Application of a near field method to reducing conducted emissions

Application of a Near Field Method to Reducing Conducted Emissions

Andrei – Marius Silaghi
Dept. of Measurements and Optical Electronics
University Politehnica Timisoara
Timisoara, Romania
andrei.silaghi@student.upt.ro

Aldo De Sabata
Dept. of Measurements and Optical Electronics
University Politehnica Timisoara
Timisoara, Romania
aldo.de-sabata@upt.ro

Ladislau Matekovits
Dept. of Electronics and Telecommunications
Politecnico di Torino
Torino, Italy
ladislau.matekovits@polito.it

***Abstract*— In order for an electronic device to be compliant with international standards and to be validated for mass production, it has to pass a series of Electromagnetic Compatibility (EMC) tests, one of which being the assessment of conducted emissions (CE). This work is intended to assist the engineers working in the EMC automotive area in the mitigation of CE levels in order to reduce the number of tests necessary in semi-anechoic chambers. We present results obtained in a shielded enclosure (standardized conducted emissions test) in comparison with a near-field scanning technique. The results prove consistency. The novelty of this approach stems from the correlation between near-field data and conducted emissions.**

Keywords—conducted emissions, near-field, EMSCAN.

I. Introduction

Electrical and electronic devices are susceptible of creating emissions that can interfere with the external environment. There are two main types of electrical emissions: radiated emissions and conducted emissions [1].

Radiated emissions (RE) consist of electromagnetic energy created by a device and released as electromagnetic fields that propagate through air, away from the device whilst conducted emissions (CE) represent electromagnetic energy created by a device and transmitted in the form of an electrical current through its power cord, data or control cables [1]. This can potentially cause problems since, e.g., power cords are connected to the entire power distribution network [1].

When CE limits imposed by standards are violated (or only suspicioned to be), the hardware project team makes several pre-compliance tests, thus making a number of bookings in shielded chambers. A faster and cheaper solution could be to locate and solve the problem by using near-field scanning, thus getting more insight about the PCB layout involved [2], [3].

This paper reports an assessment of a part of the existing equipment used for CE and near-field testing in Continental Automotive Timisoara. It is shown how a near-field scanning technique can contribute to reducing the level of CE testing by tracing the position of the source of perturbation. In the end, it is reported how results have been confirmed with the standardized measurement in a shielded enclosure [3].

The authors have been interested in the past with the problem of reducing emission levels [3] – [5]. They first started with the subject of CE reduction by making tests only in a shielded room according to the conventional method [4]. The solution with shielded coils provided the best results [4].

Afterwards, methods for reducing radiated emissions levels were outlined and explained [3], [5]. These methods were tested in far-field (standardized antenna test) in comparison with a near-field scanning technique (EMSCAN) [3], [4].

While near-field measurements are generally used for gathering information on far-field radiation in view of RE EMC assessment, we show in this paper that near-field scanned data can also be used for identifying sources of conducted emissions on PCBs. Such information is useful for design teams for optimizing PCB layouts in view of CE EMI mitigation.

The rest of the paper is organized as follows. In Section II the general standard for emission measuring (CISPR25) is briefly reviewed along with a near-field scanning equipment. Section III presents results obtained in different scenarios: normal CE tests versus near-field tests. Application of near-field results to CE EMI mitigation is also illustrated. Conclusions are drawn in last Section.

II. Conducted Emissions and Near-Field

A. Conducted Emissions

According to CISPR 25 Standard, conventional conducted emissions measurements are performed in the frequency range 9 KHz – 1 GHz [4], [6]. Standardized CE tests are performed in a shielded room, within the EMC Laboratory that belongs to Continental Automotive Romania. There are two main methods for measuring the CE of a device under test (DUT), namely the (i) Line Impedance Stabilization Network (LISN) and the (ii) current probe method [4], [6]. A basic CE - LISN test setup is presented in Fig.1.

The main equipment involved in CE testing with LISN consists of: LISN (which captures the perturbations emitted by the DUT), test receiver (which is used to measure the signal output by the LISN), and RF cables [4], [6]. For the second method, a current probe is mounted around the complete harness (including all wires, thus measuring common mode currents). According to the Standard prescriptions, the probe must be positioned at two distances: 50 mm and 750 mm from the DUT [4], [6].

Test receivers can be controlled by means of dedicated software and interface to a computer. The receiver extracts the needed information by frequency conversion to intermediate frequency and detection in standardized detection modes (peak, average and quasi-peak) [4]. The EMI (Electromagnetic Interference) receiver has well defined bandwidths of the intermediate frequency filter, also called resolution (200 Hz, 9 kHz, 120 kHz and 1 MHz) [4].

