CISPR/A/WG1 LLAS tables (Beeckman)16-02

For IEC use only

2016-08-17

INTERNATIONAL ELECTROTECHNICAL COMMISSION

INTERNATIONAL SPECIAL COMMITTEE ON RADIO INTERFERENCE (CISPR)

CISPR A WG 1: EMC instrumentation specifications

Subject:

Verification impact new proposed validation factor curve on an actual LLAS

Foreword:

The attached paper describes the validation results of an actual large loop antenna system (LLAS) applied within the EMC laboratory of Philips Lighting Innovation Labs in Eindhoven, the Netherlands.

The impact of the existing and new proposed reference validation factor curves is shown.

This paper is for consideration at the forthcoming CISPR/A WG1 meeting of 26 October in Hangzhou, China.

Pierre Beeckman

1 Introduction

During the CISPR A WG1 of 2015 meeting in Stresa [1] a number of papers were presented and discussed on the model and validation factor of the large loop antenna system (LLAS).

The paper by Mr. Beeckman [2] introduced the LLAS-model and existing tabular values in CISPR 16-1-4 [3] for conversion and validation factors based on the original work by Bergervoet [4]. Also two papers by Mr. Midori et al were presented [5][6]. Both papers by Midori introduced an alternative LAS model based on the application of a Neumann integral for calculation of the mutual inductance between the loops of the LLAS and the calibration dipole and NEC2 calculation for calculating the validation factor. The application of the more accurate value of the mutual inductance results in a reduction of the validation factor of approximately 1,6 dB, which is quite significant. Verification measurements shown by Mr. Schwarzbeck using results of measured data of 24 LLAS unit [7], and verification results reported by Mr. Midori in a later paper [8] show that the validation curve with the 1,6 dB shift provides a better match with actual LLAS in the field. The need for a 1,6 dB shift was confirmed in a recent WG1 paper of Beeckman [9].

This paper describes validation results of an actual LLAS applied within the EMC laboratory of Philips Lighting Innovation Labs in Eindhoven in the Netherlands.

The impact of the current and new proposed validation factor curves is shown. Also the effect of the application of values of the validation curve subtracted from the current graph of the validation curve in Figure C.8 of CISPR 16-1-4 is shown.

2 LLAS and test equipment applied

The LLAS used for the verification is a 2 m LLAS constructed in accordance with CISPR 16-1-4 [3]. Also the balun-dipole is according the specification in CISPR16-1-4. Both the LLAS and the balun-dipole are shown in Figure 1.

Measurements are executed using the analyser and RF generator of an R&S ESIB26 EMI test receiver. The verification test is done while the LLAS is positioned inside a 10 m SAR (see Figure 1).

More details on the validation test setup and equipment are in an internal Philips report.

