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TECHNICAL REPORT

INTERNATIONAL SPECIAL COMMITTEE ON RADIO INTERFERENCE

AMENDMENT 1

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Specification for radio disturbance and immunity measuring apparatus and methods –
Part 4-5: Uncertainties, statistics and limit modelling – Conditions for the use of alternative test methods

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FOREWORD

This amendment has been prepared by subcommittee CISPR A: Radio-interference measurements and statistical methods, of IEC technical committee CISPR: International special committee on radio interference.

The text of this amendment is based on the following documents:

DTR	Report on voting
CISPR/A/1050/DTR	CISPR/A/1069/RVC

Full information on the voting for the approval of this amendment can be found in the report on voting indicated in the above table.

The committee has decided that the contents of this amendment and the base publication will remain unchanged until the stability date indicated on the IEC web site under "http://webstore.iec.ch" in the data related to the specific publication. At this date, the publication will be

- reconfirmed,
- withdrawn,
- replaced by a revised edition, or
- amended.

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A bilingual version of this publication may be issued at a later date.

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2 Normative references

Replace, in the existing reference to IEC 60050-161, "IEC 60050-161" *by* "IEC 60050-161:1990".

Delete the existing publication date from reference CISPR 16-4-1.

3.1
established test method

Replace the existing note in this definition by the following new note:

NOTE The following test methods have been considered to be established test methods in CISPR:

– conducted disturbance measurements at mains ports using an AMN in the frequency range 9 kHz to 30 MHz; this method is defined in CISPR 16-2-1;
– radiated disturbance measurements in the frequency range 30 MHz to 1 GHz at 10 m distance on an OATS or in a SAC; this method is defined in CISPR 16-2-3;
– radiated disturbance measurements in the frequency range 1 GHz to 18 GHz at 3 m distance on an FSOATS; this method is defined in CISPR 16-2-3.

3.8
intrinsic uncertainty of the measurand

Delete, in the existing source of this definition, the words “, definition 3.6”.

Add, after the existing definition 3.9, the following new term and definition as follows:

3.10
standards compliance uncertainty
SCU
parameter, associated with the result of a compliance measurement as described in a standard, that characterizes the dispersion of the values that could reasonably be attributed to the measurand

[IEC 60050-161:1990, 311-01-02, modified, deletion of the notes]

4 Symbols and abbreviated terms

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Replace, in the existing symbol “i”, the text by “index number of an individual EUT”.

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Add, to the existing list, the following new symbols and abbreviated terms:

j	index number of an individual test lab
f	index number of an individual measured frequency
T	number of test labs
F	number of measured frequencies in the considered frequency range
RRT	round robin test
OATS	open-area test site
SAC	semi-anechoic chamber

Table 2 – Overview of quantities and defining equations for conversion process

Add, at the bottom of the existing table, the following new lines.

$U_{\mathrm{SC,XTM}}$	standards compliance uncertainty for the test method X, where X is either “E” for established test method or “A” for alternative test method	(26)
D_{K}	deviation of the single calculated conversion factor $K_i(f, j)$ from the average conversion factor $\overline{K}(f)$	(20), (21)
D_{XTM}	deviation of the single measured value $M_{\mathrm{XTM},i}(f, j)$ from the average for the measured values $\overline{M}_{\mathrm{XTM},i}$	(24), (25)
$M_{\mathrm{XTM},i(f,j)}$	measured value depending on EUT, lab, and frequency	(18), (23)

Add, after the existing 6.10, the following new clause:

7 Measurement-based procedure to derive limits for an alternative test method based on measurement results

7.1 General

As presented in Clause 6, the conversion factor $\overline{K}$ of alternative disturbance measurement methods is based on the concept of the availability of models of the measurement methods under consideration, the considered EUTs, and the application of an independent reference quantity X. In this way, the inherent uncertainties of the two methods under comparison are determined, and these uncertainties plus the intrinsic uncertainties of the measurand and the measurement instrumentation uncertainties (MIUs) are taken into account in determining the limit for the ATM [see Equations (7), (9) and (16)].

