THE COMPLEX OF UKRAINIAN NATIONAL ELECTRICAL STANDARDS OF NATIONAL METROLOGICAL INSTITUTE "UKRMETRTESTSTANDARD"

Oleh Velychko

State Enterprise "Ukrmetrteststandard", Kyiv, Ukraine, Velychko@ukrcsm.kiev.ua

Abstract: The complex Ukrainian national electrical standards of national metrological institute "Ukrmetrtest-standard", their key and supplementary comparisons and calibration and measurement capabilities "Ukrmetrtest-standard" in electrical and magnetism field are considered.

Key words: comparisons, national standards, national metrological institute, regional metrology organizations.

1. INTRODUCTION

The Mutual Recognition Arrangement (MRA) has been drawn up by the International Committee of Weights and Measures (CIPM) for signature by directors of the national metrology institutes (NMIs) of Member States of the Convention.

NMI directors sign the CIPM MRA with the approval of the appropriate authorities in their own country and thereby: accept the process specified in the CIPM MRA for establishing the database; recognize the results of key and supplementary comparisons as stated in the KCs database – KCDB Bureau of Weights and Measures (BIPM); recognize the calibration and measurement capabilities (CMCs) of other participating NMIs as stated in the KCDB.

Participation in the arrangement through their regional metrology organization (RMOs) is also open to the NMIs of States and Economies that are Associates of the General Conference of Weights and Measures (CGPM). Comparison of national measurement standards (NMSs) must be carried out periodically between NMIs from RMOs to establish the relationship between their practical units.

A Joint Committee of the RMOs and the BIPM (JCRB) is responsible for the coordination of data provided by the RMOs, and other actions undertaken by them to promote confidence in calibration and measurement certificates. Coordination of the key comparisons (KCs) is effected through consultations between the Consultative Committees (CCs) and the RMOs.

NMI "Ukrmetrteststandard" (UMTS) was designated NMI of the CIPM MRA in 2003. COOMET Quality System Forum has issued a Certificate of recognition QSF-R22 the UMTS Quality Management System's compliance to international standard ISO/IEC 17025 and international guide ISO Guide 34 in May 2011.

On 17 August 2007 UMTS got authorization to use the CIPM MRA Logo on the calibration and measurement certificates of institute in the quantities and ranges listed in institute entries in the Appendix C of the BIPM KCDB.

2. THE COMPLEX OF NATIONAL ELECTRICAL STANDARDS OF UKRAINE

The UMTS is among the largest centre of scientific, legal and practical metrology in Ukraine dealing with precise measurements and methods assuring their traceability to national standards NMIs of Ukraine and NMIs other countries.

The UMTS conducts scientific applied investigations in the field of metrology and carries out scientific research work related with establishment, improvement, maintenance and application of primary and secondary standards. In Scientific and Production Institute of Measurement Assurance of Electrical and Magnetic Values (SPIM EM) of UMTS keeping six Ukrainian State (national) standards of units in electrical and magnetism field (EM), which was created in 1998–2010 [1, 2].

The complex of Ukrainian national electrical standards of UMTS is shown on Fig. 1. The UMTS standard base includes national standards for such units as: AC voltage (up to 1000 V); DC high voltage (up to 180 kV) AC high voltage (up to $330 \cdot \sqrt{3}$ kV); power [3]; capacitance, and inductance, and secondary standard of time and frequency units.

3. INTERCOMPARISONS OF THE NATIONAL STANDARDS

The main metrological characteristics, list of inter-comparisons of Ukrainian national electrical standards, which keeping in UMTS, and UMTS CMCs are shown on Table 1. All national standards UMTS involving in key and supplementary comparisons for EM, which organized two RMOs: EURAMET (EURAMET.EM-K5.1, EURAMET. EM-S26) and COOMET (COOMET.EM-K4, COOMET. EM-S1, S2, S4, S5, S6, S7). In four comparisons for EM UMTS (COOMET.EM-K4, COOMET.EM-S2, S4, S5) are pilot NMI (laboratory) [4, 5].

