CISPR >1 GHz antenna calibration—round robin summary

Laboratory data demonstrate the need for an international standard on EMC antenna calibration.

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This article presents the FINAL results of the antenna inter-laboratory calibration comparison that was spearheaded by Hewlett-Packard between September 2002 and February 2005. Six above 1-GHz antennas were circulated to eleven antenna calibration facilities. The summary results are presented here.

INTRODUCTION

An inter-laboratory comparison of above 1-GHz antenna calibration was initiated in September 2002, managed by Hewlett-Packard. This study was initiated because data from six different calibrations of a horn antenna (Figure 1) varied significantly from data obtained in a study by NPL (National Physical Laboratory) and in a very controlled study of an X-band horn antenna[1] carried out by NIST. There were from four to six antennas circulated to ETS-Lindgren, USA; Austrian Research Center, Austria; Schwarzbeck, Germany; CONFORMITAS Ing., Germany; Rohde & Schwarz, Germany; Rolf Heine, Germany; NPL, UK; CRL, Japan; Akzo Nobel, Japan; Liberty Labs, USA and NIST, USA. Schwarzbeck has added two additional antennas to the round robin. Ten laboratories completed the calibrations. Results show worst case deviations between laboratories to be greater than 9 dB. Antennas and calibration laboratories have been coded for privacy.

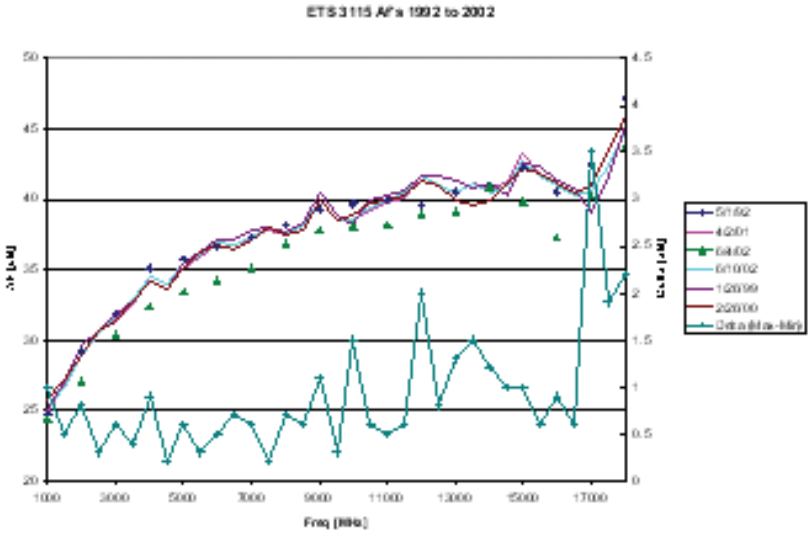

Figure 1. *Horn antenna factor variations.*

OVERVIEW

The following summarizes the results of the above 1 GHz antenna calibration round robin started in September 2002 and completed in September 2004. Ten laboratories performed the calibrations. Two antennas were added after the start of the study, and two antennas failed in the middle and were withdrawn. The information presented is a summary from 14 documents available to interested parties. The sanitized EXCEL data files are available for anyone who wants to perform their own analysis. The information was presented to CISPR/A/WG1, Shanghai, P. R. China; and ANSI C63, Austin, TX with the hope of influencing the

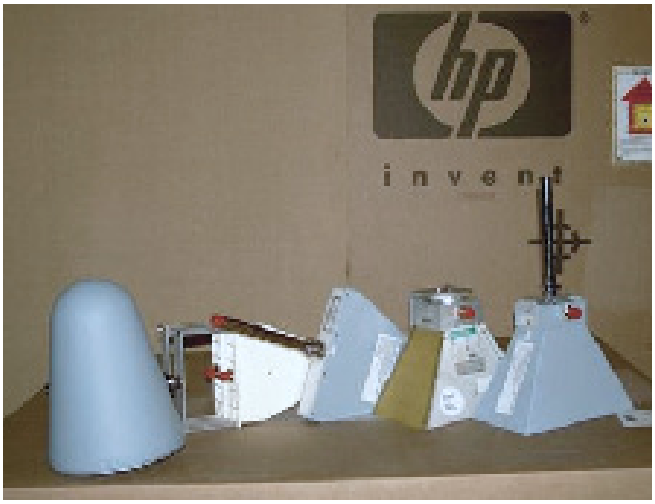

Figure 2. *The antennas.*

antenna calibration standards writing committees.

