EVALUATION OF E-FIELD UNIFORMITY FOR IMMUNITY TESTING IN A REVERBERATION CHAMBER

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1. Introduction

Testing for immunity against electromagnetic disturbances has become an important aspect of preventing malfunctions in electronic equipment, particularly medical equipment, caused by mobile and other radio transmitters. Radiated immunity tests are generally performed in an anechoic chamber as a standard method [1]. However, reverberation chamber and TEM waveguides, such as a stripline and a TEM-cell, are discussed with IEC and CISPR as an alternative or new testing to conventional measurement, which uses an anechoic chamber [2]-[4].

The reverberation chamber is a shielded enclosure equipped with one or more mechanical stirrers [5]-[8]. The stirrers are used to vary the electromagnetic boundary conditions to obtain a statistically uniform field in the chamber. Therefore, the field in a reverberation chamber, in which the direction of polarization changes randomly by the stirrers, is different from that of an anechoic chamber. Determining the number of stirrer positions and measurement locations for a given test volume in a reverberation chamber is important because they affect the uniformity and field calibration of the test volume.

We have experimentally evaluated the effect on field uniformity of the number of stirrers, their positions, and the number of locations measured for the case of a reverberation chamber applied to radiated immunity testing.

2. Field evaluation in a reverberation chamber

The reverberation chamber consists of a shielded enclosure equipped with stirrers to change the field boundary conditions. A statistically uniform field is created in the chamber by rotating the stirrers. The equipment-under-test (EUT) is placed into a rectangular test volume defined as a uniform volume in the chamber, as shown in Fig. 1.

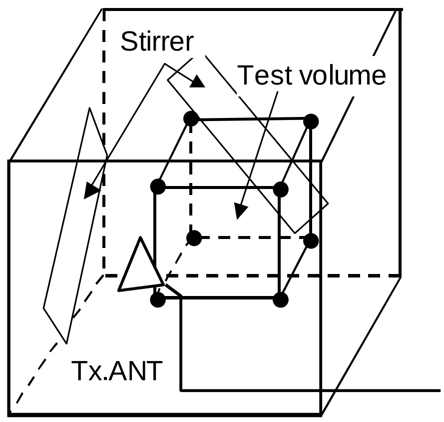
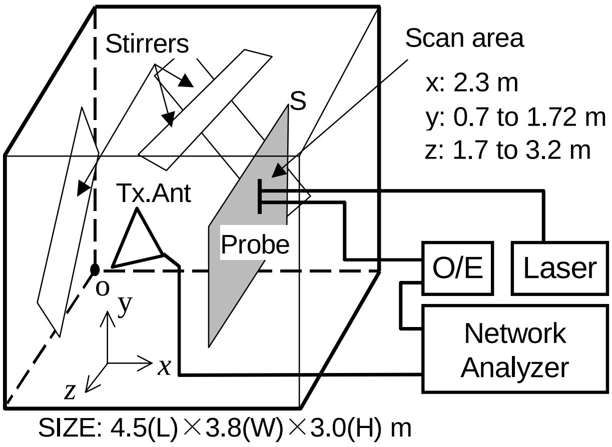
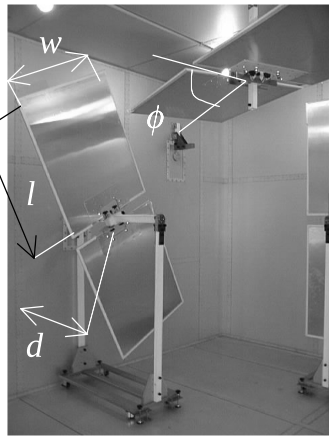


Fig. 1. Test volume in reverberation chamber.

The evaluation of the uniformity in the test volume is derived from the variation in the maximum electric field strength obtained during one rotation of the stirrers, i.e., until the stirrers return to their initial positions, for each E_x, E_y, and E_z component in the test volume. In practice, the number of locations measured in the test



(a) Measurement system



(b) Stirrer

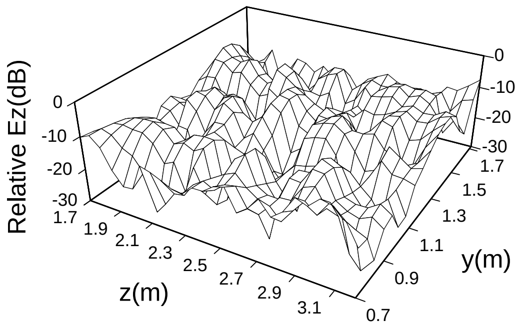
Fig. 2. Experimental set-up

volume and the number of stirrer positions are limited by the time required to measure the field strength for each three-directional component over the volume. The tolerance in uniformity proposed in IEC/TC77B for immunity testing is within 0 to 6dB of the distribution of the total components for over 75% of eight probe locations which defined at the corners of the test volume, i.e., at least 18 of the 24 data (= 8 locations×3 components) are within the tolerance [2]. However, the number of stirrer positions and probe locations affects the uniformity and field calibration of the test volume in the reverberation chamber.

