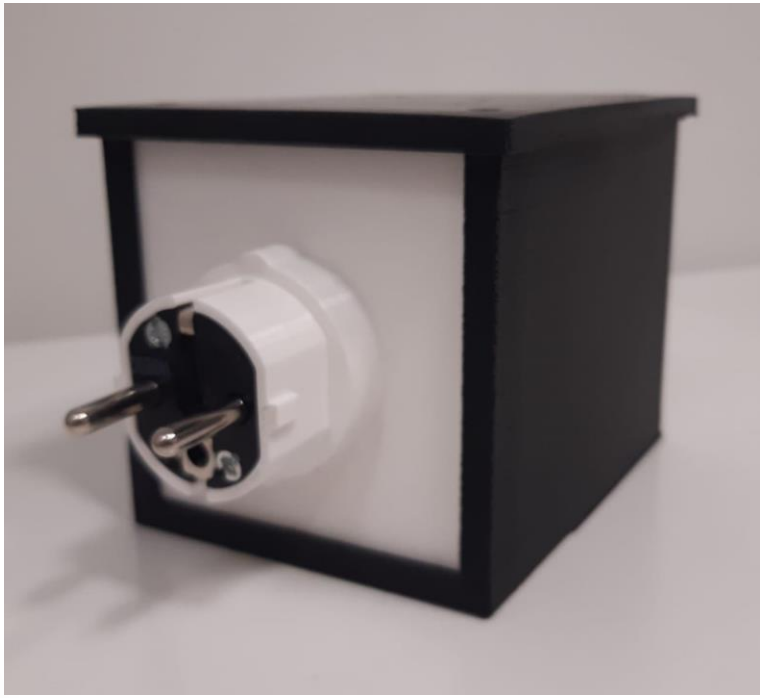
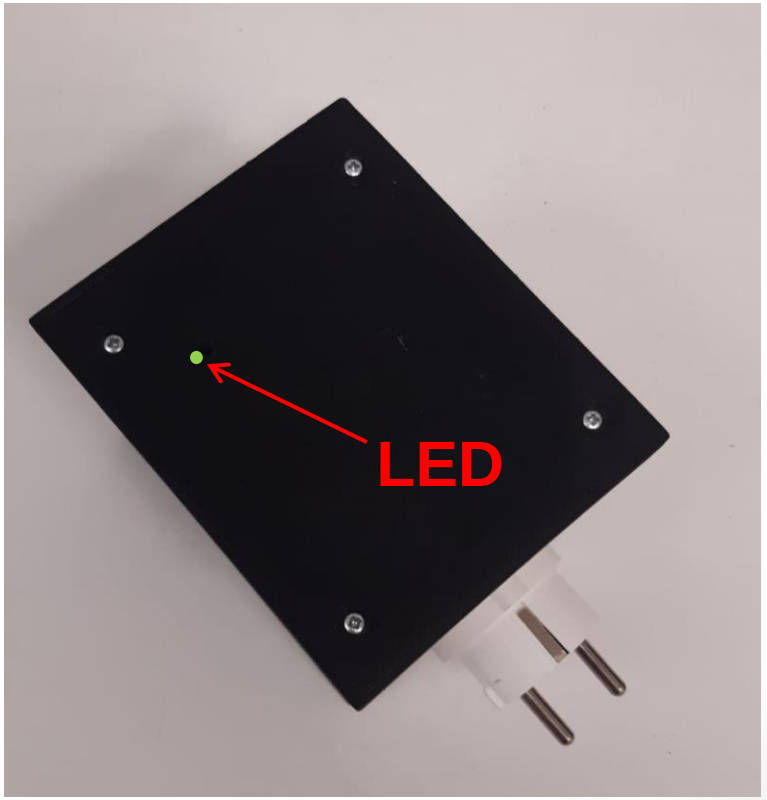
Proficiency Testing of Conducted Emission Measurements PTC(CE-9k-30M-VII)

Firenze, February 27, 2023
Rev. 0

C. Carobbi and A. Bonci, University of Florence, Firenze, Italy

Travelling Sample for the 9 kHz to 30 MHz frequency range (Conducted Emission)





General information

- Number of participants: 27
- Start date: May 2022
- Stop date: February 2023
- Issues faced: None
- Scheme of the proficiency test PTC(CE-9k-30M-VII): https://www.dinfo.unifi.it/vp-436-schemes-of-the-proficiency-tests.html

Measurement procedure

- Voltage measurement by using the AMN and EMI receiver is preceded by a preliminary check of one harmonic generated by the Sample.
- Measurement by using the AMN and EMI receiver are performed according to §7.4.2 of EN 55016-2-1:2014 and next amendments, by using a V-type Artificial Mains Network (AMN).
- The Laboratory measures the amplitude of ten (10) harmonics selected by the Coordinator in the frequency range between 9 kHz and 30 MHz (i.e., covering both band A and band B). The disturbance injected by the Sample in line and neutral conductors is measured. A total number of twenty (20) measurements (two conductors times ten frequencies) is reported to the Coordinator by the Laboratory.

