Mathematical Absorber Reflection Suppression (MARS) for Anechoic Chamber Evaluation & Improvement

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ABSTRACT

NSI's MARS technique (Mathematical Absorber Reflection Suppression) has been used to improve performance in anechoic chambers and has been demonstrated over a wide range of frequencies on numerous antenna types. MARS is a post-processing technique that involves analysis of the measured data and a special filtering process to suppress the undesirable scattered signals. The technique is a general technique that can be applied to any spherical or far-field range or Compact Antenna Test Range (CATR). It has also been applied to extend the useful frequency range of microwave absorber to both lower and higher frequencies than its normal operating band. This paper will demonstrate the use of the MARS capability in evaluating the performance of anechoic chambers used for spherical near-field measurements, as well as in improving chamber performance.

Keywords: NIST, 18-term, error evaluation, absorber, reflection, spherical near-field, suppression, MARS

1. Introduction

The NSI MARS processing technique has been in use by NSI and our customers since its introduction in 2005[1]. Validation of the MARS technique has been published in the 2005 paper and additional papers [2,3,4]. This paper will focus on use of the MARS technique for assessing the performance of anechoic chambers, and using it to improve that performance. Chamber performance is often characterized in near-field measurement systems by offsetting the AUT position and evaluating the difference in the measured results. NSI has previously published results [5] on the use of alternate measurement spheres to accomplish the same result as an easier method to accomplish the same thing more easily (figure 1), and we will expand on that here.

NSI recently commissioned a new test chamber at our factory in Torrance, CA for contract customer testing, and we used the MARS evaluation technique in our range evaluation efforts. The chamber is fitted with 36" pyramidal absorber.

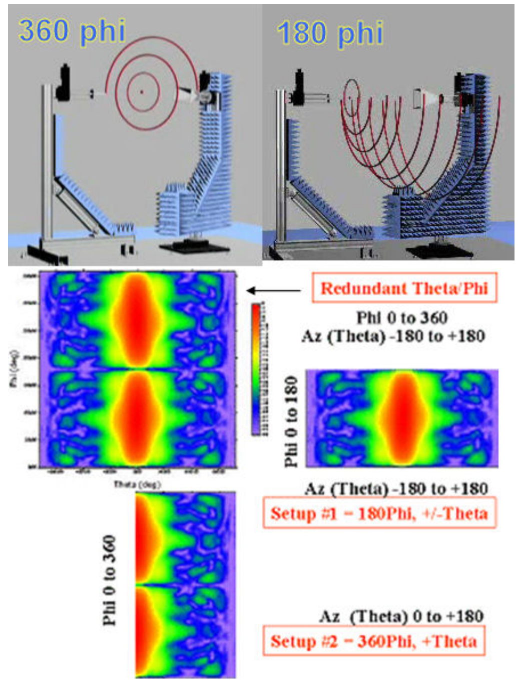

Figure 1 – Redundant data set through full rotation of theta and phi rotators, versus the two full spheres that can be derived for the "360 phi" or "180 phi" configurations

Many of the results reported here will be on an NSI-RF-DLP-03 Dual pol log periodic antenna. That antenna is shown on the NSI-700S-75 SNF system in our chamber in figures 2 & 3.

