EURAMET Key International Comparison of AC-DC Current Transfer Standards

EURAMET.EM-K12

Technical Protocol

ver. 18. September 2013

1. Scope

The Mutual Recognition Arrangement (MRA) states that its technical basis is a set of results obtained in a course of time through key comparisons carried out by the Consultative Committees of the CIPM, the BIPM and the Regional Metrology Organisations (RMOs). As part of this process, the CIPM Consultative Committee for Electricity and Magnetism (CCEM) carried out the Key International Comparison of AC-DC Current Transfer Standards CCEM-K12, with the National Measurement Laboratory, Australia (NML) as the pilot laboratory and the support group consisting of National Institute of Standards and Technology (NIST) and Justervesenet (JV).

In order to link the National Metrology Institutes organised in EURAMET to the key comparison CCEM-K12, the EURAMET Technical Committee for Electricity and Magnetism decided at its October 2009 meeting to organise the corresponding RMO key comparison EURAMET.EM-K12, with the Federal Office of Metrology and Surveying, Austria (BEV) as the pilot laboratory and the support group consisting of the Technical Research Institute of Sweden (SP), Laboratoire National de Métrologie et d'Essais, France (LNE) and the Norwegian Metrology Service Justervesenet (JV).

The procedures outlined in this document should allow for a clear and unequivocal comparison of the measurement results. The protocol was prepared following the CCEM guidelines for planning, organizing, conducting and reporting key, supplementary and pilot comparisons.

2. Definition of the Measurand

Ac-dc current transfer difference is defined as

$$d = \frac{I_{ac} - I_{dc}}{I_{dc}}$$

where

I_{ac} is an rms ac current, and
I_{dc} is a dc current which, when reversed, produces the same mean output response as the rms ac current.

Differences are expressed in microamperes per ampere (μA/A) and a positive sign signifies that more ac than dc current was required for the same output response.

3. The Travelling Standards

§ 10 mA

The travelling standard for the current of 10 mA is a Planar Multi-Junction Thermal Converter, Type PTP/IPHT Serial Number PTC 17, manufactured by IPHT Jena. It has the following nominal parameters:

Rated Input Current:	10 mA
Heater Resistance:	90 Ω
Thermocouple Resistance:	7.6 kΩ
Output Voltage at Rated Current:	approx. 100 mV

The Thermal Converter has a type N (female) input connector and a type Cannon 10SL-4S (male) output connector. An internal capacitance of 2.2 µF is soldered in parallel to the output.
A connector is provided (Cannon female to UHF twin female) which allows the connection to systems using UHF twin (male) cables. Please note that the screen is not connected.

Figure 1: Physical layout of the 10 mA travelling standard

§ 5 A

The 5 ampere travelling standard comprises a 147 mΩ coaxial shunt (Serial No B3A) connected in parallel to the PMJTC (Serial No PTC 17 as described above). The shunt has been manufactured at BEV. The main parameters are as follows:

Current Shunt, Serial No B3A:

Nominal Resistance	147 mΩ
Input Connector	type N (female)
Output Connector	type N (male)

Figure 2: Physical layout of the 5A travelling standard

4. Measurement Conditions

- Upon receiving the package, check input and output resistances of the thermal converter. Check also that there is a high resistance (>100 MΩ) between the input and the output. In making these preliminary measurements, make sure **not to exceed** the nominal current of the thermal converter (for input resistance), 1 mA (for output resistance) and 1 V for checking the isolation. In case of any failure, inform the pilot laboratory immediately.
- The ac-dc transfer difference is to be measured for the "Lo" position of the travelling standard, i.e. with both its input and output earthed. The connection to earth must remain at all times to protect the thermocouple.
- Care should be taken not to apply current above nominal, which may destroy the travelling standards.
- Recommended ambient conditions are temperature (23±1)°C and relative humidity (50±5)%.
- At least 30 minutes should be allowed for stabilisation after the first application of current.
- The measurement frequency should be within 1 % of its nominal value. The frequency and its uncertainty must be reported.
- Sufficient delay time should be used between successive applications of alternating and direct current.
- A datalogger will travel together with the travelling standard. It will be continuously monitoring temperature and relative humidity. The datalogger should be kept in the laboratory during the measurements.

5. Measuring Scheme

The ac-dc current transfer difference of each travelling standard should be measured at its nominal current and the following frequencies:

10 Hz, 55 Hz, 1 kHz, 10 kHz, 20 kHz, 50 kHz, 100 kHz.

6. Measurement Uncertainty

A detailed uncertainty analysis and an uncertainty budget in accordance with the ISO Guide to the Expression of Uncertainty in Measurement should be reported.

