Uncertainties of immunity measurements

DTI-NMSPU project R2.2b1

Annex D Details of chamber performance (radiated immunity)

SCHAFFNER

ELMAC services

Annex D

Details of chamber performance

This annex gives the graphs derived from analysis of the 44 chamber calibrations performed by Schaffner.

In 1994 Schaffner EMC Systems (then Chase EMC) decided to provide accredited calibrations of Normalised Site Attenuation and Field Uniformity. This service was provided to screened room and absorber manufacturers around the world and to date well over 100 chambers have been measured internationally which have included traditional pyramidal absorber and/or ferrite tile absorber.

Since mid 1996 some 44 anechoic and semi-anechoic chambers have been assessed for field uniformity. The data so gained has been dis-identified and analysed for this report. (The 44 chambers are a selection of the total number of calibrations performed by Schaffner, based principally on suitability of the data for analysis.) All the chambers for which data are presented in this report were measured over the range 80-1000 MHz in 1% frequency steps and comply with the field uniformity assessment procedure of either EN61000-4-3:1996 or the new amendment 77B/352/FDIS. Over 95% of the chambers meet the requirements of both documents..

The field uniformity calibration procedure used to obtain this data is the constant forward power method according to EN 61000-4-3:1996. The raw data are provided for each frequency (in 1% step increments from 80 to 1000MHz) in each polarisation at each of 16 points which define the uniform field area. In the presentations which follow, the total spread of field values – in dB – for both polarisations is plotted versus frequency for each chamber.

Data presentation

The presentations are given in four groups each with three plots. In each case the three plots show the chambers separated into one of three classes, A, B and C, according to their Normalised Standard Deviation (NSD). The plots are further colour-keyed to differentiate between types of absorber: green curves show hybrid (ferrite and carbon-loaded foam combination), blue curves show ferrite only, and red curves show pyramidal carbon-loaded foam only. Each curve on one of the three plots per group represents one chamber.

NSD

NSD is evaluated by first computing the mean and standard deviation of all measured fields in V/m (for the 16 field points in both polarisations and for all frequencies). NSD is then defined as follows:

$$NSD = 20 \, Log_{10} \text{ (standard deviation / mean)}$$

According to Dawson et al (see main report for references),

> "NSD is a negative value in decibels and a value of –20 dBav (decibels relative to the average) would correspond to a typical field variation of 10% i.e. 1 V/m in an average field of 10 V/m. An NSD of -∞ dBav corresponds to a totally uniform field and so the more negative a value of NSD is, the more uniform is the field it describes."

NSD is used here to generate a single-figure quality factor relating to the uniformity measured for all frequencies and both polarisations. The NSD ranges which correspond to the three classes, selected arbitrarily but on the basis of permitting a useful comparison to be made, are as shown:

Classification	NSD range
A	< –16 dBav
B	–16 to –14.5 dBav
C	> –14.5 dBav

Data plots

Total field variations

Group 1 is a plot of the total field variation – that is, the difference between minimum and maximum values – for all 16 points measured in the uniform area for all 44 chambers. Horizontal and vertical polarisation are plotted separately so there are two traces for each chamber – giving a total of 88 traces. All the chambers comply with the 6dB field uniformity requirement in the standard, but since this allows four out of sixteen points to be discarded, as well as 3% of frequencies to exceed even the 12-point 6dB criterion, there can be quite substantial deviations when all 16 points are considered, as is shown in these plots.

Class A chambers

For the seven chambers in this class the field variation (i.e. maximum non-uniformity) is less than 8 dB for the entire range of frequencies. There are five excursions over 6 dB all but one of which are for different chambers. Three chambers have zero FDI (see main report), i.e. there are no frequencies at which the variation is greater than 6dB. Only hybrid absorber types appear to be capable of achieving class A, and all these are large chambers.

Class B chambers

The maximum field variation for the twelve chambers in this class is 11 dB, with only three chambers having excursions of more than 10 dB. The field variation is mostly less than 8 dB below 900 MHz. Above this frequency, the ferrite absorber gives both the worst and the best performance, but over the rest of the frequency range there is little to choose between the types.

Class C chambers

The field variation peaks at 15 dB with several excursions greater than 12 dB. Below 200MHz, with a few exceptions due to poor performance of pyramidal absorber, the excursions remain below 9dB, but above this frequency both hybrid and ferrite-only types contribute equally to the worst cases.

