Technical Aspects Regarding Electromagnetic Compatibility Compliance of the Electric and Electronic Integrated Systems

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***Abstract* - The modern world's needs of electric and electronic devices and systems lead to a continuously electromagnetic interferences growing in ways that were hard to predict few decades ago, a serious reason to consider the electromagnetic compatibility (EMC) regulations a top priority for the developers and the end-users as well. An important segment of these products is represented by integrated systems, and not only the large scale ones, as a natural consequence of the increased equipments interoperability and versatility. The integrated systems developers are facing many issues regarding EMC products compliance, although the individual components of their systems are fully or partially compliant with the EMC standards and regulations. Practical solution to identify and solve these problems consists in preliminary pre-compliance tests deployed in specialized EMC laboratories. Unlike the classic EMC tests, the specialized pre-compliance probes enable the developers to improve their products, according to the provided feedback, and to minimize their efforts to reach that goal. Our specialized EMC laboratory has been involved in many testing and evaluation projects for different types of electric and electronic systems compliance characterization. The authors participated in experimentation activities as well as software simulation sfor EMI protection solutions design and realization. The accumlated experience allow us to investigate the associated phenomena related to EMC problems and to find solutions for these inconveniences**

Keywords: *EMC, compliance, Electromagnetic compatibility, EMI, shielding*

I. INTRODUCTION

The electric and electronic systems developers meet many challenges regarding their final products EMC compliance. Most of the EMI/EMC issues are a natural consequence of their functionality, caused by electric currents and voltage drops specific to all modern electric system [1]. Even, most of these problems are solved during the initial development phase, starting with the lowest design levels, there are many cases when a system integrator has very low control of these effects, and tries to get more information for a specialized EMC laboratory [10] in order to identify and to implement adequate measures. Our paper presents a general guidance for this process, taking into account the accumulated experience in this field by participating in national research programs.

II. THEORETICAL BACKGROUND

The main idea behind all EMI/EMC protection solutions is based on electromagnetic field attenuation and currents filtering [5], [9] solutions implementation in order to provide a proper environment for equipments correct functionality.

These solutions can be evaluated by specific tehcnical parameters which are directly dependent on materials type and geometry, constructive solutions and medium properties.

The shielding effectiveness, noted *SE*, is one of the most important parameter [1], [6], [7], [8] for the characterization of an electromagnetic screen and is defined as the report between the field's intensity (electric or magnetic) measured without screen Es and with screen E_0.

$$SE = 20 \cdot \log_{10}\left(\frac{E_s}{E_0}\right) \quad [dB] \tag{1}$$

or

$$SE = 10 \cdot \log_{10}\left(\frac{P_i}{P_t}\right) \tag{2}$$

A screen action on the electric or magnetic field through the following mechanisms:

- absorption (characterized by the factor of attenuation through absorption *A*),
- reflection (characterized through the factor of attenuation through reflection R),
- multiple scintillations (with significant effects in the thin screen's case) (characterized through the factor of attenuation through scintillations Rr).

Expressing the attenuations *A*, *R* and R_r in dB, it's obtained, through their summarization, the (total) efficacy *SE* of the screen.

$$SE = A + R + R_r \tag{3}$$

where:

R - through the factor of attenuation through reflection at the frontier surfaces,

A - the factor of attenuation through absorption within the screen (the transformation of the electromagnetic energy in heat through the losses due to currents circulation through the screen),

Rr - the factor of attenuation that considers the multiple scintillations in the inside of the screen.

The efficacy of the screening depending on:

– the perturbation source's frequency
– the material of the screen (generally: copper, iron, aluminium, silver)
– the field's type that must be attenuated (electric, magnetic, TEM)
– the screen's geometry (parallelepipedal, cylindrical, spherical, etc.) and thickness
– the incidence angle of the field, etc.

Each of the previously enlisted mechanisms actions in specific modes, that can be appreciated objectively through characteristic values.

The absorption is characterized through the attenuation constant, α_a, specific for every material.

A material with a attenuation constant α_a, of high value, has higher values for permeability and conductivity and implicitly has the attenuation factor *A*, high. It must be remarked that the attenuation of the material increases once with the increase of the work frequency.

III. MULTIPLE-STEP APPROACH

In some situations the end-users are able to conduct their own research activities in order to solve their EMC compliance problems, taking advantage of the existing specialized infrastructure and personnel or the financial support to conduct these activities "outside". This approach offers the advantage of getting more knowledge in this field, having more economic and efficient solutions for similar cases with the risk of an initial major investment which may not be economically feasible for their long term projects.

