

Comparison of radiated immunity tests in different EMC test facilities

Holger Streitwolf^{#1}, Ralf Heinrich^{*2}, Heinz-Günther Behnke^{#3}, Lothar Dallwitz^{#4}, Uwe Karsten^{*5}

[#]*Physikalisch-Technische Bundesanstalt, Abbestr. 2-12, 10587 Berlin, Deutschland*

¹holger.streitwolf@ptb.de

³heinz-guenther.behnke@ptb.de

⁴lothardallwitz@gmx.de

^{*}*Teseq GmbH, Landsberger Straße 255, 12623 Berlin, Deutschland*

²ralf.heinrich@teseq.com

⁵uwe.karsten@teseq.com

Abstract— This paper reports about investigations of different EMC test facilities from immunity point of view. A special test device has been developed in order to obtain a quantitative measure for the immunity test. Using this test device different test facilities are compared regarding their repeatability and reproducibility as well as other advantages and drawbacks.

I. INTRODUCTION

The main issue of EMC is to make sure that a device or system is able to function without failure in its intended electromagnetic environment. The occurring radiated coupling between high frequency driven devices respectively their sensitivity to incoming RF power is becoming more and more important in electrical engineering and development of products.

In order to test for radiated immunity several test environments and procedures are applied in EMC laboratories. During the last years different immunity test environments were defined in individual standards, i.e. IEC 61000-4-3 [1] for anechoic chambers, IEC 61000-4-20 [2] for TEM waveguides, IEC 61000-4-21 [3] for reverberation chambers and the future IEC 61000-4-22 [4] for fully anechoic rooms. However, many product standards still reference the IEC 61000-4-3 and do not use one of the other methods, although they may be equally or even better suited for the individual tests.

The suitability of different test environments shall be investigated or at least reviewed based on existing knowledge in order to motivate product committees to update their references. Preferably the best suited test environment for each product should be used. The Physikalisch-Technische Bundesanstalt (PTB) as the independent federal metrology institute in Germany has done [5] and is doing research on this topic for determining the applicability and comparability of test facilities.

The aim of this paper is the discussion of advantages and drawbacks of different test facilities from the immunity point of view. The discussion is based on our recent investigations.

II. TEST FACILITIES

The following test facilities were part of our investigations and will be discussed in the paper:

- a large anechoic chamber 21 m x 18 m x 9 m.
- a smaller fully anechoic chamber 5 m x 10 m x 5 m
- a GTEM 1750 and
- a small reverberation chamber 2.5 m x 4 m x 2.4 m

Fig. 1a-c show the test facilities used for our investigations.



Fig. 1a Anechoic chamber



Fig. 1b GTEM cell



Fig. 1c Reverberation chamber

III. TEST DEVICE

Radiated immunity tests usually give only a simple pass or fail. Therefore a special test device has been developed in order to obtain a quantitative measure as in emission tests which depends on the test field strength.

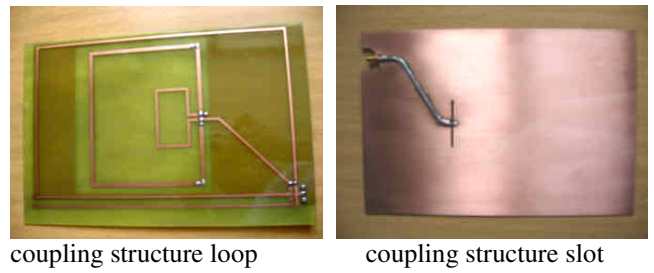
In order to get reliable comparison results several requirements should be fulfilled by the test device. The most important requirements (among others) are:

- high stability for good repeatability and reproducibility of test results
- portable, preferably battery operated and fiber optic remote controlled in order to avoid unwanted coupling into the power supply or data transmission to and from the test object. RF field coupling should instead be possible via defined coupling structures.
- dimensions as “real” test objects for realistic loading and field distortion properties

A test device was developed based on these demands. The core of the test device is a portable measurement receiver from 9 kHz up to 2.75 GHz. Different coupling structures can be attached to the measurement receiver, a loop and a slot antenna. The antenna structure is directly connected to the input of the measurement receiver via a mechanically robust semi-rigid cable. Fig. 2a shows the test device. Fig. 2b shows the two corresponding coupling structures.



Fig. 2a Test device for immunity tests



coupling structure loop coupling structure slot

Fig. 2b Coupling structures for test device

IV. MEASUREMENTS

Repeatability and reproducibility tests were performed in all test facilities. The repeatability, i.e. repeating a measurement in the same setup with the same test object was very good for both coupling structures in the investigated facilities.

Fig. 3 shows, as an example, the repeatability in the anechoic chamber using the slot coupling structure. The maximum deviation was less than 0.1 dB.

