Reducing the standard compliance uncertainty by using ferrite type CMADs during radiated disturbance measurements acc. to CISPR 16-2-3

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Abstract* — *The consideration of measurement instrumentation uncertainty (MIU) is common practice when determining compliance or non-compliance with a disturbance limit. But MIU is just a subpart of the standard compliance uncertainty (SCU) which also addresses uncertainties related to the EUT set-up, EUT operation and measurement procedure. One major influence quantity of SCU is the termination of cables leaving the test volume of the radiated disturbance measurement set-up. With the publication of Amendment A2 to 3rd Edition of CISPR 16-2-3 in 2014 new requirements for minimizing this effect become effective. It requires the termination of cables leaving the test volume using a ferrite type common mode absorption device (CMAD). The significant technical changes and measurement results with and without using CMAD are presented.

Key words: CISPR, CMAD, MIU, standard compliance uncertainty, radiated disturbance measurement.

I. Introduction

It is common CISPR policy that measurement instrumentation uncertainty (MIU) shall be taken into consideration as per CISPR 16-4-2 [1], when determining compliance with the disturbance limits. For this purpose CISPR 16-4-2 describes in detail the input quantities to be considered for the estimation and treatment of the MIU. This includes the uncertainty contributions of the measuring receiver as well as the ancillary equipment (e.g. connecting cables, transducers such as artificial mains networks (AMN), absorbing clamps and antennas) and the test sites (e.g. site attenuation, antenna distance and test table). The expanded MIU is typical 3 dB for conducted disturbance measurements and may in the order of up to 6 dB for radiated disturbance measurements [1].

Not included in CISPR 16-4-2 are uncertainties related to the equipment under test (EUT) set-up or operation of the EUT as well as of the test specification (e.g. EUT arrangement, layout and termination of cables, measurement procedure, etc.), which together with the MIU are comprised in the term **"Standard Compliance Uncertainty" (SCU)**. MIU is a subpart of the SCU. Guidance on the treatment of the SCU is given in the technical report CISPR 16-4-1 [2]. But references to CISPR 16-4-1 are not in place in product standards. As a consequence the SCU need not be taken into account in the determination of compliance today.

However compared to the MIU the magnitude of the SCU may have relatively large values, e.g. in the order of 10 dB or more and so it has much influence on the reliability and reproducibility of RF disturbance measurements. In general it is the responsibility of the product committees to reduce the intrinsic uncertainty of the measurand in question to an acceptable low level. For example, this can be achieved by a detailed specification of the EUT set-up. A good example for this approach is CISPR 32:2012 [3] on emission requirements for multimedia equipment. In this standard, detailed normative requirements are made for exercising the EUT (Annex B), measurement procedure (Annex C) as well as arrangement of EUT and associated cabling (Annex D). It comprises figures of the EUT set-up with arrangement spacing, distances and belonging tolerances.

One important input quantity of SCU is the termination of cables leaving the test volume of the radiated disturbance measurement set-up. Investigations by Ryser [4] have been shown that the termination of those cables has much influence on the measurement result in the frequency range 30 MHz to about 200 MHz. It is characterized by the impedance of the connection to the ground plane and length of the cable inside and outside the test volume. The function of the common mode absorption device (CMAD) is to avoid such influences caused by the difference in the connection point on different test sites. Therefore the SCU can be reduced.

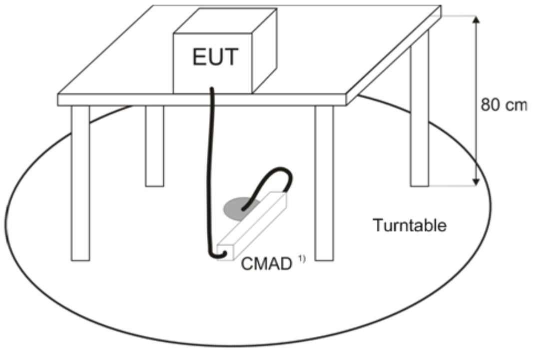
It is important to note that this deviation is related to the test site and not to the EUT set-up and so this subject is not essentially in the responsibility of product committees as mentioned above. Because of this reason the work was addressed to CISPR sub-committee A with the aim to amend the basic standard CISPR 16-2-3 accordingly.

