Proficiency Testing of Radiated Emission Measurements PTC(RE-30-6000-VII)

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Rev. 0

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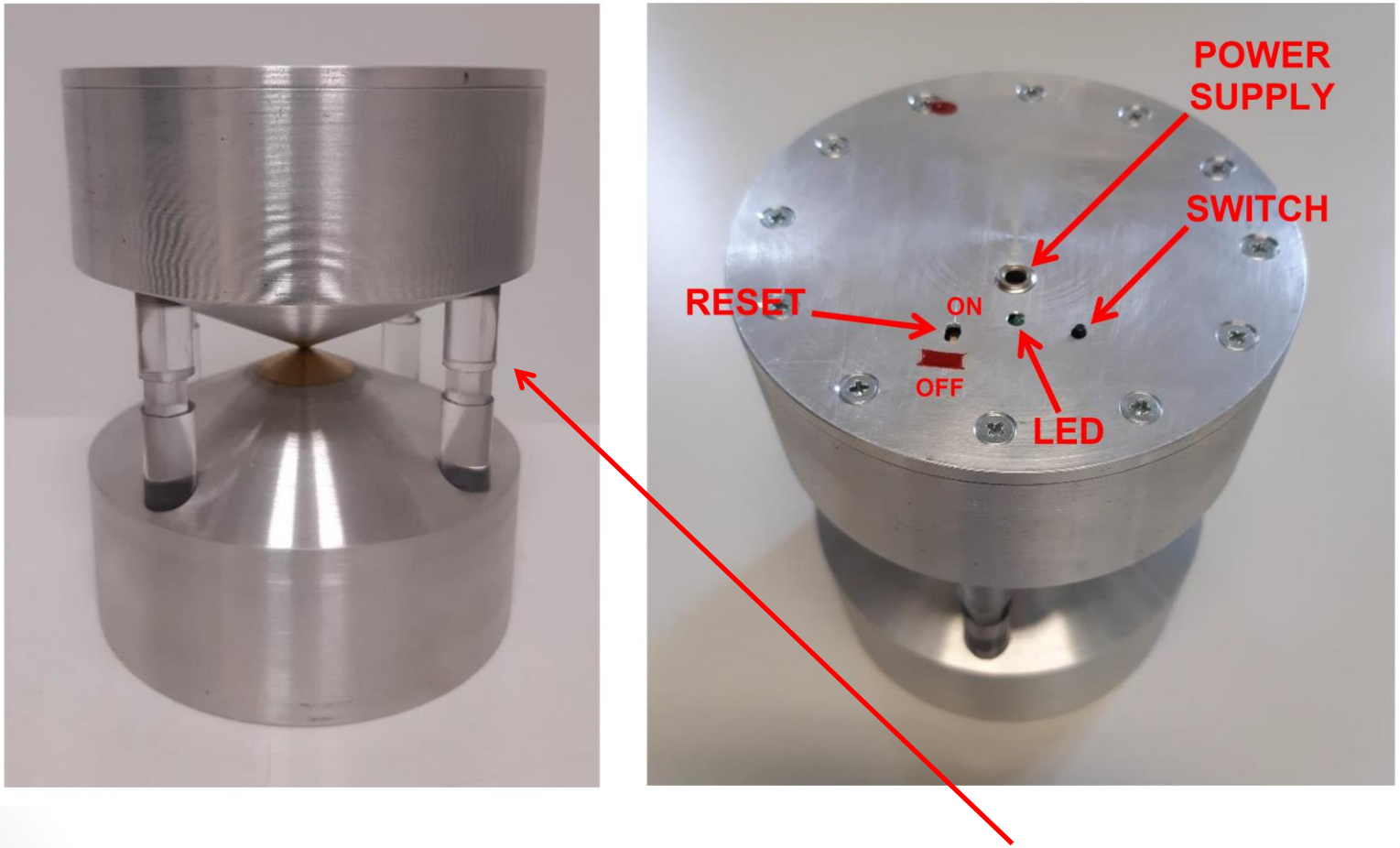
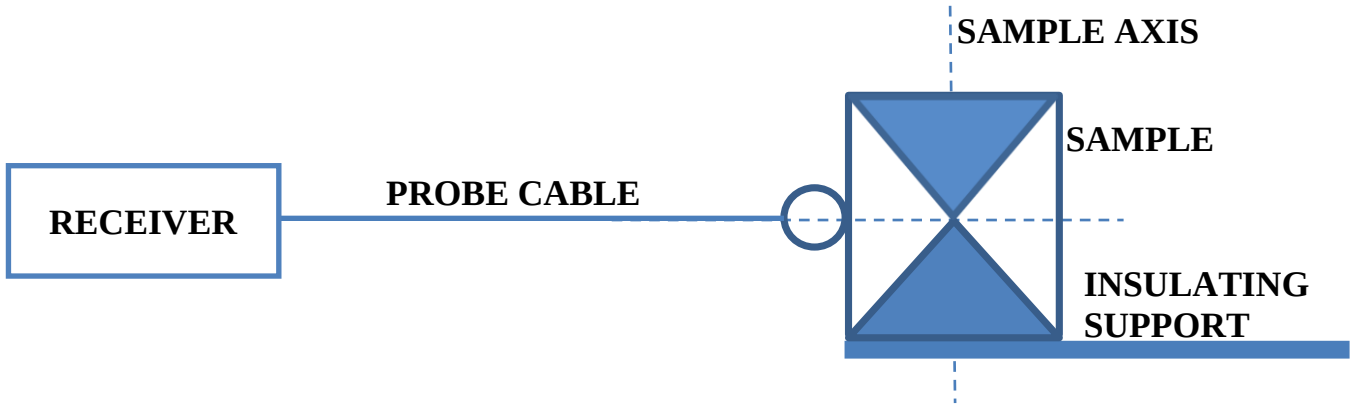
Travelling Sample for the 30 MHz to 6 GHz frequency range (Radiated Emission)