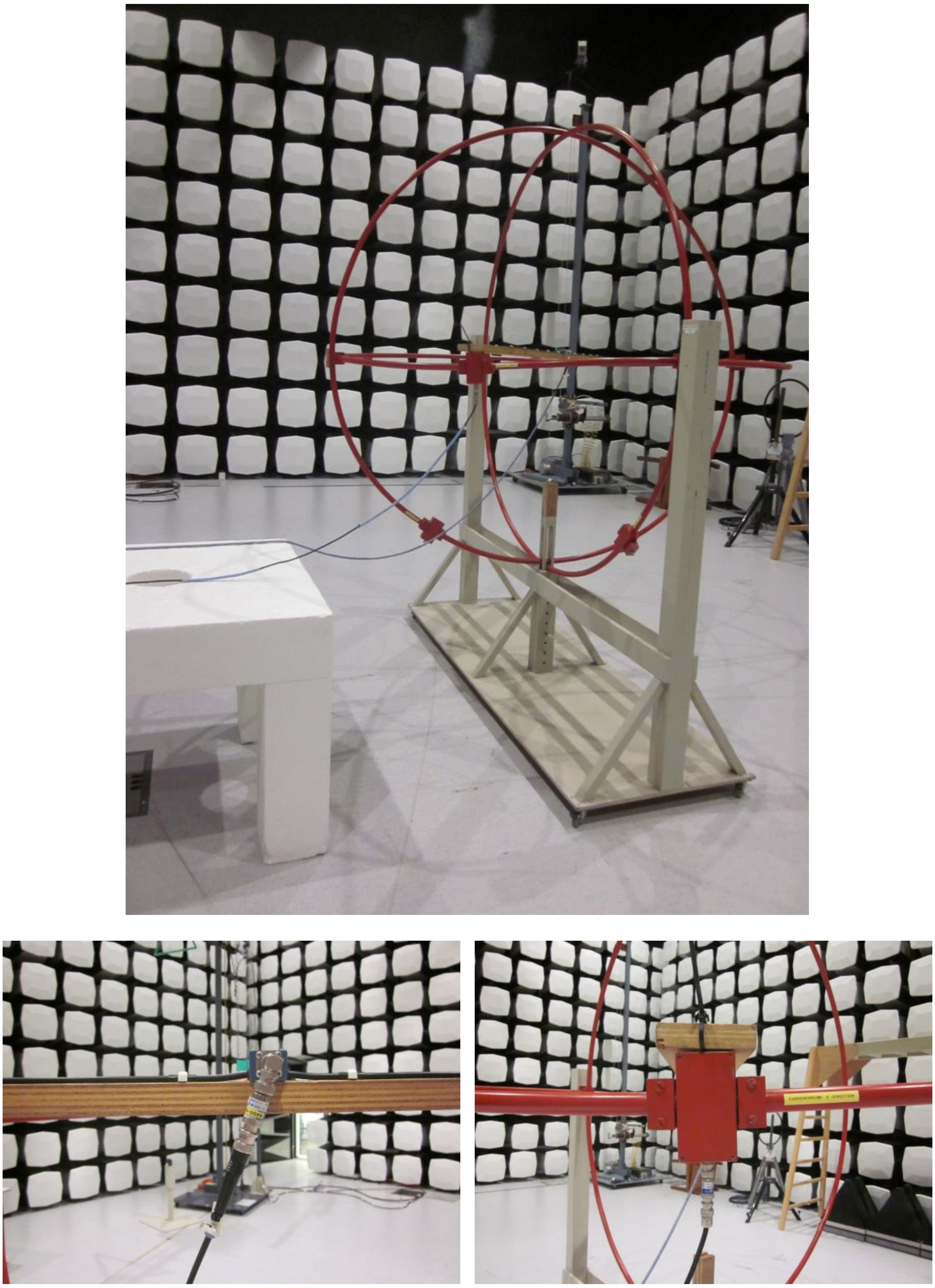


Figure 1 – LLAS used for the verification with details of the balun-dipole located in the horizontal plane

3 Validation procedure and validation factors applied

The validation procedure has been applied in accordance with the present procedure of CISPR 16-1-4 [3]. The induced current has been measured as a function of frequency in the range of 9 kHz to 30 MHz at the required eight positions of the balun-dipole (Figure 2). During this measurement the balun-dipole is in the plane of the loop under test.

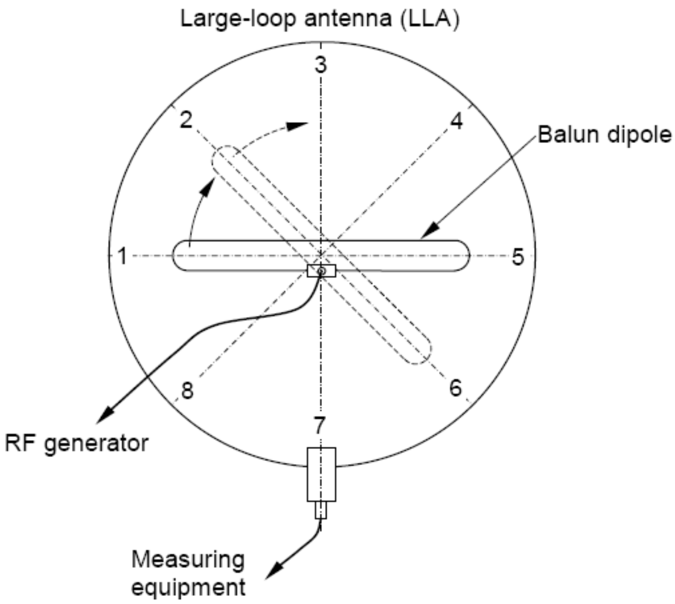


Figure 2 – Eight positions of the balun-dipole during validation of the LLAS

In each of the eight positions, the ratio of the open circuit voltage of the RF generator and the measured current in the three loops of the LLAS is measured (=measured validation factor).

Initially, the LLAS in question has been verified by comparing the measured validation factor values with the current reference validation factor curve for a 2 m LLAS given in Figure C.8 of CISPR 16-1-4 [3]. The numerical values of this curve have been subtracted from the current graph of the validation curve in Figure C.8. This is done by hand using an enlarged copy of Figure C.8. The subtracted values that were applied are given in the second column of Table 1 (column a). In column b of Table 1 also the replicated values of the current validation factor are given. These are the values derived in [2]. Finally column c of Table 1 gives the values of the new reference validation factor proposed in [5][6][9].

Note that the difference between the validation values of column b and column c is 1,64 dB for all frequencies. This is the result of the more accurate calculation of the mutual inductance between the loops of the LLAS and the balun-dipole. See [5][6][9].

From Table 1 we see that the uncertainty due to missing exact tabular values can be considerably large. The difference amounts to approximately 1 dB (the absolute difference between columns a and b).

In summary, in this paper we will assess the validation factor deviations for each of the following reference validation factors:

1) Numerical values subtracted from the current validation factor curve given in Figure C.8 of CISPR 16-1-4 [3];
2) Replicated numerical values of the current validation factor curve given in Figure C.8 of CISPR 16-1-4 [3];
3) The new validation factor with 1,64 dB shift proposed in [5][6][9].