Effect of different level-setting procedures

After removing up to 4 points from the uniformity calibration, the nominal field for testing is established at the location of the lowest field point of the 12 or more points that remain. This means that, if the 6dB range is achieved at the higher end of the field strength spread, several points will be under-tested; conversely, if it is achieved at the lower end, several points will be over-tested. The field level setting procedures in the earlier versions of the standard (up to and including edition 2: 2002-3) allow various choices to be made for the location of the lowest field. The new amendment (77B/352/FDIS) is much more prescriptive about this location. The following two groups of plots show the effect of changing between the two methods.

The data for the chambers is analysed either as specified in IEC 61000-4-3: 2002: since the procedure described in this standard is ambiguous it was necessary to choose a particular interpretation. Points which departed by more than 3dB from the mean were rejected until the total spread of those that remained was within 6dB.

Or, as specified in 77B/352/FDIS: since the procedure described in the FDIS is completely unambiguous the chamber assessment was precisely as specified.

These data are shown in the plots in groups 2 and 3. For each chamber, only those frequencies are plotted at which, at some point in the 16 total, the applied field strength is outside the +0dB/-6dB criterion.

Class A chambers

IEC 61000-4-3: 2002-03: No over-testing occurs. Under-testing of 1 dB is common throughout the frequency range and the under-testing peaks at about 3 dB. The 1 dB of under-testing even occurs for the chambers with FDI of zero where all 16 points meet the 6 dB field uniformity criterion over the whole range of frequencies, as a consequence of deleting points that are more than 3 dB from the mean field value. If the standard stated that where the total spread for all 16 points was less than 6 dB the sifting procedure was not to be used, the under-testing would not occur.

77B/352/FDIS: For one chamber under-testing of about 1 dB occurs at one frequency. Over-testing is also limited to 1 dB

Class B chambers

IEC 61000-4-3: 2002-03: There is very little over-testing and under-testing is limited to about 4 dB up to 800 MHz. Above this frequency under-testing rises to 6 dB. Over almost the entire frequency range there is under-testing of at least 1 dB.

77B/352/FDIS: Occasional over-testing of up to 3 dB takes place. Below 800 MHz the under-testing is limited to 3 dB but above this frequency it increases to about 6 dB at some frequencies. The departures are rare and only affect a few chambers.

Class C chambers

IEC 61000-4-3: 2002-03: Over-testing of 3 dB occurs at one frequency but it is mostly limited to 1 dB. Under-testing of up to 8 dB occurs below 800 MHz, with up to 6dB being common, and rises to 10 dB above this frequency.

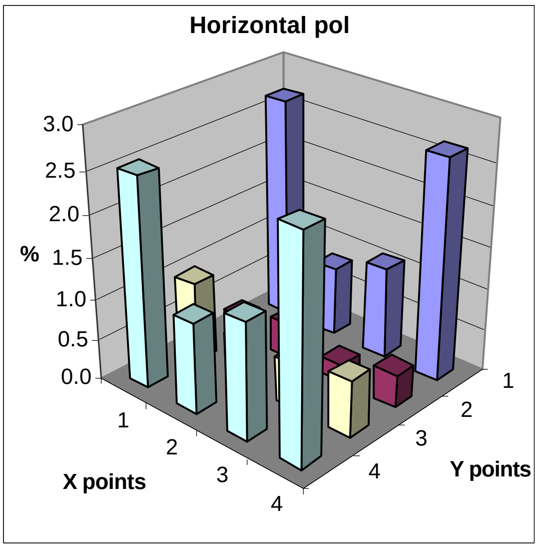
77B/352/FDIS: Over-testing to about 3 dB occurs but is mostly below 2 dB. Under-testing up to 8 dB is common over the whole range of frequencies.