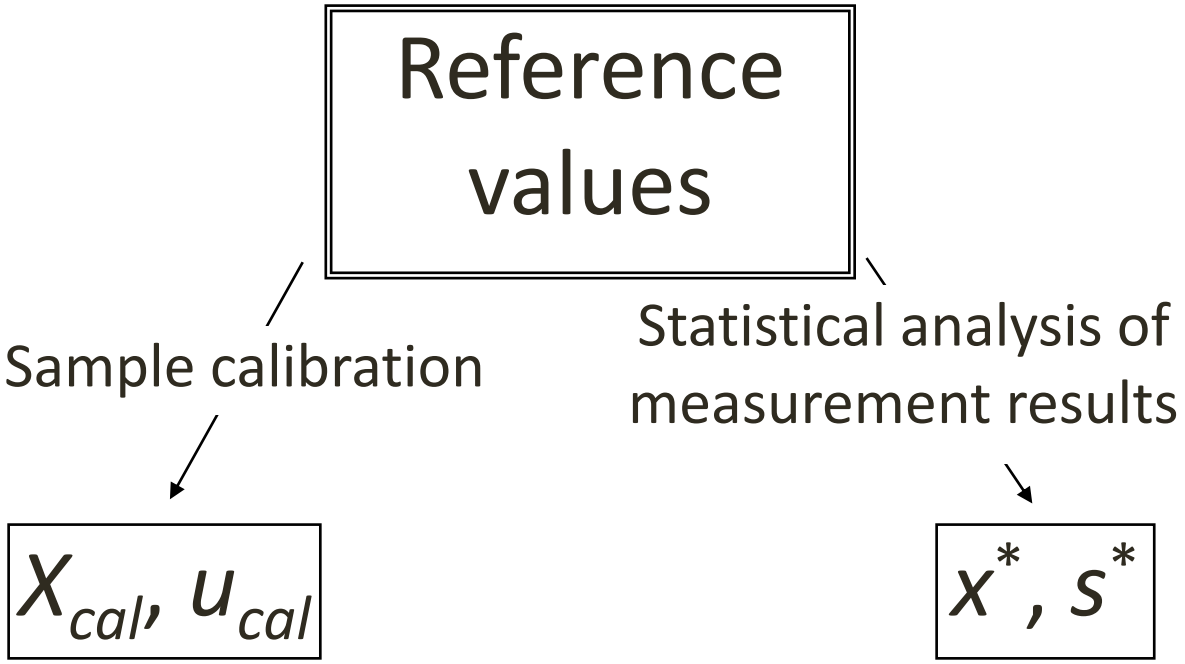
Sequence of operations

- Connect the Sample to the EUT port of the AMN;
- Power up the AMN;
- Measure the amplitude of the ten harmonics selected by the Coordinator by using the EMI receiver set with average detector;
- Power off the AMN;
- Disconnect the Sample from the AMN.

Measurement result

- The measurement result provided by the Laboratory consists of:
  - The estimate x, expressed in dB(µV), of the amplitude of the selected harmonics, measured both line-to-ground (x_{line}) and neutral-to-ground ($x_{neutral}$);
  - 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).

Reference values



Statistical (robust) analysis

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

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

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

} Initial reference value

$\delta = 1{,}5 s^*$

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

} Transformed set of data

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

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

} New reference value (iterative algorithm)

Excerpt from Annex C, algorithm A of ISO 13528:2005

Performance statistic ζ (Participant)

- Performance statistic ζ (clause 9.6 of ISO 13528:2015) that the Coordinator applies to the Participant providing the measurement result x_i with standard uncertainty u_{xi}

$$\zeta_i = \frac{x_i - X}{\sqrt{u_{xi}^2 + u_X^2}} \qquad \begin{cases} X = X_{cal}, u_X = u_{cal} \\ X = x^*, u_X = \dfrac{1{,}25 \cdot s^*}{\sqrt{p}} \end{cases}$$

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

Performance statistic *z'* (Coordinator)

- Performance statistic *z'* (clause 7.8.1 of ISO 13528:2015) that the Coordinator applies as self-check

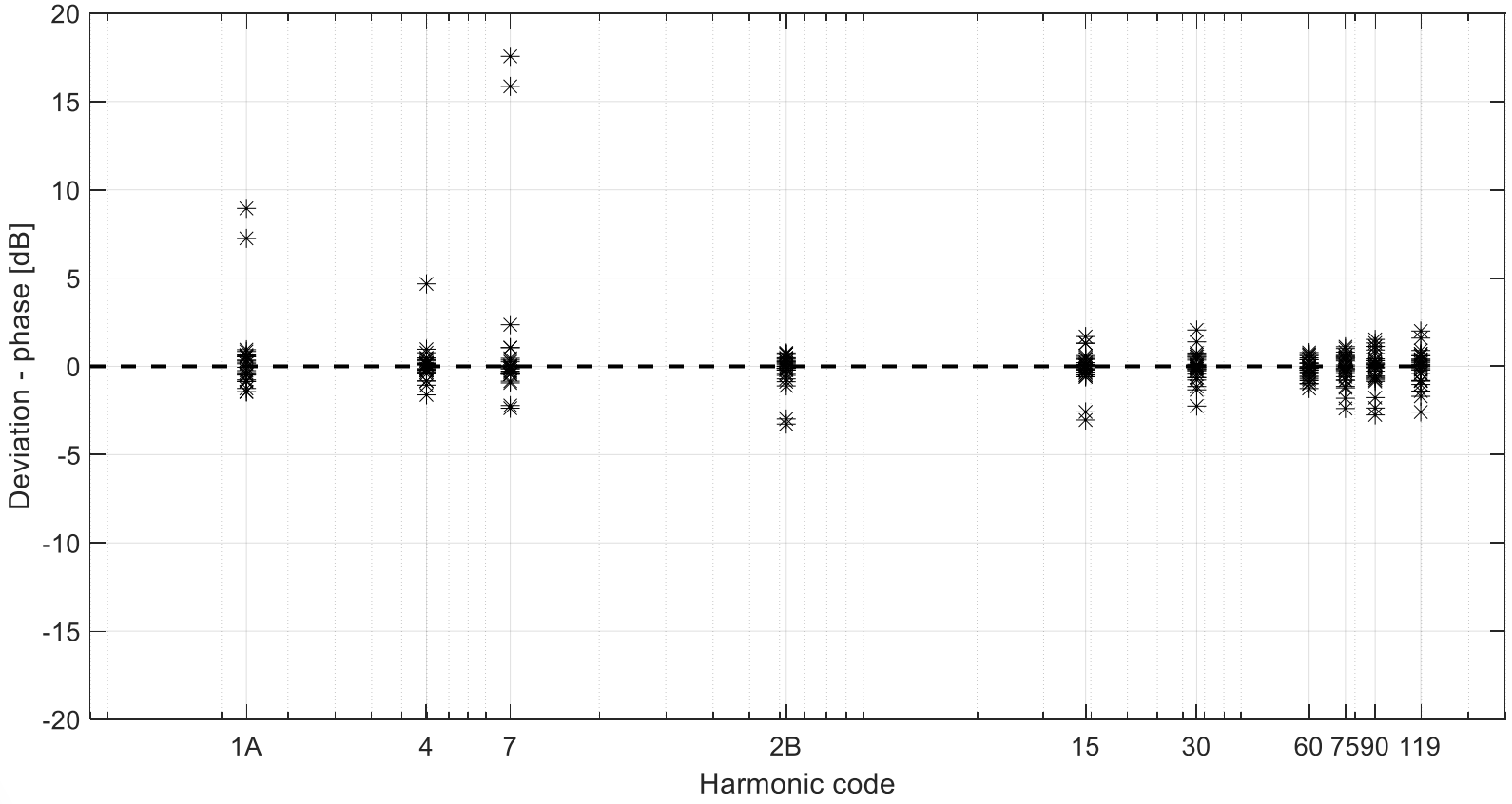
$$z' = \frac{X_{cal} - x^*}{\sqrt{u_{cal}^2 + \left(\frac{1{,}25 \cdot s^*}{\sqrt{p}}\right)^2}}$$

