An Accurate Validation Procedure for Component Testing Chambers

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A modified validation technique for absorber-lined shielded enclosures improves repeatability and avoids impedance problems.

The results of radiated emissions measurements depend on the wave propagation characteristic of the test site. This characteristic must be defined to ensure good reproducibility and to obtain similar results from different test facilities.

An absorber-lined shielded enclosure (ALSE) can be used for automotive component testing as long as some requirements are fulfilled. All standards currently prescribe a comparison between an open-area test site (OATS) and an ALSE. Unfortunately, there is neither a procedure nor a tolerance of the correlation that is defined in ISO 13766, ISO 14892, Council Directive 95/54/EC, and Council Directive 97/24/EC.[1–4] A detailed procedure and a limit are defined in CISPR 25 and SAE J1113/41.[5,6]

The current ALSE validation technique described in CISPR 25 induces some problems. This article suggests a modified ALSE validation procedure with small conical dipole antennas instead of the test harness as described in the standard. This procedure improves repeatability and avoids the impedance problems of the artificial network and the noise source.

Current Validation Technique

Calibration of an ALSE is described in Annex B of CISPR 25. Figure 1 shows the test setup. This setup uses a noise source rather than the equipment under test to generate an electric field. For this investigation, a RefRad comb generator from ARC Seibersdorf was connected via a simple wire to the artificial network. The electric field (E) of this test harness was measured with three antennas: a monopole antenna at frequencies of 150 kHz to 30 MHz, a biconical antenna from 30 to 200 MHz, and a log-periodic antenna from 200 MHz to 1 GHz.

Two field-strength measurements were performed: The first field strength was measured on an OATS as reference, and the second was the measurement in the ALSE. The difference between the two measured field strengths is the subject of investigation.

$$\text{Difference} = E_{\text{OATS}} - E_{\text{ALSE}} \quad (1)$$

A chamber is assumed to be compliant if the deviation does not exceed ±6 dB in the frequency range of 70 MHz to 1 GHz. No limits are given for other frequency ranges.

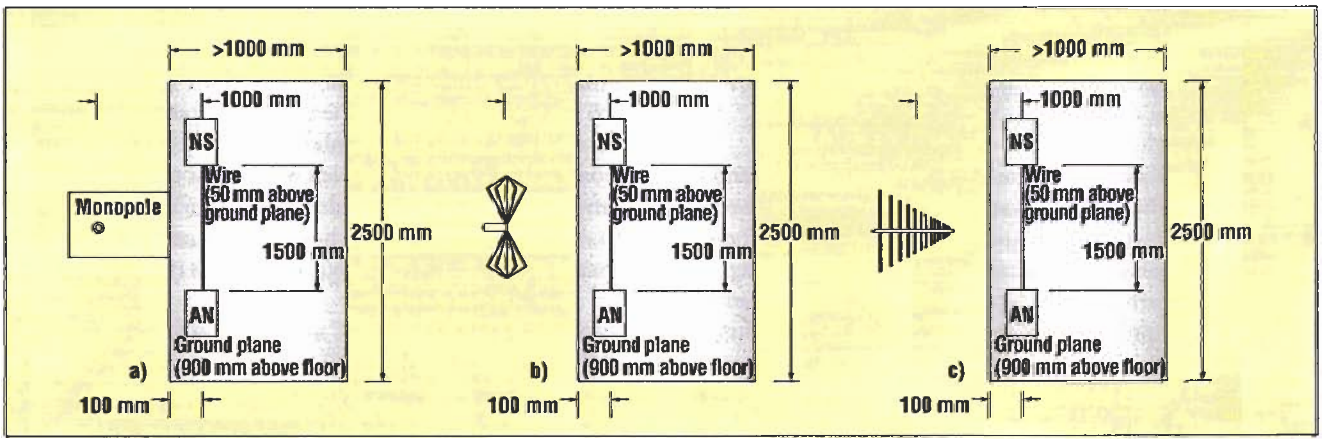

Figure 1. CISPR 25 validation setup (plan view): a) monopole, b) biconical antenna, and c) log-periodic antenna. NS = noise source; AN = artificial network.

