

Proficiency Testing of Radiated Power Measurements PTC(POW-30-300)

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Rev. 1 (issued to include results of participation of two late laboratories)

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General information

- Number of participants: 10+2
- Start date: February 2024
- Stop date: December 2024 (2 late laboratories provided measurement results in Sept.-Oct. 2025).
- Scheme of the proficiency test PTC(POW-30-300):
<https://www.dinfo.unifi.it/vp-436-schemes-of-the-proficiency-tests.html>
- Issues faced:
 - Some laboratories issued the report (annex C) with a severe delay (several months) with respect the expected date (1 week after measurements).
 - 1 multi-site laboratory was severely delayed in performing measurements with respect to the scheduled weeks (nearly 3 months). The PT closed with the same delay in January 2025.
 - 1 laboratory (the 11th participant) decided to postpone measurements (broken clamp due to transportation after periodical calibration) and 1 laboratory (the 12th participant) decided to participate in September 2025. Thus, the PT was reopened to include results of the last two late laboratories

Travelling Sample for the 30 MHz to 300 MHz Radiated Power Measurement



Picture of the Sample: top face (left), AC connector face (right)

Travelling Sample Characteristics

- The Sample is a floating (ungrounded) source of radiofrequency common mode current. The Sample is the combination of a coupling network to the AC power and a radiofrequency comb generator. The coupling network permits to provide the AC power to the comb generator and the injection of the radiofrequency common mode current generated by the comb generator into the AC power lead under test. The shape of the Sample is a paralepidid with approximate size 20 cm (width) x 10 cm (height) x 25 cm (depth).
- The nominal AC voltage feeding the Sample is 230 V, rms. A connection lead is provided with the Sample. Such lead shall be used to connect the Sample to the artificial mains network during the preliminary verification phase. Measurement of disturbance power shall be carried out with the Sample AC port directly connected to the lead under test.
- The Sample is a table-top equipment.
- The disturbance power is generated once that the Sample is fed by AC power.
- The Sample generates harmonics of the radiofrequency common mode current at 5 MHz steps from 5 MHz to above 300 MHz.
- The Sample has a top face and a bottom face clearly identified. **The top face shall be placed upwards both during the preliminary verification phase and the measurement phase.**
- The Sample does not require warm up prior to verification and measurement.

Travelling Sample Verification

- Disturbance power measurement shall be preceded by a preliminary verification of the correct operation of the Sample by using an artificial mains network and a receiver (spectrum analyzer or EMI receiver). The verification shall be as follows:
 - The Sample and the artificial mains network shall be placed on a ground plane. Connect the Sample to the EUT port of the artificial mains network by using the short lead provided with the Sample. The top face of the Sample shall be placed upwards.
 - Make a conducted emission measurement of the line and neutral disturbance voltage in accordance with the method described in §7.4.2 of EN 55016-2-1:2014/A1:2017 at the frequency of the 6th harmonic (approximately 30 MHz). Use the average detector.
 - Record the line and neutral disturbance voltage V that the Sample delivers to the artificial mains network. Register the values of V (in dB(μ V), rounded to the integer) in Table 1. Calculate and annotate the deviation $\Delta = V - V_{ref}$ (in dB, rounded to the integer).
 - Verify that $-6 \text{ dB} \leq \Delta \leq 6 \text{ dB}$
 - If the preliminary Sample verification is successful then the Laboratory can pass to the next step, i.e., the disturbance power measurement, otherwise the Coordinator is informed and the disturbance power measurement is temporarily delayed.