To have a more comparable uncertainty evaluation a list of principal uncertainty contributions is given, but the uncertainty contributions will depend on the measuring methods used.

- reference standard(s);
- step-up procedure;
- measuring set-up;
- level dependence, e.g. due to dc-effects;
- connectors;
- temperature;
- measurement frequency;
- reproducibility;

7. Method of computation of the Reference value

The reference values for each one of the measuring points will be calculated as the weighted mean of the reported values from laboratories in EURAMET who have taken part in the CCEM-K12 key comparison and whose reported values had been taken in consideration to calculate the reference values in such comparison.

8. Measurement report

Each participant is asked to submit a printed and signed report by mail within 6 weeks after completing the measurements. The report should contain at least the following:

- Detailed description of the measurement setup and the reference standard;
- Definition of the measurand;
- Detailed description of the measurement procedure;
- A statement of traceability, if the national standard is not considered to be a primary standard; otherwise a description how the own value was determined;
- The measurement results;
- The ambient conditions of the measurement: the temperature and the humidity with limits of variation;
- A complete uncertainty budget in accordance with the principles of the ISO Guide to the Expression of Uncertainty in Measurement, including degrees of freedom for every component and calculation of the coverage factor. Such an analysis is a prerequisite to be considered in the calculation of the key comparison reference value. It is also an essential part of the final report which will appear in the BIPM Key Comparison Database.

The participants are also asked to report a summary of the measurement results, see Appendix 3, and a summary of the uncertainty budget, see Appendix 4.
Please also send the report and the summary by e-mail.

The pilot laboratory will inform a participating laboratory if there is a large deviation between the results of the laboratory and the preliminary reference values. No other information on the results will be communicated before the completion of the circulation.

9. Report of the comparison

The pilot laboratory will prepare the draft A report within three months after completion of the circulation. This report will be prepared with the aid of the support group and will be sent to all participants for comments.

10. Transportation and customs

Transportation is on each laboratory's own responsibility and cost. Due to the time constraint please use a recognised courier service e.g. TNT, UPS or DHL for the transport of the travelling standard. Do not use a forwarding agent that does not guarantee an adequate delivery time, the time for customs procedures inclusive.

On receipt of the case, unpack the devices carefully and check for any damage. The list of contents of the packing case should also be checked.

Before sending the case out, check the packing list and ensure everything is enclosed.

Inside the European Union no customs paper is necessary. For the participants outside the European Union an ATA-carnet will be provided. It is the responsibility of each laboratory that the ATA-carnet is used properly. At each transport the carnet must be presented to the customs on leaving the country and upon the arrival in the country of destination.
When the package is sent unaccompanied the carnet must be included with the forwarding documents so the courier service can obtain customs clearance. IMPORTANT: Please make sure that your courier service is able to process the ATA-carnet! In countries where ATA-carnet is not recognized standard customs procedures will be used. For customs purposes and/or transport insurance the value of the equipment is 2600 EURO.

The travelling standard and accessories are packed in a transport case of size 60 x 40 x 25 cm and a total weight of 9 kg. The transport case can easily be opened for customs inspection.

Please inform the pilot laboratory of the arrival of the package by e-mail or fax. Please inform again the pilot laboratory of the details when sending the package to the next participant, and also inform the next participant by e-mail or fax. A relevant fax form is enclosed in Appendix 6. Prepare the transport to the next participant so the travelling standard can be sent immediately after the measurements are completed.

In case of damage or evident malfunctioning of the travelling standard the pilot laboratory shall be informed immediately. If the damage cannot be repaired the comparison will be carried on using a spare travelling standard of the same model.

Each participating laboratory covers the costs of the measurement, transportation and customs clearance as well as for any damage that may occur within its country. The pilot laboratory covers the overall costs for the organisation of the comparison. The pilot laboratory has no insurance for any loss or damage of the travelling standard.

11. Circulation of the Travelling Standards

The time schedule will be arranged when the list of participating laboratories is completed. As the circulation has to be finished within a reasonable period of time, only four weeks are allowed for each participant including the time of transportation to the next participant.

If unforeseen circumstances prevent a laboratory from carrying out its measurements within the agreed time period, it should send the travelling standard without delay to the laboratory next in line. If time permits, the laboratory will be able to carry out measurements at a later time.