RMO KCs must be linked to the corresponding CIPM CC KCs by means of joint participants. The degree of equivalence derived from an RMO KCs has the same status as that derived from CIPM CC KCs.

The results of KC COOMET.EM-K4 [6] (Draft A) will be linked to KC CCEM-K4 between the practical capacitance units (capacitance 10 pF) of ten NMIs from four RMOs (EUROMET.EM-K4, COOMET.EM-K4, APMP. EM-K4.1, SIM.EM-K4), and of the BIPM, which organized

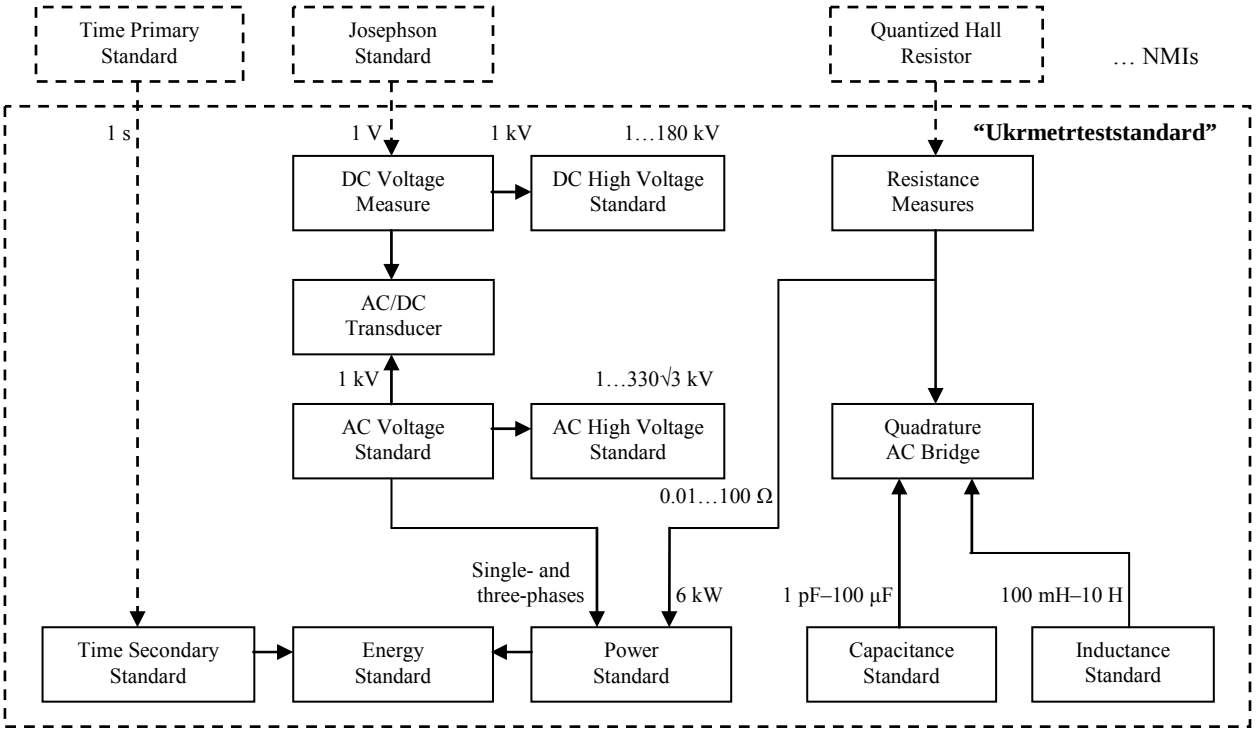

Fig. 1. The complex of Ukrainian national electrical standards of NMI "Ukrmetrteststandard"

Table 1. Ukrainian national standards of electrical units of NMI "Ukrmetrteststandard"