Table 1: Verification of the voltage that the Sample delivers to the artificial mains network.

| Harmonic # | Frequency MHz | Conductor | V_{ref} dB(μ V) | V dB(μ V) | dB |
|------------|---------------|-----------|------------------------|------------------|----|
| 6 | 30 | line | 65 | | |
| 6 | 30 | neutral | 69 | | |

Measurement Procedure

- Measurement of disturbance power shall be carried out according to the measurement procedure specified in clause 7.8.2 of the standard EN 55016-2-2:2011. It is up to the Laboratory to choose if making measurement at fixed frequencies and the clamp continuously scanning the lead under test or at fixed clamp positions along the lead under test and the receiver scanning over the frequency band of interest.
- **The top face of the Sample shall be placed upwards.** The AC port of the Sample shall be directly connected to the lead under test. The Sample is a table-top equipment.
- The EMI receiver's detector shall be set to average.
- The measurement result provided by the Laboratory shall be:
 - The estimate x , expressed in dB(pW), of the amplitude of the selected harmonics;
 - The expanded uncertainty of the estimate x , U_{lab} , expressed in dB and obtained multiplying the combined standard uncertainty by the coverage factor $k = 2$ (which corresponds to a coverage probability of about 95 % assuming normal distribution).
- **What identifies the harmonic is its order not its frequency. Frequencies are given only for guidance.**
- The Laboratory may assign a different value of U_{lab} to each measured frequency.

Reference values

Reference
values

Statistical analysis of
measurement results

\bar{x}^* , s^*

Statistical (robust) analysis

$x_1, x_2, \dots, x_i, \dots, x_p$ } Raw data (p participants)

$x^* = \text{median of } x_i \quad (i = 1, 2, \dots, p)$

$s^* = 1,483 \text{ median of } |x_i - x^*| \quad (i = 1, 2, \dots, p)$

} Initial reference value

$\delta = 1,5s^*$

$x_i^* = \begin{cases} x^* - \delta, & \text{if } x_i < x^* - \delta \\ x^* + \delta, & \text{if } x_i > x^* + \delta \\ x_i, & \text{otherwise} \end{cases}$

} Transformed set of data

$x^* = \sum x_i^* / p$

$s^* = 1,134 \sqrt{\sum (x_i^* - x^*)^2 / (p - 1)}$

} New reference value
(iterative algorithm)



Performance statistic ζ (Participant)

- Performance statistic ζ (clause 9.6 of ISO 13528:2022) that the Coordinator applies to the Participant providing the measurement result x_i with standard uncertainty u_{x_i}

