

INTERNATIONAL COMPARISON OF AC CURRENT RATIO STANDARDS 50 HZ

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Abstract: The method and the results of the international comparison of AC current ratio standards 50 Hz frequency are introduced in this article. The national metrological laboratories of Hungary (OMH), Austria (BEV) and the Czech Republic (CMI) have taken part in this comparison realized as the project DUNAMET D7. The pilot laboratory was the national metrological laboratory OMH Budapest.

Keywords: international comparison, transfer standard, transformer errors

1 INTRODUCTION

The international comparison has been formed by using a transfer standard in which errors have been measured by means of the national standards of participating states. The standard current transformer SCT-2000L, developed and made in the Technical University in Budapest, has been chosen as the transfer standard [1]. It is a two stage passive transformer and its ratio error ε and phase displacement δ have been measured in a one stage connection. The transformer has a sensitivity on the variation of burden smaller than 15ppm/VA for the ratio error and smaller than 21 μ rad/VA for the phase displacement. The measurement of the errors ε and δ has been performed for the 50 Hz frequency, rated value of primary current $I_{1R} = (1 - 2,5 - 5 - 25)$ A, rated value of secondary current $I_{2R} = 5$ A and real burden $B = 1$ VA and 5 VA. The errors of the transfer standard have been measured for (1, 2, 5, 10, 20, 50, 100 and 120) % I_{1R} . In view of the dependence of transfer standard errors on the burden B it has been recommended to hold its value with the accuracy ± 1 %. The participating laboratories have evaluated the results of measurements inclusive of uncertainties according to the document [2].

2 CONNECTION OF MEASURING CIRCUIT

The recommended connection for the measurement of ratio error ε and phase displacement δ of the transfer standard is in Fig.1. The differences ε and δ between the transfer standard and the national standard are measured by means of a system for transformer error evaluation [1], [3], [4]. The amplifier A used in the primary circuit serves for the setting of the potential of the terminal "K" of the transfer standard on the level near to the earth. It is guaranteed that the capacitive errors do not depend on a type of a national standard.

3 REALIZATION OF MEASUREMENT IN CMI

Two different standards have been used in the Czech Metrological Institute. The standard current transformer with electronic compensation of errors Tettex 4761 has been used for all measured ratios and burdens of the transfer standard. Its ratio error ε is smaller than ± 10 ppm and its phase displacement δ is smaller than $\pm 0,05'$. The automatic transformer test set Tettex 2767 has been used for the error evaluation of the transfer standard. Its measuring range is $\pm (0,1999 \div 19,99)$ % for ratio error and $\pm (0,1999 \div 19,99)$ crad for phase displacement. The measurement uncertainty of ε and δ $U_{BS} = \pm 0,5$ % RDG $\pm (0,5$ % FS or 10 ppm or 10 μ rad). The bigger of both values in brackets applies.

The compensated toroidal current comparator KPK2 developed and made in the Czech Technical University Prague [5] has been used as the second standard for all measured ratios and for the burden 5 VA. The uncertainty of its ratio error ε does not exceed ± 10 ppm and of phase displacement δ $\pm 0,01'$. Its additional burden is smaller than 2 m Ω .

The measurement of transfer standard errors has been performed ten times by the system Tettex. The transfer standard has been demagnetized before every measurement. The uncertainty A has been

evaluated for this set of measurements. The measurement by means of the KPK2 comparator has been performed only once and it has served as an additional control.