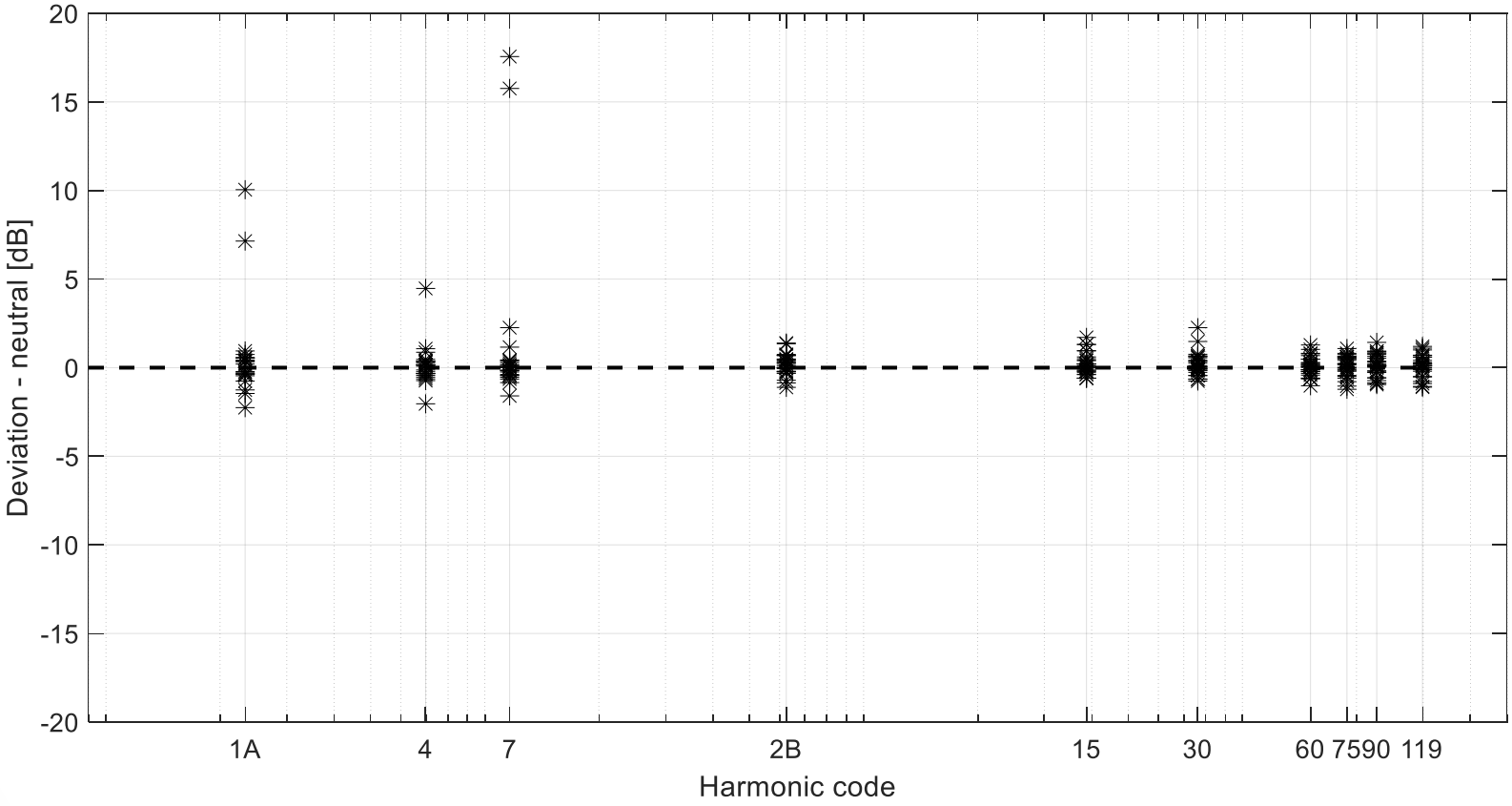
$$\begin{cases} 2 < |z'| < 3 \Rightarrow warning \\ 3 < |z'| \Rightarrow action \end{cases}$$