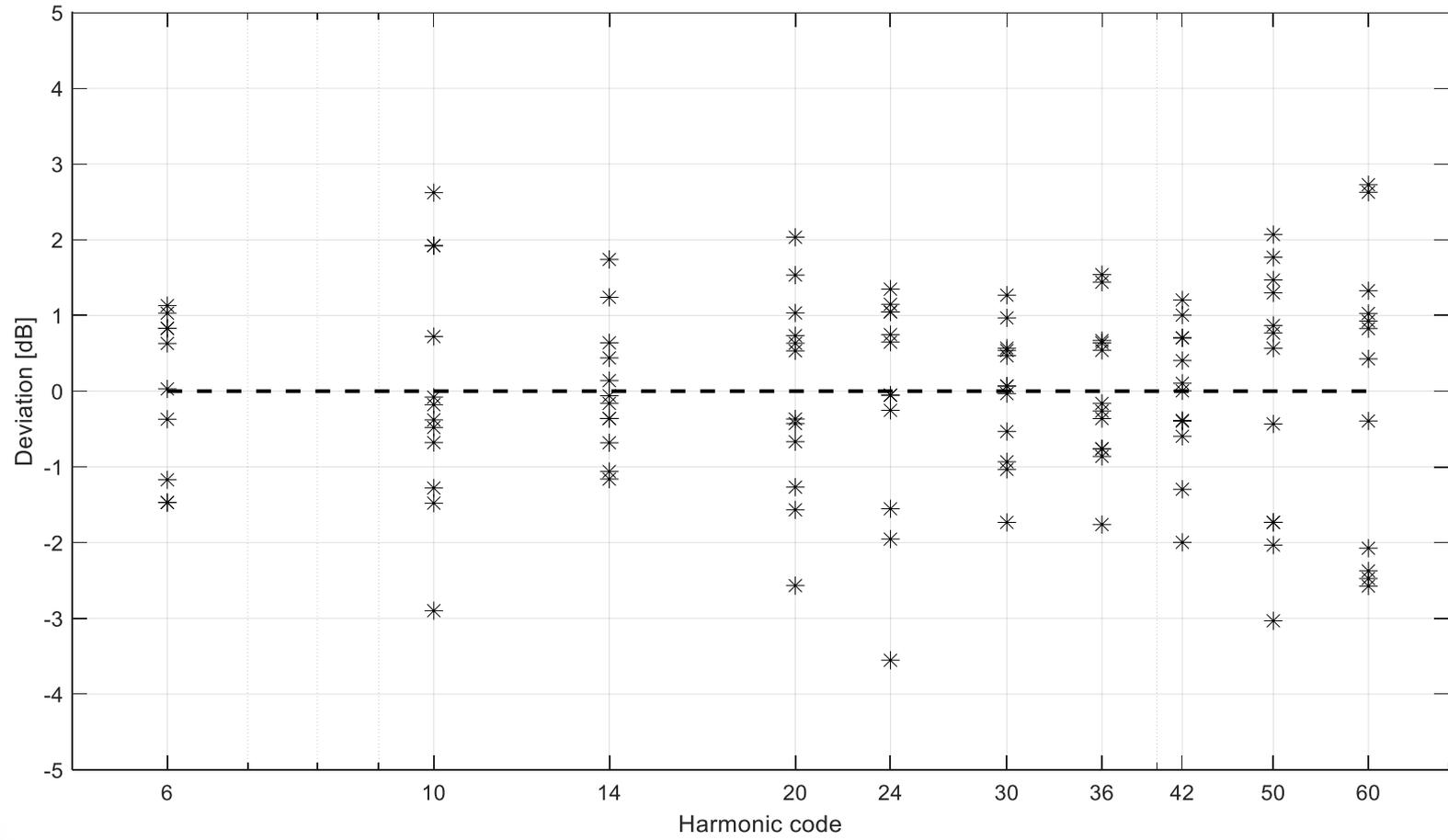
$$\zeta_i = \frac{x_i - x^*}{\sqrt{u_{x_i}^2 + \left(\frac{1,25 \cdot s^*}{\sqrt{p}}\right)^2}}$$

$$\begin{cases} 2 < |\zeta_i| < 3 \Rightarrow \text{warning} \\ 3 < |\zeta_i| \Rightarrow \text{action} \end{cases}$$

