Accounting for measurement uncertainty in the SRM-3000

A brief summary

Every measurement is subject to uncertainties. Any measurement report can only be considered to be complete when it includes the measurement uncertainties as well as the measurement results.

This Application Note is not a theoretical discussion; it is merely intended as a brief introduction to the subject. It gives some practical procedures and values that should be used when making measurements with the Selective Radiation Meter SRM-3000.

Factors affecting measurement uncertainty

Every factor that may influence the measurement result must be taken into account. The uncertainty associated with each of these factors also needs to be estimated. Generally, there are two possible sources of uncertainty or error: the measuring equipment and the person operating it.

The measurement uncertainty inherent in the measuring equipment setup can be determined from the calibration certificates and the specifications quoted by the manufacturer. Narda quotes the full values for the SRM-3000 in the data sheet for the instrument.

An empirical value can be used to represent the uncertainty in measurement samples that may be caused by the person doing the measuring.

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Standard measurement uncertainty – extended measurement uncertainty

Standard measurement uncertainty = standard deviation in the distribution of the measured quantity.

Extended measurement uncertainty = range within which the measured quantity lies for a given probability.

- A probability of 95% is normally specified.
- For normal distribution of the measured quantity, the extended measurement uncertainty for a confidence interval of 95% is twice (or exactly 1.96 times) the standard measurement uncertainty.

The extended measurement uncertainty is used for the assessment value, which is the value quoted in the measurement report.

Calculating standard measurement uncertainty

$$u = \sqrt{\sum_q u_q^2} = \sqrt{\sum_q \left(\frac{U_q}{k_q}\right)^2}$$

Where:

u Standard measurement uncertainty of measurement, %
u_q Standard measurement uncertainty of influence factor q, %
U Extended measurement uncertainty of measurement, %
U_q Specified / estimated contribution to uncertainty of influence factor q, %
k_q Divisor for reducing influence factor q to standard measurement uncertainty

Application of uncertainty data

The uncertainty data quoted in a calibration certificate is usually understood as being 95% values of a normal distribution. The divisor for calculating the standard measurement uncertainty in this case is $k_q = 2$. In other words, dividing the value specified in the certificate by 2 will give the standard measurement uncertainty.

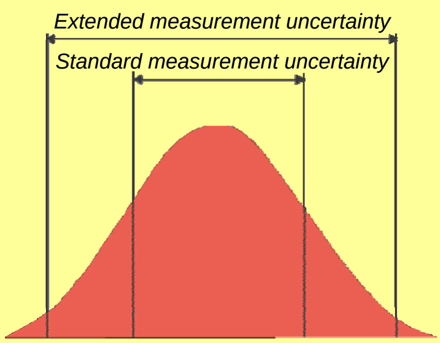
The uncertainty data given in data sheet specifications is often to be considered as being the maximum values of a rectangular distribution unless otherwise stated. The divisor for calculating the standard measurement uncertainty here is $k_q = \sqrt{3}$.

A U-shaped distribution is often assumed for the uncertainty due to mismatches. The divisor for calculating the standard measurement uncertainty in such cases is $k_q = \sqrt{2}$.

Rectangular distribution *– If the deviation in a measured value caused by any influence is equally probable within a given range, the distribution of values is a rectangular shape.*

Normal distribution *– The distribution in values that results from superimposing several independent influences approximates normal distribution, which has the appearance of a Gaussian bell curve (see below).*

Standard deviation *– This is a calculated value. If the measurement uncertainty has normal distribution, the probability that the measurement deviation is within the standard deviation is 67% (standard measurement uncertainty). The probability that the measurement deviation is within twice the standard deviation is 95% (extended measurement uncertainty.*



Values for the SRM-3000 – straight from the data sheet*

Narda quotes extended measurement uncertainties for the SRM-3000 in the data sheet. These values are for the combination of measurement antenna and RF cable together with the measuring instrument, which saves you the bother of making calculations in most cases.

Extended measurement uncertainty when using the isotropic antenna

MEASUREMENT UNCERTAINTY			
	Frequency range	Single axis measurement with isotropic antenna	Isotropic measurement
Extended measurement uncertainty (for SRM basic unit with 1.5 m RF cable)	75 – 900 MHz	+2.4 / -3.4 dB	+2.4 / -3.3 dB
	900 – 1400 MHz	+2.3 / -3.1 dB	+2.4 / -3.3 dB
	1400 – 1600 MHz	+2.2 / -3.1 dB	+2.6 / -3.7 dB
	1600 – 1800 MHz	+1.8 / -2.2 dB	+2.2 / -3.0 dB
	1800 – 2200 MHz	+1.8 / -2.2 dB	+2.4 / -3.3 dB
	2200 – 2700 MHz	+1.8 / -2.3 dB	+2.6 / -3.6 dB
	2700 – 3000 MHz	+1.9 / -2.4 dB	+3.2 / -5.3 dB

The specified values

- include the calibration uncertainty for the basic unit, antenna and cable,
- take any mismatches in the connections between the antenna and cable and the cable and basic unit into account
- also include the anisotropy / ellipticity of the measuring antenna,
- are referred to the standard measurement uncertainty by $k_q = 2$.
- The calculation is based on the worst case scenario.
- The difference in measurement uncertainty when a 5 m RF cable is used instead of 1.5 m is negligible.

***** ***Always base your calculations on the values from the latest version of the data sheet, available from www.narda-sts.com***

Example: Measurement of radiation exposure levels due to mobile telephones; source frequency 2.1 GHz (UMTS); single-axis measurement.

Extended measurement uncertainty from data sheet	+1.8 / -2.2 dB
Sampling uncertainty, estimated	+/-3 dB
The extended uncertainty in the measurement result is given by summing the squares:	+3.5 / -3.7 dB

Sum of squares:

$$U_{total} = \sqrt{U_1^2 + U_2^2}$$

To be certain that the radiation exposure level is below the limit value, 3.5 dB must be added to the measurement result.
On the other hand, to be certain that the radiation exposure level exceeds the limit value, 3.7 dB must be subtracted from the measurement result.

BUWAL also recommends summing the squares of the measurement uncertainties, but with reference to values expressed in units of field strength (not in dB). Example calculations can be found in [3].

Converting dB values to factors

Logarithmic values *L*, expressed in dBµV/m for example, can be converted back to field strength values as follows:

$$E\,[\mu V/m] = 10^{\frac{L\,[dB\mu V/m]}{20}}$$

Values expressed in dBmV/m, dBV/m or dBA/m can be treated analogously.

References

[1] ISO/IEC: Guide to the expression of uncertainty in measurement ("GUM"), Ed. 1, 1995

[2] Reg TP MV 09/EMF/3:
Measurement regulation for nationwide EMC investigative tests of existing environmental field strengths, February 2003 (in German). [The German State Telecoms and Postal Regulatory Authority (Reg TP) is now part of the State Network Agency ("Bundesnetzagentur")]

[3] BUWAL (Swiss Federal Environment, Forestry and Countryside Agency):
Mobile Telephone Base Stations (UMTS – FDD), Draft Measurement Recommendation, 17.09.2003 (in German)

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