ANECHOIC CHAMBER EVALUATION

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ABSTRACT

This paper details the evaluation of a major aerospace company's tapered anechoic chamber. Using an NSI 3' x 3' near-field scanner and software, the chamber was evaluated at 11 frequencies and two polarizations. SAR imaging techniques were used to map the chamber reflections. A new addition to the software provided the ability to map the difference between the measured phase front and the theoretical spherical phase front; the software also derives the x, y, and z phase centers of the source. Error estimates for all aspects of the evaluation will be discussed.

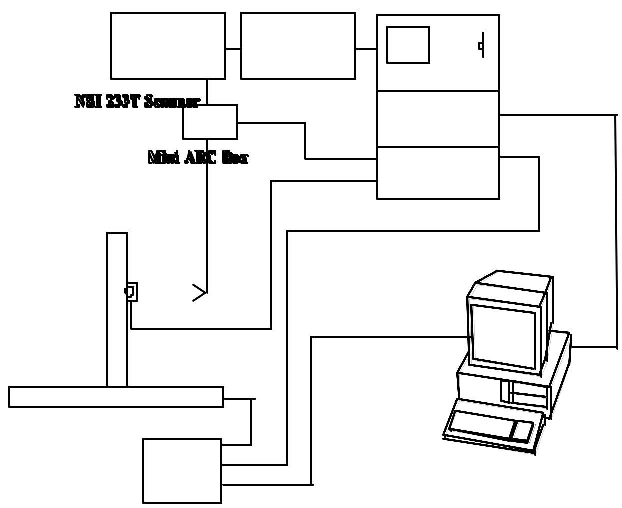
Keywords: Measurement Diagnostics, Near-Field, Planar, Scanners.

1. INTRODUCTION

In response to customer driven requirements to identify error sources involved in testing their hardware, Nearfield Systems was contracted to evaluate a major aerospace company's tapered chamber. The objective of this evaluation was to identify multipath sources and levels and to characterize the phase front in the chamber's quiet zone. An additional objective was to provide the location of the source's phase center. This was to be accomplished over several octaves of frequency. As traditional field probing and free-space VSWR test methods cannot satisfy these objectives, the SAR Imaging technique described in (1) (Hindman, 1992) was used. Additional software enhancements were coded to provide the phase front analysis. The measurements took place in the winter of 1993.

2. TEST SETUP

A fixture was fabricated to position an NSI 3' by 3' planar near-field scanner in the quiet zone of the chamber. The fixture allowed the scanner to be positioned in the center of the quiet zone, and to be shifted left and right over the quiet zone extending beyond the span of the scanner. The scanner planarity was measured using a theodolite equipped with an optical micrometer. This data was entered in the NSI

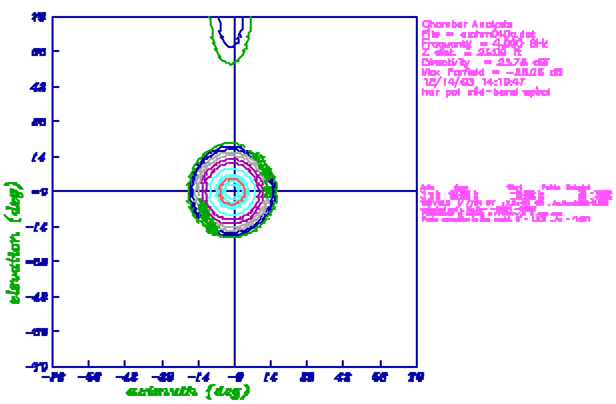


software error correction grid to eliminate the scanner planarity effect on the phase. A Hewlett Packard 8510C Network Analyzer was used as the receiver, and an HP Synthesizer was used as the signal source. A Compaq 386 computer controlled and processed the measurements using NSI's "Lite" near-field measurement software. TWT amplifiers were required to provide adequate dynamic range. (See Figure 1.)

