Antenna Pattern Comparisons used in NIST 18-Term Error Assessments on Numerous Near-field Ranges

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***Abstract* — Antenna Pattern Comparisons are a key technique used in evaluating the performance of a near-field antenna range. In a prior paper by the authors[3], we discussed the comparison technique and established a methodology for performing the comparisons. This paper will review the application of this technique on a number of near-field ranges in which NSI was contracted to perform NIST 18-Term Range Error Assessments. These Error Assessments were performed with different antennas, and different range sizes and configurations. An overview of the pattern comparison results will be shown to help highlight the usefulness of the technique and the typical results and typical uncertainty levels in real world applications.**

I. INTRODUCTION

In [3] the authors described the use of the pattern comparison technique for error evaluation. The pattern comparison technique was used on a number of different ranges and AUT types and was been found to be an effective method to quantify the estimated uncertainty in a single measurement or to quantify the difference between results on different ranges. The method provides a means to determine a confidence level associated with the estimated uncertainties and therefore improve the reliability of both the individual estimates and the combination of the individual items in estimating the total uncertainty in a measurement.

This paper will review the pattern comparison technique in section II and discuss some of the advantages and methods. We will then show typical results from a number of 18 term range assessments done on planar nearfield test ranges in section III

Finally, some comparisons between the ranges will be made in section IV

II. REVIEW OF THE PATTERN COMPARISON TECHNIQUE

The pattern subtraction technique uses the result of subtraction of two antenna patterns on the same antenna, taken with some known configuration change, to derive an Equivalent Stray Signal (ESS) level across a region of interest.

Figure 1 shows the effect of a small stray signal on th desired signal, leading to a Measured restul that is a vector combination of the true signal as well as the error signal. A quadrature phase error yields the maximum phase change to the measured signal, while an in phase eror makes the maximum amplitude change to the measured signal . Figure 2 shows the use of the standard deviation as the measure of the error signal and in the referenced paper, we show how to convert results to higher 2 sigma or 3 sigma results if higher confidence is desired.

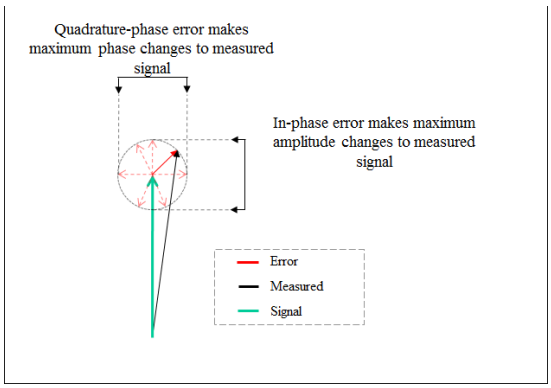

Figure 1. Errors in Vector Measurements

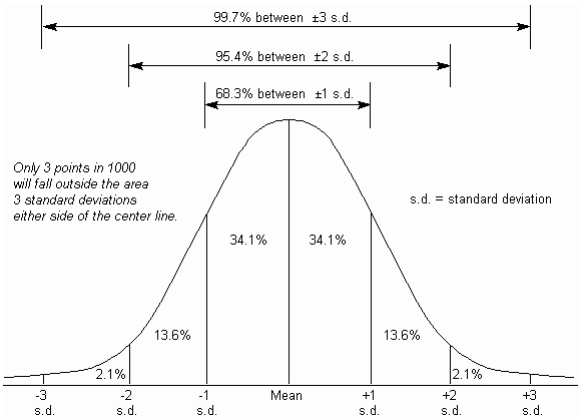

Figure 2. Use of Standard Deviation

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III. 18 TERM UNCERTAINTY RESULTS FOR RANGES

