# REDUCING MEASUREMENT UNCERTAINTY IN EMC MEASUREMENT

**Rostislav Vídenka**
Doctoral Degree Programme, FEEC BUT
E-mail: xviden01@stud.feec.vutbr.cz

Supervised by: Jiří Svačina
E-mail: svacina@feec.vutbr.cz

## ABSTRACT

There are more and more devices using electric power around us in present time. With rising number of these electronics devices there are increasing requirements on electromagnetic compatibility – EMC. Limits of acceptable device-produced disturbance are given by international standards. Almost every electric-powered product must be tested on compliance before market introduction. Testing is provided by accredited laboratory. Measurement is only way how to find out the disturbance level, but every kind of measurement has it's measurement uncertainty.

This paper deals with introduction, methodology, and some basic problems of uncertainty in EMC measurement with sight on radiated disturbance in the frequency range of 30 to 1000 MHz.

## 1. MEASUREMENT INSTRUMENTATION UNCERTAINTY

Measurement instrumentation uncertainty shall be taken into account when determining compliance or non-compliance with disturbance limit.

The measurement instrumentation uncertainty for a test laboratory shell be evaluated for those measurements addresses in the following subclause, taking into consideration each of the quantities listed there. The standard uncertainty $u(x_i)$ in decibels and the sensitivity coefficient $c_i$ shall be evaluated for the estimate $x_i$ of each quantity. The combined standard uncertainty $u_c(y)$of estimate $y$ of the measurand shall be calculated as.

$$u_c(y) = \sqrt{\sum_i c_i^2 \cdot u^2(x_i)}. \qquad (1)$$

The expanded measurement instrumentation uncertainty $U_{lab}$ for a test laboratory shall be stated in the test report and shall be calculated as

$$U_{lab} = 2u_c(y). \qquad (2)$$

where the coverage factor k=2 yields approximately a 95 % level of confidence for the near-normal distribution typical of most measurement results.

Compliance or non-compliance with a disturbance limit shall be determined in the following manner.

If $U_{lab}$ is less than or equal to $U_{cispr}$ in Table 1, then:

- compliance is deemed to occur if no measured disturbance exceeds the disturbance limit;
- non-compliance is deemed to occur if any measured disturbance exceeds the disturbance limit.

NOTE: $U_{cispr}$ resembles a value of measurement uncertainty for a specific test, which was determined by considering uncertainties associated with the quantities listed in clause 2.

If $U_{lab}$ is greater than $U_{cispr}$ in Table 1, then:

- compliance is deemed to occur if no measured disturbance, increased by ($U_{lab}$ - $U_{cispr}$), exceeds the disturbance limit;
- non-compliance is deemed to occur if any measured disturbance, increased by ($U_{lab}$ - $U_{cispr}$), exceeds the disturbance limit

| Measurement | Freq. range | $U_{cispr}$ |
|---|---|---|
| Conducted disturbance (main ports) | 9 kHz - 150 kHz | 4.0 dB |
| | 150 kHz - 30 MHz | 3.6 dB |
| Disturbance power | 30 MHz - 300 MHz | 4.5 dB |
| Radiated disturbance | 30 MHz - 1000 MHz | 5.2 dB |

**Table 1**: Values of $U_{cispr}$

NOTE: The values of $U_{cispr}$ in Table 1 are based on the expanded uncertainties in clause 2.1, which were evaluated by considering uncertainties associated with the quantities below.

## 1.1. QUANTITIES TO BE CONSIDERED FOR RADIATED DISTURBANCE MEASUREMENT OF ELECTRIC FIELD STRENGTH ON AN OPEN AREA TEST SIDE OR ALTERNATIVE TEST SIDE

- Receiver readings
- Attenuation of the connection between antenna and receiver
- Antenna factor
- Receiver sinus-wave accuracy
- Receiver pulse amplitude response
- Receiver pulse response variation with repetition frequency
- Receiver noise floor
- Mismatch effects between antenna port and receiver
- Antenna factor interpolation
- Antenna factor variation with height
- Antenna directivity
- Antenna phase center
- Antenna cross-polarisation response
- Antenna balance