12. Organisation

12.1. Coordinator, Contact person and members of the support group

The pilot laboratory for the comparison is the Federal Office of Metrology and Surveying, Austria (BEV);

Coordinator:

Mr. Wolfgang Waldmann

phone: (+43) 1 21110 6350
fax: (+43) 1 21110 6000
email: wolfgang.waldmann@bev.gv.at

Contact person for all technical questions and organizational matters:

Mr. Martin Garcocz
phone: (+43) 1 21110 6535
fax: (+43) 1 21110 6000
email: martin.garcocz@bev.gv.at

Postal and delivery address:
BEV
Arltgasse 35
A-1160 Vienna
Austria

Support group:

Mr Karl-Erik Rydler, Technical Research Institute of Sweden (SP), SE;
e-mail: karlerik.rydler@sp.se

Mr Andre Poletaeff, Laboratoire National de Métrologie et d'Essais (LNE), FR:
e-mail: andre.poletaeff@lne.fr

Mr. Kåre Lind, Justervesenet - The Norwegian Metrology Service (JV), NO:
e-mail: kli@justervesenet.no

12.2. Participants

The participating institutes are listed in the following table. The contact details are given in Appendix 1.

No	Country	Institute	Acronym
1	Austria	Bundesamt für Eich- und Vermessungswesen	BEV *)
2	Czech Republic	Czech Metrology Institute	CMI
3	Germany	Physikalisch-Technische Bundesanstalt	PTB
4	Switzerland	Federal Office of Metrology	METAS
5	Norway	Justervesenet	JV*)
6	Turkey	TÜBİTAK Ulusal Metroloji Enstitüsü	UME
7	Poland	Central Office of Measures (Główny Urząd Miar)	GUM
8	Portugal	Instituto Português da Qualidade	IPQ
9	Spain	Centro Español de Metrología	CEM
10	Italy	Istituto Nazionale di Ricerca Metrologica	INRIM
11	Sweden	Technical Research Institute of Sweden	SP*)
12	Denmark	Trescal A/S	DANIAmet-MI-Trescal
13	Bulgaria	Bulgarian Institut of Metrology	BIM
14	Hungary	Hungarian Trade Licensing Office, Section of Thermophysical, Electrical and Optical Measurements	MKEH
15	Slovenia	SIQ Ljubljana	SIQ
16	France	Laboratoire National de Métrologie et d'Essais	LNE
17	Ireland	NSAI National Metrology Laboratory	NSAI NML
18	The Netherlands	VSL	VSL
19	United Kingdom	National Physical Laboratory	NPL
20	Estonia	AS Metrosert (Central Office of Metrology)	Metrosert

*) These laboratories participated in CCEM-K12 and will assure the link to this CCEM key comparison.

Table 1: Participants

12.3. Time schedule

The circulation of the standards starts in June 2012 and is planned to end in 2014. The detailed time schedule for the comparison is given in Appendix 2.

A period of four weeks is allowed for the measurements in each laboratory, including the time necessary for transportation to the next participant. It is intended to re-measure the standards at certain intervals in the pilot laboratory.

In agreeing with the proposed circulation time schedule, each participating laboratory confirms that it is capable to perform the measurements in the limited time period allocated in the time schedule. If, for some reasons, the measurement facility is not ready or custom clearance should take too much time, the laboratory is requested to contact immediately the co-ordinator in the pilot laboratory. According to the arrangement made in this special case the travelling standards must be eventually sent directly to the next participant before the measurement has been finished or even without performing any measurements. In such a case, there is a possibility to carry out the measurements at the end of the comparison.

If delay occurs, the pilot laboratory shall inform the participants and revise - if necessary - the time schedule, or skip one NMI and put it at the end of the circulation.

