REFLECTION SUPPRESSION IN LARGE SPHERICAL NEAR-FIELD RANGE

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ABSTRACT

Reflections in antenna test ranges can often be the largest source of measurement errors, dominating all other error sources. This paper will show the results of a new technique developed by NSI to suppress reflections from the radome and gantry of a large hemi-spherical automotive test range developed for Nippon Antenna in Itzehoe, Germany. The technique, named Mathematical Absorber Reflection Suppression (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 near-field test range. It has also been applied to extend the useful frequency range of microwave absorber in a spherical near-field system in an anechoic chamber. The paper will show typical improvements in pattern performance and directivity measurements, and will show validation of the MARS technique using data measured on antennas in a conventional anechoic chamber.

Keywords: radome, absorber, reflection, spherical near-field, suppression

1.0 Introduction

This paper describes a proprietary technique developed by NSI to suppress reflections in a spherical near-field test range.

The initial development of the MARS technique was done to support operation in a hemi-spherical automotive near-field test system that NSI recently installed for Nippon Antenna in Itzehoe Germany (figures 1 and 2). The system is a combination spherical near-field and far-field test facility with a 11.5 m radius dielectric gantry provided by the Howland company, and 6.5 m diameter in-ground turntable provided by NSI. The radome is 14 m high and 24 m in diameter. The facility uses the continuous ground plane approach, rather than use of any absorber on the turntable or ground surface. Reflections from the dielectric gantry and the radome do affect the measured antenna performance, and the MARS technique is used to suppress the majority of these reflections.

NSI has also extended the MARS technique for operation with other spherical near-field test systems with limited or no absorber, as well as for use in improving the reflection performance in a traditional anechoic chamber.

Figure 1 – Nippon Antenna SNF/FF Test Range

Figure 2 – NSI rotator and gantry testing automobile

2.0 MARS Approach

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 detailed information about the AUT, probe and antenna range geometry. The processing is applied during regular near-field to far-field processing. The technique is general enough to apply to different types of spherical measurement geometries and to different antenna types. NSI has developed a mathematical operator that is applied to the measured data that helps to distinguish between the correct antenna properties and scattering. Successful processing requires more measured data than for the AUT without scattering for best performance - typically requires one half the spacing in theta and phi than recommended by sampling criteria. This will usually require about double the test time, compared to normal measurements.

3. 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[1-4], the differences in the patterns are due to the range reflections and will give a preliminary estimate of expected error signal level [5] for the far-field patterns (figure 3). This data was taken on NSI's 700S-60 Spherical NF scanner inside an anechoic chamber shown in figure 4.

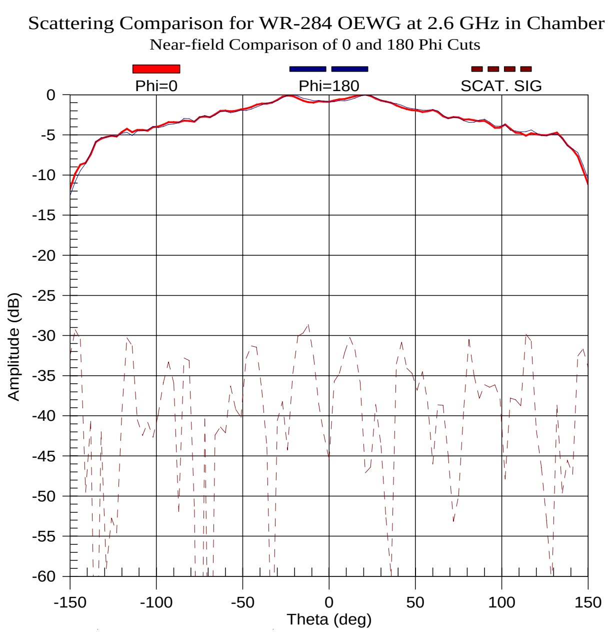

Figure 3 – Reflections at 2.6 GHz in anechoic chamber using near-field comparison of 0 and 180 deg patterns

