State Enterprise “All-Ukrainian State Scientific and Production Center of Standardization, Metrology, Certification and Protection of Consumer” (SE “Ukrmeterteststandard”)

Approved by the chairman of TC 1.3 COOMET
Chairman of TC 1.3 COOMET
_______________ T. Kolomiets

Final Report on COOMET Supplementary Comparison of Inductance at 10 mH and 100 mH at 1 kHz (COOMET.EM-S14)

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Coordinator of comparison:
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Members of comparisons:
SE “Ukrmetrteststandard”, Ukraine
GUM, Poland
KazInMetr, Kazakhstan
BelGIM, Belarus

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1 Introduction

The COOMET Supplementary Comparison (SC) of Inductance at 10 mH and 100 mH at 1 kHz (comparison identifier – COOMET.EM-S14) was conducted in the framework of COOMET 584/UA/12 project from 2013 to 2014.

This project for comparing of national standards of electrical inductance was conducted between counties which are member laboratories of regional metrology organizations COOMET and EURAMET. In this comparison take part three national metrology institutes (NMI): SE "Ukrmetrteststandard" (UMTS, Ukraine); GUM (Poland); KazInMetr (Kazakhstan), BelGIM (Belarus).

The State Enterprise "All-Ukrainian State Scientific and Production Center of Standardization, Metrology, Certification and Protection of Consumer" (SE "Ukrmetr-teststandard"), Ukraine was selected as the pilot laboratory. Sergii Shevkun and Oleh Velychko were the comparison coordinators. The pilot laboratory is responsible for providing the travelling standard, coordinating the schedule, collecting and analyzing the comparison data, preparing the draft report, etc.

2 Participants

List of participating NMIs, countries of origin is show in Table 1.

Table 1 List of participating NMIs, countries of origin and regional organizations

NMI	Country	Regional organization
UMTS – State Enterprise "All-Ukrainian State Scientific and Production Center of Standardization, Metrology, Certification and Protection of Consumer" (SE "Ukrmeterteststandard") **– pilot**	Ukraine	COOMET
GUM – Central Office of Measures	Poland	EURAMET
KazInMetr – Kazakhstan Institute of Metrology	Kazakhstan	COOMET
BelGIM – Belarussian State Institute of Metrology	Belarus	COOMET

List of participant contact information is show in Table 2.

Table 2 List of participant contact information

NMI address	Contact name, e-mail, tel. and fax number
State Enterprise "All-Ukrainian State Scientific and Production Center of Standardization, Metrology, Certification and Protection of Consumer" (SE "Ukrmeterteststandard"–**UMTS**) – **pilot** 4, Metrologichna Str. Kyiv-143, 03143, **Ukraine**	Sergii Shevkun Shevkun@ukrcsm.kiev.ua Tel./fax: +38 044 526 5568 Oleh Velychko Velychko@ukrcsm.kiev.ua Tel./fax: +38 044 526 0335

NMI address	Contact name, e-mail, tel. and fax number
Glowny Urzad Miar (**GUM**) ul. Elektoralna 2 00-139 Warszawa **Poland**	Jolanta Jursza j.jursza@gum.gov.pl Tel.: +48225819353
Kazakhstan Institute of Metrology (**KazInMetr**) 11, Orynbor St., Left bank Astana, 010000, **Kazakhstan**	Nagima Tuimekulova nagimakaz@mail.ru Tel.: +7(7172)793273
Republican Unitary Enterprise “Belarussian State Institute of Metrology” **(BelGIM)** Starovilensky tract, 93 Minsk, 220053, **Belarus**	Elena Kazakova kazakova@belgim.by Tel.: +375172331510

3 Travelling standard and measurement instructions

3.1 Description of travelling standard

The selected travelling standards are P5109 10 mH (S/N 424) and P5113 100 mH (S/N 1003) (Figure 1).

Fugure 1. Travelling standards

Thermostatically measures of inductance type P5109 (10 mH, № 424) and P5113 (100 mH, № 1003) allow the monitoring of critical parameters: the temperature difference of values within each standard thermostats and internal supply voltage. Thermostatically measures of inductance type P5109 (10 mH, № 424) and P5113 (100 mH, № 1003) contain inbuilt precision thermostat with dual temperature sensors, which provides increased reliability and accuracy of the measurement results.

Main characteristics of measures of inductance:

Instability: 10 ppm/year;

the temperature inside the thermostat: from 29.5 °C to 30.5 °C;

temperature instability: 0.05 °C/hour;

time to thermostat operating mode: not more than 3 hours;

weight measures in thermostat: 9 kg;

supply voltage thermostat: 15 V DC;

power consumption: no more than 3.5 W;

temperature coefficient: 37 ppm/°C;

linear dimensions of each enclosure measures (mm): height – 275, length – 380; width – 360.

Transportation of standards of inductance is simplified, since for high stability is not necessary to continuously monitor the temperature of the thermostat. Measures are in a sealed oven.

The description and operating manual for the standard of inductance are attached. Participants of comparisons have to read the documentation before the measurements.

3.2 Handling of travelling standard

Standards of inductance will be transported in the transport box which is designed for safe transportation. Upon arrival the participants must check the transport box to make sure that all the parts are present according to the list. After the measurement standards of inductance will be neatly stacked in a transport box in which they arrived. Linear dimensions of transport box are: 400x600x400 mm. Weight of transport box (together with the content) is about 20 kg. If the damage of transport box is found standards of inductance must be packed in new transport box which will provide the necessary protection during transporting.

Casing of measures of inductance must be carefully removed from the transport box. If noticed any malfunction of inductance standards, the participants should immediately notify the pilot laboratory by fax or email. If standards of inductance are needed to be repaired the participant must send standards of inductance to the pilot laboratory.

3.3 Measurement instructions

After power up of traveling standard in participating NMIs it stabilized for three days.

Measurements were performed under the following conditions:

temperature: 23 °C ± 1 °C;

relative humidity: from 30 % to 70 %;

measurement frequency: 1 kHz (depending on laboratory’s capability);

The full power (active and reactive) on the measurement object should not exceed 10 mW.

To connect travelling standard participants of comparisons can use any adapters but participants should take into account all relevant adjustments in order to determine the inductance value directly from the input jack measures of inductance.

The temperature coefficient does not exceed 37 ppm/°C, and that's why doing not be compensated for temperature changes in the laboratory. If the air temperature of measurements in the laboratory is significantly different from 23 °C, the influence of the ambient temperature can be accounted for in the uncertainty budget.

The data to be recorded at each measurement:

date of measurement;

frequency measuring signal;

measured inductance;

air temperature and relative humidity in the immediate vicinity of the casing and measures the measuring apparatus;

measures body temperature and the temperature difference inside the thermostat.

4 Uncertainty of measurement

The uncertainty was calculated following the JCGM 100:2008 Evaluation of measurement data. –Guide to the expression of uncertainty in measurement (GUM) [1]: standard uncertainties, degrees of freedom, correlations, scheme for the uncertainty evaluation.

All contributions to the uncertainty of measurement were listed separately in the report and identified as either Type A or Type B uncertainties. The overall uncertainty, as calculated from the individual uncertainties, was stated. Uncertainties were evaluated at the level of one standard uncertainty and the number of effective degrees of freedom is to be reported.

The main uncertainty components were expected:

experimental standard uncertainty of the mean of N independent measurements;

uncertainty in the primary standard or working standard against which the traveling standard is measured;

uncertainty due to leads correction.

Participants included additional sources of uncertainty also.

5 Traceability to the SI

The traceability to the SI of each standard participating in the comparison was provided to pilot NMI. The participating NMIs made measurements of these travelling standards in terms of either their own calculable capacitor or a quantum Hall reference standard, or have traceability to other laboratories. This meant that there were a number of independent measurements of these inductors which enabled the representation of the henry in those countries were compared.

The traceability route for the primary standard of inductance for each NMI is given in Table 3. Traceability for UMTS and GUM are obtained by comparison of the 10 mH and 100 mH inductance standards with using the *RLC* comparators and capacitance standards at 1 kHz. Traceability for KazInMetr and BelGIM are obtained by comparison of the 10 mH and 100 mH inductance standards with using the *RLC* bridges and reference inductors with value traced to VNIIM at 1 kHz.

The measurements in GUM were referred to capacitance standards 253,33 nF and 25,33 nF. GUM capacitors 1000 pF, 0,334 nF, 3,54 nF were measured by AH2700A bridge, which was referred to 4x10 pF group standard, periodically calibrated in BIPM. Thermostated capacitors

250 nF and 25 nF were measured by *RLC* comparator. The measurements in UMTS were referred to 4x100 pF group capacitance standard, calibrated in NIST, and reference inductors of national primary standard of inductance.

Table 3 Traceability route for each participating NMI

NMI	Country	Traceability Route
GUM	Poland	BIPM
UMTS	Ukraine	NIST
KazInMetr	Kazakhstan	VNIIM
BelGIM	Belarus	VNIIM

6 Behaviour of the travelling standards

The UMTS as pilot laboratory has performed repeated measurements on the travelling standards P5109 10 mH (S/N 424) and P5113 100 mH (S/N 1003) during the course of this comparison. From these measurements, the behaviour of the travelling standard can be seen in Figures 1–4.

