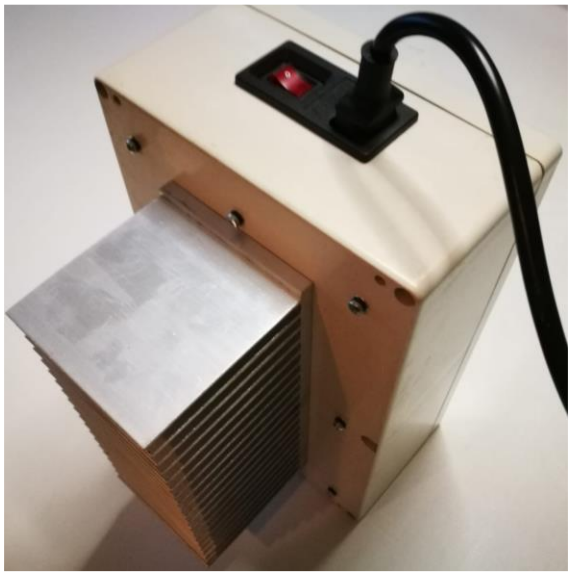
Proficiency Test of Current Harmonics Measurements PTC(HARM-CUR-50-2000)

Firenze, December 13, 2021
Rev. 0

C. Carobbi Università degli Studi di Firenze, Dipartimento di Ingegneria dell'Informazione, Firenze, Italy

Travelling Sample for harmonic current generation



Detailed description is in clause 6. of the scheme of the proficiency test.

General information

- Number of participants: 20
- Start date: March 2021
- Stop date: December 2021
- Issues faced:
  - Damage of a resistor of the non-linear load inside the travelling sample in week 18, when already three laboratories had carried out measurements. The damage was detected by the fourth laboratory. After repair (1 week), the proficiency test restarted, and the three laboratories that carried out measurements before the damage repeated the test.
  - Delay of two weeks with respect to the Doodle planning in order to allow last-minute participation from two laboratories.
- Scheme of the proficiency test PTC(HARM-CUR-50-2000):
  https://www.dinfo.unifi.it/vp-436-schemes-of-the-proficiency-tests.html

Measurement procedure

- Harmonic current measurement is carried out according to §6.3 of EN 61000-3-2:2019.
- Set the test observation period T_{obs} = 10 s (or larger)
- After measurement check that the value of the harmonic of order 1 (at the 50 Hz fundamental frequency) is 200.00 mA ± 20.00 mA. If the measured value is outside the specified 180.00 mA to 220.00 mA interval, then immediately contact the Coordinator. The interlaboratory comparison is temporarily postponed until the cause of this out-of-tolerance measured value is clarified and appropriate corrective actions are undertaken.
- Supply voltage is 230 V (rms)

Harmonics to be measured

Table 1: Table to be used for recording the harmonic currents measurement results. Column four shall be filled up by the Laboratory, the other columns (two, three and five) will be filled up by the Coordinator.

1	2	3	4	5
Harmonic order	***x**** mA	***s**** mA	***x*** mA	***z***
3	-	-		-
7	-	-		-
11	-	-		-
15	-	-		-
19	-	-		-
23	-	-		-
27	-	-		-
31	-	-		-
35	-	-		-
39	-	-		-

Reference values

- Reference values are:
  - x^* reference value of the electric field at a given frequency
  - s^* standard deviation of the electric field at a given frequency
- x^* and s^* are obtained through the robust statistical analysis in terms of robust mean and robust standard deviation

Robust statistical analysis

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

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

$s^* = 1{,}483$ 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 13528:2015

Performance statistic *z*

- Performance statistic *z* (clause 9.4.1 of ISO 13528:2015) that the Coordinator applies to the Participant providing the measurement result x_i

$$z_i = \frac{x_i - x^*}{s^*}$$

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

Reproducibility

- According to §6.3.3.2 of EN 61000-3-2:2019 measurement reproducibility can be better than $\pm(1\% \cdot I_{in} + 10$ mA) where I_{in} is the average value over the observation period of the total input current
- **Differences in measurement results that are less than standard measurement reproducibility are deemed negligible**
- For the travelling sample $I_{in} \approx 390$ mA, then measurement reproducibility should be within ±13,9 mA

