"HENRI COANDA"
AIR FORCE ACADEMY
ROMANIA

"GENERAL M.R. STEFANIK"
ARMED FORCES ACADEMY
SLOVAK REPUBLIC

INTERNATIONAL CONFERENCE of SCIENTIFIC PAPER
AFASES 2013
Brasov, 23-25 May 2013

REAL-LIFE RELIABILITY AND RADIO FREQUENCY IMMUNITY TEST LIMITS

Corneliu URSACHI, Elena HELEREA
Transilvania University of Brasov, 500036, Romania

Abstract: *Any product manufacturer is trying to create more reliable equipments, to reduce warranty costs and to have satisfied customers. It has to be properly assessing the real-life electromagnetic environment in which the equipment will operate and think proper testing procedures. The EMC Directive 2004/108/EC is supporting manufacturers by establishing a set of standard immunity tests, considered minimal, which products must pass. Passing standard immunity tests, no matter how strict and comprehensive, even military or automotive ones, does not guarantee perfect functioning in the real-life electromagnetic environment. It is imperative to always consider immunity standards limits. This article deals with the limits of standard SR EN 61000-4-6 "Immunity to conducted disturbances induced by radio frequency fields", relative to real-life electromagnetic environment.*

Keywords: *radio frequency, disturbances, immunity, reliability, limits*

1. INTRODUCTION

Environment, in terms of electromagnetic compatibility (EMC), is a electromagnetic disturbances environment. Disturbances can be classified by different criteria in: narrow and broadband; low and high frequency; continuous or transient; conducted or radiated; common or differential mode. They may be conducted into or out of apparatus, in differential or common mode, as continuous RF or transients, on either or both of the mains supply and signal ports [1,2,9].

There are two ways to report the disturbance to a reference, common mode when the signal is seen as reported to a common reference (PE-Protective Earth often) and differential mode when the signal is the difference of electric potential between two ports of the equipment.

In Figure1 top, common and differential mode voltage is defined, bottom the voltages waveforms is shown, V_1 and V_2 are sinusoidal voltages.

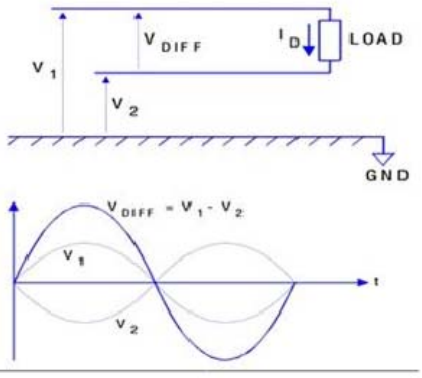

Fig. 1. Common and differential mode voltages definition

For two systems connected by lines L_1 and L_2, with a common reference plane common and differential mode currents are shown in Figure 2.

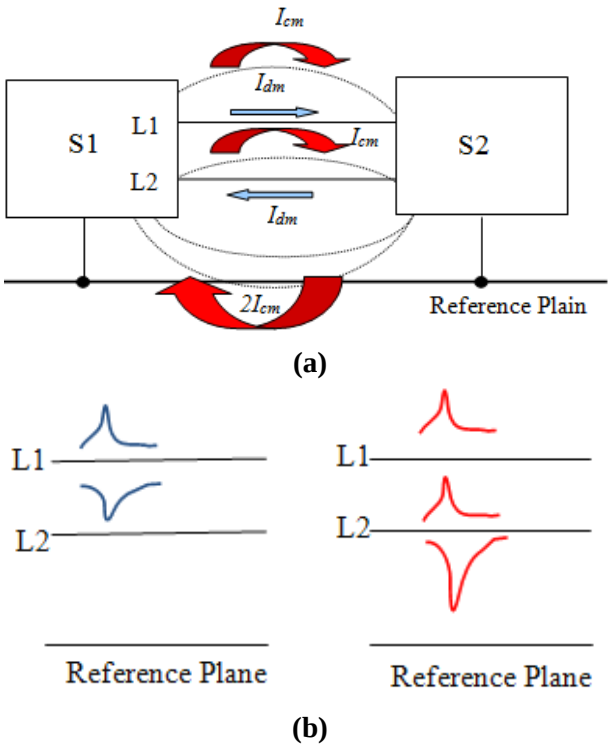

Fig. 2. Comuun and differential mode currents loops (a), Current pulse shape (b)

The standard SR EN 61000-4-6, works with common mode voltages in 150 kHz- 80 MHz frequency range

2. COUPLING PATH AND INTERFERENCE MECHANISM

The presence of mobile phones , Wi-Fi and Bluetooth devices in the vicinity of various electronic equipments, is common place, and it is a fact that cannot be predicted and entirely avoided [8]. Most of electric and electronic equipments fit in a cube with sides of 40 cm. They are small relative to the RF disturbances wavelengths.

