Euramet project 1187

Comparison of Instrument Current Transformers up to 10 kA

Technical protocol

(March 2012)

1. Introduction

AC current ratio is one of two basic parameters in the area of metrology of instrument transformers and it is very important by the measurement of electric energy. In trade with electric energy it is important to ensure the accuracy of measurement. So it is necessary to compare national standards of European states.

The relevant quantity for the measurement of AC current is the ratio of the primary and secondary current, which is a complex value. The errors of this ratio are given as the ratio error and phase displacement. These two quantities are a subject of this international comparison.

This comparison was proposed in order to demonstrate the capabilities of the NMIs in Europe in the area of AC current ratio measurement.

2. Travelling standard

Standard Current Transformer I 523:

Rated primary current: (4-5-6-8-10) kA
Rated secondary current: 5 A
Rated burden: 15 VA resistive
Ser. number: 18/1981
Class: 0.05
Mass: approx. 24 kg

Fig. 1. Travelling standard

3. Quantity to be measured

Quantity to be measured is the current ratio error ε_I and phase displacement δ_I. The current ratio error (ε_I) is defined as:

$$\varepsilon_I = \frac{I_S \cdot K_I - I_P}{I_P} \cdot 10^6 \ ,$$

where ε_I is current ratio error (ppm),
I_P actual value of the primary current (V),
I_S actual value of the secondary current (V),
K_I transformation ratio (-).

The phase displacement δ_I (' or μrad) is defined as the phase difference between the secondary I_S and primary I_P currents. The phase displacement is considered as positive when the secondary current phasor I_S leads the primary current phasor.

4. Organization

4. 1. Pilot laboratory

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4. 2. Supporting group

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MIKES Espoo, Finnland – Jari Hällström [Jari.Hallstrom@mikes.fi]

4. 3. Participants

BEV Vienna, Austria - Michael Schnaitt [michael.schnaitt@bev.gv.at]
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VSL Delft, the Netherlands – Gert Rietveld [grietveld@vsl.nl]

4. 4. Circulation scheme and time schedule

Four weeks are allowed for each participant and includes transportation time to the next participant.

Timetable

Participant	Term of measurement
BIM Sofia, Bulgaria	August 2011
CMI Prague, Czech Republic	January 2012
METAS Bern, Switzerland	March 2012
BEV Vienna, Austria	April 2012
DMDM Belgrade, Serbia	May 2012
LCOE Madrid, Spain	June 2012
LNE Paris, France	October 2012
PTB Braunschweig, Germany	December 2012
CMI Prague, Czech Republic	January, February 2013
LNE Paris, France	March (2 weeks) 2013
NPL Teddington, United Kingdom	March, April 2013
MIKES Espoo, Finnland	April 2013
SP Boras, Sweden	May 2013
INRIM Torino, Italy	June 2013
GUM Warshaw, Poland	July 2013
UME Gebze, Turkey	August 2013
VSL Delft, the Netherlands	September 2013
BIM Sofia, Bulgaria	October 2013
CMI Prague, Czech Republic	November 2013

4. 5. Transportation

Participants will be responsible for arranging transportation to the next participant. Transportation is each laboratory's own responsibility and cost.

The transfer standards will be packed in a wooden container with dimensions (75x50x28) cm, weight approx 40 kg. The container needs not be transported personally because the standard is rather robust device.

Please, inform the pilot laboratory of the arrival of the package by completing and returning the form provided by e-mail or fax.

After having completed the measurements, the package is to be transported to the next participant. It is advisable to prepare and organize this transportation beforehand. Participants should inform the next recipient by e-mail or fax. Please, when the transformer is sent on to the next laboratory, inform also the pilot laboratory by completing and returning the form provided by e-mail or fax.

4. 6. Customs information

The package will be accompanied by an ATA carnet to handle participation of the Turkish laboratory. The CMI will prepare the ATA Carnet for the journey to and from the Turkish laboratory. The ATA Carnet will be sent to the laboratory which will send the transfer standard to Turkey. The carnet should not be packed with the device into the package but be

given to the transport agency and they shall handle the proper contacts with Customs and ensure that it is duly stamped and signed. The carnet must be saved in the laboratory very carefully because a loss of the carnet may cause serious difficulties and a serious delay in the comparison schedule.

4. 7. Financial aspects, insurance

Each participating laboratory covers the costs of its measurements, transportation and possible customs charges as well as of any damage that may have occurred within its country. The insurance of the transfer standard for the transport is recommended. The pilot laboratory covers overall costs for the organization of the comparison and costs for ATA carnet. The value of the standard transformer was declared 8 500,- EUR. The pilot laboratory has no insurance for any loss or damage of the standard during transportation.