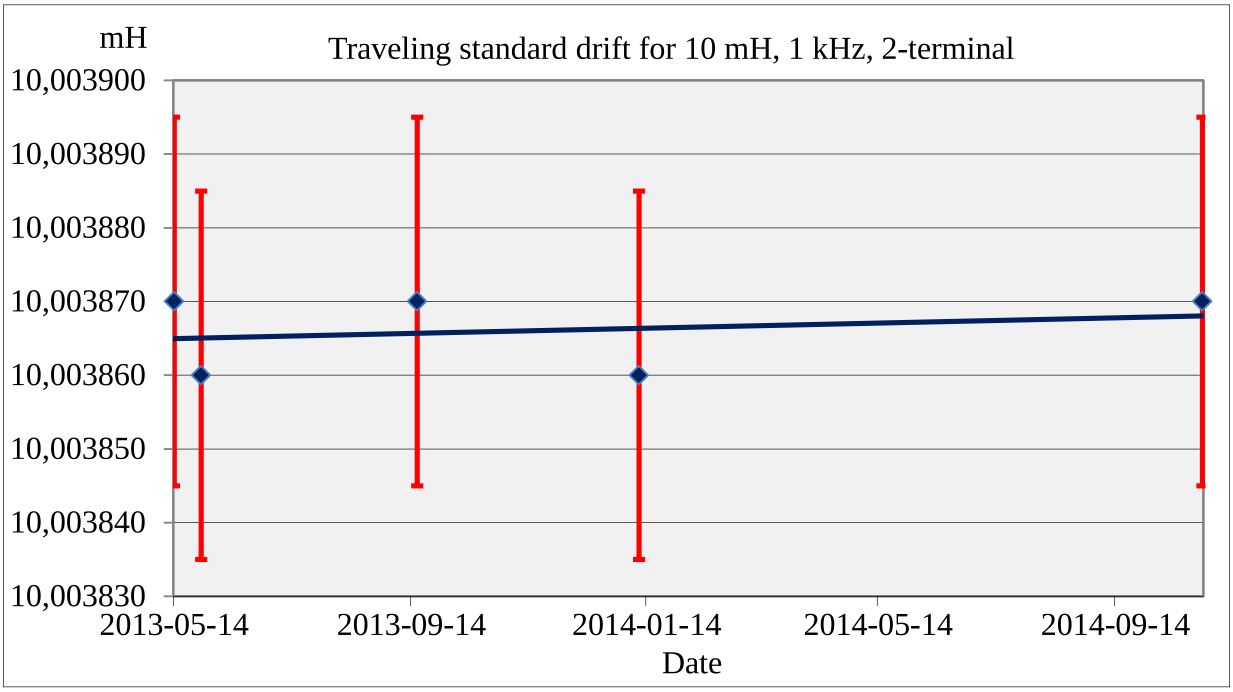

Figure 1 Behaviour of the travelling standard for 10 mH (2-terminal)

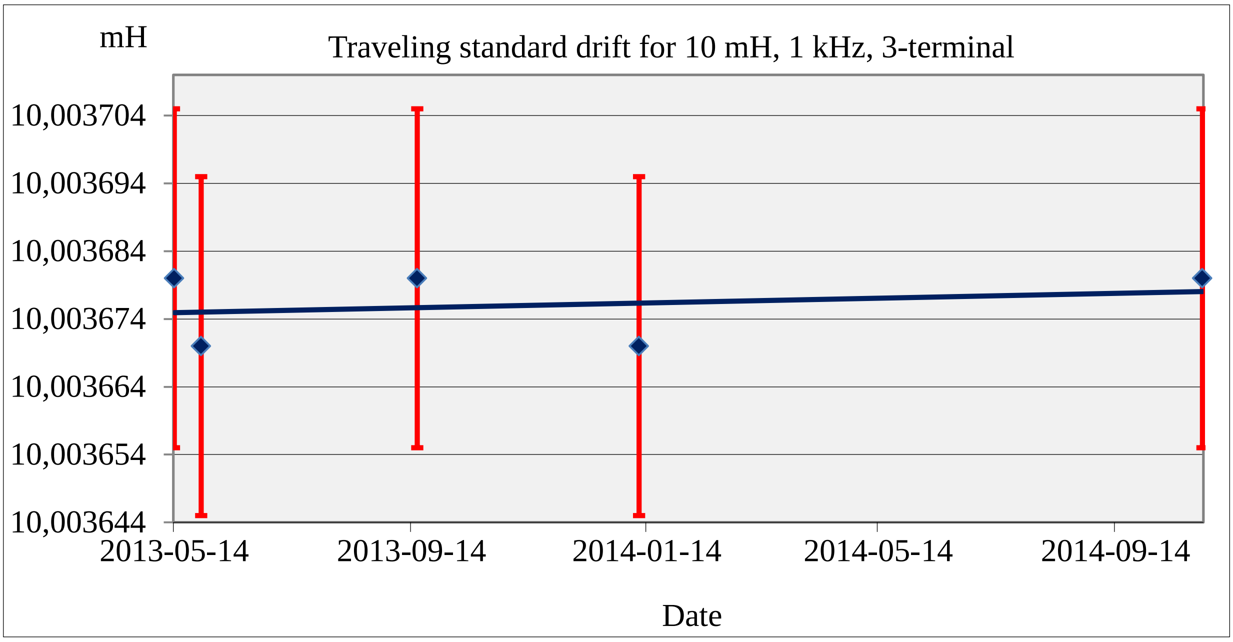

Figure 2 Behaviour of the travelling standard for 10 mH (3-terminal)

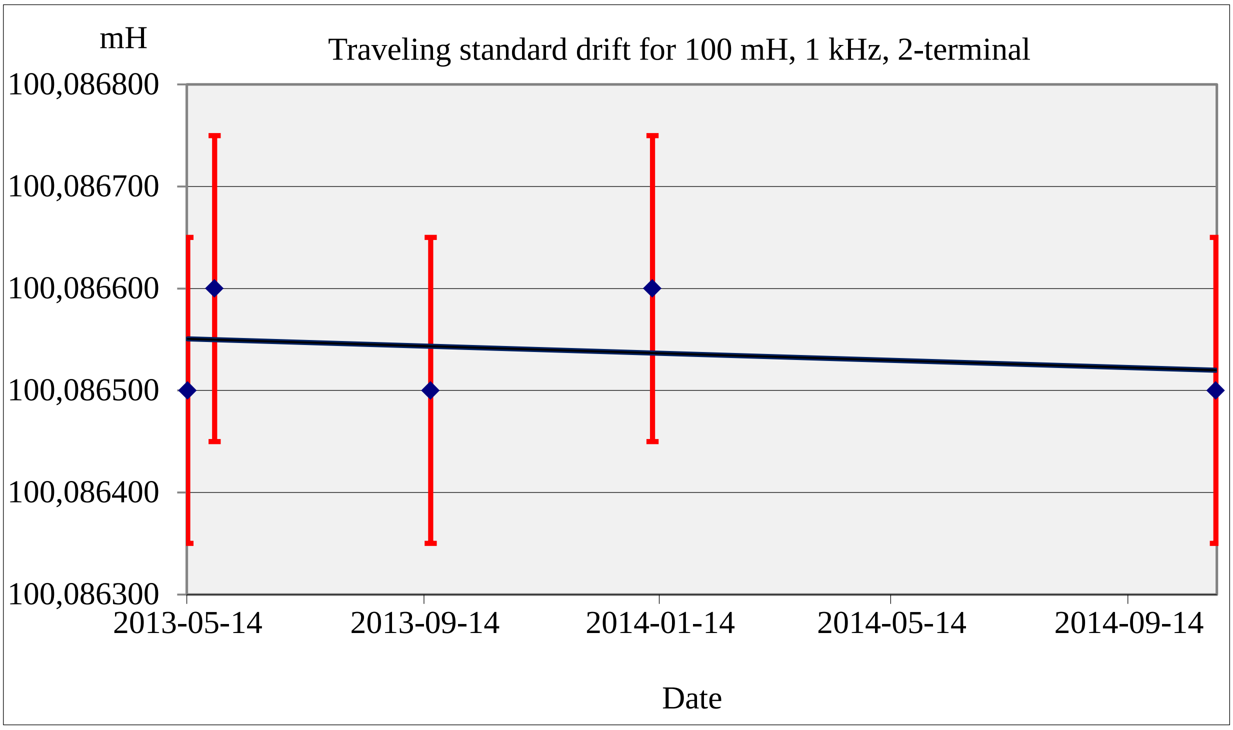

Figure 3 Behaviour of the travelling standard for 100 mH (2-terminal)

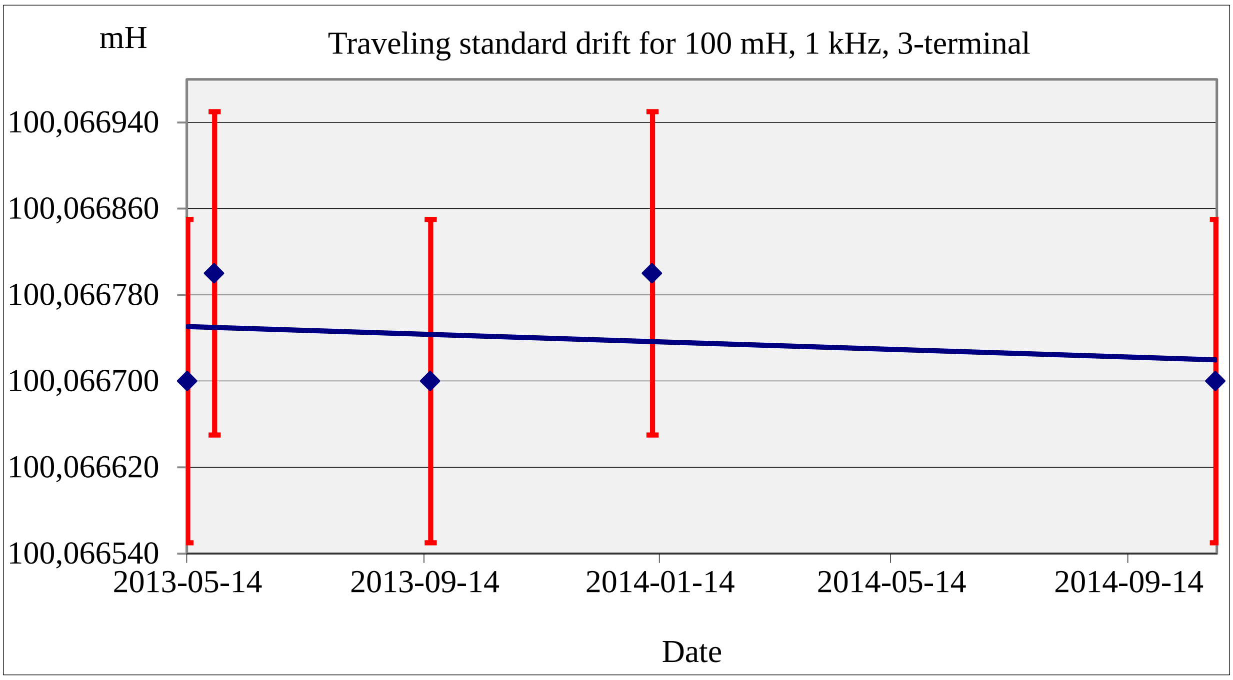

Figure 4 Behaviour of the travelling standard for 10 mH (3-terminal)

As the values of the inductance are time-dependent they were measured before and after each visit so that a drift curve for each one could be established.