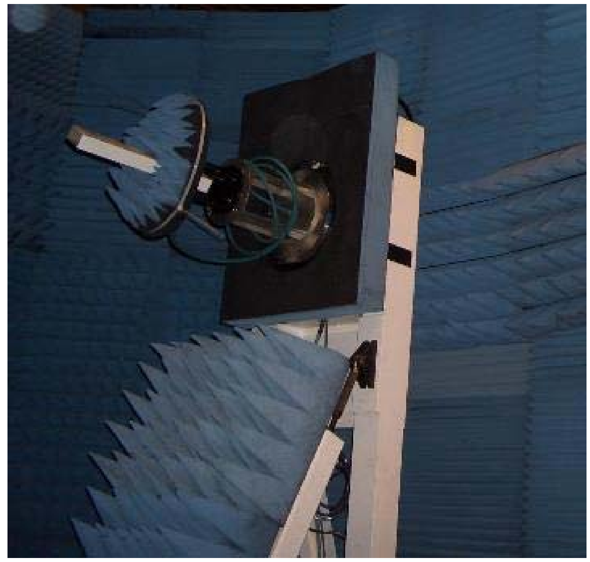

Figure 4 – NSI-RF-WR284 OEWG probe being tested at NSI on NSI-700S-60 Spherical NF in anechoic chamber

Figure 5 – NSI-RF-WR284 OEWG probe being tested at NSI on NSI-700S-90 ARCH Spherical NF in open environment with NO anechoic chamber

Figure 5 shows the same WR-284 OEWG probe now mounted in the NSI factory floor on an ARCH system, the NSI-700S-90 Spherical NF scanner, with no anechoic chamber. Again one can get an initial idea of range reflections by comparing near-field patterns with the AUT at 0 and 180 degree PHI positions. This result is shown in figure 6.

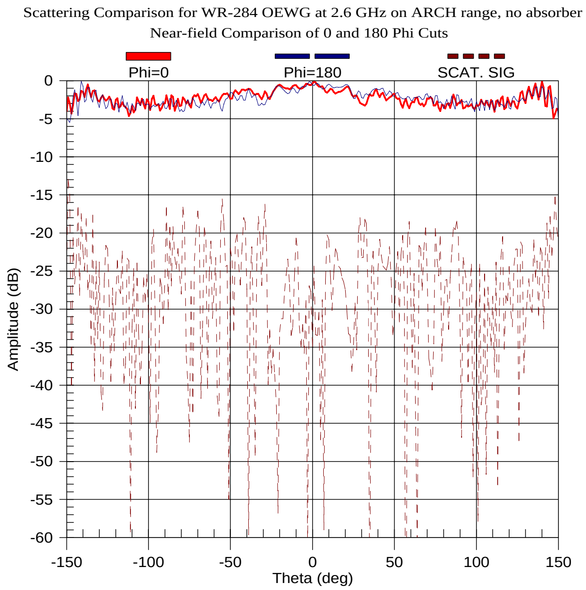

Figure 6 – Reflections at 2.6 GHz in open environment with no test chamber, using near-field comparison of 0 and 180 deg patterns

At first glance, one might think that the resulting data would indicate that measurements would be totally impractical due to the high reflection level of only about -15 dB versus the much better level of about -30 dB in the prior result in the anechoic chamber. However, with appropriate application of the MARS processing technique, we can show that the results obtained by measuring the antenna with no range absorber can be improved significantly, and can approach the accuracy achievable in a conventional anechoic chamber!

4. MARS Results with and without use of Anechoic Chamber

We measured the WR-284 probe as the antenna on the ARCH spherical range at two different Z distances from the theta/phi intersection axis. The resulting far-field calculations at 2.6 GHz without MARS processing are shown in figure 7, and compared to the result measured in the anechoic chamber. The patterns on the open range are of course quite different due to the very poor reflection environment.

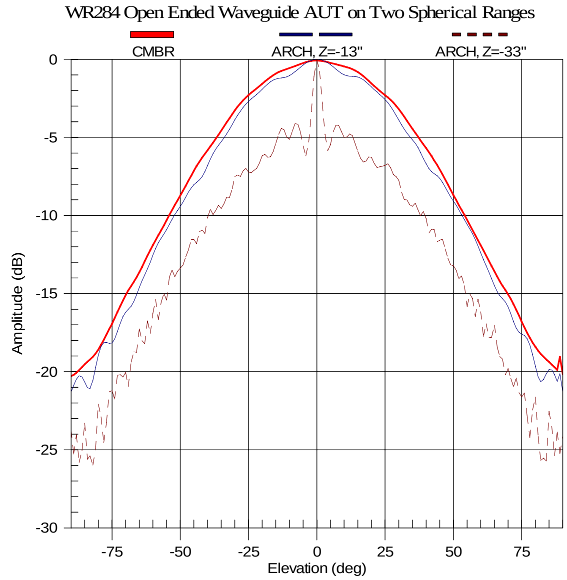

Figure 7 – Far-field comparison at 2.6 GHz of chamber measured data, versus data taken in open environment with no test chamber, with <u>No MARS correction</u>

Enabling the MARS processing yields the comparison in figure 8, overlaid with the result measured in the anechoic chamber, showing that the patterns on the open ARCH range are now quite comparable to those in the chamber. The only additional requirements were that of sampling data at twice the normal density, and applying the MARS processing.

