INTER-COMPARISON OF NEAR-FIELD ANTENNA MEASUREMENT TECHNIQUES

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ABSTRACT

This paper describes the results of an ongoing antenna measurement inter-comparison study. Details of spherical near-field facilities are presented. Instrumentation and data processing software used for the study are described. The RF instrumentation includes HP-Agilent 8530 and PNA Network Analyzers and NSI Panther receivers. The transformation software suits include CASAMS, NSI Spherical and Cylindrical NF-FF Transformation software and TICRA SNFD. Data for a set of rectangular horn antennas and a GPS antenna measured using various instrumentation setups, measurement schemes and post processed employing different transformation software suits, is presented. Analysis of measured results is carried out to illustrate a comparison of performance, accuracy and limitations of these techniques.

INTRODUCTION

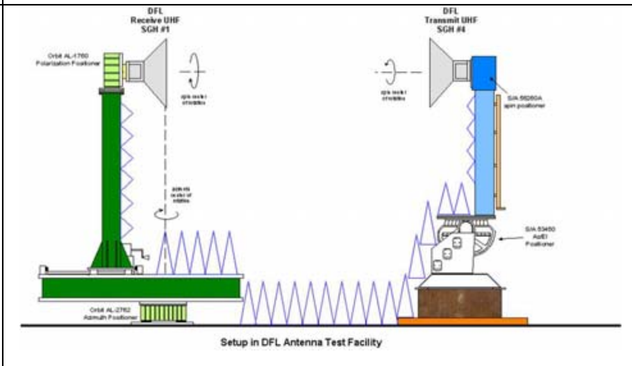
This paper describes the results of an ongoing antenna measurement study initiated to perform an inter-comparison of measurement facilities, instrumentation performance and software tools available at the David Florida Laboratory (DFL) of the Canadian Space Agency (CSA). It was observed that the recommended use procedures for each of the software suits provide specific guidelines for selection of measurement parameters such as range data acquisition grid and data sampling interval. The gain comparison and error compensation techniques differ as well. In addition the probe correction procedures and algorithms differ in the three software suites. The format of output data and available analysis results differ and must be paid attention to. Each suite offers different set of intermediate output capabilities and provides specific insight in ability to diagnose measurement issues and in estimation and compensation of measurement errors. The objective of this study is to develop guidelines for the selection of an appropriate measurement range, measurement technique, associated instrumentation, acquisition software and data processing procedures best suited and optimized for measurement and analysis of a specific antenna under test.

ANTENNA TEST FACILITIES, INSTRUMENTATION AND PROCESSING SOFTWARE

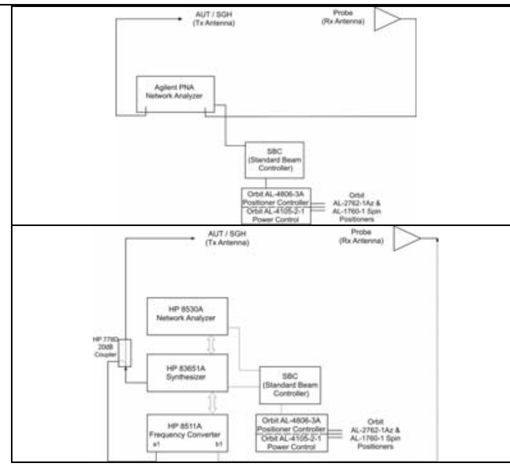
Antenna test facilities at the DFL consist of two spherical near-field test chambers, a cylindrical near-field facility, and multiple far-field ranges. The near-field facilities are housed in anechoic chambers that range in size from (13m x 13m x 25m) to (6m x 3m x 3m). The absorber treatment varies to support measurements covering a frequency range of 250MHz – 60GHz.

The available spherical near-field to far-field transformation software at DFL includes Canadian Astronautics Spherical Antenna Measurement Software (CASAMS) suite originally developed by Canadian Space Agency in collaboration with a CAL Corp (now EMS Inc.) [1], commercially available turn key Near-field Systems Inc. (NSI) spherical near-field to far-field measurement and transformation software (NSI 2000) [2] and SNFD software from TICRA Inc. The three software suites provide different features for data analysis and require their own native measurement geometry.

The RF measurement instrumentation used in the spherical near-field measurement systems and far-field ranges at the DFL includes Agilent HP- 8530 and PNA Network Analyzer Systems [3] and an NSI Panther Receiver System. For antenna and probe positioning DFL employs a mix of ORBIT, Scientific Atlanta (SA) (Now MI Technologies) and NSI supplied positioners and controllers. The available turntables in the facility range in their size, load capability and accuracy specifications to accommodate a wide range of antennas. Automated equipment control and data acquisition can be carried out by state of the art computer systems using in-house developed acquisition software or by using software supplied as part of turnkey system (NSI-2000). Figure 1 shows typical measurement and instrumentation setup used for spherical near-field measurements



Spherical Near-field Antenna Measurement Setup



Equipment Setup using
Agilent PNA and HP 8530 Network Analyzer

Figure 1 Typical Spherical Near-field Measurement Setup

DESRIPTION OF ANTENNAS, MEASUREMENT PARAMETERS AND TRANSFORMATION SOFTWARE USED

Measured results are presented for 3 different antennas.