5. Measurements

5. 1. Measurement performance

a) Measurement conditions

The travelling transformer has ratios of rated currents (4-5-6-8-10) kA/5 A. Each laboratory shall measure those ratios that are within its capabilities. On the lowest and the highest ratios that can be measured, results shall be obtained for two burdens (5 VA and 15 VA at unity power factor). For intermediate ratios results need be given for one burden only (15 VA at unity power factor). The measuring points are I_M: (120, 100, 50, 20, 10, 5 & 2) % (1 % optional) of rated current value I_R. Measurements should be made at 50 Hz frequency. It is recommended to keep the value of connected burden and its power factor within 3 % of the nominal values and established with an uncertainty better than 0,5 %.

For correct determining the reference value it is necessary – see Fig. 2.:

1. The primary conductor should have a circular cross-section and should be placed in the centre of transformer opening with maximum deviation 10 mm. An unsymmetrical position causes a big measurement error.
2. Using more parallel primary conductors it is necessary to fix them in to a concentric bundle and place it to the centre of transformer opening.
3. To use two return conductors placed symmetrically with the longitudinal axis of the primary conductor in the distance at least 60 cm from the longitudinal axis the primary conductor.
4. The recommended time for adjusting of the primary current from zero to 120 % I_R should not exceed 40 seconds. Errors should be read immediately after adjusting of the primary current. Then immediately decrease the primary current on the value 100 % I_R and 50 % I_R, respectively.
5. When the comparative method with a standard is used it is recommended to provide the each measurement twice. The second measurement should be performed with commutated (swapped) primary conductors, especially for measuring points less than 20% I_R. This can be also achieved by swapping of primary winding of a supply transformer. The result of measurement it then given as the mean value of the two measurements.

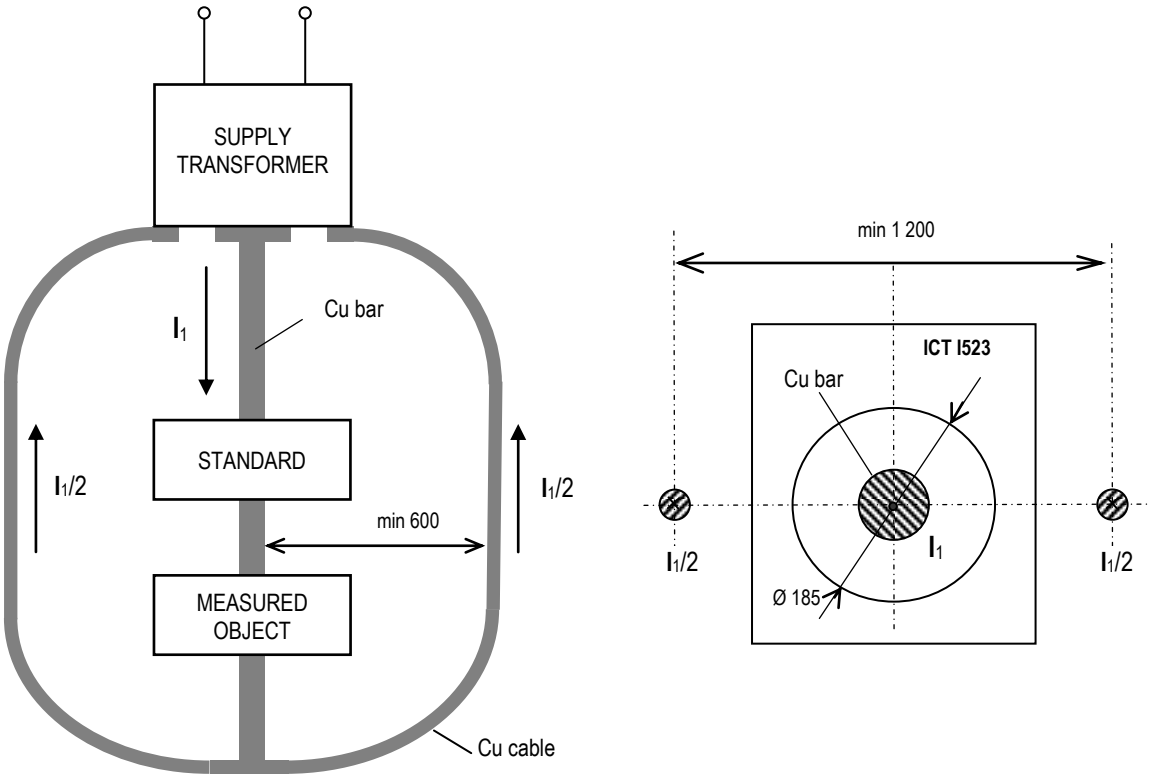

Fig. 2. Recommended arrangement of primary circuit

b) Ambient conditions

The standard transformers must be kept in the laboratory before the measurements for such a time that it reaches stable temperature. It is recommended to keep the ambient temperature on the value 23°C ± 2°C. The relative humidity shall be reported.

The data of the ambient conditions during the measurements shall be given in the measurement report.

5. 2. Measuring methods

The participating laboratories are asked to follow their usual measurement procedure to achieve their best measurement capabilities with respect to the allowed time frame for the comparison. Measurement results of individual laboratories shall include also a description of the method used and a layout of the primary current circuit with dimensions. (Annex 1).