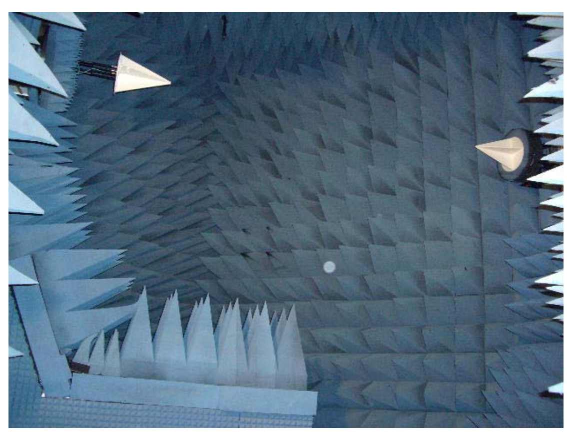

Figure 2 – NSI-700S-75 SNF System with DLP AUT and Probe

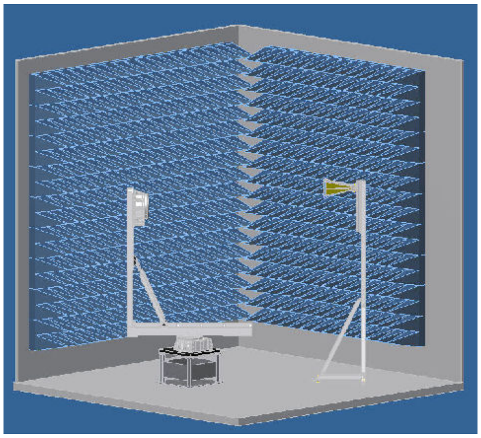

Figure 3 – NSI-700S-75 Scanner in Chamber

2. Simple Reflection Test Using Near-Field Comparison

A common and very simple technique to identify or estimate reflection levels in a test range is a comparison of a theta cut with the AUT phi changed between 0 and 180 degrees. For a correctly aligned measurement system, the differences in the patterns are due to the range reflections and will give a preliminary estimate of expected error signal level for the far-field patterns (figure 4). This data was taken at 10 GHz on NSI's 700S-75 Spherical NF scanner inside an anechoic chamber shown in figures 2 and 3. Here we see about a -40 dB reflection level on boresight, dropping to more like 50 dB or lower at most other angles. Although this technique can be used to place an upper bound on the range multipath error, and data from the alternate and conventional spheres can be averaged in an attempt to improve the measured data, other more sophisticated pattern compensation techniques are available and these will be discussed in the following sections.

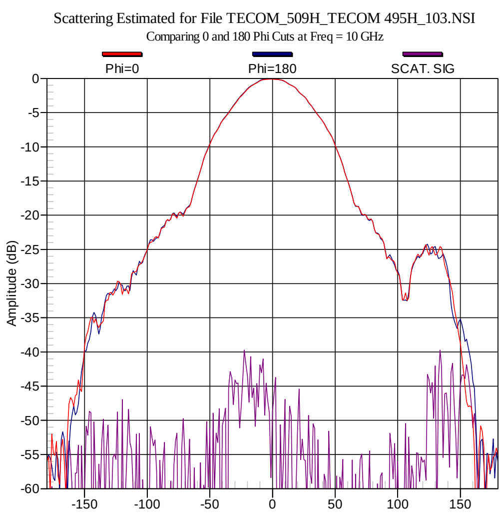

Figure 4 – Simple near-field evaluation of reflection

3. MARS Technique

The purpose of the MARS approach is to reduce the influence of scattering on far-field pattern results. We use a mathematical post processing technique that requires a minimum amount of information about the AUT, probe and antenna range geometry. The processing is applied during regular near-field to far-field transformation. MARS uses the standard NIST Spherical Near-field to Far-Field Transformation Algorithm. As an inherent part of the far-field transform, the NIST algorithm uses a mode filtering technique. The mode cutoff is based on the fact that modes above a certain index number are exponentially attenuated and not detected by the probe. The mode cutoff is determined by the physical dimensions of the AUT. A typical mode plot on the NSI-RF-DLP-03 Antenna at 2 GHz is shown in Figure 5. In this figure, we have overlaid the measured mode plot, the shifted mode plot based on analytically translating the AUT phase center to the origin, and the filtering plot, showing where we have truncated the higher order modes.

