CORRELATING FULLY ANECHOIC TO OATS MEASUREMENTS

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10m-OATS are the final reference for all radiated emission measurements in the CENELEC generic standard. 10m-site semi-anechoic chambers are very large and expensive. Therefor we developed a small fully anechoic ferrite chamber with a 3m site for CE compliance testing (emission and immunity). The theoretical emission model for the correlation to OATS has been formulated and experimentally validated. The results are better than ±4 dB according to ANSI C63.4/92. The chamber has been successfully used for more than 2 years in our accredited EMC lab. Many round robin tests have been performed additionally with other labs.

1. INTRODUCTION

According to the latest CISPR 16 and ANSI C63.4 radiated emission measurements are performed on OATS. Any alternative measurement facility must be traceable to this procedure. The maximum calibration error may not exceed ± 4 dB in the range of 30 to 1000 MHz. The European Generic standard EN 50082-1 / residential / ITE requires a 10m measurement distance. If a semi-anechoic chamber with a 10m site integrated is used the potential financial investment can easily exceed 1 Mio. US $. Using an OATS is much more cost effective. However ambients make the emission finding often difficult.

The US FCC except 3m OATS data, those chambers are naturally cheaper. A test laboratory has on the other hand the duty to conduct some radiated immunity measurements, where the placement of additional absorber material on top of the ground plane is mandatory. Changing a semi-anechoic chamber to a fully anechoic chamber each time is a cumbersome exercise. Therefore a fully anechoic chamber appears to be very attractive. In the ETSI telecom world the use of a free space environment as in a fully anechoic chamber is the preferred procedure for transmitters and antennas.

Under far field conditions it is easy to compute free space data for different measurement distances (from 3m to 10m add -10.46dB, from 3m to 30m add -20dB). Over a ground plane we have to account for additional reflections. Assuming this to be 6 dB under all circumstances is incorrect.

2. THEORETICAL MODEL

The basic model for an OATS with two antennas over a ground plane is shown in fig. 1. The transmitting antenna height is h_1 and the receiving antenna height is h_2 respectively. In the case of horizontal polarization of the antennas we find the direct path field strength in the receiving point to be:

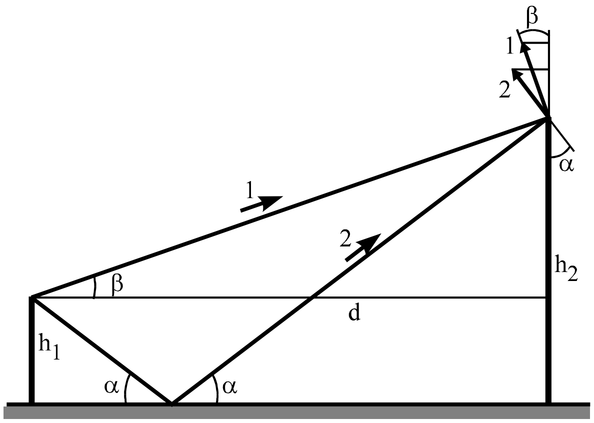

Fig. 1 OATS model with direct (1) and indirect (2) path

$$E_{1h} = \frac{K * e^{-j*k*\sqrt{(h_2-h_1)^2+d^2}}}{\sqrt{(h_2+h_1)^2+d^2}} \tag{1}$$

where K is a constant and k is the wavenumber. The indirect ray's field strength is:

$$E_{2h} = \frac{L * e^{-j*k*\sqrt{(h_2+h_1)^2+d^2}}}{\sqrt{(h_2+h_1)^2+d^2}} \tag{2}$$