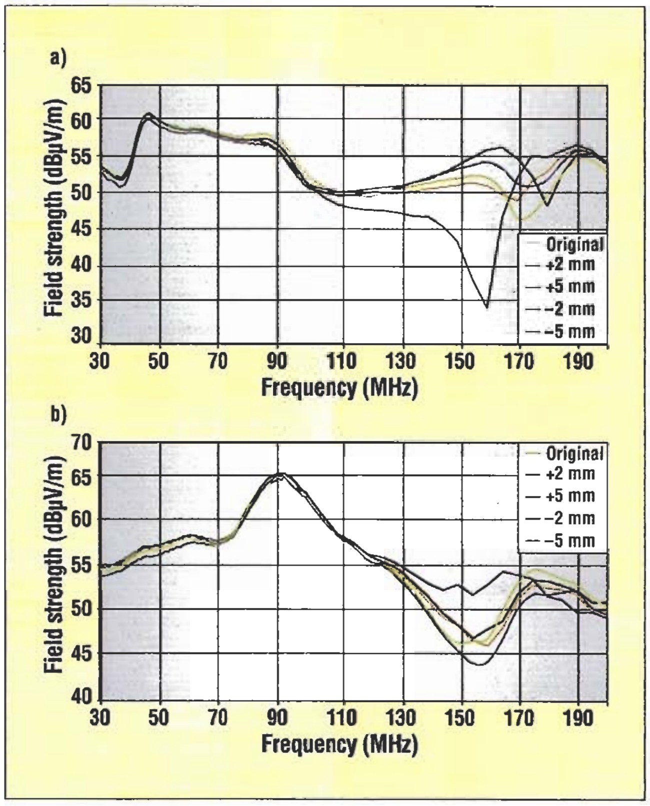

Figure 2. Sensitivity to wire position, biconical antenna: a) horizontal polarization and b) vertical polarization.

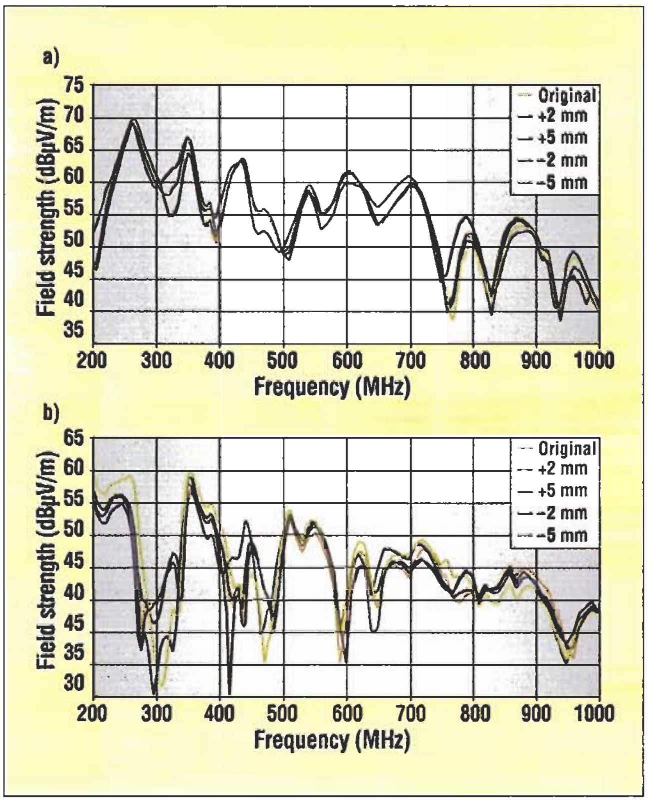

Figure 3. Sensitivity to wire position, log-periodic antenna: a) horizontal polarization and b) vertical polarization.

Problems with the Current Technique

The standardized procedure induces several problems above 100 MHz:

- Poor repeatability.
- No defined impedance of the artificial network.
- No defined impedance of the noise source.
- No defined grounding of artificial network and noise source.

