COOMET.EM-S5 FINAL REPORT

SUPPLEMENTARY COMPARISON OF AC VOLTAGE RATIO STANDARDS (COOMET PROJECT 396 / UA / 07)

V.N.Kikalo, SE «Ukrmetrteststandard», Ukraine
M.L. Petrovich, BelGIM, Republic of Belarus
N.G. Lobzhanidze, GEOSTM, Georgia
V.V. Kisilev, VNIIMS, Russian Federation
R. Styblikova, CMI, Czech Republic

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State Enterprise «All-Ukrainian state research and production center for standardization, metrology, certification and consumers' rights protection»
(SE «Ukrmetrteststandard»)
Kiev– 680, Ukraine, 4, Metrologichna St., тел. +380-044-526-34-85

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Chairman of TK 1.3

_____ T. Kolomiets

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FINAL REPORT

ON SUPPLEMENTARY COMPARISON OF AC VOLTAGE RATIO STANDARDS

under COOMET № 396 / UA / 07

Pilot laboratory SE «Ukrmetrteststandard», Ukraine

Coordinator of comparisons, Deputy Head of Department for electrical quantities of SE «Ukrmetrteststandard» V.N. Kikalo

Members of comparisons:

BelGIM, Republic of Belarus;
VNIIMS, Russian Federation;
SE «Ukrmetrteststandard», Ukraine;
the Georgian National Agency for Standards, Technical Regulation and Metrology, Georgia;
CMI, Czech Republic

Kiev – 2011

ABSTRACT

The Final Report on supplementary comparisons of AC voltage ratio standards under COOMET № 396 / UA / 07 at 50 p., tables 10, figures 80, Appendix 1.

Subject of research – are national standards of AC voltage ratio of Republic of Belarus, Georgia, Russian Federation, Czech Republic and Ukraine.

Purpose of work is as follows:

– establishment of data coordination of each national standard – member of comparisons, i.e. the degree to which the value of national standard corresponds to the reference value of the supplementary comparisons with presentation of quantitative evaluation;

– confirmation of calibration and measuring capabilities of National Metrological Institutes (NMI).

Term of realization: June 2008 – July 2010.

CONTENT

INTRODUCTION

The Final Report on supplementary comparisons is prepared in accordance with COOMET Recommendations [1].

All five NMIs , taking part in comparisons, represented to SE «Ukrmetrteststandard» – the pilot laboratory, the protocols of measurements of transfer standards characteristics in accordance with technical protocol of supplementary comparisons of AC voltage ratio standards under COOMET KOOMET № 396 / UA / 07 (technical protocol) [2].

According to the results of comparisons the Report A was prepared and sent to all members of comparisons for coordination.

In the Final Report the data of measurements and final standard uncertainties of measurement results of supplementary comparisons members are given.

Processing of measurement results is carried out in accordance with COOMET Recommendations R/GM/19 [3]. For each combination of operation voltage and burden the reference values of supplementary comparisons of voltage error f_o and phase displacement δ_o as weighted mean value of the measurement results represented by NMI are calculated.

The values of distribution function χ^2 for results of measurement of voltage error χ_f^2 and phase displacement χ_δ^2 for each transformation ratio k_u at all operation voltages and burdens are determined.

All MNI's data can be found as consistent while «Decision rule» [2-3] is executed.

The received values χ_f^2 and χ_δ^2 do not exceed the critical value $\chi_{0,95}^2(n-1)$ for the confidence level 0,95 and number of degrees of freedom $(n-1)$, that is an objective evidence of declared uncertainties.

The evaluation results of comparisons data are also represented in graphical form.

1 MEMBERS OF COMPARISONS

Members of comparisons are given in the Table 1.1.

Table 1.1

Contact person	Name and address of NMI
V.N.Kikalo	SE «Ukrmetrteststandard», 03680, Kiev-680, 4, Metrologichna St., Ukraine
M.L. Petrovich	BelGIM, 220053, Minsk, 93, Starovilenskyy Trakt, Republic of Belarus
N.G. Lobzhanidze	Georgian National Agency for Standards, Technical Regulation and Metrology, 0141, Tbilisi, 67, Chargalskaya St. Georgia
V.V. Kisilev	VNIIMS, 119361, Moscow, 46, Ozernaya St. Russian Federation
Styblikova R.	CMI, Czech Metrology Institute, 150 72 Prague 5, V Botanice 4, Czech Republic

2 MEASURABLE VALUES

Two values are measured at supplementary comparisons: voltage error f_u (voltage ratio error or transformation ratio error) and phase displacement δ_u (voltage phase difference) [4].

Voltage error f_u is determined by formula, in relative units:

$$f_u = \frac{U_2 \cdot k_{Nu} - U_1}{U_1}, \tag{2.1}$$

where U_1 – true value of the primary voltage;

U_2 – true value of the secondary voltage;

$$k_{Nu} = \frac{U_{1N}}{U_{2N}} \tag{2.2}$$

– rated value of voltage transformer transformation ratio;

U_{1N} – rated value of primary voltage;

U_{2N} – rated value of the secondary voltage.

Phase displacement δ_u in absolute units is an angle between primary voltage vector U_1 and secondary voltage vector U_2 at such directional discrimination so that this angle is zero for ideal voltage transformer.

3 TRANSFER STANDARDS

Inductive voltage transformers (owned by SE «Ukrmetrteststandard») stable in time with following metrological characteristics are used as transfer standards:

– ПЭТН-6/10: primary rated voltages 6 kV and 10 kV, secondary rated voltage 100 V; burden 1,25 V·A at $\cos\varphi = 1$ and not more than 0,1 V·A;

– НЛЛ-35: primary rated voltages 22 kV and 35 kV; secondary rated voltage 100 V; burden 5 V·A at $\cos\varphi = 1$ and not more than 0,1 V·A.

4 COMPARISONS PERFORMANCE PROCEDURE

Time of measurement realization is given in the Table 4.1.

Table 4.1

NMI name, country	Period of measurements
SE «Ukrmetrteststandard», Ukraine	May 2008, April 2010
BelGIM, Republic of Belarus;	July 2009
VNIIMS, Russian Federation	December 2008
Georgian National Agency for Standards, Technical Regulation and Metrology, Georgia	June 2008
Czech Metrology Institute (CMI), Czech Republic	February-March 2010

5 NATIONAL STANDARDS

5.1 Information about the National standards are given in the Table 5.1.

Table 5.1

NMI name	Standard name	Measurement range	Expanded uncertainty
SE «Ukrmetrteststandard»	National standard unit of AC voltage in the 1 kV to $1{,}2\cdot 330/\sqrt{3}$ kV range and ratio of voltage scale transformation at frequency of 50 Hz ДЕТУ 08-05-99	$\frac{(1 \div 330/\sqrt{3})\ \text{kV}}{(100/3 \div 150)\ \text{V}}$	U_f = 0,004 %, U_δ = 0,24′
BelGIM	Reference standard unit of voltage scale transformation at frequency of 50 Hz № ИЭ РБ 11-06	$\frac{(1 \div 110)\ \text{kV}}{(100/\sqrt{3},\ 100)\ \text{V}}$	U_f = = 0,024 % - 0,17 %, U_δ = 1,8′ - 3,4′
Georgian National Agency for Standards, Technical Regulation and Metrology	National standard of Georgia of ratio and phase angle of scale transformation of sinusoidal frequency voltage 50 Hz	$\frac{100\ \text{kV}}{(100/\sqrt{3} \div 5000)\ \text{V}}$, transformation ratio from 0,1 to 10000	U_f = = 0,005 % - 0,0042 %, U_δ = $= 2\cdot 10^{-5}+0{,}1\cdot \lvert\Delta \text{tg}\delta_x\rvert$
VNIIMS	Standard installation of unit of scale transformation ratio of AC voltage of commercial frequency	(1÷350) kV, transformation ratio from 10 to 10000	U_f = 0,01 %, U_δ = 0,17′
Czech Metrology Institute	Standard voltage transformers	5; 10; 22; 35 kV/100 V	U_f = = 0,005 % - 0,007 %, U_δ =0,20′ - 0,15′

In the Table 5.1 the following symbols are used:

U_f – expanded uncertainty of scale transformation ratio of AC voltage (voltage errors) with coverage factor $k = 2$ and confidence level $P = 0{,}95$;

U_δ – expanded uncertainty of phase difference of AC voltage (phase displacement) with coverage factor $k = 2$ and confidence level $P = 0{,}95$.

5.2 Information about reproduction of measurement unit in NMI is given in the Table 5.2.

Table 5.2

NMI	Primary measurement standard	Reference measurement standard
SE «Ukrmetrteststandard»	Yes	–
BelGIM	–	Yes
Georgian National Agency for Standards, Technical Regulation and Metrology	Yes	–
VNIIMS	Yes	–
Czech Metrology Institute	–	Yes

6 METHODS AND CONDITIONS OF MEASUREMENTS

Methods and conditions of measurements are given in the Table 6.1.

Table 6.1

NMI	Method of measurement according to GOST 8.216 [5]	Temperature, ºC	Frequency, Hz	Harmonic factor, %	Burden of transfer standards			
					ПЭТН-6/10		НЛЛ-35	
					$\cos\varphi = 1$	open circuit	$\cos\varphi = 1$	open circuit
SE «Ukrmetrtest standard»	1	21±1	50±0,02	1,5±0,3	1,25 V·A	0 V·A	*5* V·A	0 V·A
BelGIM	1	24	50,0	4,8	1,25 V·A	0 V·A	5 V·A	0 V·A
Georgian National Agency for Standards, Technical Regulation and Metrology	2	21÷23	50±0,2	<5	1,25 V·A	0,01 V·A	5 V·A	0,01 V·A
VNIIMS	1	20,6	50±0,01	1,22	1,25 V·A	0,02 V·A	5 V·A	0,02 V·A
Czech Metrology Institute	1	23±0,5	50±0,2	<2	1,25 V·A	0,1 V·A	5 V·A	0,1 V·A

In the Table 6.1 the following symbols are used:
1 – comparisons with standard voltage transformers by means of voltage comparator [5];
2 – comparisons with standard capacitor by means of current comparator [5].

7 EVALUATION COMPARISONS DATA

7.1. For each combination of operation voltage and burden the reference values of supplementary comparisons is calculated as weighted mean value of the measurement results represented by NMI by formulas:

$$f_o = \frac{\sum_{L=1}^{n} f_L \cdot u^{-2}(f_L)}{\sum_{L=1}^{n} u^{-2}(f_L)}, \quad (7.1)$$

$$\delta_o = \frac{\sum_{L=1}^{n} \delta_L \cdot u^{-2}(\delta_L)}{\sum_{L=1}^{n} u^{-2}(\delta_L)}, \quad (7.2)$$

where f_o, δ_o – are the reference values of supplementary comparisons for the voltage error and phase displacement;

f_L, δ_L – are the results of measurements of the voltage error and phase displacement for each NMI, taking part in comparisons;

$u(f_L)$, $u(\delta_L)$ – are the total standard uncertainties of the voltage error and phase displacement of each NMI, taking part in comparisons;

n – number of NMIs, taking part in comparisons (n=5).

7.2 Total standard uncertainties of the reference value of supplementary comparisons for the voltage error $u(f_o)$ and phase displacement $u(\delta_o)$ are determined by formulas:

$$u(f_o) = \frac{1}{\sqrt{\sum_{L=1}^{n} u^{-2}(f_L)}}, \quad (7.3)$$

$$u(\delta_o) = \frac{1}{\sqrt{\sum_{L=1}^{n} u^{-2}(\delta_L)}}, \quad (7.4)$$

Expanded uncertainties of reference value of voltage error $U(f_o)$ and phase displacement $U(\delta_o)$ for coverage factor K = 2 at the confidence level 0,95 are determined by formulas:

$$U(f_o) = 2u(f_0), \quad (7.5)$$

$$U(\delta_o) = 2u(\delta_0). \quad (7.6)$$

7.3 Expanded uncertainties NMI on voltage error $U(f_L)$ and phase displacement $U(\delta_L)$ for coverage factor K = 2 at the confidence level 0,95 are determined by formulas:

$$U(f_L) = 2u(f_L), \quad (7.7)$$

$$U(\delta_L) = 2u(\delta_L). \quad (7.8)$$

7.4 Reference values and their uncertainties with earn confidence and supposing that it is proper to attribute the Gaussian distribution for measurement results, are characterized by distribution function χ^2. Values of this distribution function are determined for the results of voltage error χ_f^2 and phase displacement χ_δ^2 measurement for each transformation ratio k_u at all operation voltages and burdens by formulas:

$$\chi_f^2 = \sum_{L=1}^{n} \frac{(f_L - f_o)^2}{u^2(f_L)}, \tag{7.9}$$

$$\chi_\delta^2 = \sum_{L=1}^{n} \frac{(\delta_L - \delta_o)^2}{u^2(\delta_L)}. \tag{7.10}$$

7.5 Distribution function χ^2 is tabulated. For significance level 5 % according to [6] in the Table 7.1 are given the critical values $\chi_{0,95}^2(n-1)$ distribution depending on degrees of freedom.

Table 7.1

Number of degrees of freedom $(n-1)$	Critical values for $\chi_{0,95}^2(n-1)$ distribution
4	9,488
3	7,815

7.6 NMI's data can be found as consistent while «Decision rule» execution, if the received values χ_f^2 and χ_δ^2 do not exceed a critical value $\chi_{0,95}^2(n-1)$ that is an objective evidence of declared uncertainties:

$$\chi_f^2 < \chi_{0,95}^2(n-1), \tag{7.11}$$

$$\chi_\delta^2 < \chi_{0,95}^2(n-1). \tag{7.12}$$

7.7 The difference of measurement results of NMI, taking part in comparisons, and reference value of supplementary comparisons for the voltage error $\Delta(f_L)$ and phase displacement $\Delta(\delta_L)$ are determined by formulas:

$$\Delta(f_L) = f_L - f_o, \tag{7.13}$$

$$\Delta(\delta_L) = \delta_L - \delta_o. \tag{7.14}$$

Total standard uncertainty of this difference for the voltage error $u(f_L)$ and phase displacement $u(\delta_L)$ is determined by formulas:

$$u(\Delta f_L) = \sqrt{u^2(f_L) - u^2(f_o)}, \tag{7.15}$$

$$u(\Delta\delta_L) = \sqrt{u^2(\delta_L) - u^2(\delta_o)}. \tag{7.16}$$

Expanded uncertainties of this difference for the voltage error $U(\Delta f_L)$ and phase displacement $U(\Delta\delta_L)$ are determined by formulas:

$$U(\Delta f_L) = 2u(\Delta f_L), \tag{7.17}$$

$$U(\Delta\delta_L) = 2u(\Delta\delta_L). \tag{7.18}$$

8 VOLTAGE ERROR

8.1 In the Table 8.1 is given NMI's data on voltage error f_L and total standard uncertainty $u(f_L)$, reference values f_o, calculated by formula (7.1), and their uncertainties $u(f_o)$ and $U(f_o)$, calculated by formulas (7.3) and (7.5), as well as criterion value, χ_f^2 calculated by formula (7.9).

BelGIM has not presented the results of measurement of voltage error f_L and their uncertainty $u(f_L)$ for k_{Nu}=22 kV/100 V.

According to the Table 7.1 for the primary voltages 6 kV, 10 kV and 36 kV the critical value is $\chi^2_{0,95}(5-1) = 9{,}488$. For the primary voltage 22 kV the critical value is $\chi^2_{0,95}(4-1) = 7{,}815$.

All NMI's data on voltage error in the Table 8.1 is recognized as consistent.

In the Tables 8.1 – 8.2 the following symbols are used:

– UkrMTS – SE «Ukrmetrteststandard»;

– GeorgSM – Georgian National Agency for Standards, Technical Regulation and Metrology.

8.2 In the Table 8.2 is given the difference of NMI measurement results and reference value $\Delta(f_L)$ for the voltage error, calculated by the formula (7.13), and expanded uncertainty of this difference $U(f_L)$, calculated by the formulas (7.17) и (7.15).

Table 8.1 –NMI's voltage error and uncertainty and reference value, criterion value χ_f^2.

$\chi^2_{0,95}(5-1) = 9{,}488$; $\chi^2_{0,95}(4-1) = 7{,}815$.

k_u, kV/ V	Burden, V·A	U_N, %	UkrMTS		BelGIM		GeorgSM		VNIIMS		CMI		Reference value			χ_f^2
			f_L, %	$u(f_L)$, %	f_L, %	$u(f_L)$, %	f_L, %	$u(f_L)$, %	f_L, %	$u(f_L)$, %	f_L, %	$u(f_L)$, %	f_o, %	$u(f_o)$, %	$U(f_o)$, %	
6/ 100	1, 25	40	-0,028	0,002	-0,030	0,012	-0,033	0,0025	-0,0250	0,005	-0,0252	0,0035	-0,0289	0,0014	0,0027	4,626
		60	-0,028	0,002	-0,037	0,012	-0,032	0,0025	-0,0255	0,005	-0,0247	0,0030	-0,0284	0,0013	0,0027	4,485
		80	-0,027	0,002	-0,052	0,012	-0,032	0,0025	-0,0254	0,005	-0,0243	0,0025	-0,0278	0,0013	0,0025	9,239
		100	-0,027	0,002	-0,054	0,013	-0,031	0,0025	-0,0252	0,005	-0,0236	0,0025	-0,0273	0,0013	0,0025	8,798
		120	-0,027	0,002	-0,054	0,021	-0,031	0,0025	-0,0246	0,005	-0,0214	0,0025	-0,0265	0,0013	0,0026	9,323
	≤0,1	40	-0,003	0,002	-0,043	0,025	-0,007	0,0025	-0,0003	0,005	0,0005	0,0035	-0,0036	0,0014	0,0027	6,231
		60	-0,003	0,002	-0,052	0,025	-0,006	0,0025	-0,0009	0,005	0,0014	0,0030	-0,0030	0,0013	0,0027	7,609
		80	-0,002	0,002	-0,055	0,04	-0,006	0,0025	-0,0009	0,005	0,0020	0,0025	-0,0020	0,0013	0,0026	6,924
		100	-0,002	0,002	-0,067	0,05	-0,005	0,0025	-0,0006	0,005	0,0027	0,0025	-0,0015	0,0013	0,0026	6,593
		120	-0,002	0,002	-0,069	0,05	-0,005	0,0025	-0,0001	0,005	0,0027	0,0025	-0,0015	0,0013	0,0026	6,745
10/ 100	1, 25	40	-0,014	0,002	0,028	0,025	-0,018	0,0025	-0,0132	0,005	-0,0119	0,0035	-0,0147	0,0014	0,0027	5,512
		60	-0,014	0,002	0,022	0,03	-0,018	0,0025	-0,0112	0,005	-0,0110	0,0030	-0,0143	0,0013	0,0027	5,271
		80	-0,013	0,002	0,021	0,02	-0,017	0,0025	-0,0110	0,005	-0,0108	0,0025	-0,0132	0,0013	0,0026	6,360
		100	-0,013	0,002	0,086	0,065	-0,017	0,0025	-0,0113	0,005	-0,0104	0,0025	-0,0132	0,0013	0,0026	6,048
		120	-0,013	0,002	0,074	0,06	-0,017	0,0025	-0,0109	0,005	-0,0104	0,0025	-0,0132	0,0013	0,0026	5,899
	≤0,1	40	-0,001	0,002	-0,058	0,03	-0,005	0,0025	-0,0008	0,005	0,0010	0,0035	-0,0020	0,0014	0,0027	5,967
		60	-0,001	0,002	-0,064	0,035	-0,005	0,0025	0,0011	0,005	0,0017	0,0030	-0,0015	0,0013	0,0027	6,618
		80	0,000	0,002	-0,065	0,035	-0,004	0,0025	0,0014	0,005	0,0020	0,0025	-0,0005	0,0013	0,0026	6,563
		100	0,000	0,002	-0,064	0,035	-0,004	0,0025	0,0010	0,005	0,0024	0,0025	-0,0004	0,0013	0,0026	6,747
		120	0,000	0,002	-0,062	0,035	-0,004	0,0025	0,0014	0,005	0,0024	0,0025	-0,0004	0,0013	0,0026	6,595

Continued Table 8.1 – NMI's voltage error and uncertainty and reference value, criterion value χ_f^2.