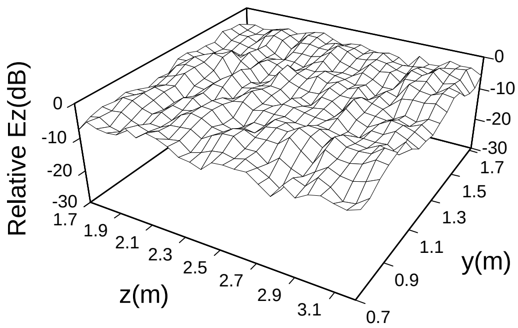
3. Experiment

The experimental set-up we used to evaluate the reverberation chamber is shown in Fig. 2. A field-generating antenna and a field-monitoring opto-electronic probe with a dipole 5 cm long were placed in the chamber and connected to a network analyzer. A log periodic or double ridge horn antenna corresponding to the frequency was used. The chamber was a shielded enclosure equipped with one, two, or three stirrers, each composed of two aluminum plates.

We measured the distributions of the maximum E-field strength over the stirrers return to their initial state at 300 MHz to 3 GHz for each E_x, E_y, and E_z component at each measurement location on plane S. The probe was scanned on the plane (z: 1.7 to 3.2 m, y: 0.7 to 1.72 m) in 6 cm steps; the total number of probe locations was 468. The stirrer's parameters were w = 0.9 m, l =1.2 m, and ϕ = 0 deg for all experiments (see Fig. 2 (b)).



(a) Stirrers stopped

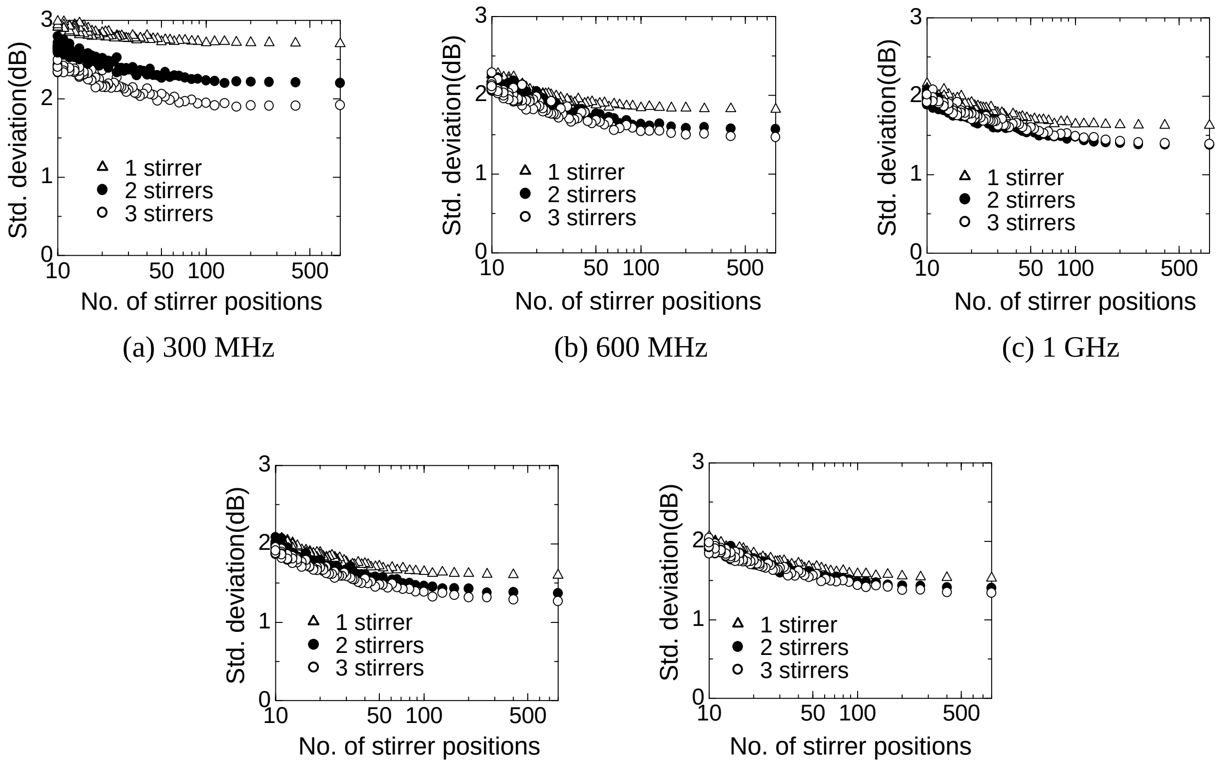


(b) Stirrers rotating

Fig. 3. Distributions of E_z component at 600 MHz on measurement plane.