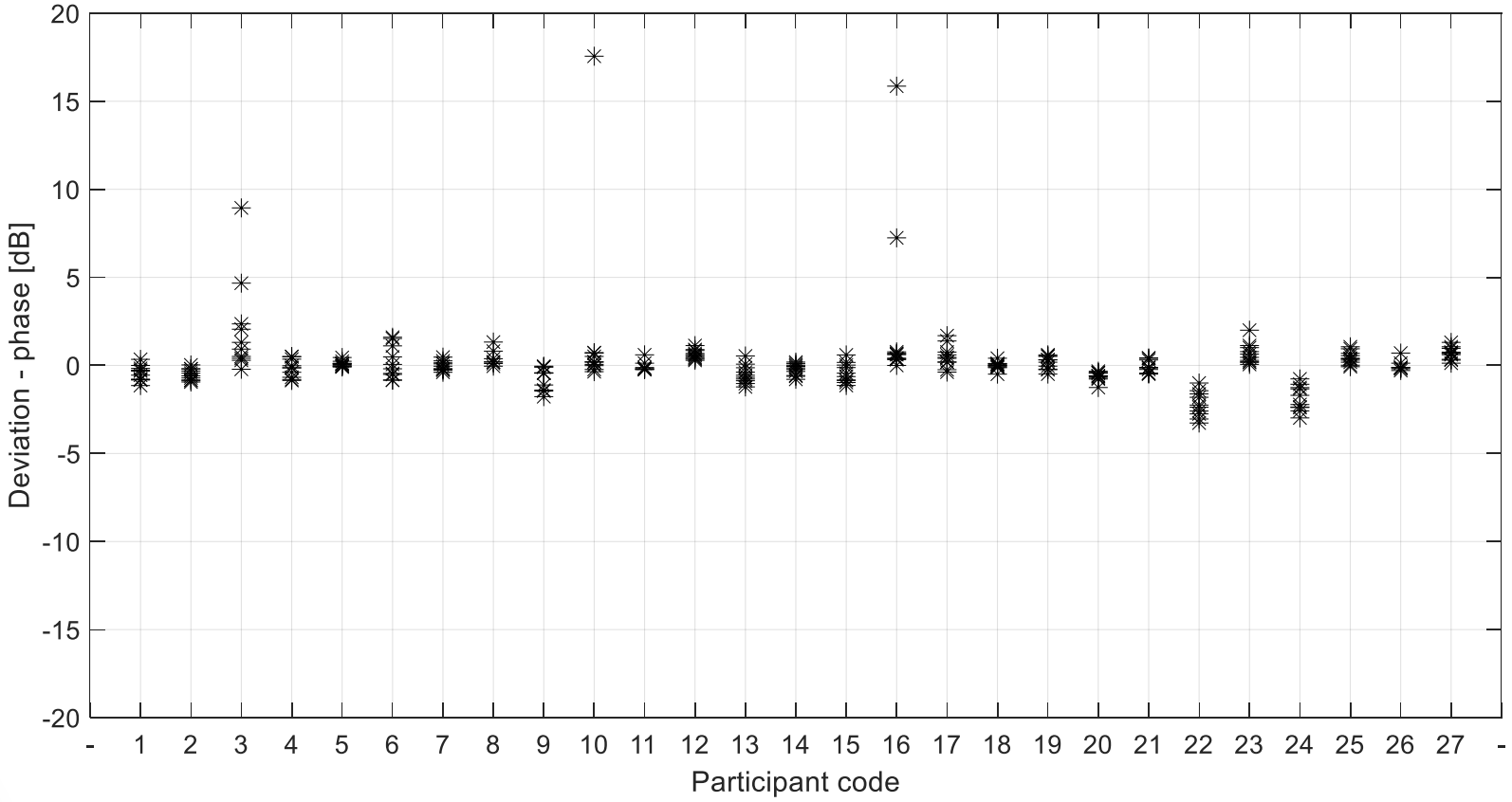
Results

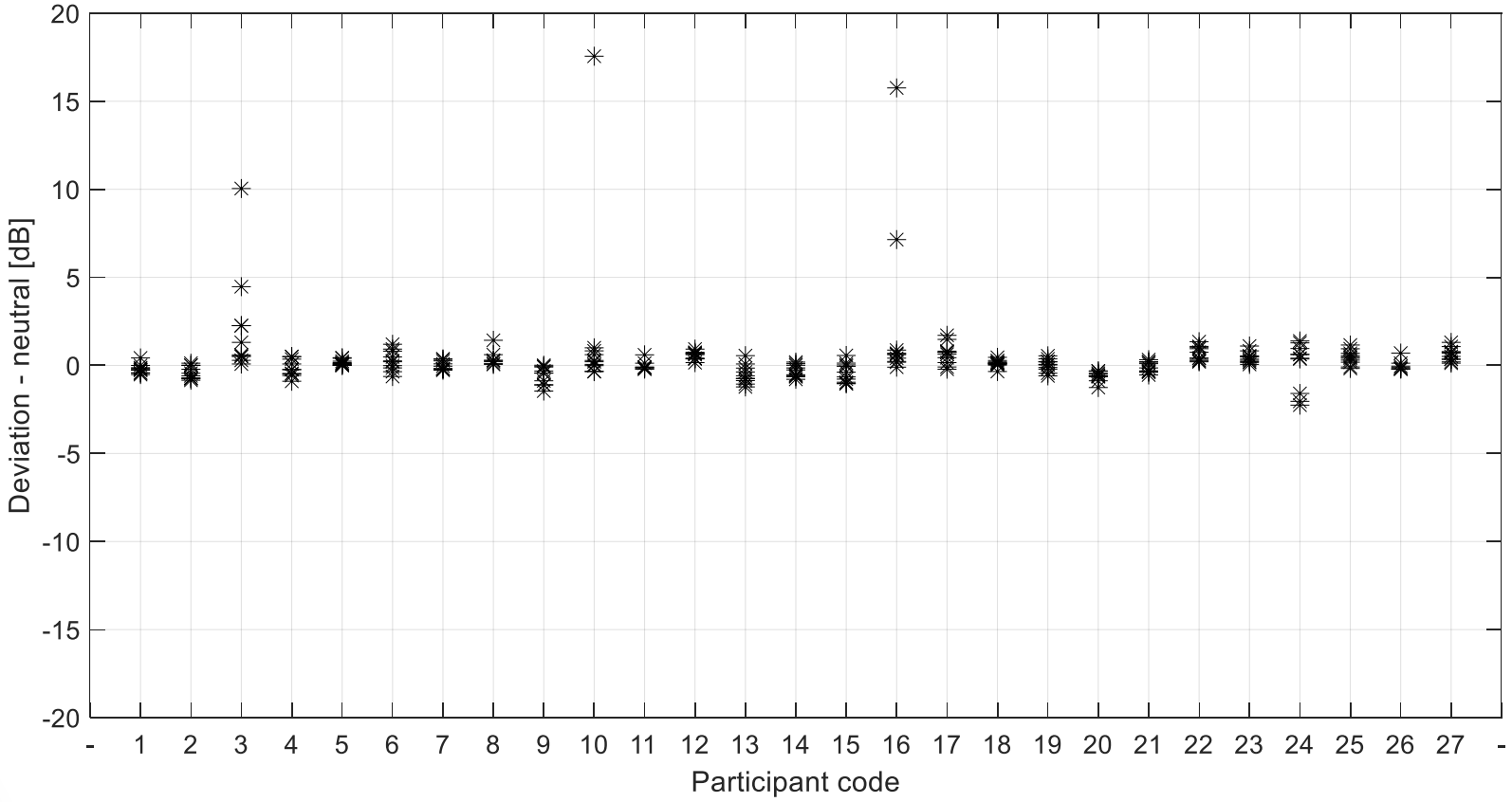
Harmonic code to frequency conversion

Band	Harmonic #	Frequency MHz
A	1	0,02325
A	4	0,06975
A	7	0,11625
B	2	0,625
