Characterising the Quiet Zone of an Anechoic Chamber

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Abstract

For accurate measurements, it is important to know the size and quality of the quiet zone of an anechoic chamber. It is also important to know the approximate direction from which the worst reflections come. The standard way to determine this is by means of a free-space VSWR test, which involves scanning a medium gain horn within the required region of the chamber. This method is practical for anechoic chambers with large dimensions in wavelengths, but where small chambers with dimensions of only a few metres are used at low frequencies, the horn dimensions become restrictive Moreover, the scanned region becomes electrically smaller and inverting the recorded data back to the sources of reflection is more challenging. This paper explores some different methods using smaller antennas.

Introduction

This paper addresses the problem of finding the location and level of unwanted scatterers in an electrically small anechoic chamber, and, specifically, a small far-field chamber operating at 900MHz.

Traditionally, a chamber is evaluated by the Free-Space VSWR method [1], a probe being scanned linearly in the region where the antenna under test (AUT) is to be located. Fluctuations in field are measured against distance and the periodicity and peak-to-peak values of these fluctuations are used to calculate the strength of the unwanted scatterers. FFT based algorithms can be applied when both amplitude and phase data has been recorded. The incident wavefronts are initially decomposed into a distribution of apparent sources, then the position and level of each source calculated. This method can be viewed as a synthetic aperture imaging technique.

Unfortunately, this approach has some drawbacks. It can only cover a limited view in a single scan and a linear positioner is needed for ease and accuracy. If the probe does not have a high enough front-to-back (F/B) ratio, it produces an ambiguous result, but a probe with such a high F/B ratio will necessarily be electrically large and therefore physically large at low frequencies.

The technique to be described employs a circular scan, which utilises a conventional azimuth positioner. A directive response is synthesised by software processing, which allows the beam to be scanned in azimuth to evaluate a source in that direction[2]. This method is essentially the formation of a steered circular array and is the circular counterpart of the linear free-space VSWR method. The procedure is shown in Figure 2.

In such a scan, the phasing used to maximise the response in a given direction serves to cancel the rear response, which is not the case for a linear geometry. For electrically large scans (of say tens of wavelengths in diameter) this phasing is very effective in improving the F/B ratio. However, for the small chamber situation at low frequencies the benefits are much smaller.

In this contribution, several probe configurations are examined. A novel scheme is proposed to overcome the difficulty of a poor F/B ratio.

The Experimental Process

Figure 1 shows the experimental configuration for a typical far-field chamber. The AUT is mounted on a turntable opposite the range antenna and the measurements taken on a network analyser, both the analyser and turntable being computer controlled. To take scans, the probe antenna is placed on a boom mounted on the turntable. To minimize the effect of this boom, it was made from Rohacell (a low dielectric material similar to expanded polystyrene). A full 360 degree pattern measurement is taken, recording both amplitude and phase.

To illustrate the problem of using a low gain probe, a measurement was made using a sleeve dipole operating at 885MHz on a circular scan of

510mm radius, with data recorded at 8 degree intervals. Figure 3 shows the characteristic of the empty chamber obtained after processing the data, with the highest response being in the direction of the range horn. This scan is three wavelengths in diameter, giving an F/B ratio of approximately 6dB. It is clear that this is unacceptable, so it becomes necessary to utilise other approaches to make measurements more unambiguous.

The first improvement is achieved by using a corner reflector as the probe, to provide higher directivity. A corner reflector with an area of $1200cm^2$ was used and Figure 3 shows the result when this new probe was used, the F/B ratio improving to 17dB. A further improvement was achieved by increasing the reflector size to $2100cm^2$, and Figure 3 shows that this increased the F/B ratio to 27dB. However, despite these improvements, the performance is still not adequate to evaluate a typical low-reflectivity chamber. It was then decided to further improve the probe radiation pattern using array synthesis in the radial direction. Two scans were made with a difference in radius of 85mm, which is λ /4 at 885MHz. In the subsequent data processing, at each angular position, the samples from the two scans were phased to produce an endfire array, which gives a null in the backward direction. Figure 3 shows the improvement achieved, with the F/B ratio of the synthesised response being greater than 40dB.

To validate the method, an artificial scatterer was introduced into the chamber. This was done by splitting the feed to the range antenna, the second antenna being placed in the rear corner of the chamber. The resulting scan is shown in Figure 4, where the presence of this second source is clearly seen.

In examining the results, it is important to separate probe pattern contributions from the effects due to the chamber itself. Thus, the response expected from an ideal chamber with only the range antenna present is needed. This was generated using the measured pattern of the corner reflector taken in phase and amplitude. The effect of rotating an antenna with this pattern on a boom arm in an ideal chamber was then simulated. This result was normalised in phase and amplitude by comparison with the measured chamber response, normalisation being done using the peak values of each data set. The two sets were then correlated in angle to establish the position giving the minimum difference between them before being subtracted to give a difference. Figure 5 shows the result of this process, which is a plot of the azimuthal scattering distribution within the chamber. Generally, over a 280 degree range, the level is around -40dB and so this should not significantly perturb antenna measurements.