The antennas (Figure 2) were supplied by Hewlett Packard, AH Systems, and Schwarzbeck. They were ETS-Lindgren 3115 Double-Ridged Guide Horn, 1 -18 GHz; AH Systems SAS-200/518 Log Periodic, 1-18 GHz; Rohde & Schwarz HL025 Log Periodic, 1 – 26 GHz; Schwarzbeck ESLP9145 Log Periodic, 1-18 GHz; and a Schwarzbeck BBHA9120D Double-Ridged Horn, 1 -18 GHz.

PROCEDURE

Since there is no internationally accepted procedure for calibrating antennas above 1 GHz, the calibration laboratories were asked to calibrate the antennas using the method their EMC customers expected. We requested they calibrate at a minimum of step size of 50 MHz because of pending requirements expected from the CISPR/A Site Validation and Measurement Methods above 1 GHz Working Group.

THE DATA

Figures 3 through 7 contain the antenna factor data plots. In some cases the calibration laboratory used frequency steps other than 50 MHz; in these cases, their data was linearly interpolated or extrapolated to equal 50-MHz steps for direct comparison. Figure 8 shows a reduced span plot, which demonstrates the need for 50-MHz as the resonances and sharp variations are not shown in the antenna factor data from calibration laboratory G that used 100 MHz steps. Figure 9 is a reduced span plot, where we can see sharp variations, up to 8 dB, that are identified in the antenna factor data from some of the laboratories. Figure 10 plots the antenna factor and VSWR of antenna LPDA3 #2; note the VSWR is about 6:1 at its highest.

VSWR is more than likely the reason for the variations between calibration laboratories. VSWR tests were performed by one laboratory; another supplied S11 data. As can be seen in Figure 10, if the VSWR is significant, then antenna factors will vary depending on the calibration systems VSWR.

