Reference site method and antenna calibration

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EM Day – CISPR session
29 November 2007 at NPL
Test Site validation

• Electronic products placed on the market must be tested for emissions – EMC Directive 2004/108/EC.

• EMC disturbance field-strength measurements are normally performed on an open area test site (OATS) or in an anechoic chamber (SAC or FAR).

• OATS are areas of cleared level terrain with a metal ground plane. The terrain shall be void of buildings, electric lines, fences, trees in order to minimise unwanted reflections.

• Chambers shall be large enough and have sufficient RF absorber lining to reduce reflections from the walls and ceiling in a SAC, plus the floor in a FAR.
NPL open area site
60 m x 30 m, flatness ±6 mm

NPL fully anechoic room
9 m x 6 m x 6 m
Site validation criteria

- IEC standard CISPR 16-1-4: the criterion for site validation is ± 4 dB. The existing criterion is for Normalised Site Attenuation (NSA) in which the measured site attenuation (SA) between two antennas is compared to theoretical values.

- The proposed Reference Site Method is to compare the SA measured on the customer’s site with the SA measured on a Reference Site.

- The specification for the Calibration Test Site is given in CISPR 16-1-5, the first stage for a Reference Site.
Antenna set up for site attenuation measurement
The Normalised Site Attenuation method

• The NSA method was introduced by A A Smith in his seminal 1982 paper in which he provided formulas for the site attenuation between two Hertzian dipoles above a ground plane. The antenna factors of the dipoles are excluded from this model.
• The radiation pattern in the E-plane is simply \( \sin \theta \)
• To compare the measured SA with this model, the antenna factors are subtracted to give:
  \[
  \text{NSA} = \text{SA} - \text{AF1} - \text{AF2}
  \]
• The antenna factors have to be measured. This is done by scanning one antenna in height in order to avoid nulls caused by the ground plane.
Problems with the NSA method

- The NSA is only as good as the antenna factors.
- In the three antenna method one antenna has two heights which causes an error in the antenna factors of all three antennas.
- There is inadequate specification in CISPR16-1-4 of the quality of the site on which the antennas are calibrated; consequently the errors of the calibration test site are incorporated in the antenna factors.
- The NSA method does not explicitly require a site of high quality, i.e. a reference test site, for the calibration of the antennas.
Problems with the NSA method (cont.)

• The latest version of NSA in ANSI C63.5 gives only generic corrections for mutual coupling between biconical antennas and their images in the ground plane.

• The model is of Hertzian dipoles whose radiation patterns do not adequately represent the patterns or phase centres of the antennas actually used.
The Reference Site Method (RSM)

- The attenuation between a pair of antennas is simply compared with the attenuation measured with the same pair in the same way on a Reference Test Site.

- The difference between the two results is compared to the site validation criterion (currently ± 4 dB).

- The RSM explicitly requires a reference site of high quality.

- The Reference Test Site is specified in CISPR 16-1-5 which started as a standard for Antenna Calibration.
Advantages of the RSM over the NSA method

• The NSA method does not state the quality of site to be used for antenna calibration:
  - this is a chicken and egg problem.
• For RSM the antennas do not need to be calibrated, which is a potential cost saving.
• The calibration of the two antennas for NSA involves two lots of additional uncertainty terms (not in RSM).
• The radiation patterns and phase centres of antennas have no impact on RSM because it is a comparison method. The influence of mutual coupling is negligible. Unlike for NSA.
• The RSM does not have the errors of NSA associated with an inadequate model.
• The RSM refers to a reference site that has been independently validated using calculable dipole antennas, documented in CISPR 16-1-5.
Introduction of the RSM to international standards

- The RSM enables site validations to lower uncertainties than the NSA method.
- It is probable that OATS just meeting the NSA criterion of ± 4 dB would meet a criterion of ± 2 dB.
- There are fears in CISPR working groups that accepting a smaller criterion would mean that some existing sites would be penalised. It has been accepted to keep ± 4 dB for the RSM for now.
- The flaws in the NSA method have been raised since 1990, and Gissin gave a paper on this at an IEEE EMC Symposium in 1993.
Introduction of the RSM to standards (cont.)

• Some providers of site evaluation services have been using a form of RSM over the last 15 years.
• This form has been justified as the NSA method via the use of dual antenna factors.
• Dual AF is the product of the AF of the two antennas obtained with just one height scan, so limiting the number of uncertainty terms.
• The first CISPR draft of the RSM was circulated to the CISPR/A working group on 12 November 2007.
• New standards take up to 5 years to be published.
Antenna calibration for NSA

- Antenna calibration for NSA use has changed in a confusing manner over the last few years. The standard most commonly used worldwide is ANSI C63.5, which has evolved though several versions.
- The current 2006 version gives a method for obtaining free-space AF, with tabulated corrections to an AF suitable for NSA use.
- The free-space AF has limited accuracy because the method is height scanning above a ground plane, rather than a method with free-space conditions.
- Currently there are only corrections for biconical antennas, so the NSA method over the range 200 MHz to 1000 MHz is uncertain.
Antenna calibration for NSA (cont.)

- Over 200 MHz to 1000 MHz it would be better to use the ANSI C63.5:1988 method, whose AFs have been coined “geometry specific antenna factors”.
- This makes sense because the NSA method mimics the method of antenna calibration. This method is more robust if the antennas are calibrated on a reference site.
- This is probably also be true for biconical antennas, certainly for the 3m range, and also given that the tables of corrections are computed using a generic biconical antenna model.
- Antennas for the RSM do not need to be calibrated, only checked that they are functioning correctly.
CISPR standard for antenna calibration

• Work started on antenna calibration in CISPR/A in 1989. An ad-hoc group was formed to write a standard in 1995.

• The first hurdle, the specification of a test site suitable for antenna calibration, was completed with the publication of the first part of CISPR 16-1-5 in 2004.

• A committee draft on antenna calibration ran out of its allotted time in 2006 and it is intended to be restarted in 2007, with a deadline of 5 years.

• There are a number of antenna types and several competing methods, which have contributed to the delay. Besides the voluntary nature of working on standards.
Conclusions

• The NSA method and the RSM are based on the same principle
• The principle is comparison of one site with another
• The NSA method does not explicitly recognise this, but in fact the site errors are embedded in the antenna factors
• The RSM is the bare essentials of the NSA method and consequently has fewer uncertainty terms.
• CISPR has found it necessary to employ a large site acceptance criterion of ±4 dB because of the NSA errors.
• With RSM a criterion closer to ±2 dB should be feasible