Before the chamber was constructed, a simulation was performed to predict its performance. This indicated that the worst reflection would be <-36dB and would come from the chamber sides.

However, two other features still remain to be explained, both in angular directions near the range horn. The larger of these is at an angle of -27 degrees from boresight and corresponds to possible scattering off the chamber walkway. The other response is likely to originate from inaccuracies in the characterisation of the probe. In measuring the probe pattern, it was not possible to do so in an ideal chamber, as it was actually measured in the chamber being characterised. In this case, we might expect the errors to be from the walkway scattering, so it is useful to model the situation. Accordingly, it was assumed that a scatterer of level -20dB relative to the main response was located at an angle of -27 degrees and a probe with a cosine-squared pattern over its forward half-space was used. The results of this simulation are shown in Figure 6 and very similar features are seen to those present in Figure 5. Thus, it can be seen that the lower response is due to the basic probe pattern measurement error contribution. Furthermore, this contribution is responsible for a small error in retrieving the amplitude of the -20dB scatterer.

Conclusions

A method of characterising a small anechoic chamber has been demonstrated. The main error source in the chamber has been found without the need for large antennas or linear positioning equipment. In the near future, the chamber walkway will be redesigned and the tests repeated. Further scans will be taken at different heights from the turntable and the information used to synthesise a beam in the elevation direction, allowing the chamber to be fully characterised.

Acknowledgements

The authors would like to thank Tim Palmer for an explanation of the chamber design.

[1] "IEEE Standard Test Procedures on Antennas" ANSI/IEEE Std. 149-1979, pp.56-57

[2] Bennett, J C and Chambers, B: "Identification of unwanted scatterers on a free-field EMI test range". IEE Proc., 130, Part F, October 1983, pp.548-556.

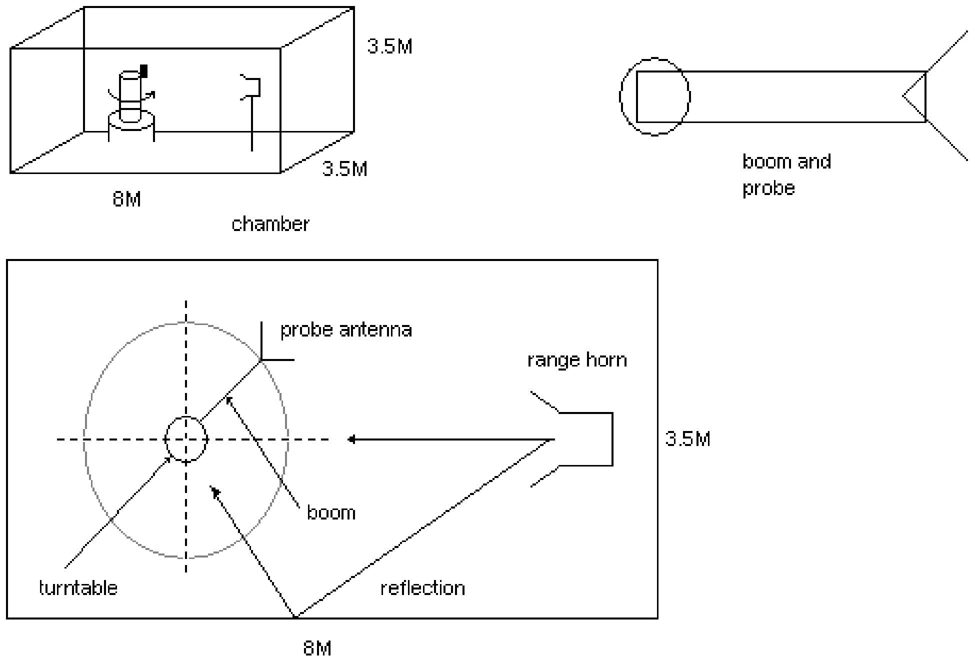

Figure 1.

Procedure

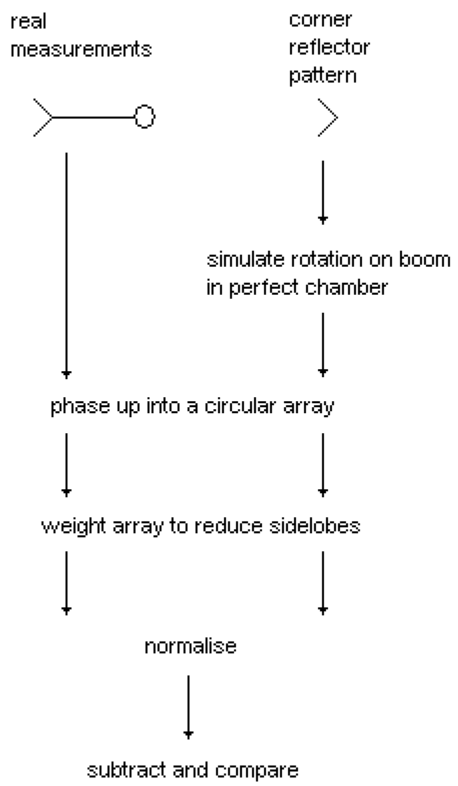

Figure 2.