Table 1 – Tabular values of the different reference validation factors used (2 m diameter LLAS)

	a	b		c
Frequency	**Current validation factor data subtracted from graph Figure C.8**	**Current validation factor of Figure C.8: replicated data**	**Absolute difference (a)-(b)**	**New validation factor [1)]**
(MHz)	**(dB)**	**(dB)**	**(dB)**	**(dB)**
0,009	74	74,16	0,16	72,52
0,15	73,8	74,17	0,37	72,53
1	74,5	74,52	0,02	72,88
2	75	75,45	0,45	73,81
3	76,5	76,65	0,15	75,01
5	79	79,10	0,1	77,46
10	82,7	83,68	0,98	82,04
15	86,4	86,54	0,14	84,90
20	87,7	88,45	0,75	86,81
25	90	89,83	0,17	88,19
30	91	90,94	0,06	89,30

NOTE 1 – The difference between the validation factor values of column b and column c is 1,64 dB for all frequencies. This is the result of the more accurate calculation of the mutual inductance between the loops of the LLAS and the balun-dipole. See [5][6][9].

4 Results

The measurement results of the validation factors for each of the three loops of the LLAS (X-, Y- and Z-loop) are given in Annex A. In this Annex A also the differences between the measurement results and each of the three reference validation factors are given.

Figure 7 shows the deviations for each of the three loops when using the reference validation factor values subtracted from the current validation factor curve given in Figure C.8 of CISPR 16-1-4.

Figure 8 gives the deviations from the current validation factor curve given in Figure C.8 of CISPR 16-1-4 (replicated numerical values);

Figure 9 gives the deviations when applying the newly proposed validation factor with the 1,64 dB shift.

For each of the three reference validation factors, the deviations for all 24 measurement results are also shown in a single figure in respectively Figure 3, Figure 4 and Figure 5.

In these figures, the maximum, mean and minimum deviation is given as a function of frequency. In all three cases, irrespective which reference validation factor is applied, the measured validation factors are (just) within the +2 dB and -2 dB deviation limits. The standard deviation of the deviations is approximately 0,1 dB and fairly constant up to 10 MHz and rises up to approximately 0,5 dB at 30 MHz. From these results we see that there is very little margin between the ±2 dB bounds and maximum and minimum values of the deviations. It is supported to provide additional margin by changing the acceptance criterion in CISPR 16-1-4 from ±2 dB to ±3 dB.

The median values of all the deviations with respect to the current and the newly proposed validation factors are respectively -0,79 dB and + 0,85 dB (compare Figure 4 and Figure 5), which is attributed to the 1,64 dB shift of the reference validation factor.

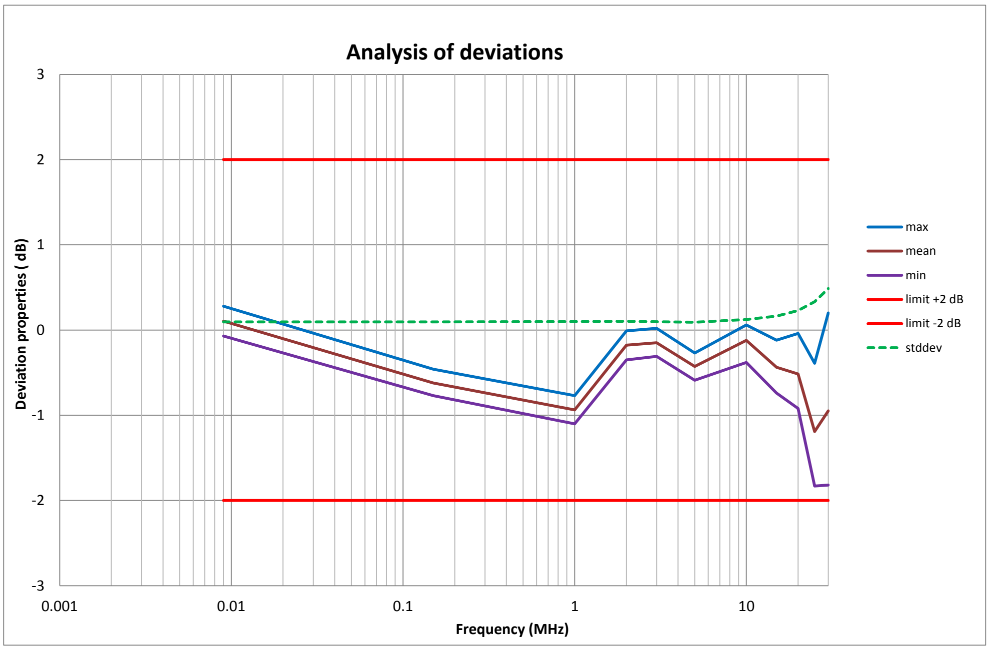


Figure 3 – Properties of the LLAS deviations w.r.t. validation factor subtracted from graph Figure C.8 (column a)