Appendix 1: Detailed list of participants

Name	Institute	Acronym	Postal address	Delivery address (if different)	Country	Telephone	Telefax	e-mail
Martin Garcocz	Bundesamt für Eich- u. Vermessungswesen	BEV	Arltgasse 35 A-1160 Vienna		Austria	+43 1 21110 6535	+43 1 21110 6000	martin.garcocz@bev.gv.at
Vera Novakova Zachovalova	Czech Metrology Institute	CMI	Okruzni 31, 638 00 Brno		Czech Republic	+420 545 555 301	+420 545 555 183	vnovakovazachovalova@cmi.cz
Dr. Torsten Funck	Physikalisch-Technische Bundesanstalt	PTB	Bundesallee 100, 38116 Braunschweig		Germany	+49 531 592 2130	+49 531 592 2345	torsten.funck@ptb.de
Alessandro Mortara	Federal Office of Metrology	METAS	Lindenweg 50, CH-3003 Bern-Wabern		Switzerland	+41 31 323 33 28	+41 31 323 32 10	alessandro.mortara@metas.ch
Kåre Lind	Justervesenet	JV	P.O.B 170, 2027 Kjeller, Norway	Fetveien 99, 2007 Kjeller, Norway	Norway	+47 64 84 84 84	+47 64 84 84 85	kli@justervesenet.no
Mehedin Arifoviç	TÜBİTAK Ulusal Metroloji Enstitüsü	UME	P.K. 54 41470 Gebze-Kocaeli		Turkey	+90 262 679 50 01	+90 262 679 50 01	mehedin.arifovic@ume.tubitak.gov.tr
Andrzej Kruszyński	Central Office of Measures (Główny Urząd Miar)	GUM	2 Elektoralna Str. 00-139 Warsaw		Poland	(+48-22) 581 92 42	(+48-22) 581 94 99	a.kruszynski@gum.gov.pl
Isabel Godinho	Instituto Português da Qualidade	IPQ	Rua António Gião, 2; 2829-513 CAPARICA, PORTUGAL		Portugal	+351 212 948 166	+351 212 948 188	igodinho@ipq.pt
Javier Díaz de Aguilar	Centro Español de Metrología	CEM	c/del Alfar nº 2, 28760 Tres Cantos. Madrid		Spain	+34918074766 +918074788 +918074722	-----	jdiaz@cem.minetur.es
Bruno Trinchera	Istituto Nazionale di Ricerca Metrologica	INRIM	Strada delle Cacce 91, 10135 Torino		Italy	+39 011 3919.433	+39 011 346384	b.trinchera@inrim.it
Karl-Erik Rydler	Technical Research Institute of Sweden	SP	Box 857, SE-501 15 BORAAS	Brinellgatan 4, SE-504 62 BORAAS	Sweden	+46 10 516 5401	+46 33 125038	karlerik.rydler@sp.se
Torsten Lippert	Trescal A/S	DANIAmet-MI-Trescal	Mads Clausens Vej 12, DK-8600 Silkeborg		Denmark	+4587206969	+4586812654	torsten.lippert@trescal.com
Ing. Radoslava Hadzhistoykova	Bulgarian Institut of Metrology	BIM	Bulgarian Institut of Department "Electrical measurements" 52-B, G.M. Dimitrov Blvd. 1040 Sofia		Bulgaria	+359 2 9702789	+359 2 9702735	r.hadzhistoykova@bim.government.bg

Name	Institute	Acronym	Postal address	Delivery address (if different)	Country	Telephone	Telefax	e-mail
Tibor Németh	Hungarian Trade Licensing Office, Section of Thermophysical, Electrical and Optical Measurements	MKEH	H1124 Budapest, Németvölgyi út 37-39		Hungary	+3614585897	+3614585927	nemetht@mkeh.hu
Bostjan Voljc	SIQ Ljubljana	SIQ	Trzaska 2, 1000 Ljubljana		Slovenia	+386 1 4778 330	+386 1 4778 303	bostjan.voljc@siq.si
POLETAEFF Andre	Laboratoire National de Métrologie et d'Essais	LNE	29, avenue Roger Hennequin 78197 TRAPPES Cedex		France	+33 (0)1 30 69 21 75		andre.poletaeff@lne.fr
Oliver Power	NSAI National Metrology Laboratory	NSAI NML	NSAI NML Griffith Avenue Extension Glasnevin Dublin 11 Ireland		Ireland	+ 353 1 808 2610	+353 1 808 2608	oliver.power@nsai.ie
Helko van den Brom	VSL	VSL	P.O. box 654, 2600 AR Delft, The Netherlands	Thijsseweg 11, 2629 JA Delft, The Netherlands	The Netherlands	+31 15 269 1500	+31 15 261 2971	hvdbrom@vsl.nl
Adrian Wheaton	National Physical Laboratory	NPL	Module 2, Hampton Road, Teddington, Middlesex. TW11 0LW		United Kingdom	+44 (0) 20 8943 6235	+44 (0) 20 8614 0539	adrian.wheaton@npl.co.uk
Andrei Pokatilov	AS Metrosert (Central Office of Metrology)	Metrosert	(from 2013) Teaduspargi 8, 12618 Tallinn, Estonia		Estonia	+372 529 7095		andrei.pokatilov@metrosert.ee

