VLAC Policy for the Uncertainty in Measurement

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1. Purpose

This document is used to a part of the standard of evaluation for laboratory accreditation that carried by Voluntary laboratory Accreditation Center Inc. (VLAC). This document provides the requirements and guidance for the practical operation for estimation of uncertainty in measurement according to 5.4.6.2 and 5.4.6.3 in VR101. An example of uncertainty components findings and budgeting is explained on this document.

2. Scope

This document is applied to estimation of uncertainty in measurement. However uncertainty is not applied to electromagnetic immunity test result that subjects not measurement but phenomenon.

3. Referenced standards and documents

(1) JCGM 100:2008 GUM with minor correction, Evaluation of measurement data - Guide to the expression of uncertainty in measurement

(2) ISO/IEC Guide 98-3:2008 Uncertainty of measurement -- Part 3: **Guide** to the expression of uncertainty in measurement (GUM:1995)

(3) International vocabulary of metrology -- Basic and general concepts and associated terms (VIM).

(4) 計測における不確かさの表現ガイド. 飯塚幸三 日本規格協会

(5) ILAC P10:01/2013 ILAC Policy on Traceability of Measurement Results

(6) JCGM 200:2012 International vocabulary of metrology – Basic and general concepts and associated terms (VIM)

(7) CISPR 16-4-2 Ed. 2.0:2011 (b) Specification for radio disturbance and immunity measuring apparatus and methods - Part 4-2: Uncertainties, statistics and limit modelling - uncertainty in measurements

(8) IEC Guide 115 Application of uncertainty of measurement to conformity assessment activities in the electrotechnical sector

(9) IECEE-CTL Guide 001 Application of uncertainty of measurement to conformity assessment activities in the electrotechnical sector

4. Concept

4.1 General The laboratory shall have and shall apply procedures for estimating the uncertainty of measurement. In certain cases the nature of the EMC test method may preclude rigorous, metrologically and statistically valid, calculation of uncertainty of measurement. In these cases the laboratory shall at least attempt to identify all the components of uncertainty and make a reasonable estimation, and shall ensure that the form of reporting of the result does not give a wrong impression of the uncertainty. Reasonable estimation shall be based on knowledge of the performance of the method and on the measurement scope and shall make use of, for example, previous experience and validation data.

[Note1] The degree of rigor needed in an estimation of uncertainty of measurement depends on factors such as:

・the requirement of the test　method;
・the requirement of the customer;
・the existence of narrow limits on which decisions on conformity to a specification are based.

[Note2] In those cases where a well-recognized test method specifies limits to the values of the major sources of uncertainty of measurement and specifies the form of presentation of calculated results, the laboratory is considered to have satisfied this clause by following the test method and reporting instruction.（e.g. CISPR16-1-4）

[Note3] The testing laboratory that carries out in-house calibration, such laboratory shall have and shall apply the procedures for estimating the uncertainty of measurement for all in-house calibration items.

[Note4] When estimating the uncertainty of measurement, all uncertainty components which are of importance in the given situation shall be taken into account using appropriate methods of analysis.

4.2　Method for estimating uncertainty of measurement

4.2.1 In the case value or estimating method of uncertainty is specified in standards

In the case value of uncertainty or estimating method is specified in standards, Follow the standards. For example, CISPR16-4-2 for EMC testing and IEC Guide 115 or IECEE-CTL 001 for electrical measurement specify the uncertainty of measurement.

4.2.2 In the case value or estimating method of uncertainty is not specified in standards

4.2.2.1 General

In the case value of uncertainty or estimating method is not specified in standards, estimating and calculation should be carried out referred with the referenced standards and documents mentioned in clause 3. An example is shown in the following clauses;

4.2.2.2 Budgeting of uncertainty components and example

A kind of uncertainty component and its value will be changed depending on the measuring instrument and the measuring procedure (measurement method). A block diagram of the measurement system helps to know what kind of uncertainty component, and where it is in the measurement system. For example, the attenuation (loss) of signal cable or the amplifier gain is often measured at EMC or telecommunication laboratories. Attenuation (loss) or gain will be measured by the 3 methods for instance as shown in Fig.1. Type of measuring instrument and measurement procedure is different each other in those methods, therefore, kind of uncertainty components and value of uncertainty components also different between the measurement methods. The uncertainty components are picked up with understanding to the measurement system using the measurement block diagram.