TRAVELLING SAMPLE WITH 4 COLUMN STANDS

NON-ISOTROPIC PATTERN OVER H-PLANE AT HIGH-FREQUENCY

Preliminary verification

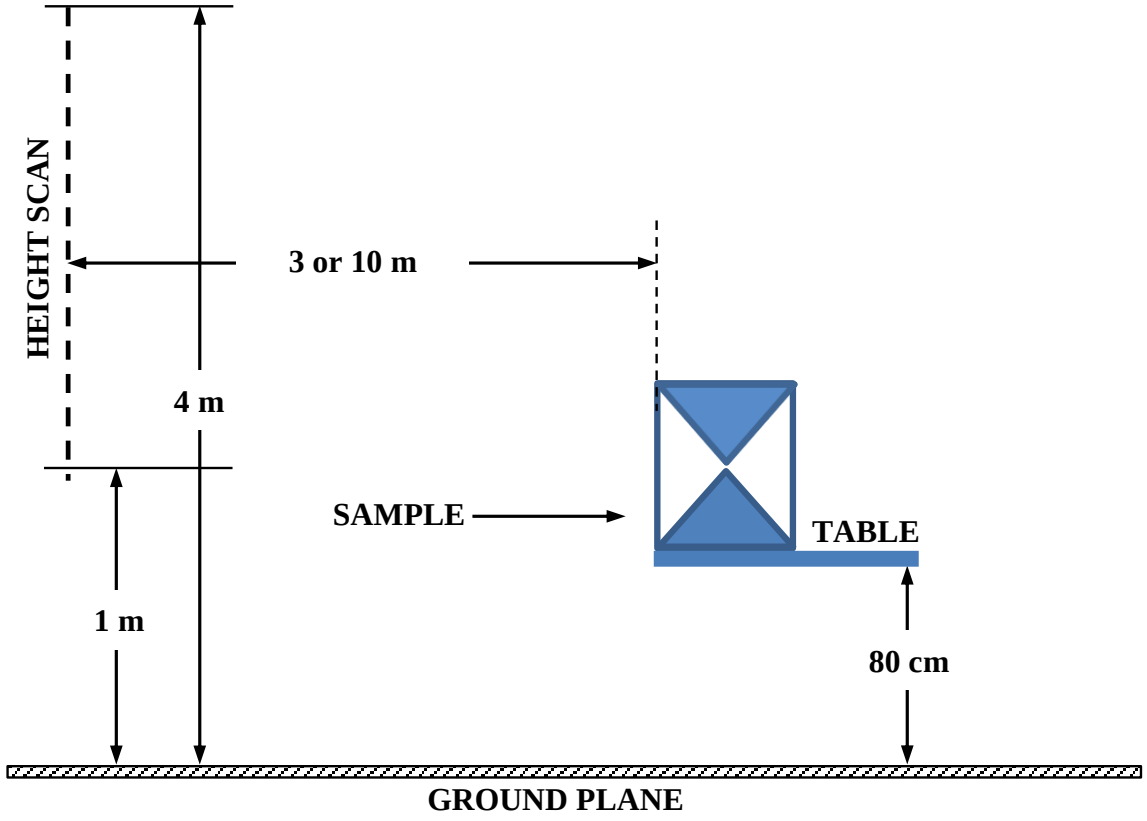


Harmonic #	Frequency MHz	P_{ref} dBm	P_m dBm	Δ dB
4	200	–41	Measured value	Deviation

Verification of the power that the probe delivers to the receiver

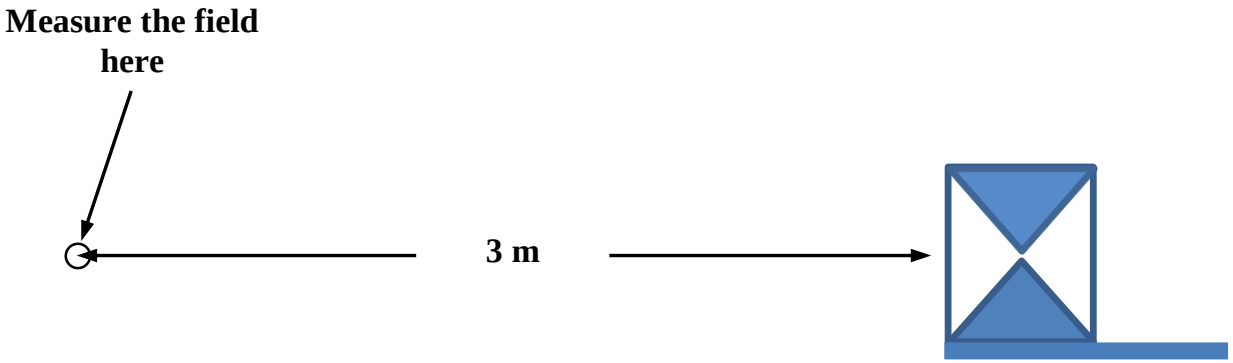
$|\Delta| < 3$ dB

Measurement setup



30 to 1000 MHz frequency rage, semi-anechoic room (3 or 10 m)