$\chi^2_{0,95}(5-1) = 9{,}488$; $\chi^2_{0,95}(4-1) = 7{,}815$.

k_u, kV/ V	Burden, V·A	U_N, %	UkrMTS		BelGIM		GeorgSM		VNIIMS		CMI		Reference value			χ_f^2
			f_L, %	$u(f_L)$, %	f_L, %	$u(f_L)$, %	f_L, %	$u(f_L)$, %	f_L, %	$u(f_L)$, %	f_L, %	$u(f_L)$, %	f_o, %	$u(f_o)$, %	$U(f_o)$, %	
22/ 100	5	40	0,012	0,002	–	–	0,007	0,0021	0,0110	0,005	0,0121	0,0035	0,0101	0,0013	0,0026	3,439
		60	0,016	0,002	–	–	0,010	0,0021	0,0130	0,005	0,0164	0,0030	0,0137	0,0013	0,0025	5,256
		80	0,018	0,002	–	–	0,012	0,0021	0,0170	0,005	0,0191	0,0025	0,0162	0,0012	0,0024	6,181
		100	0,020	0,002	–	–	0,014	0,0021	0,0190	0,005	0,0205	0,0025	0,0180	0,0012	0,0024	5,667
		120	0,021	0,002	–	–	0,014	0,0021	0,0200	0,005	0,0212	0,0025	0,0186	0,0012	0,0024	7,397
	≤0,1	40	0,045	0,002	–	–	0,040	0,0021	0,0410	0,005	0,0441	0,0035	0,0427	0,0013	0,0026	3,251
		60	0,049	0,002	–	–	0,043	0,0021	0,0460	0,005	0,0486	0,0030	0,0466	0,0013	0,0025	4,837
		80	0,051	0,002	–	–	0,046	0,0021	0,0480	0,005	0,0523	0,0025	0,0495	0,0012	0,0024	4,683
		100	0,052	0,002	–	–	0,047	0,0021	0,0480	0,005	0,0537	0,0025	0,0505	0,0012	0,0024	5,229
		120	0,053	0,002	–	–	0,048	0,0021	0,0500	0,005	0,0544	0,0025	0,0515	0,0012	0,0024	4,776
35/ 100	5	40	0,010	0,002	-0,101	0,075	0,006	0,0021	0,0129	0,005	0,0126	0,0025	0,0094	0,0012	0,0024	7,006
		60	0,016	0,002	-0,103	0,06	0,012	0,0021	0,0182	0,005	0,0167	0,0025	0,0149	0,0012	0,0024	7,025
		80	0,019	0,002	-0,107	0,08	0,014	0,0021	0,0194	0,005	0,0198	0,0025	0,0175	0,0012	0,0024	6,753
		100	0,020	0,002	-0,112	0,07	0,016	0,0021	0,0221	0,005	0,0216	0,0025	0,0191	0,0012	0,0024	7,249
		120	0,021	0,002	-0,114	0,095	0,016	0,0021	0,0241	0,005	0,0225	0,0025	0,0198	0,0012	0,0024	7,523
	≤0,1	40	0,040	0,002	-0,099	0,07	0,037	0,0021	0,0413	0,005	0,0430	0,0025	0,0397	0,0012	0,0024	7,445
		60	0,046	0,002	-0,100	0,075	0,042	0,0021	0,0471	0,005	0,0473	0,0025	0,0450	0,0012	0,0024	7,051
		80	0,049	0,002	-0,102	0,075	0,045	0,0021	0,0491	0,005	0,0503	0,0025	0,0479	0,0012	0,0024	7,183
		100	0,050	0,002	-0,103	0,085	0,046	0,0021	0,0513	0,005	0,0522	0,0025	0,0492	0,0012	0,0024	7,304
		120	0,051	0,002	-0,105	0,085	0,047	0,0021	0,0534	0,005	0,0530	0,0025	0,0502	0,0012	0,0024	7,479

Table 8.2 – Difference of NMI measurement results and reference value and uncertainty of this difference for the voltage error

k_u, kV/V	Burden, V·A	U_N, %	UkrMTS		BelGIM		GeorgSM		VNIIMS		CMI	
			$\Delta(f_L)$, %	$U(\Delta f_L)$, %	$\Delta(f_L)$, %	$U(\Delta f_L)$, %	$\Delta(f_L)$, %	$U(\Delta f_L)$, %	$\Delta(f_L)$, %	$U(\Delta f_L)$, %	$\Delta(f_L)$, %	$U(\Delta f_L)$, %
6/100	1,25	40	0,0009	0,0029	-0,0011	0,0238	-0,0041	0,0041	0,0039	0,0096	0,0037	0,0064
		60	0,0004	0,0030	-0,0086	0,0239	-0,0036	0,0043	0,0029	0,0097	0,0037	0,0054
		80	0,0008	0,0030	-0,0242	0,0239	-0,0042	0,0043	0,0024	0,0097	0,0035	0,0043
		100	0,0003	0,0030	-0,0267	0,0259	-0,0037	0,0043	0,0021	0,0097	0,0037	0,0043
		120	-0,0005	0,0030	-0,0275	0,0419	-0,0045	0,0043	0,0019	0,0097	0,0051	0,0043
	≤0,1	40	0,0006	0,0029	-0,0394	0,0499	-0,0034	0,0041	0,0033	0,0096	0,0041	0,0064
		60	0,0000	0,0030	-0,0490	0,0499	-0,0030	0,0043	0,0021	0,0097	0,0044	0,0054
		80	0,0000	0,0030	-0,0530	0,0800	-0,0040	0,0043	0,0011	0,0097	0,0040	0,0043
		100	-0,0005	0,0030	-0,0655	0,1000	-0,0035	0,0043	0,0009	0,0097	0,0042	0,0043
		120	-0,0005	0,0030	-0,0675	0,1000	-0,0035	0,0043	0,0014	0,0097	0,0042	0,0043
10/100	1,25	40	0,0007	0,0029	0,0427	0,0499	-0,0033	0,0041	0,0015	0,0096	0,0028	0,0064
		60	0,0003	0,0030	0,0363	0,0599	-0,0037	0,0043	0,0031	0,0097	0,0033	0,0054
		80	0,0002	0,0030	0,0342	0,0399	-0,0038	0,0043	0,0022	0,0097	0,0024	0,0043
		100	0,0002	0,0030	0,0992	0,1300	-0,0038	0,0043	0,0019	0,0097	0,0028	0,0043
		120	0,0002	0,0030	0,0872	0,1200	-0,0038	0,0043	0,0023	0,0097	0,0028	0,0043
	≤0,1	40	0,0010	0,0029	-0,0560	0,0599	-0,0030	0,0041	0,0012	0,0096	0,0030	0,0064
		60	0,0005	0,0030	-0,0625	0,0700	-0,0035	0,0043	0,0026	0,0097	0,0032	0,0054
		80	0,0005	0,0030	-0,0645	0,0700	-0,0035	0,0043	0,0019	0,0097	0,0025	0,0043
		100	0,0004	0,0030	-0,0636	0,0700	-0,0036	0,0043	0,0014	0,0097	0,0028	0,0043
		120	0,0004	0,0030	-0,0616	0,0700	-0,0036	0,0043	0,0018	0,0097	0,0028	0,0043

Continued Table 8.2 – Difference of NMI measurement results and reference value and uncertainty of this difference for the voltage error

k_u, kV/V	Burden, V·A	U_N, %	UkrMTS		BelGIM		GeorgSM		VNIIMS		CMI	
			$\Delta(f_L)$, %	$U(\Delta f_L)$, %	$\Delta(f_L)$, %	$U(\Delta f_L)$, %	$\Delta(f_L)$, %	$U(\Delta f_L)$, %	$\Delta(f_L)$, %	$U(\Delta f_L)$, %	$\Delta(f_L)$, %	$U(\Delta f_L)$, %
22/100	5	40	0,0019	0,0030	–	–	-0,0031	0,0033	0,0009	0,0097	0,0020	0,0065
		60	0,0023	0,0030	–	–	-0,0037	0,0033	-0,0007	0,0097	0,0027	0,0054
		80	0,0018	0,0032	–	–	-0,0042	0,0034	0,0008	0,0097	0,0029	0,0044
		100	0,0020	0,0032	–	–	-0,0040	0,0034	0,0010	0,0097	0,0025	0,0044
		120	0,0024	0,0032	–	–	-0,0046	0,0034	0,0014	0,0097	0,0026	0,0044
	≤0,1	40	0,0023	0,0030	–	–	-0,0027	0,0033	-0,0017	0,0097	0,0014	0,0065
		60	0,0024	0,0030	–	–	-0,0036	0,0033	-0,0006	0,0097	0,0020	0,0054
		80	0,0015	0,0032	–	–	-0,0035	0,0034	-0,0015	0,0097	0,0028	0,0044
		100	0,0015	0,0032	–	–	-0,0035	0,0034	-0,0025	0,0097	0,0032	0,0044
		120	0,0015	0,0032	–	–	-0,0035	0,0034	-0,0015	0,0097	0,0029	0,0044
35/100	5	40	0,0006	0,0032	-0,1104	0,1500	-0,0034	0,0034	0,0035	0,0097	0,0032	0,0044
		60	0,0011	0,0032	-0,1179	0,1200	-0,0029	0,0034	0,0033	0,0097	0,0018	0,0044
		80	0,0015	0,0032	-0,1245	0,1600	-0,0035	0,0034	0,0019	0,0097	0,0023	0,0044
		100	0,0009	0,0032	-0,1311	0,1400	-0,0031	0,0034	0,0030	0,0097	0,0025	0,0044
		120	0,0012	0,0032	-0,1338	0,1900	-0,0038	0,0034	0,0043	0,0097	0,0027	0,0044
	≤0,1	40	0,0003	0,0032	-0,1387	0,1400	-0,0027	0,0034	0,0016	0,0097	0,0033	0,0044
		60	0,0010	0,0032	-0,1450	0,1500	-0,0030	0,0034	0,0021	0,0097	0,0023	0,0044
		80	0,0011	0,0032	-0,1499	0,1500	-0,0029	0,0034	0,0012	0,0097	0,0024	0,0044
		100	0,0008	0,0032	-0,1522	0,1700	-0,0032	0,0034	0,0021	0,0097	0,0030	0,0044
		120	0,0008	0,0032	-0,1552	0,1700	-0,0032	0,0034	0,0032	0,0097	0,0028	0,0044

9 PHASE DISPLACEMENT

9.1 In the Table 9.1 is given NMI's data on phase displacement δ_L and total standard uncertainty $u(\delta_L)$, reference values δ_o, calculated by formula (7.2), and their uncertainties $u(\delta_o)$ and $U(\delta_o)$, calculated by formulas (7.4) and (7.6), as well as criterion value χ^2_δ, calculated by formula (7.10).

BelGIM has not presented the results of measurement of phase displacement δ_L and their uncertainty $u(\delta_L)$ for k_{Nu} = 22 kV/100 V.

According to the Table 7.1 for the primary voltages 6 kV, 10 kV и 36 kV the critical value is $\chi^2_{0,95}(5-1) = 9{,}488$.

For the primary voltage 22 kV the critical value is $\chi^2_{0,95}(4-1) = 7{,}815$.

NMI's data on phase displacement in the Table 9.1 is recognized as consistent.

In the Tables 9.1 – 9.2 the following symbols are used:

– UkrMTS – SE «Ukrmetrteststandard»;

– GeorgSM – Georgian National Agency for Standards, Technical Regulation and Metrology;

– min. – minutes.

9.2 In the Table 9.2 is given the difference of NMI measurement results and reference value of supplementary comparisons $\Delta(\delta_L)$ for the phase displacement, calculated by formula (7.14), and expanded uncertainty of this difference $U(\Delta\delta_L)$, calculated by formulas (7.18) and (7.16).

Table 9.1 – NMI's phase displacement and uncertainty and reference value, criterion value χ^2_δ.

$\chi^2_{0,95}(5-1) = 9{,}488$; $\chi^2_{0,95}(4-1) = 7{,}815$.

k_u, kV/ V	Burden, V·A	U_N, %	UkrMTS		BelGIM		GeorgSM		VNIIMS		CMI		Reference value			χ^2_δ
			δ_L, min.	$u(\delta_L)$, min.	δ_L, min.	$u(\delta_L)$, min.	δ_L, min.	$u(\delta_L)$, min.	δ_L, min.	$u(\delta_L)$, min.	δ_L, min.	$u(\delta_L)$, min.	δ_o, min.	$u(\delta_o)$, min.	$U(\delta_o)$, min.	
6/ 100	1, 25	40	0,10	0,12	2,1	1	0,04	0,07	0,14	0,085	0,123	0,100	0,095	0,044	0,088	4,998
		60	0,03	0,12	2,3	1,2	-0,02	0,07	0,15	0,085	0,057	0,100	0,051	0,044	0,088	5,932
		80	-0,01	0,12	2,4	1,2	-0,07	0,08	0,16	0,085	0,015	0,075	0,027	0,043	0,086	7,950
		100	-0,04	0,12	2,4	1,2	-0,11	0,08	0,15	0,085	-0,018	0,075	-0,001	0,043	0,086	9,173
		120	-0,06	0,12	2,4	1,3	-0,13	0,08	0,14	0,085	-0,040	0,075	-0,020	0,043	0,086	9,081
	≤0,1	40	0,28	0,12	2,0	0,9	0,22	0,09	0,29	0,085	0,288	0,100	0,273	0,048	0,096	4,095
		60	0,21	0,12	2,2	1	0,15	0,08	0,31	0,085	0,221	0,100	0,226	0,046	0,093	5,796
		80	0,16	0,12	2,4	1,1	0,10	0,08	0,32	0,085	0,181	0,075	0,194	0,043	0,086	7,710
		100	0,13	0,12	2,4	1,2	0,07	0,08	0,31	0,085	0,150	0,075	0,168	0,043	0,086	7,909
		120	0,11	0,12	2,4	1,4	0,04	0,07	0,32	0,085	0,126	0,075	0,142	0,041	0,082	9,227
10/ 100	1, 25	40	0,11	0,12	3,1	1,5	0,05	0,08	0,23	0,085	0,163	0,100	0,140	0,046	0,093	6,396
		60	0,04	0,12	3,3	1,7	-0,02	0,07	0,12	0,085	0,104	0,100	0,052	0,044	0,088	5,629
		80	0,01	0,12	3,3	1,7	-0,06	0,08	0,01	0,085	0,068	0,075	0,011	0,043	0,086	5,109
		100	-0,01	0,12	3,2	1,6	-0,09	0,08	0,0	0,085	0,060	0,075	-0,005	0,043	0,086	5,898
		120	-0,01	0,12	2,8	1,5	-0,09	0,08	-0,03	0,085	0,054	0,075	-0,015	0,043	0,086	5,280
	≤0,1	40	0,17	0,12	2,0	1	0,11	0,08	0,29	0,085	0,158	0,100	0,187	0,046	0,093	5,786
		60	0,10	0,12	2,2	1,1	0,05	0,07	0,18	0,085	0,161	0,100	0,117	0,044	0,088	5,265
		80	0,07	0,12	2,2	1,1	0,01	0,07	0,07	0,085	0,126	0,075	0,069	0,041	0,082	5,041
		100	0,05	0,12	2,1	1,1	-0,02	0,07	0,06	0,085	0,119	0,075	0,052	0,041	0,082	5,331
		120	0,05	0,12	1,8	0,9	-0,01	0,07	0,03	0,085	0,117	0,075	0,048	0,041	0,082	5,367

Continued Table 9.1 - NMI's phase displacement and uncertainty and reference value, criterion value χ^2_δ.

$\chi^2_{0,95}(5-1) = 9{,}488$; $\chi^2_{0,95}(4-1) = 7{,}815$.

k_u, kV/ V	Burden, V·A	U_N, %	UkrMTS		BelGIM		GeorgSM		VNIIMS		CMI		Reference value			χ^2_δ
			δ_L, min.	$u(\delta_L)$, min.	δ_L, min.	$u(\delta_L)$, min.	δ_L, min.	$u(\delta_L)$, min.	δ_L, min.	$u(\delta_L)$, min.	δ_L, min.	$u(\delta_L)$, min.	δ_o, min.	$u(\delta_o)$, min.	$U(\delta_o)$, min.	
22/ 100	5	40	-1,41	0,12	–	–	-1,61	0,23	-1,45	0,085	-1,313	0,100	-1,409	0,055	0,111	1,918
		60	-1,50	0,12	–	–	-1,69	0,24	-1,50	0,085	-1,463	0,100	-1,499	0,055	0,111	0,763
		80	-1,57	0,12	–	–	-1,72	0,24	-1,50	0,085	-1,516	0,075	-1,529	0,050	0,100	0,896
		100	-1,59	0,12	–	–	-1,74	0,24	-1,50	0,085	-1,553	0,075	-1,549	0,050	0,100	1,085
		120	-1,60	0,12	–	–	-1,74	0,24	-1,50	0,085	-1,592	0,075	-1,568	0,050	0,100	1,327
	≤0,1	40	-0,80	0,12	–	–	-0,97	0,16	-1,00	0,085	-0,736	0,100	-0,880	0,054	0,107	4,827
		60	-0,90	0,12	–	–	-1,06	0,18	-1,10	0,085	-0,877	0,100	-0,990	0,054	0,109	3,665
		80	-0,96	0,12	–	–	-1,10	0,18	-1,20	0,085	-0,918	0,075	-1,032	0,049	0,098	6,720
		100	-1,00	0,12	–	–	-1,12	0,18	-1,20	0,085	-0,945	0,075	-1,052	0,049	0,098	5,398
		120	-0,99	0,12	–	–	-1,13	0,18	-1,20	0,085	-0,979	0,075	-1,065	0,049	0,098	4,358
35/ 100	5	40	-1,22	0,12	1,6	1,4	-1,35	0,20	-1,16	0,085	-1,040	0,075	-1,126	0,049	0,099	7,134
		60	-1,26	0,12	1,7	1,5	-1,40	0,21	-1,16	0,085	-1,140	0,075	-1,178	0,049	0,099	5,567
		80	-1,26	0,12	1,7	1,5	-1,40	0,21	-1,13	0,085	-1,160	0,075	-1,177	0,049	0,099	5,642
		100	-1,27	0,12	1,7	1,5	-1,37	0,20	-1,12	0,085	-1,168	0,075	-1,178	0,049	0,099	5,674
		120	-1,25	0,12	1,8	1,5	-1,35	0,20	-1,11	0,085	-1,153	0,075	-1,164	0,049	0,099	5,708
	≤0,1	40	-0,28	0,12	1,2	0,8	-0,42	0,11	-0,24	0,085	-0,120	0,075	-0,227	0,046	0,092	8,514
		60	-0,33	0,12	1,3	0,8	-0,46	0,11	-0,24	0,085	-0,209	0,075	-0,275	0,046	0,092	7,858
		80	-0,35	0,12	1,4	0,9	-0,46	0,12	-0,22	0,085	-0,227	0,075	-0,275	0,047	0,094	7,059
		100	-0,34	0,12	1,4	0,9	-0,44	0,11	-0,20	0,085	-0,240	0,075	-0,274	0,046	0,092	7,003
		120	-0,32	0,12	1,4	0,9	-0,41	0,11	-0,19	0,085	-0,228	0,075	-0,258	0,046	0,092	6,370

Table 9.2 – Difference of NMI measurement results and reference value o and uncertainty of this difference for the phase displacement

k_u, kV/V	Burden, V·A	U_N, %	UkrMTS		BelGIM		GeorgSM		VNIIMS		CMI	
			$\Delta(\delta_L)$, min.	$U(\Delta\delta_L)$, min.	$\Delta(\delta_L)$, min.	$U(\Delta\delta_L)$, min.	$\Delta(\delta_L)$, min.	$U(\Delta\delta_L)$, min.	$\Delta(\delta_L)$, min.	$U(\Delta\delta_L)$, min.	$\Delta(\delta_L)$, min.	$U(\Delta\delta_L)$, min.
6/100	1,25	40	0,005	0,223	2,005	1,998	-0,055	0,109	0,045	0,145	0,028	0,180
		60	-0,021	0,223	2,249	2,398	-0,071	0,109	0,099	0,145	0,006	0,180
		80	-0,037	0,224	2,373	2,398	-0,097	0,135	0,133	0,147	-0,012	0,123
		100	-0,039	0,224	2,401	2,398	-0,109	0,135	0,151	0,147	-0,017	0,123
		120	-0,040	0,224	2,420	2,599	-0,110	0,135	0,160	0,147	-0,020	0,123
	≤0,1	40	0,007	0,220	1,727	1,797	-0,053	0,152	0,017	0,140	0,015	0,175
		60	-0,016	0,222	1,974	1,998	-0,076	0,131	0,084	0,143	-0,005	0,178
		80	-0,034	0,224	2,206	2,198	-0,094	0,135	0,126	0,147	-0,013	0,123
		100	-0,038	0,224	2,232	2,398	-0,098	0,135	0,142	0,147	-0,018	0,123
		120	-0,032	0,226	2,258	2,799	-0,102	0,113	0,178	0,149	-0,016	0,126
10/100	1,25	40	-0,030	0,222	2,960	2,999	-0,090	0,131	0,090	0,143	0,023	0,178
		60	-0,012	0,223	3,248	3,399	-0,072	0,109	0,068	0,145	0,052	0,180
		80	-0,001	0,224	3,289	3,399	-0,071	0,135	-0,001	0,147	0,057	0,123
		100	-0,005	0,224	3,205	3,199	-0,085	0,135	0,005	0,147	0,065	0,123
		120	0,005	0,224	2,815	2,999	-0,075	0,135	-0,015	0,147	0,069	0,123
	≤0,1	40	-0,017	0,222	1,813	1,998	-0,077	0,131	0,103	0,143	-0,029	0,178
		60	-0,017	0,223	2,083	2,198	-0,067	0,109	0,063	0,145	0,044	0,180
		80	0,001	0,226	2,131	2,198	-0,059	0,113	0,001	0,149	0,057	0,126
		100	-0,002	0,226	2,048	2,198	-0,072	0,113	0,008	0,149	0,067	0,126
		120	0,002	0,226	1,752	1,798	-0,058	0,113	-0,018	0,149	0,069	0,126

