**PTB** **UNIIM**

**Germany** **Russia**

# TECHNICAL REPORT

## Supplementary bilateral comparison of the measurement of current transformers between UNIIM and PTB

## COOMET.EM-S11

**Final report**

**COOMET Project No 513/DE-a/10**

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# Index

# 1 INTRODUCTION

A supplementary bilateral comparison was organized between PTB, Germany and FGUP "UNIIM", Russia, in the field of current transformer ratio measurements. This comparison is registered as COOMET project n0. 513/DE-a/10 and COOMET.EM-S11 in the BIPM key comparison database.

The purpose of the comparison of each national AC high current ratio measuring reference system is the determination of the equivalence degree of the national metrological institutes.

The aim of the comparison was to demonstrate the improvement and extension of the calibration and measurement capabilities (CMCs) of FGUP "UNIIM" in this area of work and to support the submission of an improved and extended CMC for FGUP "UNIIM" in Appendix C of the CIPM mutual recognition arrangement (MRA).

This comparison was financed in this framework by PTB and UNIIM and ran from March 2011 to the end of November 2011.

# 2 PARTICIPANTS

**a) Participants:**

| | |
|---|---|
| Name: | Physikalisch-Technische Bundesanstalt |
| Acronym: | PTB |
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| | |
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| Name: | Ural Scientific Research Institute of Metrology |
| Acronym: | FGUP "UNIIM" |
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**b) Pilot laboratory:** PTB, Germany, E. Mohns, G. Roeissle

**c) Comparison coordinator:** PTB, Germany, E. Mohns

# 3 COMPARISON SCHEDULE

The travelling standards were circulated as follows

**a) PTB:** March 2011 to June 2011

**b) UNIIM:** October 2011 to November 2011

The behavior of the travelling transformers during the comparison was determined from the measurements at PTB.

The transport of the travelling standards was arranged by using a door-to-door parcel service.

# 4 TRAVELLING STANDARD

The travelling standards for the comparison were two two-stage current transformers (CTs) manufactured by TME, Russia. Their owner is UNIIM. They can be operated either in a passive or an active compensation mode. The relevant technical data are summarized as follows

**a) Travelling CT #1**

| | |
|---|---|
| Type: | TTE-3000.5 |
| Current ratio: | (0,5 A – 3 kA) / 5 A; or (0,5 A – 600 A) / 1 A |
| Error limits: | 0.003 % and 0.2 min |
| Serial number: | 03-09 |

**b) Travelling CT #2**

| | |
|---|---|
| Type: | TTE-200 |
| Current ratio: | 50 kA / 250 A |
| Error limits: | 0.003 % and 0.2 min |
| Serial number: | 03-09 |

For current ratios up to 3 kA / 5 A; or equivalently 600 A / 1 A, the first CT (Std. #1 “TTE-3000.5”) is used in the active compensation mode. The burden is 100 mΩ. In order to provide a symmetrical single-turn primary winding at rated currents above 300 A, a removable bus line fixed to the CT housing is used during the comparison. A photograph is shown in Figure 1.

The second, passively operated CT (Std. #2 “TTE-200”) with a fixed current ratio of 50 k / 250 A, is used to extend the current range of the “TTE-3000.5”. The intermediate burden of the “TTE-200” is determined by the test leads to the “TTE-3000.5” and by the impedance of the primary winding used. A photograph is shown in Figure 2.

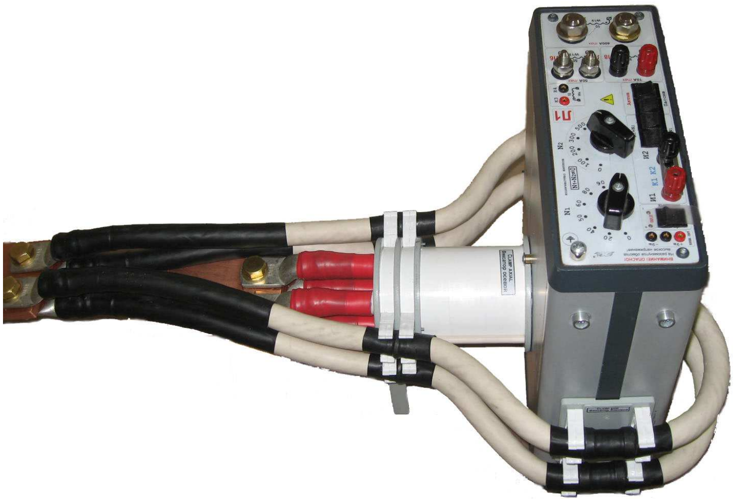


**Figure 1: Photograph of the travelling standard CT #1 "TTE-3000.5".**

**Figure 2: Photograph of the travelling standard CT #2 "TTE-200".**

# 5 MEASUREMENT CONDITIONS AND METHODS

The comparison was performed at a test frequency of 50 Hz. For the current ratio of 5 A / 5 A an additional measurement at 60 Hz was performed. The measurements were performed at 120 %, 100 %, 20 %, 5 % and 1 % of the rated current. Table 1 shows the measured current ratios.

**Table 1: List of the compared current ratios.**

| Rated secondary current in A | Travelling standards | Rated primary currents in A |
|---|---|---|
| 5 | TTE-3000.5 | 5; 20; 50; 100; 500; 1 000; 3 000 |
| | TTE-200 + TTE-3000.5 | 10 000; 30 000; 50 000 |
| 1 | TTE-3000.5 | 1; 10; 100; 500 |
| | TTE-200 + TTE-3000.5 | 5 000; 10 000; 20 000; 50 000 |

The burden of the CT "TTE-3000.5" is 100 mΩ. The intermediate burden of the "TTE-200" is determined by the test leads to the "TTE-3000.5" and by the impedance of the primary winding in use.

Each measurement was performed twice (between measurement a) and b), the primary current was inverted to cancel out systematic power line effects.). The results of these two measurements were averaged and this mean value was taken as a result of one measurement.

The participants were asked to follow their usual measurement procedure corresponding to their best measurement capabilities.

## 5.1 PTB MEASUREMENT METHOD

The CT measurement system consists mainly of a set of three current comparators (CC) based on [1], an auxiliary two-stage current transformer based on [2] and a self-calibrating current transformer test set (Std.: "SEKAM II") [3] based on the differential method. The test set is shown in Figure 3. For current ratios up to 800 A / 5 A (Std.: "IW 51") or up to 3 kA / 5 A (Std.: "IW 32"), the CCs are connected either directly as a two-stage CT to the bridge or using the auxiliary two-stage CT (Std.: "ZW 51") with the ratio 5 A / 1A in a cascade arrangement to establish a rated secondary current of 1 A. For the highest current range up to 100 kA, a CC with a rated ratio of 50 kA / 100 A (Std.: "IW 33") [4] is connected as a two-stage CT in cascade with either the "IW 51" for the rated secondary current of 5 A or with the cascade "IW 51" + "ZW 51" for the rated secondary current of 1 A.

To ensure that the CCs - connected as two-stage transformers - stay within certain limits during the calibration of the travelling standard, plausibility tests of their detector winding voltage with and without compensation winding and the associated error differences were performed. The uncertainties of the CT measurement systems were confirmed several times [5, 6].

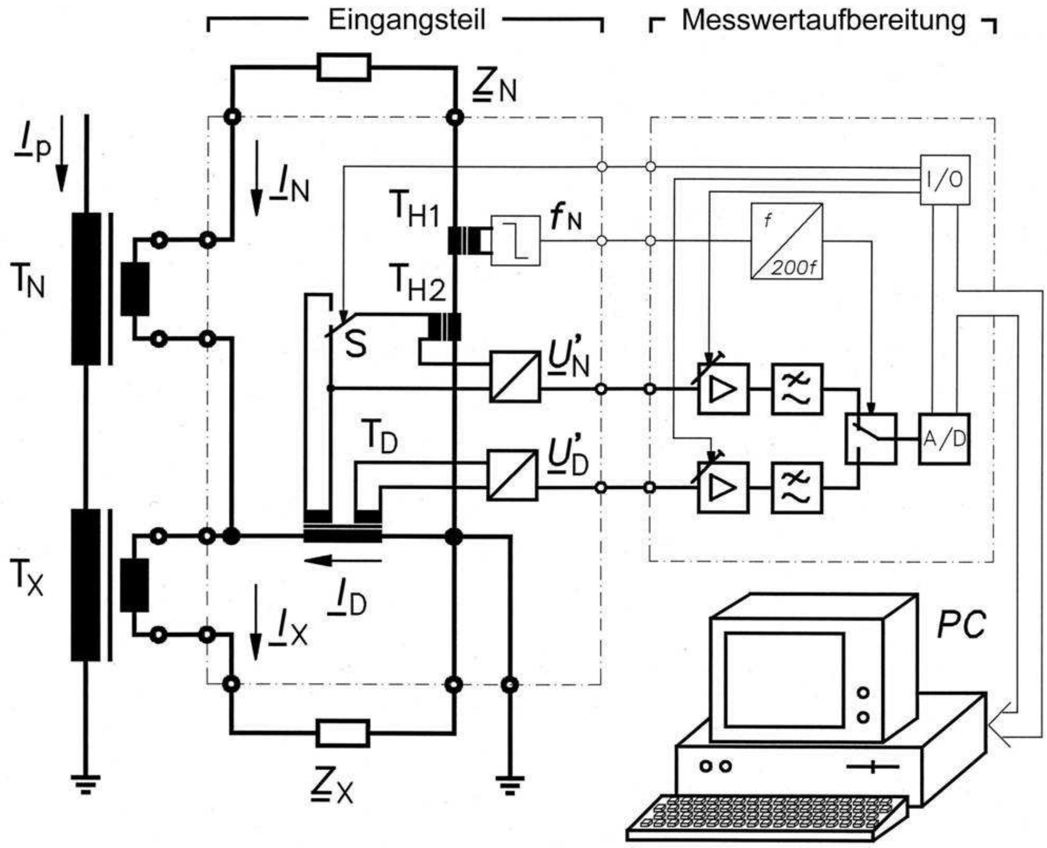



**Figure 3: Current transformer calibration circuit of PTB. The self-calibrating PTB current transformer test set "SEKAM II" based on the differential method [3] is shown in more detail. Additional current inputs for compensation windings of the CT are available but they are not shown for more simplicity.**

### 5.2 UNIIM MEASUREMENT METHOD

The measurement system for the calibration of current transformers of UNIIM consists of electronic compensated CCs (Std.: "TTEK-30K/5") and the CT test set (Std.: "KHT-05AM"). The test set is based on the differential method and is shown in Figure 4. The CC consists of two comparators as shown in Figure 5.

TTEK-30K/5 (TN) has two magnetic cores, a magnetic screen and four windings - detection winding WD, compensation winding Wc, secondary winding Ws and the primary winding Wp. WD is wound on the inner core and connected to the input of the amplifier, which generates a current through the compensation winding Wc thus reducing the magnetic flux within the inner core. This coil is placed inside a magnetic shield, on top of a magnetic shield compensation winding. The number of turns in Wc is equal to the number of winding turns in Ws. The secondary current IN is added to the compensation current to the burden of the comparator.

The current reference cascade comparator TTEK-30K / 5 consists of two comparators. The first operates in a range of primary currents from 0.5 to 3000 A for a rated secondary current of 5 A and from 0.5 to 600 A for a rated secondary current of 1 A. The second comparator is designed to extend the range of the rated primary current from 3000 A (from 600 A for a secondary rated current of 1A) to 50 kA. The operating range of the actual current is from 1 to 120 % of the rated current. The calibration of the current comparator is carried out by self-calibration methods based on a transformer ratio of 1/1 for all its windings and error detections with increasing ratio by comparing the various combinations used in the primary and secondary windings.

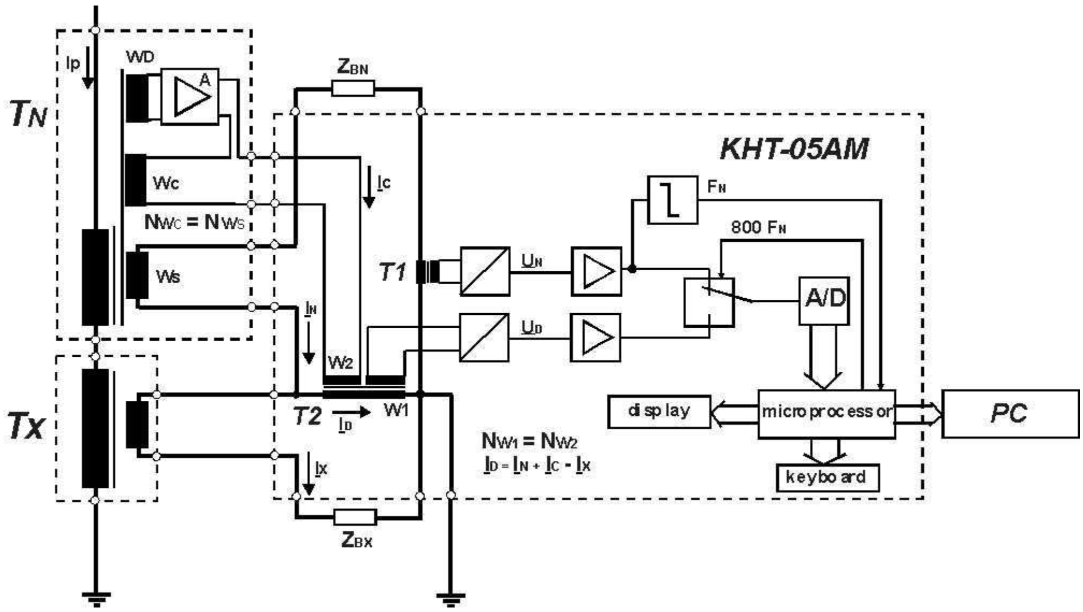



**Figure 4: Current transformer calibration circuit of UNIIM.**

The secondary windings of both transformers $T_N$ and $T_X$ are connected in series to the differential current transformer $T_2$. The compensation current $I_C$ of the current comparator $T_N$ is additionally fed into the transformer $T_2$, which operates as the summation current transformer. $T_2$ supplies the differential current $I_D = I\text{x} - I_N + I_C$. The number of turns in W2 is equal to the number of turns in W1 of the transformer $T_2$. The currents $I_N$ and $I_D$ are converted into the voltages $U_N$ and $U_D$ proportionally to these. These voltages are amplified and converted into discrete sequences. The signal source switch is operated with a clock frequency of $800{\cdot}F_N$. When analyzing the received digital data, the microcontroller selects the optimum amplifier stage for each measurement channel, and - using discrete Fourier transformation - it calculates the amplitude and the angular errors of the test transformer. The uncertainty of measurement is $2{\cdot}10^{-3}$ of the value of the respective measurement error but not less than $4{\cdot}10^{-7}$. The test set also determines the burden parameters and contents of higher harmonics in currents. The software calculates the associated Typ A measurement uncertainty of a set of measurements.

