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Bolton, MA
USA

MIMO/OTA Test Methodology Consideration for Small Anechoic Chambers

Fanny Mlinarsky
Ron Cook
octoScope, Inc.
225 Cedar Hill Street
Suite 200
Marlboro, MA 01752
USA
Phone: + 1.978.376.5841
Email: fm@octoscope.com

1. Introduction

Single-cluster MIMO/OTA measurements can be accommodated by small anechoic chambers that are modestly priced and have minimal space requirements.

This contribution explores geometry requirements pertinent to single cluster measurements per TR 37.976 [1]. This test methodology falls under the anechoic solutions 1 and 2.

According to TR 37.976 [1], a single cluster exhibits rms angular spread of 35°, which calls for a peak angular spread distribution of about 90°. To accommodate 90° angular spread, the chamber needs to be approximately square in 2 of its dimensions, as shown in Figure 1. The distance between the DUT and the probes must meet far-field distance requirement for all the frequencies and DUT formfactors of interest.

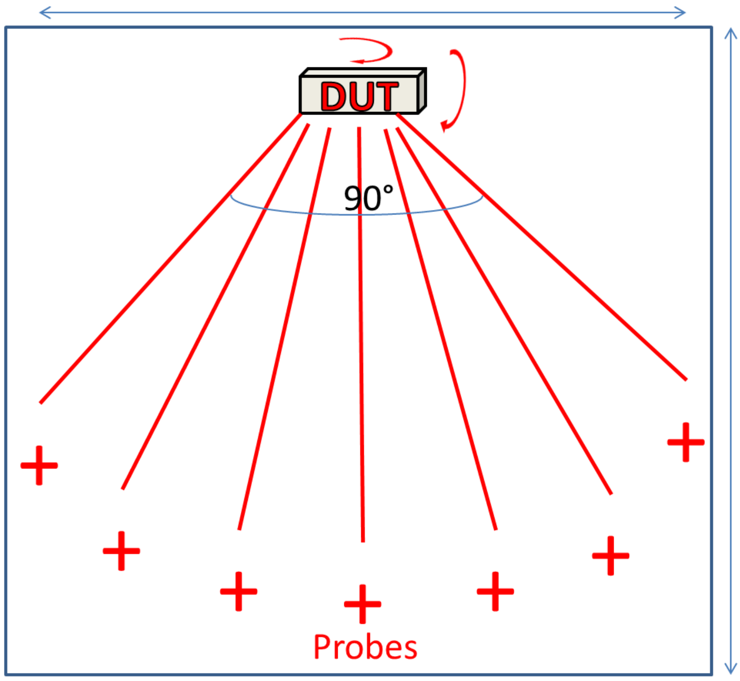

Figure 1: *Example of a small anechoic chamber designed for single cluster measurements.*

Thus, the dimensions of a small anechoic chamber are dictated by the far-field requirement. So, this contribution examines the far field requirements and poses two questions to the group:

1. Does the definition of far-field need refining? Or could the group specify a way to measure the far-field distance of a DUT?

2. Is it OK to relax peak spread from 90° down to a smaller angle, of for example, 60°?

2. Far-field definition

Draft 37.976 v1.50 [1] does not define far-field distance and instead references 3GPP TS 34.114: "User Equipment (UE) / Mobile Station (MS) Over The Air (OTA) Antenna Performance Conformance Testing" [2], presumably for a variety of parameters, including the definition of far-field.

TS 34.114 [2] defines far-field distance in E.9.3 as follows:

$$r > \max\left(\frac{2D^2}{\lambda}, 3D, 3\lambda\right)$$

where λ is the wavelength of the measurement frequency and *D* the maximum extension of the radiating structure.

Applying this formula to a typical small chamber with the spread of probes at 0.5 meter (figure 1), yields far-field distances and angular spreads summarized for typical laptops and handsets in Tables 1 and 2 respectively. The far-field distance dictates the height and width of the chamber, which may be approximately equal to attain the peak angular spread of 90°.

Table 1: Laptop formfactor (D = 0.33 m):

Far-field distance per [2], m	$2D^2/\lambda$, m	3D, m	3λ, m	f, MHz	λ, m
1.50	0.44	0.99	1.50	600	0.50
1.28	0.51	0.99	1.28	700	0.43
1.00	0.73	0.99	0.90	1000	0.30
1.45	1.45	0.99	0.45	2000	0.15
4.36	4.36	0.99	0.15	6000	0.05

As is evident from Table 1, angular spread is less than 1.5 meter for most laptop cases, except for the last line in the table, which appears to be an anomaly.

Table 2: Handset formfactor (D = 0.1 m):

Far-field distance per [2], m	$2D^2/\lambda$, m	3D, m	3λ, m	f, MHz	λ, m
1.50	0.04	0.3	1.50	600	0.50
1.28	0.05	0.3	1.28	700	0.43
0.75	0.08	0.3	0.75	1200	0.25
0.45	0.13	0.3	0.45	2000	0.15
0.40	0.40	0.3	0.15	6000	0.05

Handset configurations present less of an issue for small chambers with the far field still reaching 1.5 m.