Continued Table 9.2 – Difference of NMI measurement results and reference value and uncertainty of this difference for the phase displacement

k_u, kV/V	Burden, V·A	U_N, %	UkrMTS		BelGIM		GeorgSM		VNIIMS		CMI	
			$\Delta(\delta_L)$, min.	$U(\Delta\delta_L)$, min.	$\Delta(\delta_L)$, min.	$U(\Delta\delta_L)$, min.	$\Delta(\delta_L)$, min.	$U(\Delta\delta_L)$, min.	$\Delta(\delta_L)$, min.	$U(\Delta\delta_L)$, min.	$\Delta(\delta_L)$, min.	$U(\Delta\delta_L)$, min.
22/100	5	40	-0,001	0,213	–	–	-0,201	0,447	-0,041	0,130	0,096	0,167
		60	-0,001	0,213	–	–	-0,191	0,467	-0,001	0,130	0,036	0,167
		80	-0,041	0,218	–	–	-0,191	0,469	0,029	0,137	0,013	0,112
		100	-0,041	0,218	–	–	-0,191	0,469	0,049	0,137	-0,004	0,112
		120	-0,032	0,218	–	–	-0,172	0,469	0,068	0,137	-0,024	0,112
	≤0,1	40	0,080	0,214	–	–	-0,090	0,301	-0,120	0,131	0,144	0,168
		60	0,090	0,214	–	–	-0,070	0,343	-0,110	0,131	0,113	0,168
		80	0,072	0,219	–	–	-0,068	0,346	-0,168	0,139	0,114	0,114
		100	0,052	0,219	–	–	-0,068	0,346	-0,148	0,139	0,107	0,114
		120	0,075	0,219	–	–	-0,065	0,346	-0,135	0,139	0,086	0,114
35/100	5	40	-0,094	0,219	2,726	2,798	-0,224	0,388	-0,034	0,139	0,086	0,114
		60	-0,082	0,219	2,878	2,998	-0,222	0,408	0,018	0,139	0,038	0,114
		80	-0,083	0,219	2,877	2,998	-0,223	0,408	0,047	0,139	0,017	0,114
		100	-0,092	0,219	2,878	2,998	-0,192	0,388	0,058	0,139	0,010	0,114
		120	-0,086	0,219	2,964	2,998	-0,186	0,388	0,054	0,139	0,011	0,114
	≤0,1	40	-0,053	0,222	1,427	1,597	-0,193	0,200	-0,013	0,143	0,107	0,118
		60	-0,055	0,222	1,575	1,597	-0,185	0,200	0,035	0,143	0,066	0,118
		80	-0,075	0,221	1,675	1,798	-0,185	0,221	0,055	0,142	0,048	0,117
		100	-0,066	0,222	1,674	1,798	-0,166	0,200	0,074	0,143	0,034	0,118
		120	-0,062	0,222	1,658	1,798	-0,152	0,200	0,068	0,143	0,030	0,118

10 PRESENTATION OF EVALUATION RESULTS OF COMPARISONS DATA IN GRAPHICAL FORM

10.1 Presentation of evaluation results of comparisons data in graphical form are given in the Appendix A in figures 1 – 80.

10.2 In the figures the following symbols are used:

– UkrMTS – SE «Ukrmetrteststandard»;

– GeorgSM – Georgian National Agency for Standards, Technical Regulation and Metrology.

CONCLUSION

1 Five NMIs have participated in comparisons.

2 In the Final Report is given all data on measurement results and declared uncertainties, presented by NMIs – members of comparisons.

3 BelGIM has not presented the measurement results for voltage ratio k_{Nu} = 22 kV/100 V.

4 The evaluation results of comparisons data was performed in accordance with [3]. For all voltage values, specified in the technical protocol of comparisons, were determined values of distribution function χ^2 and critical values $\chi^2_{0,95}(n-1)$ for the significance level 0,95 and degree of freedom (n–1). It was determined that all received values χ^2_f and χ^2_δ do not exceed the critical values $\chi^2_{0,95}(n-1)$.

5 All data presented by NMIs – members of comparisons, is recognized as consistent that is an objective evidence of declared uncertainties. This is also an evidence of corresponding measuring and calibration capabilities for those values of voltage ratio, at which NMIs have performed measurements of transfer standard characteristics while comparisons.

REFERENCES

1 COOMET R/GM/11:2010. COOMET Recommendations. Regulation on Standards Comparison of National Metrological Institutes of COOMET.

2 Technical Protocol of Supplementary Comparisons of AC voltage ratio standards under COOMET № 396 / UA / 07. Version № 2 of September 22, 2009.

3 COOMET R/GM/19:2008 Guide on Supplementary Comparisons Data Evaluation of COOMET.

4 IEC 60044-2:2003. Instrument transformers. Part 2: Inductive voltage transformers.

5 GOST 8.216-88. GSI. Voltage transformers. Calibration Method**.**

6 Rabinovich S.G. Measurement uncertainties. – L.: Energiya. 1978. – 262 p.

Appendix A

Evaluation results of comparison data in the graphic form

6 kV/100 V, 0,4 U_N, S=1,25 V·A	$\Delta(f_L)$, %	$U(\Delta f_L)$,, %
UkrMTS	0,0009	0,0029
BelGIM	-0,0011	0,0238
GeorgMS	-0,0041	0,0041
VNIIMS	0,0039	0,0096
CMI	0,0037	0,0064
Reference value	0,0000	0,0027

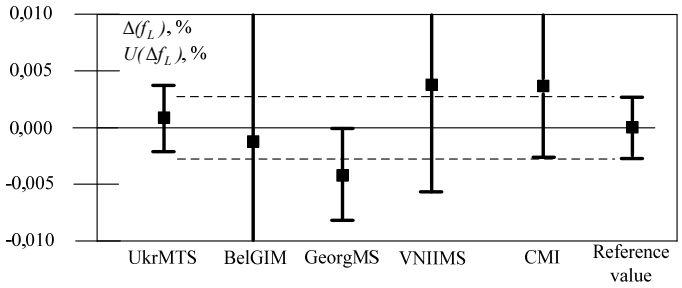

Figure 1 – Difference of NMI measurement results and reference value for the voltage error $\Delta(f_L)$ and expanded uncertainty of this difference $U(\Delta f_L)$ for k_{Nu} = 6 kV/100 V at 0,4 U_N and burden of 1,25 V·A

6 kV/100 V, 0,6 U_N, S=1,25 V·A	$\Delta(f_L)$, %	$U(\Delta f_L)$, %
UkrMTS	0,0004	0,0030
BelGIM	-0,0086	0,0239
GeorgMS	-0,0036	0,0043
VNIIMS	0,0029	0,0097
CMI	0,0037	0,0054
Reference value	0,0000	0,0027

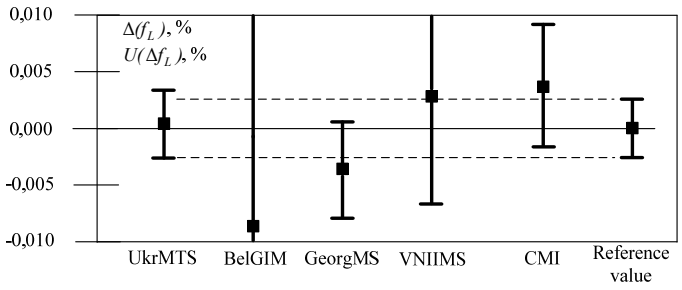

Figure 2 – Difference of NMI measurement results and reference value for the voltage error $\Delta(f_L)$ and expanded uncertainty of this difference $U(\Delta f_L)$ for k_{Nu} = 6 kV/100 V at 0,6 U_N and burden of 1,25 V·A

6 kV/100 V, 0,8 U_N, S=1,25 V·A	$\Delta(f_L)$, %	$U(\Delta f_L)$, %
UkrMTS	0,0008	0,0030
BelGIM	-0,0242	0,0239
GeorgMS	-0,0042	0,0043
VNIIMS	0,0024	0,0097
CMI	0,0035	0,0043
Reference value	0,0000	0,0025

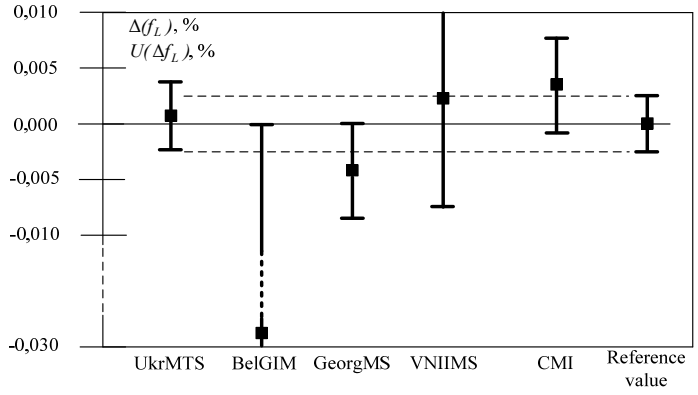

Figure 3 – Difference of NMI measurement results and reference value for the voltage error $\Delta(f_L)$ and expanded uncertainty of this difference $U(\Delta f_L)$ for k_{Nu} = 6 kV/100 V at 0,8 U_N and burden of 1,25 V·A

6 kV/100 V, U_N, S=1,25 V·A	$\Delta(f_L)$, %	$U(\Delta f_L)$, %
UkrMTS	0,0003	0,0030
BelGIM	-0,0267	0,0259
GeorgMS	-0,0037	0,0043
VNIIMS	0,0021	0,0097
CMI	0,0037	0,0043
Reference value	0,0000	0,0025

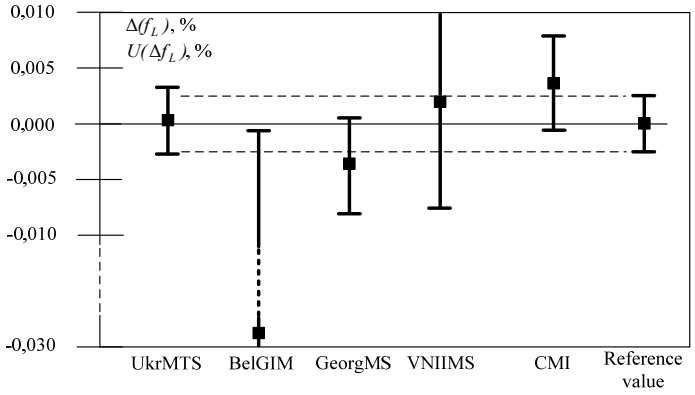

Figure 4 – Difference of NMI measurement results and reference value for the voltage error $\Delta(f_L)$ and expanded uncertainty of this difference $U(\Delta f_L)$ for k_{Nu} = 6 kV/100 V at U_N and burden of 1,25 V·A

6 kV/100 V, 1,2 U_N, S=1,25 V·A	$\Delta(f_L)$, %	$U(\Delta f_L)$, %
UkrMTS	-0,0005	0,0030
BelGIM	-0,0275	0,0419
GeorgMS	-0,0045	0,0043
VNIIMS	0,0019	0,0097
CMI	0,0051	0,0043
Reference value	0,0000	0,0026

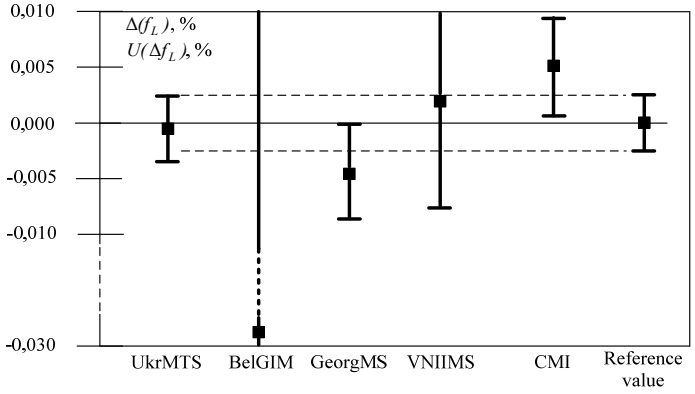

Figure 5 – Difference of NMI measurement results and reference value for the voltage error $\Delta(f_L)$ and expanded uncertainty of this difference $U(\Delta f_L)$ for k_{Nu} = 6 kV/100 V at 1,2 U_N and burden of 1,25 V·A

6 kV/100 V, 0,4 U_N, S≤0,1 V·A	$\Delta(f_L)$, %	$U(\Delta f_L)$, %
UkrMTS	0,0006	0,0029
BelGIM	-0,0394	0,0499
GeorgMS	-0,0034	0,0041
VNIIMS	0,0033	0,0096
CMI	0,0041	0,0064
Reference value	0,0000	0,0027

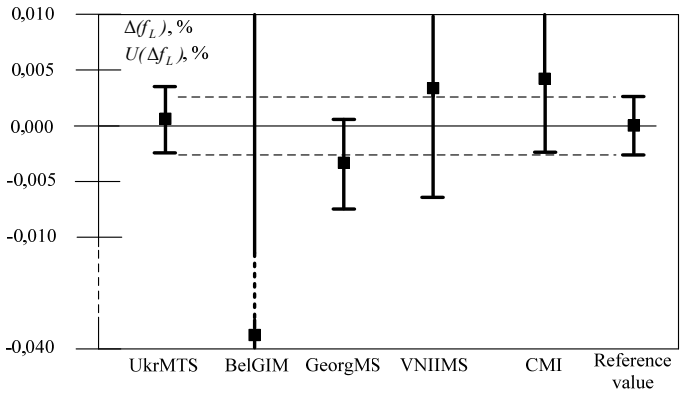

Figure 6 – Difference of NMI measurement results and reference value for the voltage error $\Delta(f_L)$ and expanded uncertainty of this difference $U(\Delta f_L)$ for k_{Nu} = 6 kV/100 V at 0,4 U_N and burden of ≤0,1 V·A

6 kV/100 V, 0,6 U_N, S≤0,1 V·A	$\Delta(f_L)$, %	$U(\Delta f_L)$, %
UkrMTS	0,0000	0,0030
BelGIM	-0,0490	0,0499
GeorgMS	-0,0030	0,0043
VNIIMS	0,0021	0,0097
CMI	0,0044	0,0054
Reference value	0,0000	0,0027

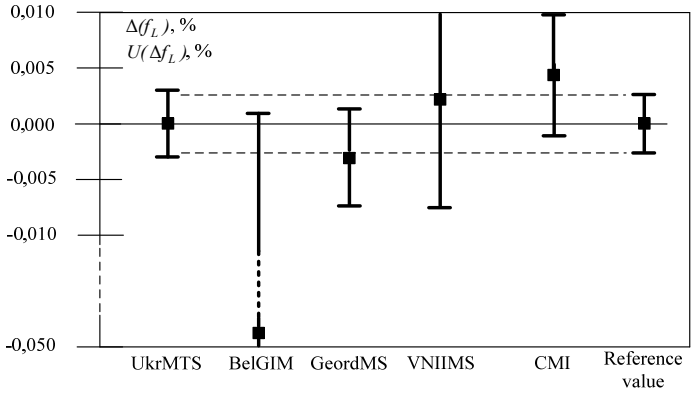

Figure 7 – Difference of NMI measurement results and reference value for the voltage error $\Delta(f_L)$ and expanded uncertainty of this difference $U(\Delta f_L)$ for k_{Nu} = 6 kV/100 V at 0,6 U_N and burden of ≤0,1 V·A

6 kV/100 V, 0,8 U_N, S≤0,1 V·A	$\Delta(f_L)$, %	$U(\Delta f_L)$, %
UkrMTS	0,0000	0,0030
BelGIM	-0,0530	0,0800
GeorgMS	-0,0040	0,0043
VNIIMS	0,0011	0,0097
CMI	0,0040	0,0043
Reference value	0,0000	0,0026

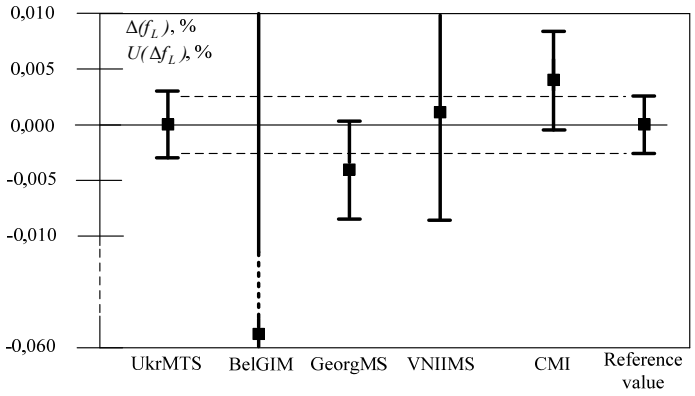

Figure 8 – Difference of NMI measurement results and reference value for the voltage error $\Delta(f_L)$ and expanded uncertainty of this difference $U(\Delta f_L)$ for k_{Nu} = 6 kV/100 V at 0,8 U_N and burden of ≤0,1 V·A

6 kV/100 V, U_N, S≤0,1 V·A	$\Delta(f_L)$, %	$U(\Delta f_L)$, %
UkrMTS	-0,0005	0,0030
BelGIM	-0,0655	0,1000
GeorgMS	-0,0035	0,0043
VNIIMS	0,0009	0,0097
CMI	0,0042	0,0043
Reference value	0,0000	0,0026

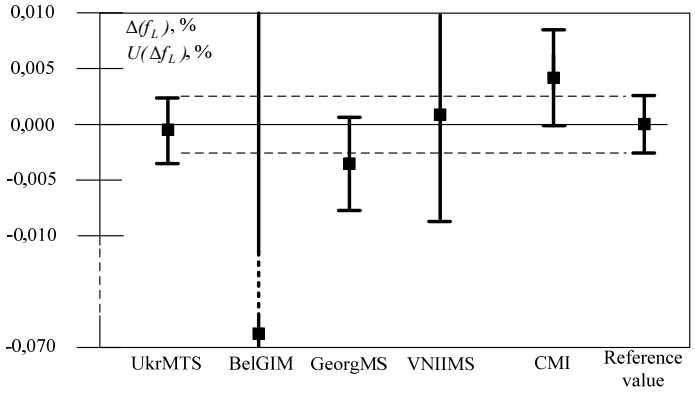

Figure 9 – Difference of NMI measurement results and reference value for the voltage error $\Delta(f_L)$ and expanded uncertainty of this difference $U(\Delta f_L)$ for k_{Nu} = 6 kV/100 V at U_N and burden of ≤0,1 V·A

6 kV/100 V, 1,2 U_N, S≤0,1 V·A	$\Delta(f_L)$, %	$U(\Delta f_L)$, %
UkrMTS	-0,0005	0,0030
BelGIM	-0,0675	0,1000
GeorgMS	-0,0035	0,0043
VNIIMS	0,0014	0,0097
CMI	0,0042	0,0043
Reference value	0,0000	0,0026

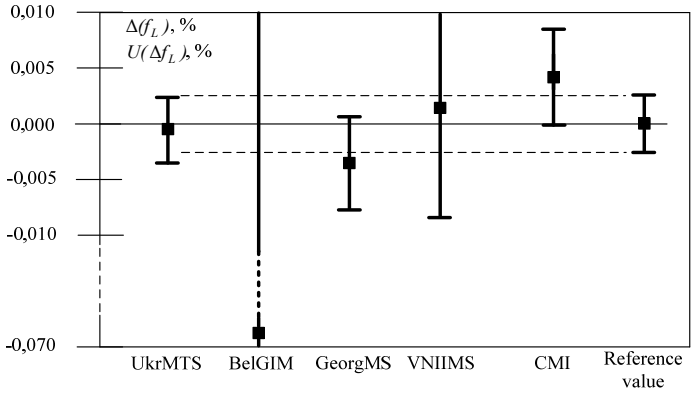

Figure 10 – Difference of NMI measurement results and reference value for the voltage error $\Delta(f_L)$ and expanded uncertainty of this difference $U(\Delta f_L)$ for k_{Nu} = 6 kV/100 V at 1,2 U_N and burden of ≤0,1 V·A