The drift of the travelling standards by using all results weighted with the variance of the measurements was checked. The drift was, and can be neglected.

7 Reported results

7.1 General information and data

A full measurement report containing all relevant data and uncertainty estimates was forwarded to the coordinator within six weeks of completing measurement of the inductance. The report included a description of the measurement method (facilities and methodology), the traceability to the SI, and the results, associated uncertainty and number of degrees of freedom.

The measurement period, the measurement frequency and the applied voltage were also reported for each inductance. Details of any corrections that have been applied (for example, bridge corrections or leads corrections) were given.

All measurement results and expended uncertainties, and additional parameters for measurement were identified with the serial number of measures inductance and nominal value.

List of measurement dates of the NMI participants is show in Table 4.

Additional parameters for measurement of the NMI participants are show in Table 5.

The inductance values and their expanded uncertainties (*U*) reported by the NMI participants for 10 mH and 100 mH at frequencies of 1 kHz shown on Table 6 and 7. All the uncertainties quoted in this report are expanded uncertainties, having a coverage factor $k = 2$ which provides a level of confidence of approximately 95%.

Table 4 List of measurement dates of the NMI participants

NMI	Measurement dates
UMTS1, Ukraine	13–16.05.2013
GUM, Poland	21–24.05.2013
UMTS2, Ukraine	27–31.05.2013
UMTS3, Ukraine	16–19.09.2013
KazInMetr, Kazakhstan	24–28.11.2013
UMTS4, Ukraine	08–11.01.2014
BelGIM, Belarus	12–24.09.2014
UMTS5, Ukraine	27–31.10.2014

Table 5 Additional parameters for measurement of the NMI participants

Parameter	Inductance 10 mH		Inductance 100 mH	
	Value	Expanded uncertainty	Value	Expanded uncertainty
GUM, Poland				
Frequency, Hz	1000	0.05	1000	0.05
Voltage, V	100.0	0.1	100.0	0.1
Measure temperature, °C	29.95…29.97	0.01	29.88…29.97	0.01
Ambient temperature, °C	22.0…23.1	0.5	22.0…23.1	0.5
Relative humidity, %	35…53	10	35…53	10
UMTS, Ukraine				
Frequency, Hz	1000.0	$1 \cdot 10^{-5}$	1000.0	$1 \cdot 10^{-5}$
Voltage, V	100.0	0.002	100.0	0.002
Measure temperature, °C	29.96…29.97	0.01	29.95…29.98	0.01
Ambient temperature, °C	21.5…22.5	0.4	21.5…22.5	0.4
Relative humidity, %	35…45	2.3	35…45	2.3

Parameter	Inductance 10 mH		Inductance 100 mH	
	Value	Expanded uncertainty	Value	Expanded uncertainty
KazInMetr, Kazakhstan				
Frequency, Hz	1000	0.06	1000	0.06
Voltage, V	100.0	0.1	100.0	0.1
Measure temperature, °C	29.99…30.00	0.01	29.95…29.96	0.01
Ambient temperature, °C	21.3	0.5	21.3	0.5
Relative humidity, %	30.6	10.0	30.6	10.0
BelGIM, Belarus				
Frequency, Hz	1000	0.115	1000	0.115
Voltage, V	100.0	0.1	100.0	0.1
Measure temperature, °C	29.97…29.99	0.01	29.93…29.97	0.01
Ambient temperature, °C	22.1…23.2	0.58	22.1…23.2	0.58
Relative humidity, %	42.7...58.0	0.99…1.34	42.7...58.0	0.99…1.34

Table 6 Deviations from nominal value 10 mH for NMI participants

NMI	2-terminal		3-terminal	
	δL_i (mH/H)	U_i (mH/H)	δL_i (mH/H)	U_i (mH/H)
GUM	0.363	0.030	0.344	0.030
UMTS	0.386	0.020	0.367	0.020
KazInMetr	0.360	0.039	0.325	0.039
BelGIM	0.315	0.101	0.332	0.101

Table 7 Deviations from nominal value 100 mH for NMI participants

NMI	**2-terminal**		**3-terminal**	
	δL_i (mH/H)	U_i (mH/H)	δL_i (mH/H)	U_i (mH/H)
GUM	0.852	0.020	0.654	0.020
UMTS	0.865	0.015	0.667	0.015
KazInMetr	0.844	0.029	0.666	0.029
BelGIM	0.848	0.101	0.648	0.101

7.2 Calculation of the reference value and its uncertainty

The reference value x_{ref} is calculated as the mean of participant results with COOMET.EM-S14 data are given by

$$x_{ref} = \sum_{i=1}^{N} \frac{x_i}{u^2(x_i)} \Bigg/ \sum_{i=1}^{N} \frac{1}{u^2(x_i)} \tag{1}$$

with associated standard uncertainty

$$u^2(x_{ref}) = 1 \Bigg/ \sum_{i=1}^{N} \frac{1}{u^2(x_i)} \, . \tag{2}$$

In cases the calculated simple weighted mean of all results was x_{ref} = 0.375 mH/H for 10 mH (2-terminal) and x_{ref} = 0.354 mH/H for 10 mH (3-terminal) with expanded uncertainty (k = 2) U_{ref} = 0.015 mH/H; x_{ref} = 0.858 mH/H for 100 mH (2-terminal) and x_{ref} = 0.663 mH/H for 100 mH (3-terminal) with expanded uncertainty (k = 2) U_{ref} = 0.011 mH/H.

7.3 Degrees of equivalence

Only one value is reported for each NMI participants. Degrees of equivalence of the NMI participants are reported with respect to the measurement for 10 mH and 100 mH at 1 kHz for 2- and 3-terminals.

The degrees of equivalence of the i-th NMI and its expanded uncertainties with respect to the comparison reference value is estimated as

$$D_i = x_i - x_{ref} \, , \tag{3}$$

$$U^2(D_i) = U^2(x_i) - U^2(x_{ref}) \, . \tag{4}$$

The declared uncertainties are judged as confirmed if the following equation is satisfied

$$|D_i| < 2u(D_i) \, . \tag{5}$$

The degrees of equivalence of the NMI participants and its expanded uncertainties (k = 2) with respect to the KCRV for 10 mH and 100 mH at 1 kHz for 2- and 3-terminal are also presented in Table 8 and 9 and the graphs in Figures 5–8.

Table 8 Degrees of equivalence of the NMI participants for 10 mH

NMI	2-terminal		3-terminal	
	D_i (mH/H)	$U(D_i)$ (mH/H)	D_i (mH/H)	$U(D_i)$ (mH/H)
GUM	–0.012	0.026	–0.010	0.026
UMTS	0.012	0.013	0.013	0.013
KazInMetr	–0.015	0.036	–0.029	0.036
BelGIM	–0.060	0.100	–0.022	0.100

Table 9 Degrees of equivalence of the NMI participants for 100 mH

NMI	2-terminal		3-terminal	
	D_i (mH/H)	$U(D_i)$ (mH/H)	D_i (mH/H)	$U(D_i)$ (mH/H)
GUM	–0.006	0.017	–0.009	0.017
UMTS	0.007	0.010	0.004	0.010
KazInMetr	–0.014	0.027	0.003	0.027
BelGIM	–0.010	0.101	–0.015	0.101

7.4 Results of the NMI participants

On the basis of the measurement results of COOMET.EM-S14 and corresponding uncertainties $\{x_i,\ u(x_i)\},\ i=1,...N$ claimed by comparisons NMI participants, the χ^2 criterion value is calculated [2]

$$\chi^2 = \sum_{i=1}^{N} \frac{(x_i - x_{ref})^2}{u^2(x_i)} \ , \tag{6}$$

where:

x_i – i-th NMI result of the COOMET.EM-S14;

x_{ref} – reference value with transformed COOMET.EM-S14 data;

$u(x_i)$ – uncertainty of i-th NMI result of the COOMET.EM-S14;

N – a number of the COOMET.EM-S14 (N = 4).