B	15	3,875
B	30	7,625
B	60	15,125
B	75	18,875
B	90	22,625
B	119	29,875

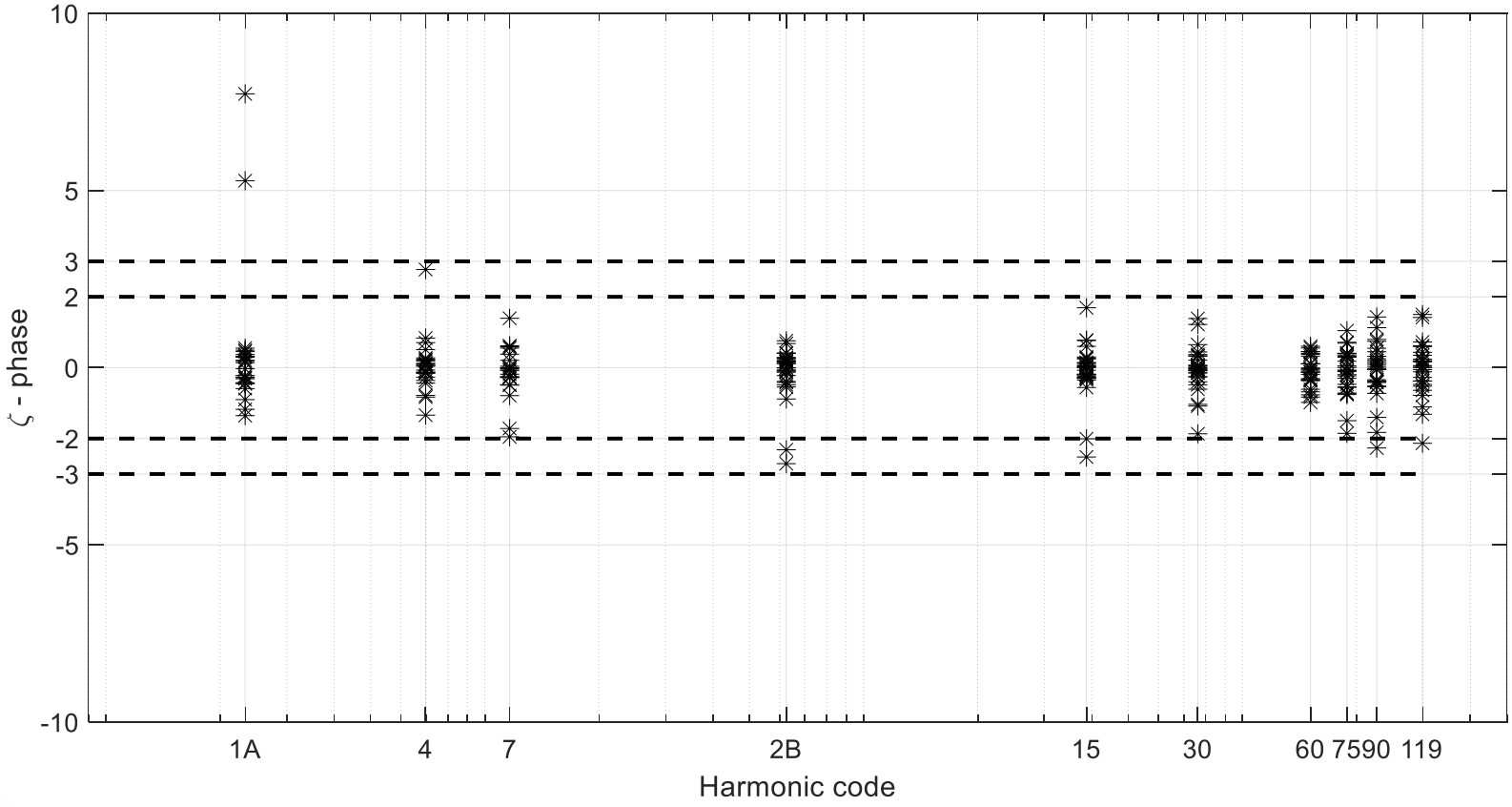

Deviation - phase [dB]
20
15
10
5
0
-5
-10
-15
-20
1A
4
7
2B
15
30
60 75
90
119
Harmonic code