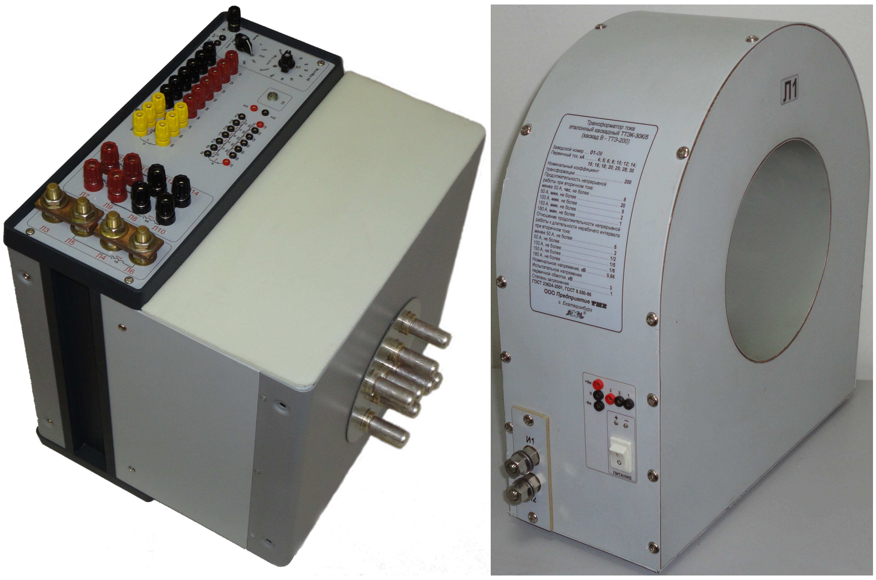



**Figure 5: Photograph of the current comparator TTEK-30K/5**

# 6 SYMBOLS AND DEFINITIONS

The quantities to be measured are the current ratio error and the phase displacement of the travelling standards. The definitions stated are in accordance with the standard IEC 61869-2 [7].

$I_p$, $I_{p,r}$ actual and rated primary current.

$I_s$, $I_{s,r}$ actual and rated secondary current.

$K_n$ nominal current ratio of the CT. It is defined by the ratio $I_{p,r}$ / $I_{s,r}$.

$\varepsilon_x$ current ratio error; the relative current error which a transformer introduces into the measurement of a current and which arises from the fact that the actual transformation ratio is not equal to the rated transformation ratio. In the measurement results the current ratio error is expressed in µA / A.

$\delta_x$ phase displacement; the difference in phase between the primary and secondary current vectors. The direction of the vectors being chosen in such a way that the phase displacement is positive when the secondary current vector leads the primary current vector. In the results the phase displacement is expressed in µrad.

$I_p$ / $I_{p,r}$ test point expressed in %.

$Z_b$ burden; the impedance of the secondary circuit including the test leads in ohms.

cos $\beta$ power factor of the burden for sinusoidal waveforms.

In complex mathematical notation, assuming sinusoidal waveforms the actual current ratio $\underline{F}_\mathrm{i}$ of the CT is given by

$$\underline{F}_\mathrm{i} = \frac{\underline{I}_\mathrm{s}}{\underline{I}_\mathrm{p}} = \frac{1+\varepsilon_\mathrm{x}}{K_\mathrm{n}} \cdot \mathrm{e}^{\mathrm{j}\delta_\mathrm{x}} \qquad \textbf{(1)}$$

# 7 UNCERTAINTY BUDGET

## 7.1 UNCERTAINTY CALCULATION OF PTB

The uncertainty budgets of the PTB results $\varepsilon_\mathrm{PTB}$ and $\delta_\mathrm{PTB}$ contain six different contributions; Type-A uncertainty of the measurement (1), uncertainty of the bridge (2), uncertainty of the standard CT (3), burden variation (4), frequency variation (5), and uncertainty of the circuit configuration (6). The expanded uncertainties ($k$ = 2) of the PTB results are calculated according to

$$\begin{aligned} U(\varepsilon_\mathrm{PTB}) &= 2 \cdot \sqrt{\sum_i u_\mathrm{i}^2(\varepsilon_\mathrm{PTB})} \\ U(\delta_\mathrm{PTB}) &= 2 \cdot \sqrt{\sum_i u_\mathrm{i}^2(\delta_\mathrm{PTB})} \end{aligned} \qquad \textbf{(2)}$$

where $u_\mathrm{i}$ represents the standard uncertainty of the contribution with index $i$. The uncertainty budgets are given in more detail in appendix 10.1.

## 7.2 UNCERTAINTY CALCULATION OF UNIIM

The uncertainty budgets of the UNIIM results $\varepsilon_\mathrm{UNIIM}$ and $\delta_\mathrm{UNIIM}$ contain nine different contributions; Type-A uncertainty of the measurement (1), uncertainty of the bridge (2), uncertainty of the standard CT (3), burden variation (4), frequency variation (5), uncertainty of the circuit configuration (6), test point variation (7), reproducibility (8), and an error dependent uncertainty for the excitation of the bridge (9). The expanded uncertainties ($k$ = 2) of the UNIIM results are calculated according to

$$\begin{aligned} U(\varepsilon_\mathrm{UNIIM}) &= 2 \cdot \sqrt{\sum_i u_\mathrm{i}^2(\varepsilon_\mathrm{UNIIM})} \\ U(\delta_\mathrm{UNIIM}) &= 2 \cdot \sqrt{\sum_i u_\mathrm{i}^2(\delta_\mathrm{UNIIM})} \end{aligned} \qquad \textbf{(3)}$$

where $u_\mathrm{i}$ represents the standard uncertainty of the contribution with index $i$. The uncertainty budgets are given in more detail in appendix 10.2.

# 8 DATA PROCESSING

To evaluate the equivalence degree of the CT measurement systems, the EN factor for the current ratio error difference EN($\Delta\varepsilon_i$) and for the phase displacement difference EN($\Delta\delta_i$) are calculated according to

$$EN(\Delta\varepsilon_i) = \frac{\Delta\varepsilon_{\text{UNIIM-PTB}}}{U_C(\Delta\varepsilon_i)}$$
$$EN(\Delta\delta_i) = \frac{\Delta\delta_{\text{UNIIM-PTB}}}{U_C(\Delta\delta_i)} \quad \textbf{(4)}$$

where $\Delta\varepsilon_{\text{UNIIM-PTB}}$ and $\Delta\delta_{\text{UNIIM-PTB}}$ are the current ratio error difference and the phase displacement difference of the results of UNIIM and PTB and

$$U_C(\Delta\varepsilon_i) = \sqrt{U^2(\varepsilon_{\text{PTB}}) + U^2(\varepsilon_{\text{UNIIM}}) + U^2_{\text{Std}}(\varepsilon)}$$
$$U_C(\Delta\delta_i) = \sqrt{U^2(\delta_{\text{PTB}}) + U^2(\delta_{\text{UNIIM}}) + U^2_{\text{Std}}(\delta)} \quad \textbf{(5)}$$

represent the combined uncertainties of the calculated current ratio error difference and of the phase displacement difference, respectively. The term $U_{\text{Std}}$ represents an additional uncertainty contribution of the travelling standard CTs (see 9.1) and is estimated from those measurements to be within ± 1 ppm (or µrad).

# 9 RESULTS

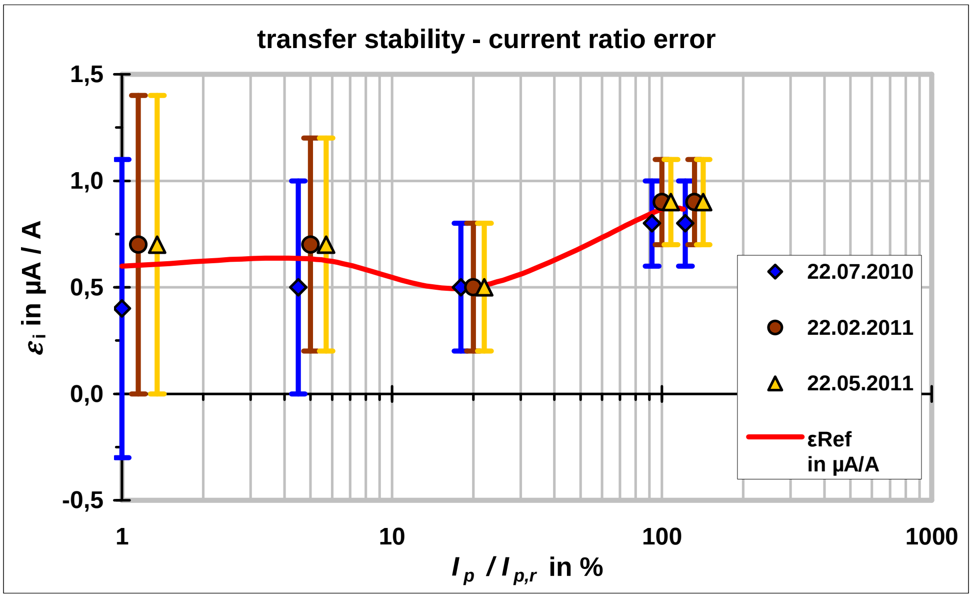
The results of the comparison are given in this section. In sub-section 9.1 the results of the determination of the behavior of the transfer standard are summarized.

The measured current ratio errors and the phase displacement of each laboratory are given in section 9.2. The results are given in Table 2 and graphically in Figure 7 to Figure 24. For illustrative purposes, the reference values of the comparison (i.e. the variance weighted-mean) are also shown. No further computation is done with this reference values.

The calculated differences of the current ratio errors and of the phase displacements between both laboratories are given in section 9.3. The degree of equivalence (EN factor) is calculated from those differences. The results are given in Table 3 and are shown graphically in Figure 25 to Figure 42.

## 9.1 TRANSFER STANDARD BEHAVIOR

PTB measured the travelling standard CT #1 three times during the project. Figure 6 shows the results for the measurements made by PTB for ratio 5 A / 5 A at test points varying from 1 % to 120 %, at a burden of 0.1 Ω, unity power factor, at a frequency of 50 Hz and at an ambient temperature of 22 °C ± 2 °C. The stability of the transfer standards is estimated from measurements to be within ± 1 ppm (or µrad).



