Methods for reducing Conducted Emissions levels

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Abstract – The conducted emissions (CE) measurement is one of the tests that cover electromagnetic compatibility testing. CISPR 25 standard specifies the frequency range and the equipment used for this test.The purpose of the paper is topresent and comment some case studies and investigate different methods that can be used for reducing CE levels.

Keywords – conducted emissions, LISN, current probe

I. INTRODUCTION

The term conducted emissions refers to the mechanism that enables electromagnetic energy to be created in an electronic device and coupled to its AC power cord. Similarly to radiated emissions, the allowable conducted emissions from electronic devices are controlled by regulatory agencies [1].

This paper reports an assessment of the equipment from Continental Timisoara, used for conducted emissions testing. It presents different methods that can be used for reducing CE levels.

Conducted emissions is one of the tests that are currently conducted within the EMC Laboratory. Other emission tests include: conducted emissions with current probe, emissions with stripline and radiated emissions.

Several authors tackle the problem of reducing conducted emissions levels: [2-5].

In 1995 K.P. Slattery presented a study regarding the repeatability of conducted emissions [2]. He emphasizes the importance of correlation between measurement levels at different product stages (development, design validation, product validation). The author also describes a series of measurements performed in order to better understand the limits of repeatability of measurements [2].

Studies that regard the influence of the test harness on conducted emissions have been made [3]. Since the cable harness is the main radiating element of a test setup, it can cause problems of repeatability in conducted emissions testing [3].

In 2009, H. Rebholz presented a paper regarding the same aspect: the influence that automotive harness has on conducted emissions testing [4]. He describes how the harness influences the filter attenuation and how to consider the effect during the development process [4].

Another method for reducing conducted emissions levels, has been described in [5]. The authors present a spread spectrum cloaking method in order to reduce these levels. They conclude that the "spreading window" increases with the frequency of the harmonics, so that the energy spread is much more effective at higher frequencies [5].

In this paper, some case studies are presents and commented that can be used for reducing CE levels. In Section II the general standard for emission measuring (CISPR25) is briefly reviewed. In Section III we present different setups used for CE measurement. Section IV presents results obtained in different situations. Conclusions are drawn in last Section.

II. TEST PROCEDURE (CISPR 25)

Conducted emissions tests are performed in a shielded room, inside the EMC Laboratory that belongs to Continental Automotive Romania. There are two main methods for measuring the conducted emissions of a DUT: LISN and current probe method.

A simplified LISN emission test setup is reported in Fig.1. The main equipment used for measurement consists of: receiver (which is used to measure the signal coming from LISN), LISN (which captures the perturbations emitted by the DUT), and RF cables.

Radio receivers acquire signal and information coming from an antenna. The receiver will extract the information it needs by converting electromagnetic waves into alternating currents.

The EMI receiver has well defined bandwidths (200Hz, 9kHz, 120kHz and 1 MHz) and standardized detector modes (peak, average and quasi-peak) [6-8].

A LISN (Line Impedance Stabilization Network) is a low-pass filter which supplies the necessary voltage and current for the Equipment under Test (EUT) and filters out perturbations introduced by the power line.

It is placed between the power source and the EUT, and also can be used to assess conducted emissions [6- 9].

According to CISPR 25 Standard, conducted

emissions measurement are performed in the frequency range 9 KHz- 1GHz. These voltage measurements are able to characterize the emissions on single leads only, and cannot characterize the radiated emissions from the PCB [6].

The conducted emissions on power supply lines are measured successively on positive power supply and power return by connecting the measuring instrument on the measuring port of the related artificial network [6].
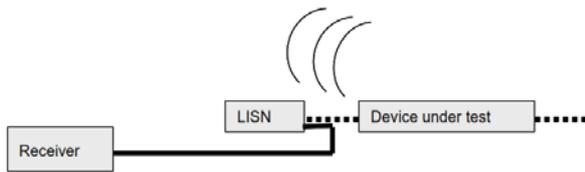

Fig. 1. List of equipment used for LISN measurement

A second method for measuring conducted emissions is presented in Fig.2.

The current probe shall be mounted around the complete harness (including all wires). The probe will be positioned at two distances: 50 mm and 750 mm from the DUT [6]. n most cases, the position of maximum emissions will be as close to the DUT connector as possible.
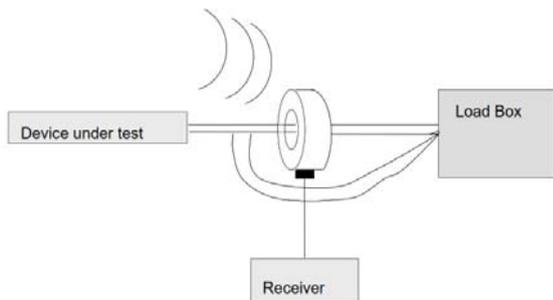

Fig. 2. List of equipment used for current probe measurement

In a Shielded Room we can also use the stripline method for measuring radiated emissions. As we can see in Fig.3. one end of the stripline is connected to the measuring receiver and one end to a 50 ohm termination.