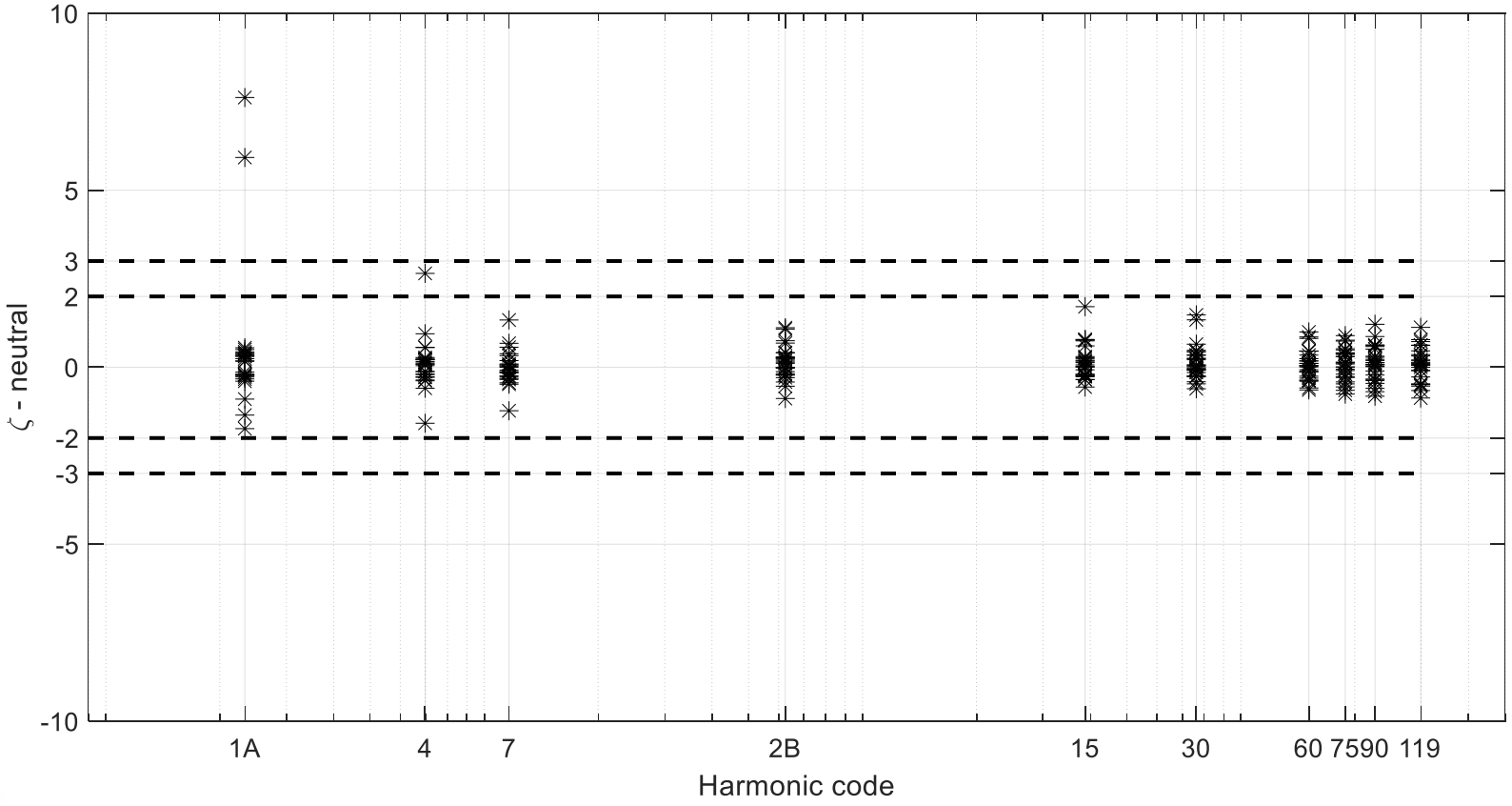

Deviation - neutral [dB]
20
15
10
5
0
-5
-10
-15
-20
1A
4
7
2B
15
30
60 75
90
119
Harmonic code