Results

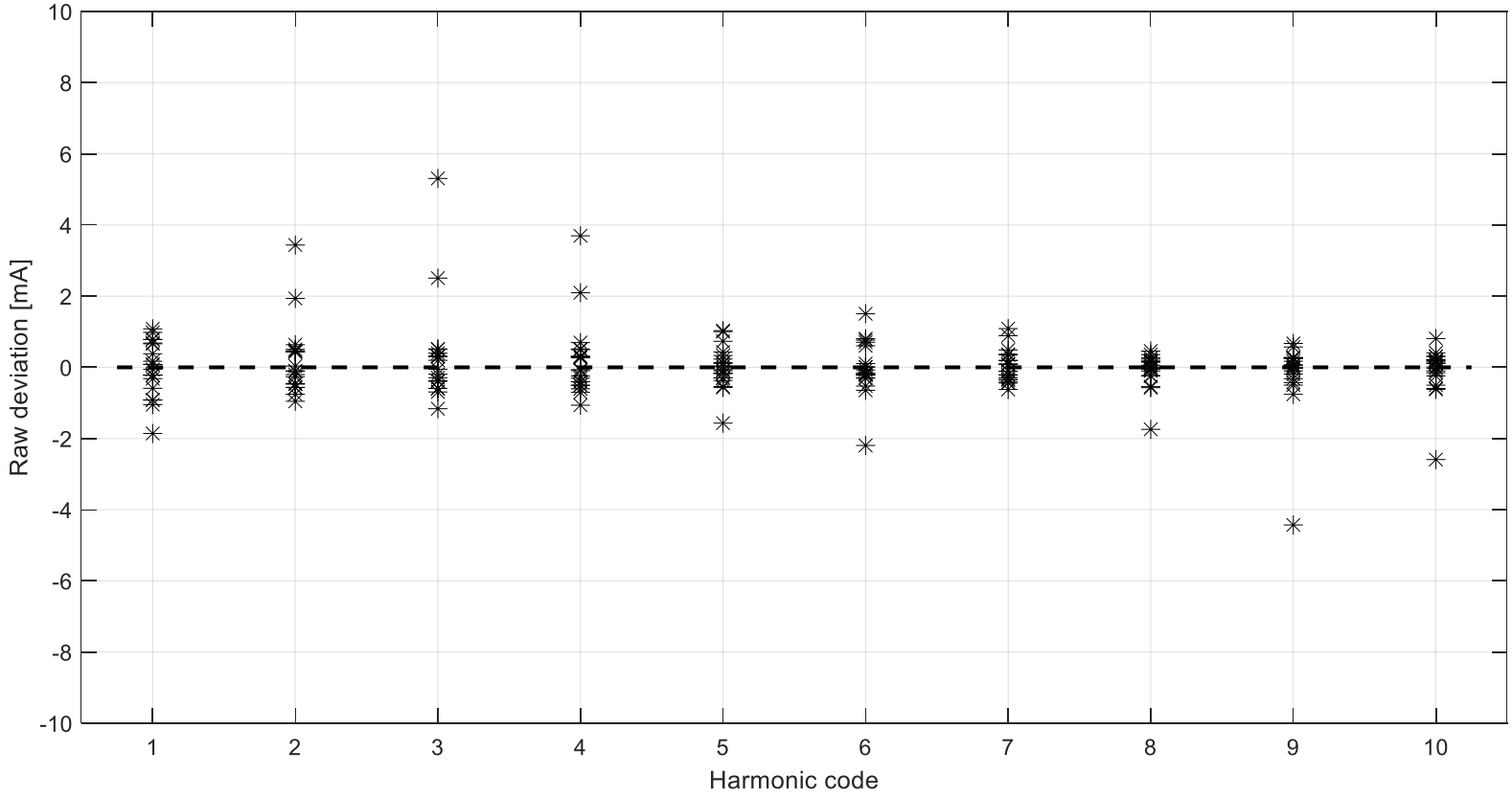
Harmonic code to frequency conversion

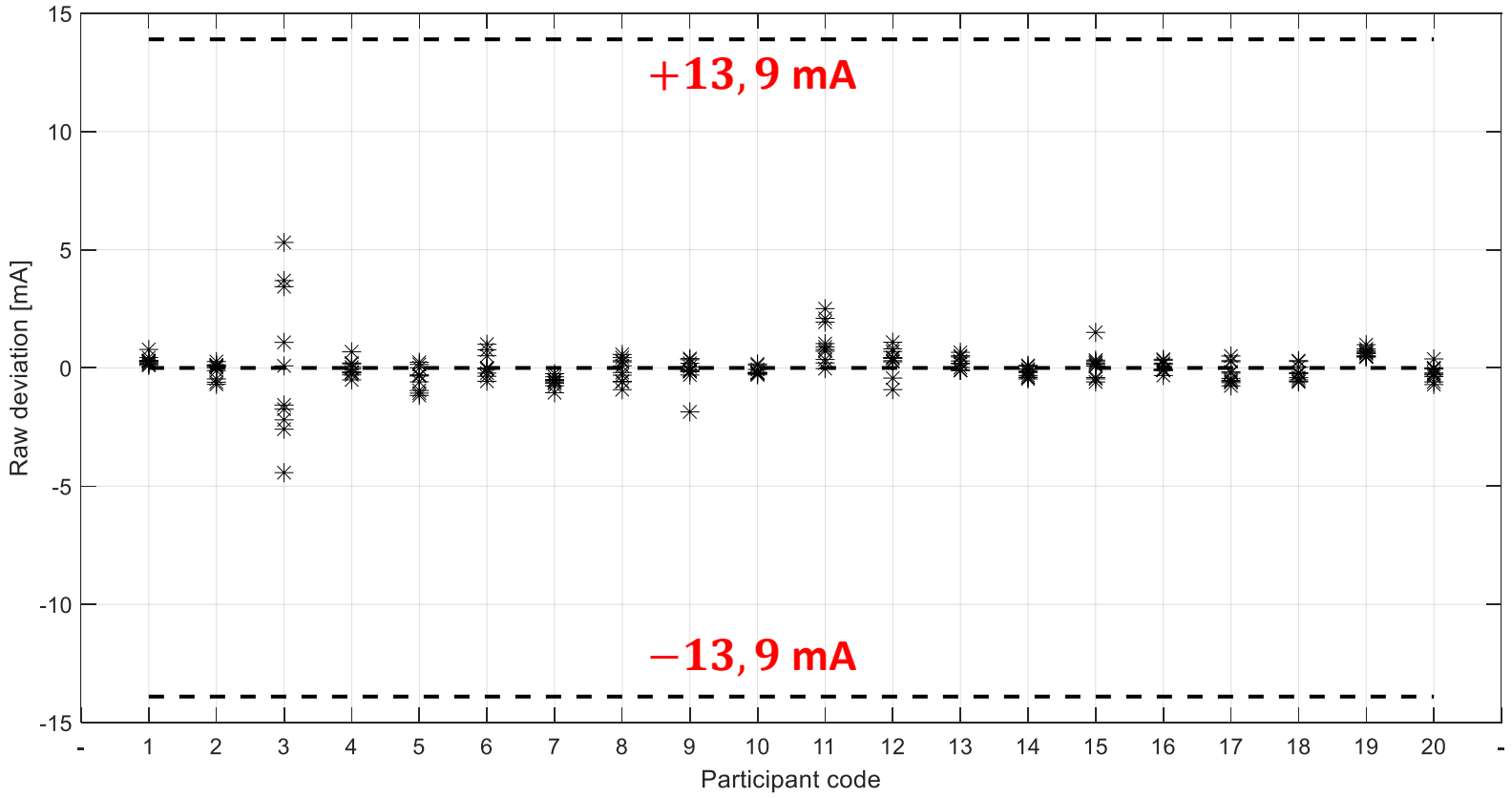
Harmonic code	Frequency Hz
1	150
2	350
3	550
4	750
5	950
6	1150
7	1350
8	1550
9	1750
10	1950