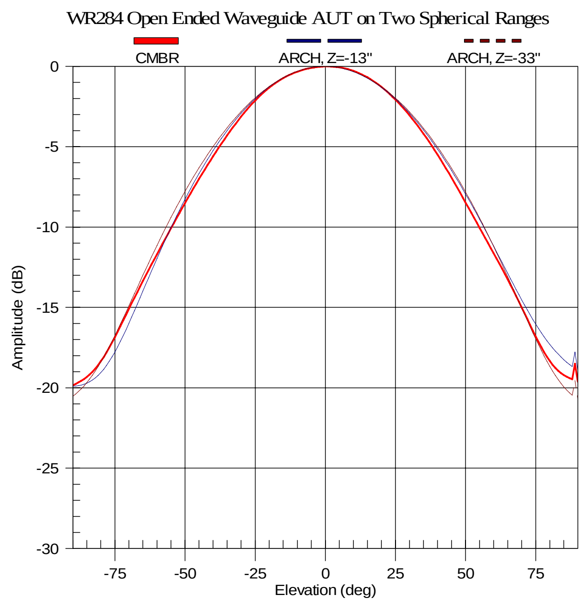

Figure 8 – Far-field comparison at 2.6 GHz of chamber measured data, versus data taken in open environment with no test chamber, <u>MARS correction enabled</u>

5. Validation of the MARS technique

In addition to the chamber comparison shown above, NSI tested a number of Standard Gain Horns (SGH) in various test ranges, with and without MARS processing. This section will summarize those tests.

One set of tests used a NSI-RF-SG284 Standard Gain Horn operating from 2.6 to 3.95 GHz. We measured the same SGH on 3 different test ranges and compared results with and without MARS processing.

Figure 9 – NSI-RF-SG284 Standard Gain Horn tested on NSI ARCH scanner with no absorber or chamber

Again, taking data with double the normal density in theta and phi angles, we can use the MARS processing to show the improved result with the reflection inhibited.

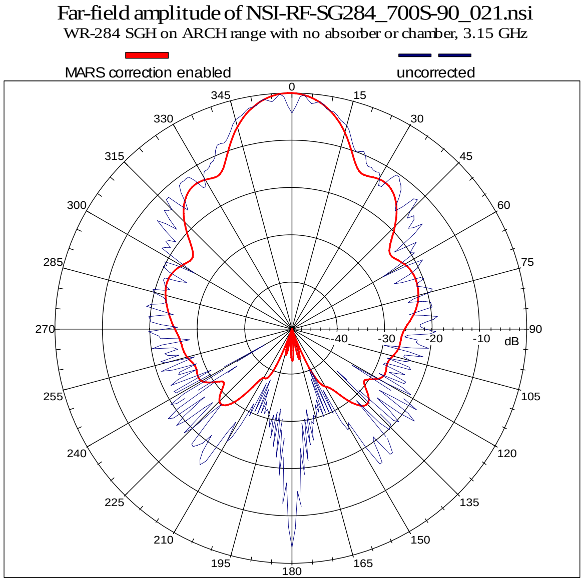

Figure 10 – NSI-RF-SG284 Standard Gain Horn tested on NSI ARCH scanner with no absorber or chamber showing pattern improvement with <u>MARS correction enabled</u>

The same SGH was tested in the NSI anechoic chamber. Here we subtract the far-field results with and without MARS correction to show the significant improvement in reflection error level achieved thru use of the processing. Without the MARS correction, the plot subtraction yields an error level or reflection effect of up to -16 dB from the beam peak. With MARS correction enabled, the error level is suppressed to below -34 dB – about a 18 dB improvement.