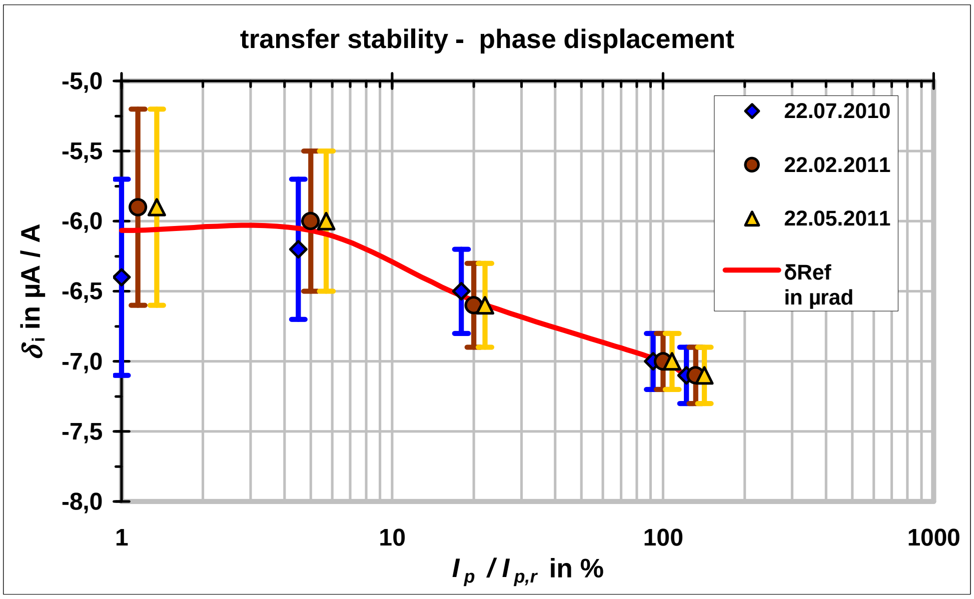




**Figure 6: Stability of the travelling standard CT #1 during July 2010 and May 2011.**

## 9.2 Measurement results of PTB and UNIIM

**Table 2: Individual current ratio error and phase displacement results of PTB and UNIIM.**

| | PTB results | | | | UNIIM results | | | |
|---|---|---|---|---|---|---|---|---|
| | **Ratio 5 A / 5 A; *f* = 50 Hz** | | | | | | | |
| $I_p$ / $I_{p,r}$ in % | $\varepsilon_{PTB}$ in µA/A | $\delta_{PTB}$ in µrad | $U(\varepsilon_{PTB})$ in µA/A | $U(\delta_{PTB})$ in µrad | $\varepsilon_{UNIIM}$ in µA/A | $\delta_{UNIIM}$ in µrad | $U(\varepsilon_{UNIIM})$ in µA/A | $U(\delta_{UNIIM})$ in µrad |
| 120 | 0,9 | -7,1 | 2,0 | 2,0 | 0,7 | -6,4 | 3,5 | 4,5 |
| 100 | 0,9 | -7,0 | 2,0 | 2,0 | 0,6 | -6,4 | 3,5 | 4,5 |
| 20 | 0,5 | -6,6 | 2,0 | 2,0 | 0,2 | -5,9 | 3,5 | 4,5 |
| 5 | 0,7 | -6,0 | 2,0 | 2,0 | 0,3 | -5,4 | 3,5 | 4,5 |
| 1 | 0,7 | -5,9 | 2,0 | 2,0 | 0,3 | -5,4 | 5,0 | 6,0 |
| | **Ratio 20 A / 5 A; *f* = 50 Hz** | | | | | | | |
| 120 | -0,3 | -0,3 | 2,0 | 2,0 | -0,4 | -1,1 | 3,5 | 4,5 |
| 100 | -0,3 | -0,3 | 2,0 | 2,0 | -0,4 | -1,0 | 3,5 | 4,5 |
| 20 | -0,3 | -0,3 | 2,0 | 2,0 | -0,4 | -1,0 | 3,5 | 4,5 |
| 5 | -0,3 | -0,2 | 2,0 | 2,0 | -0,4 | -0,9 | 3,5 | 4,5 |
| 1 | -0,4 | -0,2 | 2,0 | 2,0 | -0,5 | -0,8 | 5,0 | 6,0 |
| | **Ratio 50 A / 5 A; *f* = 50 Hz** | | | | | | | |
| 120 | 0,3 | -6,5 | 2,0 | 2,0 | 0,1 | -7,1 | 3,5 | 4,5 |
| 100 | 0,2 | -6,4 | 2,0 | 2,0 | 0,0 | -7,1 | 3,5 | 4,5 |
| 20 | -0,1 | -5,9 | 2,0 | 2,0 | -0,4 | -6,6 | 3,5 | 4,5 |
| 5 | -0,1 | -5,4 | 2,0 | 2,0 | -0,3 | -6,1 | 3,5 | 4,5 |
| 1 | -0,1 | -5,2 | 2,0 | 2,0 | -0,3 | -6,0 | 5,0 | 6,0 |
| | **Ratio 100 A / 5 A; *f* = 50 Hz** | | | | | | | |
| 120 | -0,4 | -1,0 | 2,0 | 2,0 | -0,2 | -2,0 | 3,5 | 4,5 |
| 100 | -0,5 | -1,0 | 2,0 | 2,0 | -0,2 | -2,0 | 3,5 | 4,5 |
| 20 | -0,6 | -0,9 | 2,0 | 2,0 | -0,3 | -2,0 | 3,5 | 4,5 |
| 5 | -0,5 | -0,8 | 2,0 | 2,0 | -0,3 | -1,9 | 3,5 | 4,5 |
| 1 | -0,5 | -1,0 | 2,0 | 2,0 | -0,3 | -1,8 | 5,0 | 6,0 |
| | **Ratio 500 A / 5 A; *f* = 50 Hz** | | | | | | | |
| 120 | -1,5 | -6,2 | 2,0 | 2,0 | -1,4 | -6,9 | 6,0 | 7,0 |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 100 | -1,8 | -6,2 | 2,0 | 2,0 | -1,5 | -6,9 | 6,0 | 7,0 |
| 20 | -2,1 | -6,5 | 2,0 | 2,0 | -2,1 | -7,1 | 6,0 | 7,0 |
| 5 | -1,9 | -5,8 | 2,0 | 2,0 | -1,9 | -6,3 | 6,0 | 7,0 |
| 1 | -1,9 | -5,7 | 2,0 | 2,0 | -1,8 | -5,9 | 7,0 | 7,5 |
| | **Ratio 1 000 A / 5 A; *f* = 50 Hz** | | | | | | | |
| 120 | -6,0 | 1,1 | 3,0 | 4,0 | -1,5 | -0,6 | 7,0 | 8,0 |
| 100 | -5,9 | 1,0 | 3,0 | 4,0 | -1,5 | -0,6 | 7,0 | 8,0 |
| 20 | -6,2 | 0,0 | 3,0 | 4,0 | -2,5 | -1,3 | 7,0 | 8,0 |
| 5 | -6,4 | -0,1 | 3,0 | 4,0 | -2,2 | -1,2 | 7,0 | 8,0 |
| 1 | -7,5 | 0,7 | 3,0 | 4,0 | -2,0 | -0,9 | 8,0 | 8,5 |
| | **Ratio 3 000 A / 5 A; *f* = 50 Hz** | | | | | | | |
| 120 | -4,5 | 4,0 | 3,0 | 4,0 | -1,6 | 0,4 | 8,0 | 9,0 |
| 100 | -4,7 | 3,9 | 3,0 | 4,0 | -1,6 | 0,3 | 8,0 | 9,0 |
| 20 | -4,9 | 3,3 | 3,0 | 4,0 | -1,7 | -0,1 | 8,0 | 9,0 |
| 5 | -4,8 | 3,5 | 3,0 | 4,0 | -2,3 | -0,8 | 8,0 | 9,0 |
| 1 | -4,5 | 7,5 | 3,0 | 4,0 | -2,0 | -0,4 | 9,5 | 9,5 |
| | **Ratio 10 000 A / 5 A; *f* = 50 Hz** | | | | | | | |
| 120 | 0,0 | -6,4 | 4,0 | 6,0 | -0,2 | -7,3 | 8,0 | 9,0 |
| 100 | 0,0 | -6,3 | 4,0 | 6,0 | -0,3 | -7,2 | 8,0 | 9,0 |
| 20 | -0,5 | -5,7 | 4,0 | 6,0 | -0,7 | -6,8 | 8,0 | 9,0 |
| 5 | -0,6 | -5,1 | 4,0 | 6,0 | -0,8 | -6,1 | 8,0 | 9,0 |
| 1 | -0,7 | -5,0 | 4,0 | 6,0 | -0,9 | -5,7 | 10,0 | 10,0 |
| | **Ratio 30 000 A / 5 A; *f* = 50 Hz** | | | | | | | |
| 120 | -1,2 | 0,5 | 4,0 | 6,0 | -0,4 | -0,8 | 10,0 | 10,5 |
| 100 | -1,3 | 0,5 | 4,0 | 6,0 | -0,4 | -0,8 | 10,0 | 10,5 |
| 20 | -1,1 | 0,3 | 4,0 | 6,0 | -0,6 | -0,8 | 10,0 | 10,5 |
| 5 | -1,2 | 0,4 | 4,0 | 6,0 | -1,0 | -0,6 | 10,0 | 10,5 |
| 1 | -1,4 | 0,3 | 4,0 | 6,0 | -1,3 | -0,4 | 11,0 | 12,0 |
| | **Ratio 50 000 A / 5 A; *f* = 50 Hz** | | | | | | | |
| 120 | -1,1 | 0,7 | 4,0 | 6,0 | -0,7 | -0,3 | 12,0 | 13,0 |
| 100 | -1,2 | 0,7 | 4,0 | 6,0 | -0,6 | -0,4 | 12,0 | 13,0 |
| 20 | -1,2 | 0,6 | 4,0 | 6,0 | -0,9 | -0,4 | 12,0 | 13,0 |
| 5 | -1,0 | 0,6 | 4,0 | 6,0 | -0,9 | -0,5 | 12,0 | 13,0 |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 1 | -1,1 | 0,4 | 4,0 | 6,0 | -1,2 | -0,1 | 13,5 | 14,0 |
| | **Ratio 5 A / 5 A; *f* = 60 Hz** | | | | | | | |
| 120 | 0,9 | -8,9 | 2,0 | 2,0 | 0,8 | -7,4 | 3,5 | 4,5 |
| 100 | 0,8 | -8,9 | 2,0 | 2,0 | 0,7 | -7,4 | 3,5 | 4,5 |
| 20 | 0,6 | -8,4 | 2,0 | 2,0 | 0,4 | -7,0 | 3,5 | 4,5 |
| 5 | 0,6 | -8,0 | 2,0 | 2,0 | 0,4 | -6,7 | 3,5 | 4,5 |
| 1 | 0,6 | -7,8 | 2,0 | 2,0 | 0,4 | -6,8 | 5,0 | 6,0 |
| | **Ratio 1 A / 1 A; *f* = 50 Hz** | | | | | | | |
| $I_p / I_{p,r}$ in % | $\varepsilon_{PTB}$ in µA/A | $\delta_{PTB}$ in µrad | $U(\varepsilon_{PTB})$ in µA/A | $U(\delta_{PTB})$ in µrad | $\varepsilon_{UNIIM}$ in µA/A | $\delta_{UNIIM}$ in µrad | $U(\varepsilon_{UNIIM})$ in µA/A | $U(\delta_{UNIIM})$ in µrad |
| 120 | 0,7 | -6,1 | 2,0 | 2,0 | 0,2 | -5,8 | 4,5 | 5,5 |
| 100 | 0,7 | -6,1 | 2,0 | 2,0 | 0,2 | -5,8 | 4,5 | 5,5 |
| 20 | 0,7 | -5,7 | 2,0 | 2,0 | 0,3 | -5,2 | 4,5 | 5,5 |
| 5 | 0,7 | -5,7 | 2,0 | 2,0 | 0,3 | -5,2 | 5,5 | 6,5 |
| 1 | 0,9 | -5,8 | 2,0 | 2,0 | 0,3 | -5,2 | 7,0 | 8,0 |
| | **Ratio 10 A / 1 A; *f* = 50 Hz** | | | | | | | |
| 120 | -1,6 | -5,7 | 3,0 | 3,0 | -1,2 | -3,6 | 4,5 | 5,5 |
| 100 | -1,5 | -5,7 | 3,0 | 3,0 | -1,2 | -3,6 | 4,5 | 5,5 |
| 20 | -1,2 | -5,2 | 3,0 | 3,0 | -1,1 | -3,2 | 4,5 | 5,5 |
| 5 | -2,0 | -5,5 | 3,0 | 3,0 | -1,1 | -3,2 | 5,5 | 6,5 |
| 1 | -2,0 | -6,1 | 3,0 | 3,0 | -1,0 | -3,2 | 7,0 | 8,0 |
| | **Ratio 100 A / 1 A; *f* = 50 Hz** | | | | | | | |
| 120 | -2,5 | -7,3 | 3,0 | 3,0 | -2,1 | -7,0 | 6,5 | 7,5 |
| 100 | -2,6 | -7,2 | 3,0 | 3,0 | -2,0 | -6,9 | 6,5 | 7,5 |
| 20 | -2,3 | -6,6 | 3,0 | 3,0 | -1,8 | -6,2 | 6,5 | 7,5 |
| 5 | -3,1 | -6,6 | 3,0 | 3,0 | -1,8 | -5,8 | 7,5 | 8,5 |
| 1 | -3,2 | -6,6 | 3,0 | 3,0 | -1,8 | -5,2 | 9,0 | 10,0 |
| | **Ratio 500 A / 1 A; *f* = 50 Hz** | | | | | | | |
| 120 | -3,0 | -2,5 | 3,0 | 3,0 | -1,7 | -0,1 | 8,0 | 8,5 |
| 100 | -3,1 | -2,6 | 3,0 | 3,0 | -1,9 | -0,2 | 8,0 | 8,5 |
| 20 | -3,2 | -3,2 | 3,0 | 3,0 | -2,4 | -0,7 | 8,0 | 8,5 |
| 5 | -3,7 | -3,2 | 3,0 | 3,0 | -2,2 | -0,4 | 9,0 | 10,0 |
| 1 | -3,5 | -3,0 | 3,0 | 3,0 | -1,8 | -0,1 | 10,5 | 11,0 |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | **Ratio 5 000 A / 1 A; *f* = 50 Hz** | | | | | | | |
| 120 | -1,1 | -0,3 | 5,0 | 6,0 | -0,8 | -1,1 | 8,0 | 8,5 |
| 100 | -1,1 | -0,3 | 5,0 | 6,0 | -0,8 | -1,1 | 8,0 | 8,5 |
| 20 | -1,0 | 0,0 | 5,0 | 6,0 | -1,1 | -0,8 | 8,0 | 8,5 |
| 5 | -1,9 | -0,2 | 5,0 | 6,0 | -1,2 | -0,7 | 9,5 | 10,0 |
| 1 | -2,0 | -0,4 | 5,0 | 6,0 | -1,4 | -0,5 | 11,0 | 11,5 |
| | **Ratio 10 000 A / 1 A; *f* = 50 Hz** | | | | | | | |
| 120 | -1,2 | 2,3 | 5,0 | 6,0 | -0,9 | -0,4 | 8,5 | 9,5 |
| 100 | -1,3 | 2,3 | 5,0 | 6,0 | -0,9 | -0,4 | 8,5 | 9,5 |
| 20 | -1,2 | 2,2 | 5,0 | 6,0 | -0,8 | -0,5 | 8,5 | 9,5 |
| 5 | -2,0 | 2,4 | 5,0 | 6,0 | -1,0 | -0,2 | 10,0 | 11,0 |
| 1 | -3,1 | 2,1 | 5,0 | 6,0 | -1,2 | -0,3 | 11,5 | 12,5 |
| | **Ratio 20 000 A / 1 A; *f* = 50 Hz** | | | | | | | |
| 120 | -2,7 | -4,5 | 5,0 | 6,0 | -2,5 | -6,4 | 12,0 | 13,0 |
| 100 | -2,7 | -4,4 | 5,0 | 6,0 | -2,4 | -6,3 | 12,0 | 13,0 |
| 20 | -2,2 | -3,8 | 5,0 | 6,0 | -1,9 | -5,3 | 12,0 | 13,0 |
| 5 | -3,1 | -3,3 | 5,0 | 6,0 | -2,1 | -4,9 | 13,5 | 14,5 |
| 1 | -4,3 | -3,6 | 5,0 | 6,0 | -2,0 | -5,3 | 15,0 | 16,0 |
| | **Ratio 50 000 A / 1 A; *f* = 50 Hz** | | | | | | | |
| 120 | -3,4 | 0,8 | 5,0 | 6,0 | -3,0 | -1,4 | 14,0 | 15,0 |
| 100 | -3,6 | 0,7 | 5,0 | 6,0 | -3,1 | -1,5 | 14,0 | 15,0 |
| 20 | -3,0 | 0,4 | 5,0 | 6,0 | -3,1 | -1,5 | 14,0 | 15,0 |
| 5 | -3,6 | 0,5 | 5,0 | 6,0 | -3,0 | -1,0 | 15,5 | 16,0 |
| 1 | -3,9 | 0,1 | 5,0 | 6,0 | -3,0 | -1,1 | 17,0 | 18,0 |

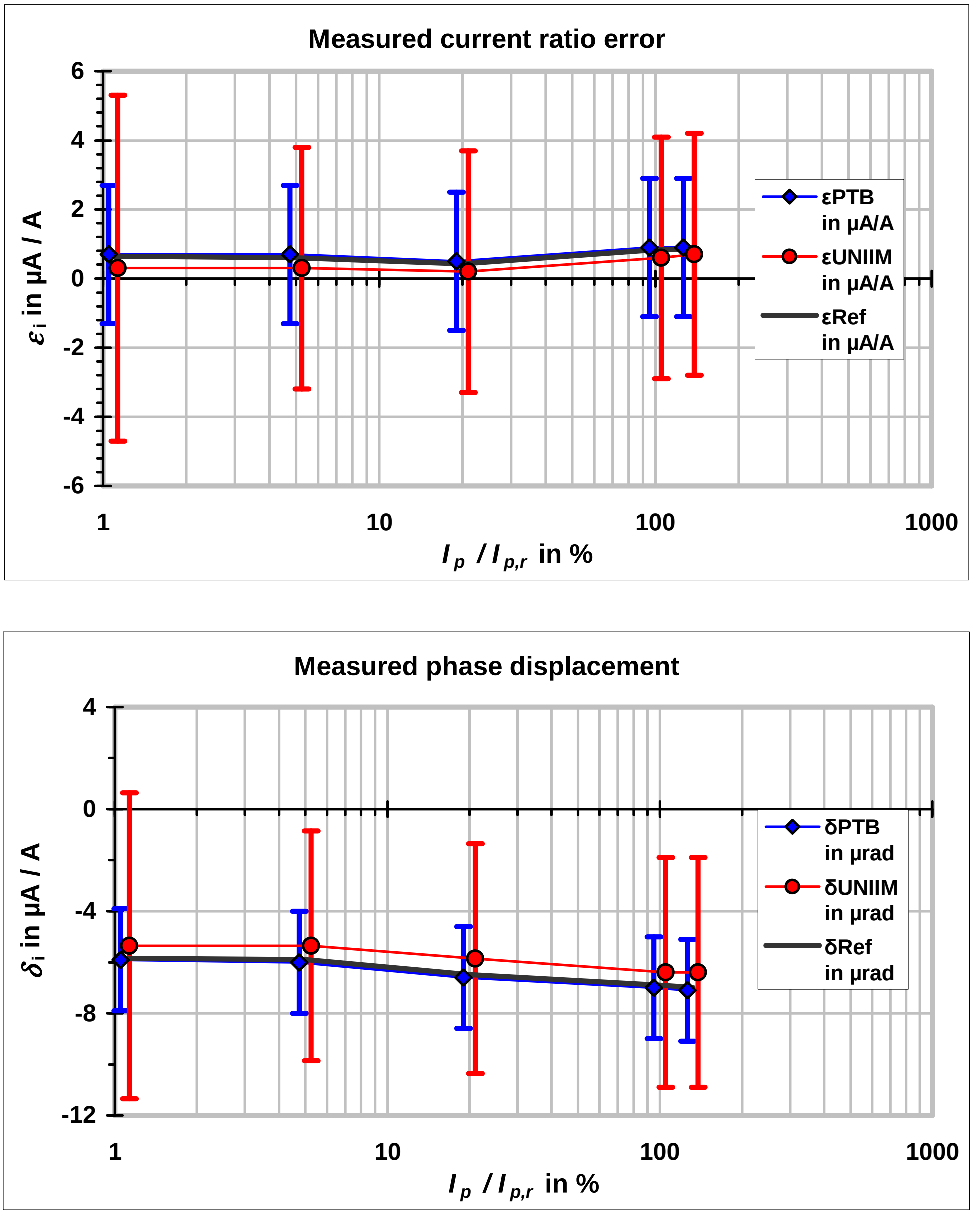
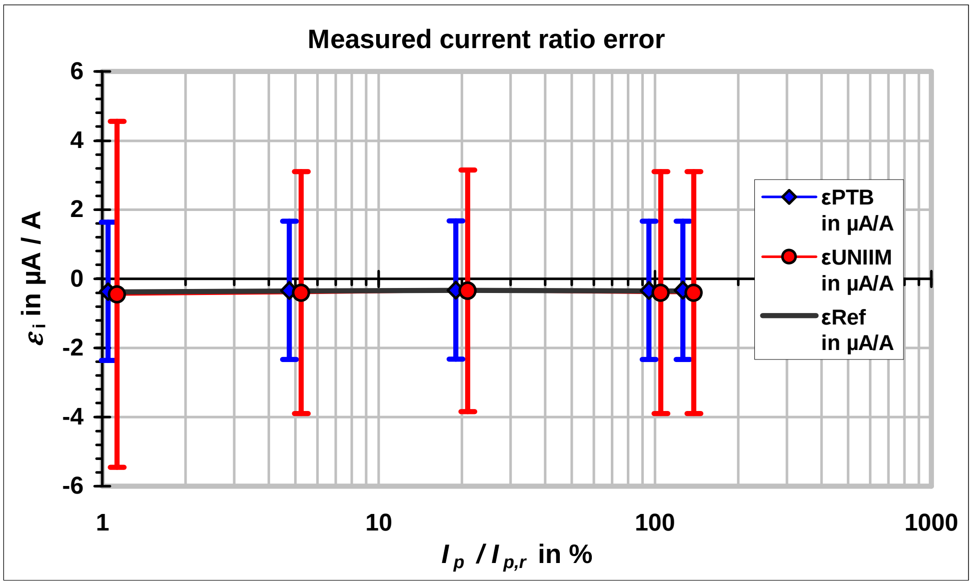



Figure 7: Ratio 5 A / 5 A; $I$ / $I_n$ = 1… 120 %; 50 Hz. Results of the measured current ratio error (upper figure) and of the phase displacement (lower figure) of UNIIM (red symbols) and PTB (blue symbols). The bars represent the individual measurement uncertainties ($k$ = 2). For illustration purposes the comparison reference values (black curve) are shown additionally.