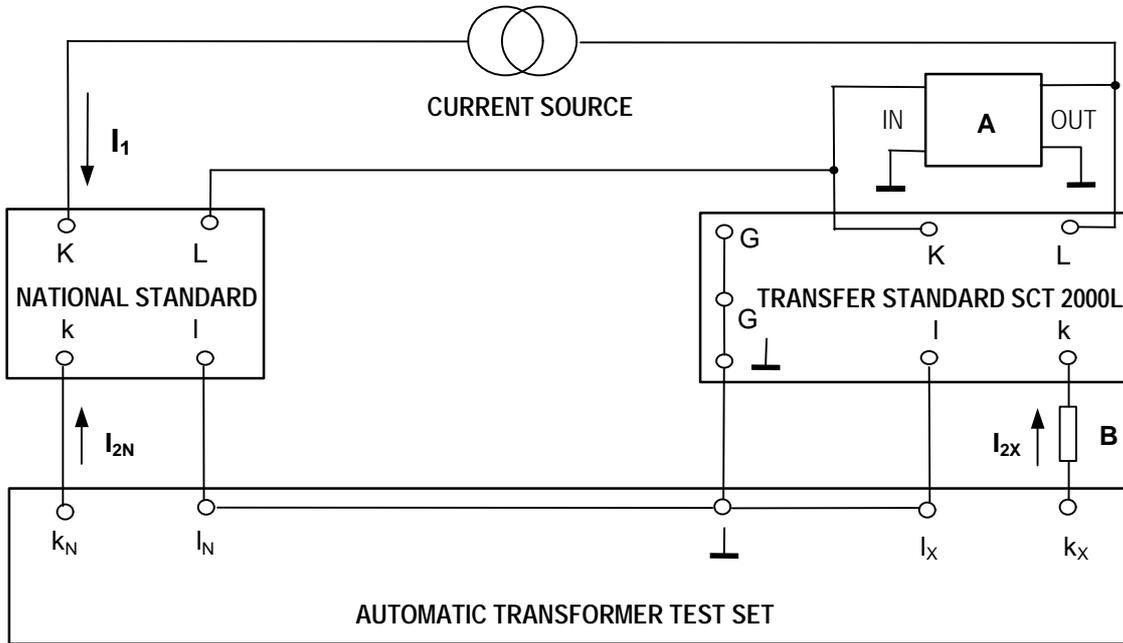


Figure 1. The connection for the measurement of ratio error ε and phase displacement δ of the transfer standard by means of an automatic transformer test set.

4 RESULT PROCESSING IN CMI

The ratio error of the transfer standard is expressed by the formula

$$e = \frac{K_N I_{2X} - I_1}{I_1}, \quad (1)$$

where e is ratio error [-], $K_N = I_1/I_{2X}$ is transformation ratio [-], I_{2X} secondary current [A], I_1 primary current [A].

The phase displacement d is given by the phase shift between the primary and secondary currents. When the errors of the national standard approach zero, they affect only the uncertainty of type B. The result of measurement by the system Tettex is given as the arithmetic mean of ten measurements.

The combined uncertainty result of measurement of errors ε and δ performed in CMI is given by formula

$$U_{eCMI} = \sqrt{U_{Ae}^2 + U_{Be}^2}; \quad U_{dCMI} = \sqrt{U_{Ad}^2 + U_{Bd}^2}, \quad (2)$$

where U_{Ae} and U_{Ad} are uncertainties type A, U_{Be} and U_{Bd} are uncertainties B.

The uncertainty of A is given as the standard deviation of one measurement from the set of ten measurements by the formula

$$U_{Ae} = \sqrt{\frac{1}{n-1} \sum_{n=1}^{10} (e_n - e_{CMI})^2}; \quad U_{Ad} = \sqrt{\frac{1}{n-1} \sum_{n=1}^{10} (d_n - d_{CMI})^2}, \quad (3)$$

where ε_n and δ_n are results of single measurement, ε_{CMI} and δ_{CMI} represent the arithmetic mean of ten measurements.

The uncertainty of B is given by parameters of the used standard and measuring devices. For uniform distribution it can be expressed by the formula

$$U_{Be} = \sqrt{\frac{1}{3} (U_{BEe}^2 + U_{BSe}^2 + U_{BBe}^2)}; \quad U_{Bd} = \sqrt{\frac{1}{3} (U_{BED}^2 + U_{BSd}^2 + U_{BBd}^2)}, \quad (4)$$

where $U_{BE\varepsilon}$ or $U_{BE\delta}$ are the uncertainty of ratio error ε or phase displacement δ of the national standard, $U_{BS\varepsilon}$ or $U_{BS\delta}$ are the uncertainty of reading ε or δ measured by system Tettex 2767, $U_{BB\varepsilon}$ or $U_{BB\delta}$ are the uncertainty ε or δ given by the adjustment of the burden B.