1. Rectangular Horn Antenna fabricated in-house for use at UHF frequencies (220 MHz to 350 MHz). Aperture size of 2.2m x 1.5m Linear Polarization. This horn was measured in DFL Antenna Test Facility 1 which consists of large anechoic chamber (13m x 13m x 25m) lined with absorber varying in height from 30cm to120cm.
2. L-Band Horn S/A 12-1.7 Pyramidal Horn Antenna, Linear Polarized.
3. GPS Antenna NovAtel GPS L5G1 Passive Antenna, RHCP Polarized.

The L-Band Horn Antenna and the GPS Antenna were measured in DFL EHF SNF Test Facility which consists of an anechoic chamber 3.6m x 3.6m x 8m in size and lined with 30cm absorber material.

The Following table shows measurement and transformation software used

Test	Antenna Measured	Measurement Software and Data Density	Measurement Frequency	Receiver Used	Test Duration	NF to FF Software
1	UHF Horn	DFL In-house Software Sampling - 2° Theta, 5° Phi.	10 Samples 294 - 319MHz	Agilent HP 8530	9 Hours	CASAMS
2	UHF Horn	NSI 2000 Sampling - 2° Theta, 5° Phi.	26 Samples 294 - 319MHz	Agilent E8362B PNA	5 Hours	CASAMS
3	UHF Horn	NSI 2000 Sampling - 6° Theta, 5° Phi.	16 Samples 294 - 319MHz	Agilent E8362B PNA	1.5 Hours	NSI 2000
4	L-Band horn	NSI 2000 Sampling - 2° Theta, 5° Phi.	18 Samples 1.2 – 1.8 GHz	Agilent HP 8530	2 Hours	CASAMS
5	L-Band horn	NSI 2000 Sampling - 5° Theta, 5° Phi.	18 Samples 1.2 – 1.8 GHz	Agilent HP 8530	2 Hours	NSI 2000
6	GPS Antenna	NSI 2000 Sampling - 2° Theta, 5° Phi.	18 Samples 1.2 – 1.8 GHz	Agilent HP 8530	2 Hours	CASAMS
7	GPS Antenna	NSI 2000 Sampling - 5° Theta, 5° Phi.	18 Samples 1.2 – 1.8 GHz	Agilent HP 8530	2 Hours	NSI 2000

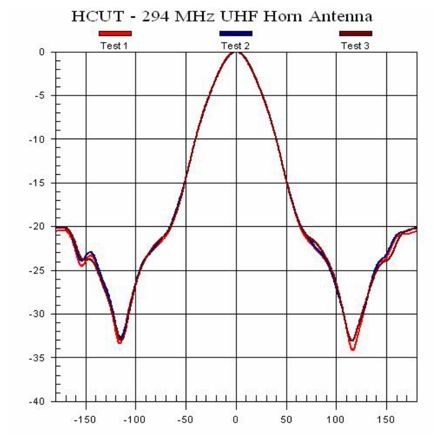


Figure 2. Comparison of resulting Far-field Pattern of the UHF Horn Antenna

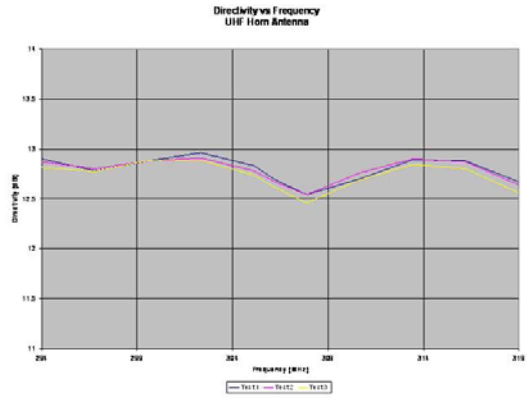


Figure 3. Comparison of measured directivity of the UHF Horn Antenna as a function of frequency

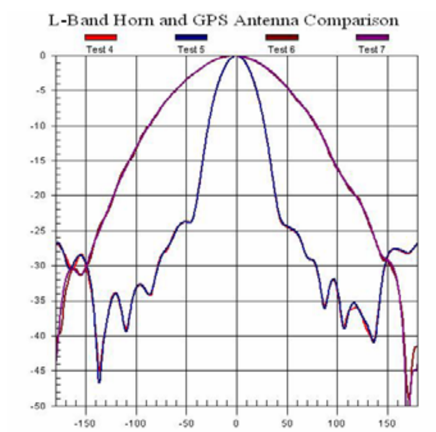


Figure 4. Comparison of resulting Far-field Patterns of the L-Band Horn Antenna and the GPS Antenna