If the criterion value calculated in accordance with the data provided by NMIs doesn't exceed the critical value χ^2 with the coverage level 0.95 and the degrees of freedom N – 1 [2]

$$\chi^2 = \sum_{i=1}^{N} \frac{(x_i - x_{ref})^2}{u^2(x_i)} \prec \chi^2_{0.95}(N-1), \tag{7}$$

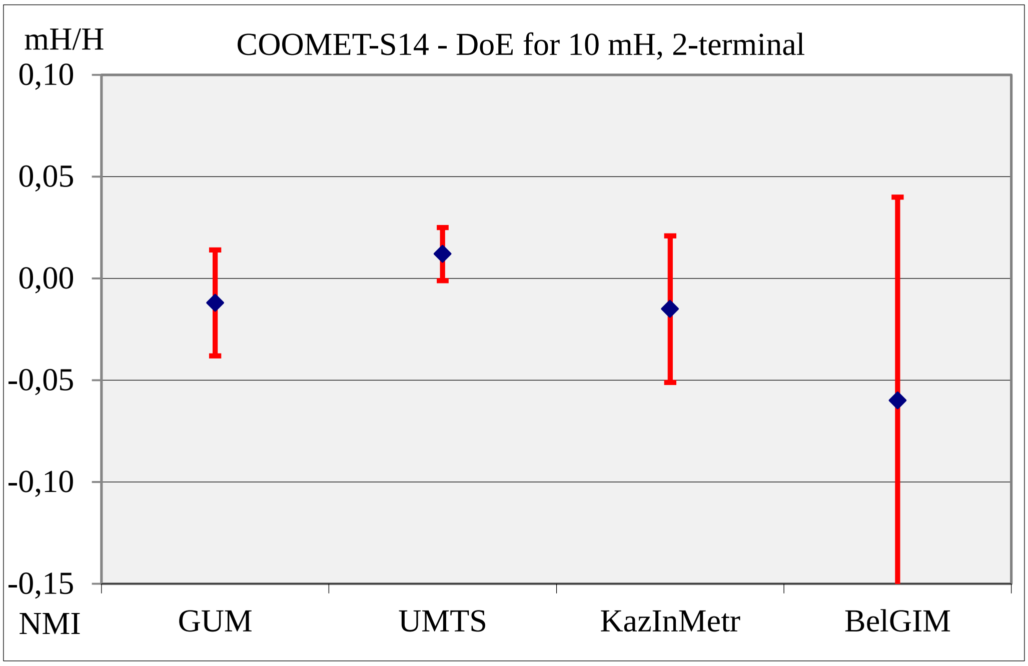

Figure 5 Degree of equivalence of the NMI participants on 10 mH (2-terminal)

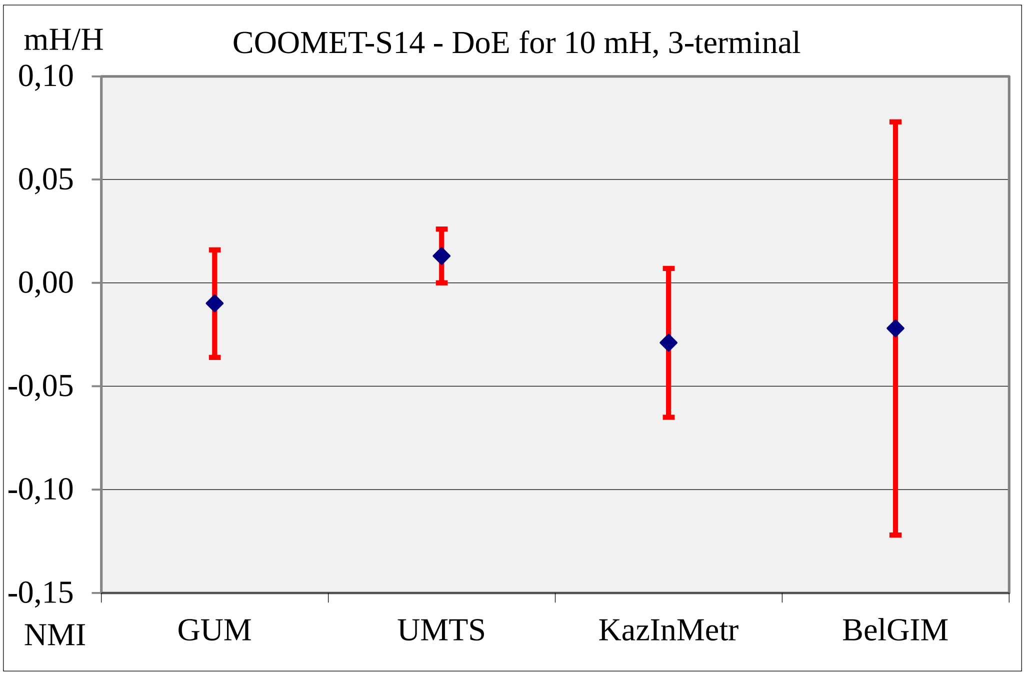

Figure 6 Degree of equivalence of the NMI participants on 10 mH (3-terminal)

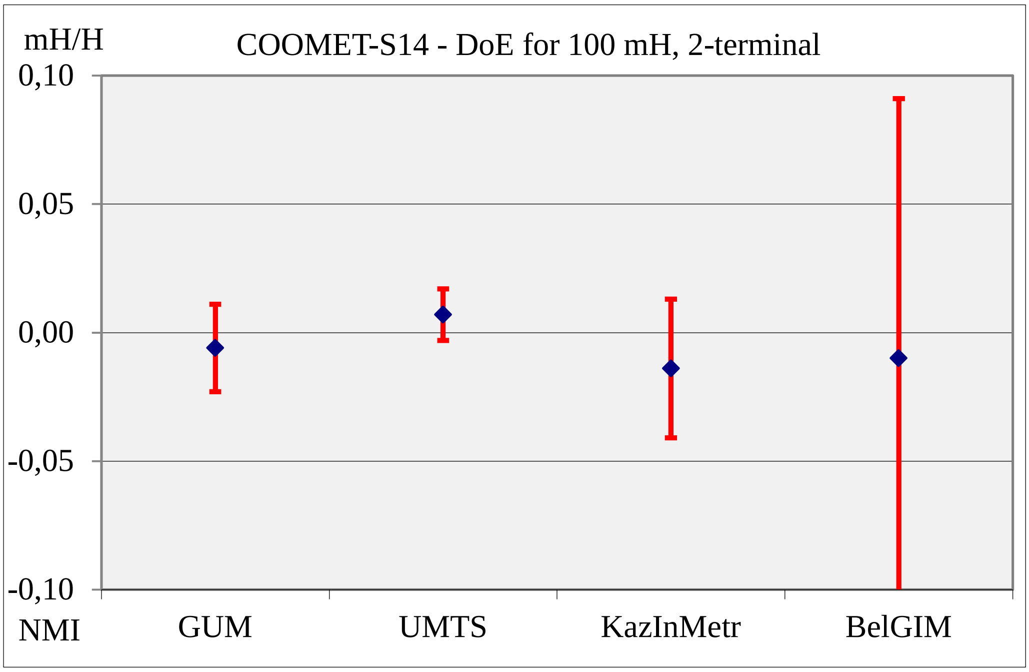

Figure 7 Degree of equivalence of the NMI participants on 100 mH (2-terminal)

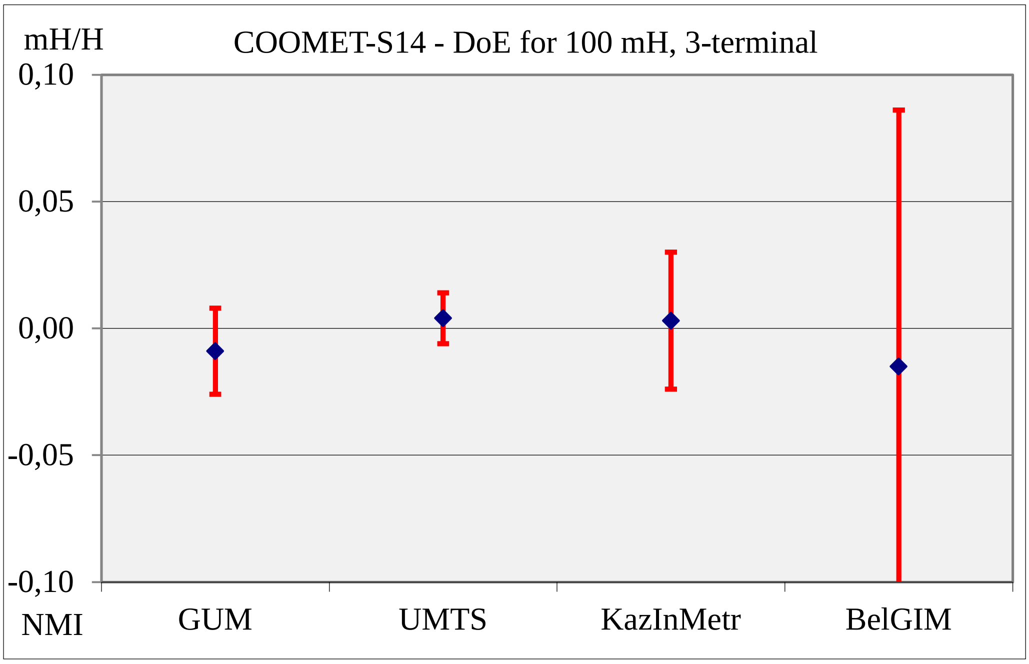

Figure 8 Degree of equivalence of the NMI participants on 100 mH (3-terminal)

then the data provided by different NMIs can be acknowledged as consistent, that is the objective confirmation of the announced uncertainties (Table 10).

Table 10 Values for χ^2 criterion

Inductance, mH	**Terminal**	χ^2	$\chi^2_{0,95}(N-1)$
10	2-terminal	3.99	7.81
	3-terminal	4.49	
100	2-terminal	2.22	
	3-terminal	1.23	

NMI that provides maximum E_N criterion is determined [2]

$$\max_i E_N = \frac{|x_i - x_{ref}|}{2\sqrt{u^2(x_i) - u^2(x_{ref})}}. \quad (8)$$

Further that NMI's data is temporary excluded from the consideration, and the procedure of checking the comparisons data consistency is repeated. The sequential exclusion of data is repeated until the condition (7) is fulfilled.