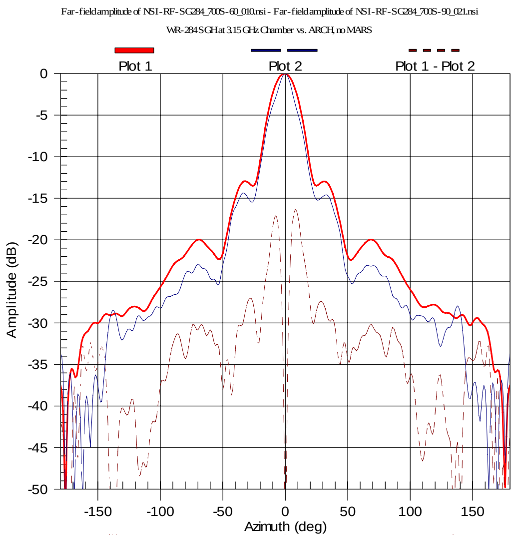

Figure 11 – Far-field comparison at 3.15 GHz of SGH data taken in chamber versus on ARCH range with no absorber or chamber, with <u>no MARS correction</u>

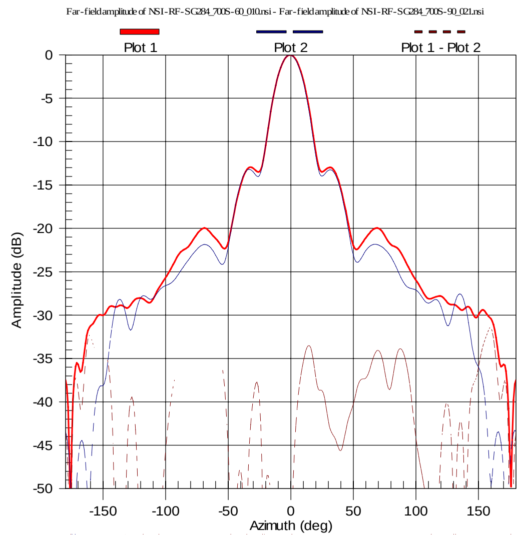

Figure 12 – Far-field comparison at 3.15 GHz of SGH data taken in chamber versus on ARCH range with no absorber or chamber, with <u>MARS correction enabled</u>

To check the performance over a broader frequency range, we can use the multi-frequency data on the SGH to calculate the directivity performance versus the NRL directivity calculations with and without the MARS processing. Figure 13 shows this result. The maximum difference from the NRL curve with MARS off is about 1.7 dB, whereas when the MARS processing is applied, the large discrepancies disappear and the maximum difference drops to only about 0.5 dB.

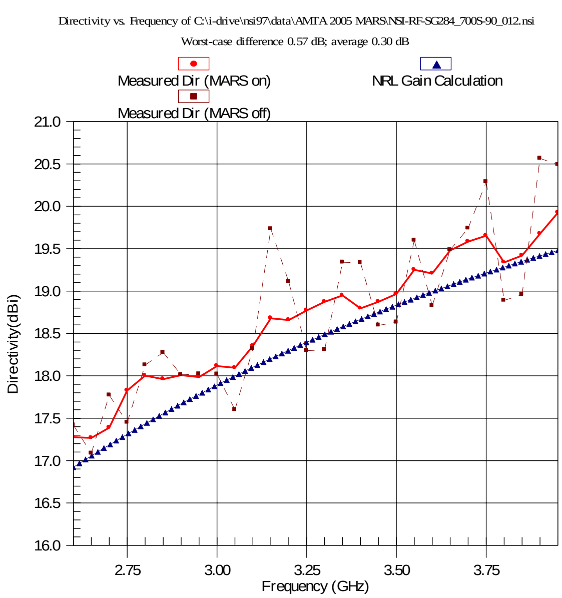

Figure 13 –Directivity versus frequency of WR-284 SGH taken on ARCH range with no absorber or chamber, compared to NRL directivity, <u>with and without MARS correction</u>

6. Test Results on Nippon SNF range with MARS processing

Figure 14 shows the result of a patch antenna tested on the Nippon Antenna range with and without MARS processing. The significant reduction in the ripple due to the reflections is evident.