II. New Requirements for Radiated Disturbance Measurements in CISPR 16-2-3

The new Amendment A2:2014 to CISPR 16-2-3:2010 [5] will require the use of ferrite clamp type CMADs to reduce the influence of cables outside the test volume on radiated disturbance measurement results. Ferrite clamps offering the highest flexibility as they can simply clamped on the cable and are applicable for almost any type of cable as long the opening of the CMAD is large enough.

The position of the CMAD in the test set-up for table-top equipment on open-area test site (OATS) or in semi-anechoic chamber (SAC) is quite important for minimizing the effect caused by the cable length.

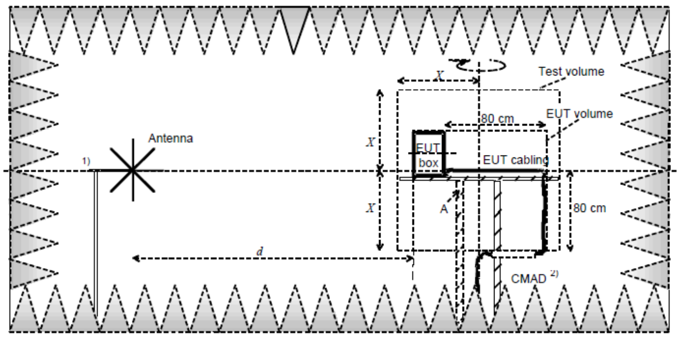
The new CISPR 16-2-3 defines it in such a way that the cable leaving the test volume shall enter the CMAD at the point where it reaches the ground plane as shown in Figure 1. In addition the CMAD shall always be placed flat on the ground plane and the part of the cable between the exit point of the CMAD and the exit point of the turntable shall be kept as short as possible.



1) CMADs shall comply with the relevant specifications of CISPR 16-1-4; their use shall be documented in the test report.

Fig. 1 Position of CMAD for table-top equipment on OATS or in SAC acc. to Amendment 2:2014 to CISPR 16-2-3:2010-04 [5]

In a fully-anechoic room (FAR) the cable leaving the test volume shall enter the CMAD at the point where it reaches the bottom of the test volume (turntable) as shown in Figure 2.



2) CMADs shall comply with the relevant specifications of CISPR 16-1-4; their use shall be documented in the test report.

Fig. 2 Position of CMAD for table-top equipment in FAR acc. to Figure 8 in CISPR 16-2-3:2010-04 [5]

Generally, each cable shall be treated with a separate CMAD. However, cables with diameters larger than the cable openings of commercially available CMADs do not have to be treated with CMADs. For EUTs with up to three cables leaving the test volume, each cable shall be treated with a CMAD during radiated disturbance measurements. This requirement applies to any type of cable (e.g. power, telecommunication, and control). For a test set-up with more than three cables leaving the test volume, only the three cables from which the highest emission is expected need to be equipped with CMADs. The cables on which the CMADs have been applied shall be documented in the test report.

III. Measurement Data

A Round-Robin Test (RRT) was performed for getting experience in using ferrite clamp type CMADs during radiated disturbance measurements. For this purpose comparison measurements on different test sites were performed with and without CMAD for both radiated disturbance measurements in a fully-anechoic room (FAR) and semi-anechoic chamber (SAC). The used CMAD (R&S®EZ-24 Ferrite Clamp) complies with the required specification in CISPR 16-1-4 [6]. The mains operated EUT consists of a comb generator with an inductive coupling (ferrite core) of the disturbance signal to the mains line. All these parts are located inside a plastic enclosure. The EUT is to be regarded as Class B table-top ITE.

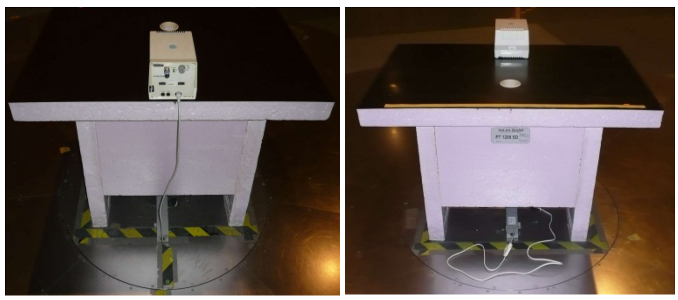
The results are presented as a series of diagrams which are showing the maximum deviation of the maximum measurement result over all azimuth planes and antenna heights with and without CMAD as a function of test frequency for each test site category. The delta result is the difference between the measurement results if the length of the cable outside the test volume is varied by 1.5 m.