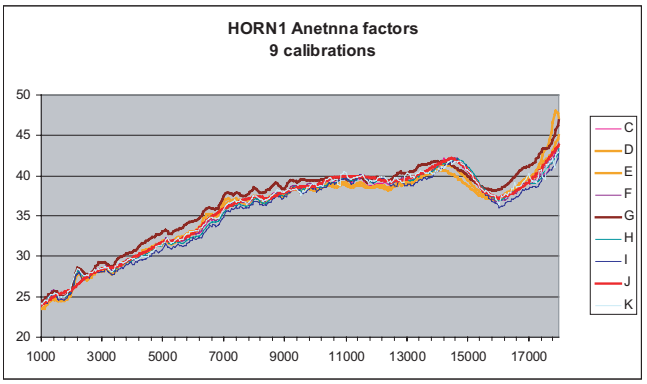

Figure 3. *Horn 1 data.*

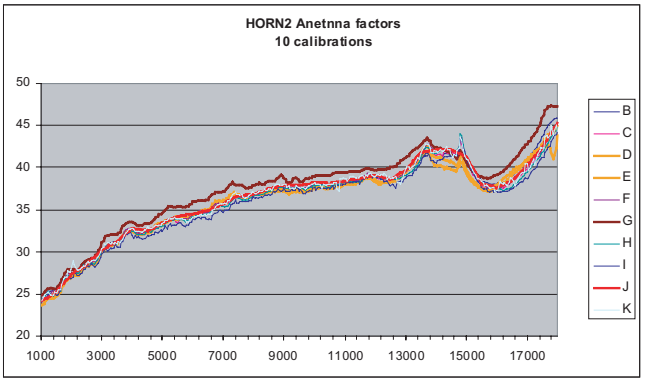

Figure 4. *Horn 2 data.*

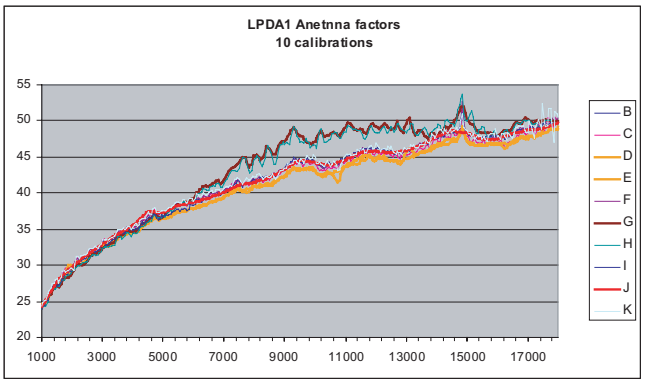

Figure 5. *LPDA 1 data.*

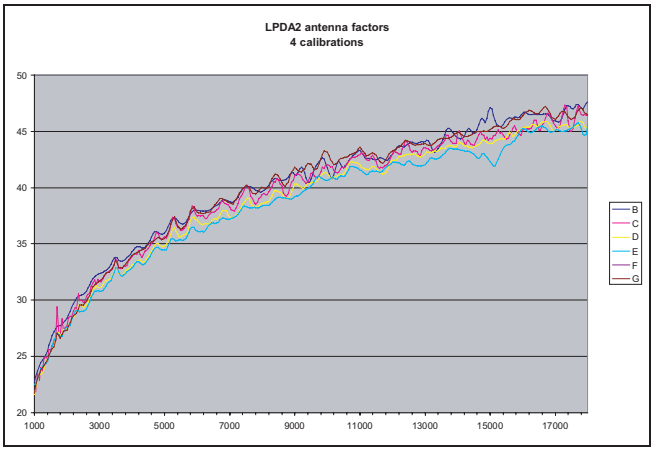

Figure 6. *LPDA 2 data.*

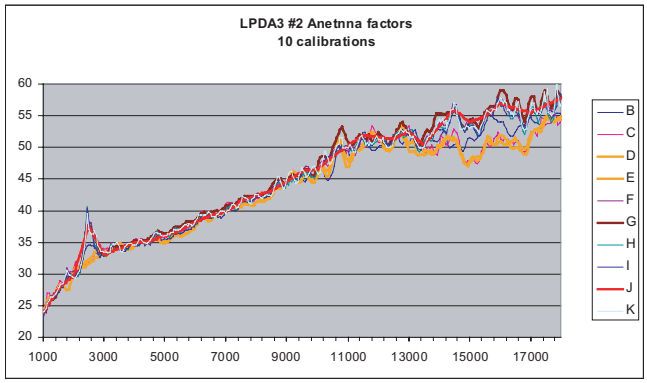

Figure 7. *LPDA 3 #2 data.*

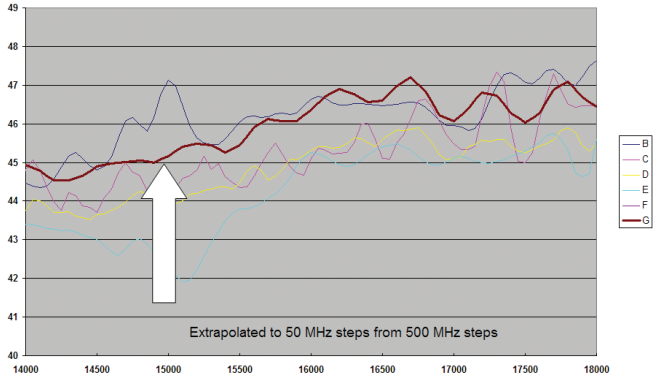

Figure 8. *500 MHz misses large variation.*

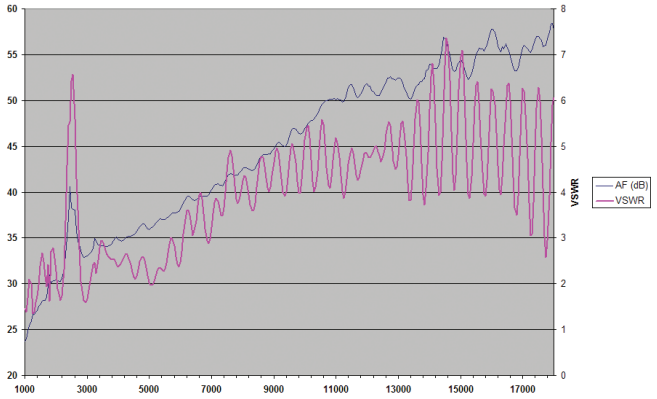

Figure 9. *Unexplained errors—mismatch???*

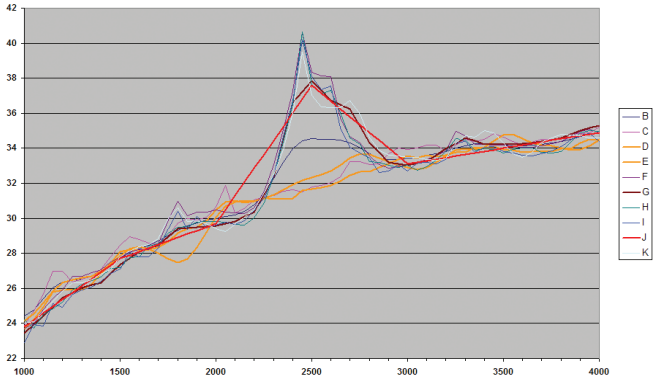

Figure 10. *VSWR and antenna factor.*

Antenna	All data Max [dB]	W/O ext data [dB]
Horn 1	6.45	6.45
Horn 2	6.3	4.57
LPDA 1	6.9	6.7*
LPDA 2-1	4.89	4.89
LPDA 2-2	2.68	2.52
LPDA 3-1	7.78	7.78
LPDA 3-2	9.15	9.15

