Analysis of the CISPR 25 Component Test Setup

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Abstract: We analyze the wave propagation characteristic of the CISPR 25 radiated emission test setup with numerical simulations. Bad repeatability of the standardized ALSE validation procedure urged us to develop a new, more stable procedure. Our new validation procedure uses a small conical dipole antenna instead of the test harness which improves the repeatability and avoids impedance problems of the artificial network and the noise source. Furthermore it allows precise measurements to investigate the influence of test bench dimensions and grounding. Results of these investigations are shown.

Keywords: CISPR 25, ALSE Validation, Site Attenuation, Test Bench grounding

Introduction

The results of a radiated emission measurement depend on the wave propagation characteristic of the test site. It is required to define this characteristic to ensure a good reproducibility and to obtain similar results from different test facilities.

For automotive component testing according to CISPR 25 [1] the wave propagation depends on the absorber lined shielded enclosure (ALSE), the test bench (metallic table) and the artificial network (AN). The described test setup and the procedures induce several severe problems regarding the accuracy and repeatability of test results. We identify these problem areas and suggest modifications for an improvement.

Current Procedures in CISPR 25

The standardized procedures show some drawbacks compared to the state of the art of measurement and validation procedures.

Measurement Procedure

The schematic test setup for radiated emission testing is shown in Figure 1.

The specifications of the artificial network used as load for the 1.5 m test harness are defined in the frequency range from 100 kHz up to 108 MHz. Nevertheless measurements up to 1 GHz are required. As the radiation characteristic of an antenna – and the test harness acts as such – depends on the source and load impedances, different AN will show different results above 108 MHz.

The radiated emissions of the test harness are measured in 1 m distance in a fixed position of the receive antenna. It is a fact that the radiation characteristic of a wire antenna that's length exceeds 1 λ shows multiple lobes. Furthermore the test harness is laid out 5 cm above a metal plate. The coupling to this plate is a major influence to the radiation characteristic too. Minor changes (few millimeters) in the cable layout can degrade the repeatability dramatically.

The minimum dimensions of the test bench (also called ground plane) are defined in CISPR 25 (2.5 m wide, 1 m long) and it is extended backwards horizontally to be connected to the shielding wall of the ALSE. Reflections from the edges of the test bench interfere with the direct signal (emissions from the test harness). Amplitude and phase of these reflections depend on the size of the test bench. Therefore different sizes will cause different RE test results.

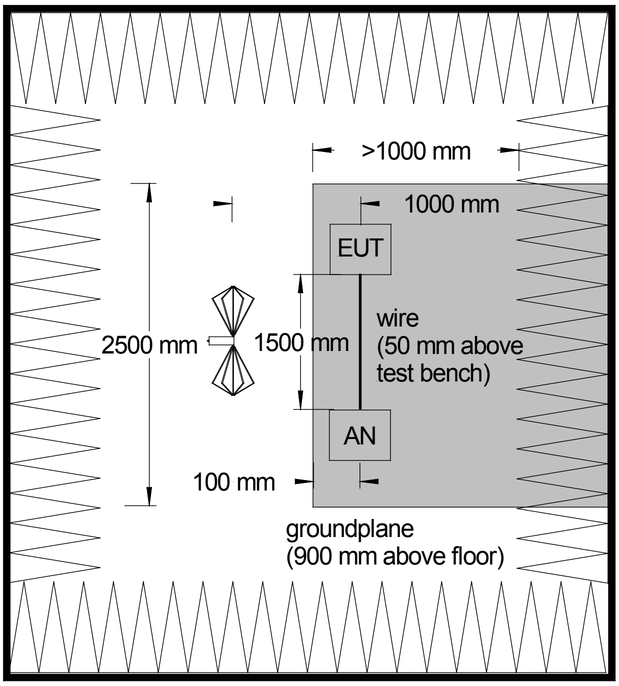

Figure 1: RE test setup

Validation Procedure

The calibration of the ALSE is described in the Annex B of CISPR 25. A noise source (NS) is used instead of the equipment under test in order to generate an electric field. For our measurements we used the comb generator RefRad (Seibersdorf) which is connected via a simple wire to the artificial network (AN). The electric field of this "test harness" is measured with a monopole antenna in the frequency from 150 kHz to 30 MHz, with a biconical antenna from 30 MHz to 200 MHz and with a log. periodic antenna from 200 MHz to 1 GHz.