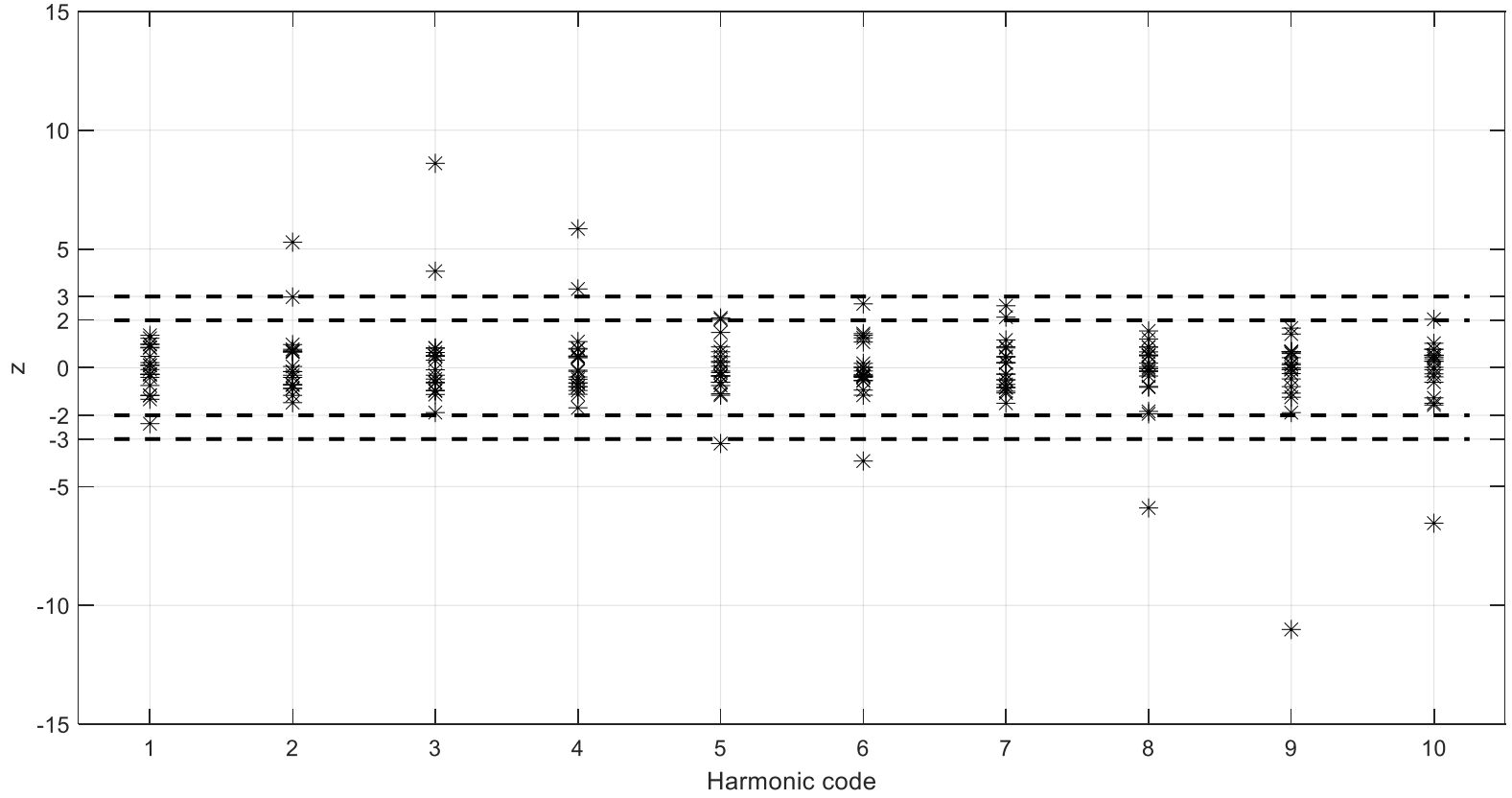
Interpretation of results

- Results are reported as:
  - Raw deviation between x_i, the measurement result of the i-th laboratory at a given frequency, and x^* reference value of the electric field at the same frequency
  - Performance statistic z_i of the i-th laboratory at a given frequency