The DUT must be located on the same side as the 50 ohm load of the stripline, and the harness must be placed under the septum of the stripline [6].
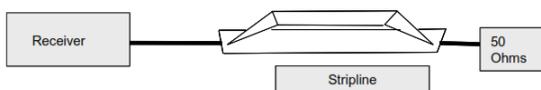

Fig. 3. List of equipment used for stripline measurement.

III.   DESCRIPTION OF THE METHOD

We performed conducted emissions with LISN tests in a shielded room (SE).

This chamber can also be used for the following tests: Bulk Current Injection, Radiated-Immunity Stripline and Conducted emissions (Current probe).

Fig. 4. Conducted emissions test setup

In Fig.4, the test setup used for measurement of the disturbances transmitted through conduction is presented. The DUT and the test harness were placed on a conductive material (polystyrene).

The DUT was located at a minimum distance of 100mm from the edge of the ground plane. The power supply lines between the connector of the LISN and the connector of the DUT have a standard length of 200mm (see Fig.5).

The total length of the harness (between the DUT and the load simulator) did not exceed 2000mm. The two LISNs were also used for supplying power tothe DUT and for ensuring a constant impedance of 50 ohm.

The conducted emissions on the power supply lines were measured successively on power supply and power return by connecting the measuring port on the measuring port of the related AN (Artificial Network), the measuring port of the AN in the other supply lines being terminated with a 50ohm load.

For this measurement we used an ESR EMI Test Receiver from Rohde&Schwarz with the frequency range: 9 kHz-3.6 GHz, and two V-LISN 5 uH from Schwarzbeck.

The receiver's parameters were: 9 kHz bandwidth between 100 kHz-26 MHz (100ms dwell time) and 120kHz bandwidth between 26-108MHz (10ms dwell time), peak and average detectors [7-9].
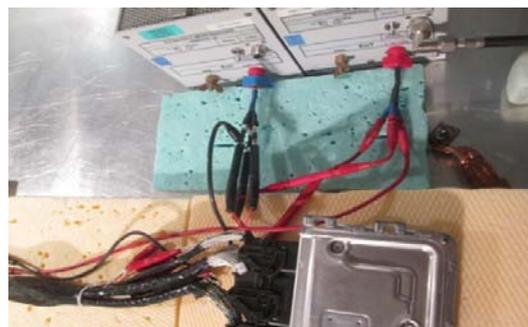

Fig. 5. LISN detail

IV. RESULTS AND DISCUSSIONS

A. Initial tests

The DUT that was subjected to CE test is an electronic unit that controls the gasoline injection and other secondary functions of the 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.
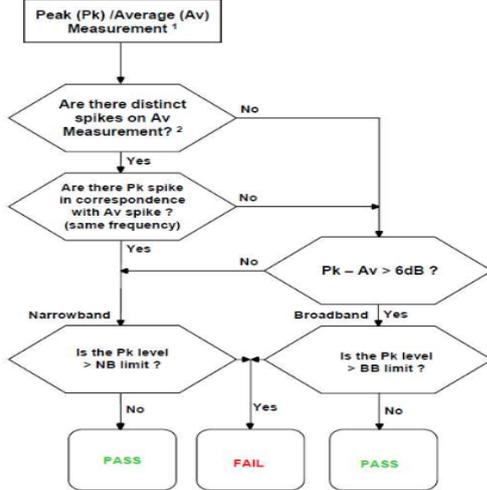
Fig. 6. Discrimination method

We used the discrimination method from Fig.6 to establish if the tests are pass or fail. We start with a measurement with peak and average detectors, and if we see distinct spikes on peak detector in correspondence with average spikes we conclude that we have a narrowband measurement.

So we compare the peak level with the narrowband limit at that frequency. If the peak level is above the narrowband limit, the sample is a fail.

In Fig.7 an initial test, which is a fail is presented. We can see spikes in average measurement in correspondence with peak spikes, and the peak level is above the narrowband limit at that place.
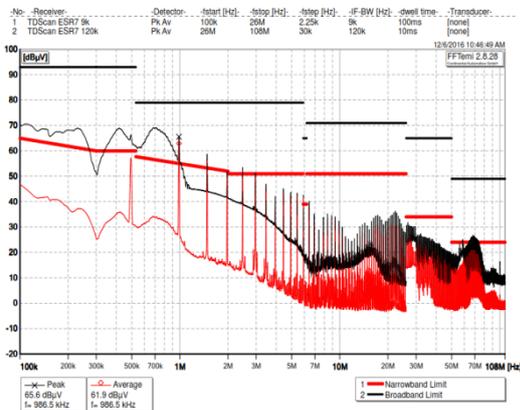
Fig. 7. Initial measurement

In this test the unit was used in two configurations: DUT insulated from the ground, and DUT insulated-grounded. Also two types of measurements were done: on +BAT of the LISN and on GND from LISN.