The maximum E_N criterion and declared uncertainties for degrees of equivalence all NMIs for 10 mH and 100 mH are judged as confirmed by equations (7) and (8) accordingly (Table 11).

Table 11 Values for E_N criterion

Inductance, mH	**Terminal**	**NMI**	$\boldsymbol{E_N}$
10	2-terminal	GUM	0.46
		UMTS	0.89
		KazInMetr	0.42
		BelGIM	0.60
	3-terminal	GUM	0.39
		UMTS	0.99
		KazInMetr	0.80
		BelGIM	0.22
100	2-terminal	GUM	0.35
		UMTS	0.71
		KazInMetr	0.52
		BelGIM	0.10
	3-terminal	GUM	0.52
		UMTS	0.43
		KazInMetr	0.12
		BelGIM	0.15

8 Summary

A supplementary comparison of inductance at 10 mH and 100 mH at 1 kHz has been conducted between participating COOMET member laboratories. In general there is good agreement between participating laboratories in the region for this quantity. It is expected that this comparison will be able to provide support for participants' entries in Appendix C of the Mutual Recognition Arrangement.

References

[1] JCGM 100:2008 Evaluation of measurement data. – Guide to the expression of uncertainty in measurement.

[2] COOMET R/GM/19:2008 Guidelines on COOMET supplementary comparison evaluation.

Appendix 1

Reported measurement results for each NMI laboratory

GUM (Poland)

<table>
<tr><td colspan="2">Measurement frequency, Hz</td><td>1000.0</td></tr>
<tr><td colspan="2">Measure temperature, ºC</td><td>29.95…29.97</td></tr>
<tr><td rowspan="3">**Measurement result**</td><td>Mean measurement date</td><td>21–24.05.2013</td></tr>
<tr><td>Mean inductance (2-terminal), mH</td><td>10.00363</td></tr>
<tr><td>Expanded uncertainty, mH</td><td>0.00030 (k = 2.0)</td></tr>
<tr><td colspan="2">Measurement frequency, Hz</td><td>1000.0</td></tr>
<tr><td colspan="2">Measure temperature, ºC</td><td>29.95…29.97</td></tr>
<tr><td rowspan="3">**Measurement result**</td><td>Mean measurement date</td><td>21–24.05.2013</td></tr>
<tr><td>Mean inductance (3-terminal), mH</td><td>10.00344</td></tr>
<tr><td>Expanded uncertainty, mH</td><td>0.00030 (k = 2.0)</td></tr>
<tr><td colspan="2">Measurement frequency, Hz</td><td>1000.0</td></tr>
<tr><td colspan="2">Measure temperature, ºC</td><td>29.88…29.97</td></tr>
<tr><td rowspan="3">**Measurement result**</td><td>Mean measurement date</td><td>21–24.05.2013</td></tr>
<tr><td>Mean inductance (2-terminal), mH</td><td>100.0852</td></tr>
<tr><td>Expanded uncertainty, mH</td><td>0.0020 (k = 2.0)</td></tr>
<tr><td colspan="2">Measurement frequency, Hz</td><td>1000.0</td></tr>
<tr><td colspan="2">Measure temperature, ºC</td><td>29.88…29.97</td></tr>
<tr><td rowspan="3">**Measurement result**</td><td>Mean measurement date</td><td>21–24.05.2013</td></tr>
<tr><td>Mean inductance (3-terminal), mH</td><td>100.0654</td></tr>
<tr><td>Expanded uncertainty, mH</td><td>0.0020 (k = 2.0)</td></tr>
</table>

UMTS (Ukraine)

Measurement frequency, Hz		1000.0
Measure temperature, ºC		29.96…29.97
Measurement result	Mean measurement date	13.05.2013–31.10.2014
	Mean inductance (2-terminal), mH	10.00387
	Expanded uncertainty, mH	0.00020 (k = 2.0)
Measurement frequency, Hz		1000.0
Measure temperature, ºC		29.96…29.97
Measurement result	Mean measurement date	13.05.2013–31.10.2014
	Mean inductance (3-terminal), mH	10.00367
	Expanded uncertainty, mH	0.0002 (k = 2.0)
Measurement frequency, Hz		1000.0
Measure temperature, ºC		29.95…29.98
Measurement result	Mean measurement date	13.05.2013–31.10.2014
	Mean inductance (2-terminal), mH	100.0865
	Expanded uncertainty, mH	0.00148 (k = 2.0)
Measurement frequency, Hz		1000.0
Measure temperature, ºC		29.95…29.98
Measurement result	Mean measurement date	13.05.2013–31.10.2014
	Mean inductance (3-terminal), mH	100.0667
	Expanded uncertainty, mH	0.00148 (k = 2.0)

KazInMetr (Kazakhstan)

Measurement frequency, Hz		1000.0
Measure temperature, ºC		29.99…30.00
Measurement result	Mean measurement date	28.11.2013
	Mean inductance (2-terminal), mH	10.00360
	Expanded uncertainty, mH	0.00039 (*k* = 2.0)
Measurement frequency, Hz		1000.0
Measure temperature, ºC		29.99…30.00
Measurement result	Mean measurement date	28.11.2013
	Mean inductance (3-terminal), mH	10.00325
	Expanded uncertainty, mH	0.00039 (*k* = 2.0)
Measurement frequency, Hz		1000.0
Measure temperature, ºC		29.95…29.96
Measurement result	Mean measurement date	28.11.2013
	Mean inductance (2-terminal), mH	100.0844
	Expanded uncertainty, mH	0.0029 (*k* = 2.0)
Measurement frequency, Hz		1000.0
Measure temperature, ºC		29.95…29.95
Measurement result	Mean measurement date	28.11.2013
	Mean inductance (3-terminal), mH	100.0666
	Expanded uncertainty, mH	0.0029 (*k* = 2.0)

BelGIM, Belarus

Measurement frequency, Hz		1000.0
Measure temperature, ºC		29.96…29.99
Measurement result	Mean measurement date	12–24.09.2014
	Mean inductance (2-terminal), mH	10.00352
	Expanded uncertainty, mH	0.00101 (k = 2.0)
Measurement frequency, Hz		1000.0
Measure temperature, ºC		29.96…29.99
Measurement result	Mean measurement date	12–24.09.2014
	Mean inductance (3-terminal), mH	10.00332
	Expanded uncertainty, mH	0.00101 (k = 2.0)
Measurement frequency, Hz		1000.0
Measure temperature, ºC		29.96…29.99
Measurement result	Mean measurement date	12–24.09.2014
	Mean inductance (2-terminal), mH	100.0848
	Expanded uncertainty, mH	0.0101 (k = 2.0)
Measurement frequency, Hz		1000.0
Measure temperature, ºC		29.93…29.97
Measurement result	Mean measurement date	12–24.09.2014
	Mean inductance (3-terminal), mH	100.0648
	Expanded uncertainty, mH	0.0101 (k = 2.0)

Appendix 2

Reported measurement results for each NMI laboratory

GUM (Poland)

Uncertainty budget table 10 mH (2-terminal)

Quantity, X_i	Estimate x_i, mH	Standard uncertainty, $u(x_i)$	Probability distribution	Method of evaluation (A, B)	Sensitivity coefficient, c_i	Uncertainty contribution, $c_i \cdot u(x_i)$, mH	Degrees of freedom, ν_i
L_C	10.00363	$2.3 \cdot 10^{-5}$ mH	normal	A	1	$2.3 \cdot 10^{-5}$	200
δL_K	0	$1.15 \cdot 10^{-4}$ mH	rectangular	B	1	$1.15 \cdot 10^{-4}$	∝
δL_d	0	$5.77 \cdot 10^{-7}$ mH	rectangular	B	1	$5.77 \cdot 10^{-7}$	∝
δL_{CW}	0	$1.5 \cdot 10^{-3}$ nF	normal	B	–0.0393 mH/nF	$-5.9 \cdot 10^{-5}$	∝
δL_{TX}	0	$2.14 \cdot 10^{-5}$ mH	rectangular	B	1	$2.14 \cdot 10^{-5}$	∝
L_s	10.00363						
		Combined standard uncertainty			u_c	0.000133 mH	
		Effective degrees of freedom			ν_{eff}	> 200, $k = 2$	
		Expanded uncertainty ($p \approx 95$ %)			U	0.00030 mH	

Uncertainty budget table 10 mH (3-terminal)

Quantity, X_i	Estimate, x_i, mH	Standard uncertainty, $u(x_i)$,	Probability distribution	Method of evaluation (A, B)	Sensitivity coefficient, c_i	Uncertainty contribution $c_i \cdot u(x_i)$, mH	Degrees of freedom, ν_i
L_C	10.00344	$2.15 \cdot 10^{-5}$ mH	normal	A	1	$2.15 \cdot 10^{-5}$	200
δL_K	0	$1.15 \cdot 10^{-4}$ mH	rectangular	B	1	$1.15 \cdot 10^{-4}$	∝
δL_d	0	$5.77 \cdot 10^{-7}$ mH	rectangular	B	1	$5.77 \cdot 10^{-7}$	∝
δL_{CW}	0	$1.5 \cdot 10^{-3}$ nF	normal	B	–0.0393 mH/nF	$-5.9 \cdot 10^{-5}$	∝
δL_{TX}	0	$2.14 \cdot 10^{-5}$ mH	rectangular	B	1	$2.14 \cdot 10^{-5}$	∝
L_s	10.00344						
		Combined standard uncertainty			u_c	0.000133 mH	
		Effective degrees of freedom			ν_{eff}	> 200, $k = 2$	
		Expanded uncertainty ($p \approx 95$ %)			U	0.00030 mH	

Model equation that follows from the measurement setup:

$$L_s = L_{\mathrm{C}} + \delta L_{\mathrm{K}} + \delta L_{\mathrm{d}} + \delta L_{\mathrm{CW}} + \delta L_{\mathrm{TX}},$$

where:

L_{C} – inductance value obtained from *C*-*L* comparison;

δL_{K} – correction due to comparison error;

δL_{d} – correction due to comparator resolution;

δL_{CW} – correction due to reference standard uncertainty;

δL_{TX} – correction due to temperature influence travelling standard.