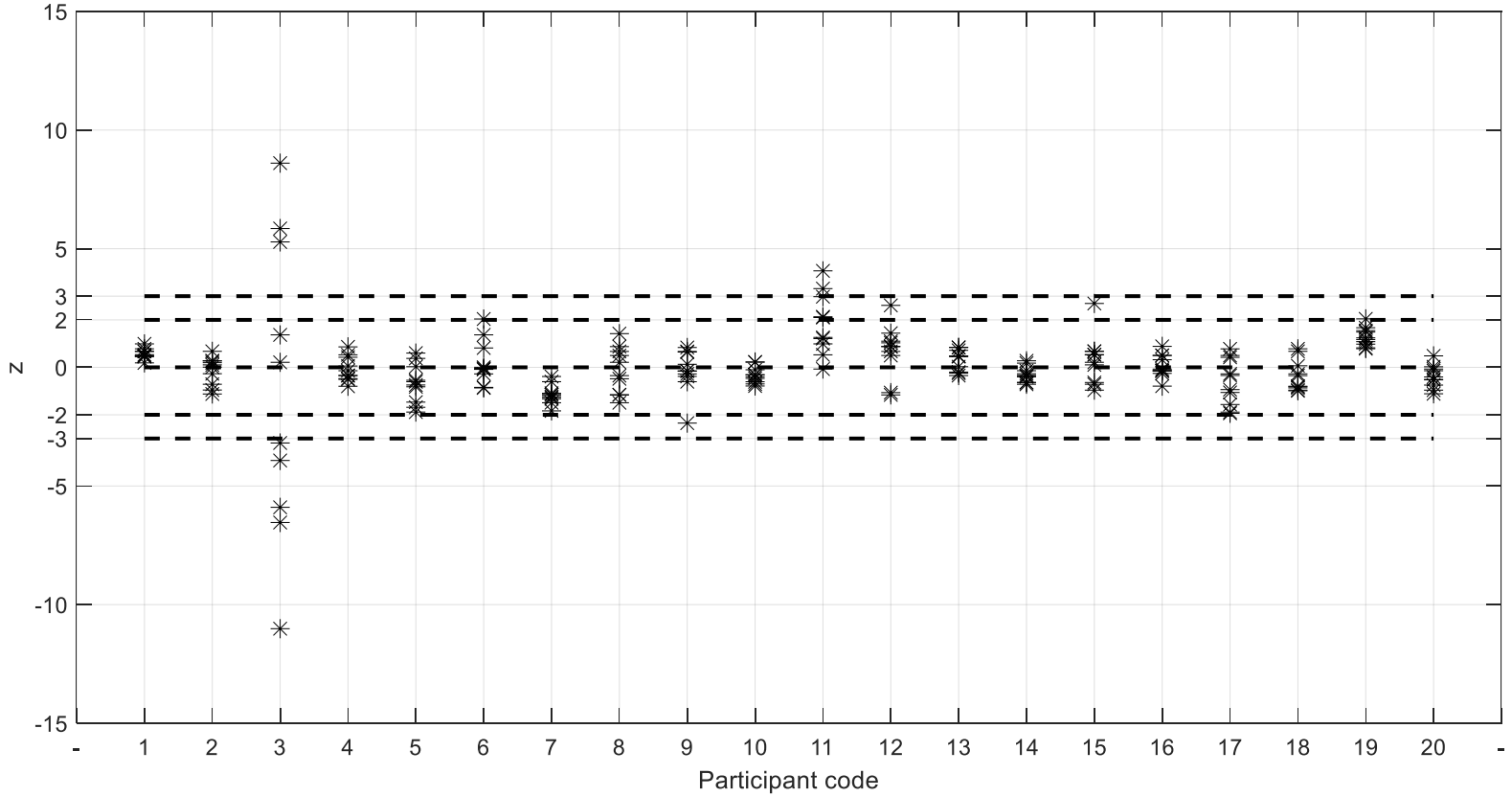
Harmonic current emission 50 Hz – 2000 Hz




+13, 9 mA
−13, 9 mA
Raw deviation [mA]
Participant code
15
10
5
0
-5
-10
-15
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20


15
10
5
3
2
0
-2
-3
-5
-10
-15
z
1
2
3
4
5
6
7
8
9
10
Harmonic code

Harmonic current emission 50 Hz – 2000 Hz



Harmonic	Frequency	*x**	*s**
#	Hz	mA	mA
3	150	184,92	0,79
7	350	144,56	0,65
11	550	89,69	0,62
15	750	44,30	0,63
19	950	29,57	0,49
23	1150	28,19	0,56
27	1350	19,91	0,42
31	1550	12,74	0,30
35	1750	12,43	0,40
39	1950	10,59	0,40

Remarks

- The measurement results provided by the 20 participants at the 10 measurement frequencies selected by the Coordinator are nearly within –5 mA to +5 mA from the reference values. Most of measurement results are within –1 mA to +1 mA from the reference values.
- 200 measurement results were provided by the participants and 18 signals (8 warning and 10 action) were issued
- The robust standard deviation *s** is comprised between 0,3 mA and 0.8 mA
- The measurement results provided by ALL laboratories are well within the expected reproducibility of ±13,9 mA
- Warning and action signals are an indication of relative performance of a participant with respect to the average of all participants
- **Since all measurement results are within the expected reproducibility warning and action signals should NOT be interpreted as a noncompliance with EN 61000-3-2 standard**