National standard	Metrological parameters	CIPM MRA	
		Intercomparisons – NMIs	Parameters
♦ The State Standard of the unit of DC electric voltage units in the range from 1 to 180 kV, DETU 08-04-99	U = 1…180 kV u = 1.2•10^{-5}	♦ COOMET.EM-S7 – **UMTS**, VNIIMS, LCOE (3 NMIs)	1, 100 kV, 5 mA
♦ The State Standard of AC electric voltage units in the range from 1 to 1,2•330 √3 kV and of scaling transformation coefficient for electrical current at the frequency of 50 Hz, DETU 08-05-99	U = 1…1.2•330√3 kV f = 50 Hz u = 7•10^{-5}	♦ COOMET.EM-S5 – **UMTS (pilot)**, VNIIMS, BelGIM, GSM, CMI (5 NMIs) ♦ COOMET.EM-S6 – **UMTS**, VNIIMS, CMI, SP, HUT, ICMET, LCOE (7 NMIs)	6, 10 kV 50 Hz, 100 V 110/√3, 220/√3, 330/√3 kV, 50 Hz
♦ The State Standard of the units of electrical capacity and dissipation factor, DETU 08-06-01	C = 10^{-3} ...100 μF tg δ = 1•10^{-5}…1 f = 1000 Hz u = 1…40 μF/F	♦ COOMET.EM-**K4**, ♦ COOMET.EM-S4 – **UMTS (pilots)**, VNIIM, PTB, BelGIM, BIM, NMIJ-AIST, KazInMetr (7 NMIs)	10 and 100 pF, 1.0 and 1.592 kHz
♦ The State Standard of the unit of AC electric voltage units from 0,1 to 1000 V at the frequency range from 20 Hz to 1 MHz, DETU 08-07-02	U = 0.1…1000 V f = 20 Hz…1 MHz u = 4•10^{-6}	♦ COOMET.EM-S1 – **UMTS** and VNIIMS (3 NMIs)	1 V 20 Hz, 1 kHz, 10 kHz, 100 kHz, 1 MHz
♦ The State Standard of the units of electrical power and power factor, DETU 08-08-02	P = 1…6000 W (single-phase and three-phases) f = 40…70 Hz, 0 to 360º U = 10…600 V I = 0.1…10 A u = 50 μW/VA	♦ EURAMET.EM-**K5.1** – **UMTS**, PTB, UME, VSL, LNE, INM, BIM, NPLI, SMU, OMH, MIKES, ZMDM (12 NMIs) ♦ COOMET.EM-S2 – **UMTS (pilot)**, BelGIM, BIM (3 NMIs)	120 V, 5 A, 53 Hz cos φ = 1, 0.5, 0.01 120 V, 5 A, 50 Hz cos φ = 1, 0.5, 0.01
♦ The State Standard of the units of inductance and dissipation factor, DETU 08-09-09	L = 100 mH –10 H f = 1 kHz u = 3•10^{-5}	♦ EURAMET.EM-S26 – **UMTS**, PTB, VSL, NPL, METAS, INETI, NML, NMISA, GUM, OMH, INM, SMD, DANIAmet-DPLE, IAI SL, SIQ, UME (16 NMIs)	100 mH, 1.0 kHz, 1 mA

the Consultative Committee for Electricity and Magnetism (CCEM). The information about NMIs (total – 39), which to participate of a KCs CCEM-K4 [7], EUROMET.EM-K4 [8]**,** APMP.EM-K4.1 [9] and SIM.EM-K4 (Draft A) and COOMET.EM-K4 are given in the Table 2. Links of KCs CCEM-K4 and KCs RMOs are given in the Fig. 2.

Table 2. Key comparisons CCEM-K4 and RMOs

KC (NMIs)	Laboratory NMIs
CCEM-K4 (10)	**NIST** (pilot); BIPM; **PTB; BNM-LCIE; NPL; NMi-VSL; MSL**; **NIM**, **NRC; VNIIM; CSIRO-NML (NMIA)**
EUROMET.EM-K4 (16)	**NPL** (pilot); BIPM; **PTB**; **BNM-LCIE**; **NMi-VSL**; BEV; CEM; CMI; GUM; IEN; SP; OFMET; UME; VTT; **NIST** (SIM); **CSIRO-NML** (APMP); CSIR (South Africa, SADCMET)
COOMET.EM-K4 (7)	UMTS (pilot), **VNIIM**, **PTB**, BelGIM, BIM, KazInMetr, NMIJ-AIST(APMP)
APMP.EM-K4.1 (13)	**NMIA** (pilot), **NIM**; **VNIIM**; NMIJ; KRISS; CMS; NPLI; NIMT; SIRIM; SCL; KIM-LIPI; A*STAR; NMISA (South Africa, SADCMET)
SIM.EM-K4 (7)	**NIST** (pilot); **NRC;** CENAM; ICE; INMETRO; UTE; INTI