10 kV/100 V, 0,4 U_N, S=1,25 V·A	$\Delta(f_L)$, %	$U(\Delta f_L)$, %
UkrMTS	0,0007	0,0029
BelGIM	0,0427	0,0499
GeorgMS	-0,0033	0,0041
VNIIMS	0,0015	0,0096
CMI	0,0028	0,0064
Reference value	0,0000	0,0027

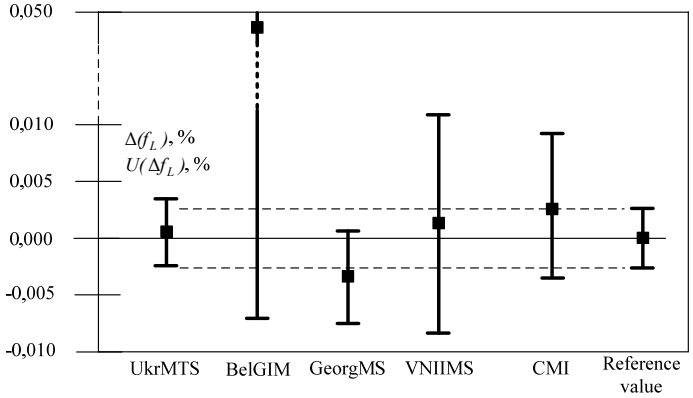

Figure 11 – Difference of NMI measurement results and reference value for the voltage error $\Delta(f_L)$ and expanded uncertainty of this difference $U(\Delta f_L)$ for k_{Nu} = 10 kV/100 V at 0,4 U_N and burden of 1,25 V·A

10 kV/100 V, 0,6 U_N, S=1,25 V·A	$\Delta(f_L)$, %	$U(\Delta f_L)$, %
UkrMTS	0,0003	0,0030
BelGIM	0,0363	0,0599
GeorgMS	-0,0037	0,0043
VNIIMS	0,0031	0,0097
CMI	0,0033	0,0054
Reference value	0,0000	0,0027

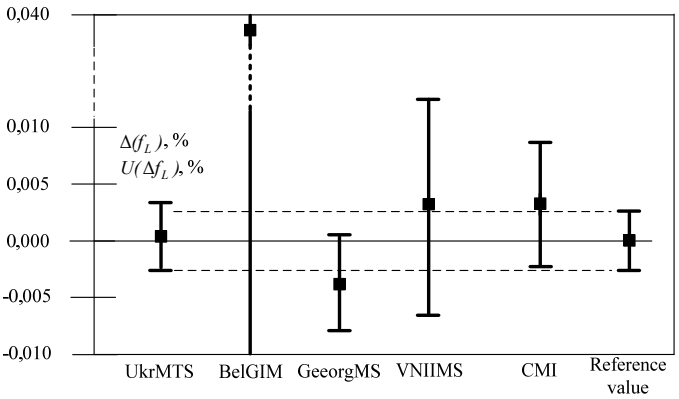

Figure 12 – Difference of NMI measurement results and reference value for the voltage error $\Delta(f_L)$ and expanded uncertainty of this difference $U(\Delta f_L)$ for k_{Nu} = 10 kV/100 V at 0,6 U_N and burden of 1,25 V·A

10 kV/100 V, 0,8 U_N, S=1,25 V·A	$\Delta(f_L)$, %	$U(\Delta f_L)$, %
UkrMTS	0,0002	0,0030
BelGIM	0,0342	0,0399
GeorgMS	-0,0038	0,0043
VNIIMS	0,0022	0,0097
CMI	0,0024	0,0043
Reference value	0,0000	0,0026

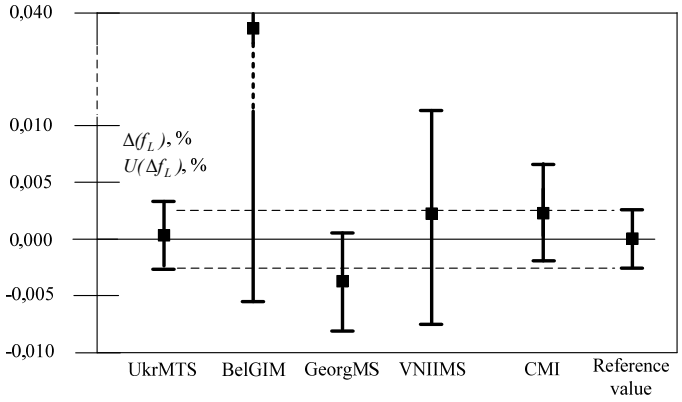

Figure 13 – Difference of NMI measurement results and reference value for the voltage error $\Delta(f_L)$ and expanded uncertainty of this difference $U(\Delta f_L)$ for k_{Nu} = 10 kV/100 V at 0,8 U_N and burden of 1,25 V·A

10 kV/100 V, U_N, S=1,25 V·A	$\Delta(f_L)$, %	$U(\Delta f_L)$, %
UkrMTS	0,0002	0,0030
BelGIM	0,0992	0,1300
GeorgMS	-0,0038	0,0043
VNIIMS	0,0019	0,0097
CMI	0,0028	0,0043
Reference value	0,0000	0,0026

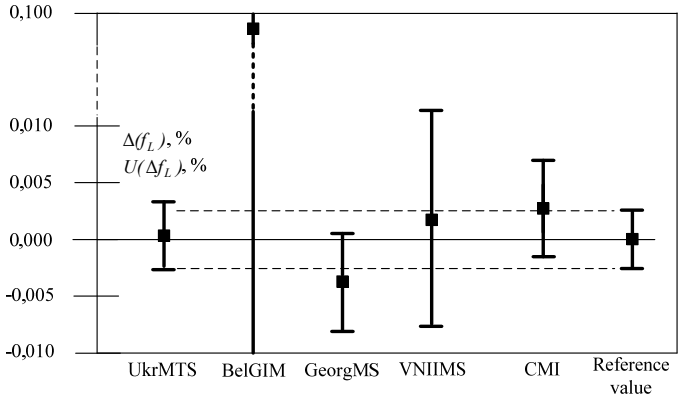

Figure 14 – Difference of NMI measurement results and reference value for the voltage error $\Delta(f_L)$ and expanded uncertainty of this difference $U(\Delta f_L)$ for k_{Nu} = 10 kV/100 V at U_N and burden of 1,25 V·A

10 kV/100 V, 1,2 U_N, S=1,25 V·A	$\Delta(f_L)$, %	$U(\Delta f_L)$, %
UkrMTS	0,0002	0,0030
BelGIM	0,0872	0,1200
GeorgMS	-0,0038	0,0043
VNIIMS	0,0023	0,0097
CMI	0,0028	0,0043
Reference value	0,0000	0,0026

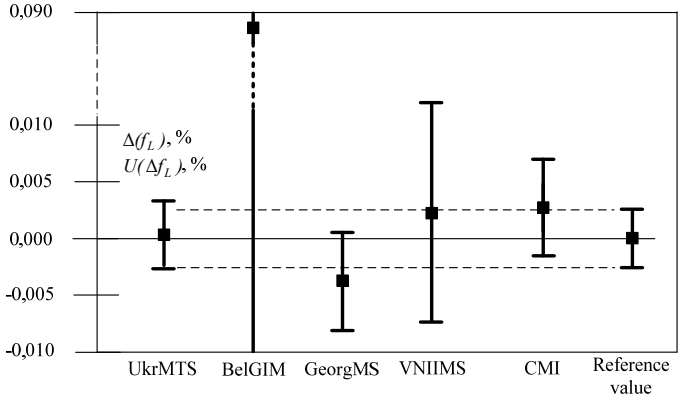

Figure 15 – Difference of NMI measurement results and reference value for the voltage error $\Delta(f_L)$ and expanded uncertainty of this difference $U(\Delta f_L)$ for k_{Nu} = 10 kV/100 V at 1,2 U_N and burden of 1,25 V·A

10 kV/100 V, 0,4 U_N, S≤0,1 V·A	$\Delta(f_L)$, %	$U(\Delta f_L)$, %
UkrMTS	0,0010	0,0029
BelGIM	-0,0560	0,0599
GeorgMS	-0,0030	0,0041
VNIIMS	0,0012	0,0096
CMI	0,0030	0,0064
Reference value	0,0000	0,0027

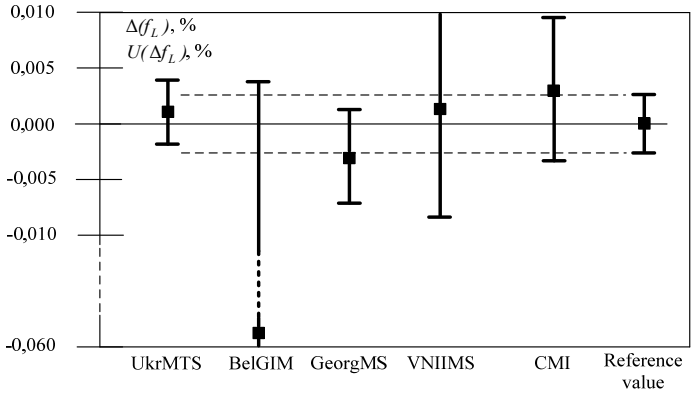

Figure 16 – Difference of NMI measurement results and reference value for the voltage error $\Delta(f_L)$ and expanded uncertainty of this difference $U(\Delta f_L)$ for k_{Nu} = 10 kV/100 V at 0,4 U_N and burden of ≤0,1 V·A

10 kV/100 V, 0,6 U_N, S≤0,1 V·A	$\Delta(f_L)$, %	$U(\Delta f_L)$, %
UkrMTS	0,0005	0,0030
BelGIM	-0,0625	0,0700
GeorgMS	-0,0035	0,0043
VNIIMS	0,0026	0,0097
CMI	0,0032	0,0054
Reference value	0,0000	0,0027

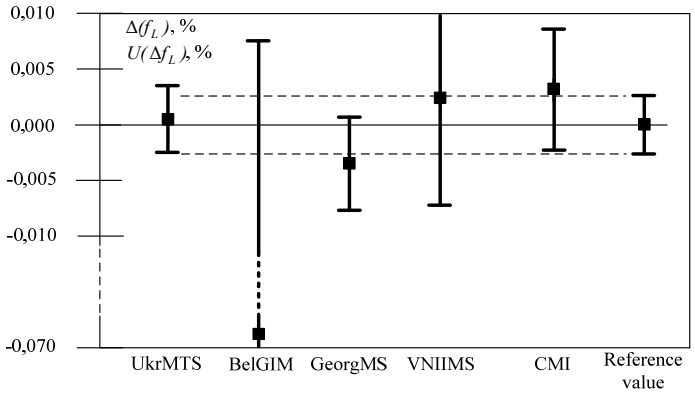

Figure 17 – Difference of NMI measurement results and reference value for the voltage error $\Delta(f_L)$ and expanded uncertainty of this difference $U(\Delta f_L)$ for k_{Nu} = 10 kV/100 V at 0,6 U_N and burden of ≤0,1 V·A

10 kV/100 V, 0,8 U_N, S≤0,1 V·A	$\Delta(f_L)$, %	$U(\Delta f_L)$, %
UkrMTS	0,0005	0,0030
BelGIM	-0,0645	0,0700
GeorgMS	-0,0035	0,0043
VNIIMS	0,0019	0,0097
CMI	0,0025	0,0043
Reference value	0,0000	0,0026

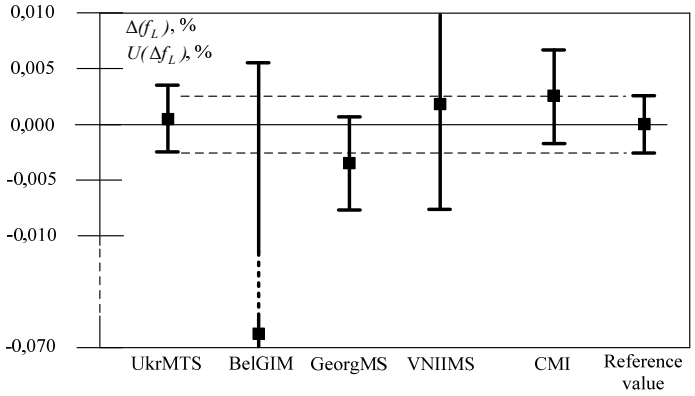

Figure 18 – Difference of NMI measurement results and reference value for the voltage error $\Delta(f_L)$ and expanded uncertainty of this difference $U(\Delta f_L)$ for k_{Nu} = 10 kV/100 V at 0,8 U_N and burden of ≤0,1 V·A

10 kV/100 V, U_N, S≤0,1 V·A	$\Delta(f_L)$, %	$U(\Delta f_L)$, %
UkrMTS	0,0004	0,0030
BelGIM	-0,0636	0,0700
GeorgMS	-0,0036	0,0043
VNIIMS	0,0014	0,0097
CMI	0,0028	0,0043
Reference value	0,0000	0,0026

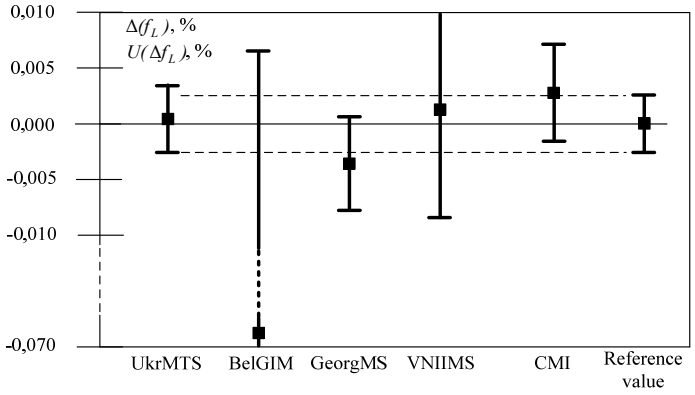

Figure 19 – Difference of NMI measurement results and reference value for the voltage error $\Delta(f_L)$ and expanded uncertainty of this difference $U(\Delta f_L)$ for k_{Nu} = 10 kV/100 V at U_N and burden of ≤0,1 V·A

10 kV/100 V, 1,2 U_N, S≤0,1 V·A	$\Delta(f_L)$, %	$U(\Delta f_L)$, %
UkrMTS	0,0004	0,0030
BelGIM	-0,0616	0,0700
GeorgMS	-0,0036	0,0043
VNIIMS	0,0018	0,0097
CMI	0,0028	0,0043
Reference value	0,0000	0,0026

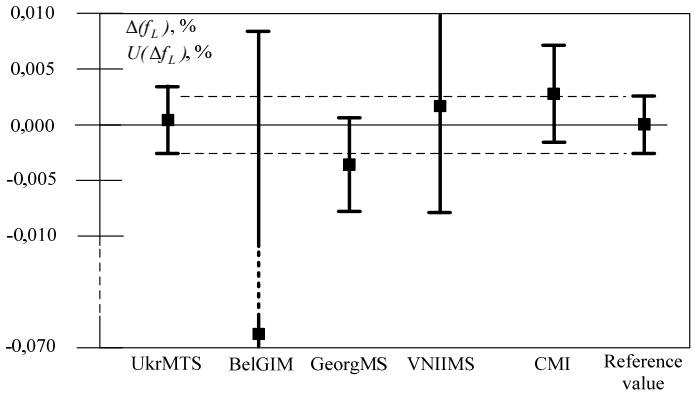

Figure 20 – Difference of NMI measurement results and reference value for the voltage error $\Delta(f_L)$ and expanded uncertainty of this difference $U(\Delta f_L)$ for k_{Nu} = 10 kV/100 V at 1,2 U_N and burden of ≤0,1 V·A

22 kV/100 V, 0,4 U_N, S=5 V·A	$\Delta(f_L)$, %	$U(\Delta f_L)$, %
UkrMTS	0,0019	0,0030
GeorgMS	-0,0031	0,0033
VNIIMS	0,0009	0,0097
CMI	0,0020	0,0065
Reference value	0,0000	0,0026

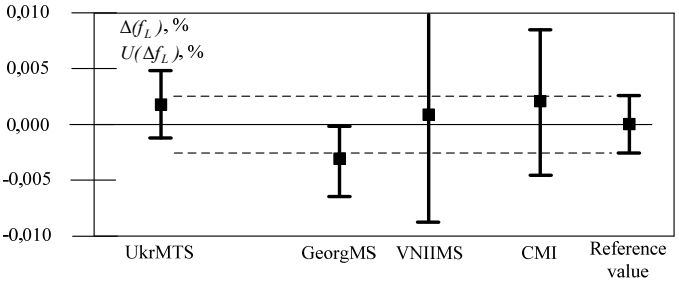

Figure 21 – Difference of NMI measurement results and reference value for the voltage error $\Delta(f_L)$ and expanded uncertainty of this difference $U(\Delta f_L)$ for k_{Nu} = 22 kV/100 V at 0,4 U_N and burden of 5 V·A

22 kV/100 V, 0,6 U_N, S=5 V·A	$\Delta(f_L)$, %	$U(\Delta f_L)$, %
UkrMTS	0,0023	0,0030
GeorgMS	-0,0037	0,0033
VNIIMS	-0,0007	0,0097
CMI	0,0027	0,0054
Reference value	0,0000	0,0025

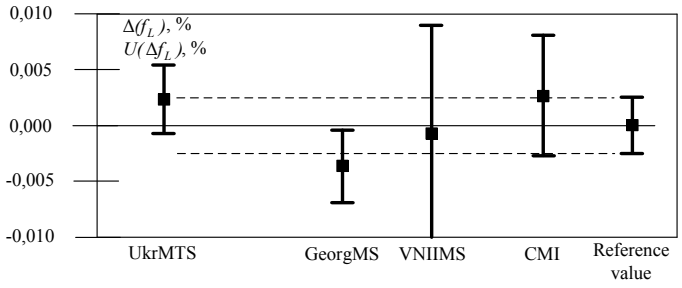

Figure 22 – Difference of NMI measurement results and reference value for the voltage error $\Delta(f_L)$ and expanded uncertainty of this difference $U(\Delta f_L)$ for k_{Nu} = 22 kV/100 V at 0,6 U_N and burden of 5 V·A

22 kV/100 V, 0,8 U_N, S=5 V·A	$\Delta(f_L)$, %	$U(\Delta f_L)$, %
UkrMTS	0,0018	0,0032
GeorgMS	-0,0042	0,0034
VNIIMS	0,0008	0,0097
CMI	0,0029	0,0044
Reference value	0,0000	0,0024

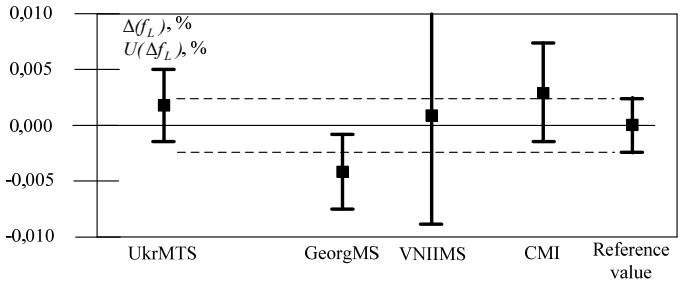

Figure 23 – Difference of NMI measurement results and reference value for the voltage error $\Delta(f_L)$ and expanded uncertainty of this difference $U(\Delta f_L)$ for k_{Nu} = 22 kV/100 V at 0,8 U_N and burden of 5 V·A

22 kV/100 V, U_N, S=5 V·A	$\Delta(f_L)$, %	$U(\Delta f_L)$, %
UkrMTS	0,0020	0,0032
GeorgMS	-0,0040	0,0034
VNIIMS	0,0010	0,0097
CMI	0,0025	0,0044
Reference value	0,0000	0,0024

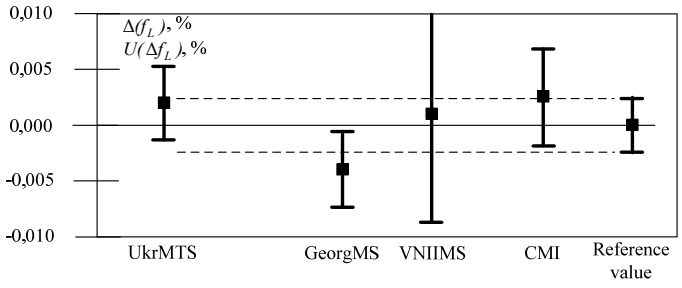

Figure 24 – Difference of NMI measurement results and reference value for the voltage error $\Delta(f_L)$ and expanded uncertainty of this difference $U(\Delta f_L)$ for k_{Nu} = 22 kV/100 V at U_N and burden of 5 V·A

22 kV/100 V, 1,2 U_N, S=5 V·A	$\Delta(f_L)$, %	$U(\Delta f_L)$, %
UkrMTS	0,0024	0,0032
GeorgMS	-0,0046	0,0034
VNIIMS	0,0014	0,0097
CMI	0,0026	0,0044
Reference value	0,0000	0,0024