In this sense, we conducted a case study for informatics equipment trying to reduce its electromagnetic radiated emissions using simple solutions.

We choose a standard desktop computer as EUT (Equipment Under Test) including a central unit, mouse, keyboard and LCD display. We tested it according with MIL-STD 461F EMC standard, RE-102 probe [2]. The configuration setup is presented in figure 1. In figure 2 there are presented the radiated emissions of the EUT in the 30 MHz – 1 GHz frequency band.

We tried to decrease the EUT emissions by usage of special ferrite across the external cables. The expected results were not very surprising, but it still proved that we can reduce some EM noise; even the solution is more used as an EMF protection than a reduction technique.

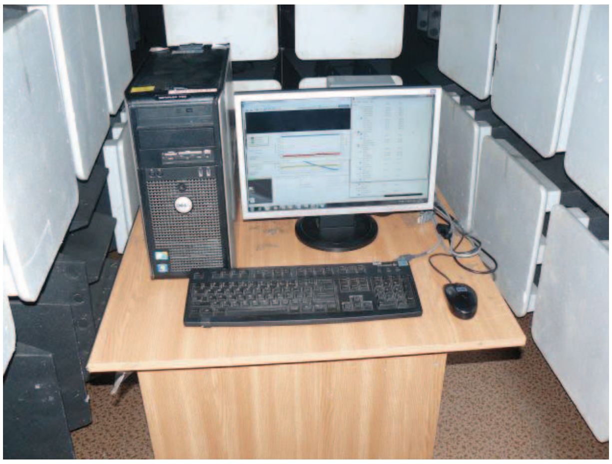

Fig.1 RE-102 probe configuration setup

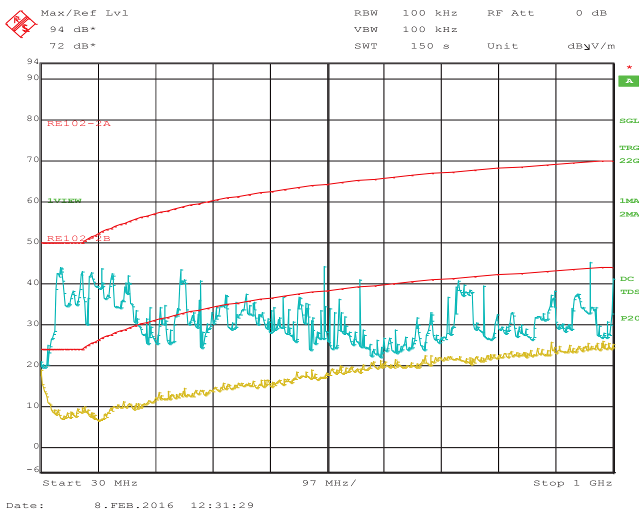

Fig.2 Initial EUT RE-102 test results

Fig.3 Ferrite installed on USB cable

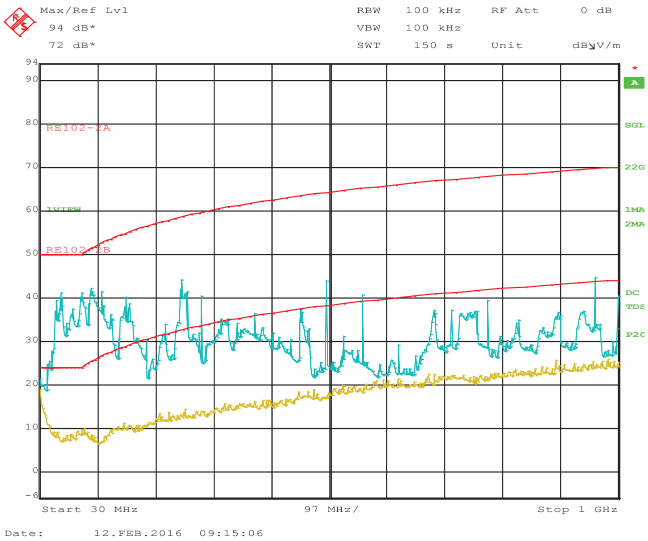

Fig.4 EUT RE after ferrites installing

In figures 5 and 6 there are presented the results obtained in third phase of our study. We shielded the interconnection cables using special metallic shielding tube. There are good results, but we still faced some EMF spikes over the limit.