Two field strength measurements are performed: The first one is measured on an open area test site as reference. The second one is the measurement in the ALSE. A chamber is assumed to be compliant if the deviation of the two measurements does not exceed ± 6 dB in the frequency range from 70 MHz to 1 GHz. No limits are given for other frequency ranges.

The standardized procedure induces several problems above 100 MHz:

- Bad repeatability
- Not defined impedance of the artificial network
- Not defined impedance of the noise source
- Not defined grounding of artificial network and noise source

Some of these problems are described by Swanson [2] and Miller [3].

The reason for the **bad repeatability** is the radiation characteristic of the wire. The wire has a length of 1.5 m, which corresponds to a wavelength of 1λ for a frequency of 200 MHz. So for higher frequencies the wire acts as beverage antenna [4]. At a frequency of 1 GHz the wire is 5λ long and the directional pattern shows many lobes. These lobes are very sensitive in direction and amplitude to the position of the wire. If the position of the wire is changed by a few millimeters the field strength changes by several dB [5].

The **impedance of the artificial network** is defined up to 108 MHz in the standard. Annex F of CISPR 25 shows the schematic for the network. For frequencies above 100 MHz the 0.1 µF capacitor can be neglected, but the inductivity of the cable to the test harness connector and the cable to ground becomes important.

The radiation characteristic of the wire antenna will change due to standing wave on the wire, which are depending on the **impedance of the source**. Therefore it is essential to use a well matched 50 Ω source like the RefRad. Alternatively matching can be improved by using a 10 dB attenuator at the output of the source.

The general problem of measurements over a metallic table is the low impedance **connection to ground**. There are several possibilities to connect the artificial network and the noise source to ground. The best way is to use wires as short as possible to decrease the inductivity.

The standard validation procedure has a very bad reproducibility and therefore investigations on the influence of the table size and on the grounding of the test bench are not possible. We developed a new validation procedure as described in the following section that is suitable for such research.

The problems of the current procedure and the advantages of the new technique is extensively described by Kriz [5] .

Suggested New Validation Technique

We suggest modifying the method for a frequency range from 30 MHz to 1 GHz. Instead of the noise source, the wire and the artificial network a small antenna should be used to generate a well defined field. This antenna is placed on five positions on the table, on a location approximate to the former wire position, see Figure 2.

The transmit antenna can be fed by a signal generator. Also a network analyzer (NWA) can be used. The advantage of this is that the drift of the test receiver can be reduced by measuring the level of the signal source. It is not required to use the same test receiver for the measurements on the OATS and in the ALSE. An advantage of the NWA is the very good accuracy. Attenuators on the feed points of both antennas should be used in order to reduce the influence of standing waves and improve the accuracy. The height of the antenna above the groundplane is 15 cm to allow measurements in vertical polarization, see Figure 2.

The site attenuation (SA) measurement procedure requires two different measurements of the voltage received. The first reading V_{DIRECT} is with the two coaxial cables disconnected from the two antennas and connected to each other. The second reading V_{SITE} is taken with the coaxial cables reconnected to the antennas.

$$SA = V_{DIRECT} - V_{SITE} \quad (1)$$

The principle of the comparison between Open Area Test Site and ALSE is the same as in CISPR 25. Therefore two SA measurements should be performed: the SA_{OATS} on the Open Area Test Site and the SA_{ALSE} in the ALSE.

$$\text{Difference} = SA_{ALSE} - SA_{OATS} \quad (2)$$

The SA measurements and comparison between different sites are described by Müllner [6].