The total field in the receive point is the superposition of E_{1h} and E_{2h}:

$$E_{3h} = E_{1h} + E_{2h} \tag{3}$$

Under free space conditions we can state:

$$E_{fs} = E_1(h_1 = h_2) \tag{4}$$

Dividing the absolute values of E_{1h} over E_{fs} results in the ratio:

$$r_{1h} = \frac{d}{\sqrt{(h_2-h_1)^2+d^2}} \tag{5}$$

For the ratio of the field strength OATS to free space follows:

$$r_{2h} = r_{1h} * \left|\frac{E_{3h}}{E_{1h}}\right| = r_{1h} * r_{3h} \tag{6}$$

with:

$$r_{3h} = \sqrt{1 + \frac{l_1^2}{l_2^2} - 2 * \frac{l_1}{l_2} * \cos\left(k * [l_2 - l_1]\right)} \tag{7}$$

$$l_1 = \sqrt{(h_2-h_1)^2+d^2}$$

and

$$l_2 = \sqrt{(h_2+h_1)^2+d^2}$$

In the vertical polarization case we get with

$E_{1v} = E_{1h} * \cos^2\beta$ and $E_{2v} = E_{2h} * \cos^2\alpha$

$r_{1v} = r_{1h}^3$ as well as $r_{2v} = r_{1v} * r_{3v}$

$$r_{3v} = \sqrt{1 + \frac{l_1^6}{l_2^6} + 2 * \frac{l_1^3}{l_2^3} * \cos\left(k * \left[l_2 - l_1\right]\right)} \qquad (8)$$

The following job is now, to determine for all used frequencies (30 - 1000 MHz) the maximum of the r_2-factors over the given height scan range, measurement distance and the appropriate transmitter antenna height. A numerical simulation has been performed for 3m, 10m, 30m and can be depicted in Fig. 2 to 7.

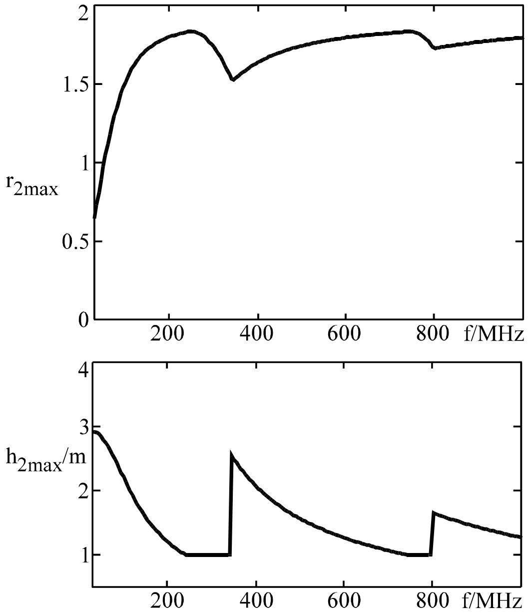

Fig. 2 Conversion factor from 3m free space to 3m OATS and the related maximum scan height for horiz. polarization

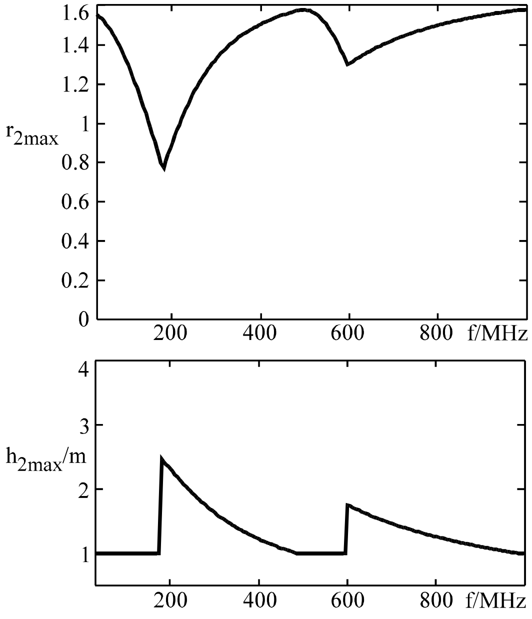

Fig. 3 Conversion factor from 3m free space to 3m OATS and the related maximum scan height for vertical polarization

The assumption is a radiating point source at 1m height and the receiving antenna height is scanned from 1m to 4m.