A LISN is a low-pass filter that provides the necessary supply voltage and current for the Equipment under Test (EUT) and filters out perturbations introduced by the power line. The LISN directs the CE of the EUT to the EMI receiver on 50 Ω output impedances and it is used to assess conducted emissions [4], [6].

In Fig. 2 an example of a test setup used for CE measurement is presented. The DUT and the test harness were placed on a non-conductive material (polystyrene), to simulate real life test conditions.

According to the Standard requirement, the DUT was placed at a minimum distance of 100 mm from the edge of the ground plane and the power supply lines between the connector of the LISN and the connector of the DUT had a standard length of 200 mm.

Care was taken so that the length of the harness (between the DUT and the load simulator) not to exceed the prescribed maximum distance of 2000 mm.

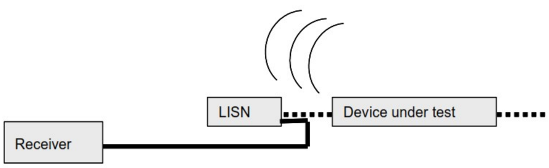

Fig. 1. List of equipment used for LISN measurement [4]

Fig. 2 Conducted emissions setup in shielded room

B. *Near-field*

For gathering near field data in the vicinity of a PCB, an equipment such as EHX system from EMSCAN can be used. The system provides near-field magnetic data to help diagnose EMC design issues and it operates from 150 kHz to 4 GHz [5], [7]. Several data acquisition modes are available, such as spectral, spatial, spectral/spatial and handheld probe scanning [3], [5], [7].

The near-field scanning system consists of the EHX scanner, which is controlled by a PC by means of EMexpert adapter, with USB connection. The PC also controls a spectrum analyzer, connected by a LAN cable, which displays RF data acquired by the EHX scanner. The measurement is triggered by a signal generated by the EM expert adapter (Fig. 3) [3], [5], [7].

Similar near-field scanning techniques have been considered in several papers [8]-[10], addressing both the issue of devising scanning systems and performing precompliance measurements. For example, a near-field sensing and measuring system with the possibility of 3D positioning of the scanning probe has been developed [8]. A near-field measurement around PCB's in view of source identification and layout optimization has been proposed [9]. The devised equipment was fit for EMI characterization and layout optimization on PCBs when combined with prediction techniques for the radiated electromagnetic field based on Hertzian dipoles [10].

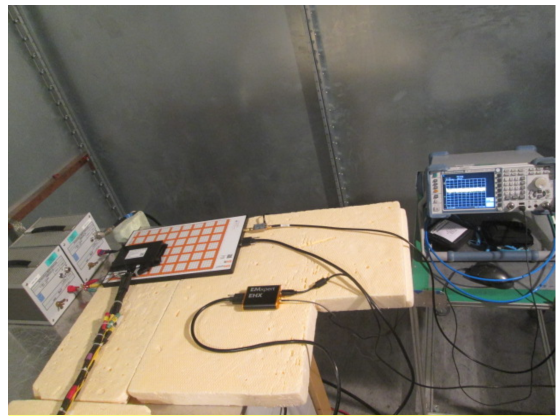

Fig. 3 EMSCAN setup in shielded room

III. MEASUREMENT RESULTS

For the measurement of CE with LISN method in a shielded room we used an ESR 7 EMI Test Receiver from Rohde&Schwarz with the frequency range: 9 kHz – 7 GHz, and two V-LISN 5uH from Schwarzbeck. The receiver's parameters were set to 9 kHz bandwidth between 84-87 MHz (1 s dwell time) and average detector [4].

The DUT was an electronic unit that was designed to control the gasoline injection and other secondary functions of a vehicle. The gasoline injection system (the ECU, its sensors and actuators) requires its own power supply wiring, isolated from the battery by a main relay.