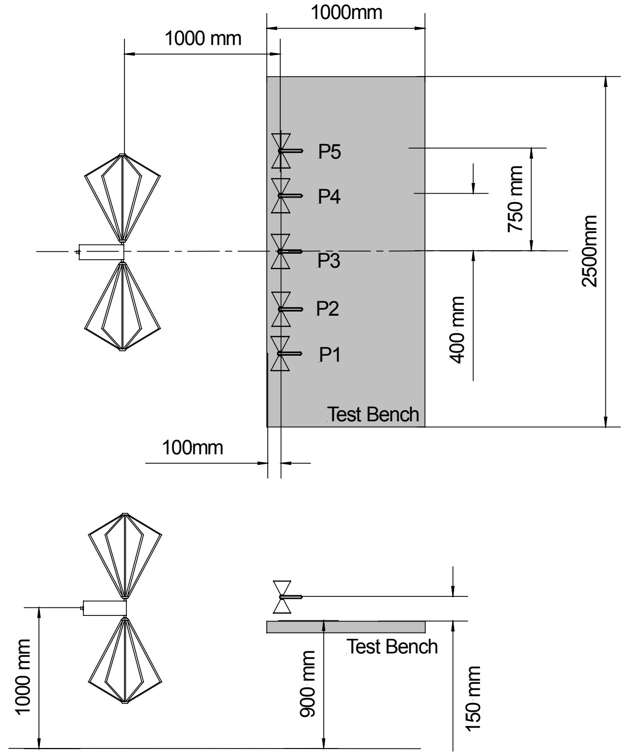

Figure 2: Setup of new validation method

Measurements have shown that the problem of the bad repeatability is solved by using the new validation technique.

Numerical Analysis of Test Bench Characteristics

We performed numerical simulations of different Test Bench configurations (size, grounding) using FDTD [7]. It is easy to simulate the test setup with a cell size of 5 cm, which leads to half a million cells. So it is possible to get results up to a frequency of nearly 600 MHz in less than 4 minutes simulation duration on a standard personal computer.

In our work we concern to the frequency range from 30 MHz to 200 MHz where the design of the groundplane is most critical. At frequencies above 200 MHz (log periodic antenna) the influence of the groundplane is less than 3 dB and in the frequency range below 30 MHz (monopole antenna) an even lower dependability is observed.

The simulation environment was an ideal OATS with a test bench of different size and with different ground connections. We choose 5 different configurations to work out, the important design details.

Configuration 1: Test bench 2.5 m x 1.0 m, no ground connection, see Figure 3 for the setup and Figure 4 for the results. This setup can be realized easily on an OATS and in an ALSE.

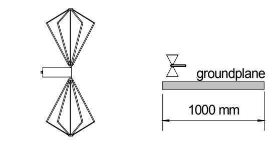

Figure 3: Setup, Configuration 1

There is strong resonance in horizontal polarization at a frequency of about 50 MHz. The point P3 (Fig. 2) leads to a peak of about 5 dB. Points at the side of the test bench contribute larger deviations up to 10 dB and 15 dB.

In vertical polarization a smooth behavior can be observed.

Due to the symmetry of test setup the points P4 and P5 are equal to the points P2 and P1. Therefore they are not shown in the diagrams.

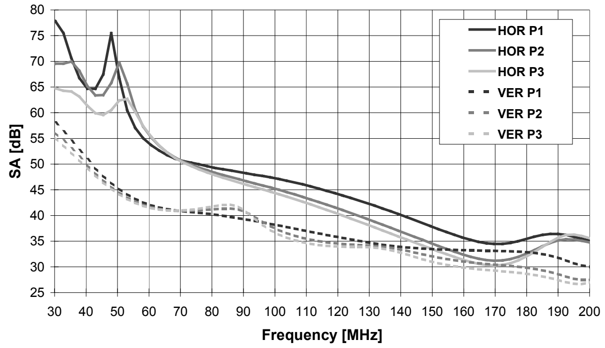

Figure 4: Simulation results, Configuration 1

Configuration 2: Test bench 2.5 m x 1.0 m, ground connection via a vertical metal plate with a size of 250 cm x 90 cm, see Figure 5 for the setup and Figure 6 for the results. This setup can be realized easily on an OATS and in an ALSE.

Many of the laboratories which perform CISPR 25 Emission Test use a similar grounding type. They use several copper bonds varying in width and number connected to the floor of the chamber.

The resonance in horizontal polarization nearly disappeared; it is reduced to 2 dB. But a new one is observed in vertical polarization at frequency of 55 MHz.