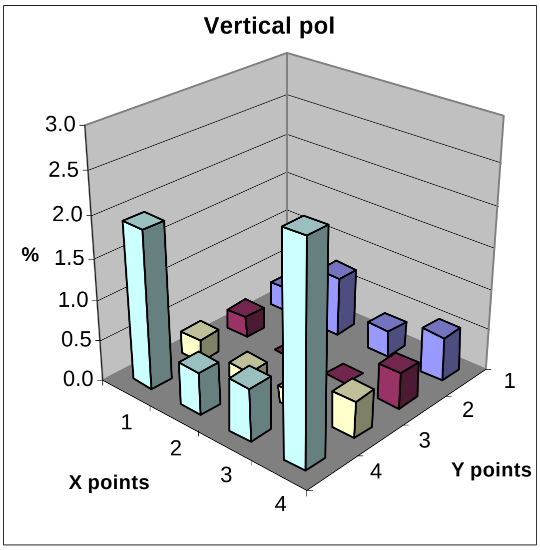
Four point field spread

Both old and new versions of the standard allow a minimum uniform area of 0.5 x 0.5m to be established with only four points. This area must meet the +0/-6dB criterion with no omissions. It may only be used if the EUT and its wires to be tested remain within the boundaries of this smaller area.

The graphs shown in group 4 are a sub-analysis of the data for each chamber, taking the four points at the centre of the lower two rows (it is assumed that a small EUT would still be located at 0.8m above the floor of the chamber) and giving the total spread as for group 1. These show that in general, for class A and B chambers, the spread remains within 4dB with a few excursions to 6dB. For class C chambers, the spread is mostly within 6dB but with a few excursions to 8dB.

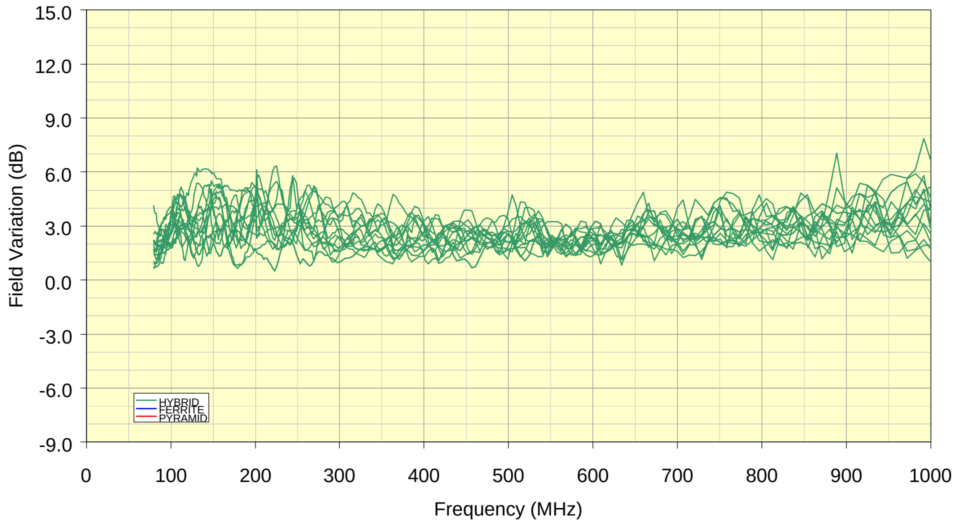
The chart below shows the number of frequencies at each point in the uniform plane at which the level falls below the nominal, for all 44 chambers and each polarisation, as a percentage of the total possible number (44 x 255 = 11220). The axes are labelled so that XY = 11 is the top left point, XY = 44 is bottom right. This clearly shows that, certainly for horizontal polarisation though less so for vertical, the corners of the uniform field area are more likely to fall outside the 6dB tolerance than are the centres.