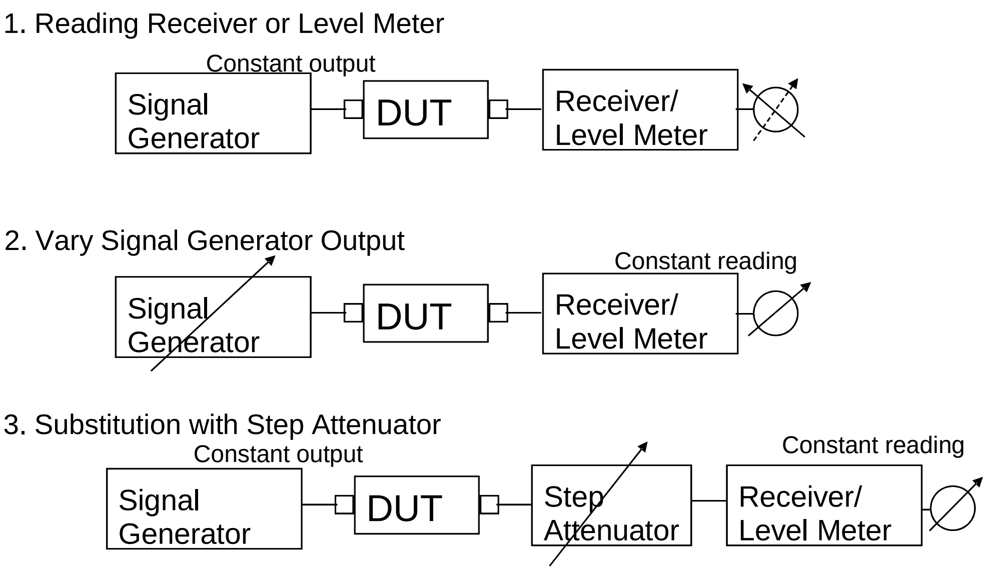


Fig.1 Methods for attenuation (loss) or gain measurement

Table 1 shows major uncertainty components includes above 3 measurement methods. Note that uncertainty components such as environmental condition or use of jigs other than shown in Table 1 may exist, however those were omitted here.

Table 1 Major uncertainty components for three measurement method in Fig.1

O:Applicable N/A: Not Applicable

Uncertainty Components	Method 1	Method 2	Method 3	Remarks
Variance of measurement result	O	O	O	Standard deviation from repeat measurement
Accuracy of Signal Generator output	N/A	N/A	N/A	Absolute value is not necessary for this measurement method
Accuracy of Receiver/Level Meter	N/A	N/A	N/A	Absolute value is not necessary for this measurement method
Linearity of Receiver/Level Meter	O	N/A	N/A	
Linearity of Signal Generator output level	N/A	O	N/A	
Accuracy of Step Attenuator	N/A	N/A	O	

Fluctuation of measurement system during direct- and DUT- measurement	N/A	N/A	N/A	Included in the repeat measurement variation
Reflection loss caused by impedance mismatch of DUT (Signal Generator side)	O	O	O	Use of fixed attenuator pads improves impedance mismatch
Reflection loss caused by impedance mismatch of DUT (Receiver/Level Meter or Step Attenuator side)	O	O	O	Use of fixed attenuator pads improves impedance mismatch

In general, following uncertainty components will be estimated (but not limited in those);

(1) Variance of measurement results. It is calculated as the standard deviation. It towards to the normal distribution in case of number of repeat times being increased.

(2) Uncertainty written in the calibration certificate.

(3) Accuracy, precision or error written in measuring instrument specification.

(4) Instrument settings such as bandwidth and range.

(5) Drift of the measurement system. E.g. drift of the signal generator output or indicator drift of the level meter during measurement.

(6) Impedance mismatch between the signal cable and the instrument.

(7) Temperature and humidity environment.

(8) Estimating based on previous data, experiences or knowledge.

