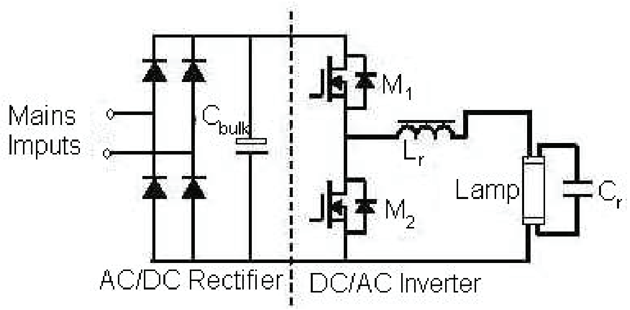


Figure 1. Electronic ballast: half-bridge series-resonant parallel loaded ballast

An electronic ballast includes a rectifier for changing the alternating current (AC) from a power line to direct current (DC) and an inverter for changing the direct current to alternating current at high frequency, typically 25-60 kHz. The inverter includes a direct coupled output that is a pair of switching transistors connected in series between a high voltage rail and a low voltage rail or common rail. The transistors conduct alternately, producing a square wave at their junction that is converted into a sine wave by a series resonant circuit coupled to the junction. A load is coupled in parallel with the series resonant capacitor. Converting from alternating current to direct current is usually done with a full wave or bridge rectifier. A filter capacitor on the output of the rectifier stores energy for powering the inverter.

## III. Emission Source

For compact lamp emission testing, we used a GTEM cell, and a receiver with a quasi peak detector Figure 2.

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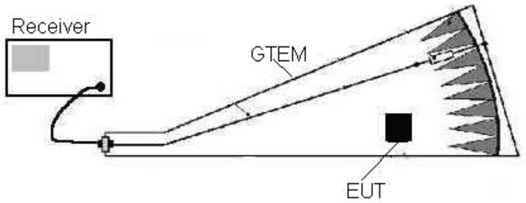

Figure 2. Emission test setup

GTEM = Gigahertz Transversal Electromagnetic Mode cell

EUT = Equipment Under Test

The GTEM cell is a Pyramidally-tapered, doubly-terminated section of 50 Ω transmission line. At the input, a normal 50 Ω coaxial line is physically transformed to a rectangular cross section.

A result of test using the GTEM test setup is presented in Figure 3.

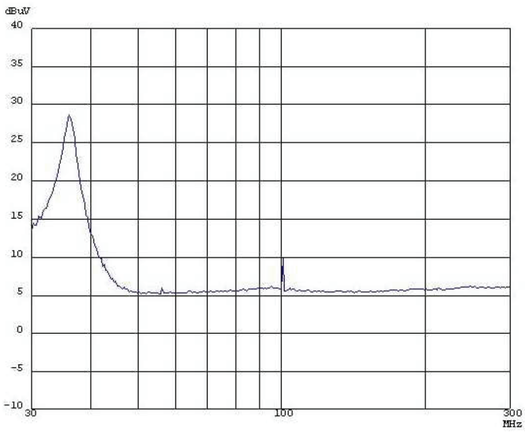
Figure 3. Results of CFL radiated disturbances emission

For identify the mechanism of CFL disturbances emission we divided the CFL in three parts Figure 4.

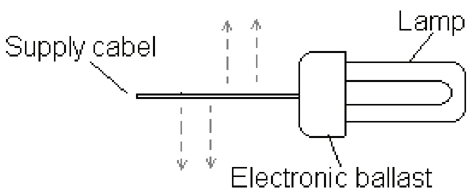

Figure 4. Disturbances emissions of CFL

The CFL radiated disturbance emissions in 30 MHz – 300 MHz frequency band is only through the supply cable. If we introduce just the CFL in an electromagnetic screened box to stop the possible emission from CFL and test the radiated emission disturbance, the result is the same like in the case without screened CFL, Figure 3.

During the CFL functioning, it is produced a common mode current. The only responsible for common mode current apparitions is the electronic ballast. This common mode current is transmitted in two directions to the lamp and back to power supply. The value of common mode current transmitted to power supply is enough to produce a radiation in far field (3 m distance from the power cable supply), and it depends on the power of the ballast. The principal source of noise in ballast is represented by half bridge inverter, which produces a wide–band noise. The radiation from the power supply cable has a vertical polarization.