Table 1. *Worst-case deviations with and without extrapolation.*

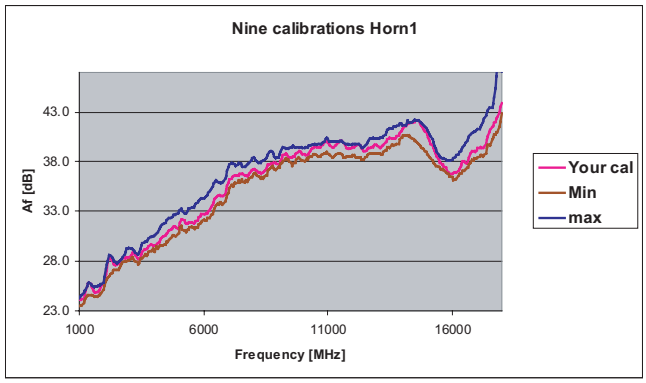

Figure 11. *Sample calibration laboratory data.*

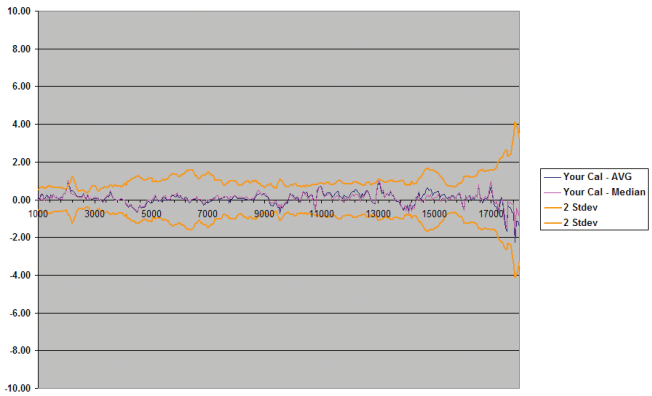

Figure 12. *Some statistics on how they compared to others.*

THE REPORTS

Due to the magnitude of the data and information, fourteen separate reports were produced. The first is a summary of the reports that can be found in CISPR_A_WG1(Hall)04-02. The next ten, CISPR_A_WG1(Hall)04-02b to 02k, are the data provided to each calibration laboratory showing how their calibration data compared to the minimum and maximum of the other participants. Figure 11 is an example of the antenna factor data, and Figure 12 shows statistical data sent to the calibration laboratories. All calibration laboratories were offered the raw data for their own analysis.

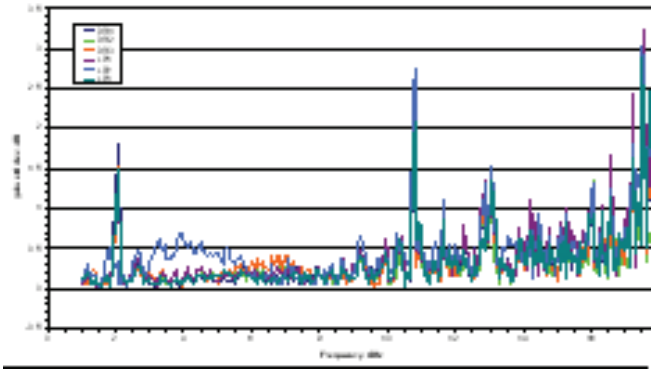

Figure 13. *Standard deviation of 5 sets of data.*

One of the calibration laboratories requested that the extrapolated data be removed from the comparisons. The data with and without extrapolations is in Table 1. The only signnificant difference was with Horn 2, 1.73 dB.

One of the laboratories, with an anechoic chamber, performed five separate calibration. They averaged the data and derived the standard deviation. The only changes were in the positions/locations of the antennas under test. Figure 13 is the standard deviation for the 5 sets of data. Although a lot of the standard deviations are below 1 dB, there are a significant number above 3.41 dB.

See "Report on an Inter-laboratory comparison of EMC antenna factors on antennas used above 1 GHz"[1], for additional material on the round robin results.

COMMENTS

There needs to be an international standard for calibration of EMC antennas.

Also, calibration laboratories need to include reproducibility and repeatability values for each test setup in their uncertainty calculations. They should verify that there are no abnormal variations caused by setup connections in the antenna factor data supplied to the customer.

Hewlett Packard, Schwarzbeck, and AH Systems will loan antennas for another round robin to validate proposed calibration standards prior to release to the EMC and calibration community.

REFERENCES

1. Ken Hall. "Report on an Inter-laboratory comparison of EMC antenna factors on antennas used above 1 GHz." 2003 IEEE EMC International Symposium. pp. 303-306.

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