Measurement setup



30 to 1000 MHz and 1000 to 6000 MHz frequency ranges in a fully-anechoic room

General information

- Number of participants: 16
- Start date: June 2022
- Stop date: March 2023
- Scheme of the proficiency test PTC(RE-30-6000-VII): https://www.dinfo.unifi.it/vp-436-schemes-of-the-proficiency-tests.html
- Issues faced:
  - At the end of January 2023, after measurement in a laboratory and before shipping, the travelling sample felt to ground, and it did not pass the preliminary verification. The pin connecting the hot terminal of the internal comb generator to the lower cone was indeed broken. Shipment to and from the University of Florence, repair, and rescheduling caused 3 to 4 weeks delay.
  - Delay in issuing the report from some laboratories.

Measurement procedure: preliminary verification

- Radiated electromagnetic field measurement must be preceded by a preliminary verification of the correct operation of the Sample by using the magnetic field probe provided by the Coordinator, a short section of coaxial cable (length less than 1 m, not provided by the coordinator) and a receiver (spectrum analyzer or EMI receiver). The verification shall be as follows:
  - Connect the probe to the input of the receiver through the short section of coaxial cable.
  - Put the Sample on the same table used for radiated emission testing of table-top equipment.
  - Turn on the Sample. The Sample shall be fed by its internal battery (the Sample shall not be connected with the power supply).
  - Place the probe in the position sketched in slide 3. In particular the probe shall be positioned so that its cable is perpendicular to the axis of the Sample and at half height of the Sample. The plane of the loop shall be the one containing the probe cable and the axis of the Sample. The probe shall touch the plastic wall of the Sample.
  - Use your hand to support the probe. No special care is required.
  - Measure the power P_m that the probe delivers to the input of the receiver at the frequency of the 4th harmonic (about 200 MHz). Register the values of P_m (in dBm, rounded to the integer) in the table in slide 3. Calculate and annotate the deviation Δ (in dB, rounded to the integer).
  - Verify that:
    - The measured power decreases by at least 20 dB rotating the probe by 90°;
    - $-3\ dB < \Delta < 3\ dB$

Measurement procedure: 30 – 1000 MHz, semi-anechoic room

- The scope of the measurement is to obtain the best estimate and measurement uncertainty of the maximum electric field strength, in dB(µV/m), emitted by the Sample in vertical polarization at the specified horizontal distance from the Sample (3 or 10 m) at a height between 1 and 4 m above the reflecting ground plane, see slide 4. The reference of the Sample for distance measurement is the plastic wall of the Sample. The use of the same measuring instrumentation as that used for radiated emission tests in the corresponding frequency range is recommended. Measurement frequencies are selected by the Coordinator.
- Measurement procedure is according to §7.3 of EN 55016-2-3:2017/A1:2019.

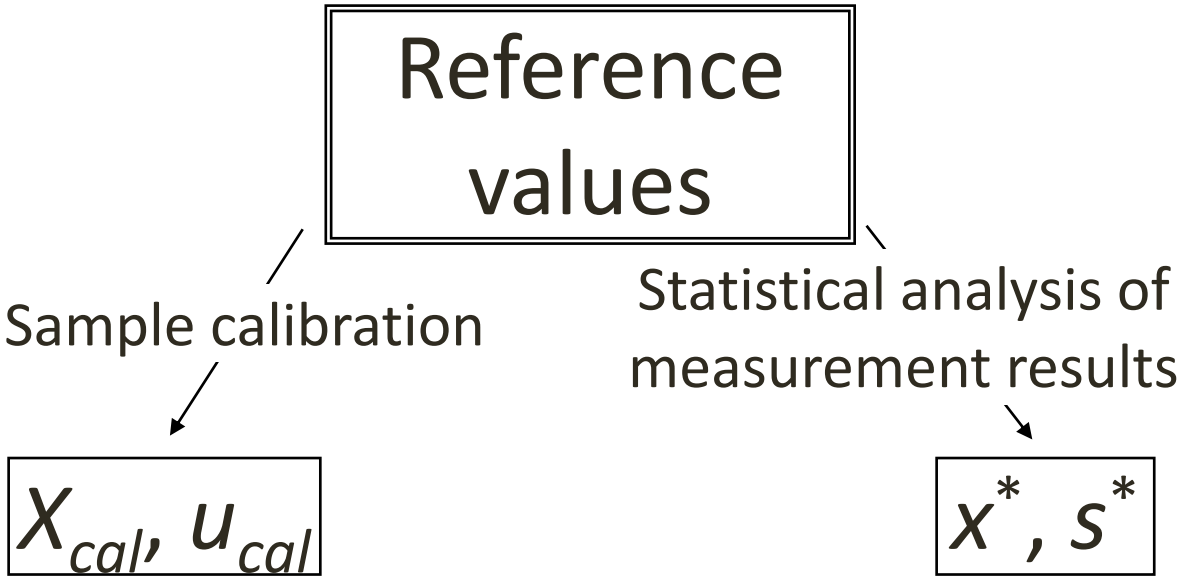
Measurement procedure: 30 – 1000 MHz and 1000-6000 MHz, fully-anechoic room

- The scope of the measurement is to obtain the best estimate and measurement uncertainty of the electric field strength, in dB(µV/m), emitted by the Sample at 3 m distance from the Sample in the boresight direction. The reference of the Sample for distance measurements is the plastic wall of the Sample facing the receiving antenna. The use of the same measuring instrumentation as that used for radiated emission tests in the corresponding frequency range is recommended. Measurement frequencies are selected by the Coordinator.
- Measurement procedure is according to §7.4 of EN 55016-2-3:2017/A1:2019 and §7.6 of EN 55016-2-3:2017/A1:2019.