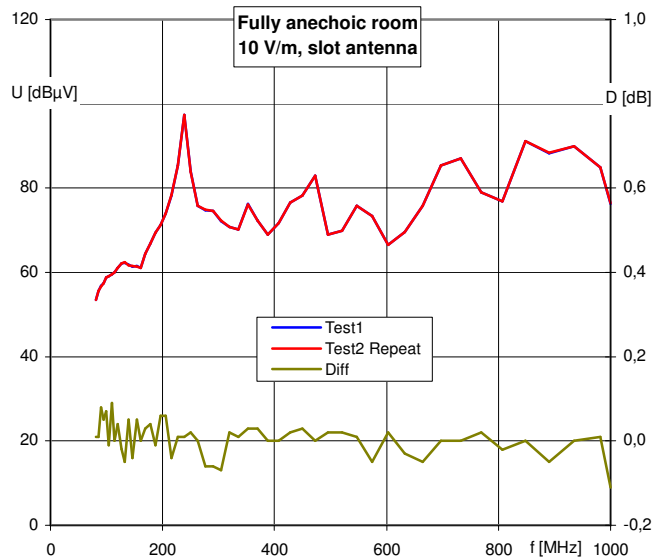


Fig. 3 Repeatability test in an anechoic chamber

Reproducibility tests were performed using different positions of the test device. Depending on the displacement of the test device different results were achieved in the test facilities as described below.

A. Anechoic chamber

Fig. 4 shows the influence of the DUT position using the loop coupling structure. Small deviations of the DUT positioning of some cm within the uniform field area show deviations of less than 6 dB. Similar results were achieved for the slot antenna.

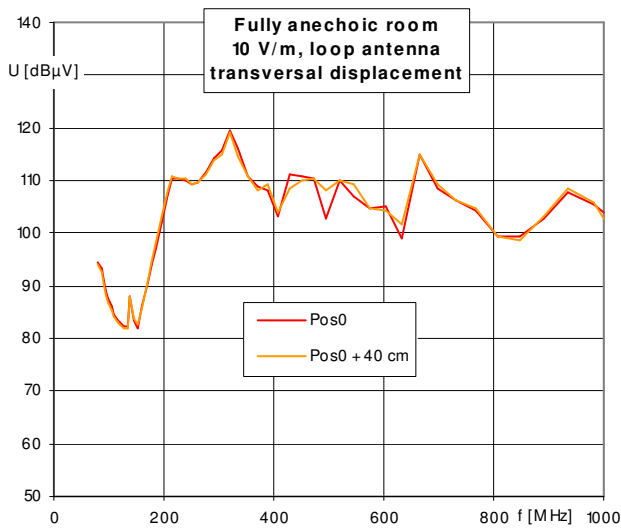


Fig. 4 Reproducibility test in an anechoic chamber using the loop coupling structure

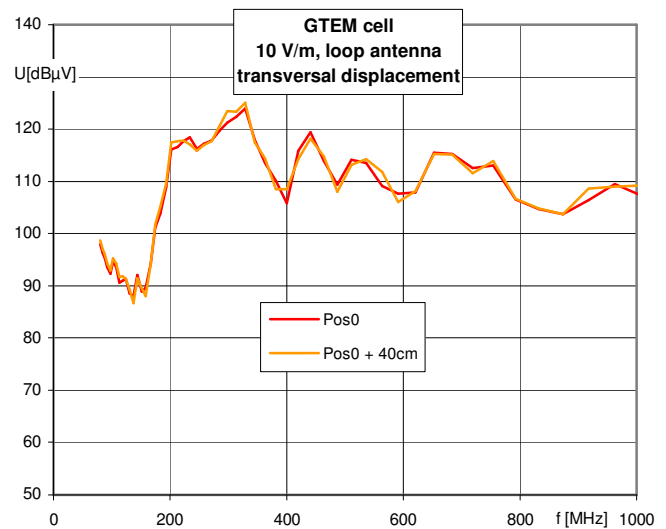


Fig. 6 Reproducibility test in a GTEM cell using the loop coupling structure

B. Reverberation chamber

A similar test was done in the reverberation chamber. The test device was placed in 2 different positions in the test volume of the reverberation chamber, which were 40 cm apart from each other. Both coupling structures were used. The maximum deviation was 2.2 dB for the loop coupling structure and 2.5 dB for the slot coupling structure.