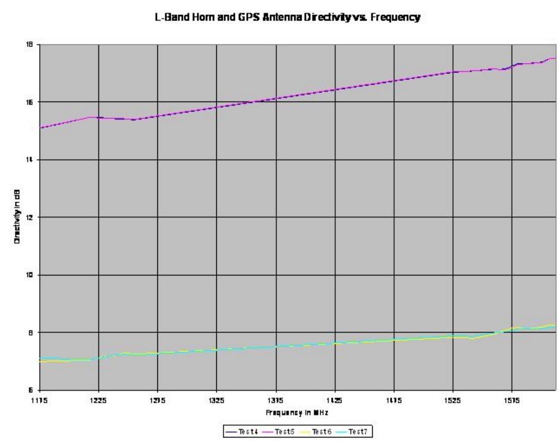


Figure 5. Comparison of measured directivity of the L-Band Horn Antenna and the GPS Antenna as a function of frequency

MEASURED RESULTS

Some illustrative comparisons of measured data are presented in the figures 2 - 5 above. Figure 2 shows the resulting far-field pattern of the UHF Horn Antenna. Figure 3 compares the directivity of the same antenna as function of frequency measured and transformed using different measurement and transformation schemes indicated in the table above. Figures 4 and 5 present similar data for the case of the L Band Horn Antenna and the GPS Antenna. All techniques result in comparable estimates for far-field patterns. Some of the discrepancies may be attributed to multi-path differences. Some of the salient observations are summarized below.

GENERAL OBSERVATIONS AND INTERPRETATIONS

- Compared to the Agilent HP-8530, the PNA has 30 dB greater sensitivity [2]. It also optionally permits direct access to the signal path of the source output, coupler input, and receiver input, thus additional 20 dB more dynamic range can be achieved.
- The variable IF band-width of The PNA reduces the need for averaging which significantly decreases sampling time.
- The NSI 2000 software uses faster hardware timing/triggering where as the DFL software utilizes software timing/triggering. This allows the NSI system to have more consistent timing and increases the measurement speed.
- The sampling density required for the CASAMS software to perform the NFFF transformation is significantly higher than NSI 2000. For example, for the UHF Horn Antenna CASAMS requires Sampling of 2° Theta, 5° Phi, and NSI 2000 requires Sampling of 6° Theta, 6° Phi.
- An important consideration in the speed of data acquisition is the amount of smear as different frequencies are measured at different points due to positioner movement. CASAMS offers a dynamic bore-site alignment correction to compensate for this error. NSI has not yet implemented appropriate correction in their software. Since the antennas measured were low gain antennas, any errors due to this effect are not evident in the data presented here.
- Probe correction is an important aspect of near-field to far-field conversion process. CASAMS offers a limited probe correction [4] where as a more rigorous correction is available in NSI and TICRA-SNFD software. There was no probe correction used in the results shown here.
- CASAMS offers corrections for displacement of antenna from the sphere centre and polarization referencing correction. These capabilities are not yet implemented in the NSI software. The effects of these corrections were not found to be significant for the low gain antennas for which the results are presented here.

CONCLUDING REMARKS

A variety of instrumentation and a number of software suits are available for spherical near-field measurements and near-field to far-field transformation. Inter-comparison is further made complicated due to differences in antenna mounting (equatorial or polar) geometries, the order in which the data is acquired (Theta or Phi scanning), the probe and other error compensation features, and the format of output data available. Post processing of the output data is necessary to have a meaningful comparison. Also for a thorough interpretation a variety of antennas need to measured.

The results presented here are only for low gain antennas and represent the initial phase of the inter-comparison study presently underway at the DFL. The future plans include measuring a mono-pulse antenna with a high gain sum pattern and a difference pattern with a deep null beam. This will provide means to estimate differences in determination of bore-site location, side-lobe levels and null-depth. Inter-comparison measurements for this antenna using different near-field geometries (Cylindrical and Planar) and also measurement in far-field and a compact range are also under consideration as further study.

REFERENCES

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2. “NSI 2000 software” Nearfield Systems Incorporated, NSI 2000 version 4.0.128 Professional
3. “Antenna and RCS Measurement Configurations” Agilent Technologies, Rev. B, Dec. 3, 2003
4. Wood P.J “Probe Correction algorithm for spherical antenna measurements” Proceedings of the AMTA Symposium, 1988, p3-9 - 3-14