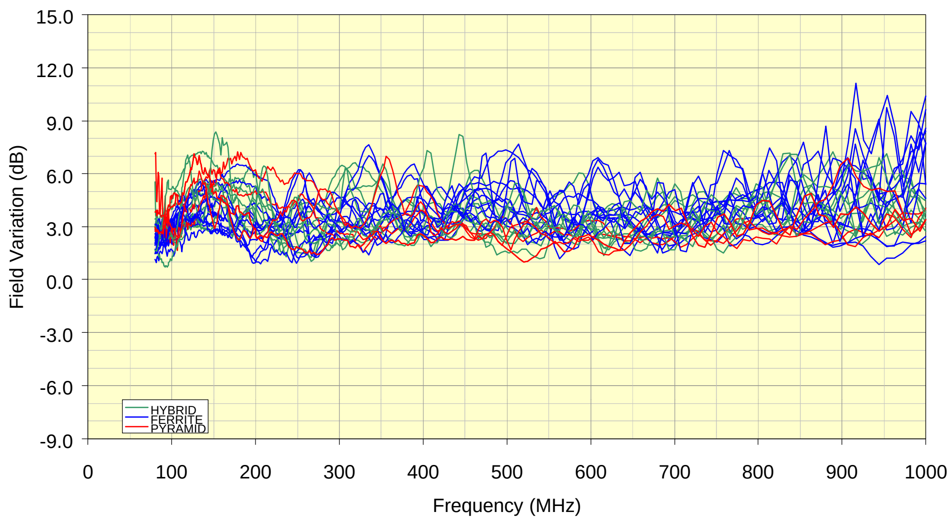


Group 1: total field variations

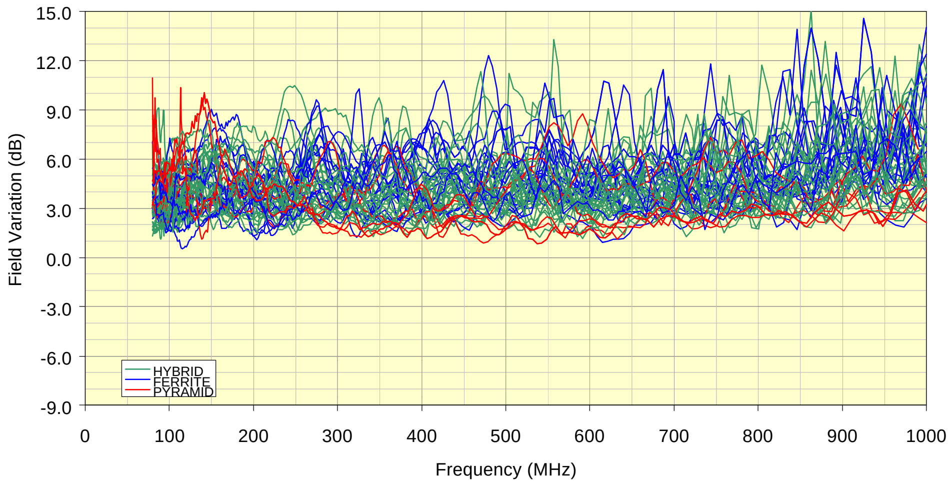
Class A (NSD -18.5 to -16)



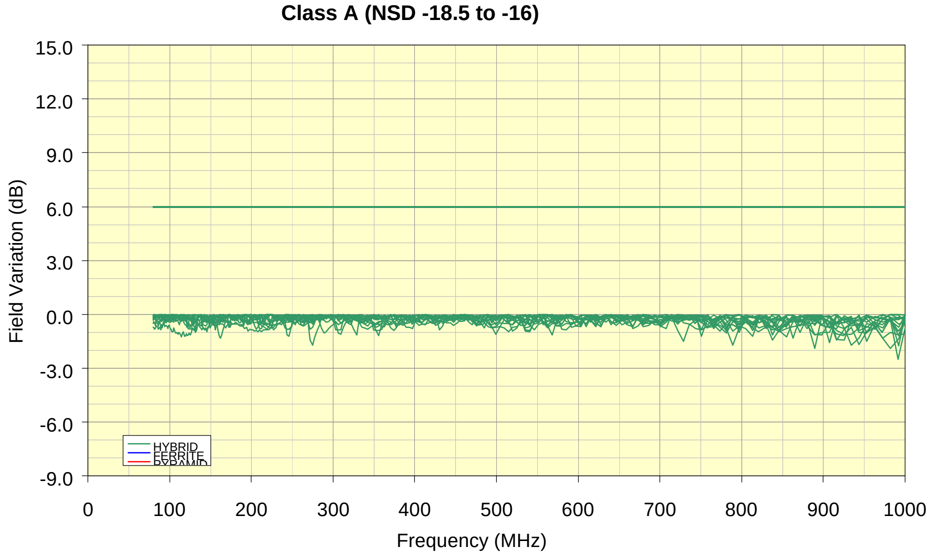
Class B (NSD -16 to -14.5)