5 FINAL RESULT EVALUATION OF THE INTERNATIONAL COMPARISON

The results of measurement of single national laboratories have been evaluated by the pilot laboratory OMH Budapest. Reference values of ratio error ε_R and phase displacement δ_R have been determined for the given value of primary current I_1 and burden B of the transfer standard according to [2]

$$\mathbf{e}_R = 1/3 (\mathbf{e}_{OMH} + \mathbf{e}_{CMI} + \mathbf{e}_{BEV}); \quad \mathbf{d}_R = 1/3 (\mathbf{d}_{OMH} + \mathbf{d}_{CMI} + \mathbf{d}_{BEV}), \quad (5)$$

where the suffixes OMH, CMI and BEV indicate the results of measurement of single laboratories.

The reference values ε_R and δ_R have been obtained from the set of 3 measurements (OMH, BEV and CMI) and their uncertainties $U_{\varepsilon R}$ and $U_{\delta R}$ have been determined according to [2] as standard deviations of the results of single laboratories by formulas

$$U_{\varepsilon R} = \sqrt{\frac{(\mathbf{e}_{OMH} - \mathbf{e}_R)^2 + (\mathbf{e}_{CMI} - \mathbf{e}_R)^2 + (\mathbf{e}_{BEV} - \mathbf{e}_R)^2}{2}}; \quad U_{\delta R} = \sqrt{\frac{(\mathbf{d}_{OMH} - \mathbf{d}_R)^2 + (\mathbf{d}_{CMI} - \mathbf{d}_R)^2 + (\mathbf{d}_{BEV} - \mathbf{d}_R)^2}{2}}. \quad (6)$$

The participating laboratories have given a combined result of uncertainties of their measurement created by the uncertainties of type A and B. The criterion of credibility for the results of each single laboratory is given by the formulas

$$E_e = \frac{|\mathbf{e}_{lab} - \mathbf{e}_R|}{\sqrt{U_{e_{lab}}^2 + U_{\varepsilon R}^2}}; \quad E_d = \frac{|\mathbf{d}_{lab} - \mathbf{d}_R|}{\sqrt{U_{d_{lab}}^2 + U_{\delta R}^2}}, \quad (7)$$

where \mathbf{e}_{lab} and \mathbf{d}_{lab} are the result values measured in each single laboratory. $U_{e_{lab}}$ and $U_{d_{lab}}$ are the uncertainties of measurement \mathbf{e} and \mathbf{d} of each single laboratory.

6 RESULTS OF THE INTERNATIONAL COMPARISON

The results of international comparisons are given in table 1 and 2. All uncertainties presented in this tables have been determined as expanded uncertainties for the coverage factor $k = 2$.

Symbols used in table 1 and 2:

I_1 primary current [A], I_{1R} rated value of primary current [A], ε_R [ppm] and δ_R [μ rad] reference values of ratio error and phase displacement, $U_{\varepsilon R}$ and $U_{\delta R}$ the uncertainty of reference value of errors, $\varepsilon_{OMH,BEV,CMI}$, $\delta_{OMH,BEV,CMI}$, $U_{\varepsilon_{OMH,BEV,CMI}}$, $U_{\delta_{OMH,BEV,CMI}}$ results and uncertainties of errors measured in laboratories of Hungary (OMH), Austria (BEV) and the Czech Republic (CMI).

In table 3 and 4 are presented results measured by the compensated toroidal comparator KPK2. Only the burden 5 VA has been used by this measurement because the burden 1 VA is difficult to fulfil in this case.

Symbols used in table 3 and 4:

ε_K , δ_K values of ratio error [ppm] and phase displacement [μ rad] measured by comparator KPK2; $U_{\varepsilon K}$, $U_{\delta K}$ uncertainties of values ε_K and δ_K ; other symbols are identical with symbols used in table 1 a 2.