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Because the independent reference quantity is not always available, the conversion factor $\overline{K}$ can be estimated by direct comparison of the measurement results [see Equation (14)]. The uncertainty of each measurement procedures is estimated by the standards compliance uncertainty (SCU). The uncertainty of the conversion factor is determined by the SCUs of the ETM and ATM, as well as by the different characteristics of the EUTs. The limit L_{ATM} is determined according to Equation (15) using the conversion factor $\overline{K}$. The limit $L_{\mathrm{ATM,U}}$ takes into account the difference between the SCUs of the ATM and ETM, as well as the uncertainty caused by the different characteristics of the EUTs.

The condition for the estimation of the conversion factor by measurements is that at least five independent sets of data for each EUT are obtained through a round robin test (RRT), and N representative EUTs are used for the RRT. To assure statistical independence of the sets of data, the RRT involves at least five test houses. For simplicity, it is assumed here that each set of data is provided by a different test house. Outliers are identified and removed from the sets of data if no correction is possible.

7.2 Application of practical measurement results to determine the conversion factors

7.2.1 The conversion factor

The conversion factor K_i in the considered frequency range can be calculated for each of the F measured frequencies, for each of the N EUTs and for each of T labs.

$$K_i(f, j) = M_{\mathrm{ATM},i}(f, j) - M_{\mathrm{ETM},i}(f, j) \quad \text{in dB} \tag{18}$$

The average conversion factor $\overline{K}(f)$ is calculated using Equation (19).

$$\overline{K}(f)=\frac{1}{NT}\sum_{i=1}^{N}\sum_{j=1}^{T}K_i(f,j) \quad \text{in dB} \tag{19}$$

The uncertainty of the average conversion factor $\overline{K}(f)$ can be estimated by the deviation $D_{K,i}(f,j)$ of each calculated conversion factor $K_i(f,j)$ from the average conversion factor $\overline{K}(f)$ and the standard deviation s_K of $D_{K,i}(f,j)$.

$$D_{K,i}(f,j)=\overline{K}(f)-K_i(f,j) \quad \text{in dB} \tag{20}$$

The experimental standard deviation can be calculated by

$$s_K=\sqrt{\frac{1}{(NTF)-1}\sum_{i=1}^{N}\sum_{j=1}^{T}\sum_{f=1}^{F}[\overline{D}_K-D_{K,i}(f,j)]^2} \quad \text{in dB} \tag{21}$$

where $\overline{D}_K$ is the average of all $D_{K,i}(f,j)$.

The resulting expanded uncertainty U_K of the conversion factor is

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$$U_K=2s_K \quad \text{in dB} \tag{22}$$

7.2.2 Estimation of SCU by measurement

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For the estimation of the SCU, the average for the measured values of all T test labs for each EUT i is calculated using Equation (23).

$$\overline{M}_{\mathrm{XTM},i}(f)=\frac{1}{T}\sum_{j=1}^{T}M_{\mathrm{XTM},i}(f,j) \quad \text{in dB} \tag{23}$$

where XTM is either ETM or ATM.

For each frequency f and for each EUT i, the deviation $D_{\mathrm{XTM},i}(f,j)$ between the measured values' average $\overline{M}_{\mathrm{XTM},i}(f)$ and each measured value $M_{\mathrm{XTM},i}(f,j)$ is calculated using Equation (24).

$$D_{\mathrm{XTM},i}(f,j)=\overline{M}_{\mathrm{XTM},i}(f)-M_{\mathrm{XTM},i}(f,j) \quad \text{in dB} \tag{24}$$

The experimental standard deviation of all these deviations $D_{\mathrm{XTM},i}(f,j)$ can be calculated by

$$s=\sqrt{\frac{1}{(NTF)-1}\sum_{i=1}^{N}\sum_{j=1}^{T}\sum_{f=1}^{F}[\overline{D}_{\mathrm{XTM}}(f)-D_{\mathrm{XTM},i}(f,j)]^2} \quad \text{in dB} \tag{25}$$

where $\overline{D}_{\mathrm{XTM}}(f)$ is the average of all $D_{\mathrm{XTM},i}(f,j)$.