Model equation that follows from the measurement setup for reference standard C_{W}:

$$C_{\mathrm{W}} = C_{\mathrm{CA250}} + C_{3540} + \delta C_{\mathrm{CW}} + \delta B_{\mathrm{RLC}} + \delta B_{\mathrm{RLCd}} + \delta C_{\mathrm{TCA250}};$$

$$C_{3540} = C_{\mathrm{AH}} + \delta B_{\mathrm{AH}} + \delta B_{\mathrm{AHd}} + \delta C_{\mathrm{T3540}},$$

where:

C_{CA250} – capacitance value obtained from *RLC* comparator (250 nF);

C_{3540} – capacitance value of added capacitor (3540 pF);

δC_{CW} – correction due to reference standard uncertainty (25 nF);

δB_{RLC} – correction due to *C*-*C* error in *RLC* comparator;

δB_{RLCd} – correction due to *RLC* comparator resolution;

$\delta C_{\mathrm{TCA250}}$ – correction due to temperature influence thermostated C_{CA250} (250 nF);

C_{AH} – capacitance value obtained from AH bridge (3540 pF);

δB_{AH} – correction due to AH bridge error;

δB_{AHd} – correction due to AH bridge resolution;

$\delta C_{\mathrm{T3540}}$ – correction due to temperature influence C_{3540} (3540 pF).

Uncertainty budget table 253 nF (C_W)

Quantity, X_i	Estimate, x_i	Standard uncertainty, $u(x_i)$	Probability distribution	Method of evaluation (A, B)	Sensitivity coefficient, c_i	Uncertainty contribution $c_i \cdot u(x_i)$, nF	Degrees of freedom, ν_i
C_{CA250}	249.7992 nF	0.0000852 nF	normal	A	1	0.0000852	200
C_{3540}	3540.15 pF	0.0154 pF	normal	B	0.0715 nF/pF	0.0011	200
δC_{CW}	0	0.000065 nF	normal	B	10.12	0.0006578	∝
δB_{RLC}	0	0.00014434 nF	rectangular	B	1	0.00014434	∝
δB_{RLCd}	0	$5.774 \cdot 10^{-6}$ nF	rectangular	B	1	$5.774 \cdot 10^{-6}$	∝
δC_{TCA250}	0	$3.46 \cdot 10^{-5}$ nF	rectangular	B	1	$3.46 \cdot 10^{-5}$	∝
C_W	253.3394 nF						
		Combined standard uncertainty			u_c	0.0013 nF	
		Effective degrees of freedom			ν_{eff}	> 200, k = 2	
		Expanded uncertainty ($p \approx 95\%$)			U	0.0030 nF	

Uncertainty budget table 3540 pF (C_{3540})

Quantity, X_i	Estimate, x_i	Standard uncertainty, $u(x_i)$, pF	Probability distribution	Method of evaluation (A, B)	Sensitivity coefficient, c_i	Uncertainty contribution, $c_i \cdot u(x_i)$, pF	Degrees of freedom, ν_i
C_{AH}	3540.15 pF	0.0129	normal	A	1	0.0129	200
δB_{AH}	0	0.00613	rectangular	B	1	0.00613	∝
δB_{AHd}	0	0.00577	rectangular	B	1	0.00577	∝
δC_{T3540}	0	0	rectangular	B	1	0	∝
C_{3540}	3540.15 pF						
		Combined standard uncertainty			u_c	0.0154 pF	
		Effective degrees of freedom			ν_{eff}	> 200, k = 2	
		Expanded uncertainty ($p \approx 95$ %)			U	0.03 pF	

Uncertainty budget table 100 mH (2-terminal)

Quantity, X_i	Estimate, x_i	Standard uncertainty, $u(x_i)$	Probability distribution	Method of evaluation (A, B)	Sensitivity coefficient, c_i	Uncertainty contribution, $c_i \cdot u(x_i)$, mH	Degrees of freedom, ν_i
L_C	100.0852 mH	$2.48 \cdot 10^{-4}$ mH	normal	A	1	$2.48 \cdot 10^{-4}$	200
δL_K	0	$5.77 \cdot 10^{-4}$ mH	rectangular	B	1	$5.77 \cdot 10^{-4}$	$\propto$
δL_d	0	$5.77 \cdot 10^{-7}$ mH	rectangular	B	1	$5.77 \cdot 10^{-7}$	$\propto$
δL_{CW}	0	$1.5 \cdot 10^{-4}$ nF	normal	B	–3.93 mH/nF	$–5.9 \cdot 10^{-4}$	$\propto$
δL_{TX}	0	$2.14 \cdot 10^{-4}$ mH	rectangular	B	1	$2.14 \cdot 10^{-4}$	$\propto$
L_s	100.0852 mH						
		Combined standard uncertainty			u_c	0.0009 mH	
		Effective degrees of freedom			ν_{eff}	> 200, $k = 2$	
		Expanded uncertainty ($p \approx 95$ %)			U	0.0020 mH	

Uncertainty budget table 100 mH (3-terminal)

Quantity, X_i	Estimate, x_i	Standard uncertainty, $u(x_i)$	Probability distribution	Method of evaluation (A, B)	Sensitivity coefficient, c_i	Uncertainty contribution, $c_i \cdot u(x_i)$, mH	Degrees of freedom, ν_i
L_C	100.0654 mH	$4.93 \cdot 10^{-5}$ mH	normal	A	1	$4.93 \cdot 10^{-5}$	200
δL_K	0	$5.77 \cdot 10^{-4}$ mH	rectangular	B	1	$5.77 \cdot 10^{-4}$	$\propto$
δL_d	0	$5.77 \cdot 10^{-7}$ mH	rectangular	B	1	$5.77 \cdot 10^{-7}$	$\propto$
δL_{CW}	0	$1.5 \cdot 10^{-4}$ nF	normal	B	–3.93 mH/nF	$–5.9 \cdot 10^{-4}$	$\propto$
δL_{TX}	0	$2.14 \cdot 10^{-4}$ mH	rectangular	B	1	$2.14 \cdot 10^{-4}$	$\propto$
L_s	100.0654 mH						
		Combined standard uncertainty			u_c	0.0009 mH	
		Effective degrees of freedom			ν_{eff}	> 200, $k = 2$	
		Expanded uncertainty ($p \approx 95$ %)			U	0.0020 mH	

Model equation that follows from the measurement setup:

$$L_s = L_\mathrm{C} + \delta L_\mathrm{K} + \delta L_\mathrm{d} + \delta L_\mathrm{CW} + \delta L_\mathrm{TX}$$

where:

L_C – inductance value obtained from *C*-*L* comparison;

δL_K – correction due to comparison error;

δL_d – correction due to *RLC* comparator resolution;

δL_CW – correction due to reference standard uncertainty;

δL_TX – correction due to temperature influence travelling standard.

Model equation that follows from the measurement setup for reference standard C_W:

$$C_\mathrm{W} = C_\mathrm{CA25} + C_{334} + \delta C_\mathrm{CW} + \delta B_\mathrm{RLC} + \delta B_\mathrm{RLCd} + \delta C_\mathrm{TCA25};$$

$$C_{334} = C_\mathrm{AH} + \delta B_\mathrm{AH} + \delta B_\mathrm{AHd} + \delta C_\mathrm{T334},$$

where:

C_CA25 – capacitance value obtained from *RLC* comparator (25 nF);

C_{334} – capacitance value of added capacitor (334 pF);

δC_CW – correction due to reference standard uncertainty (10 nF);

δB_RLC – correction due to *C*-*C* error in *RLC* comparator;

δB_RLCd – correction due to *RLC* comparator resolution;

δC_TCA25 – correction due to temperature influence thermostated C_CA25 (25 nF);

C_AH – capacitance value obtained from AH bridge (334 pF);

δB_AH – correction due to AH bridge error;

δB_AHd – correction due to AH bridge resolution;

δC_T334 – correction due to temperature influence C_{334} (334 pF).

Uncertainty budget table 25 nF (C_W)

Quantity, X_i	Estimate, x_i	Standard uncertainty, (x_i)	Probability distribution	Method of evaluation(A, B)	Sensitivity coefficient, c_i	Uncertainty contribution, $c_i \cdot u(x_i)$, nF	Degrees of freedom, ν_i
C_{CA25}	24.9986 nF	0.0000076 nF	normal	A	1	0.0000076	200
C_{334}	334.323 pF	0.0015 pF	normal	B	0.0757 nF/pF	0.0001136	200
δC_{CW}	0	0.000025 nF	normal	B	2,53	0.00006325	$\propto$
δB_{RLC}	0	$1.44 \cdot 10^{-5}$ nF	rectangular	B	1	$1.44 \cdot 10^{-5}$	$\propto$
δB_{RLCd}	0	$5.77 \cdot 10^{-7}$ nF	rectangular	B	1	$5.77 \cdot 10^{-7}$	$\propto$
δC_{TCA25}	0	$3.61 \cdot 10^{-6}$ nF	rectangular	B	1	$3.61 \cdot 10^{-6}$	$\propto$
C_W	25.3329 nF						
		Combined standard uncertainty			u_c	0.000131 nF	
		Effective degrees of freedom			ν_{eff}	> 200, k = 2	
		Expanded uncertainty ($p \approx 95$ %)			U	0.0003 nF	

Uncertainty budget table 334 pF (C_{334})