Fig. 4 Initial conducted emissions test

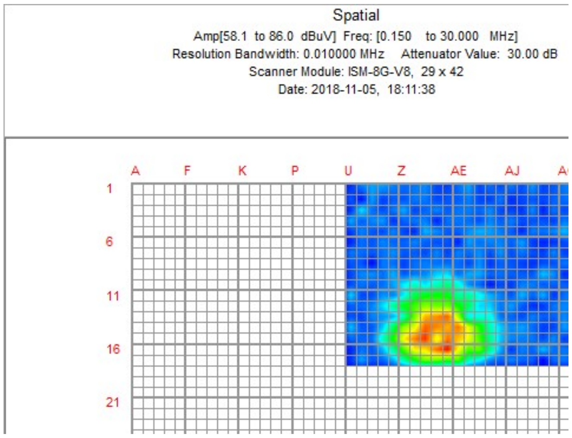

Fig. 5 Spatial scanning between 0.15 – 30 MHz

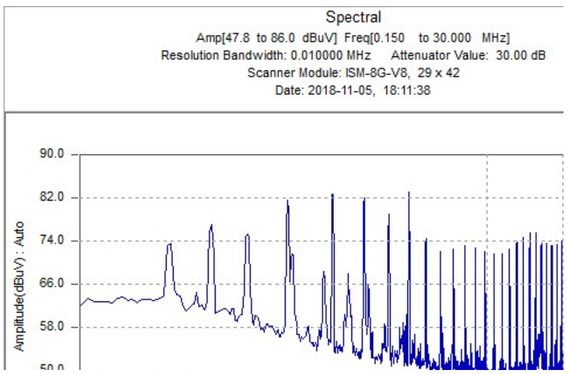

Fig. 6 Spectral scanning between 0.15 – 30 MHz

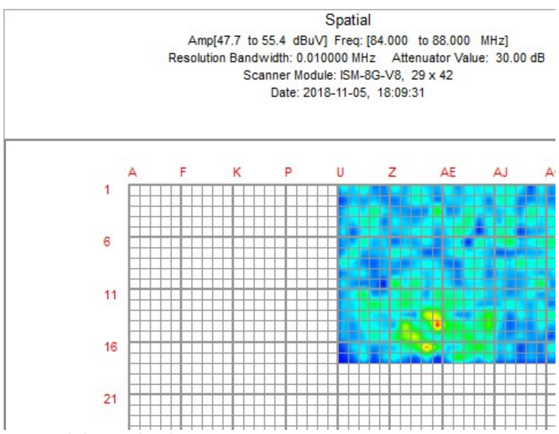

Fig. 7 Spatial scanning between 84 – 88 MHz

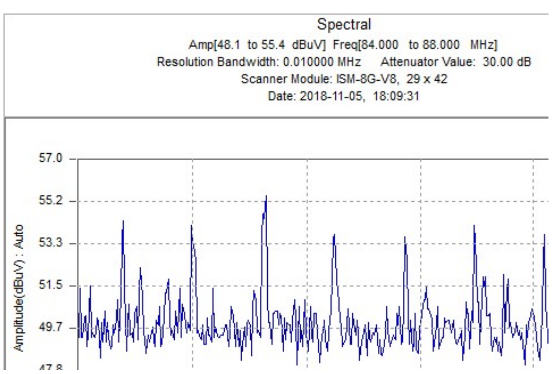

Fig. 8 Spectral scanning between 84 – 88 MHz

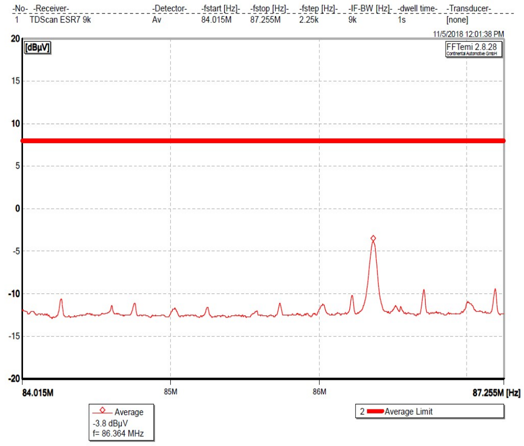

Fig. 9 Final conducted emissions test

The first result with the standardized equipment for CE can be seen in Fig. 4 (between 84 – 87.25 MHz). A lot of spikes can be noticed at the average detector output, which can violate limits requested by other customers.

So, at the request of the project team, by using the setup from Fig. 3, the same project was tested in near-field [5], [11]. Firstly, we made near-field scans between 0.15 - 30 MHz. This is the operation range of the DC-DC converter from the supply part of the DUT.

A spatial scan is reported in Fig. 5, which highlights the place where the converter was positioned on the PCB layout.

In Fig. 6, results of a spectral scanning are shown. The scan performed again in 0.15 – 30 MHz frequency range, revealed the influence of the converter in the spectral domain.

In Fig. 7, spatial results between 84 – 88 MHz are presented and spectral results in the same frequency range are reported in Fig. 8 (with peaks corresponding to those in Fig. 4). Thus, we obtained a good correlation between CE results and near-field data.

In order to reduce these resonant spikes, a spread spectrum technique (SS) could be applied, by widening the bandwidth of the signal to an extent larger than necessary for the information it carries [5, 12]. This technique has been applied previously for mitigation of RE [5] and CE [12] in the Automotive EMC environment.