A. Measurement Data in SAC (3 m and 10 m)

The following four cable set-ups were used for the test.

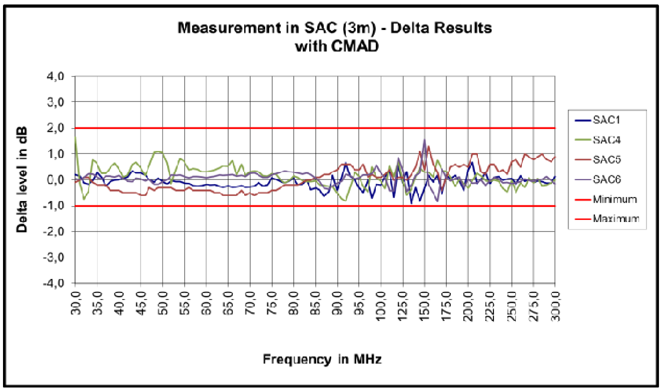
a) First test: With CMAD, standard mains cable (length = 1.6 m) extended by 3 m.
b) Second test: With CMAD, standard mains cable (length = 1.6 m) extended by 1.5 m.
c) Third test: Without CMAD, standard mains cable (length = 1.6 m) extended by 3 m.
d) Fourth test: Without CMAD, standard mains cable (length = 1.6 m) extended by 1.5 m.

Note: The difference of cable length outside the test volume is 1.5m between tests a) and b) for measurements with CMAD and again 1.5m between tests c) and d) for measurements without CMAD. All other arrangements of the test set up remain unchanged.



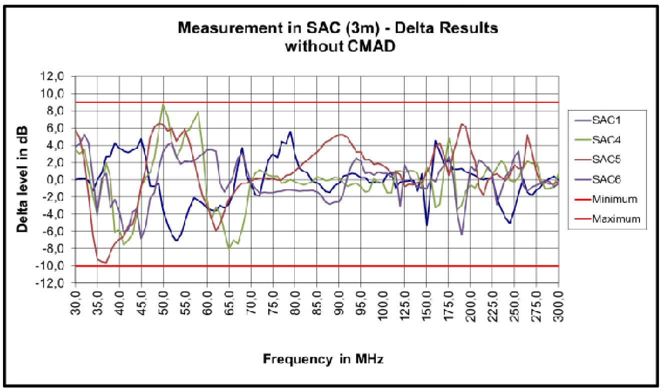
Front view Rear view

Fig. 3 First test in SAC with CMAD – standard mains cable (length = 1.6 m) extended by 3 m



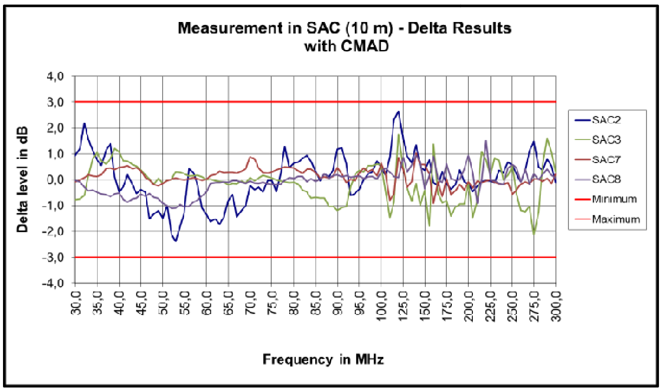
Delta result = Difference between maximum results of first and second test

Fig. 4 Maximum deviation in SACs 1, 4, 5 and 6 **with** CMAD (3 m)