To find which part of CFL is responsible for disturbance generating we have two possibilities:

1. We separate the lamp from the ballast and replace the lamp with a variable resistor. The role of the variable resistor is adjusting the working point of the ballast at specified nominal power. The connection between the variable resistor and the ballast is realized with four wires, which has approximately 1.9 m length. The power supply cable is very short so the ballast is near to the socket, which in this GTEM cells type is on the lateral wall. In this case we measure just the disturbance emission through the connection wires between variable resistors and the ballast. The results of the testing shows whether the ballast produced the common mode current and this current flows to the lamp, not just to the power supply cable. The result of the experiment is presented in Figure 5

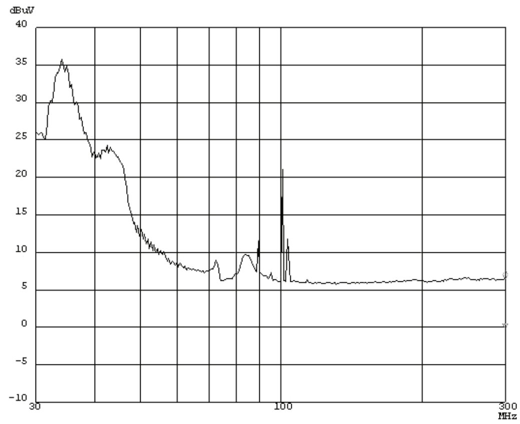
Figure 5. Results of radiated emission test from electronic ballast

2. For the second possibility we use a separate lamp from the ballast. The lamp is connected to ballast with 4 wires (two for anode, and two for cathode). The length of the wires should be approximately 1.9 m. This experiment is based on the ferrites proprieties to have a high dissipation of the high frequency currents (common mode currents in our case). If we put ferrite cores near to the ballast (on the connection wires between lamp and ballast), the emissions are reduced almost totally they practically disappear. When the ferrite cores are near to the lamp, the disturbances remain (Figure 6.) This second test shows whether the ballast produces the common mode current

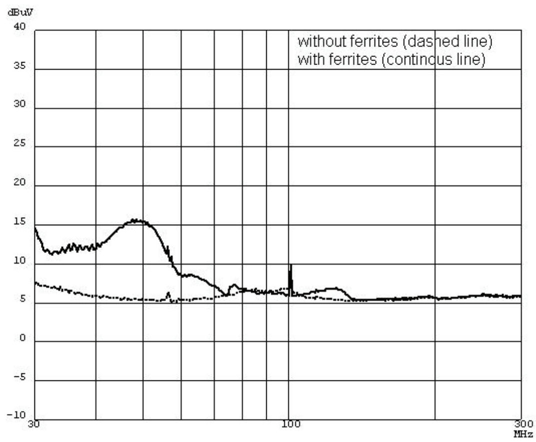

Figure 6. Results of tests with and without ferrites

## IV. RADIATION THROUGH THE POWER SUPPLY CABLE

The frequency band of the radiated disturbance produced by common mode current depends on the length of cable. If we measure the impedance's of power supply cable of a CFL in 1 MHz – 300 MHz bandwidth at a certain frequency we observe that the cable has a series resonance frequency (the cable was introduced in parallel in the measurement circuit). For this measurement it is enough an EMI receiver (it has a generator output and a measurement input). The frequency band of the radiated disturbance depends on the resonance frequency of the power supply cable because in this case the cable radiates at its own resonant frequency. The resonant frequency depends on the lenght of the cable, and on the CFL. The functioning CFL increases or decreases the resonant frequency of the cable. This depends on the length of the cable. For example to a cable of 70 cm length the resonant frequency is decreased. In Figure 7, there are presented some resonant frequencies for different lengths of power supply cables.

*l* = length of power supply cable

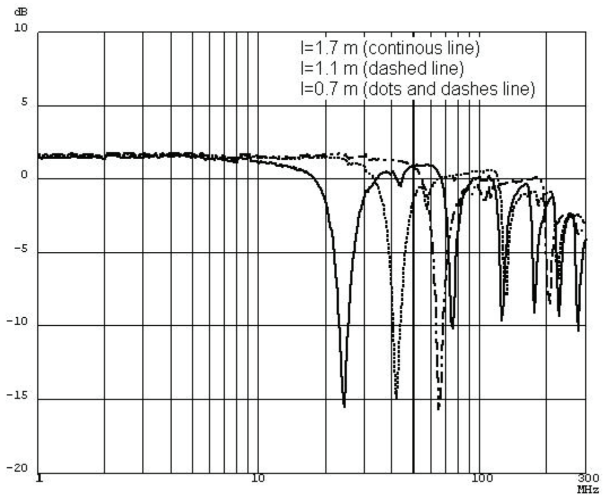


Figure 7. Result of power supply cable resonant frequency

In Fig 8 is presented the results of the test of radiated emissions disturbance using the same cable like in previous test.