No.	Item	Uncertainty (dB)	S/E Level (dB)	Source
1	Probe relative pattern	0.2	33	OEWG model
2	Probe polarization ratio	0.9	20	N/A
3	Probe gain measurement	0.00	None	N/A
4	Probe alignment error	0.29	30	Error calc at 60 deg
5	Normalization constant	0.00	None	N/A
6	Impedance mismatch error	0.00	None	N/A
7	AUT alignment error	0.00	None	N/A
8	Data point spacing (aliasing)	0.08	33	Aliasing test
9	Measurement area truncation	0.44	26	Truncation test
10	Probe XY position errors	0.00	85	K-correction
11	Probe Z position error	0.00	85	K-correction
12	Mutual coupling (Probe/AUT)	0.44	26	1/4 wave test
13	Receiver amplitude linearity	0.28	30	Attenuator test
14	System phase error	0.01	63	System phase test
15	Receiver dynamic range	0.00	87	S/N and calc
16	Room scattering	0.98	19	1/4 wave test
17	Leakage and crosstalk	0.44	26	Loaded port test
18	Random amplitude/phase errors	0.12	37	Repeatability
	RSS Total =	1.60	-14.8	

TABLE I. -15 DB SIDELOBE UNCERTAINTY BUDGET FOR THE ETS 3106B DUAL-RIDGED HORN AT 500 MHZ ON 500H-50X50 PNF

No.	Item	Uncertainty (dB)	S/E Level (dB)	Source
1	Probe relative pattern	0.200	32.9	OEWG model
2	Probe polarization ratio	0.000	None	N/A
3	Probe gain measurement	0.000	None	N/A
4	Probe alignment error	0.150	35	Error calc at 60 deg
5	Normalization constant	0.000	None	N/A
6	Impedance mismatch error	0.000	None	N/A
7	AUT alignment error	0.000	None	N/A
8	Data point spacing (aliasing)	0.194	33	Aliasing test
9	Measurement area truncation	0.275	30	Truncation test
10	Probe XY position errors	0.055	44	X error map
11	Probe Z position error	0.055	44	Z error map
12	Mutual coupling (Probe/AUT)	0.173	34	1/4 wave test
13	Receiver amplitude linearity	0.218	32	Attenuator test
14	System phase error	0.097	39	System phase test
15	Receiver dynamic range	0.001	81	S/N and calc
16	Room scattering	0.979	19	1/4 wave test
17	Leakage and crosstalk	0.097	39	Loaded port test
18	Random amplitude/phase errors	0.077	41	Repeatability
	RSS Total =	**1.117**	**17.86**	

TABLE II. -30 dB SIDELOBE UNCERTAINTY BUDGET FOR THE CONICAL HORN AT 20 GHZ ON 500H-50X50 PNF NORTH RANGE

No.	Item	Uncertainty (dB)	S/E Level (dB)	Source
1	Probe relative pattern	0.200	32.90	OEWG model
2	Probe polarization ratio	0.000	None	N/A
3	Probe gain measurement	0.000	None	N/A
4	Probe alignment error	0.060	43.20	Error calc at 60 deg
5	Normalization constant	0.000	None	N/A
6	Impedance mismatch error	0.000	None	N/A
7	AUT alignment error	0.000	None	N/A
8	Data point spacing (aliasing)	0.215	32.14	Aliasing test
9	Measurement area truncation	0.247	30.91	Truncation test
10	Probe XY position errors	0.028	49.72	X error map
11	Probe Z position error	0.028	49.72	Z error map
12	Mutual coupling (Probe/AUT)	0.182	33.58	1/4 wave test
13	Receiver amplitude linearity	0.136	36.10	Attenuator test
14	System phase error	0.065	42.56	System phase test
15	Receiver dynamic range	0.001	81.10	S/N and calc
16	Room scattering	0.813	20.60	1/4 wave test
17	Leakage and crosstalk	0.046	45.57	Loaded port test
18	Random amplitude/phase errors	0.084	40.26	Repeatability
	RSS Total =	**0.938**	**19.37**	