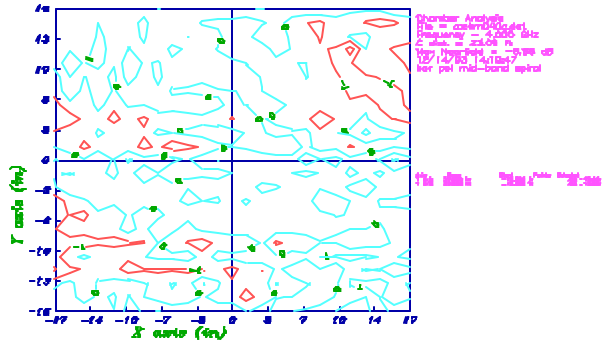
A measurement was made with the scanner positioned off- axis to determine the receiver leakage values for the final error estimate, a technique described in reference (2) (Slater, 1991). The scanner was then aligned to the center of the quiet zone, perpendicular to the direction of propagation using an autocollimating theodolite and mirrors. The NSI software was put in the Microwave Imaging mode, and the automatic scan parameter determining feature was used to set up the scans. The TWT amplifiers used to increase dynamic range introduced phase noise into the test set up. The preliminary error estimate indicated that a signal-to-noise ratio of 30 dB or better was required to meet the test requirements. The ability of the software to set the receiver averaging allowed an SNR of 30 dB or better throughout the testing. Data was collected at 11 frequencies at both horizontal and vertical polarizations. Next the scanner was shifted to the left and then to the right to acquire the data over the entire quiet zone.

3. TEST RESULTS

The measured data was processed through the far-field transform after apodizing. This is equivalent to -80 dB sidelobes on the SAR image. The data was plotted in an elevation over an azimuth coordinate system. (See Figure 2.)



A theodolite could then be placed in the scan center and be used to locate the offending reflection. The measured data was processed to remove the phase resulting from spherical curvature. The focus distance was the distance that yielded the smallest rms phase. This was derived by processing through a range of distances. (See Figure 3.)



The software also determines the location of the signal source phase center. Statistical analysis on the phase deviation from spherical phase front data is provided. (See Table 1.)

4. ERROR ESTIMATES

National Institute of Standards and Technology (NIST) recommends the use of an 18 term error estimate model for near-field measurements. Tables 2 through 5 are the error estimates for these measurements based on this model as they apply to the different aspects of the test.

5. SUMMARY

The results of these imaging techniques provide more information about a chamber than conventional field probing and free-space VSWR methods. NSI's portable near-field scanners are a very cost effective analysis tool. In less than 20 minutes at each frequency, not only can amplitude /phase taper and ripple be measured, but also reflection plots and phase deviation from spherical data can be generated.

The phase deviation from spherical data resulting from the measurements described above has been used by the customer in developing calibration data for testing their hardware.

REFERENCES

1) Hindman, G., Anechoic Diagnostic Imaging, AMTA Symposium, Antenna Measurement Techniques Association, Columbus, OH, 1992.
Describes a measurement technique utilizing NSI's near-field measurement system to evaluate anechoic chambers.

2) Slater, D., Near-Field Antenna Measurements, Artech House, Norwood, MA, 1991.

Chapters 4.6.2 SAR Processing, 4.6.3 SAR Imaging, and Chapter 9 Antenna Test Range Error Analysis.

TABLE 1. An excerpt of the focus distance and location, along with the phase front statistics.

File Name:	S/N Ratio (dB)	Focus (ft)	Beam el (deg)	Beam az (deg)	Avg Phase (deg)	Std dev (deg)	Surface err (mil)
CHM030C1.DAT	49.000	23.300	0.051	0.516	-0.015	0.947	10.350
CVM030C3.DAT	53.000	23.160	0.097	0.518	-0.007	1.064	11.627
CHM040C.DAT	52.000	23.090	0.059	0.678	0.006	0.738	6.050
CVM040C.DAT	51.000	23.355	0.056	0.675	-0.068	0.696	5.701

TABLE 2. Chamber reflection error budget for the highest frequency, 70° pattern angle, and -45 dB pattern level.