6. Uncertainty of measurement

All participants shall provide their results with the associated uncertainty of measurement and a complete uncertainty budget. The uncertainty of the measurement shall be determined according to the ISO Guide to the Expression of Uncertainty in Measurement (GUM).
All participants shall supply a statement of traceability to the SI.

A list of the typical components of the uncertainty budget to be evaluated by each participant cannot be included in this technical protocol. It is supposed that each participating laboratory

applies a different method depending on its facilities. Therefore a list of the typical components, relevant for all participants, cannot be presented.

7. Measurement report

The measurement results (Annex 2), a short description of the measuring setup (Annex 1) and a detailed evaluation of the standard and combined uncertainty ***u*** of measurement (Annex 3) for the ratio error and phase displacement are to be reported. The measurement report forms in the Annex 1 - 3 of this document are sent by e-mail to all participants. Please use these forms for your report. The report should be sent to the pilot laboratory no later than four weeks after the measurements have been completed. No information about differences of the reported results with respect to others will be communicated before the completion of the comparison, unless large deviations of a laboratory's result, with respect to the preliminary reference results obtained by the pilot laboratory, are observed.

8. Report of the comparison

Within 3 months after completion of all measurements the coordinator will prepare a first draft report and send it to the participants for comments. In this report an overview about the different measuring systems and used standards will be included.

References:

[1] European co-operation for accreditation (EA) – publication on references EA-4/02 "Expression of the uncertainty of measurement in calibration", Dec.1999.

[2] Renata Styblíková, Karel Draxler and Beat Jeckelmann: Comparison of voltage ratio standards. Final Report of Euromet Project 599.

Measurement report, part A

Annex 1

In this part A of the report a free description should be given including drawings and references, whereas in part B a tabular form has to be filled out. This information will be used in the final report to be prepared by the pilot laboratory.

A) Description of the measurement method(s), measurement schematic diagram and relevant instruments:

Short description, measuring layout, possibly a photo.

Participating laboratory:

Date: ..... Signature …....…….....……...

Annex 2

Measurement results and uncertainty budget for transfer standard I 523, ser. No.: 18/1981

Measurand: **Ratio error ε_I**

Burden (VA)	Ratio (kA/A)	Measured current I_M (% I_R)	Result value of ratio error ε_I (ppm)	Standard uncertainty type A of ε_I u_{A_ε} (ppm)	Standard uncertainty type B of ε_I u_{B_ε} (ppm)	Combined uncertainty of ε_I u_ε (ppm)
5 resistive	4/5	120				
		100				
		50				
		20				
		10				
		5				
		2				
		1				
	10/5	120				
		100				
		50				
		20				
		10				
		5				
		2				
		1				

Measurand: **Phase displacement δ_I**

Burden (VA)	Ratio (kA/A)	Measured current I_M (% I_R)	Result value of phase displacement δ_I (')	Standard uncertainty type A of δ_I u_{A_δ} (')	Standard uncertainty type B of δ_I u_{A_δ} (')	Combined uncertainty of δ_I u_{A_δ} (')
5 resistive	4/5	120				
		100				
		50				
		20				
		10				
		5				
		2				
		1				
	10/5	120				
		100				
		50				
		20				
		10				
		5				
		2				
		1				

Measurand: **Ratio error ε_I**

Burden (VA)	Ratio (kA/A)	Measured current I_M (% I_R)	Result value of ratio error ε_I (ppm)	Standard uncertainty type A of ε_I u_{A_ε} (ppm)	Standard uncertainty type B of ε_I u_{B_ε} (ppm)	Combined uncertainty of ε_I u_ε (ppm)
15 resistive	**4/5**	120				
		100				
		50				
		20				
		10				
		5				
		2				
		1				
	5/5	120				
		100				
		50				
		20				
		10				
		5				
		2				
		1				
	6/5	120				
		100				
		50				
		20				
		10				
		5				
		2				
		1				
	8/5	120				
		100				
		50				
		20				
		10				
		5				
		2				
		1				
	10/5	120				
		100				
		50				
		20				
		10				
		5				
		2				
		1				

Measurand: **Phase displacement δ_I**

Burden (VA)	Ratio (kA/A)	Measured current I_M (% I_R)	Result value of phase displacement δ_I (')	Standard uncertainty type A of δ_I $u_{A\delta}$ (')	Standard uncertainty type B of δ_I $u_{B\delta}$ (')	Combined uncertainty of δ_I u_δ (')
15 resistive	**4/5**	120				
		100				
		50				
		20				
		10				
		5				
		2				
		1				
	5/5	120				
		100				
		50				
		20				
		10				
		5				
		2				
		1				
	6/5	120				
		100				
		50				
		20				
		10				
		5				
		2				
		1				
	8/5	120				
		100				
		50				
		20				
		10				
		5				
		2				
		1				
	10/5	120				
		100				
		50				
		20				
		10				
		5				
		2				
		1				

Temperature:

Frequency:

Annex 3

Uncertainty budget

for ratio error ε_I and phase displacement δ_I