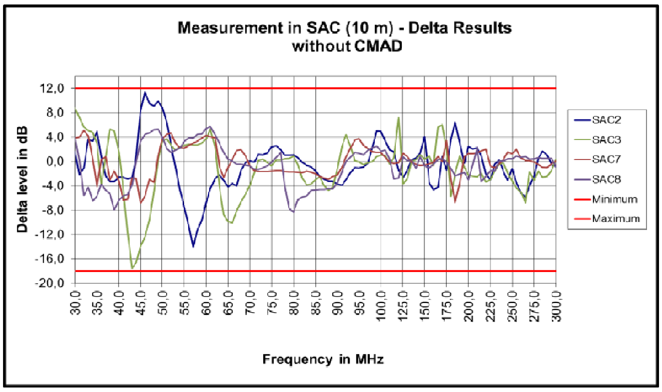
Delta result = Difference between maximum results of third and fourth test

Fig. 5 Maximum deviation in SACs 1, 4, 5 and 6 **without** CMAD (3 m)



Delta result = Difference between maximum results of first and second test

Fig. 6 Maximum deviation in SACs 2, 3, 7 and 8 **with** CMAD (10 m)



Delta result = Difference between maximum results of third and fourth test

Fig. 7 Maximum deviation in SACs 2, 3, 7 and 8 **without** CMAD (10 m)

B. Measurement Data in FAR (3 m)

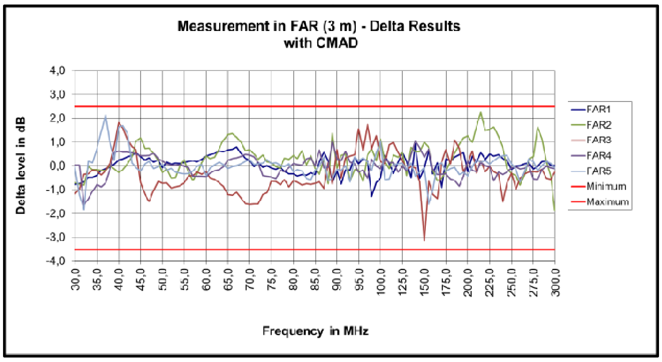
The following four cable set-ups were used for the test.

a) First test: With CMAD, standard mains cable (length = 1.6 m) extended by 3 m.

b) Second test: With CMAD, standard mains cable (length = 1.6 m) extended by 3 m +1.5 m.

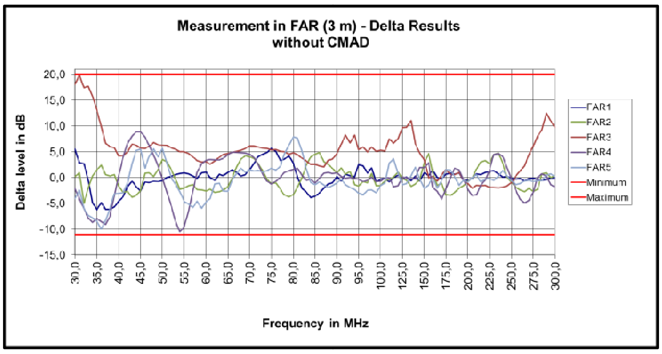
c) Third test: Without CMAD, standard mains cable (length = 1.6 m) extended by 3 m.

d) Fourth test: Without CMAD, standard mains cable (length = 1.6 m) extended by 3 m + 1.5 m.



Delta result = Difference between maximum results of first and second test

Fig. 8 Maximum deviation in FARs 1, 2, 3, 4 and 5**with** CMAD (3 m)



Delta result = Difference between maximum results of third and fourth test

Fig. 9 Maximum deviation in FARs 1, 2, 3, 4 and 5 **without** CMAD (3 m)

IV. Discussion of Results

The maximum deviation between the tests with CMAD on each test site is much smaller than without CMAD as shown in Figures 4 to 9. The extreme values for each test site are presented in Table I. For the measured EUT the maximum deviation with CMAD is less than 3.2 dB whereas without CMAD it became up to 19.8 dB in FAR3. Therefore, applying the ferrite type CMAD results in a significant reduction of the SCU and so the reliability of the measurement results is much better.

The absolute maximum result might be lower with CMAD. But from the data of this RRT it can be concluded that a correction of the field strength limits is not justified as the deviation of the measurement results without CMAD compared to the results with CMAD are as much positive as negative.