Quantity X_i	Estimate x_i, pF	Standard uncertainty, $u(x_i)$, pF	Probability distribution	Method of evaluation (A, B)	Sensitivity coefficient, c_i	Uncertainty contribution $c_i \cdot u(x_i)$, pF	Degrees of freedom, ν_i
C_{AH}	334.323	0.001209	normal	A	1	0.001209	200
δB_{AH}	0	$5.79 \cdot 10^{-4}$	rectangular	B	1	$5.79 \cdot 10^{-4}$	$\propto$
δB_{AHd}	0	$5.77 \cdot 10^{-4}$	rectangular	B	1	$5.77 \cdot 10^{-4}$	$\propto$
δC_{T334}	0	0	rectangular	B	1	0	$\propto$
C_{334}	334.323						
		Combined standard uncertainty			u_c	0.0015 pF	
		Effective degrees of freedom			ν_{eff}	> 200, k = 2	
		Expanded uncertainty ($p \approx 95$ %)			U	0.003 pF	

UMTS (Ukraine)

Uncertainty budget table 10 mH (2-terminal)

Quantity, X_i	Estimate, x_i	Relative standard uncertainty, $u(x_i)/x_i$, ppm	Probability distribution	Method of evaluation (A, B)	Sensitivity coefficient, p_i	Relative uncertainty contribution, $p_i \cdot u(x_i)/x_i$, ppm
K_1	0.100055	7.00	normal	A	1	7.00
ω, rad/s	6283.185307	0.10	normal	B	–2	–0.20
K_2	2.532112	1.50	rectangular	A	–1	–1.50
K_3	10.000239	1.20	rectangular	A	–1	–1.20
K_4	10.000245	1.20	normal	A	–1	–1.20
K_5	0.099952	7.00	normal	A	1	7.00
C_{100}, pF	100.00014	0.40	rectangular	B	–1	–0.40
L_X, mH	10.003866					
		Combined standard uncertainty			u_c	10.165136
		Effective degrees of freedom			ν_{eff}	> 200, k = 2
		Expanded uncertainty ($p \approx 95\%$)			U	0.000203 mH

Uncertainty budget table 10 mH (3-terminal)

Quantity, X_i	Estimate, x_i	Relative standard uncertainty, $u(x_i)/x_i$, ppm	Probability distribution	Method of evaluation (A, B)	Sensitivity coefficient, p_i	Relative uncertainty contribution, $p_i \cdot u(x_i)/x_i$, ppm
K_1	0.100035	7.00	normal	A	1	7.00
ω, rad/s	6283.185307	0.10	normal	B	–2	–0.20
K_2	2.532112	1.50	rectangular	A	–1	–1.50
K_3	10.000239	1.20	rectangular	A	–1	–1.20
K_4	10.000245	1.20	normal	A	–1	–1.20
K_5	0.099970	7.00	normal	A	1	7.00
C_{100}, pF	100.00014	0.40	rectangular	B	–1	–0.40
L_X, mH	10,003676					
		Combined standard uncertainty			u_c	10.165136
		Effective degrees of freedom			ν_{eff}	> 200, k = 2
		Expanded uncertainty ($p \approx 95\%$)			U	0.000203 mH

Uncertainty budget table 100 mH (2-terminal)

Quantity, X_i	Estimate, x_i	Relative standard uncertainty, $u(x_i)/x_i$, ppm	Probability distribution	Method of evaluation (A, B)	Sensitivity coefficient, p_i	Relative uncertainty contribution, $p_i \cdot u(x_i)/x_i$, ppm
K_1	0.100055	7.00	normal	A	1	7.00
ω, rad/s	6283.185307	0.10	normal	B	–2	–0.20
K_2	2.532112	1.50	rectangular	A	–1	–1.50
K_3	10.000239	1.20	rectangular	A	–1	–1.20
K_4	10.000245	1.20	normal	A	–1	–1.20
C_{100}, pF	100.00014	0.40	rectangular	B	–1	–0.40
L_X, mH	100.086540					
		Combined standard uncertainty			u_c	7.370889
		Effective degrees of freedom			ν_{eff}	> 200, k = 2
		Expanded uncertainty ($p \approx 95\%$)			U	0.001475 mH

Uncertainty budget table 100 mH (3-terminal)

Quantity, X_i	Estimate, x_i	Relative standard uncertainty, $u(x_i)/x_i$, ppm	Probability distribution	Method of evaluation (A, B)	Sensitivity coefficient, p_i	Relative uncertainty contribution, $p_i \cdot u(x_i)/x_i$, ppm
K_1	0.100035	7.00	normal	A	1	7.00
ω, rad/s	6283.185307	0.10	normal	B	–2	–0.20
K_2	2.532112	1.50	rectangular	A	–1	–1.50
K_3	10.000239	1.20	rectangular	A	–1	–1.20
K_4	10.000245	1.20	normal	A	–1	–1.20
C_{100}, pF	100.00014	0.40	rectangular	B	–1	–0.40
L_X, mH	100.06674					
		Combined standard uncertainty			u_c	7.370889
		Effective degrees of freedom			ν_{eff}	> 200, k = 2
		Expanded uncertainty ($p \approx 95\%$)			U	0.001475 mH

Model equation that follows from the measurement setup:

for 10 mH: $$L_X = \frac{K_1 K_5}{\omega^2 K_2 K_3 K_4 C_{100pF}},$$

for 100 mH: $$L_X = \frac{K_1}{\omega^2 K_2 K_3 K_4 C_{100pF}},$$

where:

$$C_{100pF} = C_S + \Delta C_C + 2\delta C_{QC} - \delta C_{Tx} + \delta C_{SC} + \delta C_{CE} + \delta C_\gamma,$$

C_{100pF} – the value of the reference capacitance measure by time drift reference parameter as well as other influencing factors;

K_1 – the transmission coefficient of comparator during calibration the measure of inductance 100 mH with reliance on the reference measure of capacitance 25 nF and the frequency ω;

ω – the operating frequency of the signal 6283.185 rad/s (1 kHz), being measured;

K_2 – the transmission coefficient of comparator during calibration the measures the electric capacitance of 25 nF with reliance on the reference measure of capacitance 10 nF from the store thermostatically measures CA 5200RC;

K_3 – the transmission coefficient of comparator during calibration measures of the electrical capacitance of 10 nF with reliance on the reference measure capacitance from 1 nF from the store thermostatically measures CA 5200RC;

K_4 – the transmission coefficient of comparator during calibration the measures of the capacitance 1 nF with reliance on the reference measure capacitance AN11A with nominal value of 100 pF;

K_5 – the transmission coefficient of comparator during calibration the measure of the inductance 10 mH with reliance on the reference the measure inductance 100 mH;

C_S – value of reference standard;

ΔC_C – correction due to difference between value of measured standard and value of reference standard;

δC_{QC} – deviation due to the quantization error of the comparator;

δC_{Tx} – correction due to temperature influence on measured standard;

δC_{SC} – correction for the sensitivity of the comparator;

δC_{CE} – error of the comparison;

δC_γ – correction due to annual drift of reference standard.

Uncertainty budget table 100 pF

Quantity, X_i	Estimate, x_i	Standard uncertainty, $u(x_i)$, pF	Probability distribution	Method of evaluation (A, B)	Sensitivity coefficient, c_i	Relative uncertainty contribution, $c_i \cdot u(x_i)$, pF
C_S	100.00002	$3.70 \cdot 10^{-5}$	normal	B	1	$3.70 \cdot 10^{-5}$
ΔC_C	0.00005403	$8.20 \cdot 10^{-6}$	normal	A	1	$8.2 \cdot 10^{-6}$
δC_{QC}	0	$6.01 \cdot 10^{-7}$	rectangular	B	2	$1.2 \cdot 10^{-6}$
δC_{Tx}	0	$8.30 \cdot 10^{-6}$	rectangular	B	–1	$-8.3 \cdot 10^{-6}$
δC_{SC}	0	$1.07 \cdot 10^{-8}$	rectangular	B	1	$1.07 \cdot 10^{-8}$
δC_{CE}	0	$7.90 \cdot 10^{-6}$	rectangular	A	1	$7.90 \cdot 10^{-6}$
δC_{γ}	$6.65 \cdot 10^{-5}$	$8.50 \cdot 10^{-7}$	rectangular	B	1	$8.50 \cdot 10^{-7}$
C_{100}	100.00014					
		Combined standard uncertainty			u_c	$3.962 \cdot 10^{-5}$
		Effective degrees of freedom			ν_{eff}	>200, k = 2
		Expanded uncertainty ($p \approx 95\%$)			U	$7.924 \cdot 10^{-5}$

KazInMetr (Kazakhstan)

Uncertainty budget table 10 mH (2-terminal)

Quantity, X_i	Estimate, x_i, mH	Standard uncertainty, $u(x_i)$, mH	Probability distribution	Method of eva-luation (A, B)	Sensitivity coefficient, c_i	Uncertainty contribution, $c_i \cdot u(x_i)$, mH
L_{xm}	10.00387	$1.14 \cdot 10^{-6}$	normal	A	1	$1.14 \cdot 10^{-6}$
L_{xs}	9.998626	$6.90 \cdot 10^{-7}$	normal	A	1	$6.90 \cdot 10^{-7}$
L_{ts}	9.99890	$2.40 \cdot 10^{-5}$	normal	B	–1	$-2.40 \cdot 10^{-5}$
$\delta L_{\gamma s}$	0	$8.66 \cdot 10^{-5}$	rectangular	B	1	$8.66 \cdot 10^{-5}$
δL_c	0	$1.73 \cdot 10^{-4}$	rectangular	B	1	$1.73 \cdot 10^{-4}$
δL_f	0	$2.89 \cdot 10^{-5}$	normal	B	1	$2.89 \cdot 10^{-5}$
L_X	10.003597					
		Combined standard uncertainty			u_c	$1.951350 \cdot 10^{-4}$
		Effective degrees of freedom			ν_{eff}	> 200, k = 2
		Expanded uncertainty ($p \approx$ 95%)			U	0.00039027