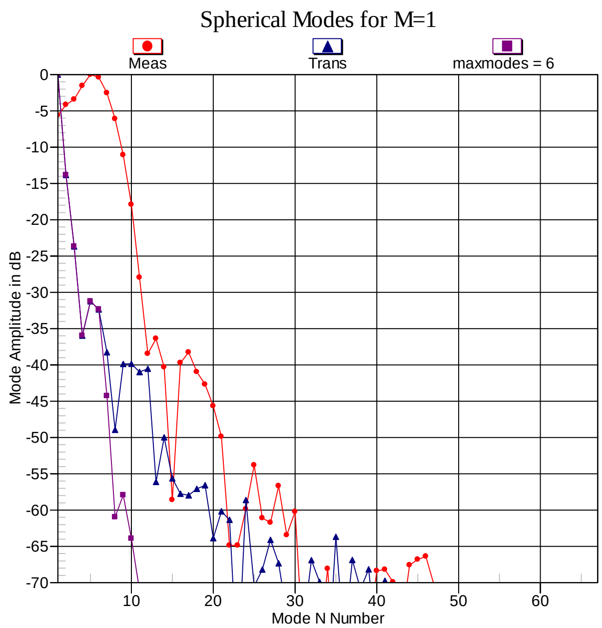

Figure 5 – Spherical Modes and MARS Filtering Example

The selection of which modes to filter out is made automatically by the MARS processing algorithm based on user inputs identifying the physical size MRE (Maximum Radial Extent) sphere which can contain the antenna. The user can also override the default filtering for evaluation during processing. In this case, the minimum sphere which contains the translated antenna aperture causes the MARS processing to filter out all higher order modes above N=18 as these can not be part of the antenna's far-field radiation pattern.

4. MARS Reflection Results with DLP

Using the technique described previously, we compare the two measurement spheres acquired, and see the reflection estimates at 1 GHz, 10 GHz and 18 GHz in figures 6 thru 8. One can easily see the errors in the sidelobes due to the chamber reflection level.

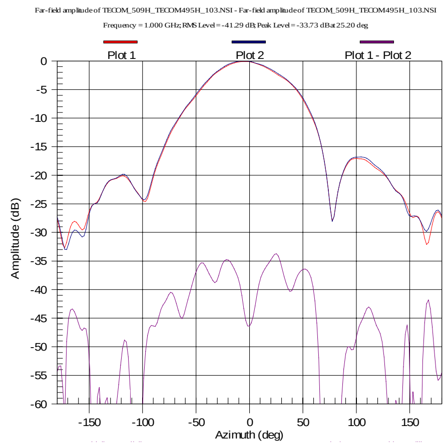

Figure 6 – Reflection at 1 GHz

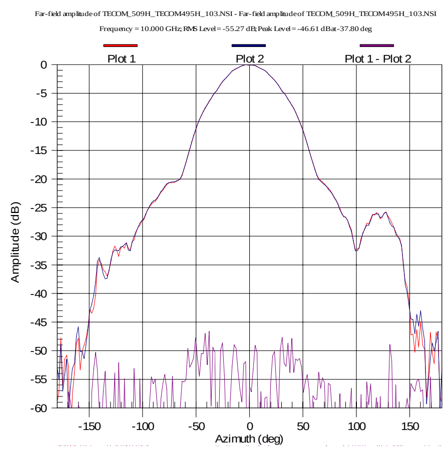

Figure 7 – Reflection at 10 GHz

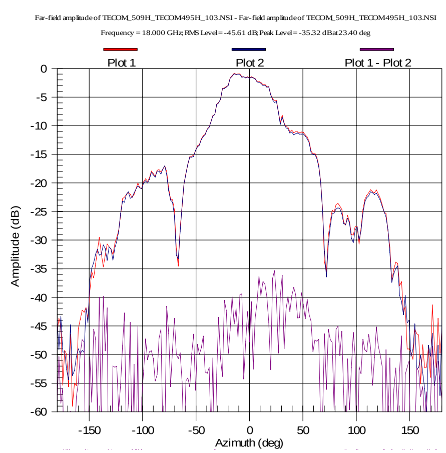

Figure 8 – Reflection at 18 GHz

Applying the MARS correction on the data in figures 6 thru 8 yields the result in Figures 9 thru 11. A significant improvement is noticeable in the error level, essentially eliminating any difference in the sidelobe results.