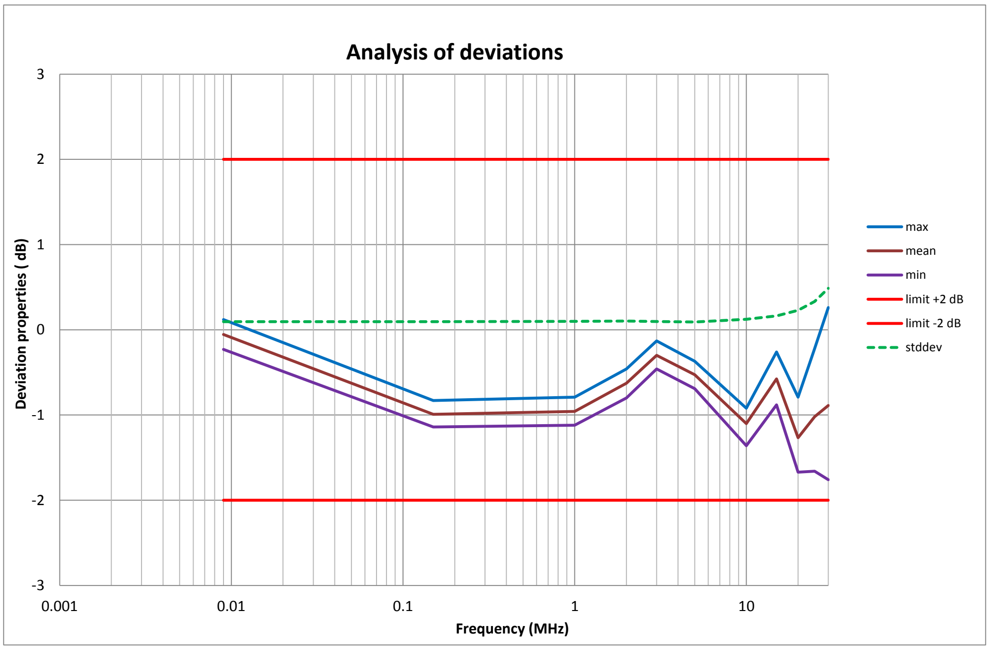


Figure 4 – Properties of the LLAS deviations w.r.t. current replicated validation factor (column b)

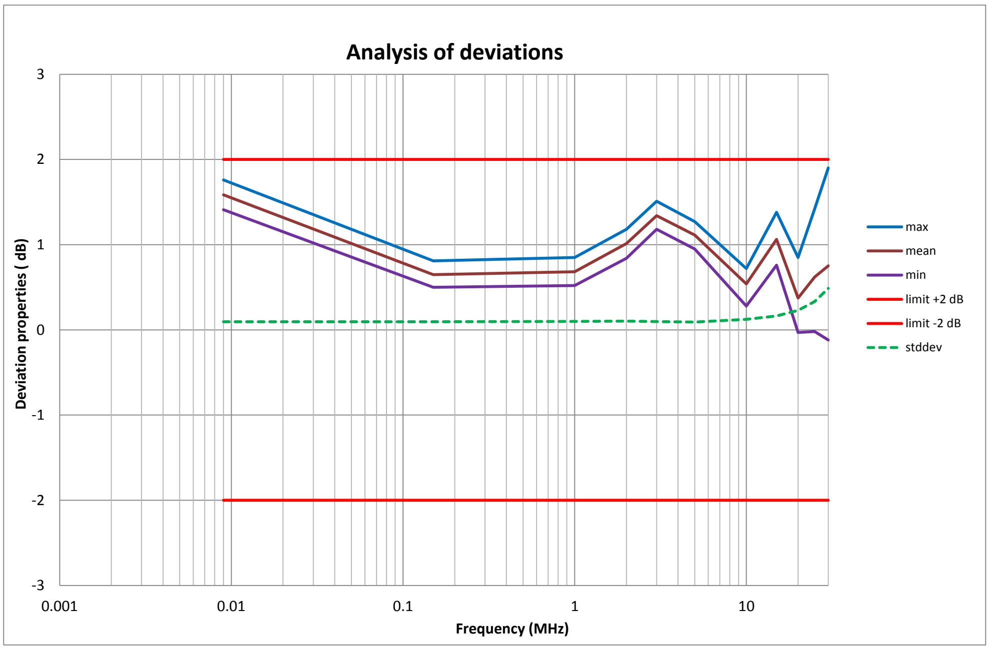


Figure 5 – Properties of the LLAS deviations w.r.t. new proposed validation factor (column c)

5 Summary

This paper describes validation results of an actual LLAS applied within the EMC laboratory of Philips Lighting Innovation Labs in Eindhoven in the Netherlands.

The impact of the current and new proposed validation factor curves is shown.

The measurement results of the validation factors are compared with the current and new proposed reference validation factor curves. In both cases, the measured validation factors are just within the +2 dB and -2 dB deviation limits.

In both cases there is very little margin between the ±2 dB bounds and maximum and minimum values of the deviations. It is supported to provide additional margin by changing the acceptance criterion for the LLAS validation in CISPR 16-1-4 from ±2 dB to ±3 dB

Also the effect of the application of values of the validation curve subtracted from the current graph of the validation curve in Figure C.8 of CISPR 16-1-4 is shown. The uncertainty due to missing exact tabular values can be considerably large. The difference amounts to approximately 1 dB. This justifies the need for more accurate tabular numerical values of the LLAS validation factor.