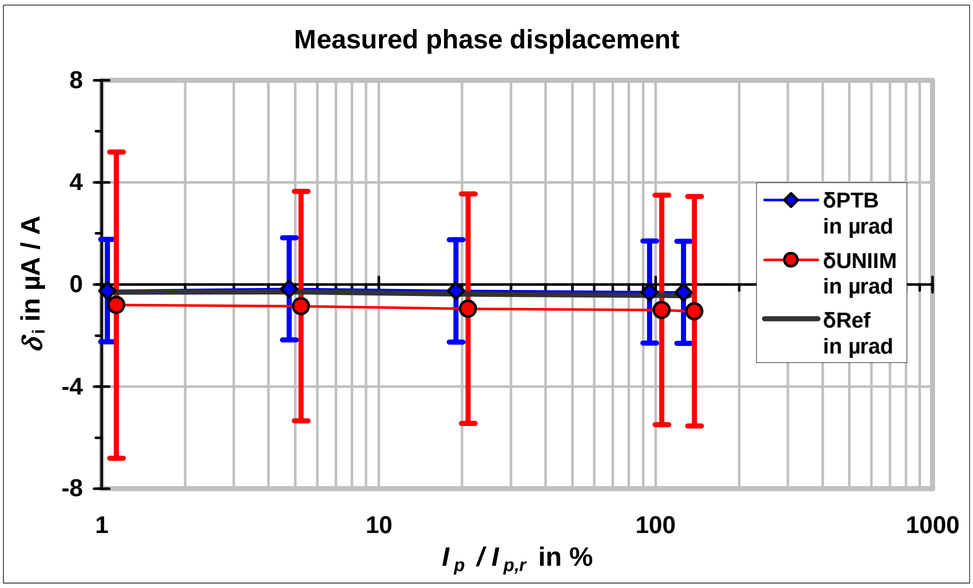
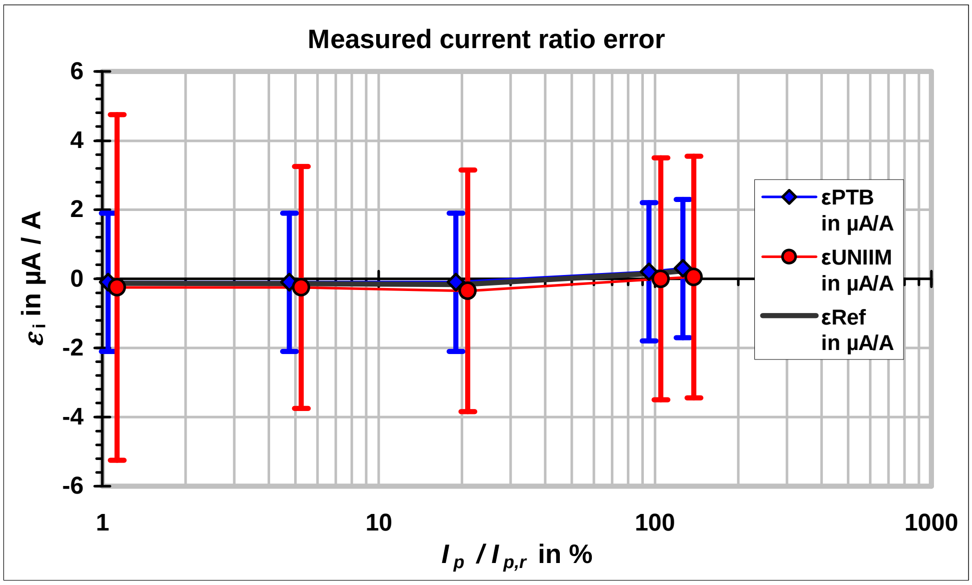




Figure 8: Ratio 20 A / 5 A; $I$ / $I_n$ = 1… 120 %; 50 Hz. Results of the measured current ratio error (upper figure) and of the phase displacement (lower figure) of UNIIM (red symbols) and PTB (blue symbols). The bars represent the individual measurement uncertainties ($k$ = 2). For illustration purposes the comparison reference values (black curve) are shown additionally.



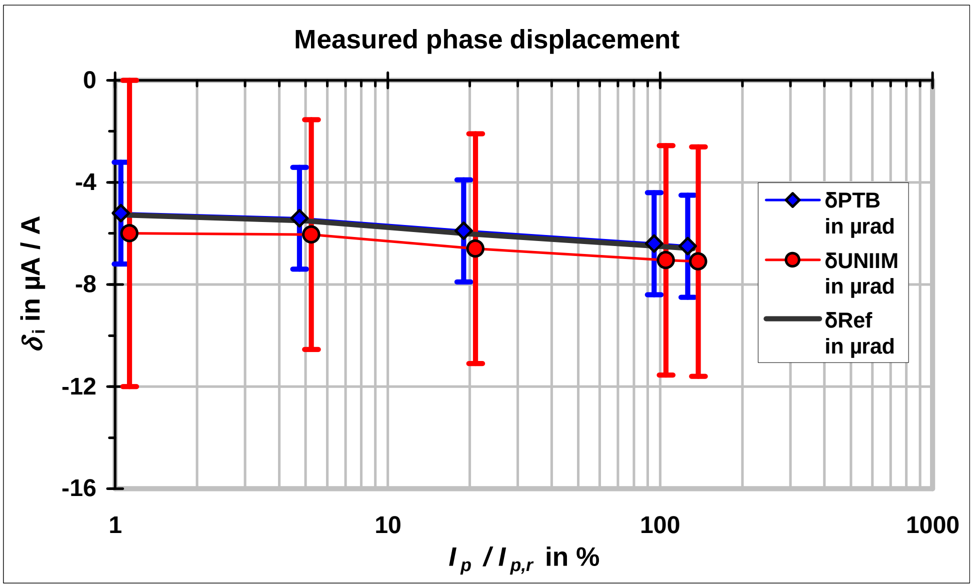
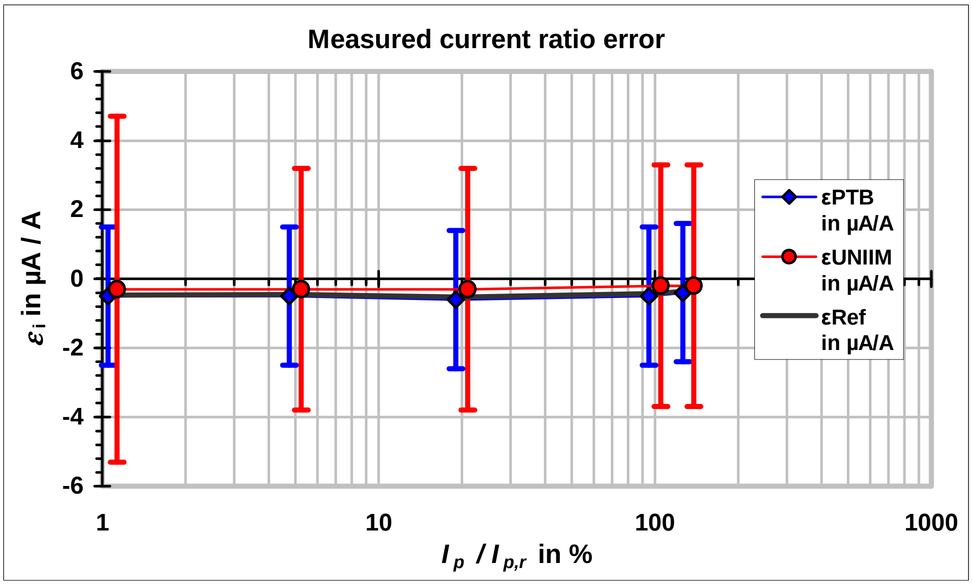




Figure 9: Ratio 50 A / 5 A; $I$ / $I_n$ = 1… 120 %; 50 Hz. Results of the measured current ratio error (upper figure) and of the phase displacement (lower figure) of UNIIM (red points) and PTB (blue points). The bars represent the individual measurement uncertainties ($k$ = 2). For illustration purposes the comparison reference values (black curve) are shown additionally.



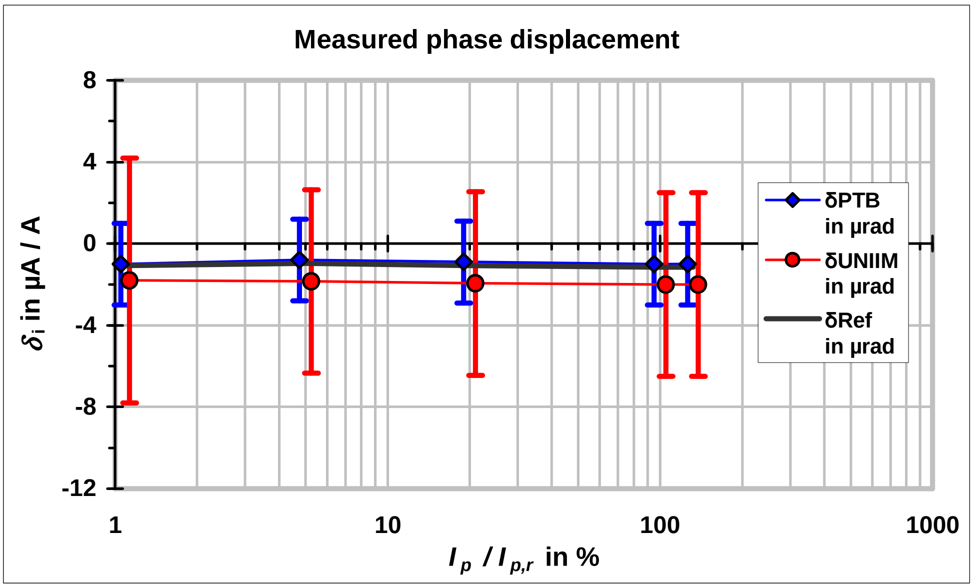
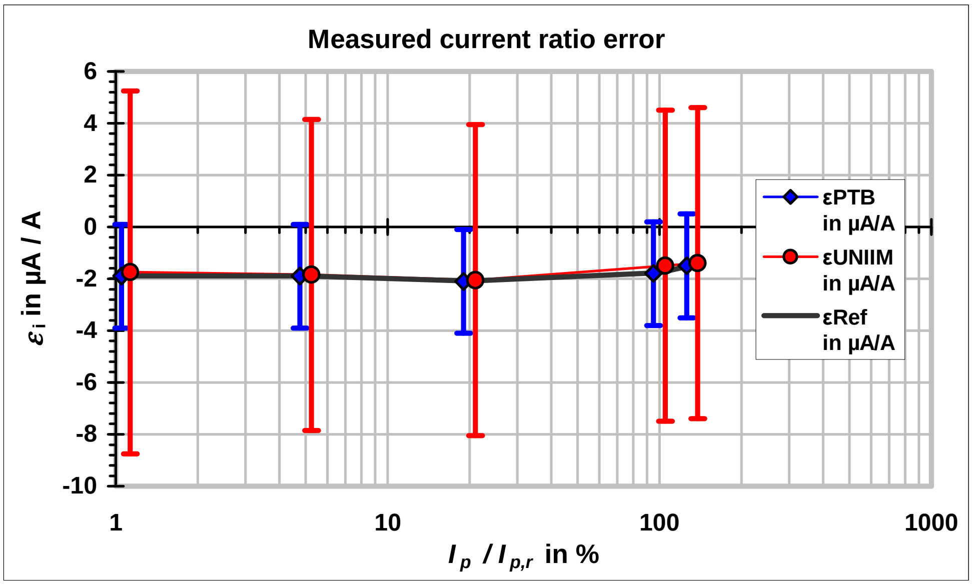




Figure 10: Ratio 100 A / 5 A; $I$ / $I_n$ = 1… 120 %; 50 Hz. Results of the measured current ratio error (upper figure) and of the phase displacement (lower figure) of UNIIM (red symbols) and PTB (blue symbols). The bars represent the individual measurement uncertainties ($k$ = 2). For illustration purposes the comparison reference values (black curve) are shown additionally.



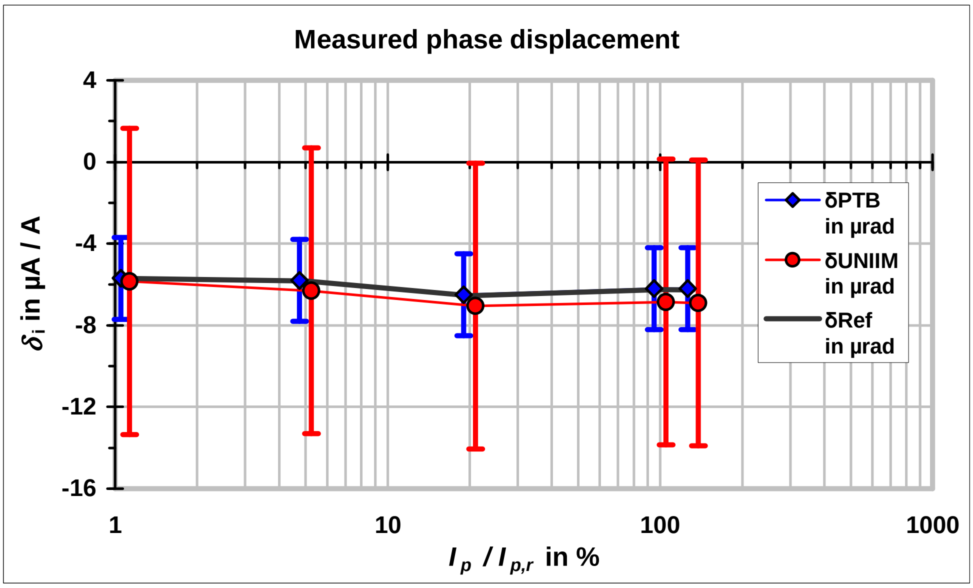
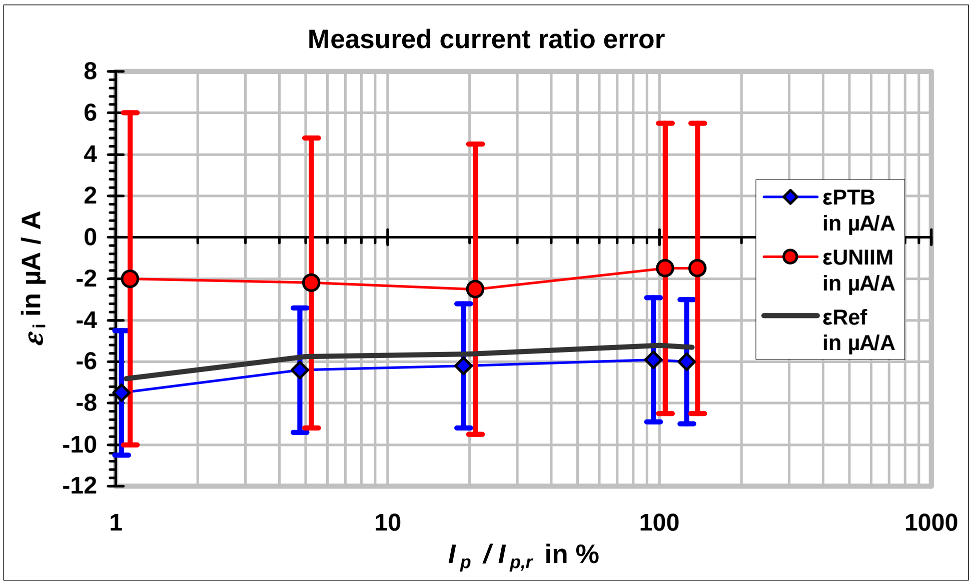




**Figure 11:** Ratio 500 A / 5 A; $I / I_n = 1 \ldots 120$ %; 50 Hz. Results of the measured current ratio error (upper figure) and of the phase displacement (lower figure) of UNIIM (red symbols) and PTB (blue symbols). The bars represent the individual measurement uncertainties ($k = 2$). For illustration purposes the comparison reference values (black curve) are shown additionally.