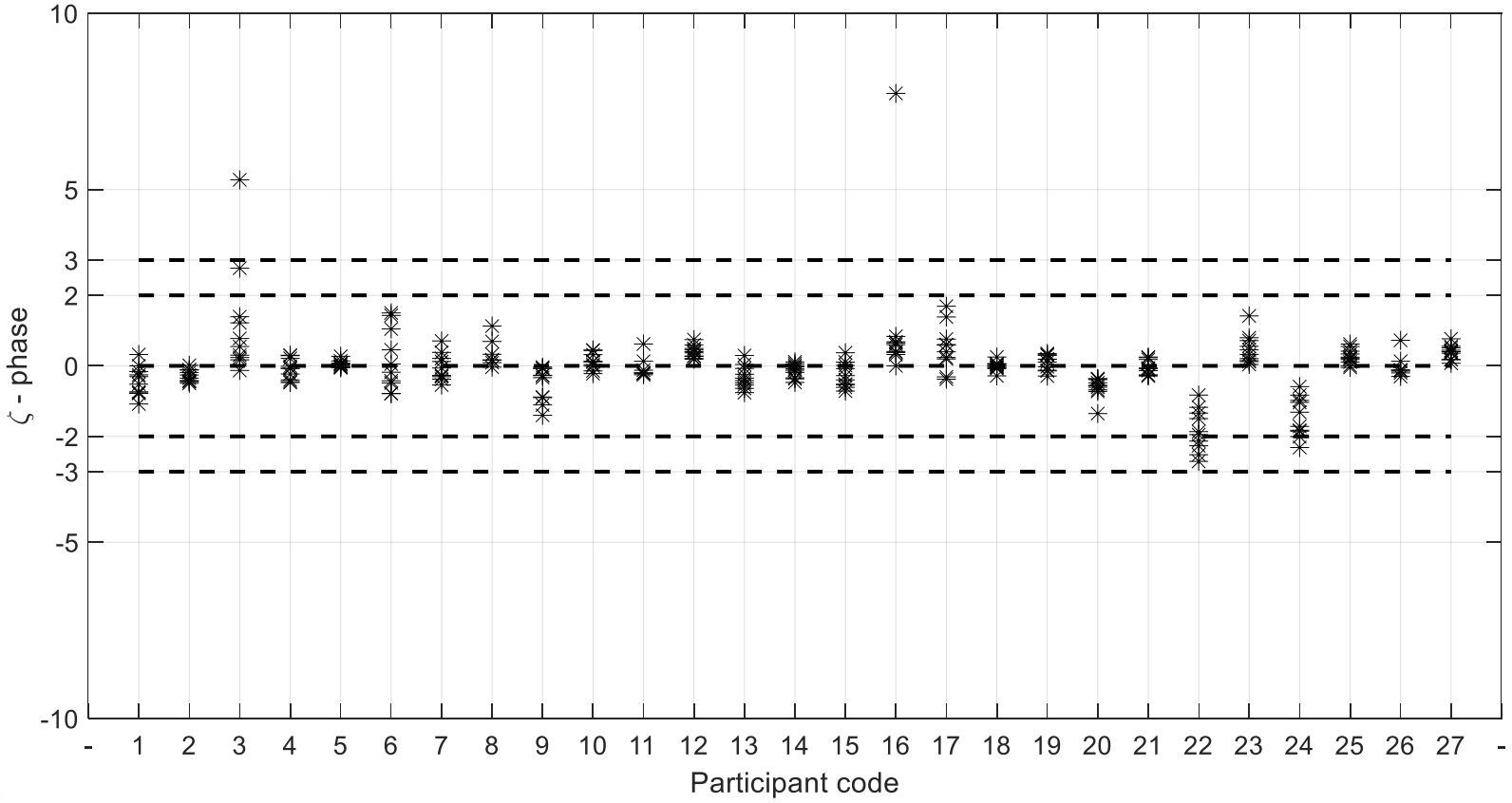

Deviation - phase [dB]
20
15
10
5
0
-5
-10
-15
-20
- 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 -
Participant code