TABLE III. -30 dB SIDELOBE UNCERTAINTY BUDGET FOR THE CONICAL HORN AT 20 GHZ ON 500H-50X50 PNF SOUTH RANGE

No.	Item	Uncertainty (dB)	S/E Level (dB)	Source
1	Probe relative pattern	0.200	32.9	OEWG model
2	Probe polarization ratio	0.000	None	N/A
3	Probe gain measurement	0.000	None	N/A
4	Probe alignment error	0.060	43.2	Error calc at 60 deg
5	Normalization constant	0.000	None	N/A
6	Impedance mismatch error	0.000	None	N/A
7	AUT alignment error	0.000	None	N/A
8	Data point spacing (aliasing)	0.338	28.2	Aliasing test
9	Measurement area truncation	0.245	31.0	Truncation test
10	Probe XY position errors	0.055	44.0	X error map
11	Probe Z position error	0.055	44.0	Z error map
12	Mutual coupling (Probe/AUT)	0.421	26.3	1/4 wave test
13	Receiver amplitude linearity	0.216	32.1	Attenuator test
14	System phase error	0.426	26.2	System phase test
15	Receiver dynamic range	0.001	84.0	S/N and calc
16	Room scattering	0.123	37.0	1/4 wave test
17	Leakage and crosstalk	0.013	56.7	Loaded port test
18	Random amplitude/phase errors	0.194	33.0	Repeatability
	RSS Total =	**0.829**	**20.4**	

TABLE IV. -30 DB SIDELOBE UNCERTAINTY BUDGET FOR THE NSI-RF-SG75 PYRAMIDAL STANDARD GAIN HORN AT 15 GHZON 500H-67X54 PNF

No.	Item	Uncertainty (dB)	S/E Level (dB)	Source
1	Probe relative pattern	0.10	-40	OEWG model
2	Probe polarization ratio			N/A
3	Probe gain measurement			N/A
4	Probe alignment error	0.10	-40	Error calc at 60 deg
5	Normalization constant			N/A
6	Impedance mismatch error			N/A
7	AUT alignment error			N/A
8	Data point spacing (aliasing)	0.10	-40	Aliasing test
9	Measurement area truncation	0.01	-60	Truncation test
10	Probe XY position errors	0.01	-60	X error map
11	Probe Z position error	0.01	-60	Z error map
12	Mutual coupling (Probe/AUT)	0.50	-25	1/4 wave test
13	Receiver amplitude linearity	0.001	-80	Attenuator test
14	System phase error	0.05	-45	System phase test
15	Receiver dynamic range	0.30	-30	S/N and calc
16	Room scattering	0.30	-30	1/4 wave test
17	Leakage and crosstalk	0.02	-55	Loaded port test
18	Random amplitude/phase errors	0.05	-45	Repeatability
	RSS Total =	**0.70**	**22**	

TABLE V. -30 DB SIDELOBE UNCERTAINTY BUDGET FOR 1 M DIA REFLECTOR ANTENNA AT 8.2 GHZ ON 300V-40X20 PNF

No.	Item	Uncertainty (dB)	S/E Level (dB)	Source
1	Probe relative pattern	0.10	-39	OEWG model
2	Probe polarization ratio			N/A
3	Probe gain measurement			N/A
4	Probe alignment error	0.2	-33	Error calc at 60 deg
5	Normalization constant			N/A
6	Impedance mismatch error			N/A
7	AUT alignment error			N/A
8	Data point spacing (aliasing)	0.15	-35	Aliasing test
9	Measurement area truncation	0.04	-45	Truncation test
10	Probe XY position errors	0.01	-58	X error map
11	Probe Z position error	0.14	-36	Z error map
12	Mutual coupling (Probe/AUT)	0.27	-30	1/4 wave test
13	Receiver amplitude linearity	0.15	-35	Attenuator test
14	System phase error	0.15	-35	System phase test
15	Receiver dynamic range	0.48	-25	S/N and calc
16	Room scattering	0.27	-30	1/4 wave test
17	Leakage and crosstalk	0.03	-50	Loaded port test
18	Random amplitude/phase errors	0.15	-35	Repeatability
	RSS Total =	**0.75**	**21**	

TABLE VI. -30 DB SIDELOBE UNCERTAINTY BUDGET FOR REFLECTOR ANNTENNA AT 10 GHZ ON 300V-12X12 PNF

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