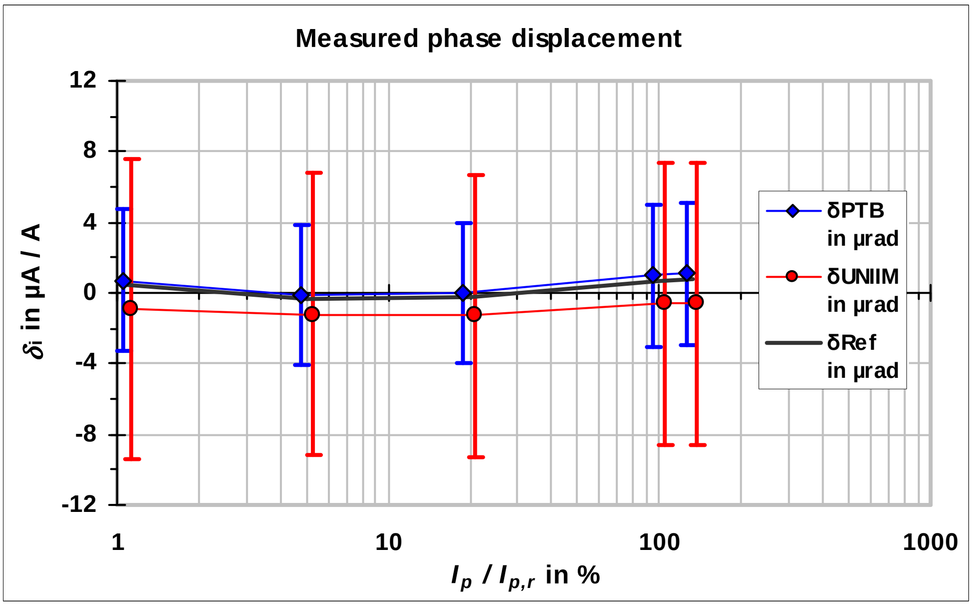
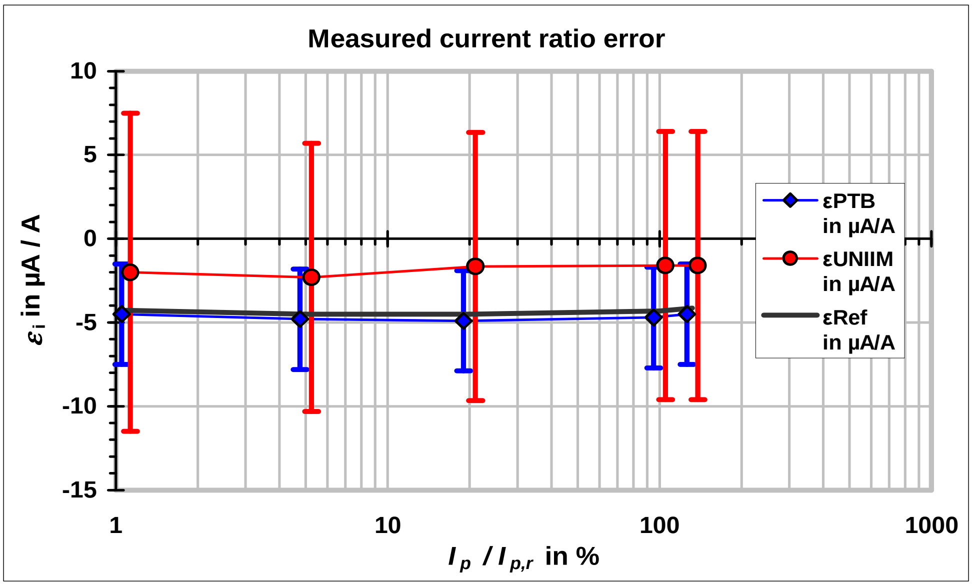




Figure 12: Ratio 1 000 A / 5 A; $I$ / $I_n$ = 1… 120 %; 50 Hz. Results of the measured current ratio error (upper figure) and of the phase displacement (lower figure) of UNIIM (red symbols) and PTB (blue symbols). The bars represent the individual measurement uncertainties ($k$ = 2). For illustration purposes the comparison reference values (black curve) are shown additionally.



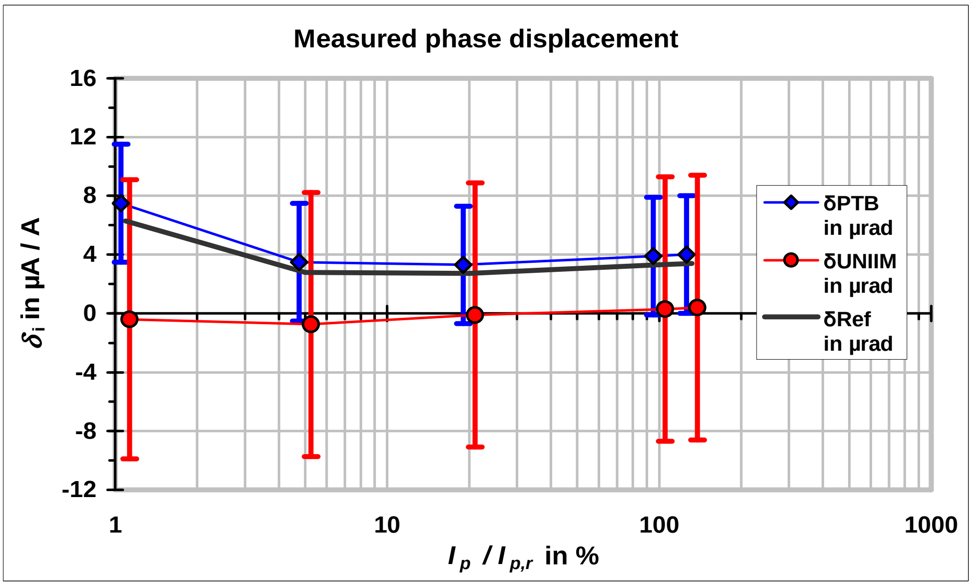




Figure 13: Ratio 3 000 A / 5 A; $I$ / $I_n$ = 1… 120 %; 50 Hz. Results of the measured current ratio error (upper figure) and of the phase displacement (lower figure) of UNIIM (red symbols) and PTB (blue symbols). The bars represent the individual measurement uncertainties ($k$ = 2). For illustration purposes the comparison reference values (black curve) are shown additionally.

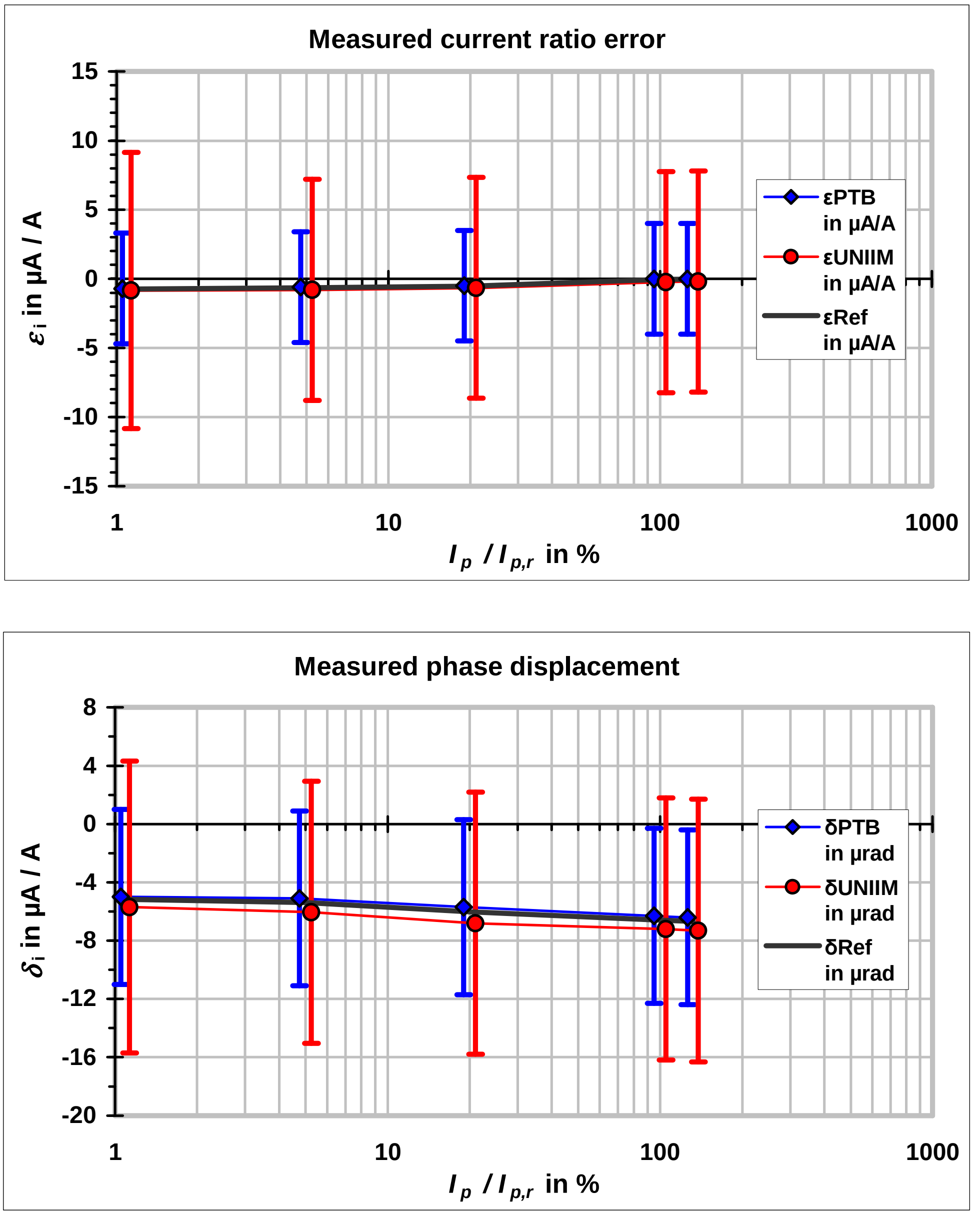
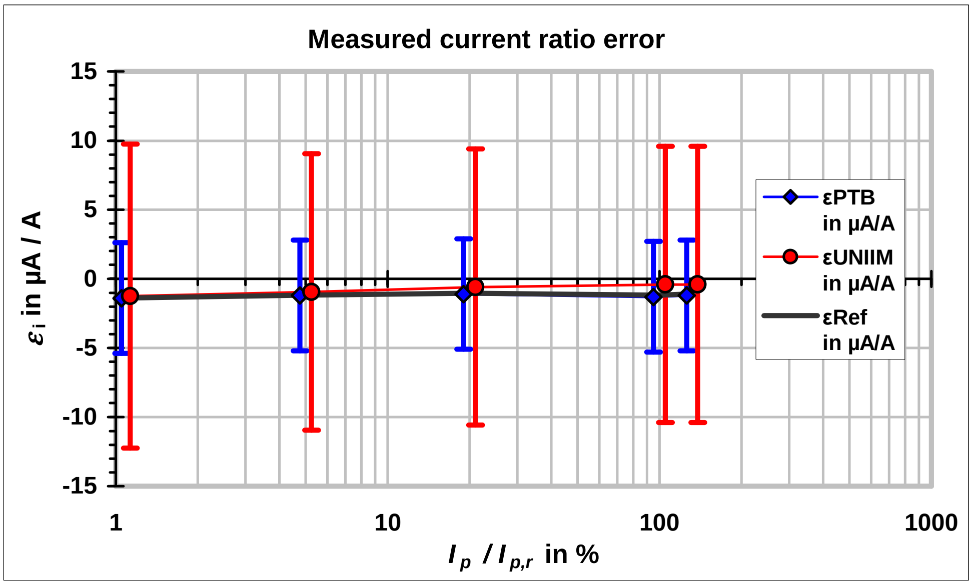



Figure 14: Ratio 10 000 A / 5 A; $I / I_n$ = 1… 120 %; 50 Hz. Results of the measured current ratio error (upper figure) and of the phase displacement (lower figure) of UNIIM (red symbols) and PTB (blue symbols). The bars represent the individual measurement uncertainties ($k = 2$). For illustration purposes the comparison reference values (black curve) are shown additionally.