An interesting cross check with ANSI C63-4/1992 is presented in Fig. 8 and 9. The theoretical normalized site attenuation has been converted to the equivalent free space attenuation. The agreement between the four curves is excellent. This proves that ANSI's model assumes point sources.

To finalize the conversion from OATS to a 3m fully anechoic chambers (FALC) one has to subtract the additional free space attenuation (from 3m to 10m subtract 10.46dB, from 3m to 30m subtract 20dB).

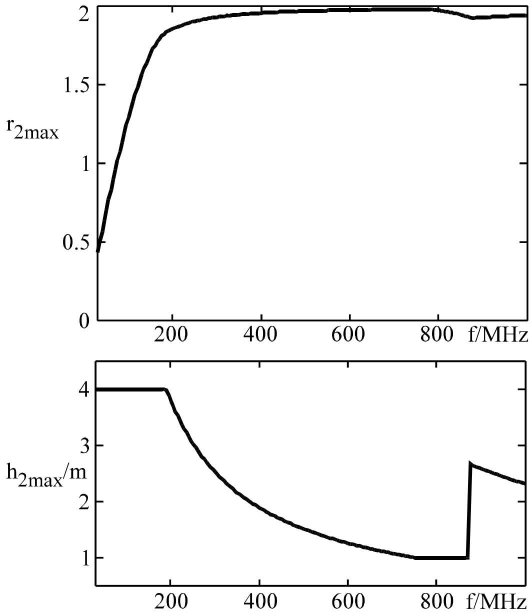

Fig. 4 Conversion factor from 10m free space to 10m OATS and the related maximum scan height for horiz. polarization

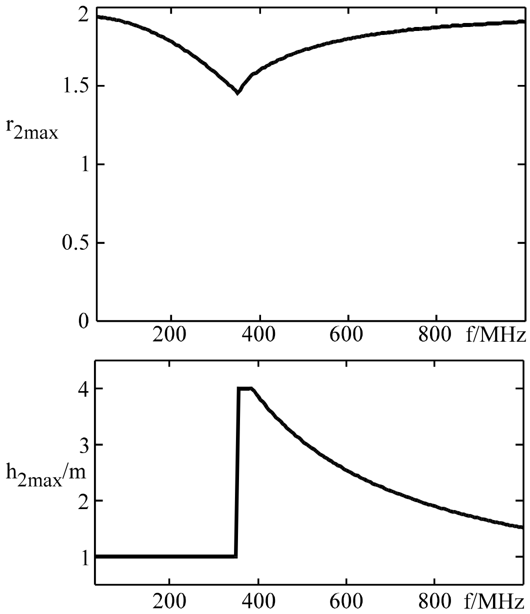

Fig. 5 Conversion factor from 10m free space to 10m OATS and the related maximum scan height for vertical polarization

For the 3m case we have additionally considered the first near field term for checking the sensitivity. This effect was detected to be of minor importance.

To allow for arbitrary radiators to be measured we recommend a reduced height scan of ± 0.9m to meet 10m OATS requirements. This results from a trigonometry analysis. The negative scan is made to collect the potential contributions of downwards directed radiator patterns.

