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Free Space and Absorber Box Methods of Planar Shielding Dawson, J. & Pissoort, D., "Overview of the P2715 WG - IEEE Guide for the Characterization of the shielding effectiveness of Measurement planar material: Double Horn Set-up/Absorber Box"

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Electromagnetic Compatibility (EMC), 2019 IEEE International

Symposium on, 2019

Davy Pissort, KU Leuven, BE With results from: C Stott, BAE Systems, UK F Moglie & V M Primiani, Universita Politecnica delle Marche, IT A Bohbe, CISCO Systems, US

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The free space method - concept

- Why not just shine a beam at the sample ?
- Edge diffraction and reflections make this difficult
- Need a focussed (Gaussian Beam)
- Sample must be large in wavelengths





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The free space method - reality

- Need to focus beam (Gaussian beam)
- Minimise edge diffraction
- Sample must be large in wavelengths
 - 600mm x 600mm sample for 8.2GHz to 12.4GHz.
- May need absorber on and around jig to minimise reflections
- May be able to time gate reflections



See also: Clarke, B., Gregory, A., Cannel, D., Patrick, M., Wylie, S., Youngs, I., & Hill, H. (2003). *A guide to characterisation of dielectric materials at RF and microwave frequencies*. London: NPL



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The free space method - SE

• Thru, Reflect, Line calibration of A Simple calculation of SE used here:

 $SE = -20 \log_{10} S_{12,\text{sample}} \text{ dB}$

- $S_{12,\text{sample}}$ is the transmission between antennas for the jig with sample in place
- Can measure two polarisations by rotating sample and cross polar also if antenna is rotated.











Absorber box method – concept



- Surround one (or both) Antenna(s) with radio absorptive material
- Prevent diffraction and reflections
- No sample edge preparation just overlap
- Works 1-10GHz (current system)

Marvin, A. C.; Dawson, L.; Flintoft, I. D. & Dawson, J. F., "A Method for the Measurement of Shielding Effectiveness of Planar Samples Requiring No Sample Edge Preparation or Contact", *IEEE Transactions on Electromagnetic Compatibility*, *vol. 51, no. 2*, 255-262, May, 2009



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Absorber box method - SE



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• SE using known reference:

$$SE = SE_{ref} + 20 \log_{10} \frac{S_{21,ref}}{S_{21,sample}} dB$$

- $S_{21,ref}$ is the transmission between antennas with known sample having SE_{ref} (in dB)
- $S_{21,\text{sample}}$ is the between antennas with unknown sample in place
- Can measure two polarisations by rotating sample



Absorber box method - reality







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Absorber box method - reality



- In practice we use a known reference sample for calibration
- Proximity of the absorber to RAM means simple free-space assumptions no longer apply
- As sample just sits on absorber no special preparation is required
- Anisotropic materials can be measured easily



Measurement video





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Video showing measurement of reference sheet and sample takes about 90s. The sample edge is prepared with plastic tape to avoid fraying and to protect hands from fibres

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Some results compared to <u>sample 3 ave - 20404E Nonwoven Ni/C 34gsm</u> Mbsorber system, referenced to no sample



Corrected and uncorrected measurements of secondperforated brass plate (in absorber system) and ASTM cell

measurement.

Marvin, A. C.; Dawson, L.; Flintoft, I. D. & Dawson, J. F., "A Method for the Measurement of Shielding Effectiveness of Planar Samples Requiring No Sample Edge Preparation or Contact", *IEEE Transactions on Electromagnetic Compatibility*, vol. 51, no. 2, 255-262, May, 2009



Comparing the free space (BAE), and Absorber box (UoY) average SE with Coaxial (WUST/La Sapienza) and Reverberation chamber measurements for anisotropic material.

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Anisotropic materials – sample #3



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Comparing two orientations for a anisotropic non woven material

See also: Dawson, J. F.; Austin, A. N.; Flintoft, I. D. & Marvin, A. C., "Shielding Effectiveness and Sheet Conductance of Nonwoven Carbon-fibre Sheets", *Electromagnetic Compatibility, IEEE Transactions on*, vol. 59, no. 1, 84-92, Feb, 2017, DOI: 10.1109/TEMC.2016.2601658, Available: http://eprints.whiterose.ac.uk/104001/

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Dynamic range



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Modeled and measured dynamic range of the absorber system with a 300-mm square sample.

Marvin, A. C.; Dawson, L.; Flintoft, I. D. & Dawson, J. F., "A Method for the Measurement of Shielding Effectiveness of Planar Samples Requiring No Sample Edge Preparation or Contact", *IEEE Transactions on Electromagnetic Compatibility*, vol. 51, no. 2, 255-262, May, 2009

Ultimate Shielding Effectiveness (SE) dynamic range for sample sizes (300mm, 350mm, 400mm and 600mm square).

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Conclusions: Free-space and Absorber box



• Pro

- Simple method with no surface preparation of sample required
- Extended low frequency range compared with Free space for given sample size (AB)
 - Low frequency limit is that of antenna
- Good dynamic range
- No need to machine sample to fit jig, a range of shapes an sizes possible
- Fast measurement
- Can measure anisotropic materials
- Can measure features such as joints and seams
- Con
 - Needs relatively large sample compared to some methods
 - Sample size must be a number of wavelengths in size (FS only)
 - Sample must overlap absorber sufficiently to achieve isolation (AB only)
 - Needs reference sample (AB only)
 - Upper frequency limit due to higher order modes in absorber waveguide cavity (AB only)