6 References

[1] CISPR/A/WG1(Secretary)15-03, *Unconfirmed minutes of the meeting of Working Group 1 of CISPR/A, held in Stresa, Italy on September 24*, November 20, 2015.

[2] CISPR/A/WG1 LAS tables (Beeckman)15-01, *LAS model and tabular values of LLA figures in Annex C of CISPR 16-1-4*, 2015-01-21.

[3] CISPR 16-1-4: 2012-07 (ed. 3.1), *Specification for radio disturbance and immunity measuring apparatus and methods – Part 1-4: Radio disturbance and immunity measuring apparatus – Antennas and test sites for radiated disturbance measurements*.

[4] J.R. Bergervoet, H. van Veen, *A Large-Loop Antenna for Magnetic Field Measurements*, Proceedings of the 8th International Zürich Symposium on Electromagnetic Compatibility, March 1989, ETH Zentrum - IKT, 8092 Zürich, Switzerland, p. 29-34.

[5] CISPR/A/WG1 LAS Tables (Midori-Kurihara-Fujii-Shinozuka)15-01, Proposal of tabular values of validation factor for LAS, February 2015.

[6] CISPR/A/WG1 LAS Tables (Midori-McLean-Kurihara-Fujii-Shinozuka)15-02, *Proposal of tabular values of validation factor and conversion factor for LAS*, August 2015.

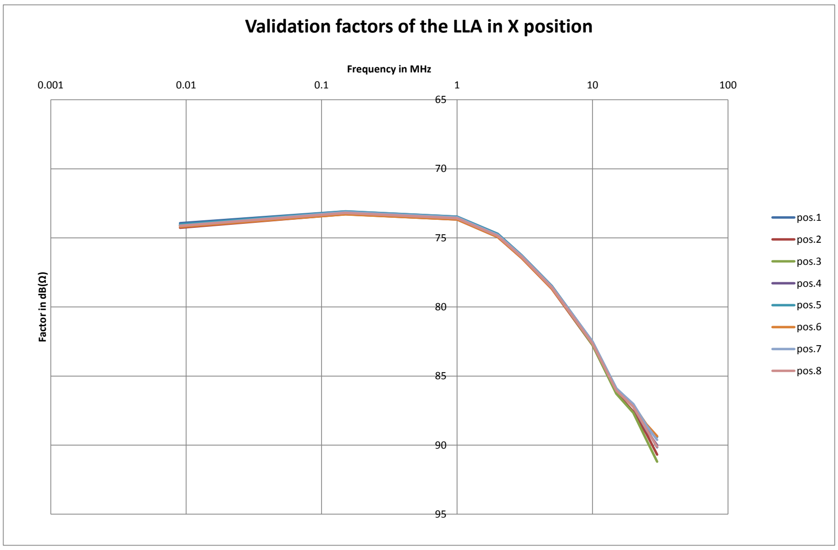
[7] CISPR A WG1 paper Schwarzbeck (Stresa meeting 2015), *Loop Antenna System CISPR 16-1-4 Ed. 3*.

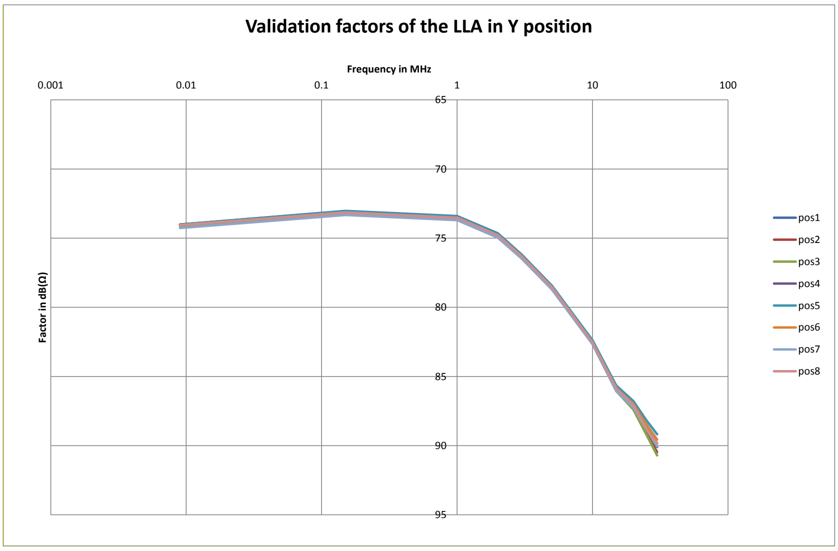
[8] CISPR/A/WG1 LAS Tables (Midori-Kurihara-Fujii-Shinozuka)15-04, *Verification of the calculation model of validation factor and the tolerance of validation factor for LAS*, January 2016.

[9] CISPR/A/WG1 LLAS tables (Beeckman)16-01, *Updated LLAS model and amended figures and tabular values of LLAS figures in Annex C of CISPR 16-1-4*, 2016-07-21.