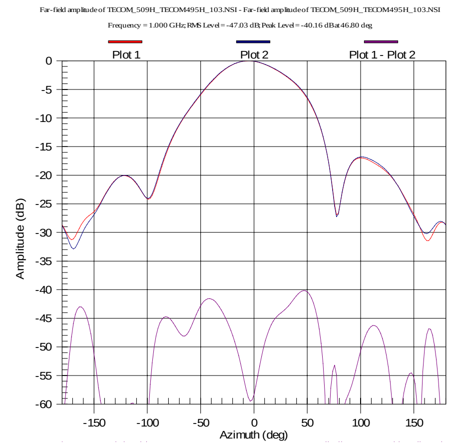

Figure 9 – Reflection at 1 GHz - MARS corrected

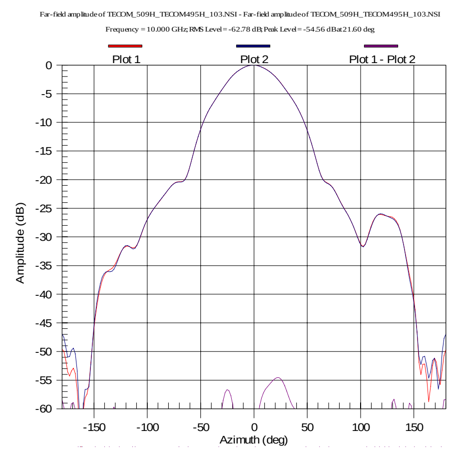

Figure 10 – Reflection at 10 GHz - MARS corrected

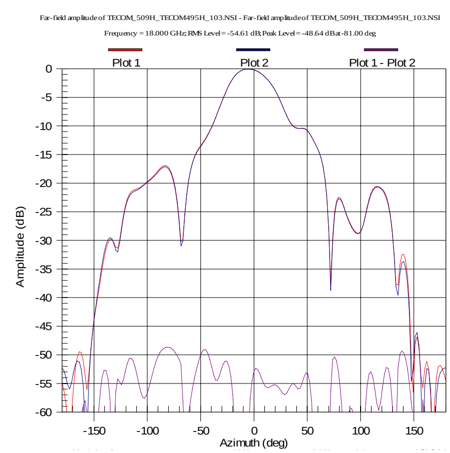

Figure 11 – Reflection at 18 GHz - MARS corrected

The reflection data was taken over the full frequency range of the AUT, 0.5 to 18 GHz. With an automated processing routine, we can derive the MARS reflection improvement over the full band by plotting the error level before and after MARS (Figure12).

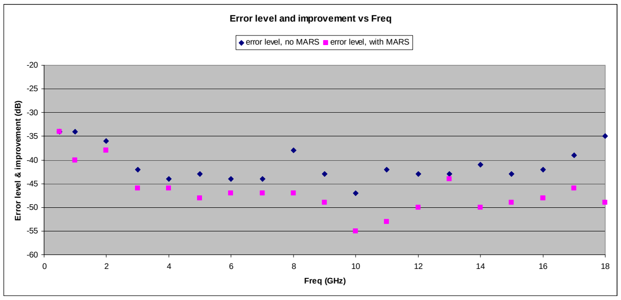

Figure 12 – Reflection level with and without MARS correction

Figure 13 shows just the improvement due to MARS vs frequency. Notice the general characteristic of the improvement, with smaller improvement at the lower frequency, and better improvement at the higher frequencies. The reflections in the range are frequency sensitive, and there are some frequencies where the MARS process does not work as well as at others. In some cases this occurs when the reflection level is already low enough without MARS , but in other cases it is less clear and is a subject of further study.