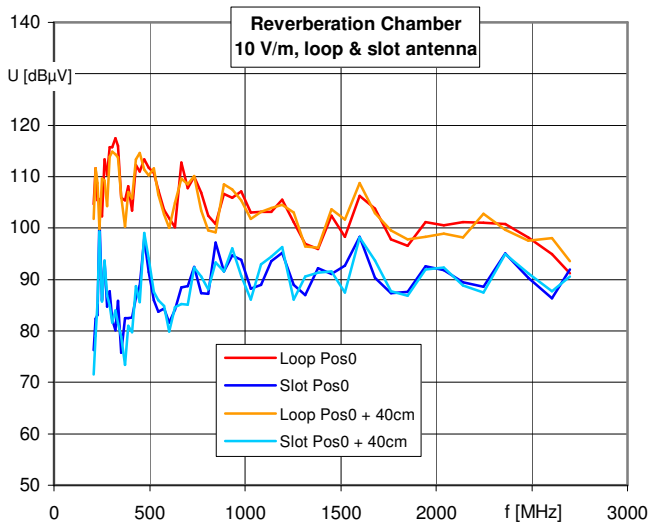


Fig. 5 Reproducibility test in a reverberation chamber using the slot & loop coupling structure

C. GTEM

A good reproducibility was also found in the GTEM cell as shown in Fig. 6. The test device was placed at two different locations at the uniform field area (horizontally displacement 40 cm, septum height 1516 mm). The maximum deviation was less than 2.6 dB for both coupling structures.

V. DISCUSSION OF THE TEST FACILITIES

Historically the anechoic chamber served as a reference method. It has not any fundamental limits regarding the test object size (provided that the chamber is big enough) and is suitable up to a very high frequency range.

Drawbacks of the anechoic chamber are high investment costs for the chamber as well as for the amplifiers, as the anechoic chamber has higher input power demands for a certain field strength than other test facilities.

The reverberation chamber has several advantages, i.e. a good reproducibility of the measurements also in completely different reverberation chambers, a large test volume in respect of the chamber size and a test field strength coming from all directions without turning of the DUT. The most popular advantage is the very low input power requirement even taking the loading of the DUT and modulation into account. The investment costs are relatively low, depending on the size of the chamber.

The reverberation chamber operates from a lowest usable frequency. Low frequencies, such as 80 MHz for example require very large chambers of 12 m length or more. Furthermore testing is not efficient in the lower frequency range because a large number of stirrer steps is required in order to achieve the desired field homogeneity. Therefore the use of reverberation chambers is most beneficial only in the higher frequency range above several 100 MHz.

The GTEM cell provides a good reproducibility and is easy to use. No additional antenna is needed and therefore no cabling inside the cell which may influence reproducibility. It requires less input power than the anechoic chamber. The test object size is limited by the size of the cell.

An additional issue besides the selection of the test facilities according their suitability, advantages and drawbacks is the determination of limits for each test facility and method. Comparison tests using the test device can

provide first results regarding this issue. The comparison measurements were performed in different test facilities which were calibrated using field probes of less than 1.3 dB calibration uncertainty.

In spite of the independence of the test facilities their test severity is quite similar as shown in Fig. 7. However, more research is needed in order to gain more experience and reliability for different test devices, especially large DUTs.

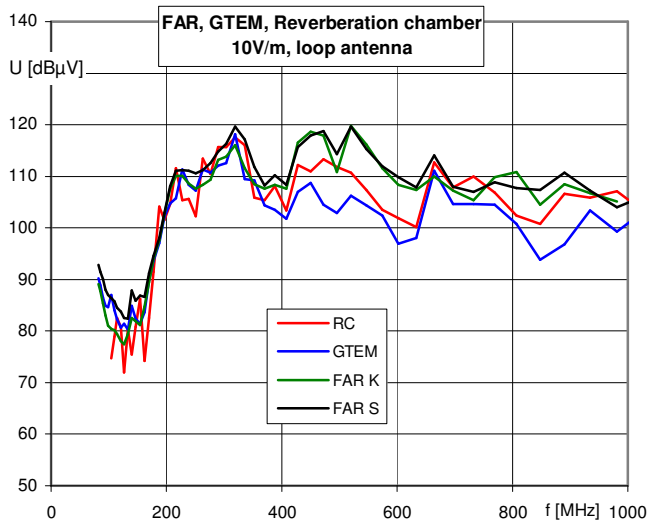


Fig. 7 Immunity tests in different test facilities

VI. CONCLUSIONS

A special test device for test and comparison of different immunity test facilities has been developed. This test device allows traceability of the immunity test to a measurable quantity for comparison of different test facilities.

Two anechoic chambers, a GTEM cell and a reverberation chamber were investigated. The repeatability was very good in all test facilities, but they react differently to a displacement of the test object.

Further experiments are planned, especially in the frequency range above 1 GHz and regarding large test objects using power supply and/or data connection lines connected to the DUT. Furthermore we are working on the characterisation of the test device for numerical simulations.

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