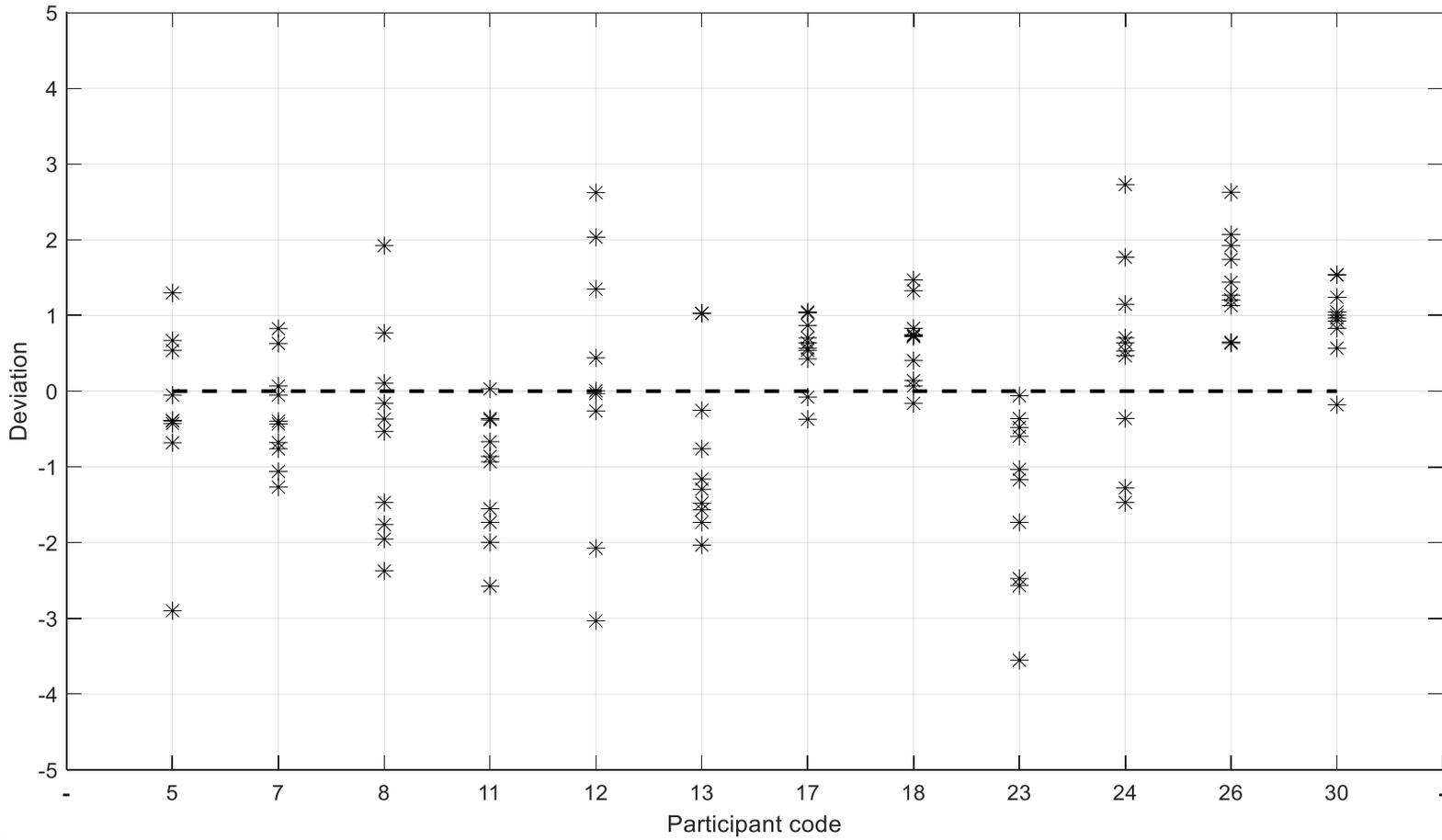
Results

Harmonic code to frequency conversion

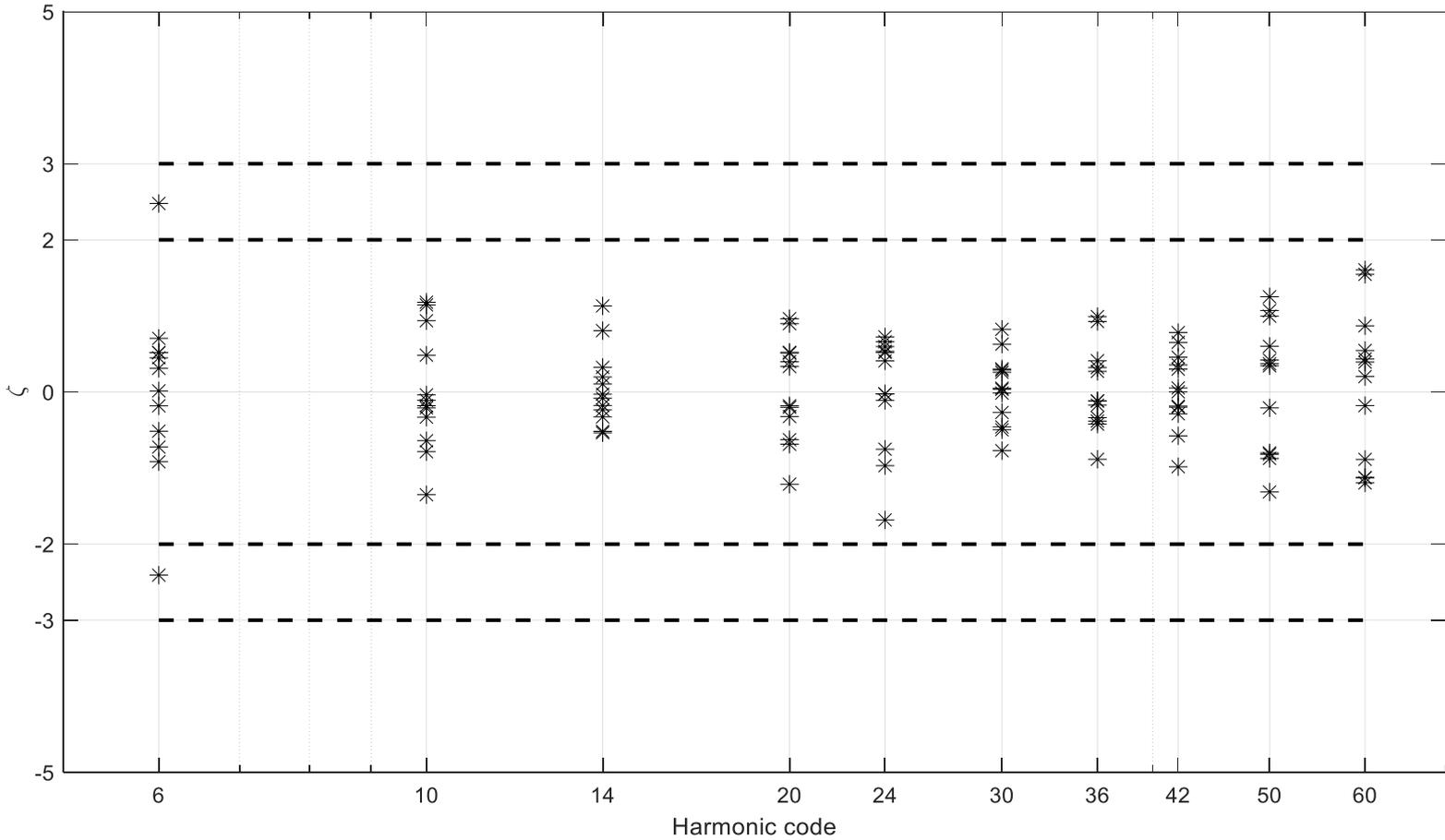
| Band | Harmonic code | Frequency MHz |
|------|---------------|---------------|
| C | 6 | 30 |
| C | 10 | 50 |
| C | 14 | 70 |
| C | 20 | 100 |
| C | 24 | 120 |
| C | 30 | 150 |
| C | 36 | 180 |
| C | 42 | 210 |
| C | 50 | 250 |
| C | 60 | 300 |