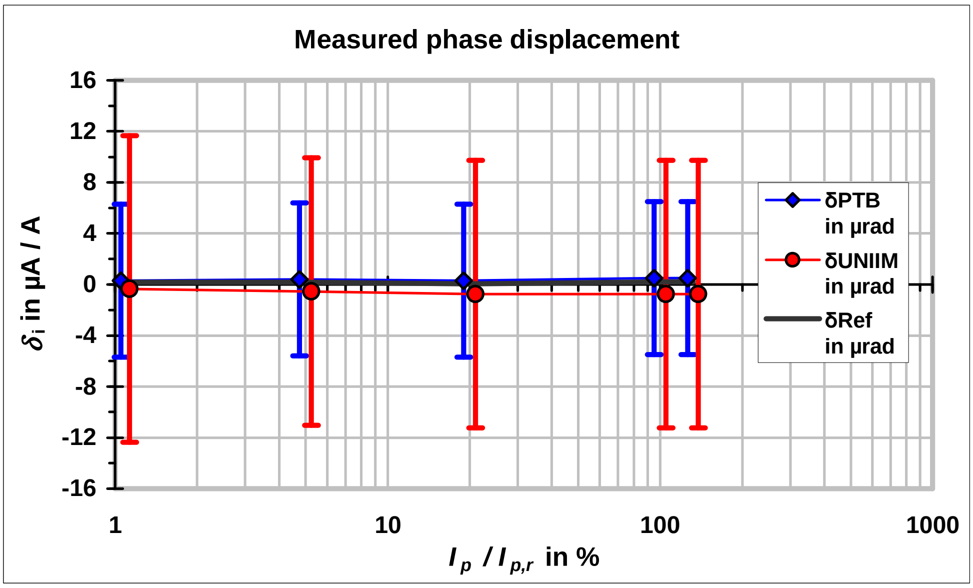
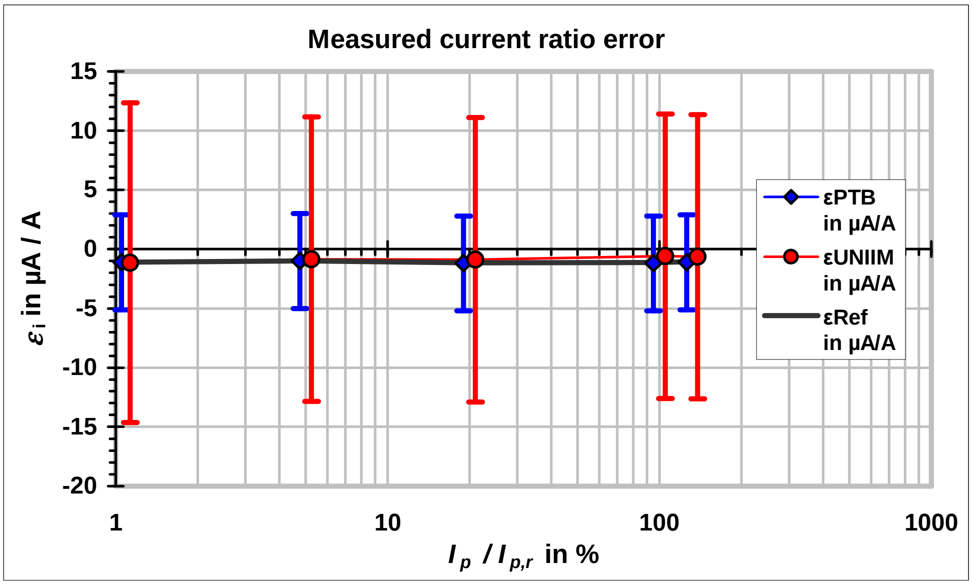




**Figure 15: Ratio 30 000 A / 5 A; $I / I_n = 1 \ldots 120$ %; 50 Hz. Results of the measured current ratio error (upper figure) and of the phase displacement (lower figure) of UNIIM (red symbols) and PTB (blue symbols). The bars represent the individual measurement uncertainties ($k = 2$). For illustration purposes the comparison reference values (black curve) are shown additionally.**



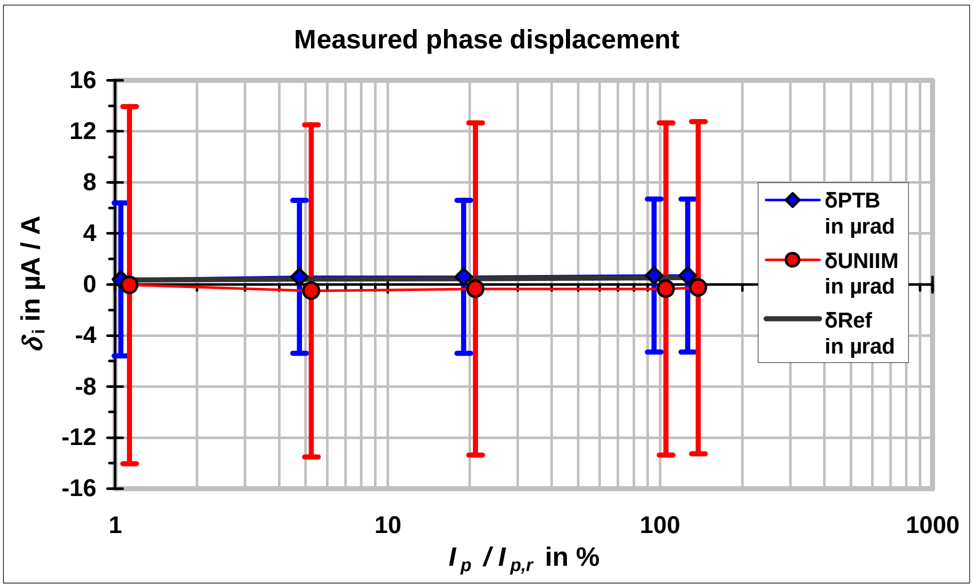
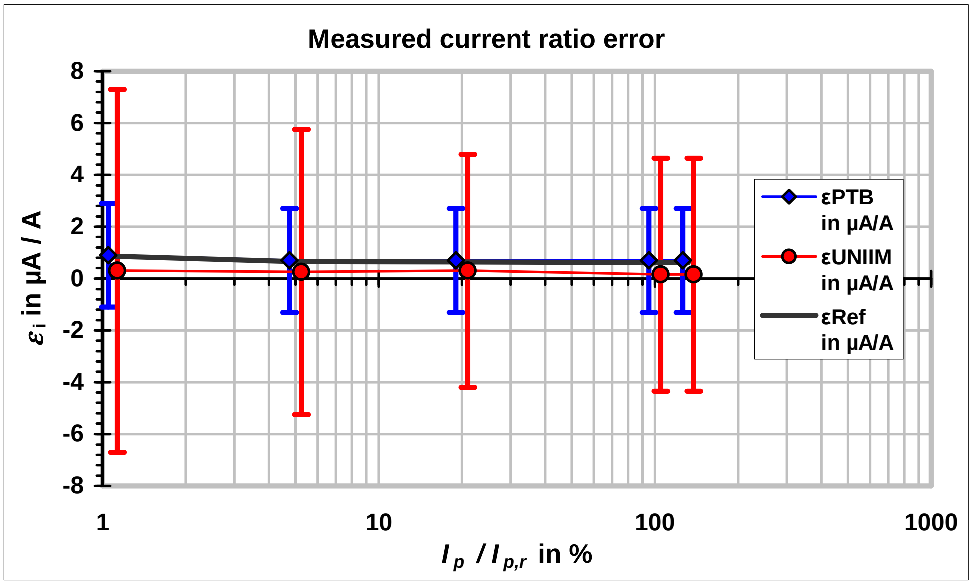




Figure 16: Ratio 50 000 A / 5 A; $I$ / $I_n$ = 1… 120 %; 50 Hz. Results of the measured current ratio error (upper figure) and of the phase displacement (lower figure) of UNIIM (red symbols) and PTB (blue symbols). The bars represent the individual measurement uncertainties ($k$ = 2). For illustration purposes the comparison reference values (black curve) are shown additionally.



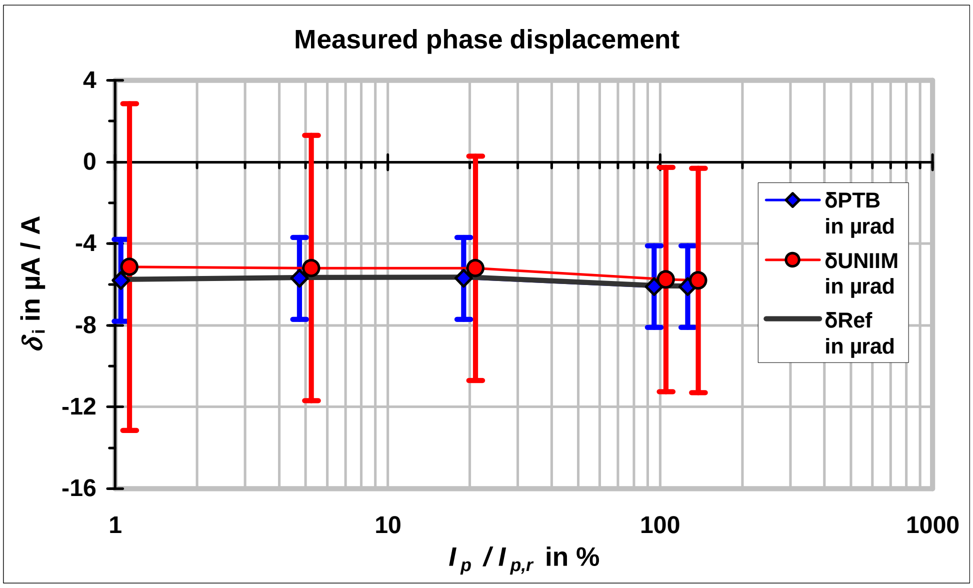
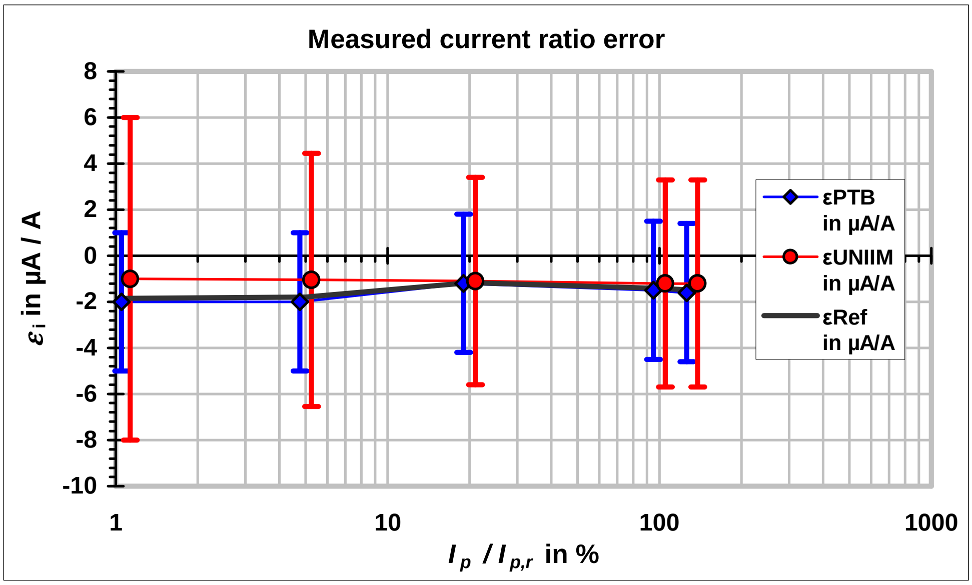




Figure 17: Ratio 1 A / 1 A; $I$ / $I_n$ = 1… 120 %; 50 Hz. Results of the measured current ratio error (upper figure) and of the phase displacement (lower figure) of UNIIM (red symbols) and PTB (blue symbols). The bars represent the individual measurement uncertainties ($k$ = 2). For illustration purposes the comparison reference values (black curve) are shown additionally.



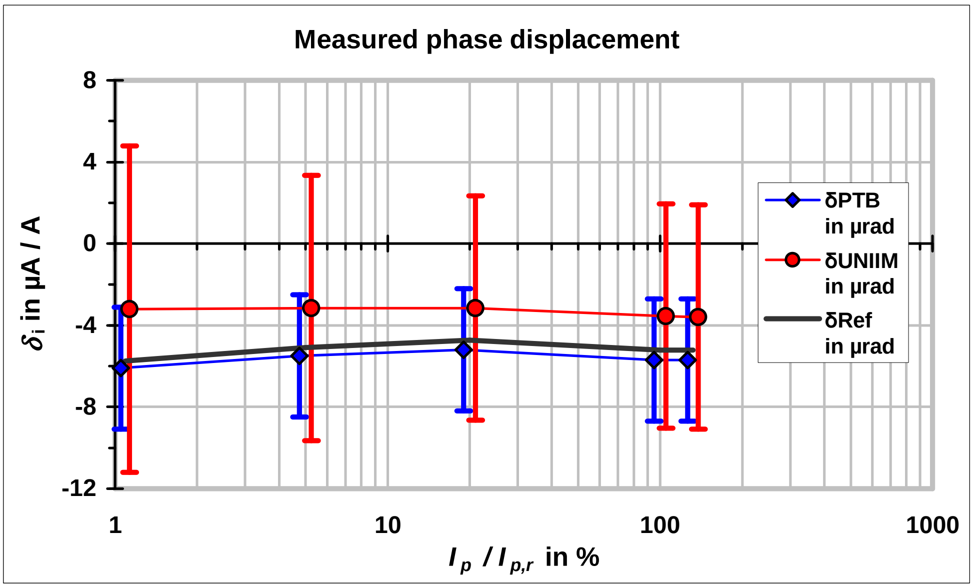




Figure 18: Ratio 10 A / 1 A; $I$ / $I_n$ = 1… 120 %; 50 Hz. Results of the measured current ratio error (upper figure) and of the phase displacement (lower figure) of UNIIM (red symbols) and PTB (blue symbols). The bars represent the individual measurement uncertainties ($k$ = 2). For illustration purposes the comparison reference values (black curve) are shown additionally.

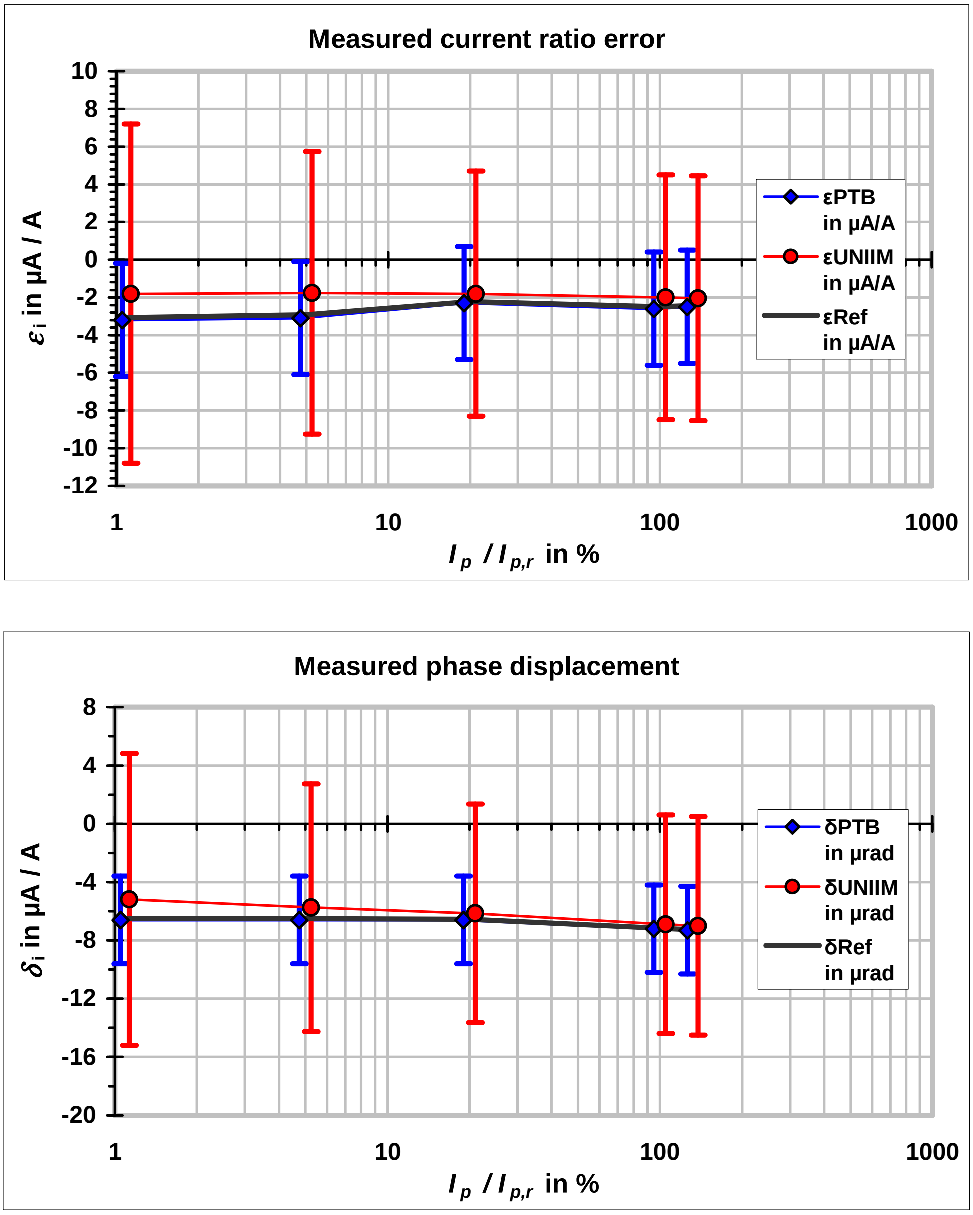
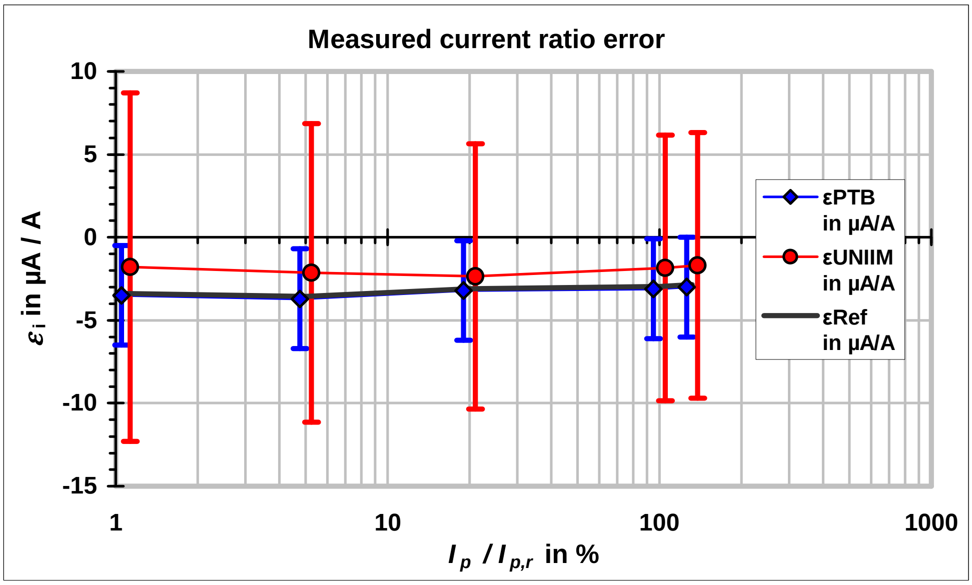