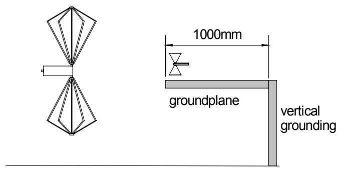

Figure 5: Setup, Configuration 2

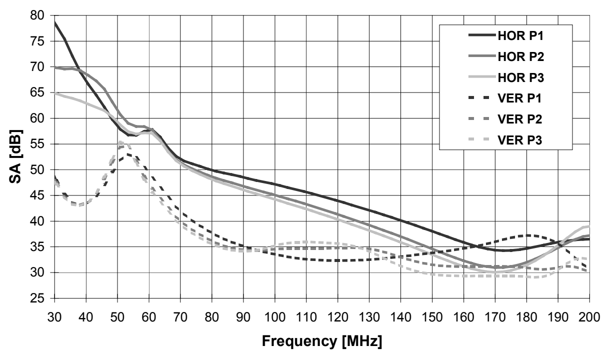

Figure 6: Simulation results, Configuration 2

Configuration 3: Test bench 2.5 m x infinite length at the backside, no ground connection, see Figure 7 for the setup and Figure 8 for the results.

This setup is only a theoretical approach and can not be realized in the real world. So it is not possible to realize this setup for calibration purposes on an OATS. It could be realized in a perfect ALSE by connecting the test bench to the shielding as described in CISPR 25.

The result is that all resonances in both polarizations disappeared.

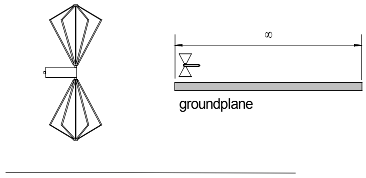

Figure 7: Setup, Configuration 3

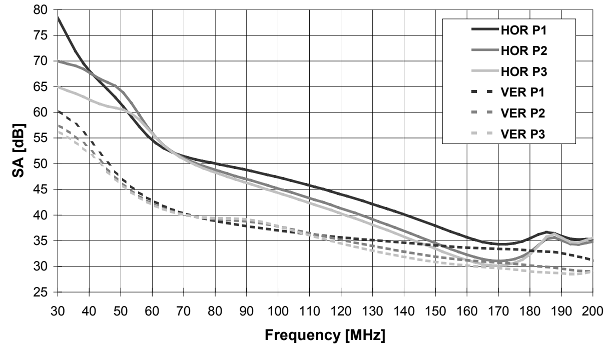

Figure 8: Simulation results, Configuration 3

Configuration 4: Test bench 2.5 m x 2.0 m, see Figure 9 for the setup and Figure 10 for the results. This setup can be realized easily on an OATS and in an ALSE. It similar to Configuration 1, but the Test bench has twice the width. This setup can be realized easily on an OATS and in an ALSE.

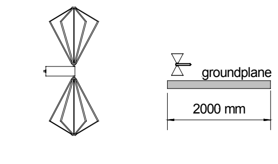

Figure 9: Setup, Configuration 4

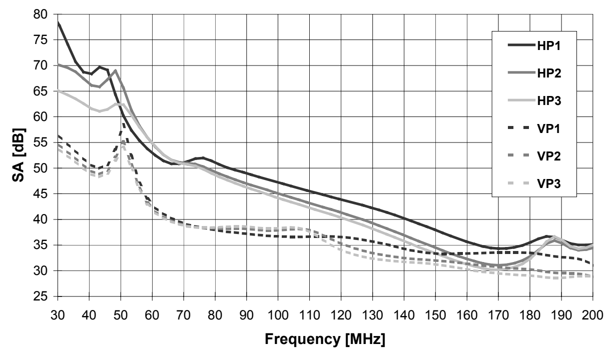

Figure 10: Simulation results, Configuration 4

There is weak resonance of about 5 dB in horizontal polarization at a frequency of about 50 MHz. Compared to Configuration 1 this resonance is reduced.

Also in vertical polarization a resonance at this frequency can be observed. Compared to Configuration 1 a new strong (more than 15 dB) resonance occurs. So one has to be careful when resizing the Test Bench due to this behavior.

Configuration 5: Test bench 2.5 m x 1.0 m, with no ground connection, but a vertical plate with a size of 2.5 m x 0.8 m, see Figure 11 for the setup and Figure 12 for the results. This setup can be realized easily on an OATS and in an ALSE. It similar to Configuration 2, but the Test Bench has no connection to ground.