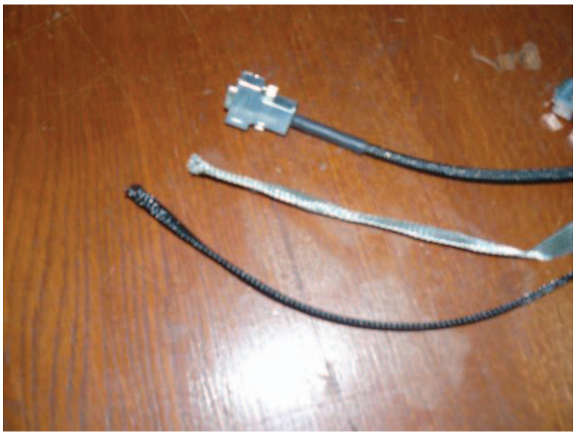

Fig.5 VGA shielded cable

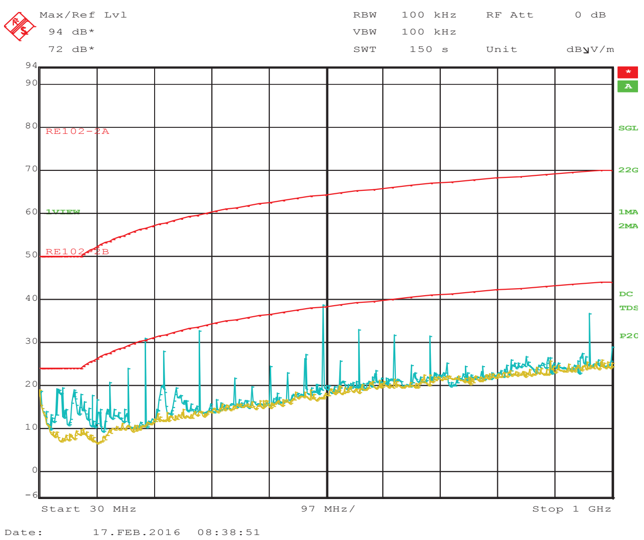

Fig.6 EUT with shielded cables RE test results

The final step consisted in usage of a special electromagnetic shielding system for EUT, which was developed in a previous research project. The EUT has been installed in this special system and tested according RE-102. The special electromagnetic shielding system for EUT (SPE) is presented in figure 7.

The SPE design was created in accordance with informatics systems specific requirements for electromagnetic emissions reduction [4], [6] and product functionality assurance. In order to establish these requirements we conducted several EMI measurements for a representative set of informatics systems (classical architecture including central unit, display unit and standard peripherals). In figure 7 there is presented the central unit SPE component including attenuation system (shielded enclosure, shielded cables, EMI gaskets) and filtering equipments (power line filters, honeycomb vents).

Fig.7 Special EM Protection System

In figure 8 there is presented the comparison between initial EUT and the special protection system EM emissions.

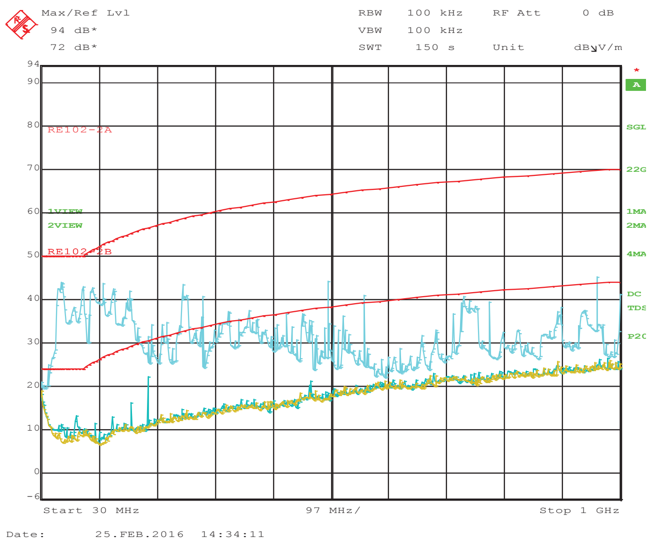

Fig.8 Initial EUT emissions vs SPE results

IV. PRE-COMPLIANCE EMC TESTS

A modern specialized EMC testing and evaluation infrastructure must include measurement equipment and platforms that allow more data to be collected and to be analyzed in order to offer an "answer" for system developer. The advantage of this approach is the fact that the end-user can "find" in a more efficient and more economic way a solution to the EMC/EMI problems without investing time and personnel for it.