**Figure 19:** Ratio 100 A / 1 A; $I$ / $I_n$ = 1… 120 %; 50 Hz. Results of the measured current ratio error (upper figure) and of the phase displacement (lower figure) of UNIIM (red symbols) and PTB (blue symbols). The bars represent the individual measurement uncertainties ($k$ = 2). For illustration purposes the comparison reference values (black curve) are shown additionally.



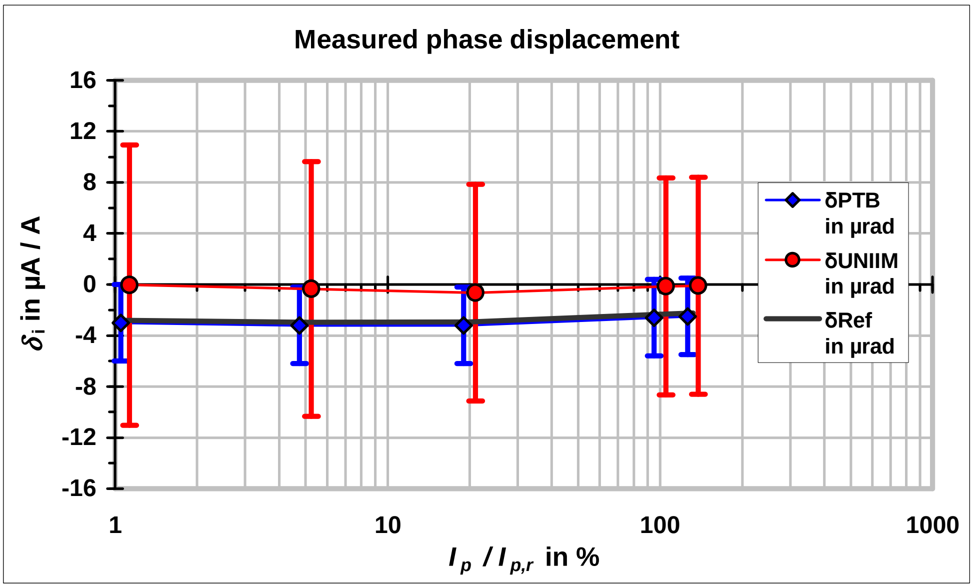
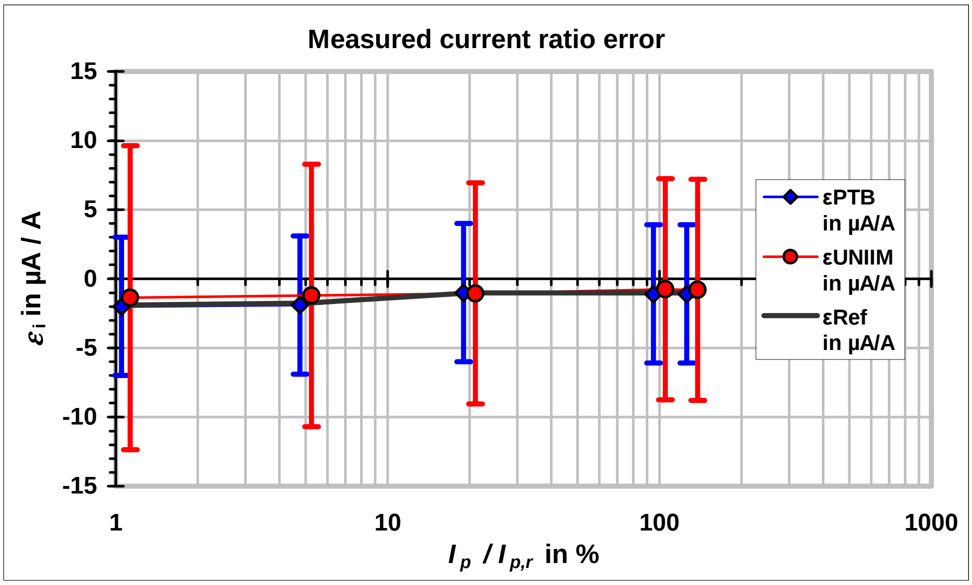




**Figure 20:** Ratio 500 A / 1 A; $I$ / $I_n$ = 1… 120 %; 50 Hz. Results of the measured current ratio error (upper figure) and of the phase displacement (lower figure) of UNIIM (red symbols) and PTB (blue symbols). The bars represent the individual measurement uncertainties ($k$ = 2). For illustration purposes the comparison reference values (black curve) are shown additionally.



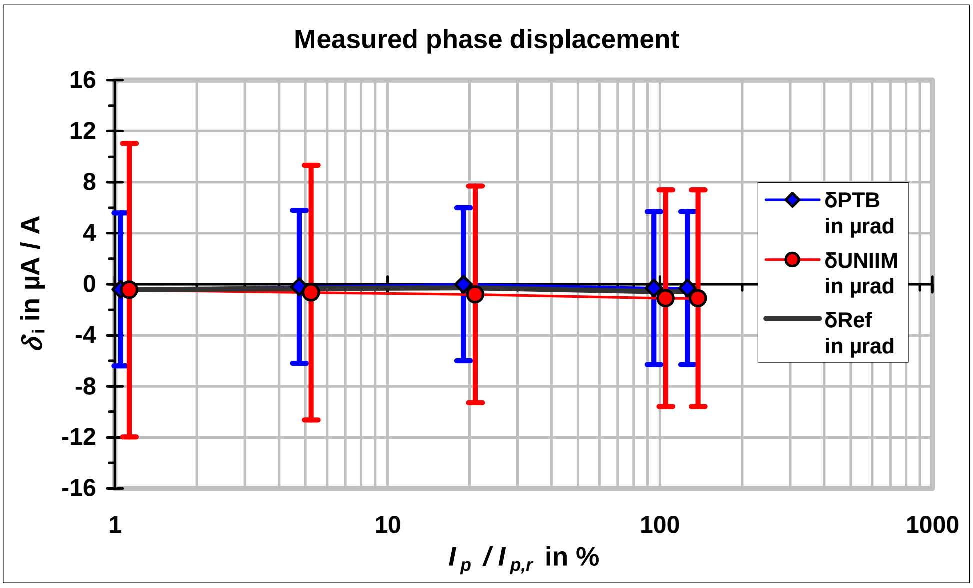
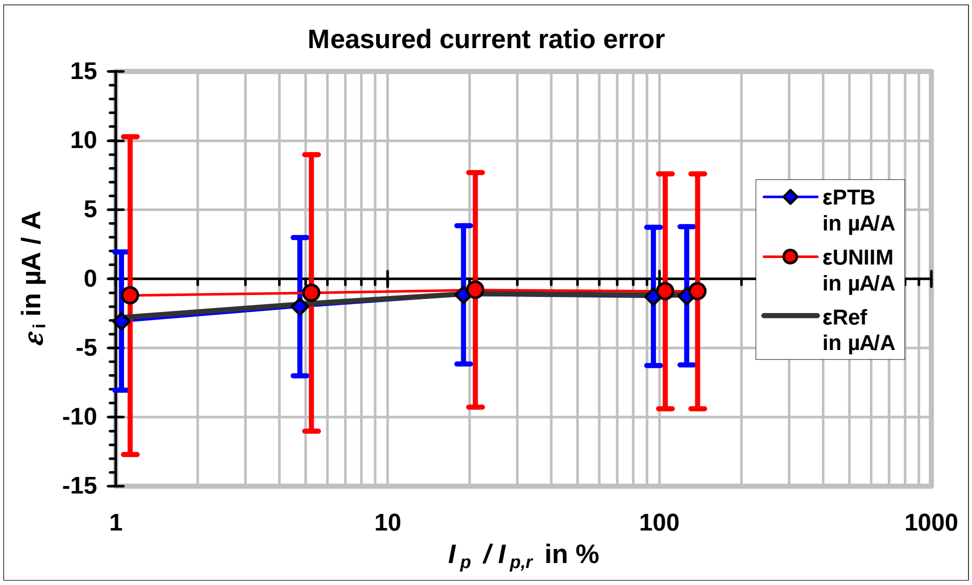




**Figure 21:** **Ratio 5 000 A / 1 A; $I$ / $I_n$ = 1… 120 %; 50 Hz. Results of the measured current ratio error (upper figure) and of the phase displacement (lower figure) of UNIIM (red symbols) and PTB (blue symbols). The bars represent the individual measurement uncertainties ($k$ = 2). For illustration purposes the comparison reference values (black curve) are shown additionally.**



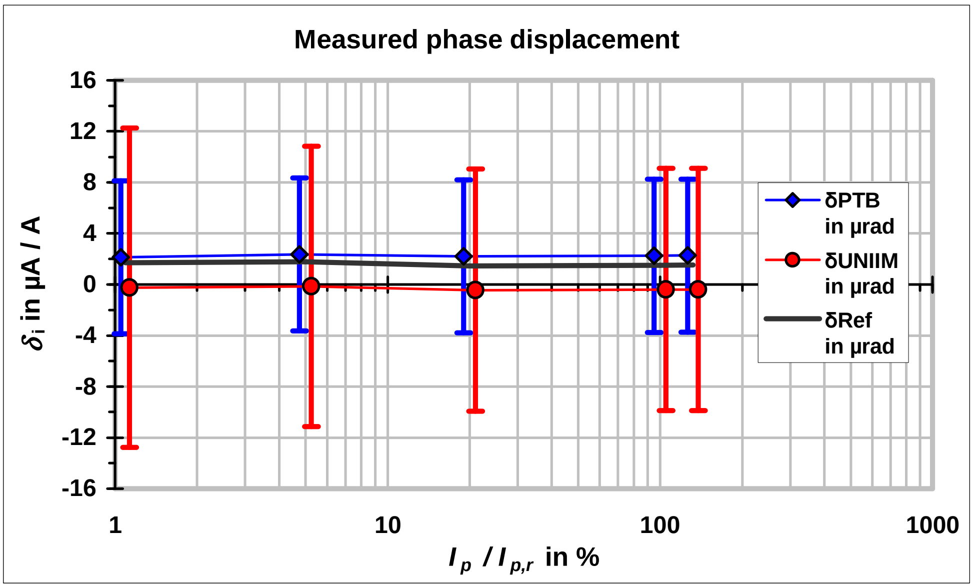
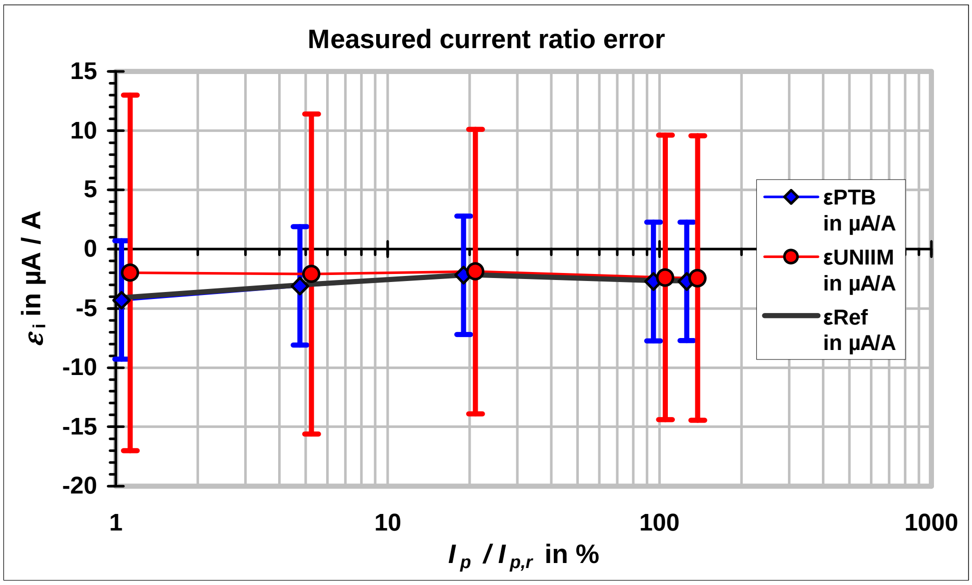




Figure 22: Ratio 10 000 A / 1 A; $I$ / $I_n$ = 1… 120 %; 50 Hz. Results of the measured current ratio error (upper figure) and of the phase displacement (lower figure) of UNIIM (red symbols) and PTB (blue symbols). The bars represent the individual measurement uncertainties ($k = 2$). For illustration purposes the comparison reference values (black curve) are shown additionally.