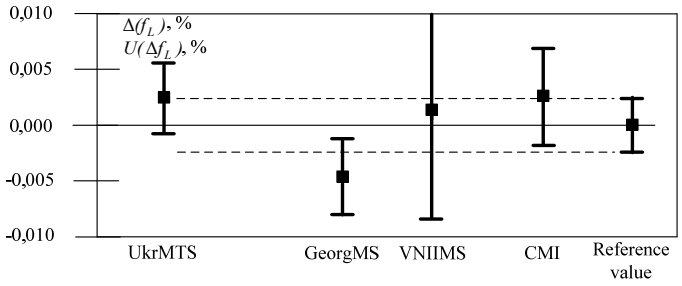

Figure 25 – Difference of NMI measurement results and reference value for the voltage error $\Delta(f_L)$ and expanded uncertainty of this difference $U(\Delta f_L)$ for k_{Nu} = 22 kV/100 V at 1,2 U_N and burden of 5 V·A

22 kV/100 V, 0,4 U_N, S≤0,1 V·A	$\Delta(f_L)$, %	$U(\Delta f_L)$, %
UkrMTS	0,0023	0,0030
GeorgMS	-0,0027	0,0033
VNIIMS	-0,0017	0,0097
CMI	0,0014	0,0065
Reference value	0,0000	0,0026

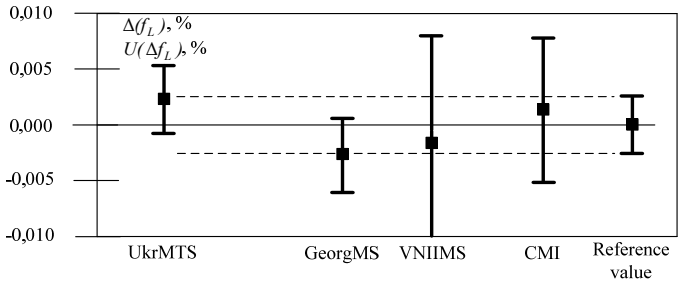

Figure 26 – Difference of NMI measurement results and reference value for the voltage error $\Delta(f_L)$ and expanded uncertainty of this difference $U(\Delta f_L)$ for k_{Nu} = 22 kV/100 V at 0,4 U_N and burden of ≤0,1 V·A

22 kV/100 V, 0,6 U_N, S≤0,1 V·A	$\Delta(f_L)$, %	$U(\Delta f_L)$, %
UkrMTS	0,0024	0,0030
GeorgMS	-0,0036	0,0033
VNIIMS	-0,0006	0,0097
CMI	0,0020	0,0054
Reference value	0,0000	0,0025

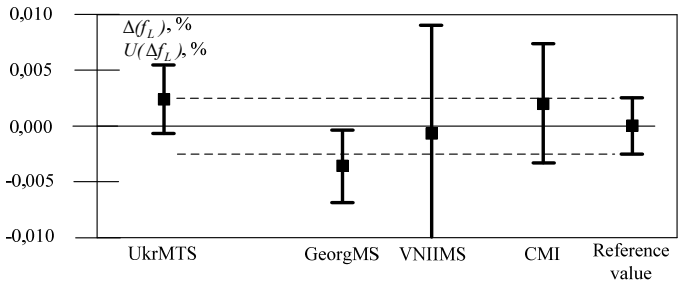

Figure 27 – Difference of NMI measurement results and reference value for the voltage error $\Delta(f_L)$ and expanded uncertainty of this difference $U(\Delta f_L)$ for k_{Nu} = 22 kV/100 V at 0,6 U_N and burden of ≤0,1 V·A

22 kV/100 V, 0,8 U_N, S≤0,1 V·A	$\Delta(f_L)$, %	$U(\Delta f_L)$, %
UkrMTS	0,0015	0,0032
GeorgMS	-0,0035	0,0034
VNIIMS	-0,0015	0,0097
CMI	0,0028	0,0044
Reference value	0,0000	0,0024

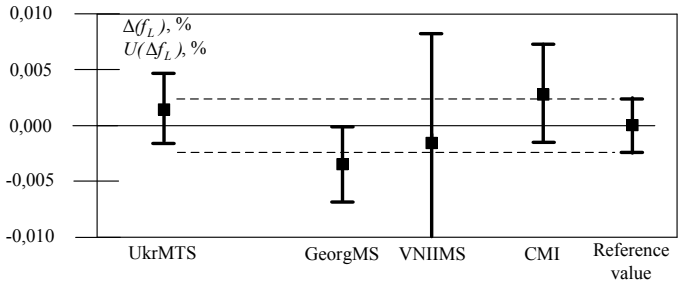

Figure 28 – Difference of NMI measurement results and reference value for the voltage error $\Delta(f_L)$ and expanded uncertainty of this difference $U(\Delta f_L)$ for k_{Nu} = 22 kV/100 V at 0,8 U_N and burden of ≤0,1 V·A

22 kV/100 V, U_N, S=≤0,1 V·A	$\Delta(f_L)$, %	$U(\Delta f_L)$, %
UkrMTS	0,0015	0,0032
GeorgMS	-0,0035	0,0034
VNIIMS	-0,0025	0,0097
CMI	0,0032	0,0044
Reference value	0,0000	0,0024

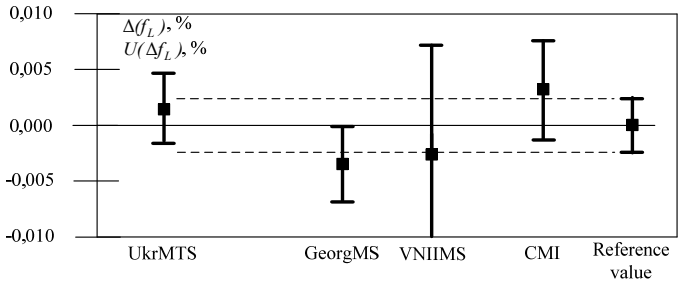

Figure 29 – Difference of NMI measurement results and reference value for the voltage error $\Delta(f_L)$ and expanded uncertainty of this difference $U(\Delta f_L)$ for k_{Nu} = 22 kV/100 V at U_N and burden of ≤0,1 V·A

22 kV/100 V, 1,2 U_N, S≤0,1 V·A	$\Delta(f_L)$, %	$U(\Delta f_L)$, %
UkrMTS	0,0015	0,0032
GeorgMS	-0,0035	0,0034
VNIIMS	-0,0015	0,0097
CMI	0,0029	0,0044
Reference value	0,0000	0,0024

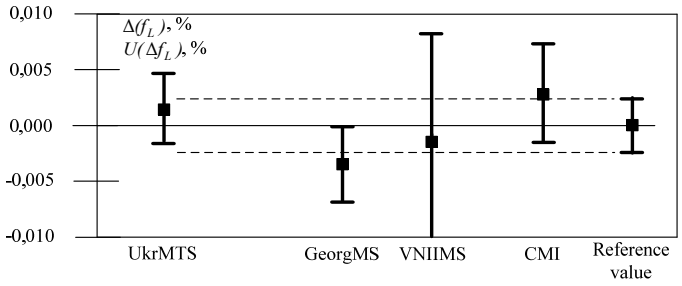

Figure 30 – Difference of NMI measurement results and reference value for the voltage error $\Delta(f_L)$ and expanded uncertainty of this difference $U(\Delta f_L)$ for k_{Nu} = 22 kV/100 V at 1,2 U_N and burden of ≤0,1 V·A

35 kV/100 V, 0,4 U_N, S=5 V·A	$\Delta(f_L)$, %	$U(\Delta f_L)$, %
UkrMTS	0,0006	0,0032
BelGIM	-0,1104	0,1500
GeorgMS	-0,0034	0,0034
VNIIMS	0,0035	0,0097
CMI	0,0032	0,0044
Reference value	0,0000	0,0024

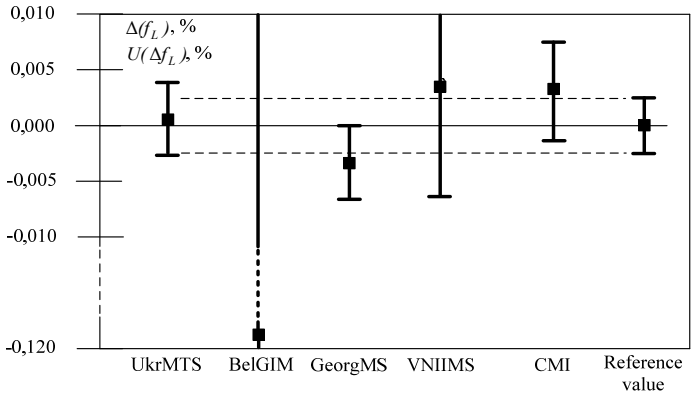

Figure 31 – Difference of NMI measurement results and reference value for the voltage error $\Delta(f_L)$ and expanded uncertainty of this difference $U(\Delta f_L)$ for k_{Nu} = 35 kV/100 V at 0,4 U_N and burden of 5 V·A

35 kV/100 V, 0,6 U_N, S=5 V·A	$\Delta(f_L)$, %	$U(\Delta f_L)$, %
UkrMTS	0,0011	0,0032
BelGIM	-0,1179	0,1200
GeorgMS	-0,0029	0,0034
VNIIMS	0,0033	0,0097
CMI	0,0018	0,0044
Reference value	0,0000	0,0024

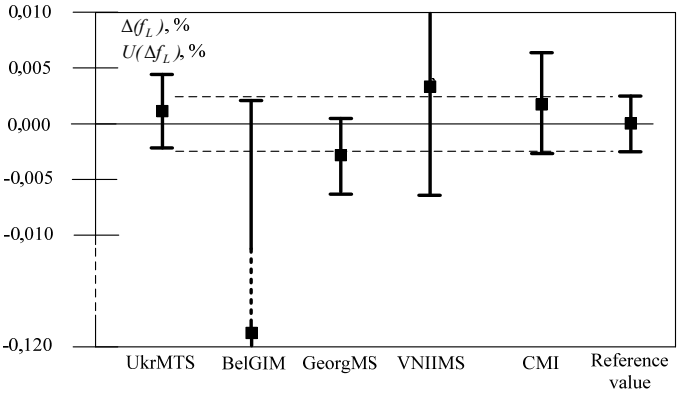

Figure 32 – Difference of NMI measurement results and reference value for the voltage error $\Delta(f_L)$ and expanded uncertainty of this difference $U(\Delta f_L)$ for k_{Nu} = 35 kV/100 V at 0,6 U_N and burden of 5 V·A

35 kV/100 V, 0,8 U_N, S=5 V·A	$\Delta(f_L)$, %	$U(\Delta f_L)$, %
UkrMTS	0,0015	0,0032
BelGIM	-0,1245	0,1600
GeorgMS	-0,0035	0,0034
VNIIMS	0,0019	0,0097
CMI	0,0023	0,0044
Reference value	0,0000	0,0024

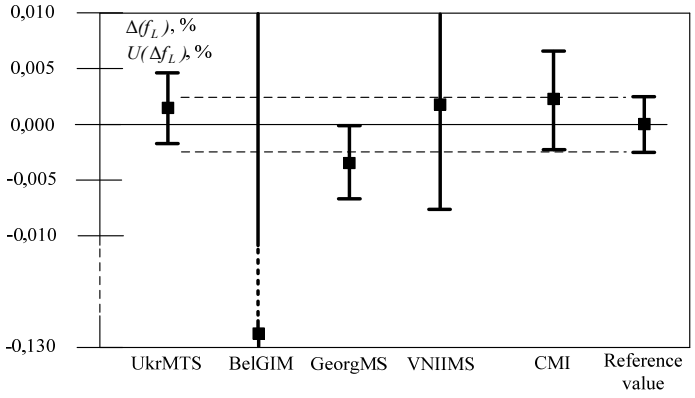

Figure 33 – Difference of NMI measurement results and reference value for the voltage error $\Delta(f_L)$ and expanded uncertainty of this difference $U(\Delta f_L)$ for k_{Nu} = 35 kV/100 V at 0,8 U_N and burden of 5 V·A

35 kV/100 V, U_N, S=5 V·A	$\Delta(f_L)$, %	$U(\Delta f_L)$, %
UkrMTS	0,0009	0,0032
BelGIM	-0,1311	0,1400
GeorgMS	-0,0031	0,0034
VNIIMS	0,0030	0,0097
CMI	0,0025	0,0044
Reference value	0,0000	0,0024

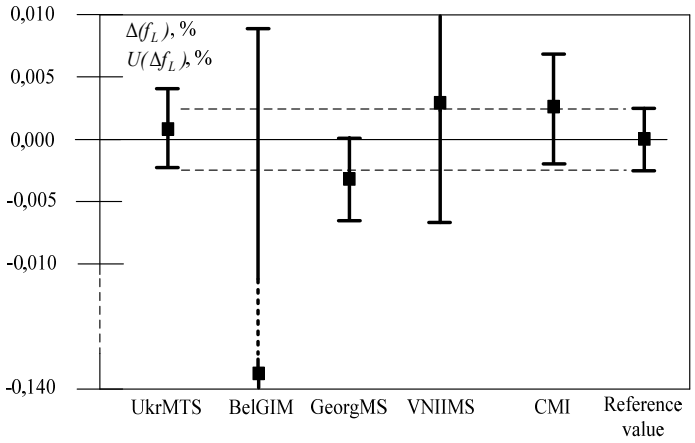

Figure 34 – Difference of NMI measurement results and reference value for the voltage error $\Delta(f_L)$ and expanded uncertainty of this difference $U(\Delta f_L)$ for k_{Nu} = 35 kV/100 V at U_N and burden of 5 V·A

35 kV/100 V, 1,2 U_N, S=5 V·A	$\Delta(f_L)$, %	$U(\Delta f_L)$, %
UkrMTS	0,0012	0,0032
BelGIM	-0,1338	0,1900
GeorgMS	-0,0038	0,0034
VNIIMS	0,0043	0,0097
CMI	0,0027	0,0044
Reference value	0,0000	0,0024

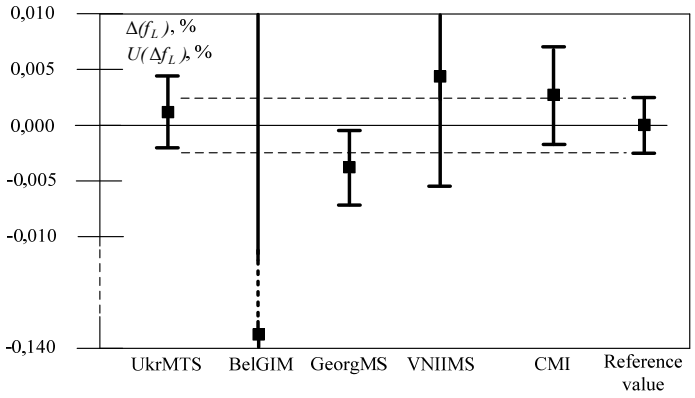

Figure 35 – Difference of NMI measurement results and reference value for the voltage error $\Delta(f_L)$ and expanded uncertainty of this difference $U(\Delta f_L)$ for k_{Nu} = 35 kV/100 V at 1,2 U_N and burden of 5 V·A

35 kV/100 V, 0,4 U_N, S≤0,1 V·A	$\Delta(f_L)$, %	$U(\Delta f_L)$, %
UkrMTS	0,0003	0,0032
BelGIM	-0,1387	0,1400
GeorgMS	-0,0027	0,0034
VNIIMS	0,0016	0,0097
CMI	0,0033	0,0044
Reference value	0,0000	0,0024

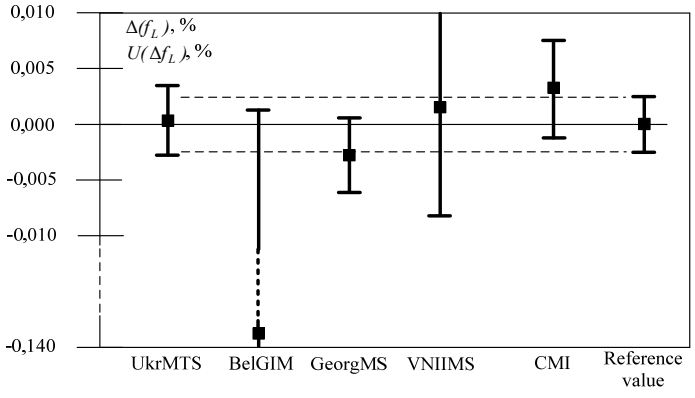

Figure 36 – Difference of NMI measurement results and reference value for the voltage error $\Delta(f_L)$ and expanded uncertainty of this difference $U(\Delta f_L)$ for k_{Nu} = 35 kV/100 V at 0,4 U_N and burden of ≤0,1 V·A

35 kV/100 V, 0,6 U_N, S≤0,1 V·A	$\Delta(f_L)$, %	$U(\Delta f_L)$, %
UkrMTS	0,0010	0,0032
BelGIM	-0,1450	0,1500
GeorgMS	-0,0030	0,0034
VNIIMS	0,0021	0,0097
CMI	0,0023	0,0044
Reference value	0,0000	0,0024

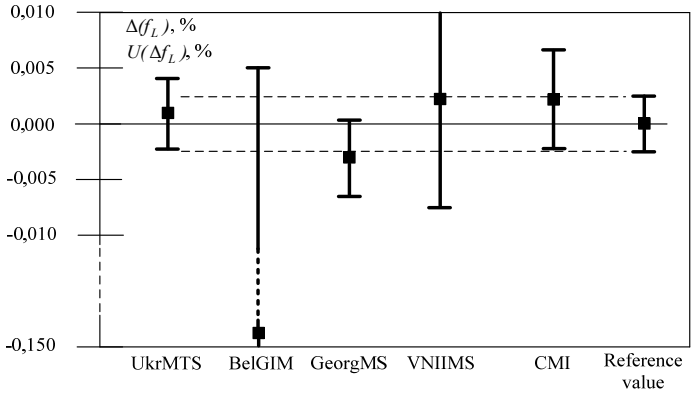

Figure 37 – Difference of NMI measurement results and reference value for the voltage error $\Delta(f_L)$ and expanded uncertainty of this difference $U(\Delta f_L)$ for k_{Nu} = 35 kV/100 V at 0,6 U_N and burden of ≤0,1 0 V·A

35 kV/100 V, 0,8 U_N, S≤0,1 V·A	$\Delta(f_L)$, %	$U(\Delta f_L)$, %
UkrMTS	0,0011	0,0032
BelGIM	-0,1499	0,1500
GeorgMS	-0,0029	0,0034
VNIIMS	0,0012	0,0097
CMI	0,0024	0,0044
Reference value	0,0000	0,0024

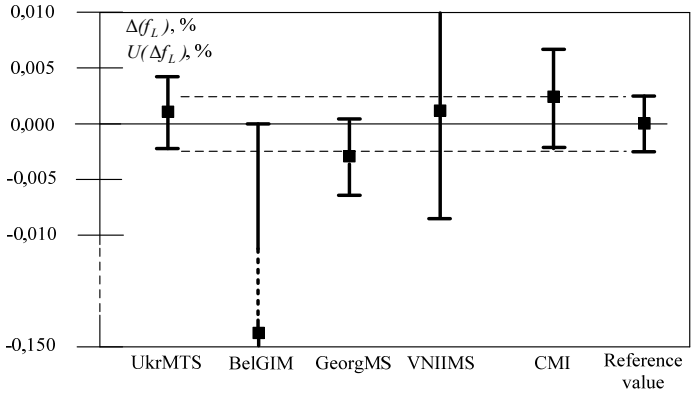

Figure 38 – Difference of NMI measurement results and reference value for the voltage error $\Delta(f_L)$ and expanded uncertainty of this difference $U(\Delta f_L)$ for k_{Nu} = 35 kV/100 V at 0,8 U_N and burden of ≤0,1 V·A

35 kV/100 V, U_N, S≤0,1 V·A	$\Delta(f_L)$, %	$U(\Delta f_L)$, %
UkrMTS	0,0008	0,0032
BelGIM	-0,1522	0,1700
GeorgMS	-0,0032	0,0034
VNIIMS	0,0021	0,0097
CMI	0,0030	0,0044
Reference value	0,0000	0,0024

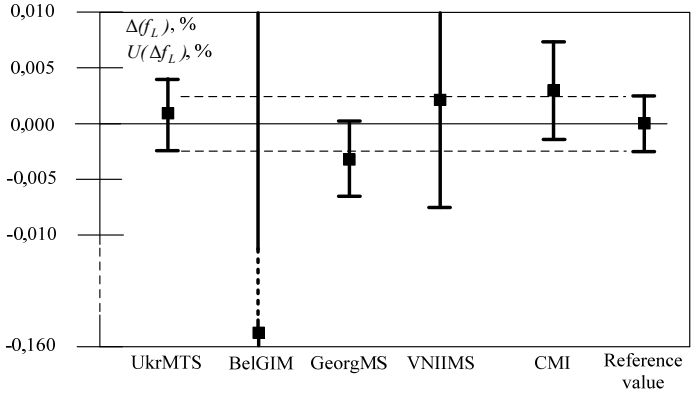

Figure 39 – Difference of NMI measurement results and reference value for the voltage error $\Delta(f_L)$ and expanded uncertainty of this difference $U(\Delta f_L)$ for k_{Nu} = 35 kV/100 V at U_N and burden of ≤0,1 V·A