Appendix 2: Time Schedule of the measurements

Institute	Country	Start date	Time for measurements and transport
Pilot (BEV)	Austria	until May 2012	
CMI	Czech Republic	June 2012	4 weeks
PTB	Germany	July 2012	4 weeks
Pilot (BEV)	Austria	August 2012	4 weeks
METAS	Switzerland	September 2012	4 weeks
JV	Norway	October 2012	4 weeks
UME	Turkey	November 2012	4 weeks
Pilot (BEV)	Austria	December 2012	4 weeks
GUM	Poland	January 2013	4 weeks
IPQ	Portugal	February 2013	4 weeks
CEM	Spain	March 2013	4 weeks
INRIM	Italy	April 2013	4 weeks
SP	Sweden	May 2013	postponed
DANIAmet-MI-Trescal	Denmark	June 2013	4 weeks
BIM	Bulgaria	July 2013	4 weeks
MKEH	Hungary	August 2013	4 weeks
SIQ	Slovenia	September 2013	4 weeks
LNE	France	October 2013	4 weeks
NSAI NML	Ireland	November 2013	4 weeks
VSL	The Netherlands	December 2013	4 weeks
NPL	United Kingdom	January 2014	4 weeks
Metrosert	Estonia	February 2014	4 weeks
SP	Sweden	March 2014	4 weeks
Pilot (BEV)	Austria	April 2014	4 weeks
	repeat (any)	from May 2014	

Appendix 3: Summary of Results

EURAMET Key International Comparison of AC-DC Current Transfer Standards EURAMET.EM-K12

Please also send this information by e-mail to martin.garcocz@bev.gv.at.

Institute:

Date of measurements:

Remarks:

Measurement Results:

Current	Measured ac-dc current difference (μA/A) at frequency						
	10 Hz	55 Hz	1 kHz	10 kHz	20 kHz	50 kHz	100 kHz
10 mA							
5A							

Expanded Uncertainty:

Current	Expanded Uncertainty (μA/A) at frequency						
	10 Hz	55 Hz	1 kHz	10 kHz	20 kHz	50 kHz	100 kHz
10 mA							
5A							

Measurement Frequency:

Current	Nominal Frequency						
	10 Hz	55 Hz	1 kHz	10 kHz	20 kHz	50 kHz	100 kHz
Meas. Frequency							
Expanded Uncertainty							

Environmental parameters:

	Min	Max	Remarks
Ambient temperature (°C)			
Relative humidity (%)			

Appendix 4: Summary of Uncertainty Budget

EURAMET Key International Comparison of AC-DC Current Transfer Standards EURAMET.EM-K12

Please also send this information by e-mail to martin.garcocz@bev.gv.at.

Institute:

Date:

Remarks:

Measurement Current: 10 mA

Contribution of:	Standard Uncertainty (μA/A) at frequency							Type A or B	Distri-bution
	10 Hz	55 Hz	1 kHz	10 kHz	20 kHz	50 kHz	100 kHz		

Standard unc:							
Expanded unc:							
Coverage factor *k*:							

Measurement Current: 5 A

Contribution of:	Standard Uncertainty (μA/A) at frequency							Type A or B	Distri-bution
	10 Hz	55 Hz	1 kHz	10 kHz	20 kHz	50 kHz	100 kHz		

Standard unc:							
Expanded unc:							
Coverage factor *k*:							

Appendix 5: Packing List

EURAMET Key International Comparison of AC-DC Current Transfer Standards EURAMET.EM-K12

Item	Approx. Value (EURO)	Dimensions (cm)	Weight (kg)
Multi Junction Thermal Converter, PTP/IPHT Serial No PMJTC 17	1500	6 dia x 8 l	1,1
Current Shunt, BEV Serial No B3A	1000	6 w x 6 h x 34 l	0,9
Adapter UHF twin to Cannon 10SL-4S	50	3 w x 3 h x 25 l	0,1
Data logger	50	3 dia x 10 l	0,1
This Protocol			
Total Value	2600		2,2

The items are to be transported in the custom carry case supplied. The dimensions of the carry case are 60 x 40 x 25 cm. The total weight of the package is less than 9 kg.

Please note: from Mar 2013 the serial number of the Converter changed to “PMJTC 19”

Appendix 6: Forms for Notifying Receipt and Shipment of Artefact

EURAMET Key International Comparison of AC-DC Current Transfer Standards
EURAMET.EM-K12

Please send this information by e-mail to martin.garcocz@bev.gv.at.

ARTEFACTS RECEIVED

From:…*(sender and coordinator)*….

The package was received at ……..*(name of laboratory)*…. on …*(date)*..

The condition when it was received was *in good physical and working order

*damaged – *(explain)*

_____
(name of participant)

ARTEFACTS SHIPPED

To: *(recipient and coordinator)*

The package was shipped through ….*(shipper)*..... on ….....*(date)*..

Shipping Details:

Expected date of arrival at destination country:……..

Air Way Bill No. (tracking #): …….

_____
(name of participant)