Annex A

Results validation factor measurements and deviations calculated for the different reference validation factors





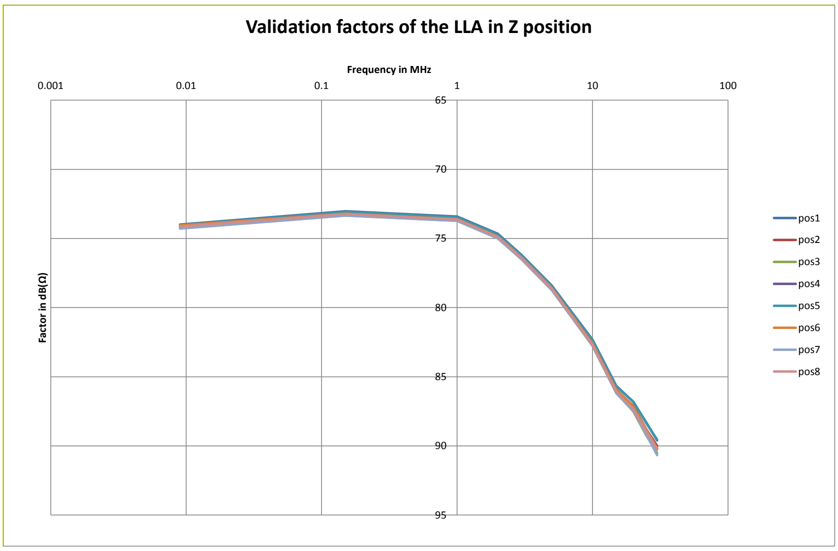
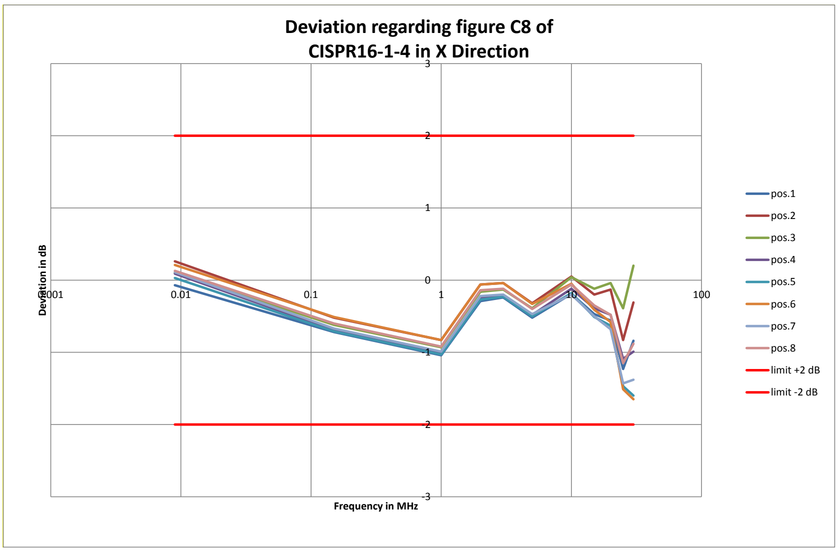
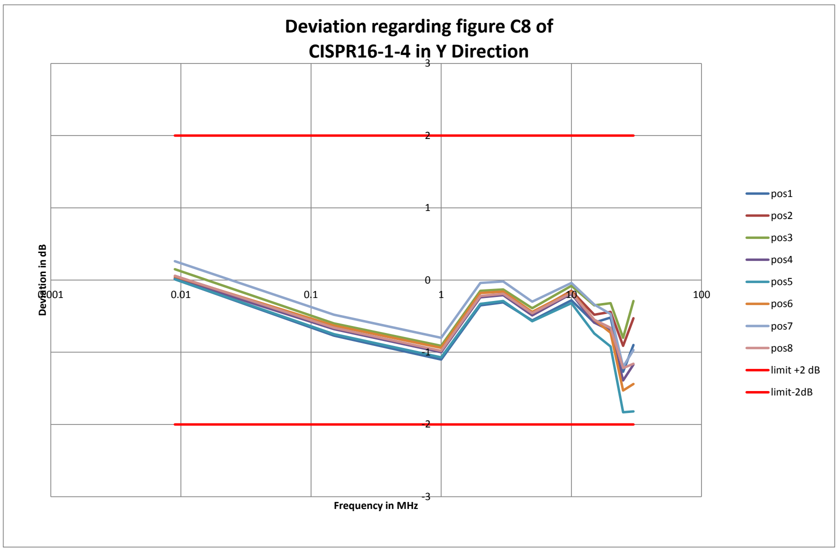