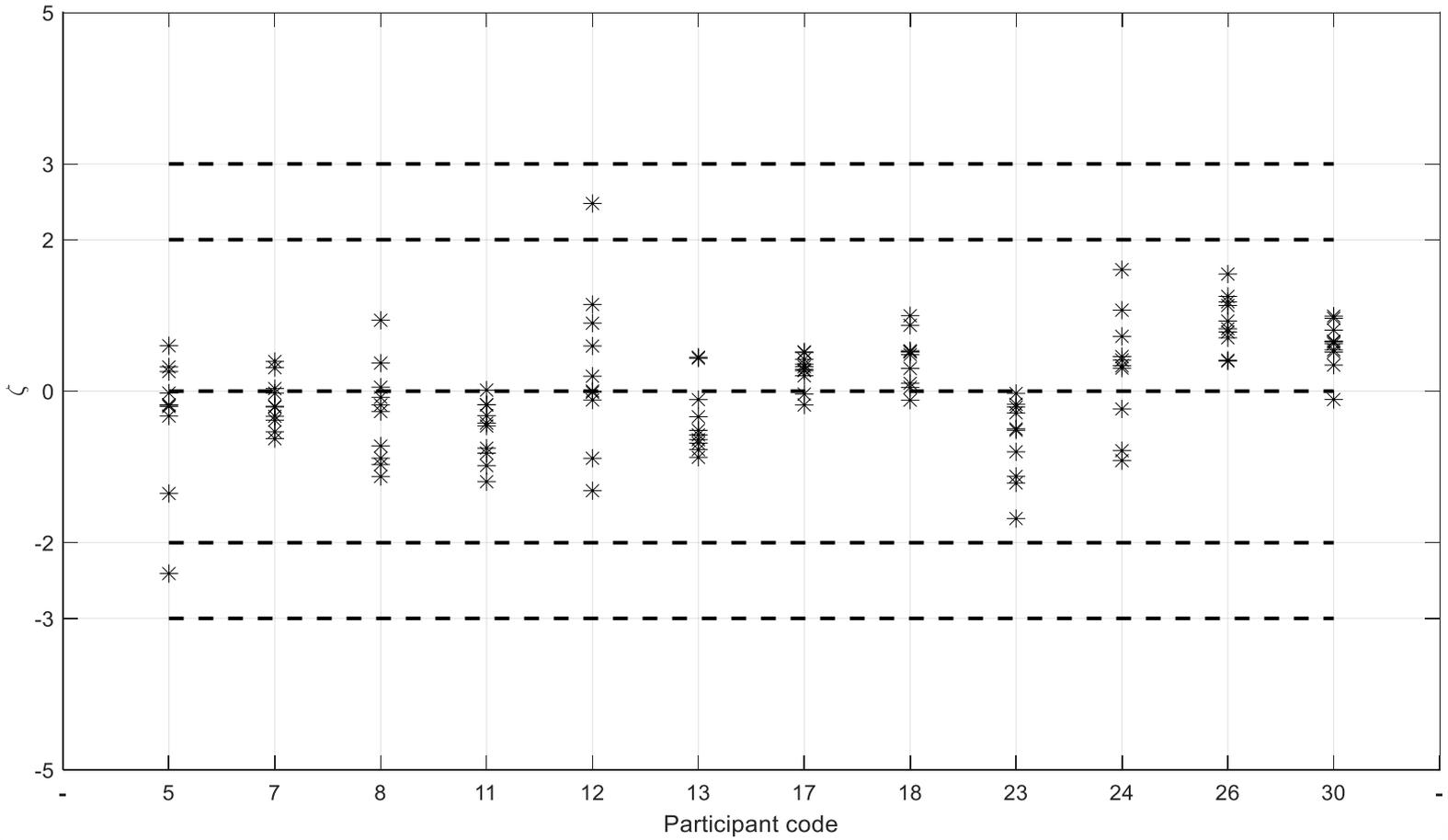
- Deviations from reference value x^* (horizontal axis is harmonic code)