Some of the technique's problems have been described by Swanson and by Miller.[7,8]

The radiation characteristic of the wire causes the poor repeatability. The length of the wire is 1.5 m, which corresponds to a wavelength of 1λ for a frequency of 200 MHz. So for higher frequencies, the wire acts as a Beverage antenna. At a frequency of 1 GHz, the wire is 5λ long, and the directional pattern shows many lobes. These lobes are very sensitive in both direction and amplitude to the position of the wire. If the position of the wire is changed by 5 mm, the field strength changes by several decibels (see Figures 2 and 3). Below a frequency of 100 MHz, the traces are within 2 dB. Above this frequency, the situation becomes worse. Table I summarizes the maximum deviation of the positioning experiment.

The impedance for an artificial network is provided for up to 108 MHz in the standard. Annex F of CISPR 25 shows the schematic for an artificial network. For frequencies above 100 MHz, the 0.1-µF capacitor can be ignored; however, the inductivity of the cable to the test harness connector and of the cable to ground become important. So, the impedance increases above a frequency of ~70 MHz (see Figure 4). A strong resonance can be observed at ~400 MHz, where the impedance reaches nearly 400 Ω.

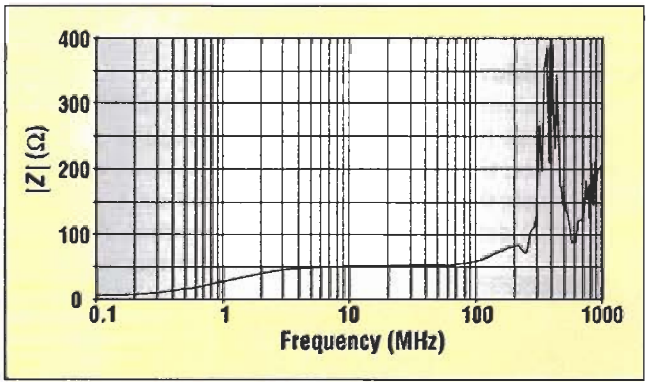

Figure 4. Impedance characteristics of an artificial network.

The radiation characteristic of the wire antenna will change due to a standing wave on the wire, which depends on the source impedance. Therefore, it is essential to use a well-matched 50-Ω source such as the RefRad. Alternatively,

Antenna Type	Horizontal Polarization	Vertical Polarization
Biconical	21.7 dB	9.0 dB
Log periodic	11.7 dB	18.0 dB

Table I. Maximum deviation due to wire position sensitivity.