7 CONCLUSION

It is an obvious very good agreement of results between the national laboratories of Hungary, Austria and the Czech Republic. The confidence coefficients E_ε and E_δ do not exceed 0,5. It is necessary to take in to account that the transformer errors depend on the magnetic parameters of the transformer core. These parameters change with the value of measured current and burden of the transformer and depend on previous magnetizing of the transformer core. This effect is apparent especially for small values of measured current or for small measured errors. Therefore the proper demagnetization of the core before measurement is necessary. The adjustment of proper value of measured current and burden is important for correct results of measurement as well.

The results of the controlled measurement formed by the compensated toroidal current comparator KPK2 show good agreement of both used methods.

From the results of measurement it is obvious that the range given by uncertainties of participant laboratories is much wider than the range given by reference values and results of single participants.

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Table 1. Results of international comparison of transfer standard of AC current ratio frequency 50 Hz SCT-2000L, measured by real burden 1 VA.

Ratio [A/A]	I ₁ [%] I _R	reference value				Hungary				Austria				Czech Republic			
		ε _R [ppm]	δ _R [μrad]	U _{εR} [ppm]	U _{δR} [μrad]	ε _{OMH} [ppm]	δ _{OMH} [μrad]	U _{εOMH} [ppm]	U _{δOMH} [μrad]	ε _{BEV} [ppm]	δ _{BEV} [μrad]	U _{εBEV} [ppm]	U _{δBEV} [μrad]	ε _{CM1} [ppm]	δ _{CM1} [μrad]	U _{εCM1} [ppm]	U _{δCM1} [μrad]
25/5	120	-96	+210	7	24	-100	+223	8,6	14,3	-93	+20	35,4	44,6	-95	+19	15,1	14,8
	100	-99	+217	6	20	-102	+229	9,3	34,9	-97	+21	35,4	44,6	-97	+21	15,4	17,0
	50	-107	+270	4	9	-109	+275	9,7	57,9	-108	+26	35,4	44,6	-105	+26	17,3	28,0
	20	-117	+343	6	42	-120	+359	10,2	34,9	-114	+31	35,4	44,6	-116	+35	17,5	45,2
	10	-123	+420	3	34	-124	+427	9,9	48,4	-123	+40	35,4	44,6	-121	+43	17,5	91,1
	5	-113	+488	6	41	-113	+502	13,5	55,6	-110	+46	35,4	44,6	-116	+49	19,8	58,6
	2	-91	+560	9	50	-86	+561	15,6	47,4	-94	+53	35,4	44,6	-93	+58	38,0	67,7
	1	-73	+562	24	137	-59	+489	53,7	323,3	-82	+57	35,4	44,6	-77	+62	59,5	82,9
10/5	120	-99	+206	3	12	-99	+210	6,0	14,3	-97	+20	35,4	44,6	-100	+19	13,8	15,3