The main purpose of the EMC pre-compliance testing is to find and to investigate the EMI sources that cause product incompliance. In order to achieve that, the first step consists in a general EUT standard evaluation followed by a data analysis and interpretation. The intermediary tests will focus on physical regions testing by using special antenna arrays or near field probes set. If there is a technical specification available, the provided feedback will be more consistent, testing engineers being able to indicate the accurate source of the problem and possible ways to counterattack the undesired effects [3].

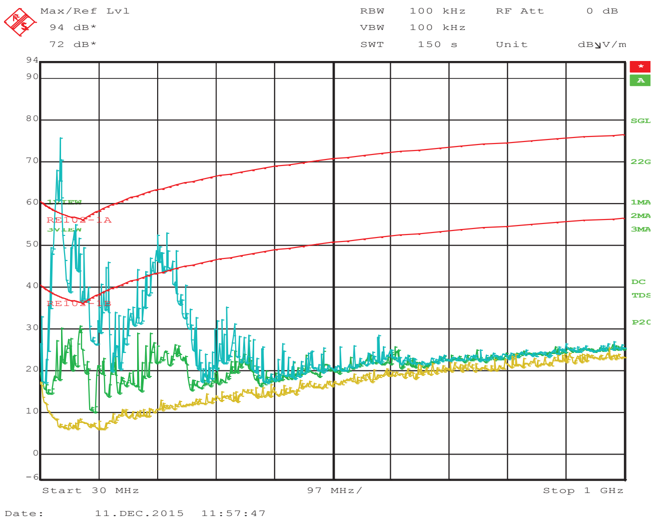

Fig. 9 Preliminary EUT evaluation (2 operational modes)

In the figure 9 there are presented the standard EUT first evaluation results, carried out in our specialized laboratory for an integrated command and control system, which consisted of a standard console (keyboard and joystick), display device, multisensory data interface device and an engine control device. There were two operational modes tested (idle, maximum functionality) and at a first glance the product was far of being compliant with the EMC regulations specific to its working destination.

Using a near field probes set we conducted several measurements in the "hot" frequency band areas and we collected enough data for EMI source identification. We also made some suggestions for product EMI improvement, like cables shielding, connectors replacement, display protection, EMI gaskets usage and others. After all, the provided feedback was useful and helpful for the developer because of the results obtained after several EMI shielding/filtering implementations, as it is shown in figure 10.

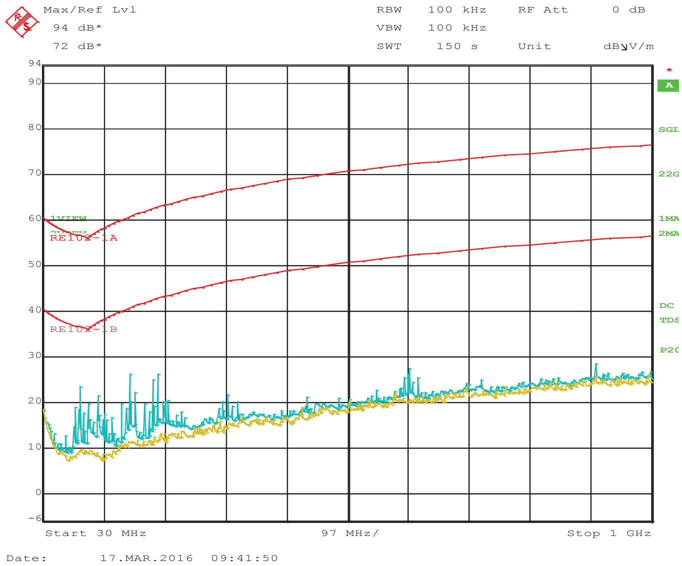

Fig. 10 Final EUT evaluation

V. CONCLUSIONS

The information technologies market is in a continuous evolution and change and there are many economical agents involved in many complex projects design and development. The EMC compliance problems must be threaten seriously, considering the risks involved regarding products safety and reliability, as well as human health and security. Our presented cases show some possible approaches that can be taking into account by a system integrator/developer in a EMI/EMC improvement process.

Both presented solutions conducted the end-user to its goal but a preliminary analysis should be carried out before access one of them, considering the advantages and disadvantages related to economical, technical and quality aspects.

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