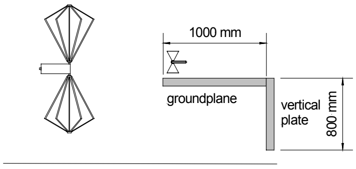

Figure 11: Setup, Configuration 5

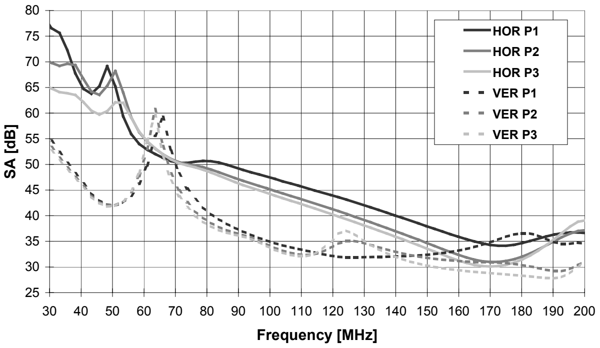

Figure 12: Simulation results, Configuration 5

The results are very similar to these of Configuration 4, although the designs are completely different. The vertical grounding plate acts as extension of the horizontal groundplane.

Conclusion

Our suggestion for a modified validation method using a small conical dipole avoids the problems of the CISPR 25 procedure like: bad repeatability, undefined impedance of the artificial network, unmatched noise source. For optimum accuracy a network analyzer can be used for the ALSE validation measurement.

The new validation procedure also allows reproducible investigations (simulations and measurements) on the size and grounding of the test bench. Comparisons between several simulations are given.

In horizontal polarization in the frequency range from 30 MHz to 40 MHz the results are independent of the design. Between 40 MHz and 60 MHz the results are dependent on the size of the groundplane. For higher frequencies only a small dependency can be observed because edge diffraction in horizontal polarization are not important. The electromagnetic waves are reflected by the test bench to the space above the transmit antenna. Below the test bench the electric field strength is relative low.

In vertical polarization there is a complete different behavior. The waves are traveling along the surface of the Test Bench and are diffracted at the edges. The results are very sensitive to the configuration. Below the test bench the electric field strength is high, and a strong coupling with the conductive parts for the grounding occurs.

It is important to notice that the low impedance ground connection acts as an extension of the groundplane size and shape. Therefore the grounding has a big influence on the total characteristic of the test site and special care has to be taken for defined and repeatable grounding.

For validating the ALSE performance the grounding at the reference measurement is very critical. The ideal case (Configuration 3) can not be realized for reference measurements. Therefore we suggest the following approximation: Use **Configuration 2** (identical size of groundplane, vertical grounding) for reference measurements in **horizontal** polarization. Use **Configuration 1** (identical size of groundplane, NO grounding) for reference measurements in **vertical** polarization.

This new technique has been used successfully for several ALSE validations for Automotive EMC Laboratory Recognition Program (AEMCLRP) accreditation.

Our further work will concern on several measurements to prove the results of the simulations. We want to work out guidelines how to construct a test bench where high precision tests are possible.

References

[1] CISPR 25: “Limits and methods of measurement of radio disturbance characteristics for protection of receivers used on board vehicles”, Second edition 2002-08, IEC

[2] D. Swanson: “Investigation of the Calibration Procedure from CISPR 25, Annex B, for use with Vehicle Component Testing”, IEEE EMC Symposia Record 1998

[3] P. Miller: “A Comparison of Radiated Emissions Testing to European Directive 95/54/EC Using an Open Field Test Site and a Semi-anechoic Chamber”, IEEE EMC Symposia Record 1999

[4] W. L. Stutzman, G. A. Thiele: “Antenna Theory and Design”, John Wiley & Sons Inc., New York, 1998

[5] A. Kriz, W. Müllner: “An Accurate Validation Procedure for Component Testing Chambers”, Compliance Engineering, Nov/Dec 2002, Page 40-43

[6] W. Müllner, H. Garn: “From NSA to site-reference method for EMC test site validation”, Int. Symp. on EMC, Montreal 2001, page 948-953 vol. 2

[7] A. Taflove: “Computational Electrodynamics: The Finite-Difference Time-Domain Method”, Boston, MA: Artech House, 1995

Biographical notes

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