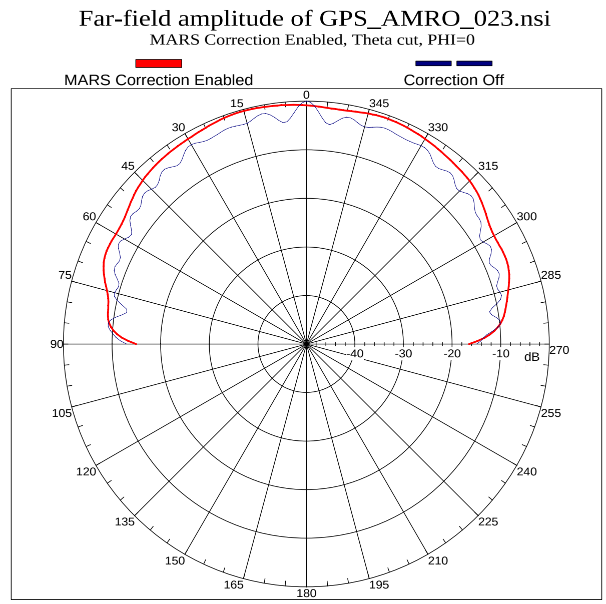

Figure 14 – Far-field comparison at 1.575 GHz of patch antenna on a ground plane taken in Nippon Antenna SNF range with and without MARS correction enabled.

We also tested a WR-430 Standard Gain horn on the Nippon Antenna range and compared the result to the result from another SGH of the same NSI model#, tested in a spherical NF system in an anechoic chamber delivered to one of our customers. These comparisons are shown in Figure 15 & 16.

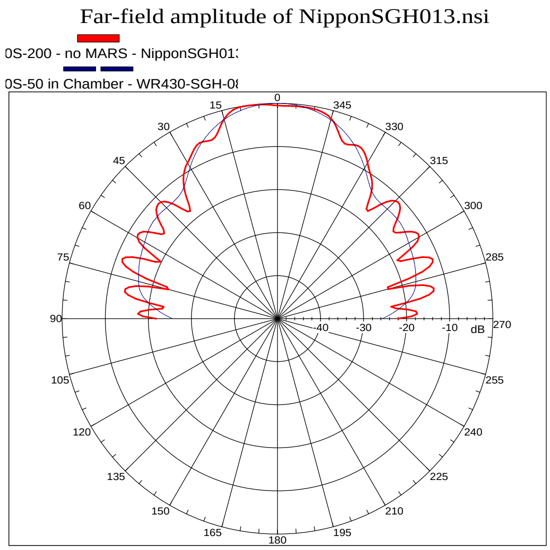

Figure 15 – Far-field comparison at 1.7 GHz of WR-430 SGH taken in Nippon Antenna SNF range with NO MARS correction against same model # SGH tested in anechoic chamber

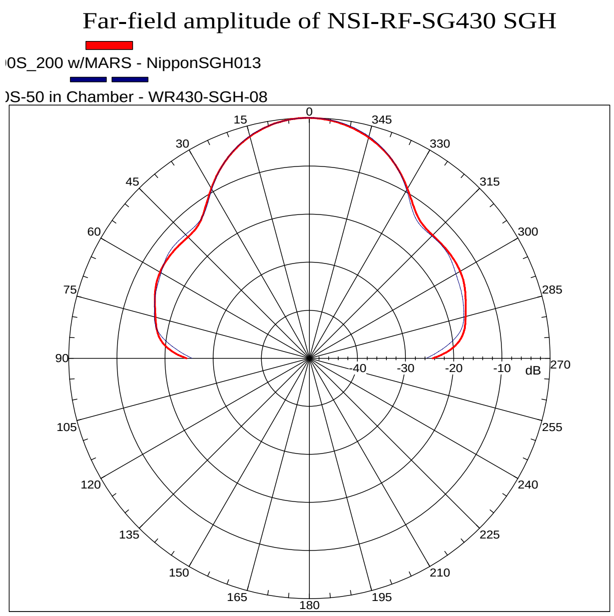

Figure 16 – Far-field comparison at 1.7 GHz of WR-430 SGH taken in Nippon SNF range with MARS correction enabled against same model # SGH tested in anechoic chamber

7. MARS Requirements and Limitations

The key requirement for MARS processing is the need to over-sample the theta/phi data by about a factor of two. This can typically be done in only double the test time if the receiver system is fast enough or if one limits the number of frequencies. One must also estimate or determine the phase center location of the antenna since this is used in the post-processing. Other than these restrictions, the process is quite straightforward for the user with NSI's MARS processing algorithm.

8. Summary

NSI has developed and validated a novel technique to suppress reflections on spherical near-field ranges. The technique is quite general and can be used to achieve acceptable results with use of minimal absorber or even with no anechoic chamber. It can also improve the reflection levels in a traditional anechoic chamber by 10 dB or more, allowing improved accuracy as well as the ability to use existing chambers down to lower frequencies than the absorber used might indicate.

8. REFERENCES

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