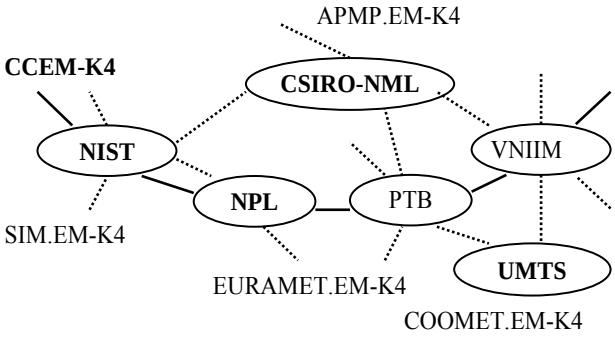

Fig 2. Links of key comparisons CCEM-K4 and RMOs

The results of KC EURAMET.EM-K5.1 linked to KC CCEM-K5 (Fig. 3) [10], which organized the CCEM, between the practical power units of twelve NMIs of EURAMET and COOMET. Electrical standards of low-frequency (50/60 Hz) power were compared at ten NMIs of EURAMET member states and at two NMIs of COOMET and APMP member states, to establish the relationship between the electrical units of AC power at these laboratories. PTB was proposed to be the linking NMI for the linking process between CCEM-K5 and EURAMET. EM-K5.1 KCs. The results of this comparison are described in [11].

4. CALIBRATION AND MEASUREMENT CAPABILITIES FOR ELECTRICAL

UMTS CMCs list for EM includes 34 lines and 4 matrix (capacitance, inductance, AC voltage, DC and AC high voltage, and AC high current) for all national standard of UMTS. The list of all UMTS CMCs is shown on Table 3.

Only 13 NMIs from all countries (EURAMET – 7, APMP – 2, SIM – 2, COOMET – 2) have CMCs for AC (>200 kV) and DC (>150 kV) high voltage for meters (Table 4). UMTS have CMCs for high AC voltage up to 220 kV with expanded uncertainty $6 \cdot 10^{-4}$ and for high DC voltage up to 180 kV with expanded uncertainty $3.6 \cdot 10^{-4}$.

Comparison of NMIs CMCs for high AC voltage up to 200 kV (only 9 NMIs) and for high DC voltage up to 150 kV (only 12 NMIs) shown on Fig. 4.

5. CONCLUSION

The NMI "Ukrmetrteststandard" carry out works on the comparisons of all national measurement standards, which organized the CCQM, EUROMET and COOMET. In COOMET KC of capacitance 10 pF (COOMET.EM-K4) and SC of capacitance 100 pF (COOMET.EM-S4) the NMI "Ukrmetrteststandard" is pilot. The results of this comparison will be linked to KCs CCEM-K4 and EUROMET.EM-K4**,** APMP.EM-K4.1, SIM.EM-K4.

The NMI "Ukrmetrteststandard" are pilot laboratories for supplementary comparisons COOMET.EM-S2 (electrical power) and COOMET.EM-S5 (AC high voltage).

The NMI "Ukrmetrteststandard" have published on KCDB BIPM CMCs for all national electrical standards for four categories of calibration and measurement service (capacitance, inductance, AC voltage, power, energy, high DC voltage, high AC voltage and current).