Figure 6 – Measured validations factors for each of the three loops of the LLAS

136





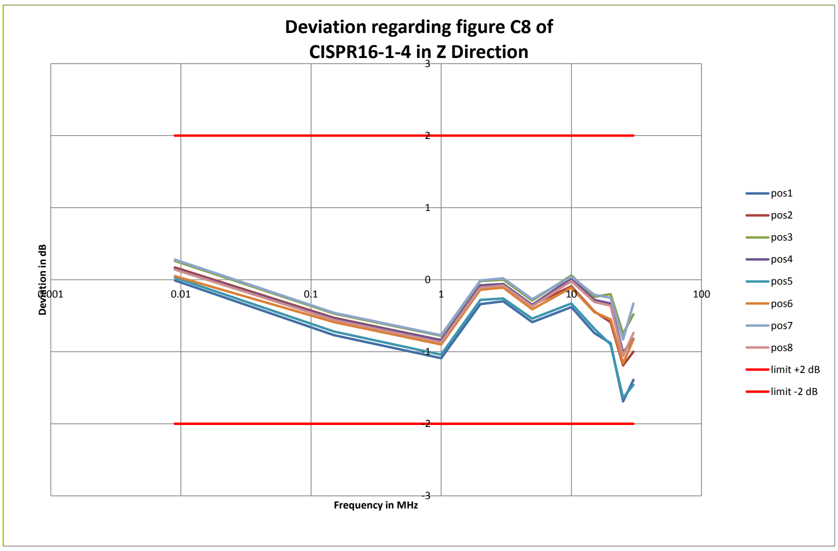
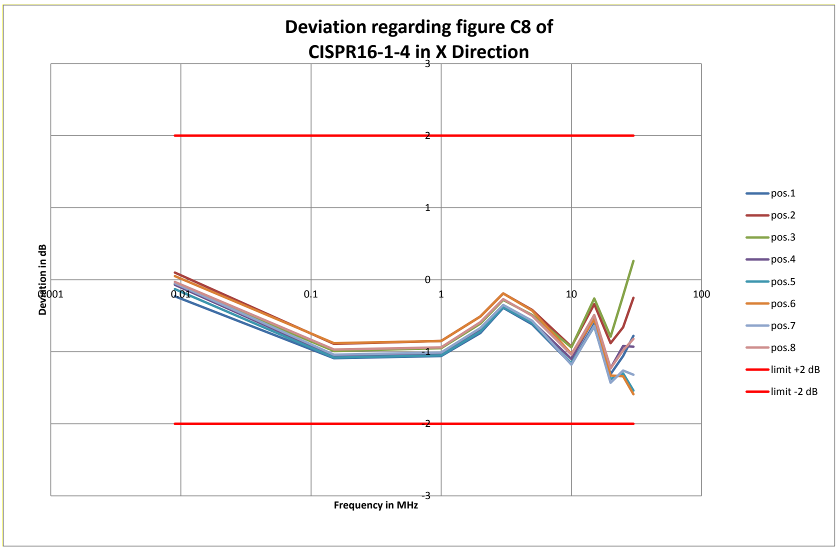
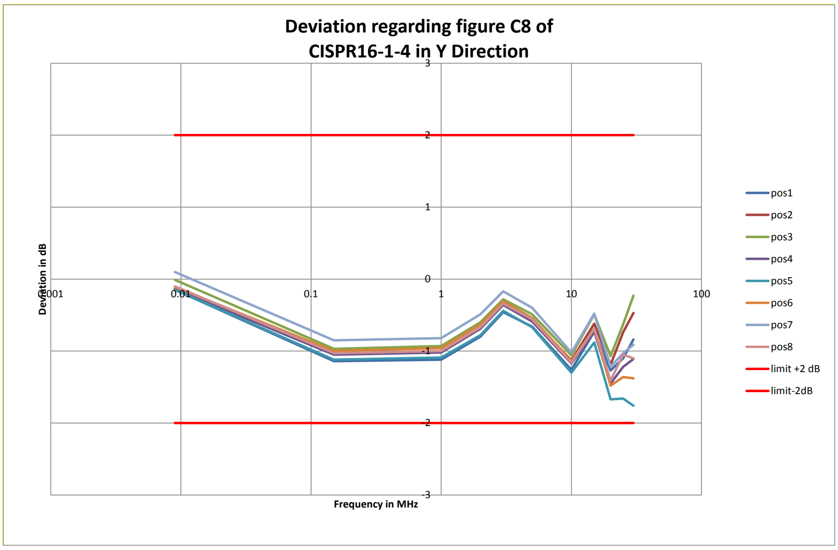


Figure 7 – Deviations of validation factors using data subtracted from the current graph of the validation curve in Figure C.8