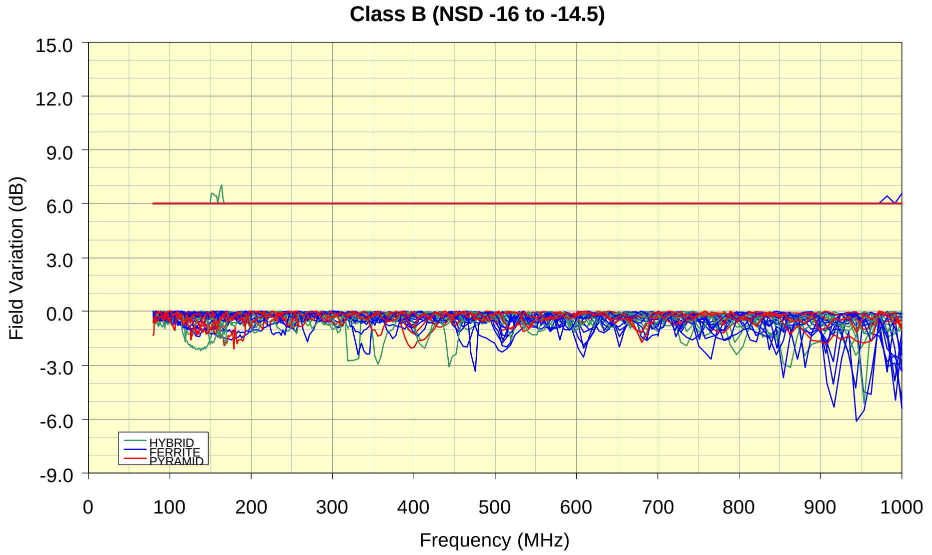


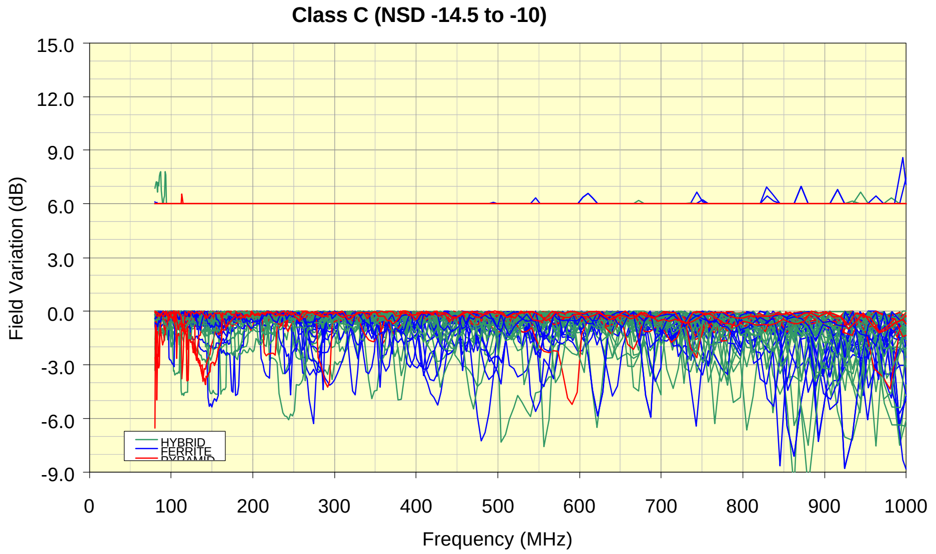
Class C (NSD -14.5 to -10)