B. Methods for reducing CE levels

After studying the PCB along with the project team we established a few solutions for reducing the CE level. The DUT has emissions with fundamental frequency 500 KHz because of the switching of transistors. Also on the PCB a LC filter is formed with resonant frequency at 26MHz.
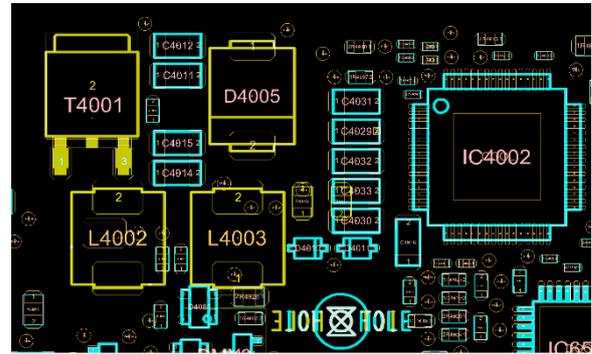
Fig. 8. PCB tested

The PCB contains a Sepic Converter with the following components: T4001, D4005, L4002 and L4003 (yellow in Fig.8).

In Fig. 9, a first solution is presented: adding capacitors with values between 10 and 220 nF on middle, left and right screws.
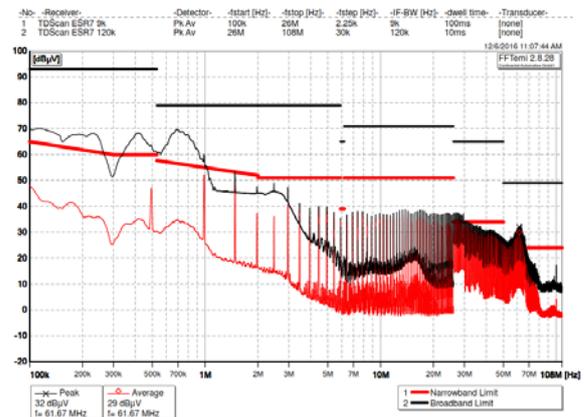
Fig. 9. Capacitors on middle screw

This solution has noticeable influence on the peak spikes, leaving a problem only at 1 MHz. Fig. 11 shows another solution which solves the problem at 1MHz.It consists in removing the mechanical capacitors.

Another situation is presented in Fig.10. L4002 and L4003 were replaced with a shielded coil. We used a SMD power winding inductor coil NR5020 (10uH NR magnetic shielding).
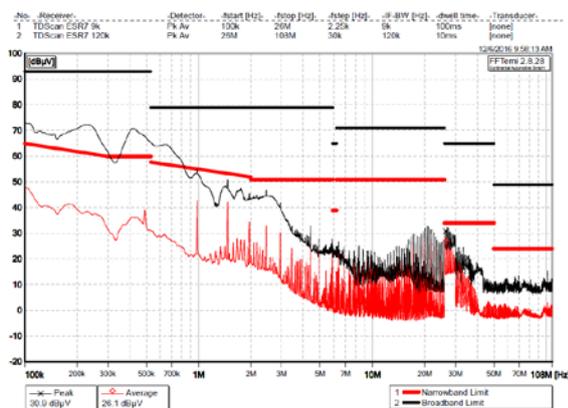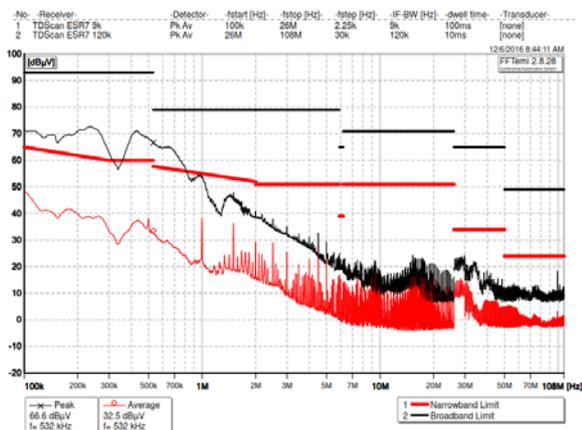
Fig. 10. Shielded coils

Fig. 11. Mechanical capacitors removed

The solutions with shielded coils and with the removal of mechanical capacitors both obtain a PASS solution, but with the last one we obtain smaller levels of emissions.

V. CONCLUSIONS

In this paper we reported the use of an automotive DUT for comparing different scenarios regarding conducted emissions testing.

We presented the CISPR 25 standard with the frequency range and equipment used for testing, with the two methods: LISN and current probe.

Afterwards, we described the method that was chosen for comparison (LISN) with setup representations.

We presented a case study concerning devised methods for reducing conducted emissions levels so that the client demands are satisfied and concluded that by removing the mechanical capacitors we obtain the smallest levels for conducted emissions.

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