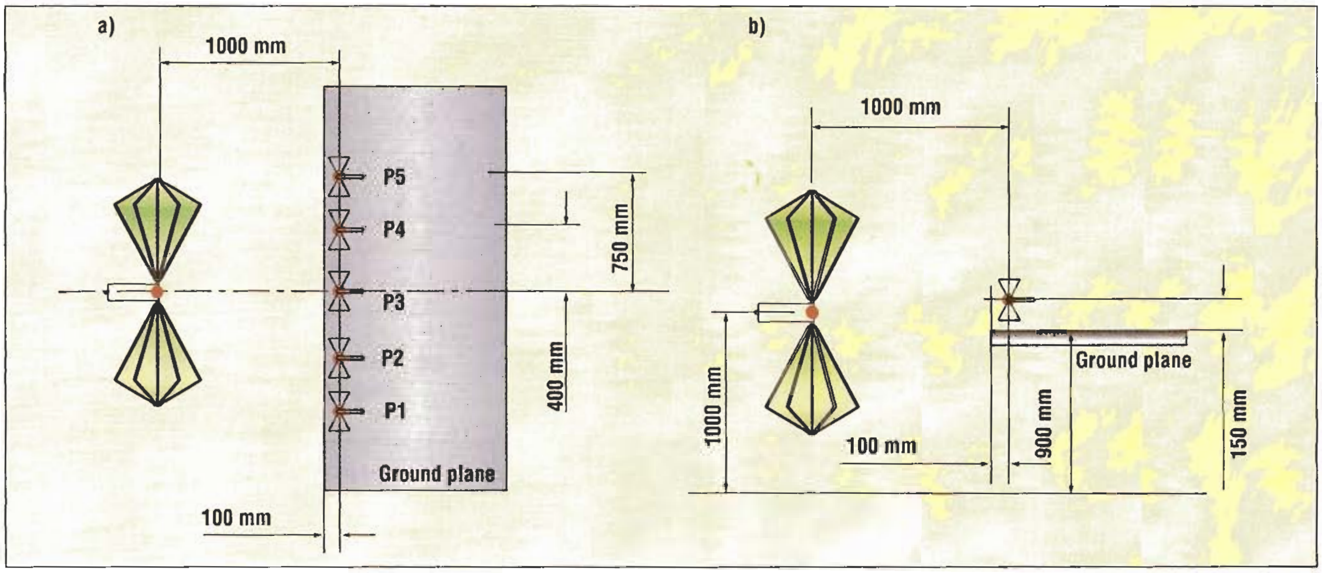

Figure 5. Setup of new validation method: a) horizontal polarization and b) vertical polarization.

matching can be improved by using a 10-dB attenuator at the output of the source.

In general, it is difficult to take measurements over a metallic table because of the low-impedance connection to ground. The artificial network and the noise source can be connected to ground in several ways. The best way is to use wires that are as short as possible, which then decreases the inductivity.

Antenna Type	Horizontal Polarization	Vertical Polarization
Biconical	1.04 dB	0.54 dB
Log periodic	0.58 dB	1.12 dB

Table II. Maximum deviation due to antenna position sensitivity measured on antenna P3 as shown in Figure 5.

New Validation Technique

A new technique modifies the current method for the frequency range from 30 MHz to 1 GHz. Instead of using the noise source, the wire, and the artificial network to define field strength, the new technique uses a small antenna to generate a well-defined field. For the investigation, this small antenna was placed at five positions on the table near the former wire position (see Figure 5a). Table II shows the maximum deviation due to antenna position sensitivity.

Figure 6. PCD 3100 (ARC Seibersdorf Research, Seibersdorf, Austria).

The transmit antenna can be fed by a signal or by a tracking generator. A network analyzer also can be used. By measuring the level of the signal source, this method reduces the drift of the test receiver. It is not necessary to use the same test receiver for the measurements on the OATS and in the ALSE. A network analyzer provides very good accuracy. Attenuators should be used on the feed points of both antennas to reduce the influence of standing waves and to further improve the accuracy. The height of the antenna above the ground plane should be 150 mm to allow measurements in vertical polarization (see Figure 5b). A precision conical dipole antenna such as the PCD 3100 (ARC Seibersdorf Research) can be used for this purpose (see Figure 6).

The site attenuation (SA) measurement procedure requires two different measurements of the voltage received. The first reading (V_{DIRECT}) is taken 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.

$$SA = V_{\mathrm{DIRECT}} - V_{\mathrm{SITE}} \qquad (2)$$

The principle of the comparison between the OATS and the ALSE is the same as described in CISPR 25. Therefore, two site attenuation measurements should be performed: SA_{OATS} on the OATS and SA_{ALSE} in the ALSE.

$$\text{Difference} = SA_{\mathrm{ALSE}} - SA_{\mathrm{OATS}} \qquad (3)$$

In Equation 3, the positions of OATS and ALSE change from those in Equation 1. The reason for this change is the