Cables connected to ports, with lengths of several meters (mains cables - 1.5 m, communication cables - 2-10 m, interface cables - 1.5 - 5 m) act as more or less effective receiving antenna networks. So, an ordinary mains cable, with length of 1.5 m, becomes a $\lambda/4$ or $\lambda/2$ receiving antenna, for disturbances of 50 MHz, respectively, of 100 MHz, according to equation $f = c/\lambda$.

Cable networks, connected to equipment, as receiving antennas, generate at their ports common mode voltages, as a potential difference between a port and the protective earth.

There are three interference mechanisms [7]:

- Direct interference: RF disturbance frequency is close enough to a electronic circuit digital signal frequency or one of its harmonics.
- Rectification/Demodulation: A semiconductor has a non-linearly, a square law response to low voltages, such as disturbances, so that positive –going part of the disturbance is significantly greater than negative-going part, and a d.c. offset is generated with a level related to disturbance's level. This is the so called Rectification. An amplitude modulated RF disturbance, creates a variable d.c. offset, and results a demodulated signal, Figure 3.

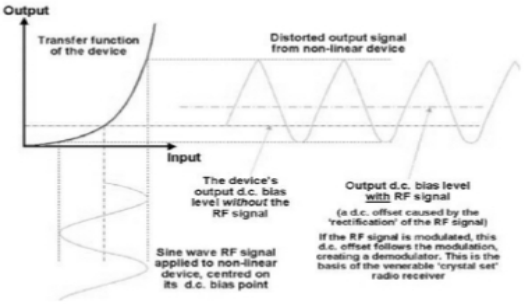

Fig. 3. Disturbance rectification

- Intermodulation: the same time presence of two disturbances, having the frequencies f_1 and f_2, generates f_1-f_2 and f_1+f_2 disturbances, Figure4.

The number of intermmodulation disturbances greats significantly if there are more frequencies implied; e.g.: if three initial frequencies, than eight intermodulation children are born.

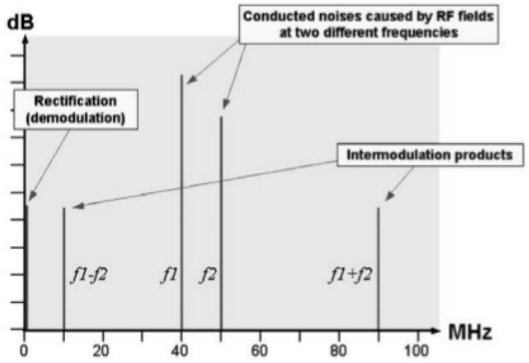

Fig.4. Disturbance intermodulation

3. IMMUNITY TEST LIMITS

The immunity testing method regulated by SR EN 61000-4-6:2009 standard defines electromagnetic environment types, and accordingly, voltage test levels: Level 1- 1V, Level 2- 3V, Level 3- 10V, Level X- Special.

SR EN 61000-4-6:2009, imposes parameters and wave shape for RF disturbances. Frequency range is 150 kHz – 80 MHz. The disturbances are sinusoidal un-modulated signals and amplitude modulated ones, depicted modulating signal has 1 kHz, in the range of an intelligible human conversation (between 1 kHz and 2 kHz). During the test, disturbances are coupled to mains cables by Coupling Decoupling Network (type CDN M3), having common mode impedance of 100 Ω. The CDN, on one hand, injects, by a RC network, common mode disturbances to Equipment Under Test (EUT), and on the other hand, rejects by a high impedance RF disturbances from the mains

Regarding the standard SR EN 61000-4-6 limits, relative to real-life electromagnetic environment they refer to the way disturbances are applied: only to one port, than, in turn, to all the others. In fact, the RF disturbances enter simultaneously on all ports. But taking into account the difficulties and costs of applying by CDNs, disturbances to all ports simultaneously, this is the regulated procedure.

Another limit refers to 150 kHz-80 MHz frequency range. There are many types of equipment, such as switch-mode converters working below 150 kHz, many transmitted signals are modulated by frequencies below 150 kHz. Meanwhile, GHz order disturbances may generate intermodulation products below 150 kHz.

Disturbance signal modulation, only at 1 kHz, as regulated by standard, is an unrealistic approach of real-life electromagnetic environment, characterized by the simultaneous existence of multiple modulation frequencies, none of 1 kHz. May be used a modulating frequency range, according to the electromagnetic environment the equipment will work.