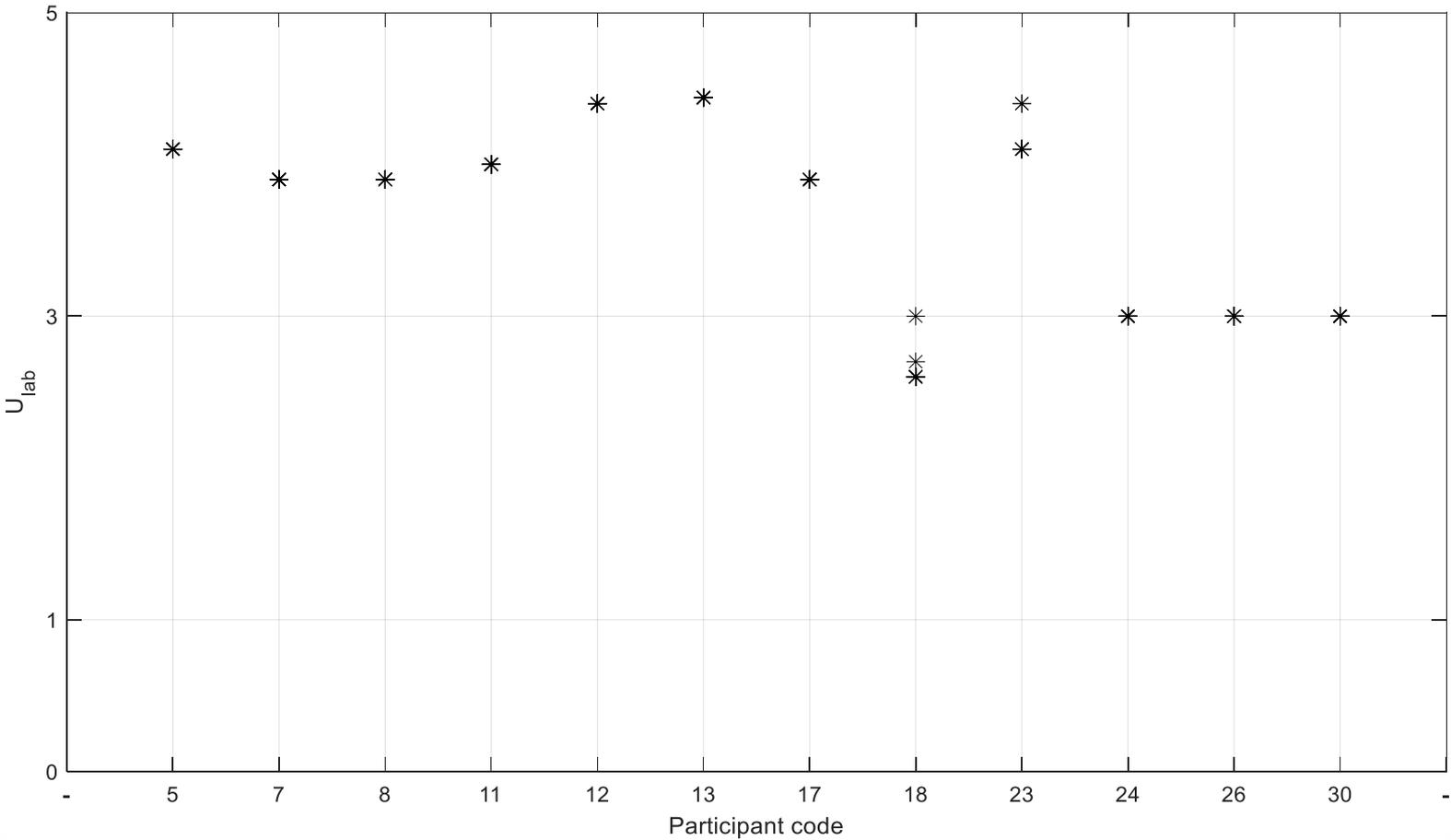
- Deviations from reference value x^* (horizontal axis is participant code)



- Performance statistic ζ (horizontal axis is harmonic code)



- Performance statistic ζ (horizontal axis is participant code)



- Expanded uncertainty U_{lab} (horizontal axis is participant code)

Measurement reproducibility (quantified by robust std. dev. s^*)

| Band | Harmonic # | Frequency MHz | s^* dB |
|------|------------|---------------|----------|
| C | 6 | 30 | 1.6 |
| C | 10 | 50 | 1.8 |
| C | 14 | 70 | 0.9 |
| C | 20 | 100 | 1.5 |
| C | 24 | 120 | 1.4 |
| C | 30 | 150 | 0.9 |
| C | 36 | 180 | 1.1 |
| C | 42 | 210 | 1.0 |
| C | 50 | 250 | 1.9 |
| C | 60 | 300 | 2.2 |

Remarks

- The raw measurement results provided by the 12 participants at the 10 measurement frequencies selected by the Coordinator are within -4 dB to +3 dB from reference value x^* .
- Two warning signals has been detected over 120 measurement results, both at the first frequency harmonic of 30 MHz.
- Standard measurement uncertainty declared by the laboratories comprised between nearly 1,3 dB and 2,3 dB, robust standard deviation s^* is between 0,9 dB and 2,2 dB.