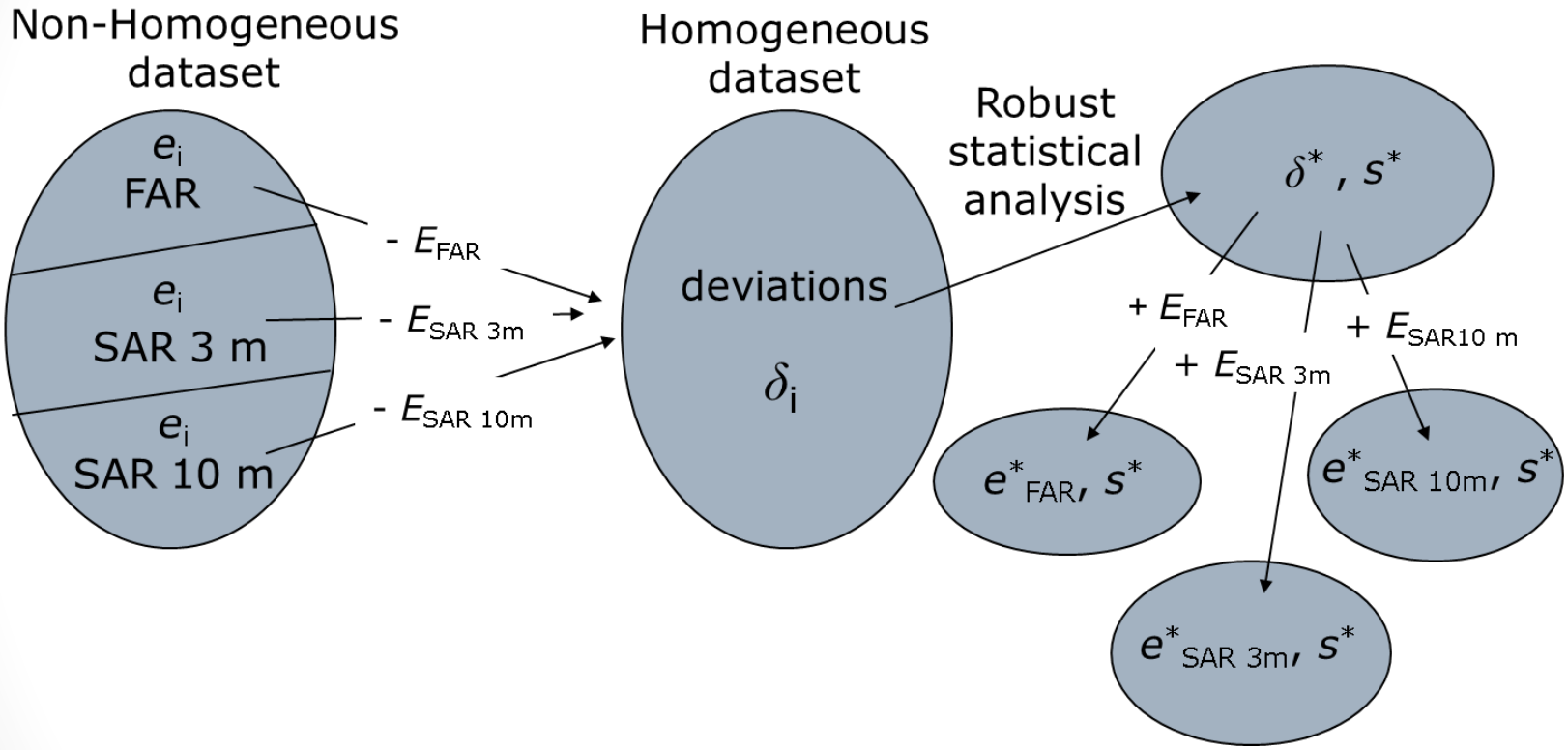
Other instructions

- It is up to the Laboratory to charge the battery before preliminary verification and measurement. Handle the Sample with care.
- 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(µV/m), 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).
- The Laboratory may assign a different value of U_{lab} to each measured frequency.
- The measured disturbance electric field strength *x*, in dB(µV/m), shall be rounded up to 1 decimal figure (e.g. 68,5 dB(µV/m)). Measurement uncertainty U_{lab}, in dB, shall be rounded up to 2 significant figures (e.g. 3,2 dB).