	100	-101	+215	2	10	-101	+221	6,0	15,3	-100	+21	35,4	44,6	-102	+21	14,1	17,5
	50	-109	+258	3	34	-108	+270	6,7	19,2	-110	+23	35,4	44,6	-110	+26	16,1	30,3
	20	-119	+339	5	37	-119	+347	6,0	22,5	-116	+31	35,4	44,6	-121	+35	16,5	52,7
	10	-121	+405	11	61	-123	+416	13,2	30,2	-115	+37	35,4	44,6	-125	+42	15,8	66,8
	5	-116	+485	9	43	-117	+490	9,5	37,9	-111	+46	35,4	44,6	-120	+50	18,0	73,5
	2	-95	+558	8	54	-91	+559	18,8	116,8	-95	+53	35,4	44,6	-99	+58	37,1	79,3
	1	-79	+590	12	66	-72	+572	13,4	58,3	-83	+57	35,4	44,6	-82	+62	59,2	92,4
5/5	120	-97	+202	9	16	-99	+211	6,0	21,4	-92	+19	35,4	44,6	-100	+20	13,8	15,3
	100	-99	+211	8	26	-100	+223	7,1	15,5	-94	+19	35,4	44,6	-102	+21	14,1	17,5
	50	-106	+262	8	29	-107	+273	7,7	17,4	-102	+24	35,4	44,6	-110	+26	16,0	30,3
	20	-115	+339	11	44	-117	+349	10,5	18,8	-109	+31	35,4	44,6	-120	+35	16,7	52,1
	10	-121	+403	8	78	-121	+421	15,3	24,6	-117	+35	35,4	44,6	-125	+43	15,9	65,6
	5	-115	+484	8	74	-111	+506	29,2	65,6	-114	+44	35,4	44,6	-119	+50	18,3	71,2
	2	-91	+573	14	59	-87	+592	25,6	62,8	-87	+53	35,4	44,6	-99	+58	37,1	77,6
	1	-75	+595	16	88	-66	+571	21,7	295,2	-76	+56	35,4	44,6	-82	+64	59,2	132,7
2,5/5	120	-98	+202	5	20	-100	+213	7,7	17,9	-98	+19	35,4	44,6	-95	+20	13,3	14,8
	100	-100	+212	4	34	-102	+228	7,7	30,3	-100	+19	35,4	44,6	-98	+21	13,9	16,4
	50	-104	+263	9	35	-108	+277	9,7	32,8	-99	+24	35,4	44,6	-105	+26	15,7	29,2
	20	-117	+341	4	51	-119	+357	12,2	47,9	-115	+31	35,4	44,6	-116	+35	16,5	51,6
	10	-119	+406	10	85	-122	+433	18,3	75,2	-113	+35	35,4	44,6	-121	+42	16,0	65,6
	5	-112	+488	6	82	-110	+520	24,8	110,6	-110	+44	35,4	44,6	-115	+50	18,2	72,4
	2	-88	+568	9	108	-86	+609	29,3	122,6	-85	+50	35,4	44,6	-93	+58	37,2	78,7
	1	-74	+603	8	108	-70	+642	23,5	124,5	-73	+54	35,4	44,6	-78	+62	59,3	91,9
1/5	120	-97	+190	6	56	-98	+212	5,3	15,3	-93	+15	35,4	44,6	-99	+20	13,5	15,3
	100	-99	+199	7	65	-100	+223	7,1	13,3	-95	+16	35,4	44,6	-102	+21	13,9	17,0
	50	-107	+261	5	34	-106	+274	7,1	21,0	-105	+24	35,4	44,6	-110	+26	15,8	29,7
	20	-117	+339	9	46	-119	+352	8,6	29,8	-112	+31	35,4	44,6	-121	+35	16,4	53,9
	10	-123	+404	6	76	-122	+426	11,3	56,4	-120	+36	35,4	44,6	-126	+42	15,7	69,1
	5	-114	+485	13	72	-113	+510	26,3	67,1	-108	+44	35,4	44,6	-121	+50	18,3	76,4
	2	-92	+566	15	99	-85	+603	30,2	100,9	-92	+51	35,4	44,6	-100	+58	37,1	82,6
	1	-78	+596	14	90	-70	+618	23,8	200,7	-80	+54	35,4	44,6	-84	+62	59,2	93,9