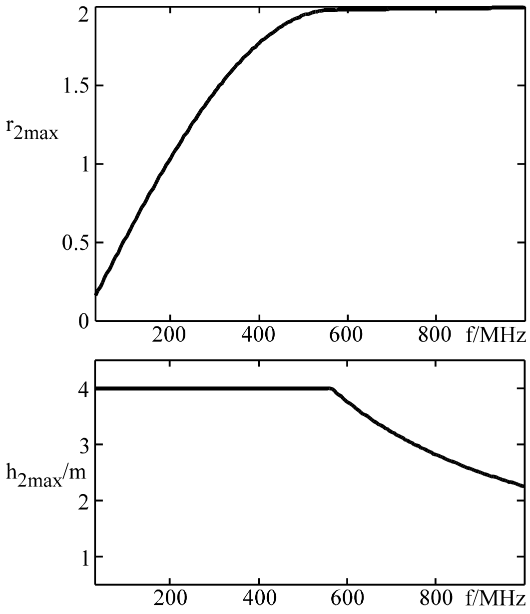

Fig. 6 Conversion factor from 30m free space to 30m OATS and the related maximum scan height for horiz. polarization

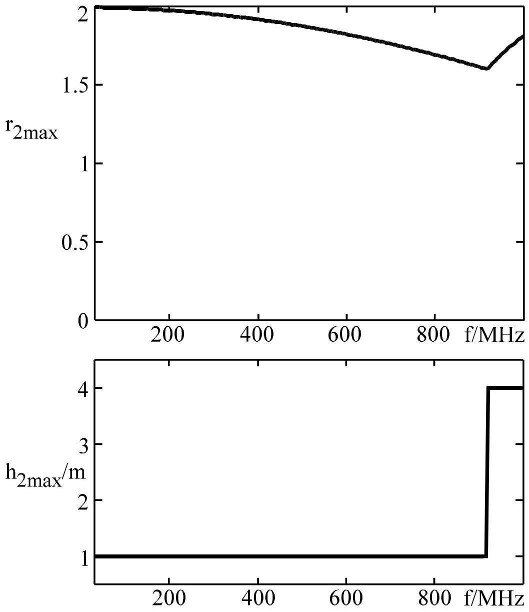

Fig. 7 Conversion factor from 30m free space to 30m OATS and the related maximum scan height for vertical polarization

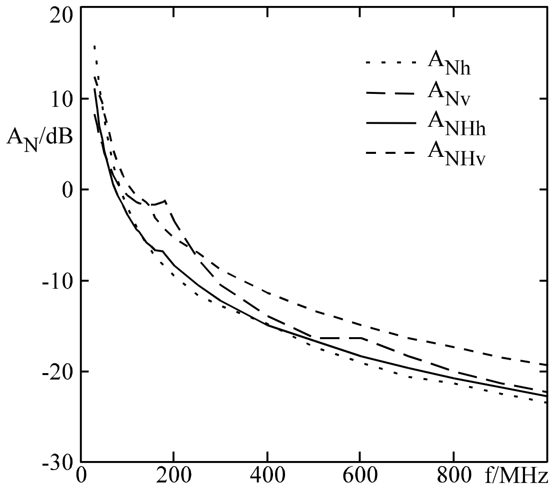

Fig. 8 Theoretical normalized ANSI 3m site attenuation
$_{Nh}$= horizontal h_1= 1m, A_{Nv}= vertical h_1= 1m,
$_{Hh}$= horizontal h_1= 2m, A_{NHv}= vertical h_1= 2.75m)

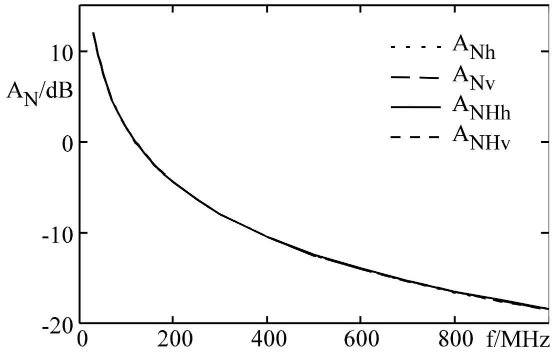

Fig. 9 Theoretical normalized ANSI 3m site attenuation converted to free space (nomenclature see Fig. 8)

2. EXPERIMENTAL VERIFICATION

To verify our theory we designed and tested a fully anechoic chamber (7 x 4 x 3 m) with a measurement distance of 3m, following the ANSI C63.4 / 1992 calibration for alternative sites. Our antennas where basically free space calibrated and traceable to national standards. The ferrite material used for the chamber is manufactured by Kabelwerke Eupen model "Cunico", which presents a reflectivity of typically in between 12 and 19 dB from 30-1000 MHz.