Reference values



Inhomogeneous data



E_{FAR}, $E_{SAR\ 3m}$, $E_{SAR\ 10m}$ = predicted 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 13528:2015

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}

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

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

Performance statistic *z'* (Coordinator)

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

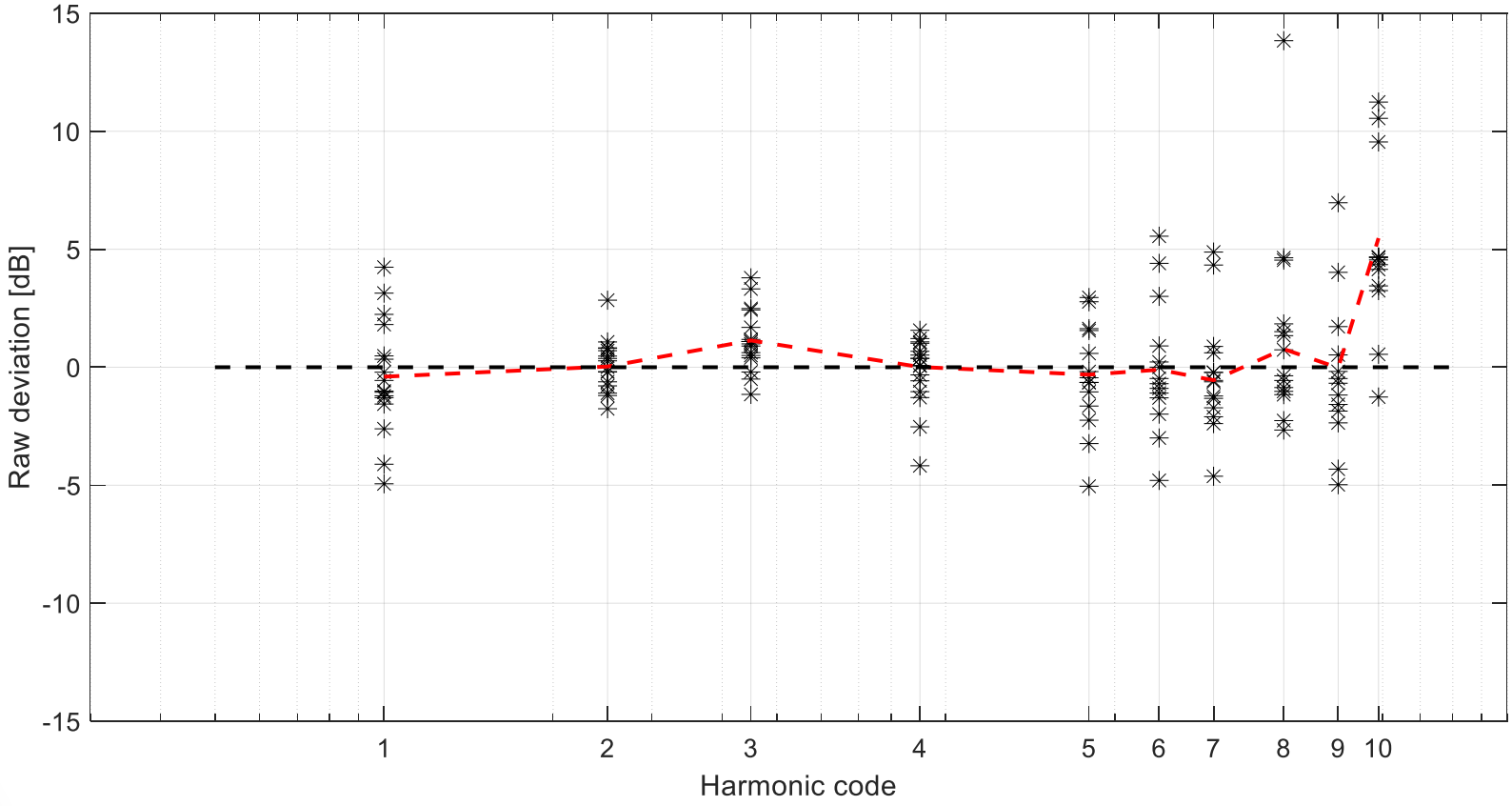
$$z' = \frac{X_{cal} - x^*}{\sqrt{u_{cal}^2 + \left(\frac{1{,}25 \cdot s^*}{\sqrt{p}}\right)^2}}$$