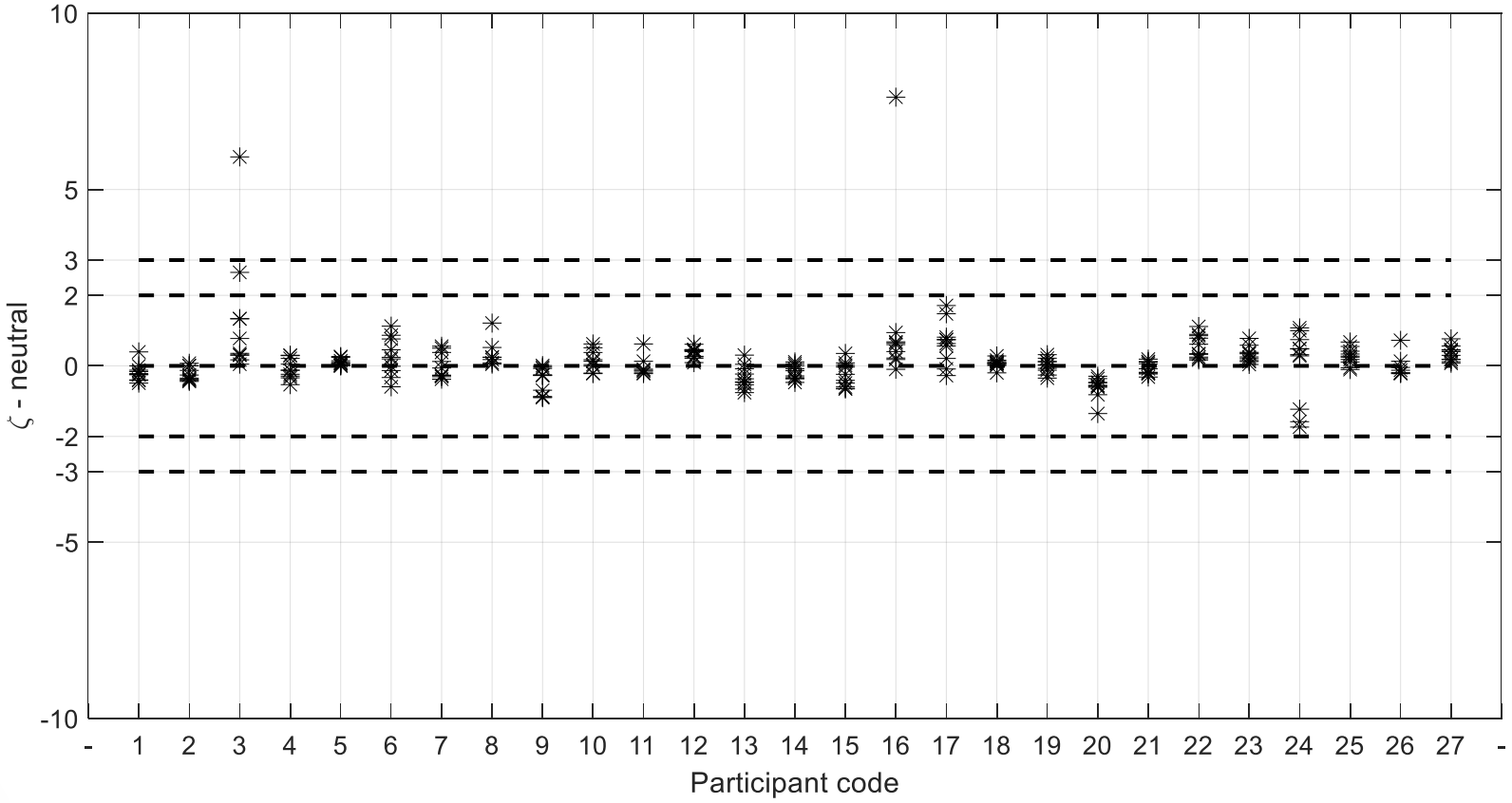


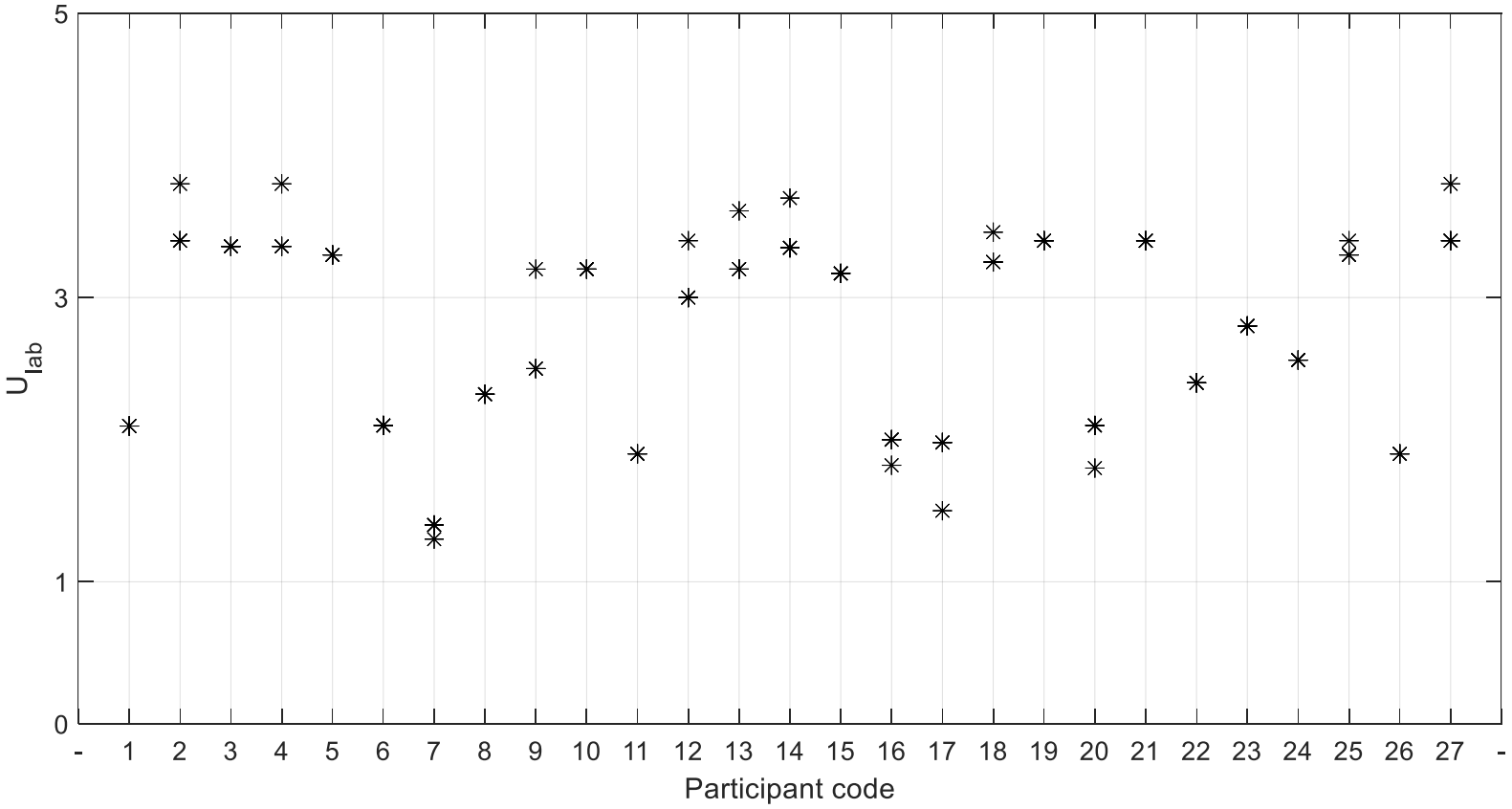
Conducted Emission 9 kHz – 30 MHz


10
5
3
2
0
-2
-3
-5
-10
ζ - phase
1A
4
7
2B
15
30
60 7590 119
Harmonic code


10
5
3
2
0
-2
-3
-5
-10
ζ - neutral
1A
4
7
2B
15
30
60
75
90
119
Harmonic code


10
5
3
2
0
-2
-3
-5
-10
ζ - phase
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27
Participant code


10
5
3
2
0
-2
-3
-5
-10
ζ - neutral
- 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 -
Participant code


5
3
1
0
U_{lab}
- 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 -
Participant code

Ref. vales – comparison

f MHz	*u* dB	*X* - *x** dB	*s** dB	*z'*
0.02325	1.25	0.4	0.9	0.30
0.06975	1.25	0.4	0.6	0.32
0.11625	1.25	0.4	0.8	0.29
0.625	1.25	0.5	0.6	0.44
3.875	1.25	0.5	0.5	0.43
7.625	1.25	0.6	0.6	0.45
15.125	1.25	0.8	0.5	0.60
18.875	1.25	0.9	0.6	0.75
22.625	1.25	1.0	0.8	0.83
29.875	1.25	1.0	0.8	0.82

Remarks

- The reference values obtained from calibration of the Sample and from robust statistical analysis are compatible each other (maximum deviation 0.9 dB, over ten frequencies).
- The measurement results provided by the 20 participants at the 10 measurement frequencies selected by the Coordinator are approximately within –5 dB to +20 dB from the reference values. Most of measurement results are within –2 dB to +2 dB from the reference values.
- 582 measurement results were provided by the participants and 13 signals (warning and action) were issued.
- The standard measurement uncertainty declared by the laboratories is comprised approximately between 0.5 dB and 2 dB, robust standard deviation s^* is less than 0.9 dB.