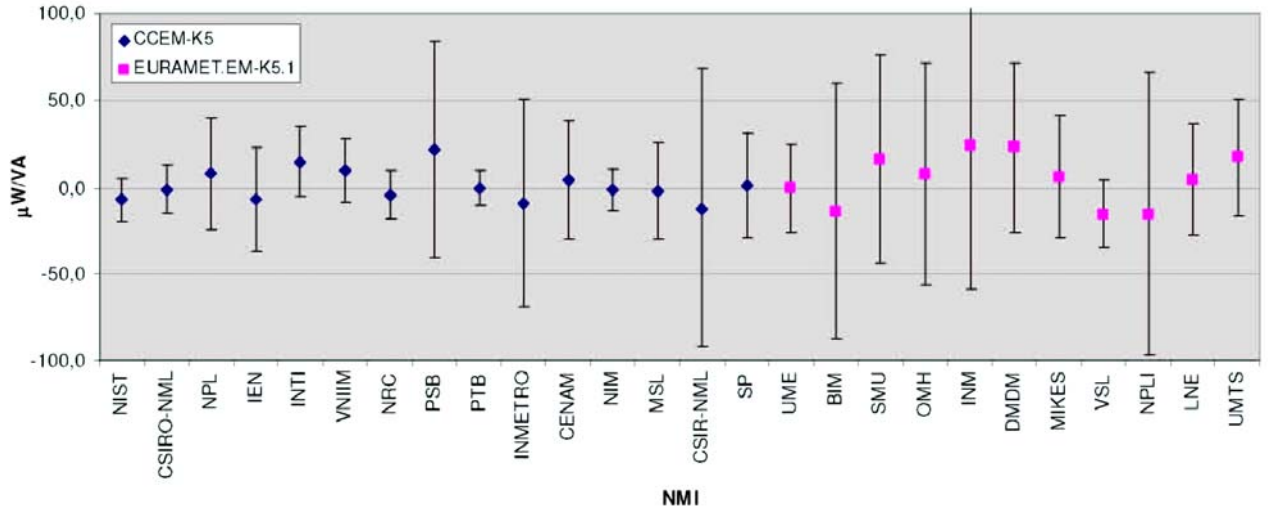

Fig 3. Links of key comparisons CCEM-K5 and EURAMET.EM-K5.1

Table 3. CMCs of NMI "Ukrmetrteststandard"

Calibration or Measurement Service for Electrical and Magnetism	CMCs (lines/ matrix)		Categories	NMI services
	lines	matrix		
♦ Capacitance (capacitors, dissipation factor, meter)	7	0	4.2.1, 4.2.2, 4.2.4	15–21
♦ Inductance (self inductance, quality factor, meter)	5	0	4.3.2, 4.3.5, 4.3.6	22–26
♦ AC voltage (AC-DC transfer difference)	3	1	5.1.1, 5.1.2, 5.1.3	1–3
♦ AC voltage up to 1000 V (sources, meters)	2	1	5.2.1, 5.2.2	4, 5
♦ AC power (active and reactive power, single and three phase)	4	2	7.1.1, 7.1.3	27–30
♦ AC energy (active and reactive energy, single and three phase)	4	0	7.1.1, 7.1.3	31–34
♦ High DC voltage (sources, meters, ratio)	3	0	8.1.1, 8.1.2, 8.1.3	6–8
♦ High AC voltage (sources, meters, ratio)	4	0	8.3.1, 8.3.2, 8.1.4	9–12
♦ High AC current (ratio)	2	0	8.6.3	13, 14
Total:	**34**	**4**	**4, 5, 7, 8**	**1–34**

Table 4. CMCs of NMIs for AC and DC high voltage

NMI, country	Voltage/uncertainty		RMO
	AC>200 kV	DC>150 kV	
PTB, Germany	800 kV $5 \cdot 10^{-4}$	300 kV $1 \cdot 10^{-5}$	EURAMET
NMIA, Australia	550 kV 0.1 %	700 kV 1 %	APMP
UME, Turkey	400 kV 3 mV/V	400 kV 5.5 mV/V	EURAMET
SP, Sweden	300 kV 0.2 mV/V	300 kV 1 mV/V	EURAMET
BEV, Austria	250 kV 2 mV/V	–	EURAMET
UMTS, Ukraine	220 kV $6 \cdot 10^{-4}$	180 kV $3.6 \cdot 10^{-4}$	COOMET
INMETRO, Brazil	200 kV 0.1 mV/V	150 kV 50 μV/V	SIM
MIKES, Finland	200 kV 100 μV/V	200 kV 500 μV/V	EURAMET
LCOE, Spain	200 kV 500 mV/V	200 kV 200 mV/V	EURAMET
VNIIMS, Russia	–	800 kV $3 \cdot 10^{-4}$	COOMET
LNE, France	–	250 kV 40 μV/V	EURAMET
A*STAR, Singapore	–	200 kV 70 μV/V	APMP
NRC, Canada	–	200 kV 100 μV/V	SIM