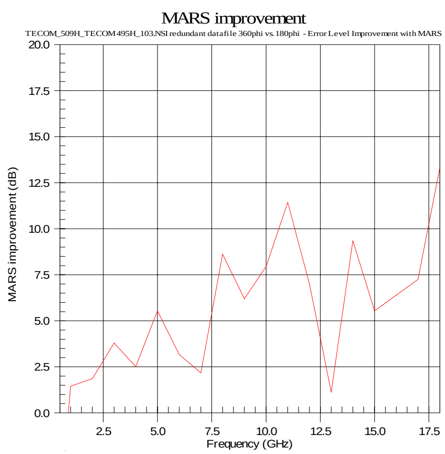

Figure 13 – Reflection improvement with MARS correction

5. MARS Reflection Results with OEWG Probe

In addition to the broadband DLP antenna, we also used an Open Ended Waveguide (OEWG) antenna as both the AUT and probe in a spherical near-field measurement. The much broader illumination pattern of the OEWG will make the measurements much more sensitive to chamber scattering and provide a stringent test of the MARS processing capability. The OEWG is also more representative of lower gain antennas that will be tested in the chamber.

We used a NSI-RF-SG284 OEWG probe, and tested it over its frequency range of 2.6 GHz to 3.95 GHz. Figure 14 shows the reflection results without MARS, and figure 15 shows the results with the MARS processing at 2.6 GHz. Figure 16 shows the improvement versus frequency.

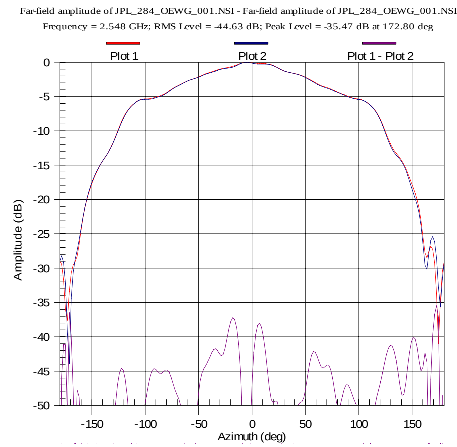

Figure 14 – OEWG Reflection at 2.6 GHz without MARS

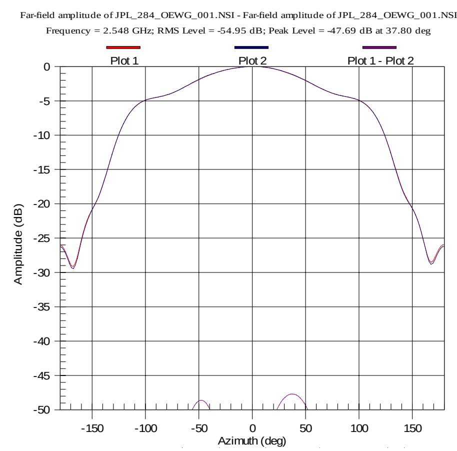

Figure 15 – OEWG Reflection at 2.6 GHz – MARS corrected

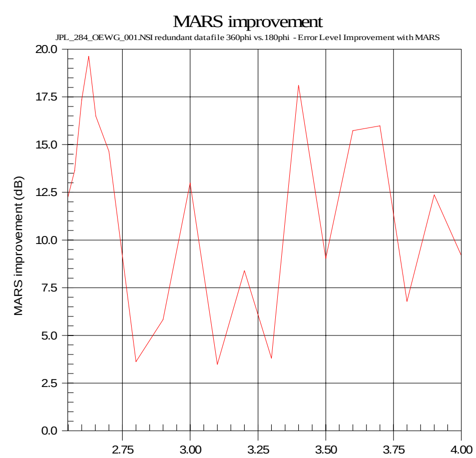

Figure 16 – OEWG Reflection improvement with MARS

6. Summary

This paper describes the application of the MARS technique to a chamber evaluation of a newly commissioned chamber at NSI. The 180/360 phi comparison technique for reflection evaluation gives us an easy to use figure of merit for chamber reflection, and the MARS technique shows the significant improvement that can be achieved.

The tests have verified that the peak error signal level in the final far-field patterns due to scattering is below -34 dB from the frequency range of 0.5 to 2 GHz, and below -44 dB over the 3 to 18 GHz range when MARS processing is used. This level is achieved for broad beam AUT's like OEWG probes and medium gain antennas like SGH's. Further testing is in work for higher gain antennas and also evaluating the chamber at higher frequencies.

7. REFERENCES

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