VLAC Policy for the Uncertainty in Measurement

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1. Purpose

This document provides an interpretation for specific operations regarding the evaluation of measurement uncertainty. For reference, an example of estimating the measurement uncertainty components of the transmission attenuation (gain) of the device performed at the electromagnetic compatibility test is also shown.

2. Scope

This document is applied to the evaluation of uncertainty in measurement for test, measurement and calibration that is carry out by the testing laboratories.

3. Referenced documents

(1) ISO/IEC Guide 99:2007 International vocabulary of metrology -- Basic and general concepts and associated terms (VIM)
(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) 測定不確かさ評価の最前線.今井秀孝，日本規格協会
(6) 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
(7) ISO/IEC 17025:2017General requirements for the competence of testing and calibration laboratories (JIS Q 17025:2018 試験所及び校正機関の能力に関する一般要求事項)
(8) ILAC G17:01/2021 ILAC Guidelines for Measurement Uncertainty in Testing

4. Basic concept

4.1 General

Laboratories and laboratories conducting internal calibration should evaluate the measurement uncertainty. If it is impossible to estimate the measurement uncertainty that is exact, metrologically and statistically valid from the nature of the test method, it is necessary to identify all components of uncertainty, and estimate reasonably. A reasonable estimate is, for example, to take advantage of previous experiences or validation data.
If the test method limits the values of the major components of measurement uncertainty and specifies the representation of the calculation results, the laboratory shall follow the instructions of the test method and reporting method (eg CISPR16-4-2 describes the information for calculating the measurement uncertainty of the radiated electromagnetic disturbance measurement and the application of the measurement uncertainty when determining the conformity judgement for the limits value).
Also, for the results of qualitative tests that do not involve measurement, identify the components that affect the results as “measurement uncertainty components”. [JIS Q 17025:2018 解説 5.p)]

4.2 Method for evaluation of uncertainty in measurement

4.2.1 Appling the uncertainty in measurement

The measurement uncertainty assessment is applied as follows.

(1) Tests that express the results as measured values (quantitative tests), calibration by the laboratory itself (internal calibration), and measurements for equipment conformity verification are possible while identifying the factors that affect the results. In the case, the uncertainty of measurement is calculated by metrological and statistical methods and rational methods.

Examples of quantitative test- radiated emission measurement, leakage current measurement, transmission power measurement, sound pressure level measurement and power consumption measurement.

Examples of internal calibration- Loss/Gain measurement of radiated emission measurement system*.

Examples of equipment verification- Site attenuation, E-field uniformity, acoustic transmission attenuation.

[*Note] Measurements of parameters used to correction factors of test results are considered calibration.

(2) When the test result is expressed as a phenomenon (qualitative test), identify the components that influence the result.

Examples: Immunity test, impact test, load test.

(3) For the test conditions set by the measured value, identify the components that affect the set value and calculate the uncertainty of the set value if possible.

Examples: Electric field strength for EMC immunity test, setting temperature of constant temperature bath, applied voltage for withstand voltage test.

4.2.2 An example of budgeting of uncertainty components

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.

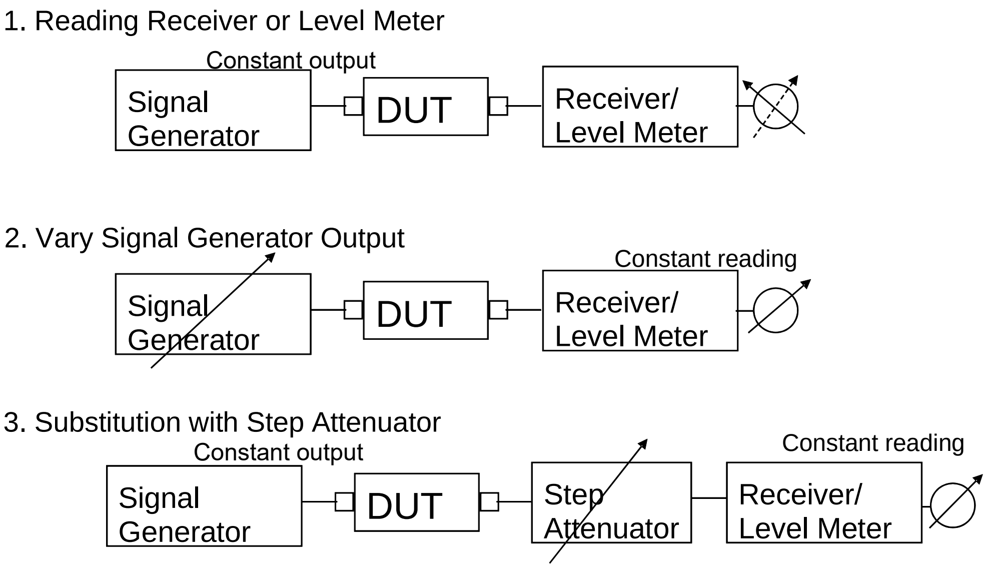


Fig.1 Methods for attenuation (loss) or gain measurement

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	O	O	O	Use of fixed attenuator pads

side)				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.

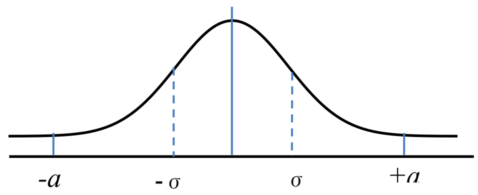
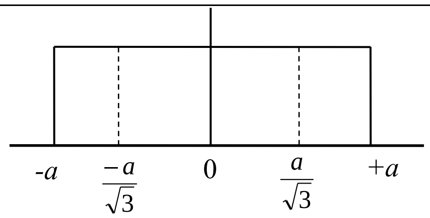
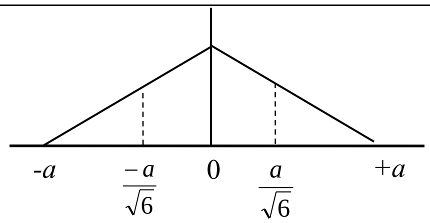
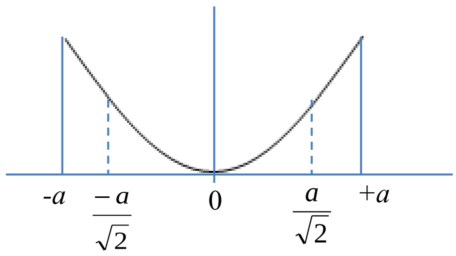
(9) Measurement method, measurement procedure and competence or skill of personnel.

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.

4.2.3 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	

4.2.4 Combined standard uncertainty

Combine the standard uncertainties (standard deviation) u_i using following equation (1).

$$u = \sqrt{u_1^2 + u_2^2 + \cdots u_n^2} \qquad (1)$$

4.2.5 Expanded uncertainty

Multiple the coverage factor k the above (1) combined standard uncertainty to obtain the expanded uncertainty.

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

4.3 Reporting

For the description of uncertainty to the test report, follow ISO / IEC 17025: 2017 clause 7.8.3.1 c).