Group 2: reference point selected as per IEC 61000-4-3: 2002-3

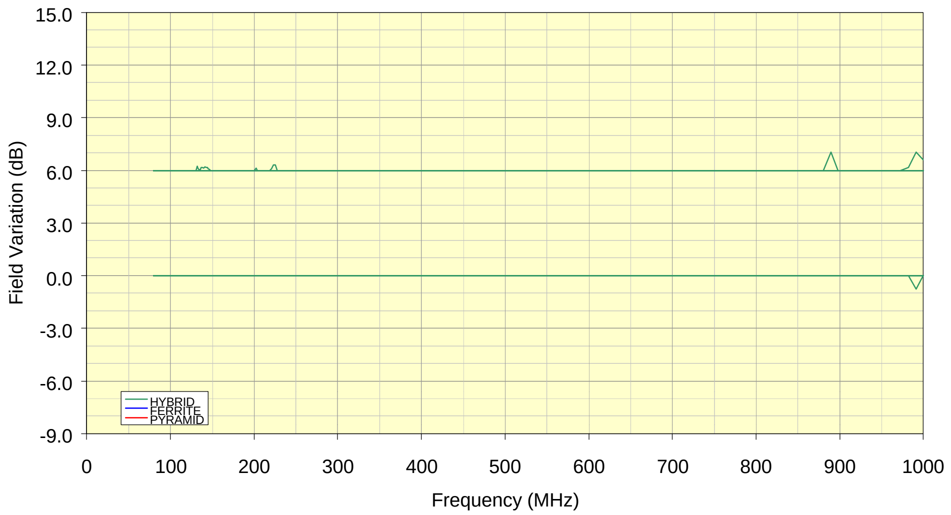




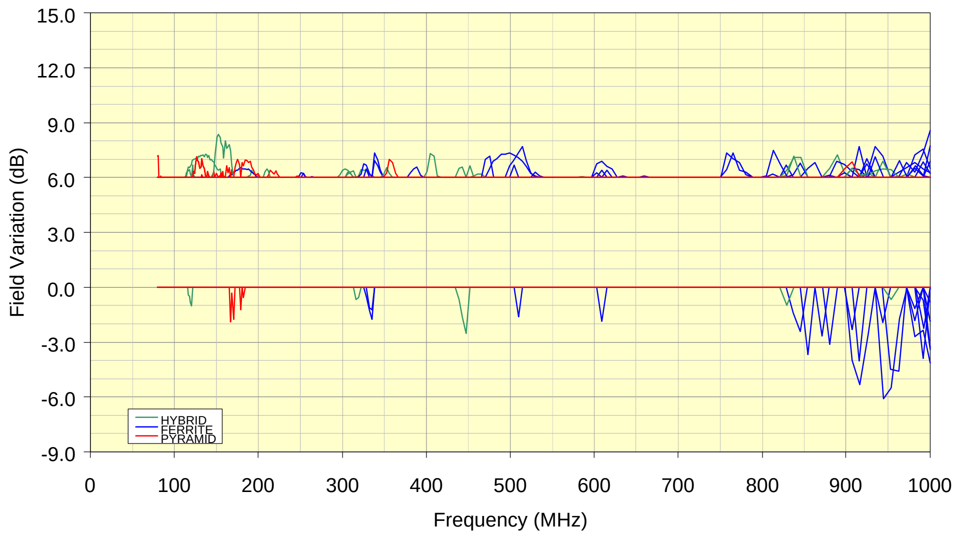


Group 3: reference point selected as per 77B/352/FDIS

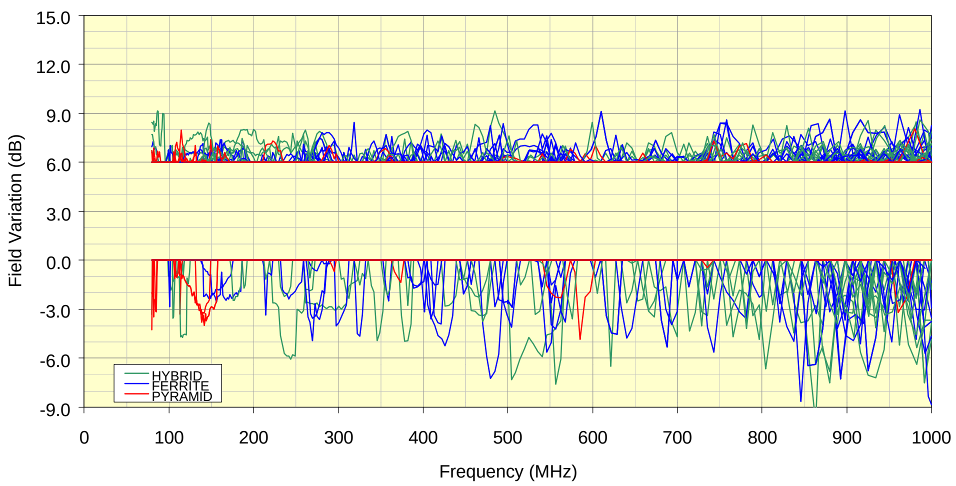
Class A (NSD -18.5 to -16)



Class B (NSD -16 to -14.5)



Class C (NSD -14.5 to -10)



Group 4: four point field spread