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

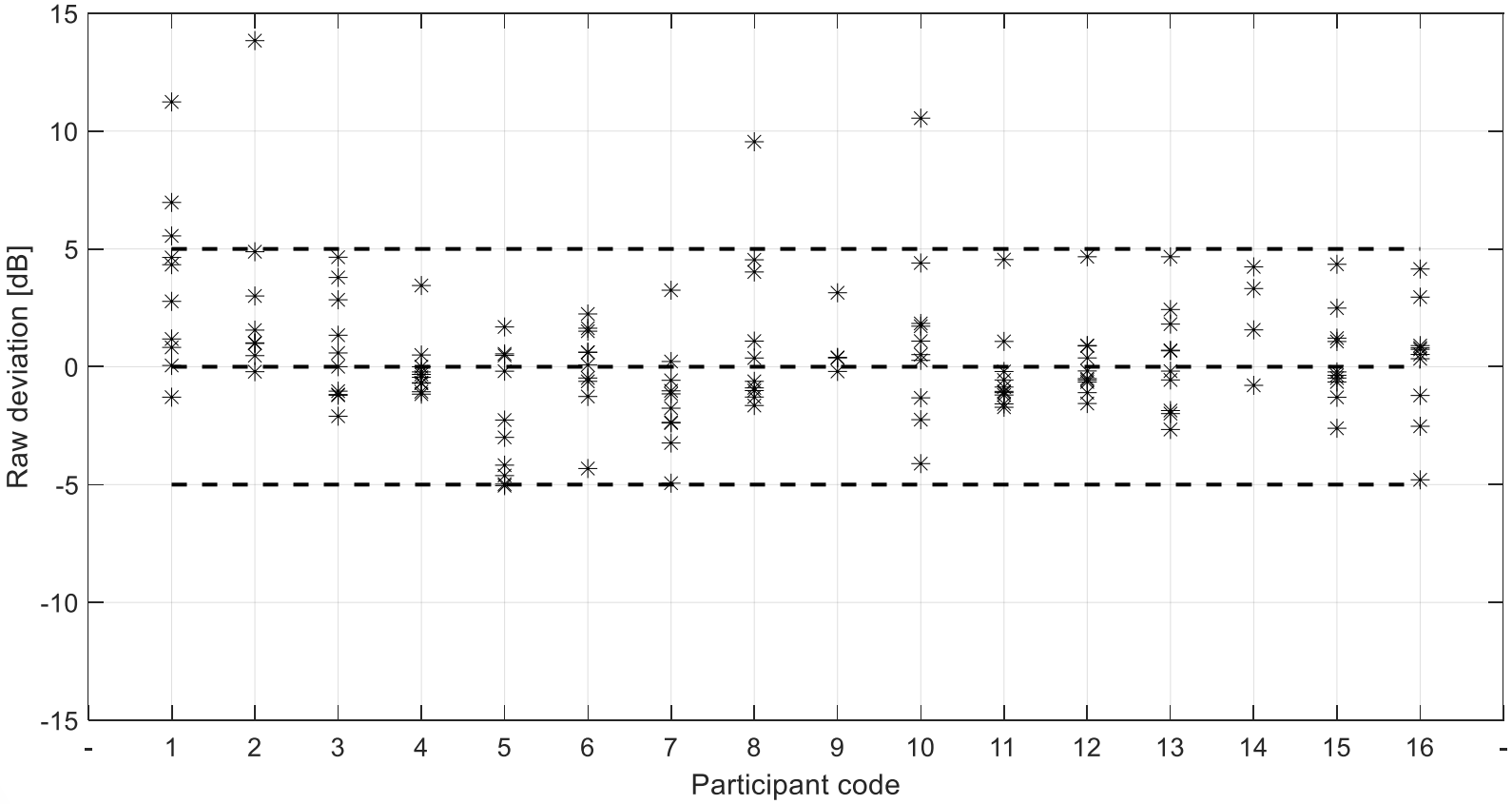
Results

Harmonic code to frequency conversion

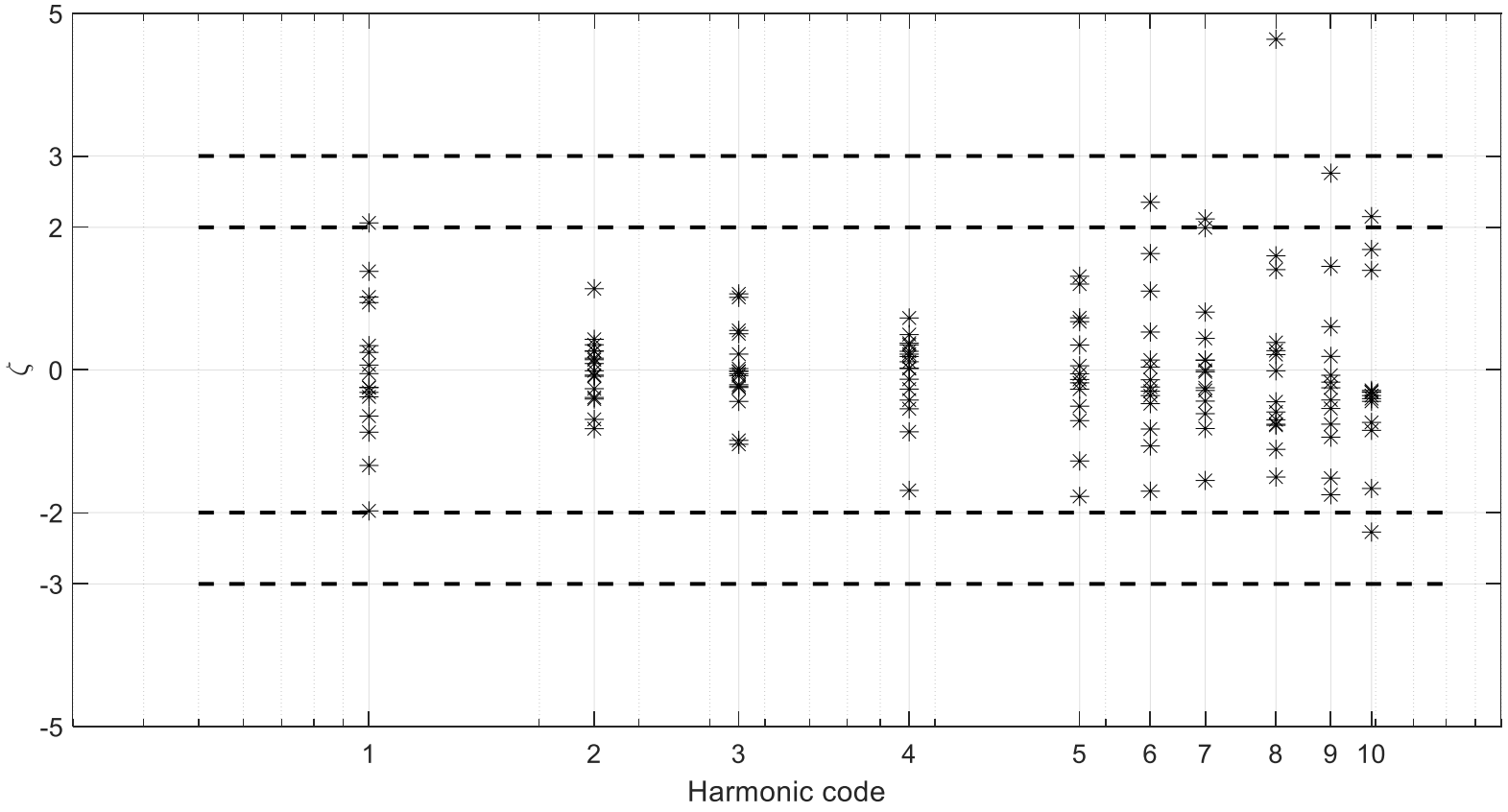
Band	Harmonic code	Frequency MHz
C	1	100
C	2	250
D	3	450
D	4	900
E	5	1800
E	6	2400
E	7	3000
E	8	4000
E	9	5000
E	10	5900