The uncertainty that causes this deviation depends on the measurement equipment and the measurement procedure. This uncertainty is the SCU, and it is estimated by

$$U_{SC,XTM} = 2s \text{ in dB} \tag{26}$$

7.2.3 Applying the conversion factor

The limit of an established test method can be converted into limit conditions for an alternative test method using the average conversion factor [see Equation (15)] and the measurement uncertainties of ETM and ATM [see Equations (16) and (17)].

Equations (16) and (17) take into account the instrumentation uncertainty. The inherent and intrinsic uncertainty of the measurand is considered by using a reference quantity X in estimating the conversion factor $\overline{K}(f)$. If $\overline{K}(f)$ is estimated by measuring the influence of all uncertainties, then the instrumentation uncertainty, the uncertainty of the measurement procedure, and the uncertainty caused by the different radiation characteristics of the EUTs are all taken into account. Therefore the difference Δ_{meas} of the uncertainties of the ATM and ETM is:

$$\Delta_{meas} = U_{ATM} - U_{SC,ETM} \text{ in dB} \tag{27}$$

For the estimation of the uncertainty U_{ATM}[see Equation (32)], the uncertainty of the conversion factor U_K is investigated. The amount of the uncertainty U_K of the conversion factor can be estimated by:

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$$U_K^2 = U_{SC,ETM}^2 + U_{SC,ATM}^2 + U_{EUT}^2 \tag{28}$$

where

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$U_{SC,ETM}$ is the SCU of the ETM,

$U_{SC,ATM}$ is the SCU of the ATM, and

U_{EUT} is the uncertainty that is caused by the different radiation characteristics of the EUTs, which is estimated by Equations (29) to (31).

The different characteristics cause a unique conversion factor for each EUT. The difference between the conversion factors is estimated by the deviation $D_{K,EUT}$ between the average conversion factor $\overline{K}(f)$ and the average conversion factor for each EUT $\overline{K}_i(f)$.

$$D_{K,EUT}(f) = \overline{K}(f) - \overline{K}_i(f) \tag{29}$$

$D_{K,EUT}$ has standard deviation

$$s_{EUT} = \sqrt{\frac{1}{(NF)-1}\sum_{i=1}^{N}\sum_{f=1}^{F}[\overline{D}_{K,i} - D_{K,EUT}(f)]^2} \tag{30}$$

where $\overline{D}_{K,i}$ is the average of all $D_{K,EUT}(f)$.

The uncertainty U_{EUT} is estimated by

$$U_{EUT} = 2s_{EUT} \text{ in dB.} \tag{31}$$

The uncertainty U_{ATM} is determined by the uncertainty $U_{SC,ATM}$ of the ATM and the uncertainty U_{EUT} caused by the EUTs. Therefore U_{ATM} can be estimated by

$$U_{ATM} = \sqrt{U_{EUT}{}^2 + U_{SC,ATM}{}^2} \; . \qquad (32)$$

Therefore, using Equation (27) the application of Equation (17) becomes

$$L_{ATM,U} = L_{ATM} - \Delta_{meas} \text{ if } \Delta_{meas} > 0\text{, and} \qquad (33)$$

$$L_{ATM,U} = L_{ATM} \text{ if } \Delta_{meas} \leq 0 \qquad (34)$$

It should be considered that $U_{SC,ETM}$ in Equation (27) is estimated in accordance with CISPR 16-4-1, which estimates generally the U_{SC} for 3 m test site results in the frequency range 30 MHz to 300 MHz to be 15,5 dB; for the conditions of the RRT and the terminated cables, U_{SC} may be reduced to 11 dB. CISPR 16-4-1 gives no value for the $U_{SC,ETM}$ of the 10 m test site results, but the value can be expected to be in the order of about 10 dB.

B.1.1.5 Estimate the standard uncertainties of the test methods (see 6.6)

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Replace, in the existing text for intrinsic uncertainty, "CISPR 16-4-1:2003" *by* "CISPR 16-4-1".

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B.2.1.5 Estimate the standard uncertainties of the test methods (see 6.6)

Replace, in the existing text for intrinsic uncertainty, "CISPR 16-4-1 ed.1.1" *by* "CISPR 16-4-1".

Add, at the end of the existing B.3, the following new annex.