35 kV/100 V, 1,2 U_N, S≤0,1 V·A	$\Delta(f_L)$, %	$U(\Delta f_L)$, %
UkrMTS	0,0008	0,0032
BelGIM	-0,1552	0,1700
GeorgMS	-0,0032	0,0034
VNIIMS	0,0032	0,0097
CMI	0,0028	0,0044
Reference value	0,0000	0,0024

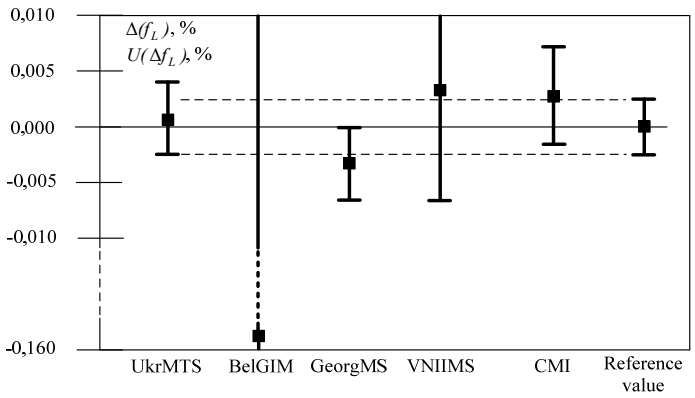

Figure 40 – Difference of NMI measurement results and reference value for the voltage error $\Delta(f_L)$ and expanded uncertainty of this difference $U(\Delta f_L)$ for k_{Nu} = 35 kV/100 V at 1,2 U_N and burden of ≤0,1 V·A

6 kV/100 V, 0,4 U_N, S=1,25 V·A	$\Delta(\delta_L)$, minutes	$U(\Delta\delta_L)$, minutes
UkrMTS	0,005	0,223
BelGIM	2,005	1,998
GeorgMS	-0,055	0,109
VNIIMS	0,045	0,145
CMI	0,028	0,180
Reference value	0,000	0,088

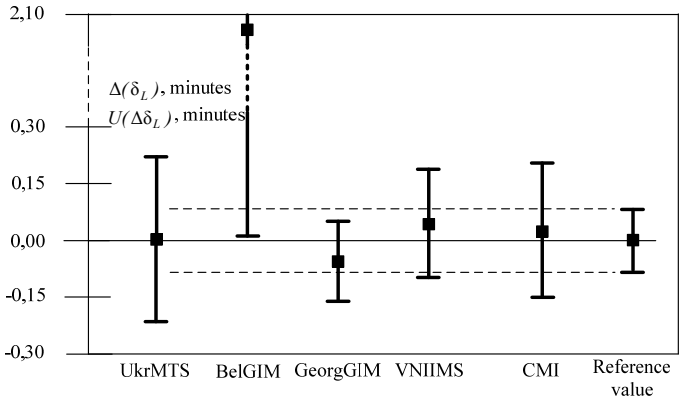

Figure 41 – Difference of NMI measurement results and reference value for the phase displacement $\Delta(\delta_L)$ and expanded uncertainty of this difference $U(\Delta\delta_L)$ for k_{Nu} = 6 kV/100 V at 0,4 U_N and burden of 1,25 V·A

6 kV/100 V, 0,6 U_N, S=1,25 V·A	$\Delta(\delta_L)$, minutes	$U(\Delta\delta_L)$, minutes
UkrMTS	-0,021	0,223
BelGIM	2,249	2,398
GeorgMS	-0,071	0,109
VNIIMS	0,099	0,145
CMI	0,006	0,180
Reference value	0,000	0,088

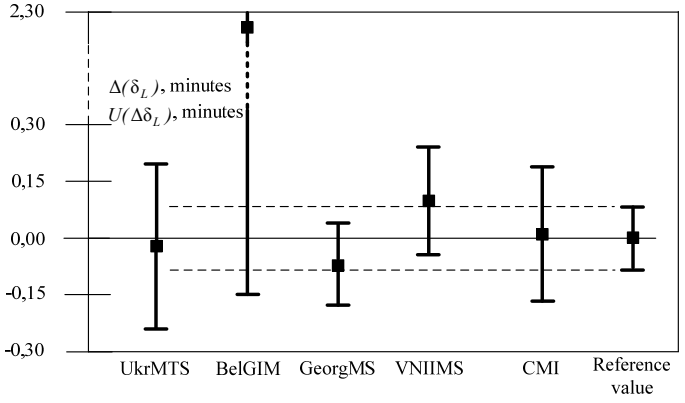

Figure 42 – Difference of NMI measurement results and reference value for the phase displacement $\Delta(\delta_L)$ and expanded uncertainty of this difference $U(\Delta\delta_L)$ for k_{Nu} = 6 kV/100 V at 0,6 U_N and burden of 1,25 V·A

6 kV/100 V, 0,8 U_N, S=1,25 V·A	$\Delta(\delta_L)$, minutes	$U(\Delta\delta_L)$, minutes
UkrMTS	-0,037	0,224
BelGIM	2,373	2,398
GeorgMS	-0,097	0,135
VNIIMS	0,133	0,147
CMI	-0,012	0,123
Reference value	0,000	0,086

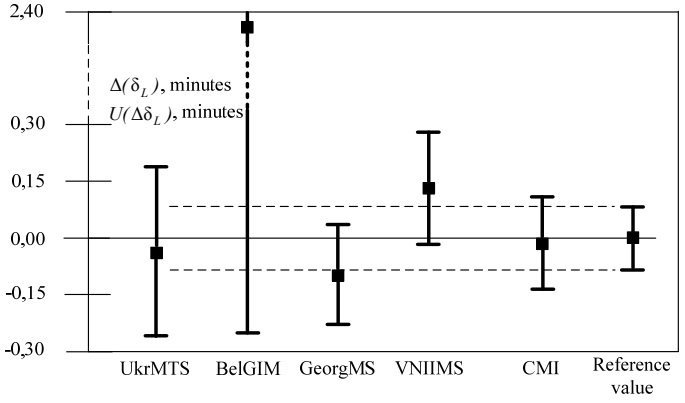

Figure 43 – Difference of NMI measurement results and reference value for the phase displacement $\Delta(\delta_L)$ and expanded uncertainty of this difference $U(\Delta\delta_L)$ for k_{Nu} = 6 kV/100 at 0,8 U_N and burden of 1,25 V·A

6 kV/100 V, U_N, S=1,25 V·A	$\Delta(\delta_L)$, minutes	$U(\Delta\delta_L)$, minutes
UkrMTS	-0,039	0,224
BelGIM	2,401	2,398
GeorgMS	-0,109	0,135
VNIIMS	0,151	0,147
CMI	-0,017	0,123
Reference value	0,000	0,086

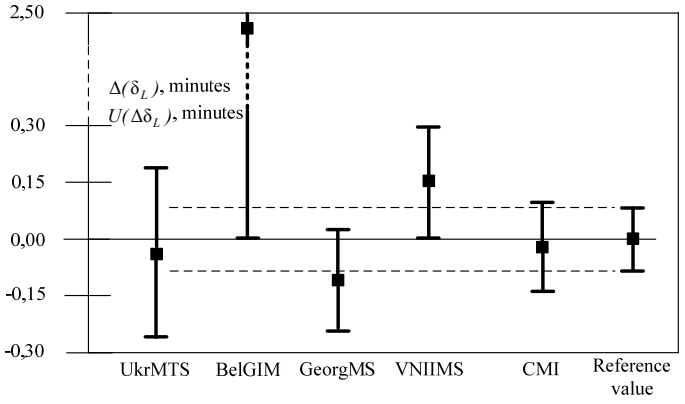

Figure 44 – Difference of NMI measurement results and reference value for the phase displacement $\Delta(\delta_L)$ and expanded uncertainty of this difference $U(\Delta\delta_L)$ for k_{Nu} = 6 kV/100 V at U_N and burden of 1,25 V·A

6 kV/100 V, 1,2 U_N, S=1,25 V·A	$\Delta(\delta_L)$, minutes	$U(\Delta\delta_L)$, minutes
UkrMTS	-0,040	0,224
BelGIM	2,420	2,599
GeorgMS	-0,110	0,135
VNIIMS	0,160	0,147
CMI	-0,020	0,123
Reference value	0,000	0,086

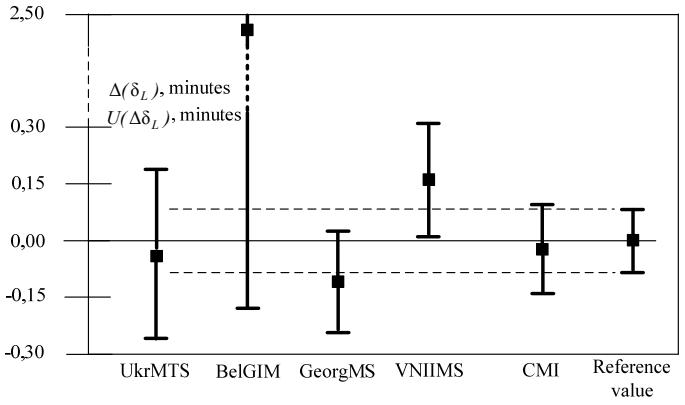

Figure 45 – Difference of NMI measurement results and reference value for the phase displacement $\Delta(\delta_L)$ and expanded uncertainty of this difference $U(\Delta\delta_L)$ for k_{Nu} = 6 kV/100 V at 1,2 U_N and burden of 1,25 V·A

6 kV/100 V, 0,4 U_N, S≤0,1 V·A	$\Delta(\delta_L)$, minutes	$U(\Delta\delta_L)$, minutes
UkrMTS	0,007	0,220
BelGIM	1,727	1,797
GeorgMS	-0,053	0,152
VNIIMS	0,017	0,140
CMI	0,015	0,175
Reference value	0,000	0,096

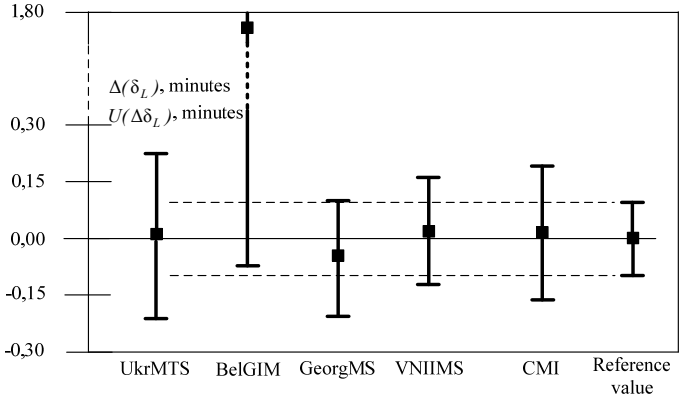

Figure 46 – Difference of NMI measurement results and reference value for the phase displacement $\Delta(\delta_L)$ and expanded uncertainty of this difference $U(\Delta\delta_L)$ for k_{Nu} = 6 kV/100 V at 0,4 U_N and burden of ≤0,1 V·A

6 kV/100 V, 0,6 U_N, S≤0,1 V·A	$\Delta(\delta_L)$, minutes	$U(\Delta\delta_L)$, minutes
UkrMTS	-0,016	0,222
BelGIM	1,974	1,998
GeorgMS	-0,076	0,131
VNIIMS	0,084	0,143
CMI	-0,005	0,178
Reference value	0,000	0,093

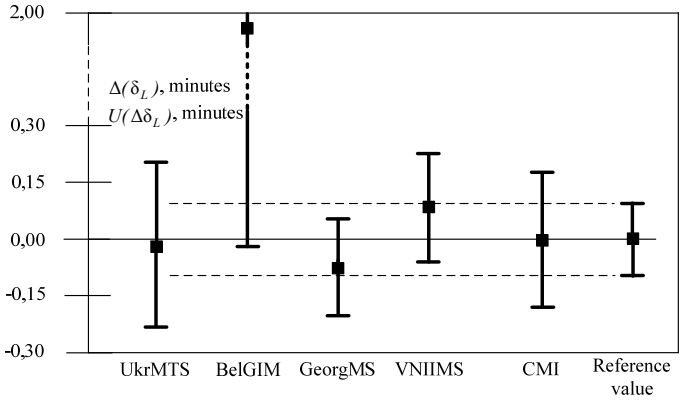

Figure 47 – Difference of NMI measurement results and reference value for the phase displacement $\Delta(\delta_L)$ and expanded uncertainty of this difference $U(\Delta\delta_L)$ for k_{Nu} = 6 kV/100 V at 0,6 U_N and burden of ≤0,1 V·A

6 kV/100 V, 0,8 U_N, S≤0,1 V·A	$\Delta(\delta_L)$, minutes	$U(\Delta\delta_L)$, minutes
UkrMTS	-0,034	0,224
BelGIM	2,206	2,198
GeorgMS	-0,094	0,135
VNIIMS	0,126	0,147
CMI	-0,013	0,123
Reference value	0,000	0,086

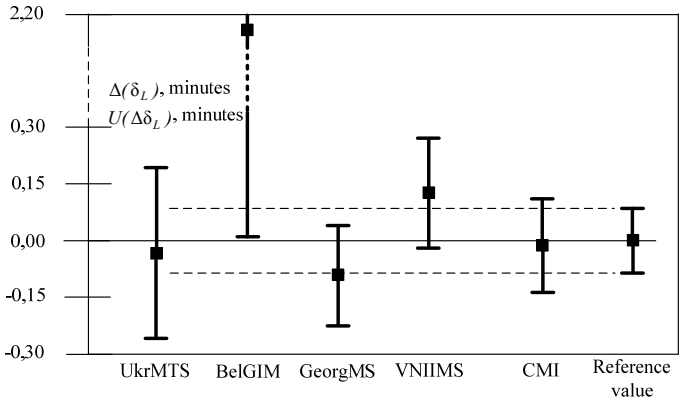

Figure 48 – Difference of NMI measurement results and reference value for the phase displacement $\Delta(\delta_L)$ and expanded uncertainty of this difference $U(\Delta\delta_L)$ for k_{Nu} = 6 kV/100 V at 0,8 U_N and burden of ≤0,1 V·A

6 kV/100 V, U_N, S≤0,1 V·A	$\Delta(\delta_L)$, minutes	$U(\Delta\delta_L)$, minutes
UkrMTS	-0,038	0,224
BelGIM	2,232	2,398
GeorgMS	-0,098	0,135
VNIIMS	0,142	0,147
CMI	-0,018	0,123
Reference value	0,000	0,086

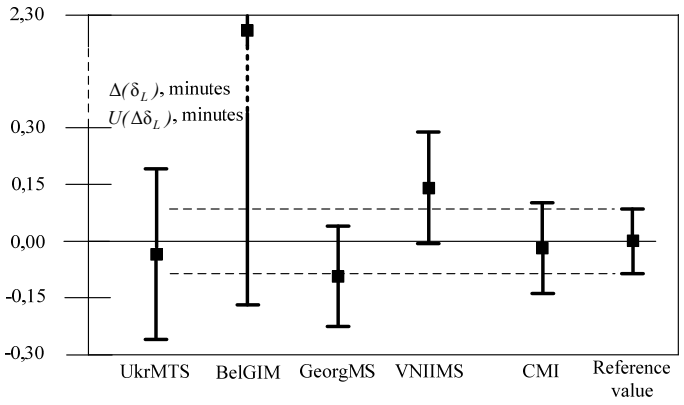

Figure 49 – Difference of NMI measurement results and reference value for the phase displacement $\Delta(\delta_L)$ and expanded uncertainty of this difference $U(\Delta\delta_L)$ for k_{Nu} = 6 kV/100 V at U_N and burden of ≤0,1 V·A

6 kV/100 V, 1,2 U_N, S≤0,1 V·A	$\Delta(\delta_L)$, minutes	$U(\Delta\delta_L)$, minutes
UkrMTS	-0,032	0,226
BelGIM	2,258	2,799
GeorgMS	-0,102	0,113
VNIIMS	0,178	0,149
CMI	-0,016	0,126
Reference value	0,000	0,082

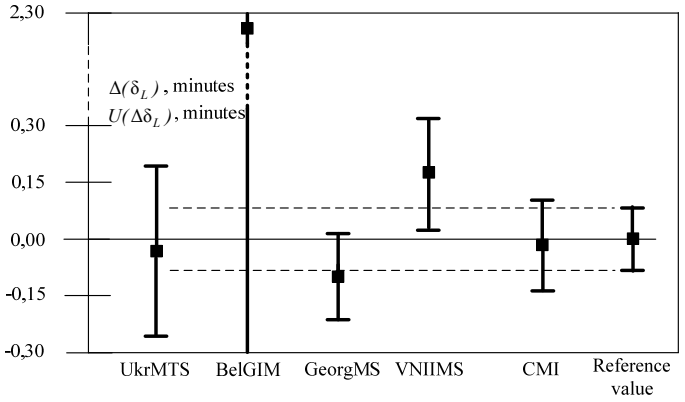

Figure 50 – Difference of NMI measurement results and reference value for the phase displacement $\Delta(\delta_L)$ and expanded uncertainty of this difference $U(\Delta\delta_L)$ for k_{Nu} = 6 kV/100 V at 1,2 U_N and burden of ≤0,1 V·A

10 kV/100 V, 0,4 U_N, S=1,25 V·A	$\Delta(\delta_L)$, minutes	$U(\Delta\delta_L)$, minutes
UkrMTS	-0,030	0,222
BelGIM	2,960	2,999
GeorgMS	-0,090	0,131
VNIIMS	0,090	0,143
CMI	0,023	0,178
Reference value	0,000	0,093

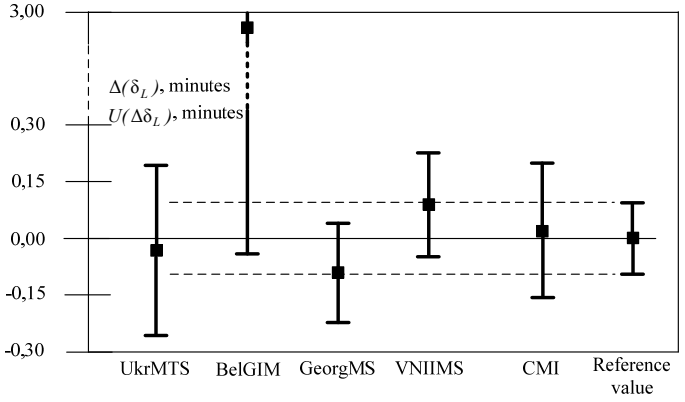

Figure 51 – Difference of NMI measurement results and reference value for the phase displacement $\Delta(\delta_L)$ and expanded uncertainty of this difference $U(\Delta\delta_L)$ for k_{Nu} = 10 kV/100V at 0,4 U_N and burden of 1,25 V·A

10 kV/100 V, 0,6 U_N, S=1,25 V·A	$\Delta(\delta_L)$, minutes	$U(\Delta\delta_L)$, minutes
UkrMTS	-0,012	0,223
BelGIM	3,248	3,399
GeorgMS	-0,072	0,109
VNIIMS	0,068	0,145
CMI	0,052	0,180
Reference value	0,000	0,088

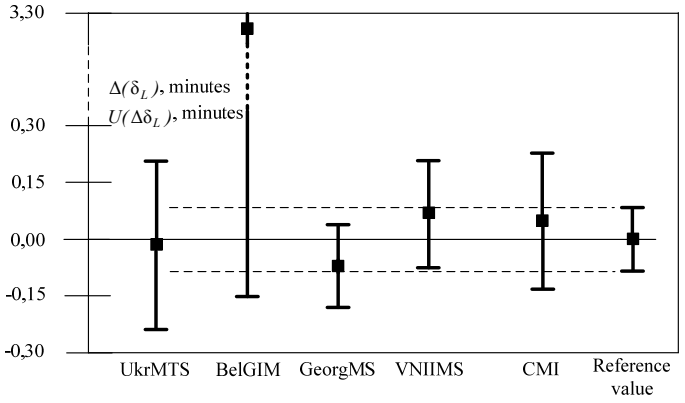

Figure 52 – Difference of NMI measurement results and reference value for the phase displacement $\Delta(\delta_L)$ and expanded uncertainty of this difference $U(\Delta\delta_L)$ for k_{Nu} = 10 kV/100Vat 0,6 U_N and burden of 1,25 V·A

10 kV/100 V, 0,8 U_N, S=1,25 V·A	$\Delta(\delta_L)$, minutes	$U(\Delta\delta_L)$, minutes
UkrMTS	-0,001	0,224
BelGIM	3,289	3,399
GeorgMS	-0,071	0,135
VNIIMS	-0,001	0,147
CMI	0,057	0,123
Reference value	0,000	0,086