The results of the test, shows the connection between the frequency band of radiated emission disturbance of CFL and the resonant frequency of the cable. In the Figure 7 we can see parasitic resonances; in this case they don't have any role. The parasitic resonances become important when the length of the cable is extended. For example at 2.7 m length the disturbances are radiated at the parasitic resonance frequencies as well. The principal source of noise in ballast is represented by half bridge inverter, which produces a wide–band noise.

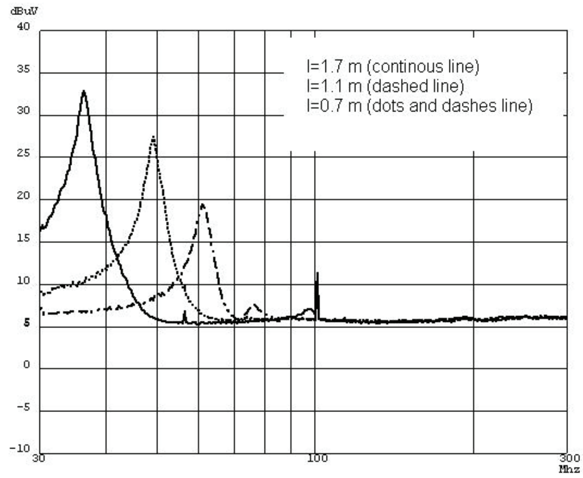


Figure 8. Result of radiated emission test of different length of power supply cable.

## V. CONCLUSION

The result of the tests shows that the frequency of radiated emission disturbances depends on resonant frequency of power supply cable. The resonant frequency of power supply cable depends on the length of power supply cable and on the CFL.

## REFERENCES

[1] Antoniu Mihai, *Măsurări Electronice* vol.1 Ed. Satya, Iaşi, 2001
[2] ETS-Emco GTEM! 5407 Operation Manual, ETS-Emco, Austin, Texas, 1997
[3] P. A. Chatterton and M. A. Houlden, *EMC Electromagnetic Theory to Practical Design*, John Wiley & Sons Ltd, 1992
[4] CISPR/F/399/CDV
[5] Fodor György, *Elektromágneses Terek* Műegyetemi kiadó, Budapest 1993
[6] Simonyi Károly, *Villamoságtan* Akademia kiadó, Budapest 1964
[7] Komarik József, *Nemlineáris áramkörök* Tankönyvkiadó, Budapest 1975
[8] Heinz Zenker, Alexander Gerfer Bernhard Rall, *Trilogy of Inductors*, Würth elektronik
[9] Istvánffy Edvin, Tápvonalak, antennák, hullámterjedés, Tankönyvkiadó, Budapest 1967
[10] A. Vitanza, R. Scollo, A. Hayes , *Electronic Fluorescent Lamp Ballast*, http://eu.st.com/stonline/books/pdf/docs/3706.pdf
[11] Jinghai Zhou, *Electronic Ballast for Fluorescent Lamps*, http://www.cpes.vt.edu/_files/public/courses/modules/ballast.pdf
[12] EN 55022 European standard Information technology equipment- Radio disturbance characteristics- Limits and methods of measurement, September 2006.
[13] EN 55011 European standard Industrial, scientific and medical (ISM) radio-frequency equipment. Radio disturbance characteristics. Limits and methods of measurement, 2007.
[14] EN 61000-4-6 European standard Testing and measurement techniques. Immunity to conducted disturbances, induced by radio-frequency fields, 1996
[15] Loes van Wershoven, *The Effect of Cable Geometry on the Reproducibility of EMC Measurements*, in Proceedings of IEEE International Symposium on EMC, (Seattle: IEEE EMC Society, 1999).
[16] William D. Kimmel and Daryl D. Gerke *Ten Common EMI Problems* Compliance Engineering 2005
[17] Martin Alexander, Using Antennas to Measure the Strength of Electric Fields near Equipment Compliance Engineering 2000
[18] S. B. Worm, *On the relation between radiated and conducted RF emission tests*, 13th International Zurich Symposium on Electromagnetic Compatibility February 1999.