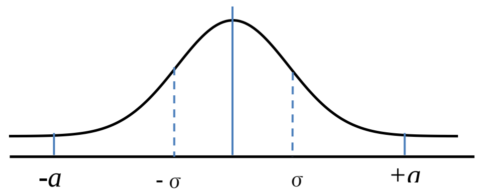
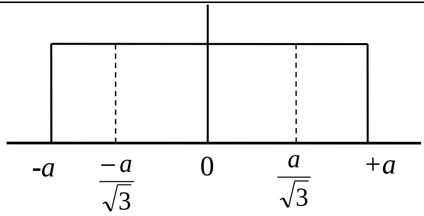
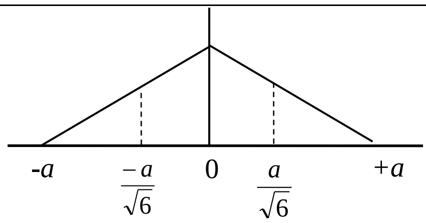
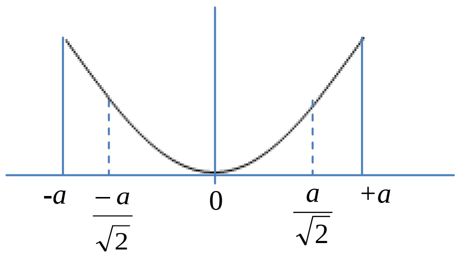
(9) Measurement method, measurement procedure and competence or skill of personnel.

Estimating probability distribution and range for the picked-up uncertainty component. The previous experience or similar data will be referred to determine the probability distribution if statistical analysis is difficult due to the less data or the uncertain background.

4.2.2.3 Standard uncertainty

Any probability distribution is transferred to the normal distribution (it is proofed by the central limit theorem). Table 2 shows the example of the probability distribution transformation. The standard deviation is obtained by operation with range (+a) to (–a) divided by the devisor.

Table 2　Probability distribution and transformation to the standard deviation

Distribution	devisor	Example of uncertainty component	remarks
Standard deviation（σ）	1	Standard deviation of repeat measurement results	
Normal	2 or k	Uncertainty written in calibration certificate	Twice standard deviation（2σ）、or times k
rectangular	$\sqrt{3}$	Measuring instrument specification written in operating manual or catalog. Apply in those cases where less repeat times, distribution is unknown or only range in known.	
triangular	$\sqrt{6}$	Measuring instrument specification written in operating manual or catalog.	
U-shape	$\sqrt{2}$	Impedance mismatch	

4.2.2.4　Combined standard uncertainty

Combine the standard uncertainties *Ui* using (1).

$$U = \sqrt{U_1^2 + U_2^2 + \cdots U_n^2} \qquad (1)$$

4.2.2.5 Expanded uncertainty

Twice the combined standard uncertainty is expanded uncertainty.

$$2U = 2 \times U \qquad (2)$$

Finally, uncertainty of measurement should be reported as the expanded uncertainty.

4.3 Reporting

Refer to 5.10.3.1 c) in VR101 for reporting in test report.

5. Policy for application of uncertainty for testing in VLAC accredited sector

Table 3 shows the policy for application of uncertainty depending on testing sector.

Table 3 Policy of application of uncertainty

	Accreditation Sector	Policy of application of uncertainty
1	**EMC** Emission Harmonics Voltage variation	(1) Follow the provisions of CISPR16-4-2 if applicable (2) Follow the provisions of the applicable standards. (3) Follow the provisions of VR105 unless otherwise specified in the applicable standard.
2	**EMC** Immunity	It does not apply for immunity test result. However laboratory shall have procedures to confirm uncertainty for applied electric field, voltage, current, time etc.
3	**Telecommunications equipment performance**	(1) Follow the provisions of the applicable standards. ex.ETSI EN 300 330-1、ETSI TR100 028-1、ETSI TR100 028-2、ETSI TR102 273-3 (2) Follow the provisions of VR105 unless otherwise specified in the standard.
4	**EM exposure** SAR	Follow the provisions of the applicable standards. ex. IEC62209-1、IEC62209-2
5	**Acoustic** Acoustic noise	Follow the provisions of the applicable standards.
6	**Environment** Energy star	(1) Follow the provisions of the Energy star Rules. (2) Follow the provisions of VR105 unless otherwise specified in the standard.