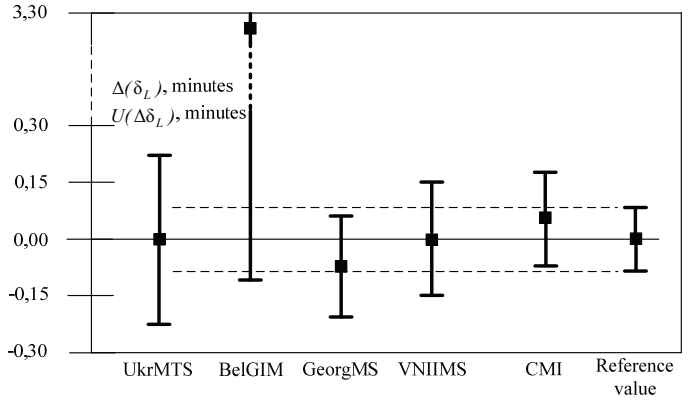

Figure 53 – Difference of NMI measurement results and reference value for the phase displacement $\Delta(\delta_L)$ and expanded uncertainty of this difference $U(\Delta\delta_L)$ for k_{Nu} = 10 kV/100Vat 0,8 U_N and burden of 1,25 V·A

10 kV/100 V, U_N, S=1,25 V·A	$\Delta(\delta_L)$, minutes	$U(\Delta\delta_L)$, minutes
UkrMTS	-0,005	0,224
BelGIM	3,205	3,199
GeorgMS	-0,085	0,135
VNIIMS	0,005	0,147
CMI	0,065	0,123
Reference value	0,000	0,086

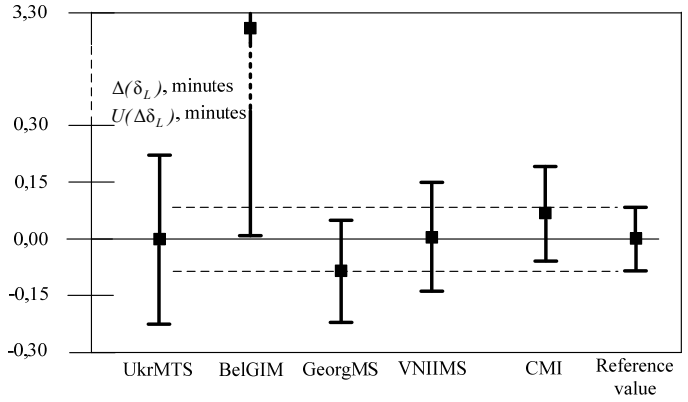

Figure 54 – Difference of NMI measurement results and reference value for the phase displacement $\Delta(\delta_L)$ and expanded uncertainty of this difference $U(\Delta\delta_L)$ for k_{Nu} = 10 kV/100 V at U_N and burden of 1,25 V·A

10 kV/100 V, 1,2 U_N, S=1,25 V·A	$\Delta(\delta_L)$, minutes	$U(\Delta\delta_L)$, minutes
UkrMTS	0,005	0,224
BelGIM	2,815	2,999
GeorgMS	-0,075	0,135
VNIIMS	-0,015	0,147
CMI	0,069	0,123
Reference value	0,000	0,086

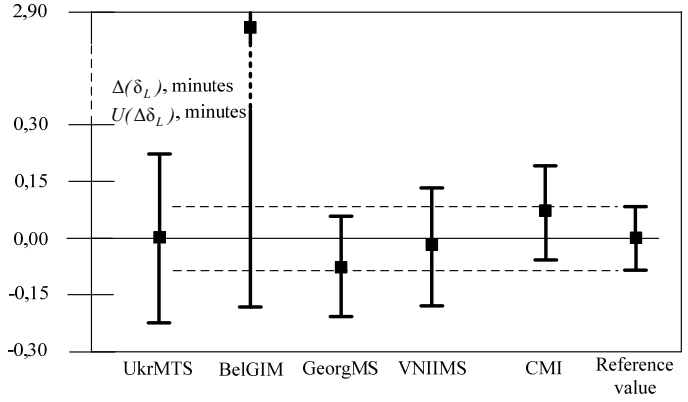

Figure 55 – Difference of NMI measurement results and reference value for the phase displacement $\Delta(\delta_L)$ and expanded uncertainty of this difference $U(\Delta\delta_L)$ for k_{Nu} = 10 kV/100 V at 1,2 U_N and burden of 1,25 V·A

10 kV/100 V, 0,4 U_N, S≤0,1 V·A	$\Delta(\delta_L)$, minutes	$U(\Delta\delta_L)$, minutes
UkrMTS	-0,017	0,222
BelGIM	1,813	1,998
GeorgMS	-0,077	0,131
VNIIMS	0,103	0,143
CMI	-0,029	0,178
Reference value	0,000	0,093

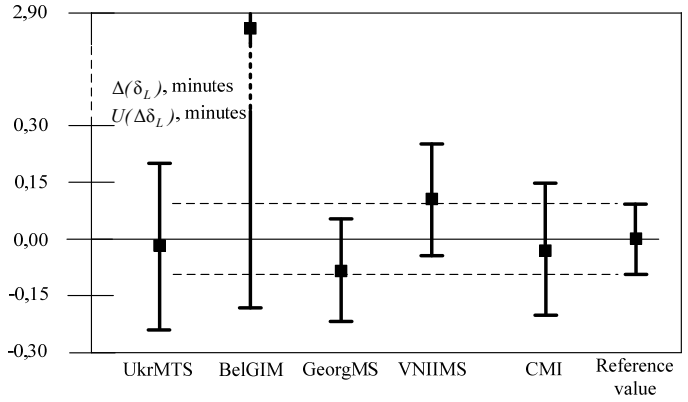

Figure 56 – Difference of NMI measurement results and reference value for the phase displacement $\Delta(\delta_L)$ and expanded uncertainty of this difference $U(\Delta\delta_L)$ for k_{Nu} = 10 kV/100 V at 0,4 U_N and burden of ≤0,1 V·A

10 kV/100 V, 0,6 U_N, S≤0,1 V·A	$\Delta(\delta_L)$, minutes	$U(\Delta\delta_L)$, minutes
UkrMTS	-0,017	0,223
BelGIM	2,083	2,198
GeorgMS	-0,067	0,109
VNIIMS	0,063	0,145
CMI	0,044	0,180
Reference value	0,000	0,088

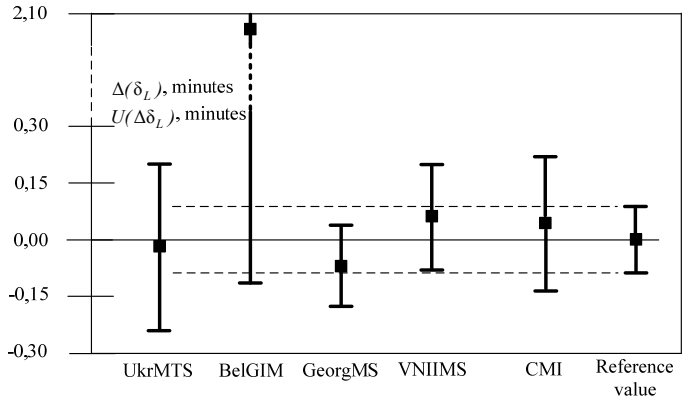

Figure 57 – Difference of NMI measurement results and reference value for the phase displacement $\Delta(\delta_L)$ and expanded uncertainty of this difference $U(\Delta\delta_L)$ for k_{Nu} = 10 kV/100 V at 0,6 U_N and burden of ≤0,1 V·A

10 kV/100 V, 0,8 U_N, S≤0,1 V·A	$\Delta(\delta_L)$, minutes	$U(\Delta\delta_L)$, minutes
UkrMTS	0,001	0,226
BelGIM	2,131	2,198
GeorgMS	-0,059	0,113
VNIIMS	0,001	0,149
CMI	0,057	0,126
Reference value	0,000	0,082

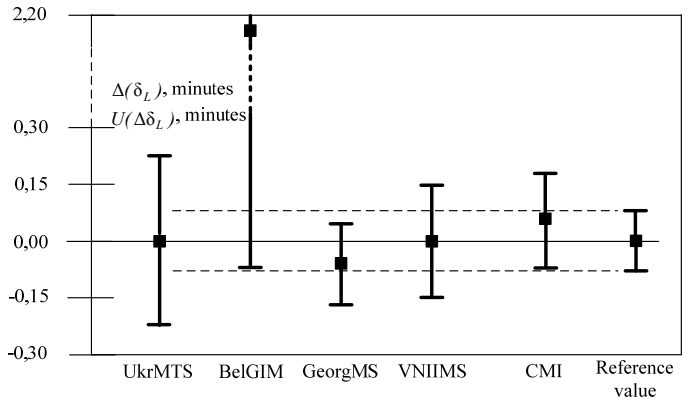

Figure 58 – Difference of NMI measurement results and reference value for the phase displacement $\Delta(\delta_L)$ and expanded uncertainty of this difference $U(\Delta\delta_L)$ for k_{Nu} = 10 kV/100 V at 0,8 U_N and burden of ≤0,1 V·A

10 kV/100 V, U_N, S≤0,1 V·A	$\Delta(\delta_L)$, minutes	$U(\Delta\delta_L)$, minutes
UkrMTS	-0,002	0,226
BelGIM	2,048	2,198
GeorgMS	-0,072	0,113
VNIIMS	0,008	0,149
CMI	0,067	0,126
Reference value	0,000	0,082

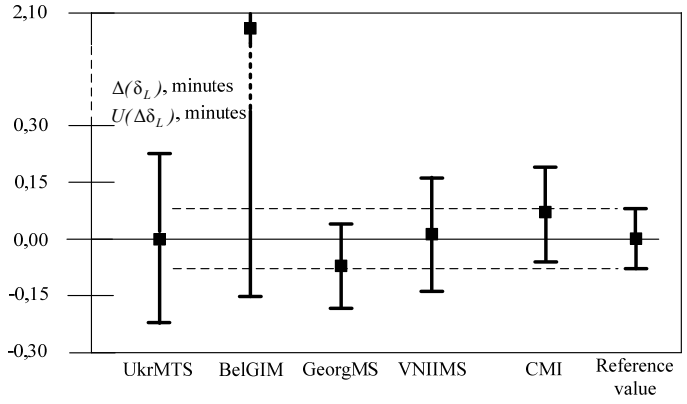

Figure 59 – Difference of NMI measurement results and reference value for the phase displacement $\Delta(\delta_L)$ and expanded uncertainty of this difference $U(\Delta\delta_L)$ for k_{Nu} = 10 kV/100 V at U_N and burden of ≤0,1 V·A

10 kV/100 V, 1,2 U_N, S≤0,1 V·A	$\Delta(\delta_L)$, minutes	$U(\Delta\delta_L)$, minutes
UkrMTS	0,002	0,226
BelGIM	1,752	1,798
GeorgMS	-0,058	0,113
VNIIMS	-0,018	0,149
CMI	0,069	0,126
Reference value	0,000	0,082

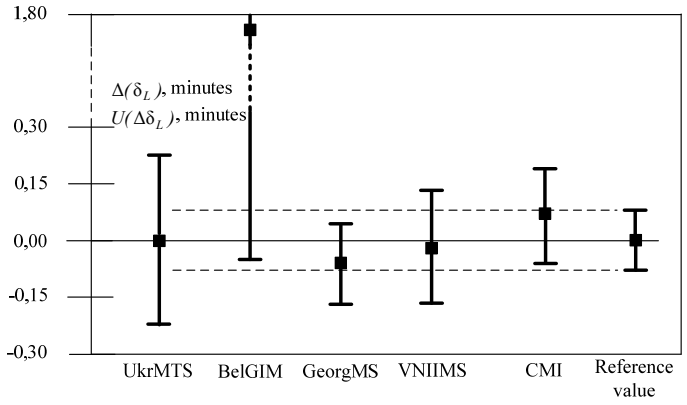

Figure 60 – Difference of NMI measurement results and reference value for the phase displacement $\Delta(\delta_L)$ and expanded uncertainty of this difference $U(\Delta\delta_L)$ for k_{Nu} = 10 kV/100 V at 1,2 U_N and burden of ≤0,1 V·A

22 kV/100 V, 0,4 U_N, S=5 V·A	$\Delta(\delta_L)$, minutes	$U(\Delta\delta_L)$, minutes
UkrMTS	-0,001	0,213
GeorgMS	-0,201	0,447
VNIIMS	-0,041	0,130
CMI	0,096	0,167
Reference value	0,000	0,111

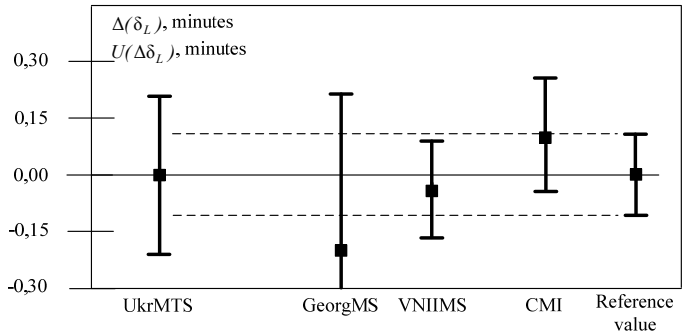

Figure 61 – Difference of NMI measurement results and reference value for the phase displacement $\Delta(\delta_L)$ and expanded uncertainty of this difference $U(\Delta\delta_L)$ for k_{Nu} = 22 kV/100 V at 0,4 U_N and burden of 5 V·A

22 kV/100 V, 0,6 U_N, S=5 V·A	$\Delta(\delta_L)$, minutes	$U(\Delta\delta_L)$, minutes
UkrMTS	-0,001	0,213
GeorgMS	-0,191	0,467
VNIIMS	-0,001	0,130
CMI	0,036	0,167
Reference value	0,000	0,111

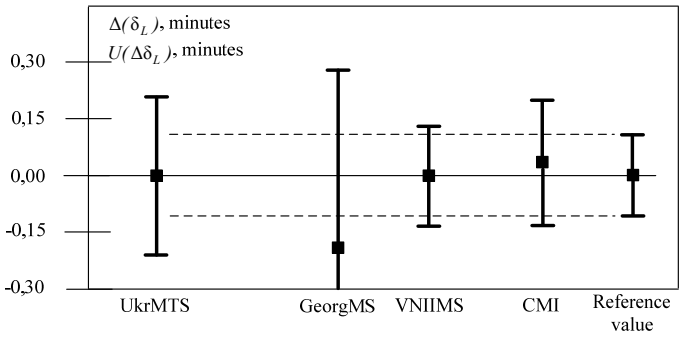

Figure 62 – Difference of NMI measurement results and reference value for the phase displacement $\Delta(\delta_L)$ and expanded uncertainty of this difference $U(\Delta\delta_L)$ for k_{Nu} = 22 kV/100 V at 0,6 U_N and burden of 5 V·A

22 kV/100 V, 0,8 U_N, S=5 V·A	$\Delta(\delta_L)$, minutes	$U(\Delta\delta_L)$, minutes
UkrMTS	-0,041	0,218
GeorgMS	-0,191	0,469
VNIIMS	0,029	0,137
CMI	0,013	0,112
Reference value	0,000	0,100

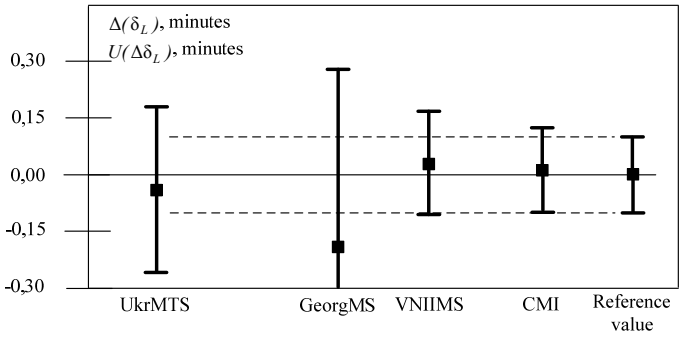

Figure 63 – Difference of NMI measurement results and reference value for the phase displacement $\Delta(\delta_L)$ and expanded uncertainty of this difference $U(\Delta\delta_L)$ for k_{Nu} = 22 kV/100 V at 0,8 U_N and burden of 5 V·A

22 kV/100 V, U_N, S=5 V·A	$\Delta(\delta_L)$, minutes	$U(\Delta\delta_L)$, minutes
UkrMTS	-0,041	0,218
GeorgMS	-0,191	0,469
VNIIMS	0,049	0,137
CMI	-0,004	0,112
Reference value	0,000	0,100

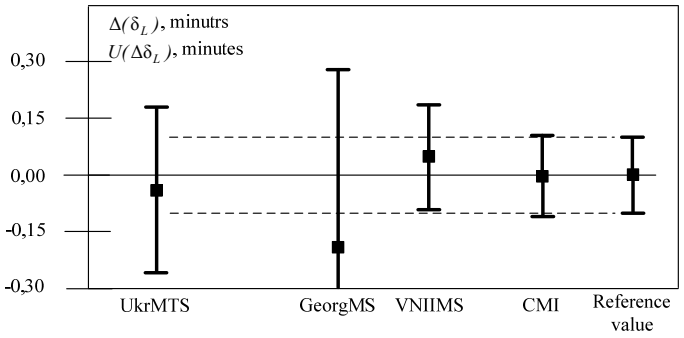

Figure 64 – Difference of NMI measurement results and reference value for the phase displacement $\Delta(\delta_L)$ and expanded uncertainty of this difference $U(\Delta\delta_L)$ for k_{Nu} = 22 kV/100 V at U_N and burden of 5 V·A

22 kV/100 V, 1,2 U_N, S=5 V·A	$\Delta(\delta_L)$, minutes	$U(\Delta\delta_L)$, minutes
UkrMTS	-0,032	0,218
GeorgMS	-0,172	0,469
VNIIMS	0,068	0,137
CMI	-0,024	0,112
Reference value	0,000	0,100

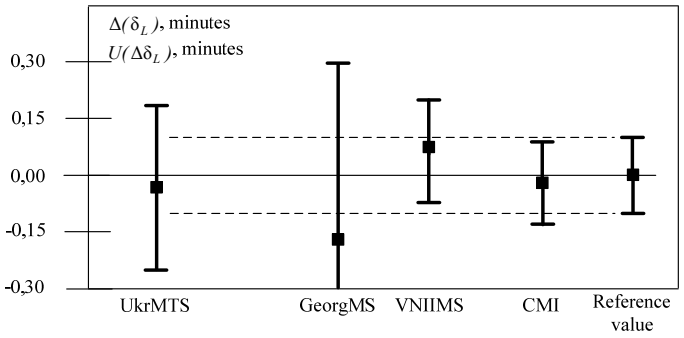

Figure 65 – Difference of NMI measurement results and reference value for the phase displacement $\Delta(\delta_L)$ and expanded uncertainty of this difference $U(\Delta\delta_L)$ for k_{Nu} = 22 kV/100 V at 1,2 U_N and burden of 5 V·A

22kV/100 V, 0,4 U_N, S≤0,1 V·A	$\Delta(\delta_L)$, minutes	$U(\Delta\delta_L)$, minutes
UkrMTS	0,080	0,214
GeorgMS	-0,090	0,301
VNIIMS	-0,120	0,131
CMI	0,144	0,168
Reference value	0,000	0,107

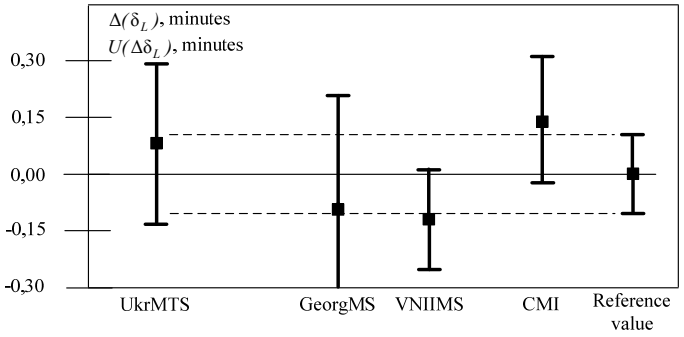

Figure 66 – Difference of NMI measurement results and reference value for the phase displacement $\Delta(\delta_L)$ and expanded uncertainty of this difference $U(\Delta\delta_L)$ for k_{Nu} = 22 kV/100 V at 0,4 U_N and burden of ≤0,1·V·A

22 kV/100 V, 0,6 U_N, S≤0,1 V·A	$\Delta(\delta_L)$, minutes	$U(\Delta\delta_L)$, minutes
UkrMTS	0,090	0,214
GeorgMS	-0,070	0,343
VNIIMS	-0,110	0,131
CMI	0,113	0,168
Reference value	0,000	0,109