- Test site
- Separation between equipment under test and measuring antenna
- Height of table supporting the equipment under test

### 1.2. QUANTITIES SEPARATED INTO GROUPS BY MEANING

- Receiver readings
- Attenuation of the connection between antenna and receiver
- Antenna factor
- Receiver correction:
    - sinus-wave voltage accuracy
    - pulse amplitude response
    - pulse repetition rate response
    - noise floor proximity
- Mismatch: antenna – receiver
- Log-periodic antenna corrections:
    - AF frequency interpolation
    - AF height deviations
    - Directivity difference
    - Phase center location
    - Cross – polarisation
    - Balance
- Site corrections:
    - Site imperfections
    - Separation distance
    - Table height

## 2. BASIC FOR DETERMINING CISPR LIMITS

There are four basic types of measurements in sight on radiated disturbance (30 – 1000 MHz):

- horizontally polarized radiated disturbance from 30 to 200 MHz using a biconical antenna
- vertically polarized radiated disturbance from 30 to 200 MHz using a biconical antenna
- horizontally polarized radiated disturbance from 200 MHz to 1000 MHz using a log-periodic antenna
- vertically polarized radiated disturbance from 200 MHz to 1000 MHz using a log-periodic antenna

Extended partitioning for four previous positions is in separation between EUT and receiving antenna: 3 m, 10 m and 30 m. Together this means twelve cases.

### 2.1. BIGGEST SOURCE OF UNCERTAINTY

Groups of quantities ordered by their contributions on overall measurement uncertainty are listed in the following table, which holds for the worst case – horizontally polarized disturbance from 200 MHz to 1000 MHz using a log-periodic antenna at a distance 3 m.

| Group of quantities | Combined standard uncertainty [dB] |
|---|---|
| Site correction | 1.64 |
| Receiver correction | 1.35 |
| Antenna factor | 1.00 |
| Antenna correction | 0.86 |
| Mismatch: antenna-receiver | 0.67 |
| Receiver readings | 0.10 |
| Attenuation: antenna-receiver | 0.05 |

**Table 2**: Contributions for overall uncertainty (combined standard uncertainty is evaluated using (1) and (2))

Overall measurement uncertainty evaluated using (1) and (2) for 95% level of confidence (k=2) is 5.19 dB and from this following $U_{cispr}$=5.2 dB mentioned in table 1.

As shown in Table 2, the highest uncertainty contribution is from „Site corrections“ and from is’t element „Site imperfection“.

The second highest contribution is from „Receiver correction“.

## 3. REDUCING MEASUREMENT UNCERTAINTY IN LABORATORIES

Almost each test lab’s customer wants to know, how accurate is the result of measurement of his device.

Thus, the knowledge of exact value of uncertainty is essential for every test laboratory, school laboratory etc.

One of the ways, how to reduce overall measurement uncertainty, is to specify each quantity listed in section 1.2.

Of course, some quantities can not be easily specified and reduced, because for example “Receiver readings” are not easy to validate with equipment available in most of test labs. So, we have to assume calibration parameters from receiver producer.

Other interesting thing is that in CISPR standard [3] is written that antenna factor height deviation for biconical horizontally polarized antenna is 0 dB according to CISPR 16-4 standard [3]. It could be truth in full-anechoic chamber, but not in EMC semi-anechoic chamber with metalic floor (ground plane). This case is discussed in [5], where antenna factor deviation is up to 3 dB.

All these facts should be taken into account when evaluating overall measurement uncertainty in a particular test site.

## 4. CONCLUSION

Now I am standing on the beginning of my research. “Guidebook of uncertainty” for non high-equipped EMC laboratoriem is supposed aim of the whole research. This guidebook should help firstly in all pre-compliance test labs to specify and reduce overall measurement uncertainty of their EMC measurements.

The influence of each parameter influencing the overall measurement uncertainty in radiated disturbance, especially the antenna factor, antenna corrections and site corrections, will be taken into account.


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