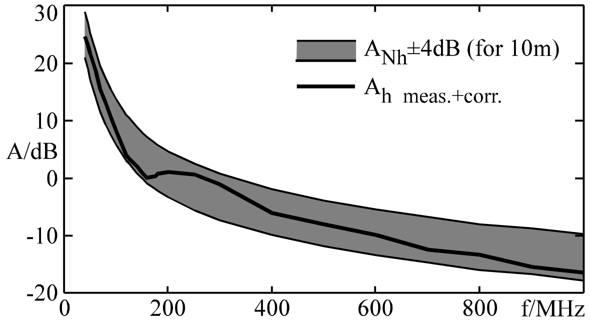

Fig. 10 Horizontal site Attenuation of a 3m FALC correlated to a 10m OATS

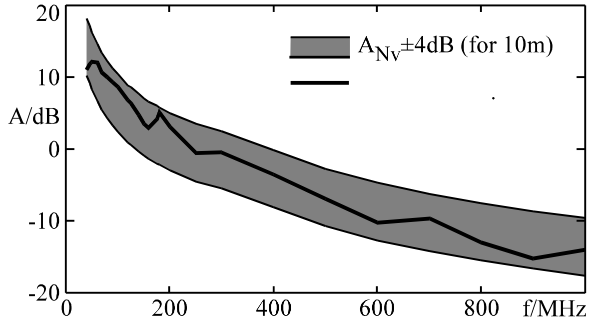

Fig. 11 Horizoal site Attenuation of a 3m FALC correlated to a 10m OATS

The correlation to the 10m OATS was better than ± 4 dB (see fig. 10 and 11).

As ANSI requires for alternative sites we also did a volumetric check, moving the antenna 0.75 m from the center position. We took the diagonal distance for the measurements. The actual used antenna mast and turn table were installed. The following equipment was used, immediately after DKD/R&S external calibration:

- receiver ESVS30 R&S (includes a acking generator, 50 Ohms)
- biconical antenna HK116 R&S
- log. per. antenna HL223 R&S

Additionally we have participated in many round robin tests with other accredited EMC labs, demonstrating excellent agreement within the known tolerances. The investment of the chamber for us was less than 0.35 Mio. US $. The chamber fulfills additionally the immunity requirements (IEC 801-3, ENV 50140). We are using the described chamber since more than two years very successfully with the EES algorithm.

4. REFERENCES

[1] F.B.J. Leferink, D.J. Groot-Boerle, B.R.M. Puylaert, "OATS Emission Data Compared with Free Space Emission Data", Proceedings of the IEEE 1995 International Symposium on EMC, August Atlanta, USA, ISBN 0-7803-2573-7, pp. 333-337

[2] "American National Standard for Methods of Measurement of Radio-Noise Emissions from Low-Voltage Electrical and Electronic Equipment in the Range of 9 kHz to 40 GHz", ANSI C63.4-1992, ISBN 1-55937-212-5

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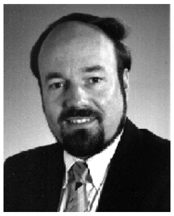
BIOGRAPHICAL NOTES

Dr.-Ing. habil. Detlef Ristau is vice president of EES Teltow near Berlin. He is leading the EES R&D division. Dr. Ristau is holding all engineering, Ph.D. and lecturer degrees from the university of transport Dresden, Germany. He has published numerous scientific contributions in major professional journals and symposia and he is one of the inventors of the EUROTEM. His particular interest includes sophisticated electromagnetic field problems He is a member of the IEEE EMC society of the United States.



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