137

138





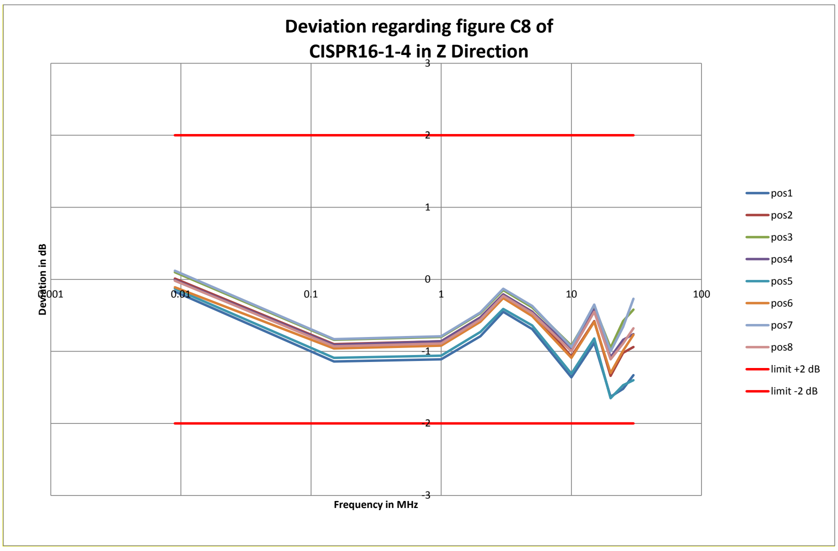
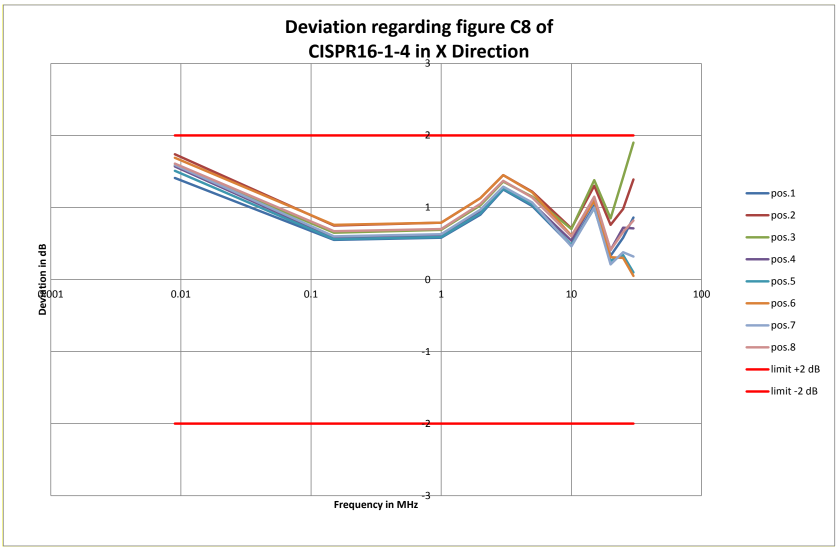
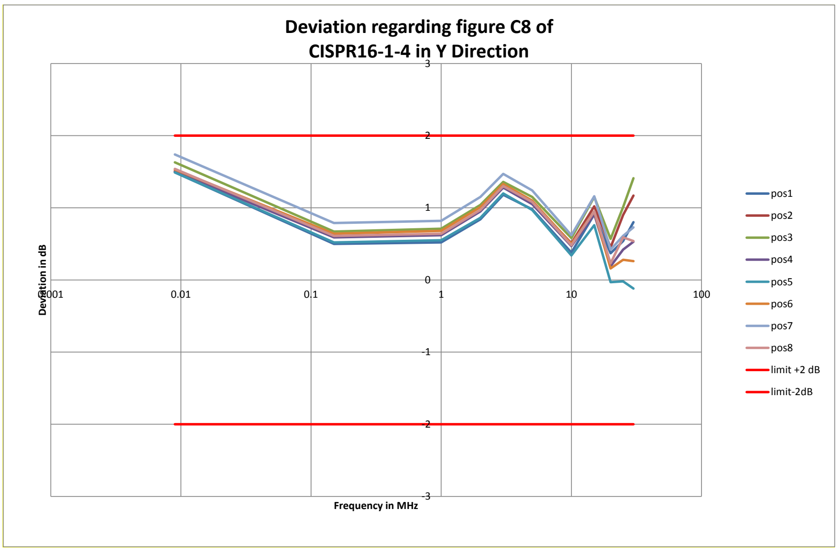


Figure 8 – Deviations from the current validation factor (using replicated tabular values of the current graph of the validation curve in Figure C.8)

142





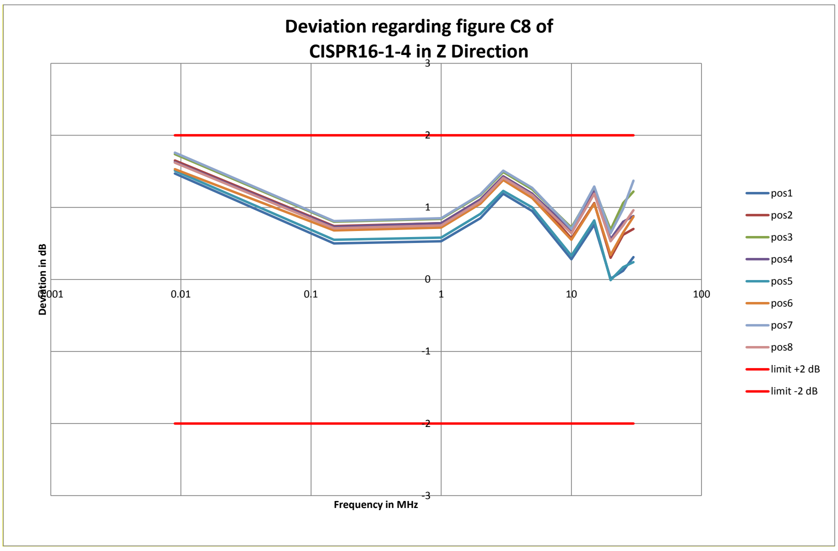


Figure 9 – Deviations from the new proposed validation factor

143