3. Discussion of far-field

For small anechoic chambers, since far-field distance determines their size and cost, it is important to know the far-field distance more definitively than for traditional chambers that are not similarly constrained.

There is also a potential issue of phase curvature of the probes that could introduce an error. In addition to specifying far-field, TS 34.114 [2] specifies in E.9.3 an error due to phase curvature. This error is said to originate from the finite far-field measurement distance, which causes phase curvature across the DUT. If the measurement distance is >10λ, this error is assumed to be negligible. The document goes on to state that at 2 GHz λ is 0.15 m, thus 10λ is 1.5 m, which is a safe distance for measurement accuracy. The document does not explain why 2 GHz is significant and whether at other frequencies a distance of 10λ is warranted.

In summary, there exists some level of confusion of the required distance between the probes and the DUT.

3. Measuring far-field

It is generally accepted that far-field antenna radiation is characterized by path loss proportional to 1/r [3], whereas near-field radiation is characterized by path loss proportional to $1/r^2$ or $1/r^3$ or a product thereof, as shown in Figure 2.

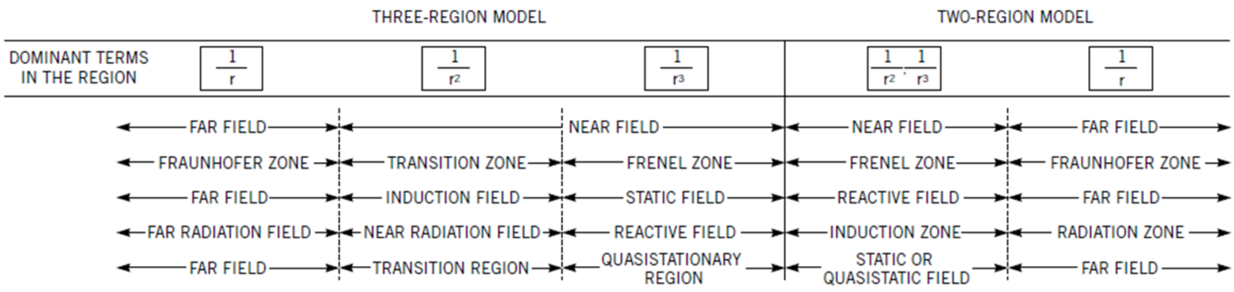

Figure 2: 2 and 3 region far-field models described in [3]

Could far-field be characterized by measuring field strength vs. distance for a range of DUT orientations, for example?

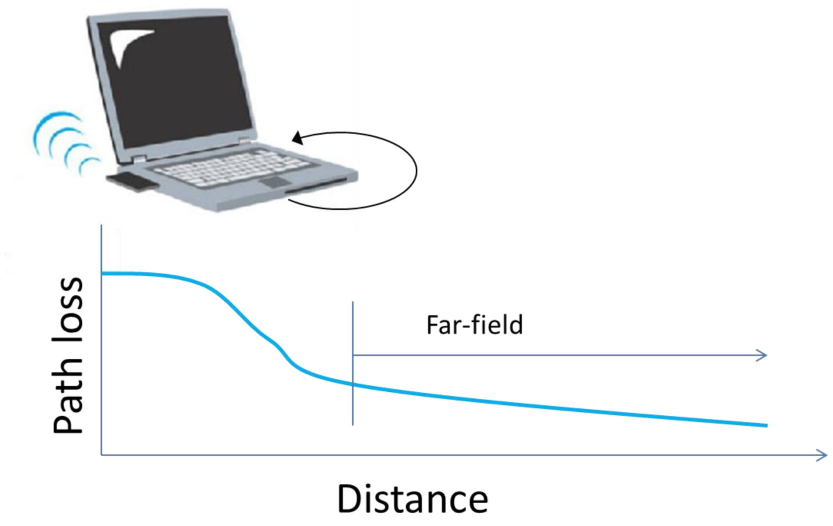

Figure 3: *Example of a method to determine far-field for a DUT – by measuring path loss vs. distance from the radiating antenna and looking for transition in slope to a slope dominated by 1/r factor.*

4. Conclusion and questions for the group

This contribution is intended to facilitate the design of small anechoic chambers for single-cluster MIMO/OTA measurements.

For optimizing the cost and size of a small anechoic chamber, it may be helpful to know the far-field more precisely than defined by the standards today.

Thus, the first question to the group is: could we better define the far-field requirement or would it make sense to define a test methodology for measuring the far-field of a particular DUT?

The second question is: could the angular spread requirement be reduced down from 90° down to 60° in order to reduce the width of the chamber?

5. References

[1] R4-112505 MIMO OTA technical report update: TR 37.976 Version 1.5.0

[2] 3GPP TS 34.114: "User Equipment (UE) / Mobile Station (MS) Over The Air (OTA) Antenna Performance Conformance Testing"

[3] Charles Capps, "Near field or far field?", EDN, Aug 16, 2001

[4] CTIA, "Test Plan for Mobile Station Over the Air Performance - Method of Measurement for Radiated RF Power and Receiver Performance", Revision 3.1, January 2011