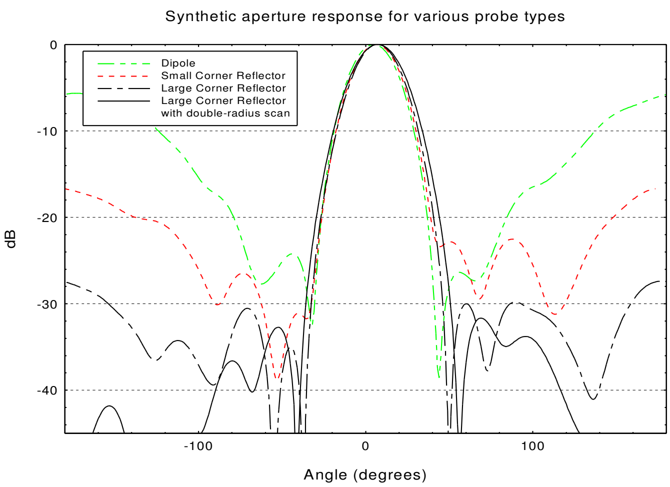

Figure 3.

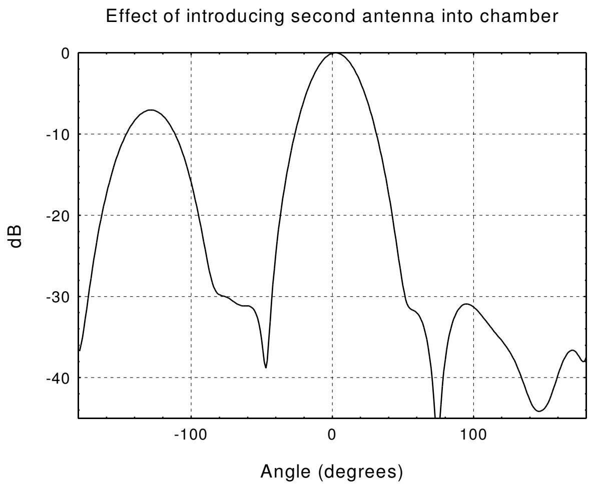

Figure 4.

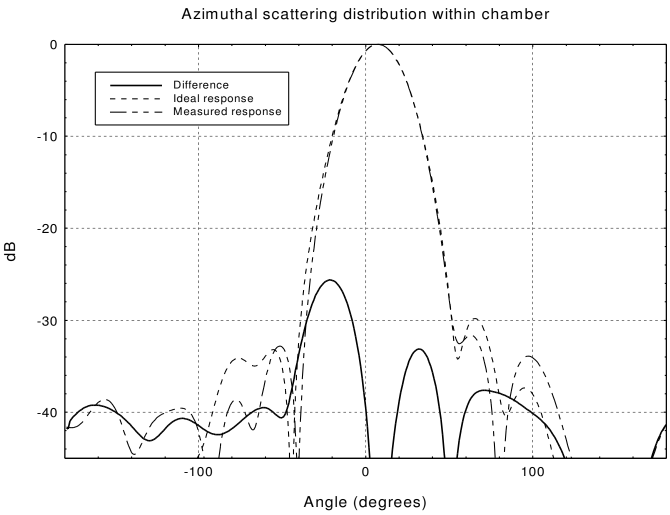

Figure 5.

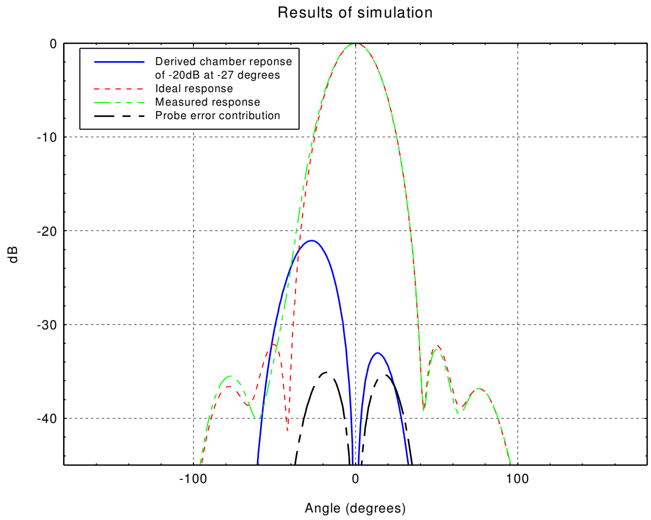

Figure 6.