Uncertainty budget table 10 mH (3-terminal)

Quantity, X_i	Estimate, x_i, mH	Standard uncertainty, $u(x_i)$, mH	Probability distribution	Method of eva-luation (A, B)	Sensitivity coefficient, c_i	Uncertainty contribution, $c_i \cdot u(x_i)$, mH
L_{xm}	10.00366	$1.12 \cdot 10^{-6}$	normal	A	1	$1.12 \cdot 10^{-6}$
L_{xs}	9.998279	$1.29 \cdot 10^{-6}$	normal	A	1	$1.29 \cdot 10^{-6}$
L_{ts}	9.99869	$2.40 \cdot 10^{-5}$	normal	B	–1	$-2.40 \cdot 10^{-5}$
$\delta L_{\gamma s}$	0	$8.66 \cdot 10^{-5}$	rectangular	B	1	$8.66 \cdot 10^{-5}$
δL_c	0	$1.73 \cdot 10^{-4}$	rectangular	B	1	$1.73 \cdot 10^{-4}$
δL_f	0	$2.89 \cdot 10^{-5}$	normal	B	1	$2.89 \cdot 10^{-5}$
L_X	10.003253					
		Combined standard uncertainty			u_c	$1.936567 \cdot 10^{-4}$
		Effective degrees of freedom			ν_{eff}	> 200, k = 2
		Expanded uncertainty ($p \approx$ 95%)			U	0,00038731

Uncertainty budget table 100 mH (2-terminal)

Quantity, X_i	Estimate, x_i, mH	Standard uncertainty, $u(x_i)$, mH	Probability distribution	Method of evaluation (A, B)	Sensitivity coefficient, c_i	Uncertainty contribution, $c_i \cdot u(x_i)$, mH
L_{xm}	100.0836	$8.38 \cdot 10^{-5}$	normal	A	1	$8.38 \cdot 10^{-5}$
L_{xs}	100.03791	$1.36 \cdot 10^{-5}$	normal	A	1	$1.36 \cdot 10^{-5}$
L_{ts}	100.03460	$2.40 \cdot 10^{-4}$	normal	B	–1	$-2.40 \cdot 10^{-4}$
$\delta L_{\gamma s}$	0	$8.66 \cdot 10^{-5}$	rectangular	B	1	$8.66 \cdot 10^{-5}$
δL_c	0	$1.44 \cdot 10^{-3}$	rectangular	B	1	$1.44 \cdot 10^{-3}$
δL_f	0	$2.89 \cdot 10^{-5}$	normal	B	1	$2.89 \cdot 10^{-5}$
L_X	100.08689					
		Combined standard uncertainty			u_c	$1.468212 \cdot 10^{-3}$
		Effective degrees of freedom			ν_{eff}	> 200, $k = 2$
		Expanded uncertainty ($p \approx 95\%$)			U	0.00293642

Uncertainty budget table 100 mH (3-terminal)

Quantity, X_i	Estimate, x_i, mH	Standard uncertainty, $u(x_i)$, mH	Probability distribution	Method of evaluation (A, B)	Sensitivity coefficient, c_i	Uncertainty contribution, $c_i \cdot u(x_i)$, mH
L_{xm}	100.06363	$1.93 \cdot 10^{-5}$	normal	A	1	$1.93 \cdot 10^{-5}$
L_{xs}	100.03796	$1.11 \cdot 10^{-5}$	normal	A	1	$1.11 \cdot 10^{-5}$
L_{ts}	100.03460	$2.40 \cdot 10^{-4}$	normal	B	–1	$-2.40 \cdot 10^{-4}$
$\delta L_{\gamma s}$	0	$8.66 \cdot 10^{-5}$	rectangular	B	1	$8.66 \cdot 10^{-5}$
δL_c	0	$1.44 \cdot 10^{-3}$	rectangular	B	1	$1.44 \cdot 10^{-3}$
δL_f	0	$2.89 \cdot 10^{-5}$	normal	B	1	$2.89 \cdot 10^{-5}$
L_X	100.06699					
		Combined standard uncertainty			u_c	$1.466208 \cdot 10^{-3}$
		Effective degrees of freedom			ν_{eff}	> 200, $k = 2$
		Expanded uncertainty ($p \approx 95\%$)			U	0.00293242

Model equation that follows from the measurement setup:

$L_X = L_{xs} + \Delta L + \delta L_{\gamma s} + \delta L_c + \delta L_f$,

where:

$\Delta L = L_{xm} - L_{ts}$,

L_{xm} – measured value of calibrated measure of inductance;

L_{xs} – measured value of reference measure of inductance;

L_{ts} – conventional true value of standard measure;

$\delta L_{\gamma s}$ – correction for instability of reference measure;

δL_c – correction due to the error of comparator;

δL_f – correction due to the error of frequency.

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Uncertainty budget table 10 mH (2-terminal)

Quantity, X_i	Estimate, x_i, mH	+/- r, mH	Method of eva-luation (A, B)	Probability distribution	Standard uncertainty, $u(x_i)$, mH	Sensitivity coefficient c_{i}	Uncertainty contribution $c_{\mathrm{i}} \cdot u(x_{\mathrm{i}})$, *mH*
$\bar{L}_{xm}$	10.00329		A	normal	$7 \cdot 10^{-6}$	1.000023	0.000007
$\bar{L}_{xs}$	9.99627		A	normal	$8 \cdot 10^{-6}$	–1.000725	-0.000008
L_{cs}	9.9965	0.001	B	rectangular	$5 \cdot 10^{-4}$	1.000702	0.000500
δL_{γ}	0.0	0.0001	B	rectangular	$5.8 \cdot 10^{-5}$	1.000702	0.000058
L_X	10.00352						
		Combined standard uncertainty				u_{c}	$5.05 \cdot 10^{-4}$
		Effective degrees of freedom				ν_{eff}	> 200, $k = 2$
		Expanded uncertainty (p ≈ 95%)				U	0.00101

Uncertainty budget table 10 mH (3-terminal)

Quantity, X_i	Estimate, x_i, mH	+/- r, mH	Method of eva-luation (A, B)	Probability distribution	Standard uncertainty, $u(x_i)$, mH	Sensitivity coefficient, c_i	Uncertainty contribution, $c_{\mathrm{i}} \cdot u(x_{\mathrm{i}})$, mH
$\bar{L}_{xm}$	10.00309		A	normal	$7 \cdot 10^{-6}$	1.000023	0.000007
$\bar{L}_{xs}$	9.99627		A	normal	$8 \cdot 10^{-6}$	–1.000705	–0.000008
L_{cs}	9.9965	0.001	B	rectangular	$5 \cdot 10^{-4}$	1.000682	0.000500
δL_{γ}	0.0	0.0001	B	rectangular	$5.8 \cdot 10^{-5}$	1.000682	0.000058
L_X	10.00332						
		Combined standard uncertainty				u_{c}	$5.05 \cdot 10^{-4}$
		Effective degrees of freedom				ν_{eff}	> 200, $k = 2$
		Expanded uncertainty (p ≈ 95%)				U	0.00101

Uncertainty budget table 100 mH (2-terminal)

Quantity, X_i	Estimate, x_i, mH	+/- r, mH	Method of eva-luation (A, B)	Probability distribution	Standard uncertainty, $u(x_i)$, mH	Sensitivity coefficient, c_i	Uncertainty contribution, $c_i \cdot u(x_i)$, mH
$\bar{L}_{xm}$	100.0830		A	normal	$5.5 \cdot 10^{-5}$	1.000018	0.000055
$\bar{L}_{xs}$	99.9492		A	normal	$4.2 \cdot 10^{-5}$	–1.001356	–0.000042
L_{cs}	99.9510	0.01	B	rectangular	$5 \cdot 10^{-3}$	1.001338	0.005006
δL_{γ}	0.0	0.001	B	rectangular	$5.77 \cdot 10^{-4}$	1.001338	0.000578
L_X	100.0848						
		Combined standard uncertainty				u_c	$5.05 \cdot 10^{-3}$
		Effective degrees of freedom				ν_{eff}	> 200, k = 2
		Expanded uncertainty (p ≈ 95%)				U	0.0101

Uncertainty budget table 100 mH (3-terminal)

Quantity, X_i	Estimate, x_i, mH	+/- r, mH	Method of eva-luation (A, B)	Probability distribution	Standard uncertainty $u(x_i)$, mH	Sensitivity coefficient, c_i	Uncertainty contribution, $c_i \cdot u(x_i)$, mH
$\bar{L}_{xm}$	100.0630		A	normal	$5.5 \cdot 10^{-5}$	1.000018	0.000055
$\bar{L}_{xs}$	99.9492		A	normal	$4.2 \cdot 10^{-5}$	–1.001156	–0.000042
L_{cs}	99.9510	0.01	B	rectangular	$5 \cdot 10^{-3}$	1.001138	0.005006
δL_{γ}	0.0	0.001	B	rectangular	$5.77 \cdot 10^{-4}$	1.001138	0.000578
L_X	100.0648						
		Combined standard uncertainty				u_c	$5.05 \cdot 10^{-3}$
		Effective degrees of freedom				ν_{eff}	> 200, k = 2
		Expanded uncertainty (p ≈ 95%)				U	0.0101

Model equation that follows from the measurement setup:

$$L_X = \left(\left(L_{cs} + \delta L_\gamma \right) / \overline{L}_{xs} \right) \overline{L}_{xm},$$

where:

L_{cs} – the value of the standard of the calibration certificate;

$\overline{L}_{xs}$ – the arithmetic mean of the measured value of the reference standard;

$\overline{L}_{xm}$ – the arithmetic mean of the measured value traveling standard;

δL_γ – the correction to the instability of the reference standard.