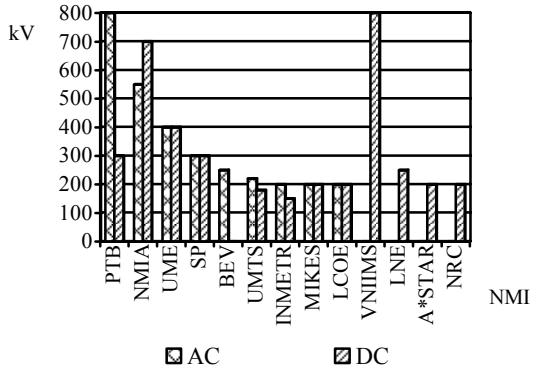

Fig. 4. Comparison of NMIs CMCs for high AC and DC voltage

REFERENCES

[1] O. M. Velychko, A. A-B. Akhmadov, Yu. F. Pavlenko, M. M. Surdu. Standard Basis of Ukraine in the Field of Electrical and Magnetic Values Measurements. Proc. of the 16th IEEE Instrumentation and Measurement Technology Conf. IMTC/99. Venice, Italy, 1999, Vol. 3, pp. 1879–1882.

[2] O. Velychko. Complex of national electrical standards of Ukrainian national metrological institute "Ukrmetrtest-standard". Digest of 2006 Conf. on Precision Electromagnetic Measurement. Torino, Italy, 2006, pp. 182–183.

[3] S. O. Akhmadov, O. A.-B. Akhmadov, O. Velychko. The automation of reproduction, measurement and transfer of unit electrical power in the State Standard of Ukraine. Summaries of Third International Conference on Systems, Signals & Devices (SSD'05). Sousse, Tunisia. IEEE, 2005, pp. 127–128.

[4] O. Velychko. Comparisons of Ukrainian national standards and CMC of the national metrological institute of "Ukrmetrteststandard". Proceedings 1st Regional Metrology Organisations Symposium (RMO 2008); 20th Intern. Metrology Symp. Cavtat-Dubrovnik, Croatia, 2008, pp. 71–75.

[5] O. Velychko. Implementation of the CIPM MRA of the national metrological institute "Ukrmetrteststandard". Proceedings Joint IMEKO TC 11–TC 19–TC 20 Intern. Symp. "Metrological Infrastructure, Environmental and Energy Measurement" (IMEKO-MI2011). Cavtat, Dubrovnik Riviera, Croatia, 2011, pp. 100–104.

[6] S. O. Akhmadov, O. A.-B. Akhmadov, O. Velychko. International comparison of 10 pF and 100 pF capacitance standards: degrees of equivalence determination in the COOMET project 345/UA/05. Digest of 2006 Conf. on Precision Electromagnetic Measurement. Torino, Italy, 2006, p. 185.

[7] A-M. Jeffery. Final report on key comparison CCEM-K4 of 10 pF capacitance standards. Metrologia, 2002, Vol. 39, Tech. Suppl. 01003.

[8] J. H. Belliss. Final report on key comparison EUROMET.EM-K4 of 10 pF and 100 pF capacitance standards. Metrologia, 2002, Vol. 39, Tech. Suppl. 01005.
[9] J. Leigh et al. Final report on the APMP comparison of capacitance at 10 pF: APMP.EM-K4.1. Metrologia, 2009, Vol. 46, Tech. Suppl. 01003.
[10] H. Çayci. Link between CCEM-K5 and EURAMET. EM-K5.1, March 2011, 28 p.
[11] H. Çayci. Final report on key comparison EURAMET.EM-K5.1 (EURAMET Project No. 687): Comparison of 50/60 Hz power. Metrologia, 2011, Vol. 48, Tech. Suppl. 01009.