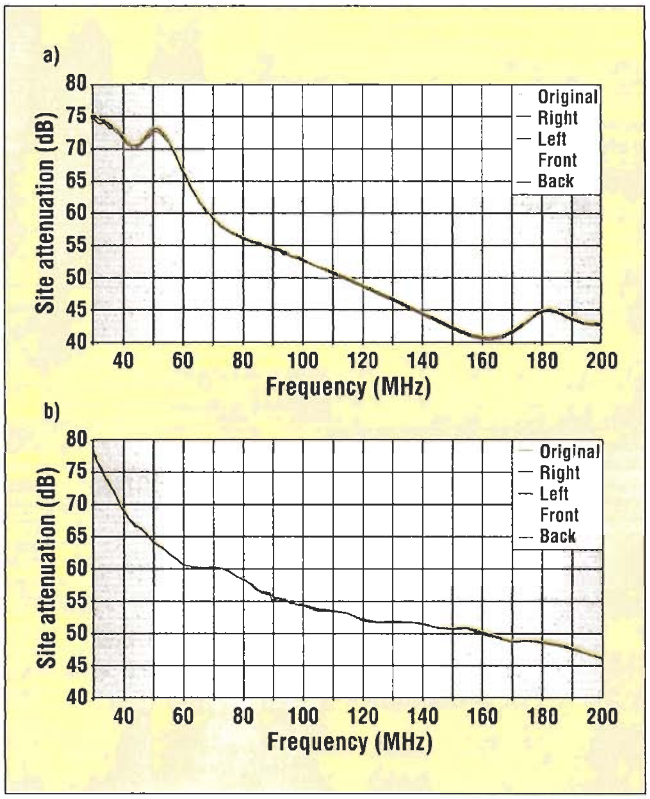

Figure 7. Sensitivity to antenna position using a new technique, biconical antenna: a) horizontal polarization and b) vertical polarization.

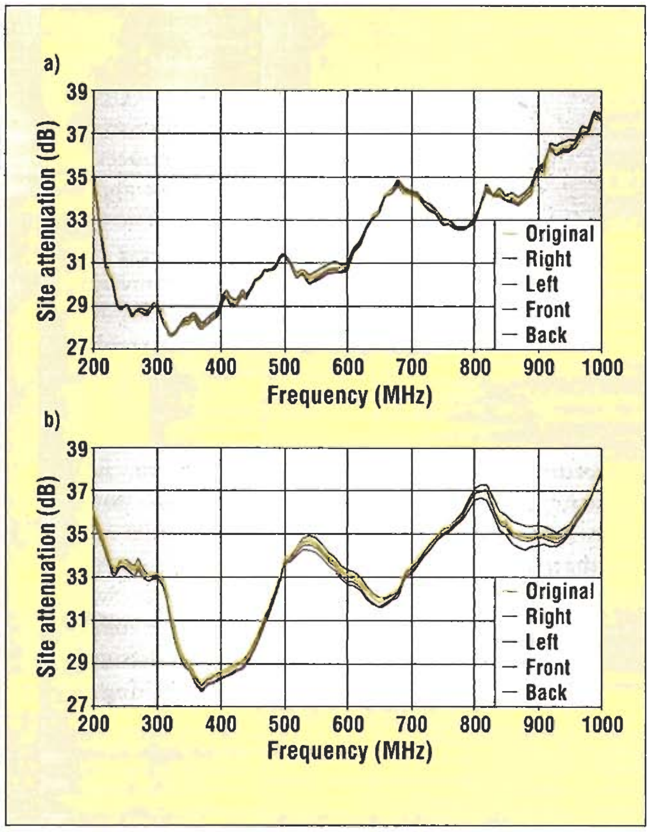

Figure 8. Sensitivity to antenna position using a new technique, log-periodic antenna: a) horizontal polarization and b) vertical polarization.

different sign of the site attenuation. The site attenuation measurements and a comparison of different sites are extensively described by Müllner.[9]

Measurements have shown that the problem of poor repeatability is solved by using the new validation technique. Figures 7 and 8 show the site attenuation measurements when the position of the small conical dipole antenna is changed slightly. The antenna was moved 10 mm to the right, left, front, and back from its original position.

Conclusion

The suggestion for a modified validation method using a small conical dipole avoids the problems that arise using the CISPR 25 procedure: poor repeatability, undefined impedance of the artificial network, and unmatched noise source. For optimum accuracy, a network analyzer can be used for the ALSE validation measurement. This new technique has been used successfully for an ALSE validation. This procedure was carried out to get an Automotive EMC Laboratory Recognition Program (AEMCLRP) accreditation.

References

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