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Table 2. Results of international comparison of transfer standard of AC current ratio frequency 50 Hz SCT-2000L, measured by real burden 5 VA.

ratio [A/A]	I ₁ [%] I _R	reference value				Hungary				Austria				Czech Republic			
		ε _R [ppm]	δ _R [μrad]	U _{εR} [ppm]	U _{δR} [μrad]	ε _{OMH} [ppm]	δ _{OMH} [μrad]	U _{εOMH} [ppm]	U _{δOMH} [μrad]	ε _{BEV} [ppm]	δ _{BEV} [μrad]	U _{εBEV} [ppm]	U _{δBEV} [μrad]	ε _{CM1} [ppm]	δ _{CM1} [μrad]	U _{εCM1} [ppm]	U _{δCM1} [μrad]
25/5	120	-156	+290	7	45	-159	+315	10,6	23,9	-152	+28 5	35,4	44,6	-158	+27 1	14,5	23,9
	100	-160	+304	7	44	-162	+329	12,9	37,1	-156	+29 5	35,4	44,6	-162	+28 8	14,7	37,1
	50	-171	+383	5	29	-171	+399	15,9	75,5	-169	+37 9	35,4	44,6	-174	+37 1	16,7	75,5
	20	-185	+498	10	64	-186	+530	18,3	41,4	-179	+46 6	35,4	44,6	-189	+49 9	17,8	41,4
	10	-199	+600	6	39	-200	+615	25,1	97,8	-196	+57 8	35,4	44,6	-202	+60 8	16,9	97,8
	5	-198	+717	14	66	-197	+744	23,8	94,0	-192	+68 0	35,4	44,6	-206	+72 7	19,0	94,0
	2	-172	+868	16	78	-166	+897	10,8	129,9	-170	+82 4	35,4	44,6	-181	+88 4	37,7	129,9
	1	-140	+924	30	92	-123	+896	48,9	251,3	-147	+89 9	35,4	44,6	-151	+97 7	59,7	251,3
10/5	120	-158	+284	6	21	-157	+294	8,0	14,6	-155	+28 6	35,4	44,6	-161	+27 3	13,3	13,1
	100	-162	+298	6	22	-161	+310	9,5	14,0	-159	+29 3	35,4	44,6	-165	+29 0	13,6	14,2
	50	-172	+370	8	42	-169	+388	9,3	20,1	-171	+34 7	35,4	44,6	-177	+37 4	16,2	23,5
	20	-185	+490	12	44	-183	+502	11,4	34,9	-181	+46 4	35,4	44,6	-192	+50 3	17,5	44,6
	10	-197	+586	17	71	-198	+598	17,1	22,8	-188	+54 6	35,4	44,6	-205	+61 4	16,3	61,6
	5	-201	+712	15	54	-199	+721	28,3	27,8	-194	+68 1	35,4	44,6	-209	+73 3	19,1	70,6
	2	-175	+858	17	65	-170	+863	17,6	93,0	-170	+82 3	35,4	44,6	-185	+88 7	37,8	78,7
	1	-140	+900	34	171	-120	+813	52,3	332,9	-146	+90 3	35,4	44,6	-153	+98 3	59,6	93,9
5/5	120	-156	+281	11	24	-157	+294	6	29,7	-150	+27 2	35,4	44,6	-161	+27 6	13,2	13,7
	100	-160	+297	11	34	-160	+316	8,2	39,3	-154	+28 2	35,4	44,6	-165	+29 4	13,5	14,8
	50	-170	+377	12	36	-169	+394	6,6	38,4	-165	+35 8	35,4	44,6	-177	+37 8	15,7	24,6
	20	-183	+493	19	54	-183	+511	9	31,6	-173	+46 2	35,4	44,6	-192	+50 6	17,6	45,2
	10	-197	+589	16	92	-196	+615	18,9	46,2	-190	+53 6	35,4	44,6	-206	+61 7	16,5	63,9
	5	-199	+717	19	105	-192	+757	29,2	113	-196	+65 7	35,4	44,6	-210	+73 6	19,7	74,1
	2	-172	+878	24	101	-167	+920	31,9	140,7	-164	+82 2	35,4	44,6	-186	+89 3	37,9	83,2
	1	-143	+964	21	106	-135	+100 3	37,7	180,7	-138	+90 4	35,4	44,6	-155	+98 6	59,6	98,8
2,5/5	120	-156	+280	4	33	-158	+299	7,1	19	-156	+26 9	35,4	44,6	-154	+27 3	14,7	12,6
	100	-160	+295	3	39	-161	+316	7,1	25	-160	+27 8	35,4	44,6	-158	+29 0	14,9	14,8
	50	-167	+374	12	43	-172	+397	5,3	33,2	-160	+35 4	35,4	44,6	-169	+37 2	17,3	25,2
	20	-183	+491	6	60	-184	+516	6,9	30,5	-179	+45 8	35,4	44,6	-185	+49 9	18,3	46,9
	10	-193	+589	13	96	-196	+624	20,6	60,9	-186	+53 4	35,4	44,6	-198	+60 8	17,5	65,0
	5	-197	+712	11	97	-199	+751	38,2	94,7	-191	+65 7	35,4	44,6	-202	+72 7	19,6	75,8
	2	-168	+867	17	129	-167	+919	61,7	160,5	-160	+79 4	35,4	44,6	-177	+88 7	38,0	83,7
	1	-138	+957	17	149	-133	+102 0	46,0	156,6	-134	+87 5	35,4	44,6	-148	+97 7	59,7	97,8
1/5	120	-155	+271	6	52	-156	+297	5,3	11,8	-152	+24 5	35,4	44,6	-158	+27 2	13,5	15,3
	100	-160	+285	7	63	-160	+314	7,1	15,8	-156	+25 2	35,4	44,6	-163	+28 9	13,9	17,0
	50	-170	+374	7	40	-170	+395	7,1	23,4	-167	+35 6	35,4	44,6	-174	+37 1	15,8	29,7
	20	-184	+493	13	53	-185	+516	8,6	31,2	-177	+46 4	35,4	44,6	-190	+49 9	16,4	53,9
	10	-198	+589	10	86	-199	+620	11,3	48,2	-193	+54 0	35,4	44,6	-203	+60 8	15,7	69,1
	5	-198	+715	19	93	-197	+754	26,3	107,4	-189	+66 3	35,4	44,6	-208	+72 7	18,3	76,4
	2	-173	+870	21	139	-165	+933	30,2	167	-170	+79 6	35,4	44,6	-185	+88 1	37,1	82,6
	1	-143	+952	19	131	-134	+100 4	23,8	187,9	-143	+87 9	35,4	44,6	-153	+97 4	59,2	93,9