#	Item	Level	Noise	Source
1	Probe relative pattern	0.50 dB	-24.55 dB	Pattern match @ 70°
2	Probe polarization ratio	0.00 dB	none	N/A
3	Probe gain measurement	0.00 dB	none	N/A
4	Probe alignment error	0.40 dB	-26.53	1° alignment error
5	Normalization constant	0.00 dB	none	N/A
6	Impedance mismatch error	0.00 dB	none	N/A
7	AUT alignment error	0.00 dB	none	N/A
8	Data point spacing (aliasing)	0.00 dB	none	N/A
9	Measurement area truncation	0.15 dB	-35.00 dB	Simulation - pattern level
10	Probe XY position error	0.00 dB	-66.00 dB	5 mils rms
11	Probe Z position error	0.00 dB	-73.00 dB	1 mils rms
12	Mutual coupling (Probe / AUT)	0.00 dB	none	Negligible
13	Receiver amplitude linearity	0.00 dB	none	Constant RF level
14	Systematic phase error	0.02 dB	-55.00 dB	Estimate - previous test data
15	Receiver dynamic range	0.43 dB	-26.00 dB	NF s/n + xform gain
16	Room scattering	0.00 dB	none	Measurement purpose
17	Leakage and crosstalk	0.48 dB	-25.00 dB	HP spec - pattern level
18	Random amplitude/phase errors	0.20 dB	-32.66 dB	Repeatability
	Total (rss) =	0.91 dB	-19.11 dB	

TABLE 3. Phase center azimuth and elevation location error budget for the highest test frequency.

#	Item	Error	Source
1	Probe relative pattern	0.000°	N/A
2	Probe polarization ratio	0.000°	N/A
3	Probe gain measurement	0.000°	N/A
4	Probe alignment error	0.000°	N/A
5	Normalization constant	0.000°	N/A
6	Impedance mismatch error	0.000°	N/A
7	AUT alignment error	0.005°	Estimate of fixture errors
8	Data point spacing (aliasing)	0.000°	N/A
9	Measurement area truncation	0.000°	N/A
10	Probe XY position error	0.000°	Negligible
11	Probe Z position error	0.006°	2 mil error
12	Mutual coupling (Probe / AUT)	0.000°	Negligible
13	Receiver amplitude linearity	0.000°	Negligible
14	Systematic phase error	0.012°	Previous data on similar cable
15	Receiver dynamic range	0.00009°	31 dB SNR + 40 dB process gain
16	Room scattering	0.002°	-45 dB worst case reflection
17	Leakage and crosstalk	0.0001°	HP spec
18	Random amplitude/phase errors	0.012°	Based on worst case thermal drift
	Total (rss) =	0.019°	

TABLE 4. Phase center Z distance error budget.

#	Item	Error(ft)	Source
1	Probe relative pattern	0.00	N/A
2	Probe polarization ratio	0.00	N/A
3	Probe gain measurement	0.00	N/A
4	Probe alignment error	0.00	N/A
5	Normalization constant	0.00	N/A
6	Impedance mismatch error	0.00	N/A
7	AUT alignment error	0.00	N/A
8	Data point spacing (aliasing)	0.00	N/A
9	Measurement area truncation	0.00	N/A
10	Probe XY position error	0.03	Simulation
11	Probe Z position error	0.03	Simulation
12	Mutual coupling (Probe / AUT)	0.00	N/A
13	Receiver amplitude linearity	0.00	N/A
14	Systematic phase error	0.00	Simulation
15	Receiver dynamic range	0.00	Simulation
16	Room scattering	0.00	Simulation
17	Leakage and crosstalk	0.00	Simulation
18	Random amplitude/phase errors	0.00	Simulation
	Total (rss)=	0.042	

TABLE 5. Phase deviation from spherical phase front error budget for the highest test frequency.

#	Item	Phase error	Source
1	Probe relative pattern	0.000°	N/A
2	Probe polarization ratio	0.000°	N/A
3	Probe gain measurement	0.000°	N/A
4	Probe alignment error	0.000°	N/A
5	Normalization constant	0.000°	N/A
6	Impedance mismatch error	0.000°	N/A
7	AUT alignment error	0.000°	N/A
8	Data point spacing (aliasing)	0.000°	N/A
9	Measurement area truncation	0.000°	N/A
10	Probe XY position error	0.044°	Manufacturer specification
11	Probe Z position error	1.098°	2 mil error
12	Mutual coupling (Probe / AUT)	0.000°	Negligible
13	Receiver amplitude linearity	0.000°	Negligible
14	Systematic phase error	1.414°	Previous data on similar cable
15	Receiver dynamic range	1.615°	31 dB SNR
16	Room scattering	0.322°	-45 dB worst case reflection
17	Leakage and crosstalk	0.016°	HP spec
18	Random amplitude/phase errors	1.232°	Based on worst case thermal drift
	Total (rss) =	2.727°	