4. Results

The distributions of the maximum strength of the E_z component on plane S when the three stirrers were stopped and when they were rotated at 600 MHz are shown in Fig. 3. This result indicates that the statistically uniform field can be obtained by rotating the stirrers. Figure 4 shows the relations between of the number of stirrer positions during one rotation of the stirrers and the standard deviations of the total components (E_{total}) of E_x, E_y, and E_z at 300 MHz to 3 GHz for one, two, or three stirrers rotating. The variations in the E_{total} distribution obtained by two stirrers, when the number of



(a) 300 MHz (b) 600 MHz (c) 1 GHz (d) 2 GHz (e) 3 GHz

Fig. 4. Effect on uniformity of the number of stirrers and stirrer positions

Table 1 Effect on uniformity of the number of stirrer positions.

Freq.	Variation (dB)							
	100 positions		50 positions		20 positions		10 positions	
	$E_{75\%}$	$E_{95\%}$	$E_{75\%}$	$E_{95\%}$	$E_{75\%}$	$E_{95\%}$	$E_{75\%}$	$E_{95\%}$
300 MHz	5.54	9.88	5.65	9.95	6.21	11.61	7.01	12.64
600 MHz	4.18	6.87	4.55	7.45	5.23	8.92	5.89	10.29
1 GHz	3.60	6.44	4.03	6.80	4.56	7.86	5.39	9.30
2 GHz	3.74	6.12	3.99	6.52	4.63	7.58	5.54	9.26
3 GHz	3.74	6.21	4.04	6.41	4.60	7.42	5.38	8.67

Two stirrers rotated; 468 probe locations

$E_{75\%}$: 12.5% to 87.5%; $E_{95\%}$: 2.5% to 97.5% (in cumulative probability) stirrer positions was 10 to 100, are listed in Table 1.

The uniformity was improved slightly by increasing the number of stirrers from two to three stirrers, except at near lowest frequency like 300 MHz, although the best uniformity was always obtained by using three stirrers. In addition, sufficient uniformity was obtained with about 100 stirrer positions and was not improved much by increasing the number of stirrer positions further.

Figure 5 shows the maximum, minimum, and averaged values of the maximum field distributions against the number of probe locations measured on the plane when using two stirrers rotating at 600 MHz. The field uniformity became better apparently when the number of locations was reduced. For example, the variation in the max-to-min at 15 locations was 5.5 dB better than that at 468 locations.

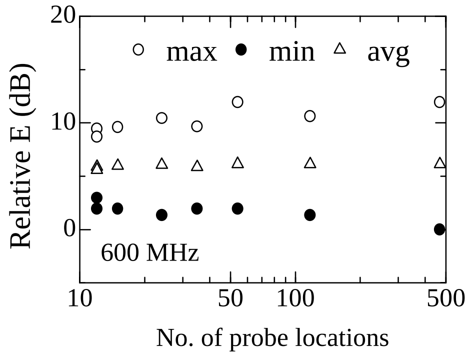


Fig. 5. Effect of number of measurement locations.

The variation in the distribution may appear smaller than the actual variation when the uniformity is evaluated at a few measurement locations such as described in the proposal to IEC/TC77B [2][3].

5. Conclusion

We have experimentally evaluated the effect on the field uniformity of the number of stirrers, their positions, and the measurement locations, in a reverberation chamber used for the radiated immunity testing.

We found that (1) sufficient field uniformity was obtained by using two stirrers; (2) uniformity was not improved much by using more than 100 stirrer positions; and (3) the uniformity evaluated using a few measurement locations appeared better than the actual uniformity.

References

[1] Publication IEC 61000-4-3, "Radiated, Radio-frequency, electromagnetic field immunity test."

[2] IEC 77B/273/CDV, 1999.

[3] IEC 77B/260/CD, 1999.

[4] CISPR Publication 16-1, "Reverberation chamber for total radiated power measurement," 1996.

[5] M. L. Crawford and G. H. Koepke, "Design, evaluation, and use of a reverberation chamber for performing electromagnetic susceptibility/vulnerability measurements," *NBS Tech. Note 1092*, April 1986.

[6] D. A. Hill, D. G. Camell, K. H. Cavcey, and G. H. Koepke, "Radiated emissions and Immunity of microstrip transmission lines theory and reverberation chamber measurements," *IEEE Trans. Electromagn. Compat*., vol.EMC-38, no.2, pp. 294-299, Nov. 1994.

[7] P. Corona, G. Ferrara, and M. Migliaccio, "Reverberaing chambers as sources of stochastic electromagnetic fields," *IEEE Trans. Electromagn. Compat*., vol.EMC-38, no.3, pp. 348-356, Aug. 1996.

[8] K. Harima, "FDTD Analysis of Electromagnetic Field in a Reverberation Chamber," *IEICE Trans. Commun*., vol. E81-B, no. 10, pp. 1946-1950, Oct. 1998.