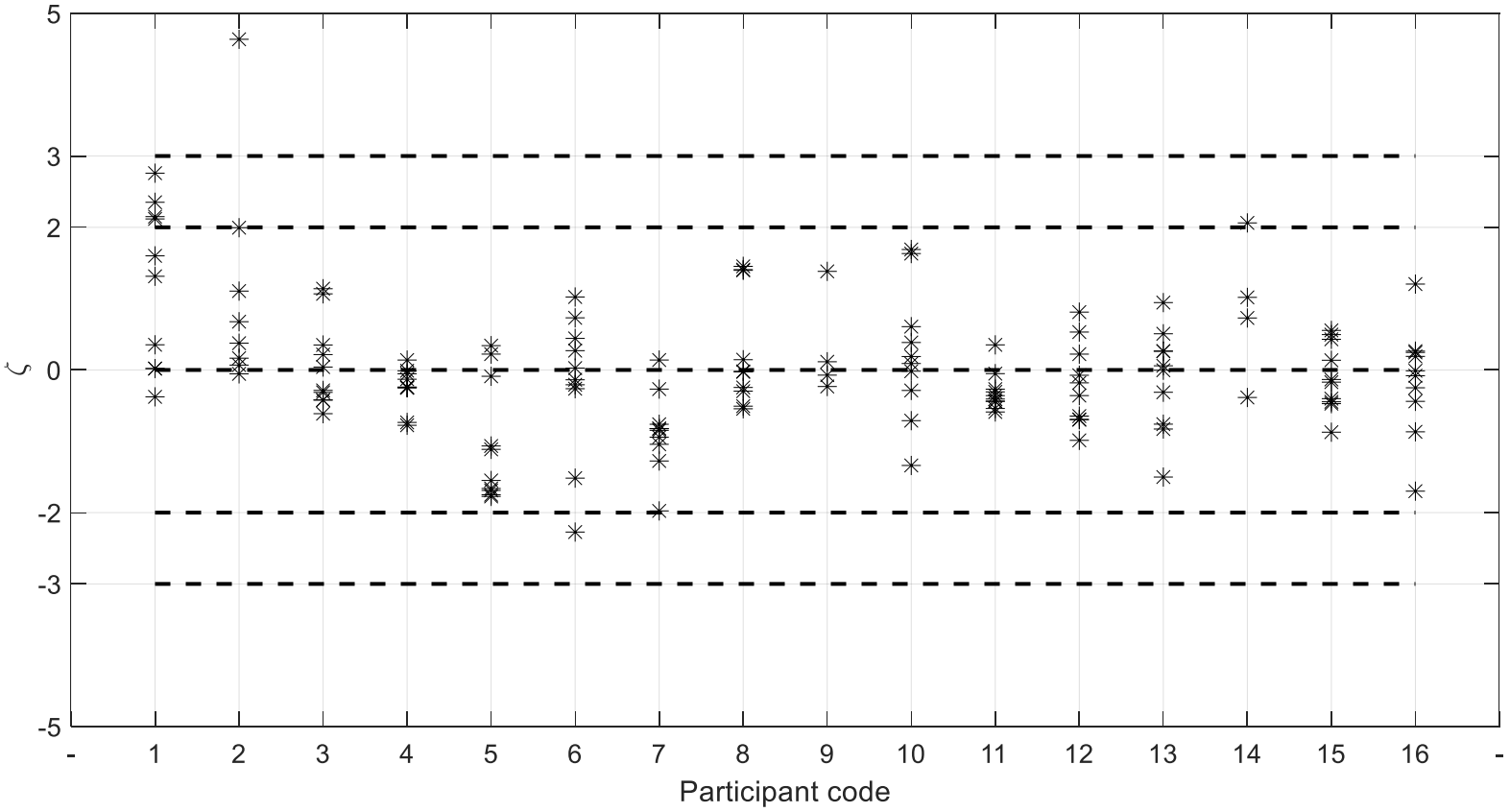
- Deviations from X_{cal} (two out-of-scale values at harmonic codes 9 and 10)
- Black dashed line represents deviation from calibrated reference value X_{cal}
- Red dashed line represents deviation of x^* from X_{cal}