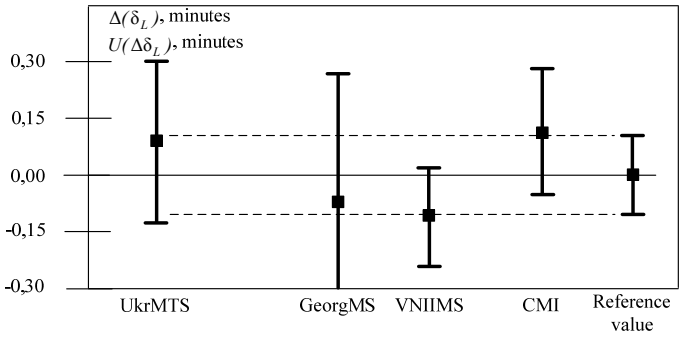

Figure 67 – Difference of NMI measurement results and reference value for the phase displacement $\Delta(\delta_L)$ and expanded uncertainty of this difference $U(\Delta\delta_L)$ for k_{Nu} = 22 kV/100 V at 0,6 U_N and burden of ≤0,1·V·A

22 kV/100 V, 0,8 U_N, S≤0,1 V·A	$\Delta(\delta_L)$, minutes	$U(\Delta\delta_L)$, minutes
UkrMTS	0,072	0,219
GeorgMS	-0,068	0,346
VNIIMS	-0,168	0,139
CMI	0,114	0,114
Reference value	0,000	0,098

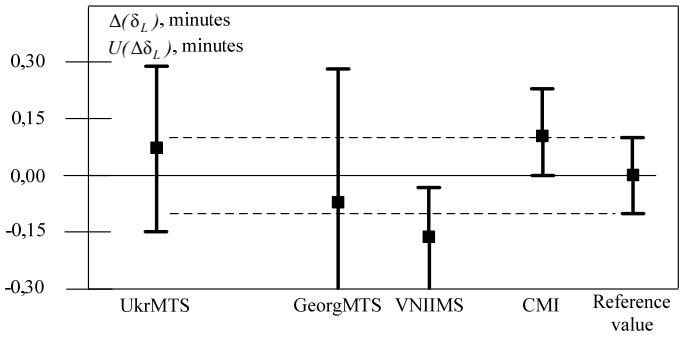

Figure 68 – Difference of NMI measurement results and reference value for the phase displacement $\Delta(\delta_L)$ and expanded uncertainty of this difference $U(\Delta\delta_L)$ for k_{Nu} = 22 kV/100 V at 0,8 U_N and burden of ≤0,1·V·A

22 kV/100 V, U_N, S≤0,1 V·A	$\Delta(\delta_L)$, minutes	$U(\Delta\delta_L)$, minutes
UkrMTS	0,052	0,219
GeorgMS	-0,068	0,346
VNIIMS	-0,148	0,139
CMI	0,107	0,114
Reference value	0,000	0,098

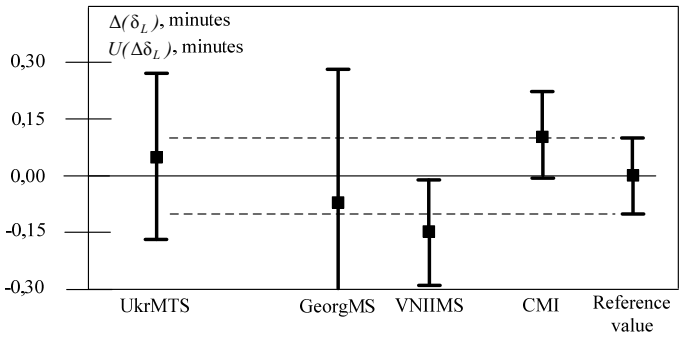

Figure 69 – Difference of NMI measurement results and reference value for the phase displacement $\Delta(\delta_L)$ and expanded uncertainty of this difference $U(\Delta\delta_L)$ for k_{Nu} = 22 kV/100 V at U_N and burden of ≤0,1·V·A

22 kV/100 V, 1,2 U_N, S≤0,1 V·A	$\Delta(\delta_L)$, minutes	$U(\Delta\delta_L)$, minutes
UkrMTS	0,075	0,219
GeorgMS	-0,065	0,346
VNIIMS	-0,135	0,139
CMI	0,086	0,114
Reference value	0,000	0,098

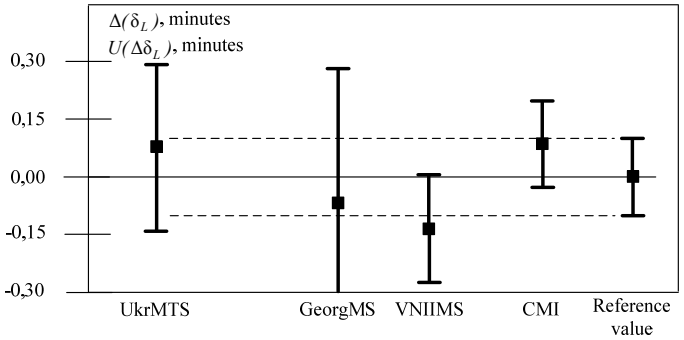

Figure 70 – Difference of NMI measurement results and reference value for the phase displacement $\Delta(\delta_L)$ and expanded uncertainty of this difference $U(\Delta\delta_L)$ for k_{Nu} = 22 kV/100 V at 1,2 U_N and burden of ≤0,1·V·A

35 kV/100 V, 0,4 U_N, S=5 V·A	$\Delta(\delta_L)$, minutes	$U(\Delta\delta_L)$, minutes
UkrMTS	-0,094	0,219
BelGIM	2,726	2,798
GeorgMS	-0,224	0,388
VNIIMS	-0,034	0,139
CMI	0,086	0,114
Reference value	0,000	0,099

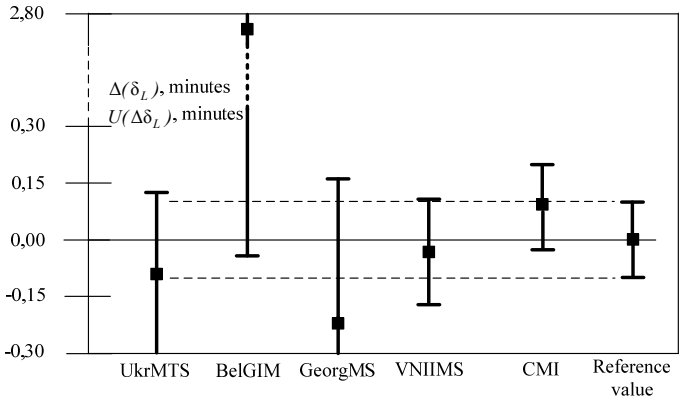

Figure 71 – Difference of NMI measurement results and reference value for the phase displacement $\Delta(\delta_L)$ and expanded uncertainty of this difference $U(\Delta\delta_L)$ for k_{Nu} = 35 kV/100 V at 0,4 U_N and burden of 5·V·A

35 kV/100 V, 0,6 U_N, S=5 V·A	$\Delta(\delta_L)$, minutes	$U(\Delta\delta_L)$, minutes
UkrMTS	-0,082	0,219
BelGIM	2,878	2,998
GeorgMS	-0,222	0,408
VNIIMS	0,018	0,139
CMI	0,038	0,114
Reference value	0,000	0,099

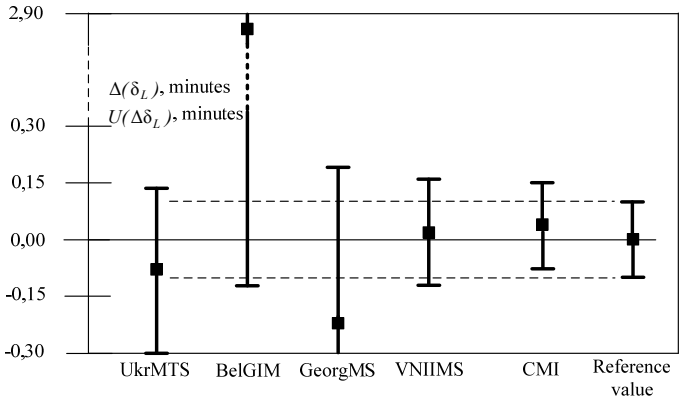

Figure 72 – Difference of NMI measurement results and reference value for the phase displacement $\Delta(\delta_L)$ and expanded uncertainty of this difference $U(\Delta\delta_L)$ for k_{Nu} = 35 kV/100 V at 0,6 U_N and burden of 5·V·A

35 kV/100 V, 0,8 U_N, S=5 V·A	$\Delta(\delta_L)$, minutes	$U(\Delta\delta_L)$, minutes
UkrMTS	-0,083	0,219
BelGIM	2,877	2,998
GeorgMS	-0,223	0,408
VNIIMS	0,047	0,139
CMI	0,017	0,114
Reference value	0,000	0,099

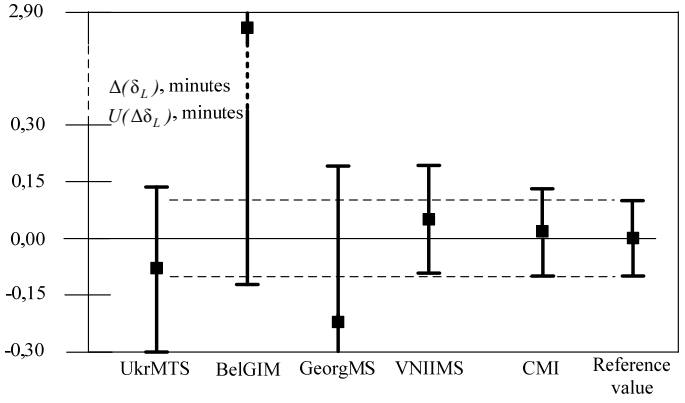

Figure 73 – Difference of NMI measurement results and reference value for the phase displacement $\Delta(\delta_L)$ and expanded uncertainty of this difference $U(\Delta\delta_L)$ for k_{Nu} = 35 kV/100 V at 0,8 U_N and burden of 5·V·A

35 kV/100 V, U_N, S=5 V·A	$\Delta(\delta_L)$, minutes	$U(\Delta\delta_L)$, minutes
UkrMTS	-0,092	0,219
BelGIM	2,878	2,998
GeorgMS	-0,192	0,388
VNIIMS	0,058	0,139
CMI	0,010	0,114
Reference value	0,000	0,099

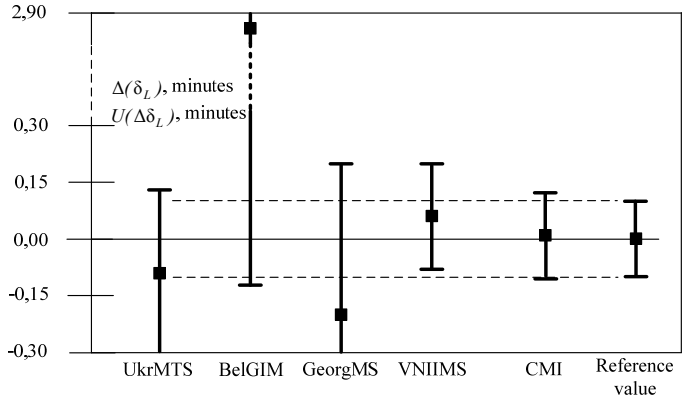

Figure 74 – Difference of NMI measurement results and reference value for the phase displacement $\Delta(\delta_L)$ and expanded uncertainty of this difference $U(\Delta\delta_L)$ for k_{Nu} = 35 kV/100 V at U_N and burden of 5·V·A

35 kV/100 V, 1,2 U_N, S=5 V·A	$\Delta(\delta_L)$, minutes	$U(\Delta\delta_L)$, minutes
UkrMTS	-0,086	0,219
BelGIM	2,964	2,998
GeorgMS	-0,186	0,388
VNIIMS	0,054	0,139
CMI	0,011	0,114
Reference value	0,000	0,099

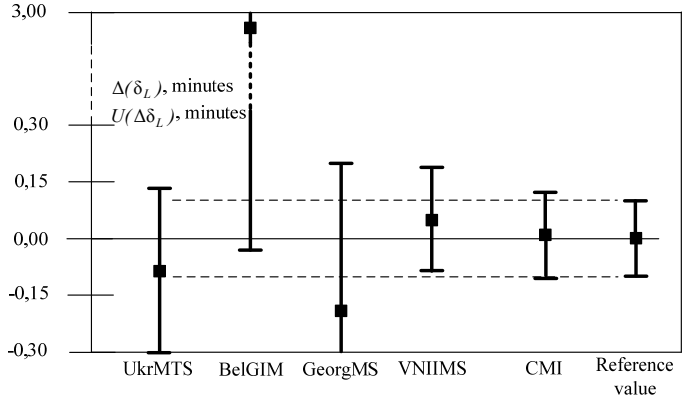

Figure 75 – Difference of NMI measurement results and reference value for the phase displacement $\Delta(\delta_L)$ and expanded uncertainty of this difference $U(\Delta\delta_L)$ for k_{Nu} = 35 kV/100 V at 1,2 U_N and burden of 5·V·A

35 kV/100 V, 0,4 U_N, S≤0,1 V·A	$\Delta(\delta_L)$, minutes	$U(\Delta\delta_L)$, minutes
UkrMTS	-0,053	0,222
BelGIM	1,427	1,597
GeorgMS	-0,193	0,200
VNIIMS	-0,013	0,143
CMI	0,107	0,118
Reference value	0,000	0,092

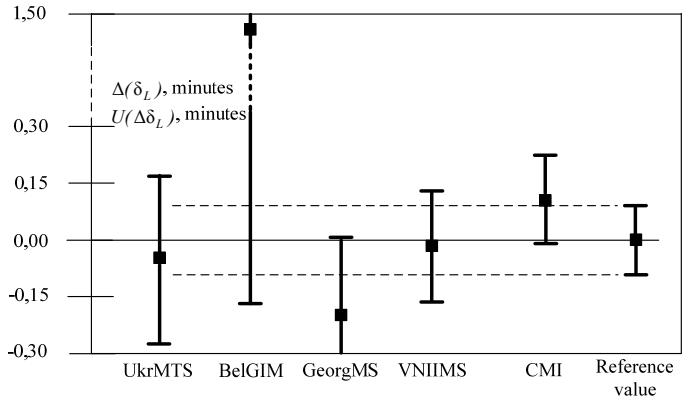

Figure 76 – Difference of NMI measurement results and reference value for the phase displacement $\Delta(\delta_L)$ and expanded uncertainty of this difference $U(\Delta\delta_L)$ for k_{Nu} = 35 kV/100 V at 0,4 U_N and burden of ≤0,1·V·A

35 kV/100 V, 0,6 U_N, S≤0,1 V·A	$\Delta(\delta_L)$, minutes	$U(\Delta\delta_L)$, minutes
UkrMTS	-0,055	0,222
BelGIM	1,575	1,597
GeorgMS	-0,185	0,200
VNIIMS	0,035	0,143
CMI	0,066	0,118
Reference value	0,000	0,092

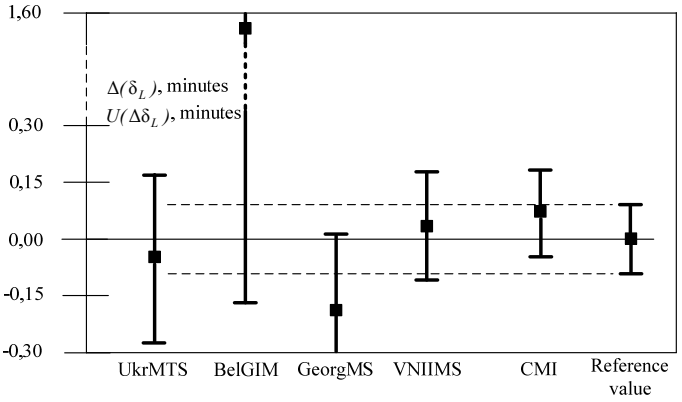

Figure 77 – Difference of NMI measurement results and reference value for the phase displacement $\Delta(\delta_L)$ and expanded uncertainty of this difference $U(\Delta\delta_L)$ for k_{Nu} = 35 kV/100 V at 0,6 U_N and burden of ≤0,1·V·A

35 kV/100 V, 0,8 U_N, S≤0,1 V·A	$\Delta(\delta_L)$, minutes	$U(\Delta\delta_L)$, minutes
UkrMTS	-0,075	0,221
BelGIM	1,675	1,798
GeorgMS	-0,185	0,221
VNIIMS	0,055	0,142
CMI	0,048	0,117
Reference value	0,000	0,094

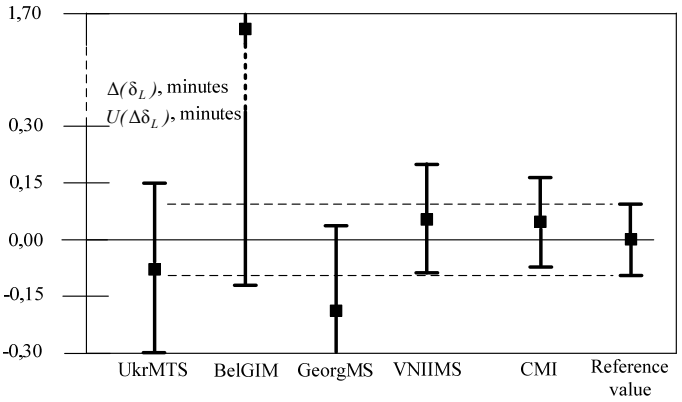

Figure 78 – Difference of NMI measurement results and reference value for the phase displacement $\Delta(\delta_L)$ and expanded uncertainty of this difference $U(\Delta\delta_L)$ for k_{Nu} = 35 kV/100 V at 0,8 U_N and burden of ≤0,1·V·A

35 kV/100 V, U_N, S≤0,1 V·A	$\Delta(\delta_L)$, minutes	$U(\Delta\delta_L)$, minutes
UkrMTS	-0,066	0,222
BelGIM	1,674	1,798
GeorgMS	-0,166	0,200
VNIIMS	0,074	0,143
CMI	0,034	0,118
Reference value	0,000	0,092

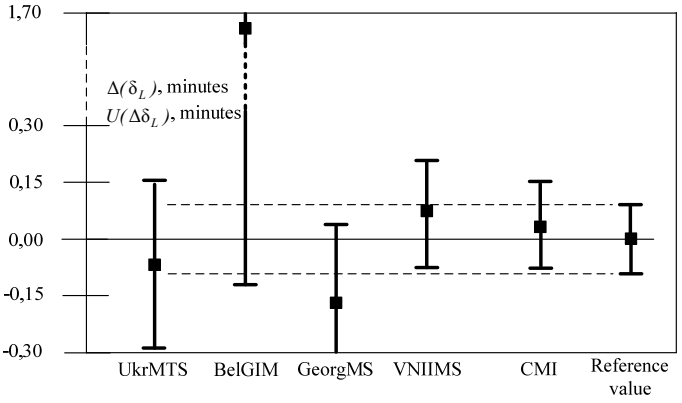

Figure 79 – Difference of NMI measurement results and reference value for the phase displacement $\Delta(\delta_L)$ and expanded uncertainty of this difference $U(\Delta\delta_L)$ for k_{Nu} = 35 kV/100 V at U_N and burden of ≤0,1·V·A

35 kV/100 V, 1,2 U_N, S≤0,1 V·A	$\Delta(\delta_L)$, minutes	$U(\Delta\delta_L)$, minutes
UkrMTS	-0,062	0,222
BelGIM	1,658	1,798
GeorgMS	-0,152	0,200
VNIIMS	0,068	0,143
CMI	0,030	0,118
Reference value	0,000	0,092

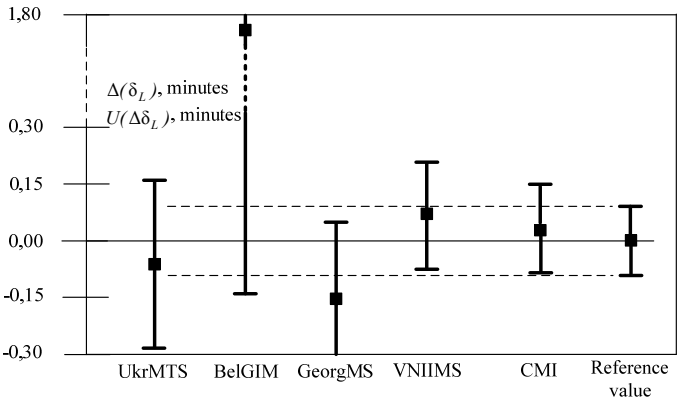

Figure 80 – Difference of NMI measurement results and reference value for the phase displacement $\Delta(\delta_L)$ and expanded uncertainty of this difference $U(\Delta\delta_L)$ for k_{Nu} = 35 kV/100 V at 1,2 U_N and burden of ≤0,1·V·A