Table 3. Results of supplementary measurement of ratio error of transfer standard of AC current ratio frequency 50 Hz SCT-2000L, measured by compensated current comparator KPK2, real burden 5 VA.

I_1 [%]	1 A / 5 A			2,5 A / 5 A			5 A / 5 A			10 A / 5 A			25 A / 5 A			U_{eK} [ppm]
	e_R [ppm]	e_K [ppm]	$e_R - e_K$ [ppm]													
120	-155	-149	-6	-156	-151	-5	-156	-156	0	-158	-156	-2	-156	-153	-3	10
100	-160	-152	-8	-160	-152	-8	-160	-159	-1	-162	-159	-3	-160	-155	-5	10
50	-170	-160	-10	-167	-159	-8	-170	-167	-3	-172	-168	-4	-171	-162	-9	10
20	-184	-170	-14	-183	-172	-11	-183	-182	-1	-185	-181	-4	-185	-180	-5	10
10	-198	-185	-13	-193	-179	-14	-197	-196	-1	-197	-196	-1	-199	-195	-4	15
5	-198	-182	-16	-197	-187	-10	-199	-197	-2	-201	-199	-2	-198	-198	0	20
2	-173	-155	-18	-168	-156	-12	-172	-161	-11	-175	-167	-8	-172	-164	-8	25
1	-143	-105	-38	-138	-102	-36	-143	-120	-23	-140	-120	-20	-140	-118	-22	30

Table 4. Results of supplementary measurement of phase displacement of transfer standard of AC current ratio frequency 50 Hz SCT-2000L, measured by compensated current comparator KPK2, real burden 5 VA.

I_1 [%]	1 A / 5 A			2,5 A / 5 A			5 A / 5 A			10 A / 5 A			25 A / 5 A			U_{dK} [mrad]
	d_R [mrad]	d_K [mrad]	$d_R - d_K$ [mrad]													
120	271	279	-8	280	273	7	281	283	-2	284	262	22	290	276	14	8
100	285	297	-12	295	292	3	297	299	-2	298	279	19	304	294	10	8
50	374	376	-2	374	370	4	377	379	-2	370	355	15	383	365	18	8
20	493	490	3	491	485	6	493	502	-9	490	466	24	498	476	22	8
10	589	590	-1	589	586	3	589	609	-20	586	564	22	600	578	22	12
5	715	707	8	712	709	3	717	733	-16	712	679	33	717	692	25	16
2	870	872	-2	867	874	-7	878	897	-19	858	839	19	868	857	11	20
1	952	967	-15	957	975	-18	964	990	-26	900	940	-40	924	951	-27	25

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