The standard SR EN 61000-4-6, uses only common mode disturbances, so the case of differential mode disturbances, generated by switch-mode power converters, working below 10 MHz is inaccessible.[7]

3. CASE STUDY

The frequency at which a equipment has high susceptibility, correlated with the real-life electromagnetic environment in which it will work, is of prime importance for its reliability. A PC switching-mode power supply, a ubiquitous subassembly, a essential part of a computer is very suitable to be tested in terms of susceptibility to radio frequency disturbances.

The general view of test set-up is shown in Figure 5 and the mounting diagram according SR-EN 61000-6-4 is shown in Figure 6.

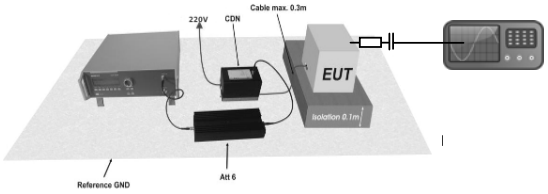

Fig.5. General view of test setup

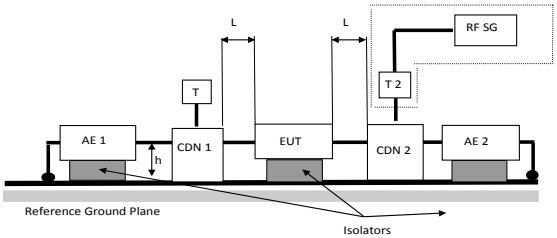

Fig.6. Mounting diagram, according SR-EN 61000-6-4 (0.1m<L<0.3m; 30mm<h<50mm)

The results of the test with un-modulated sinusoidal disturbance, Level 1 of 1 V, in 150 kHz-80 MHz range, injected into the mains cables of the EUT (the switching power supply), by the generator, through a 6 dB attenuator, and then by a CDN-M3 [15], are shown in Figure7.

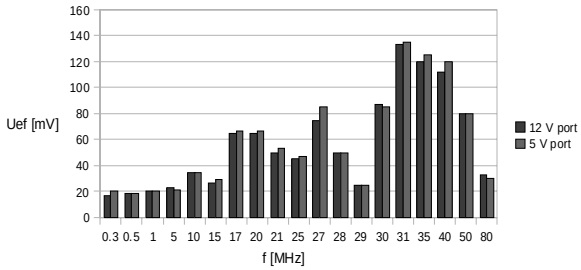

Fig.7. Switching-mode power supply frequency response

It can be underlined that the Power Supply has high susceptibility in 30 – 40 MHz range, but output disturbances do not exceed 3 % of the output voltage, less than 150 mV, at the 5 V output.

5. CONCLUSIONS

Passing standard immunity tests, even military or automotive ones, does not guarantee perfect functioning, we have to consider their limits. This article highlights the limits of the standard SR EN 61000-4-6, relative to real-life electromagnetic environment. It's regulations, regarding the way electromagnetic disturbances apply to equipment's ports, disturbance's mode (common mode), frequency range, the frequency of the modulating signal (1 kHz), are giving standard's limits too. The standard is only partially suitable for a more nuanced reality.

The EMC expert has to properly assess the real-life electromagnetic environment in which the equipment will operate, to find and remove susceptibilities, to achieve safety and reliable products.

REFERENCES

1. Schwab, A., *Electromagnetic Compatibility (Compatibilitate electromagnetică)*, Bucureşti , Editura Tehnica, pp. 51-77, (1996).
2. Adăscăliței, A., Ball, R., Cretu, M., David, V., Lever, P., Montanari, I., et all *Electromagnetic compatibility testing and measurement. Practical manual*, The University of Warwick, pp. 257-264, (2002).
3. Electromagnetics, CRC Press LLC, 2001
4. SR EN 61000-4-6, *Immunity to conducted disturbances induced by radio frequency fields*.
5. Schmitt, R., *Understanding Electromagnetic Fields and Antenna Radiation Need No Math*' (March, 2000), www.ednmag.com.
6. Ott, W. *Understanding and controlling common mode emission in high power electronics,* Henry Ott Consultants, Livingstone, (2001).
7. Armstrong, K. *Testing and measurements techniques-Immunity to conducted disturbances induced by radio frequency fields, A practical guide for EN-61000-4-6*, REO UK LTD, [Online], Available: http://www.reo.co.uk/files/handbook_en61000-4-6_v2.pdf
8. *Manual for operation- Continuous Wave Simulator type CWS 500N1*, EM Test (October, 2010).
9. Seymour J., Horsley T**.,** *The Seven Types of Power Problems,* APC White Paper #18;
10. David, V., Cretu, M., *Masurarea intensitatii campului electromagnetic : teorie si aplicatii.* Iasi. Casa de Editura Venus, (2006).