In the present case, the project team applied a 2% SS. Furthermore, by knowing the location of large near-field values (Fig. 5 and Fig. 7) a PCB layout optimization has been performed which included: ground system splitting into separate ground nets and also routing all high speed signals completely above the area with the ground they were referred to.

After the near-field investigations and implementation of the proposed solutions, a last standardized test in the shielded room was performed. The final result with the standardized equipment for CE can be seen in Fig. 9. A significant reduction of peaks has been obtained.

IV. Conclusions

In this paper we reported the use of a near-field scan technique for troubleshooting CE EMI problems. The EMSCAN tool has been used for near-field measurements.

In a first stage of a CE test for DUT's in Automotive industry, the device is tested by the conventional method in the shielded room, with LISN, in order for the customer to have an idea of the problems they will encounter in the subsequent formal testing, called qualification.

In the Automotive industry, CE tests are performed according to the procedures, frequency range and equipment specified in the International Standard CISPR 25.

We presented a case study. We started with a CE PCB measurement in a shielded room, which emitted many spikes. If the complexity of the PCB does not allow the project team to find the source of the emissions, measurements in near-field of the PCB allows to gain insight into the problem. In the considered case, both spectral scanning and spatial scanning where used to gather information and to guide the quest for a solution.

Following this idea, by using a near-field method with spectral scans, we obtained a solution to reduce CE levels. The final test, which confirmed the solution, was performed in the shielded room and lead to a pass result, after we implemented the proposed solution. So, the DUT could be certified for mass production.

Acknowledgment

The authors wish to acknowledge the support given by Continental Automotive Timisoara (Qualification Laboratory).

This work was partially supported by a grant of the Romanian Ministry of Research and Innovation, CCDI-UEFISCDI, project number PN-III-P1-1.2-PCCDI-2017-0917/ contract number 21PCCDI.2018, within PNCDI III.

References

[1] https://sciencing.com/difference-between-conducted-radiated-emissions-14351.html

[2] P.M. Nicolae, I.D. Nicolae, and R.A. Aipu, "Some Considerations Concerning Radiated Emissions Produced by a Board Display," in *Annals of University of Craiova*, Electrical Engineerieng Series, no. 40, 2016, pp. 60-65

[3] A. Silaghi, R. Aipu, A. De Sabata, P.M. Nicolae, "Near-field scanning technique for reducing radiated emissions in automotive EMC," 2018 IEEE International Symposium on Electromagnetic Compatibility and 2018 IEEE Asia-Pacific Symposium on Electromagnetic Compatibility (EMC/APEMC), 14-18 May 2018, Singapore (Singapore), pp.831-836, 2018.

[4] A. Silaghi, A. Buta, S. Baderca, A. De Sabata, "Methods for reducing Conducted Emissions levels," IMEKO 2017, 14-15 Sept 2017, Iasi (Romania), pp.325-355, 2017.

[5] A. Silaghi, A. Motateanu, R. Aipu, A. De Sabata, "Far field versus Near field measurement in Automotive EMC," SIITME 2018, Iasi (Romania), pp. , 2018.

[6] International Standard CISPR 25, "Vehicles, boats and internal combustion engines - Radio disturbance characteristics," 3.0 ed. 2008.

[7] EMxpert EHX User manual v5.0.6.1-10.15.

[8] D. Baudry, F. Bicrel, L. Bouchelouk, A. Louis, B. Mazari, P. Eudeline, "Near-field techniques for detecting EMI sources," 2004 International Symposium on Electromagnetic Compatibility, 9-13 August 2004, Silicon Valley (USA), pp. 11-13.

[9] D. Rinas, S. Niedzwiedz, J. Jia, S. Frei, "Optimization methods for equivalent source identification and electromagnetic model creation based on near-field measurements," EMC Europe 2011 York, 26-30 September 2011, York (UK), pp. 298-303, 2011.

[10] B. Archambeault, "Predicting EMI emission levels using EMSCAN," Symposium Record., 1993 IEEE International Symposium on Electromagnetic Compatibility, 9-13 August 1993, Dallas (USA), pp. 48-50, 1993.

[11] K. Wyatt, 2017 EMC Pre-compliance test guide, Interference technology: www.interferencetechnology.com.

[12] F. Galtie, C. Marot, "Spread Spectrum Clocking applied to Charge Pump for Conducted Emissions improvement in Automotive," 2008 Asia-Pacific Symposium on Electromagnetic Compatibility & 19th International Zurich Symposium on Electromagnetic Compatibility, 19–22 May 2008, Singapore (Singapore), pp. 267-270, 2008.