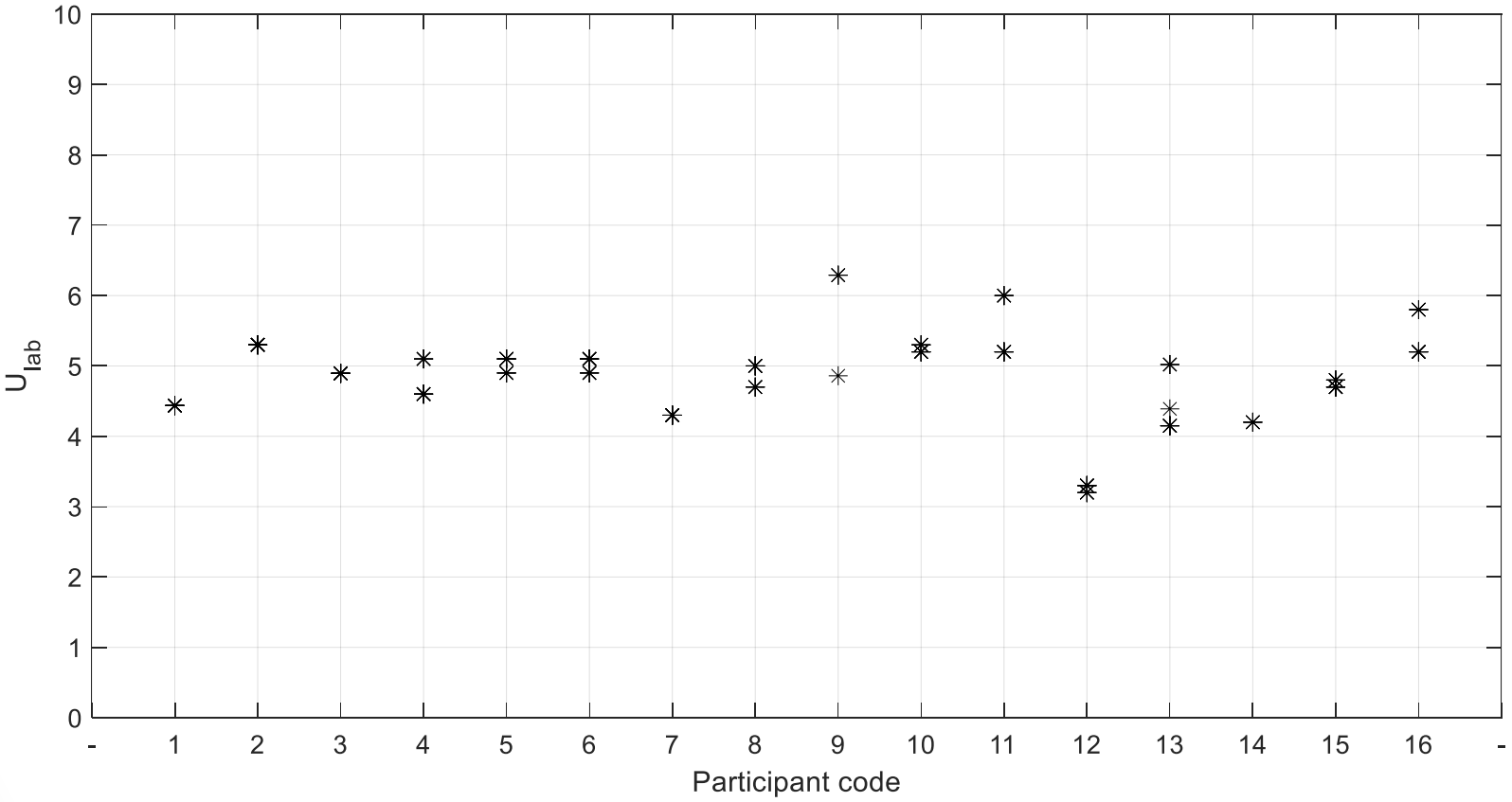
- Deviations from X_{cal} (two out-of-scale values for lab 2)



- Performance statistic ζ (see page 14, two out-of-scale values at harmonic codes 9 and 10)



- Performance statistic ζ (see page 14, two out-of-scale values for lab 2)


10
9
8
7
6
5
4
3
2
1
0
U_{lab}
-
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
-
Participant code

Ref. vales – comparison

f MHz	δ_{cal} dB	U dB	δ^* dB	s^* dB	z' 1
100	0	3	-0.4	2.6	0.2
250	0	3	0.0	1.0	0.0
450	0	3	1.1	1.4	-0.7
900	0	3	0.0	1.2	0.0
1800	0	3	-0.3	2.3	0.2
2400	0	3	-0.1	2.8	0.1
3000	0	3	-0.6	1.9	0.3
4000	0	3	0.8	2.9	-0.4
5000	0	3	0.0	3.7	0.0
5900	0	3	5.5	4.5	-2.6

Remarks

- The reference values obtained from calibration of the Sample and from robust statistical analysis are compatible each other at almost all frequencies (maximum deviation 1,1 dB, performance statistic *z'* less than 0,7 over nine frequencies).
- At 5.9 GHz a warning signal is issued to the coordinator. The reason for the relatively large discrepancy at such frequency will be investigated.
- The raw measurement results provided by the twelve participants at the ten measurement frequencies selected by the Coordinator are within -5 dB to +14 dB from the calibrated reference.
- 6 warning and 3 action signals are detected over 148 measurement results.
- 12 laboratories do not exhibit any anomaly.
- Standard measurement uncertainty declared by the laboratories comprised between nearly 1,5 dB and 3,2 dB, robust standard deviation s^* between 1,0 dB and 4,5 dB.
- Relatively larger spread s^* at increasing frequency (effect of non-isotropic pattern over H-plane)