TABLE I
Maximum Deviation with and without CMAD on each Test Site

Test Site	Measurement Distance in m	Maximum Deviation **with** CMAD in dB	Maximum Deviation **without** CMAD in dB
SAC 1	3	-0.9 / +0.7	-7.1 / +5.6
SAC 4	3	-0.8 / +1.7	-8.0 / +8.7
SAC 5	3	-0.6 / +1.3	-9.6 / +6.6
SAC 6	3	-0.8 / +1.5	-6.8 / +5.3
SAC 2	10	-2.4 / +2.6	-14.1 / +11.4
SAC 3	10	-2.1 / +1.8	-17.5 / +8.8
SAC 7	10	-0.9 / +1.0	-6.9 / +5.1
SAC 8	10	-1.1 / +1.5	-8.3 / +5.7
FAR 1	3	-1.3 / +0.9	-6.2 / +5.6
FAR 2	3	-1.9 / +2.2	-5.0 / +4.9
FAR 3	3	-3.2 / +1.8	-2.0 / +19.8
FAR 4	3	-1.7 / +1.1	-10.5 / +8.9
FAR 5	3	-1.8 / +2.1	-10.0 / +7.9

Furthermore, the reproducibility in case of re-testing on different test sites can be improved significantly using the ferrite type CMAD as shown in Table II.

TABLE II
Maximum Deviation from Average for each Type of Test Site

Test Site	Measurement Distance in m	Maximum deviation from normalised average 1) **with** CMAD in dB	Maximum deviation from normalised average 1) **without** CMAD in dB
SAC 1,4,5,6	3	-4.0 / +4.4	-9.0 / +7.0
SAC 2,3,7,8	10	-6.6 / +4.3	-14.9 / +8.3
FAR 1-5	3	-10.1 / +6.6	-15.1 / +10.2

1) Normalised Average = Mean value over maximum results for tests with and without CMAD

V. Conclusions

The termination of cables leaving the test volume of the radiated disturbance measurement set-up has much influence on the measurement result in the frequency range 30 MHz to about 200 MHz. With the publication of Amendment A2 to 3rd Edition of CISPR 16-2-3 in 2014 new requirements for minimizing this effect become effective. It requires the termination of cables leaving the test volume using a ferrite type common mode absorption device.

Using such CMADs during radiated disturbance measurements will result in a significant reduction of the standard compliance uncertainty with the advantage to get a better reproducibility if the measurements are performed at different test sites. In general the maximum deviation with CMAD in one laboratory is much smaller than without CMAD. For the measured EUT the maximum deviation in FAR3 was reduced from about 20 dB without CMAD to about 3 dB using the CMAD. In SAC4 (3 m) it was reduced from about 9 dB to about 2 dB and in SAC3 (10 m) it was reduced from about 18 to about 2 dB.

It is recommended to perform further comparison measurements for getting more experience particular with real EUTs.

VI. Acknowledgment

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VII. References

[1] CISPR 16-4-2:2011-06 (Edition 2) Specification for radio disturbance and immunity measuring apparatus and methods – Part 4-2: Uncertainties, statistics and limit modelling – Uncertainties in EMC measurements

[2] CISPR/TR 16-4-1:2009-02 (Edition 2) Specification for radio disturbance and immunity measuring apparatus and methods – Part 4-1: Uncertainties, statistics and limit modelling – Uncertainties in standardized EMC tests

[3] CISPR 32:2012-01 (Edition 1) Electromagnetic compatibility of multimedia equipment – Emission requirements

[4] Ryser, H., Motivation for the use of CMAD in radiated emission measurements (CMAD: Common mode absorption devices), Report 207-218-630, Federal Office of Metrology (METAS), Bern-Wabern, Switzerland, 11 September 2007, available as a downloaded PDF from http://www.metas.ch/2007-218-630

[5] Amendment A2:2014 to CISPR 16-2-3:2010-04 (Edition 3) Specification for radio disturbance and immunity measuring apparatus and methods – Part 2-3: Methods of measurement of disturbances and immunity – Radiated disturbance measurements

[6] CISPR 16-1-4:2010-04 (Edition 3) 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