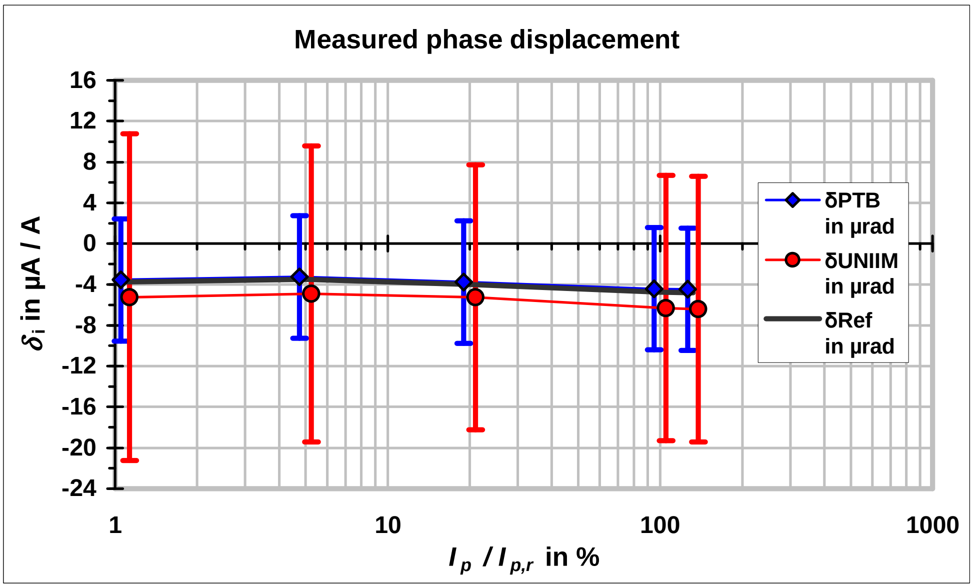
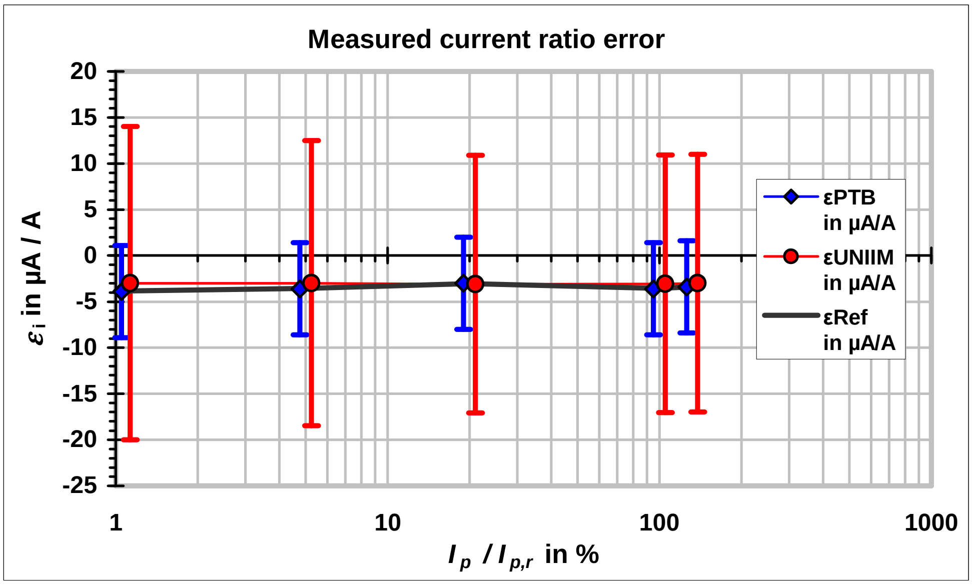




Figure 23: Ratio 20 000 A / 1 A; $I\,/\,I_n = 1\ldots\ 120\ \%$; 50 Hz. Results of the measured current ratio error (upper figure) and of the phase displacement (lower figure) of UNIIM (red symbols) and PTB (blue symbols). The bars represent the individual measurement uncertainties ($k = 2$). For illustration purposes the comparison reference values (black curve) are shown additionally.



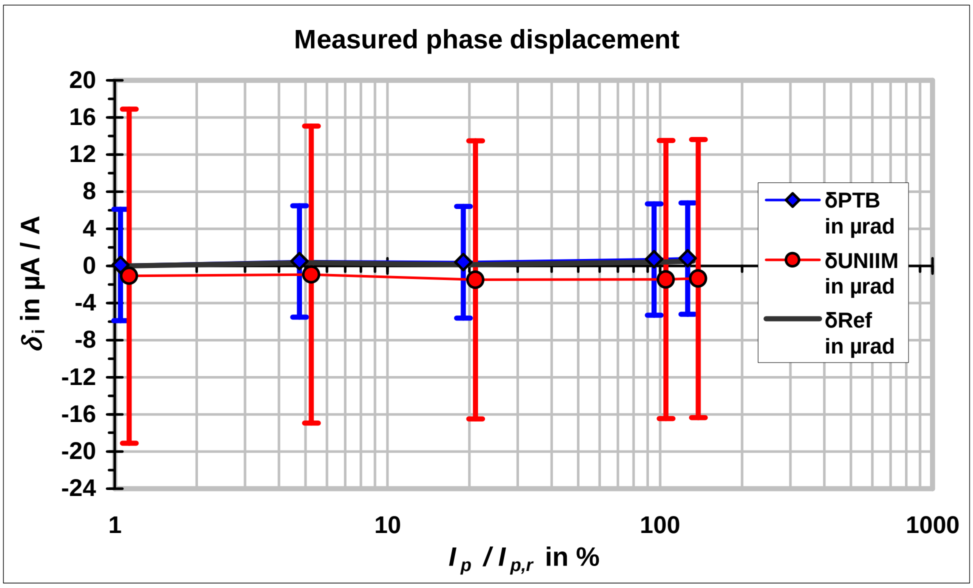




Figure 24: Ratio 50 000 A / 1 A; $I$ / $I_n$ = 1… 120 %; 50 Hz. Results of the measured current ratio error (upper figure) and of the phase displacement (lower figure) of UNIIM (red symbols) and PTB (blue symbols). The bars represent the individual measurement uncertainties ($k$ = 2). For illustration purposes the comparison reference values (black curve) are shown additionally.

## 9.3 DIFFERENCES AND EQUIVALENCE DEGREE OF THE PTB AND UNIIM RESULTS

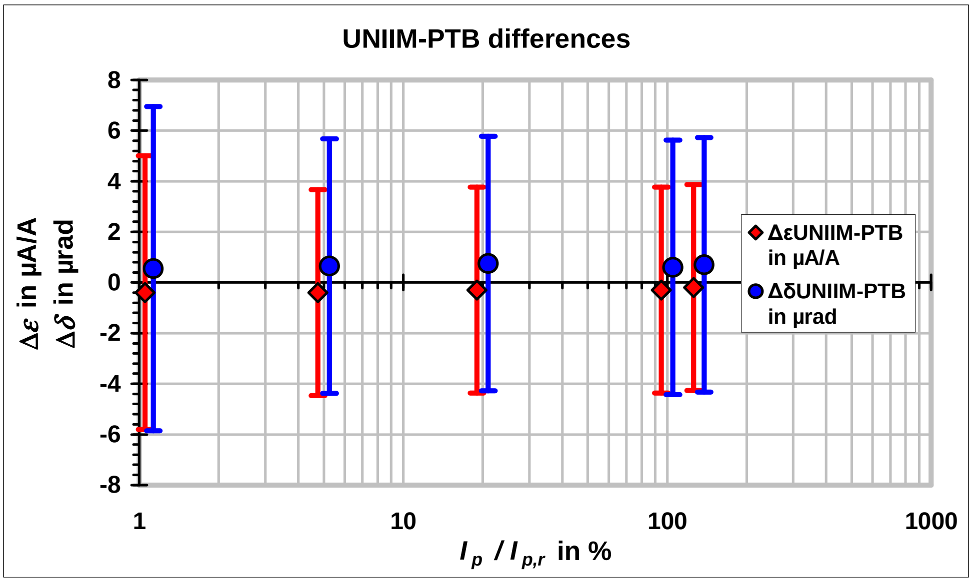
**Table 3: Differences of the current ratio error and of the phase displacement results of PTB and UNIIM, and their EN factor.**

| | Ratio 5 A / 5 A; $f$ = 50 Hz | | | | | |
|---|---|---|---|---|---|---|
| $I_p$ / $I_{p,r}$ in % | $\Delta\varepsilon_{UNIIM-PTB}$ in µA/A | $\Delta\delta_{UNIIM-PTB}$ in µrad | $U_C(\Delta\varepsilon)$ in µA/A | $U_C(\Delta\delta)$ in µrad | EN($\Delta\varepsilon$) | EN($\Delta\delta$) |
| 120 | -0,2 | 0,7 | 4,1 | 5,0 | 0,0 | 0,1 |
| 100 | -0,3 | 0,6 | 4,1 | 5,0 | -0,1 | 0,1 |
| 20 | -0,3 | 0,8 | 4,1 | 5,0 | -0,1 | 0,1 |
| 5 | -0,4 | 0,7 | 4,1 | 5,0 | -0,1 | 0,1 |
| 1 | -0,4 | 0,6 | 5,4 | 6,4 | -0,1 | 0,1 |
| | Ratio 20 A / 5 A; $f$ = 50 Hz | | | | | |
| 120 | -0,1 | -0,7 | 4,2 | 5,3 | 0,0 | -0,1 |
| 100 | -0,1 | -0,7 | 4,2 | 5,3 | 0,0 | -0,1 |
| 20 | 0,0 | -0,7 | 4,2 | 5,3 | 0,0 | -0,1 |
| 5 | -0,1 | -0,7 | 4,2 | 5,3 | 0,0 | -0,1 |
| 1 | -0,1 | -0,6 | 5,5 | 6,6 | 0,0 | -0,1 |
| | Ratio 50 A / 5 A; $f$ = 50 Hz | | | | | |
| 120 | -0,3 | -0,6 | 4,2 | 5,3 | -0,1 | -0,1 |
| 100 | -0,2 | -0,6 | 4,2 | 5,3 | 0,0 | -0,1 |
| 20 | -0,3 | -0,7 | 4,2 | 5,3 | -0,1 | -0,1 |
| 5 | -0,2 | -0,6 | 4,2 | 5,3 | 0,0 | -0,1 |
| 1 | -0,2 | -0,8 | 5,5 | 6,6 | 0,0 | -0,1 |
| | Ratio 100 A / 5 A; $f$ = 50 Hz | | | | | |
| 120 | 0,2 | -1,0 | 4,2 | 5,3 | 0,0 | -0,2 |
| 100 | 0,3 | -1,0 | 4,2 | 5,3 | 0,1 | -0,2 |
| 20 | 0,3 | -1,1 | 4,2 | 5,3 | 0,1 | -0,2 |
| 5 | 0,2 | -1,1 | 4,2 | 5,3 | 0,0 | -0,2 |
| 1 | 0,2 | -0,8 | 5,5 | 6,6 | 0,0 | -0,1 |
| | Ratio 500 A / 5 A; $f$ = 50 Hz | | | | | |
| 120 | 0,1 | -0,7 | 6,4 | 7,5 | 0,0 | -0,1 |
| 100 | 0,3 | -0,6 | 6,4 | 7,5 | 0,0 | -0,1 |

| | | | | | | |
|---|---|---|---|---|---|---|
| 20 | 0,1 | -0,6 | 6,4 | 7,5 | 0,0 | -0,1 |
| 5 | 0,0 | -0,5 | 6,4 | 7,5 | 0,0 | -0,1 |
| 1 | 0,2 | -0,1 | 7,3 | 8,0 | 0,0 | 0,0 |
| | **Ratio 1 000 A / 5 A; *f* = 50 Hz** | | | | | |
| 120 | 4,5 | -1,7 | 7,7 | 9,2 | 0,6 | -0,2 |
| 100 | 4,4 | -1,6 | 7,7 | 9,2 | 0,6 | -0,2 |
| 20 | 3,7 | -1,3 | 7,7 | 9,2 | 0,5 | -0,1 |
| 5 | 4,2 | -1,1 | 7,7 | 9,2 | 0,5 | -0,1 |
| 1 | 5,5 | -1,6 | 8,6 | 9,6 | 0,6 | -0,2 |
| | **Ratio 3 000 A / 5 A; *f* = 50 Hz** | | | | | |
| 120 | 2,9 | -3,6 | 8,6 | 10,0 | 0,3 | -0,4 |
| 100 | 3,1 | -3,6 | 8,6 | 10,0 | 0,4 | -0,4 |
| 20 | 3,3 | -3,4 | 8,6 | 10,0 | 0,4 | -0,3 |
| 5 | 2,5 | -4,3 | 8,6 | 10,0 | 0,3 | -0,4 |
| 1 | 2,5 | -7,9 | 10,0 | 10,5 | 0,2 | -0,8 |
| | **Ratio 10 000 A / 5 A; *f* = 50 Hz** | | | | | |
| 120 | -0,2 | -0,9 | 9,0 | 11,0 | 0,0 | -0,1 |
| 100 | -0,3 | -0,9 | 9,0 | 11,0 | 0,0 | -0,1 |
| 20 | -0,2 | -1,1 | 9,0 | 11,0 | 0,0 | -0,1 |
| 5 | -0,2 | -1,0 | 9,0 | 11,0 | 0,0 | -0,1 |
| 1 | -0,2 | -0,7 | 10,8 | 11,8 | 0,0 | -0,1 |
| | **Ratio 30 000 A / 5 A; *f* = 50 Hz** | | | | | |
| 120 | 0,8 | -1,3 | 10,8 | 12,3 | 0,1 | -0,1 |
| 100 | 0,9 | -1,3 | 10,8 | 12,3 | 0,1 | -0,1 |
| 20 | 0,5 | -1,1 | 10,8 | 12,3 | 0,0 | -0,1 |
| 5 | 0,3 | -1,0 | 10,8 | 12,3 | 0,0 | -0,1 |
| 1 | 0,2 | -0,7 | 11,7 | 13,6 | 0,0 | 0,0 |
| | **Ratio 50 000 A / 5 A; *f* = 50 Hz** | | | | | |
| 120 | 0,5 | -1,0 | 12,7 | 14,5 | 0,0 | -0,1 |
| 100 | 0,6 | -1,1 | 12,7 | 14,5 | 0,0 | -0,1 |
| 20 | 0,3 | -1,0 | 12,7 | 14,5 | 0,0 | -0,1 |
| 5 | 0,2 | -1,1 | 12,7 | 14,5 | 0,0 | -0,1 |
| 1 | 0,0 | -0,5 | 14,1 | 15,4 | 0,0 | 0,0 |
| | **Ratio 5 A / 5 A; *f* = 60 Hz** | | | | | |

| | | | | | | |
|---|---|---|---|---|---|---|
| 120 | -0,1 | 1,5 | 4,1 | 5,0 | 0,0 | 0,3 |
| 100 | -0,1 | 1,5 | 4,1 | 5,0 | 0,0 | 0,3 |
| 20 | -0,2 | 1,4 | 4,1 | 5,0 | 0,0 | 0,3 |
| 5 | -0,2 | 1,3 | 4,1 | 5,0 | 0,0 | 0,3 |
| 1 | -0,3 | 1,0 | 5,4 | 6,4 | 0,0 | 0,1 |
| | **Ratio 1 A / 1 A; *f* = 50 Hz** | | | | | |
| 120 | -0,6 | 0,3 | 5,0 | 6,2 | -0,1 | 0,0 |
| 100 | -0,6 | 0,4 | 5,0 | 6,2 | -0,1 | 0,1 |
| 20 | -0,4 | 0,5 | 5,0 | 6,2 | -0,1 | 0,1 |
| 5 | -0,5 | 0,5 | 5,9 | 7,1 | -0,1 | 0,1 |
| 1 | -0,6 | 0,6 | 7,3 | 8,5 | -0,1 | 0,1 |
| | **Ratio 10 A / 1 A; *f* = 50 Hz** | | | | | |
| 120 | 0,4 | 2,1 | 5,5 | 6,6 | 0,1 | 0,3 |
| 100 | 0,3 | 2,2 | 5,5 | 6,6 | 0,1 | 0,3 |
| 20 | 0,1 | 2,1 | 5,5 | 6,6 | 0,0 | 0,3 |
| 5 | 1,0 | 2,4 | 6,3 | 7,4 | 0,1 | 0,3 |
| 1 | 1,0 | 2,9 | 7,7 | 8,8 | 0,1 | 0,3 |
| | **Ratio 100 A / 1 A; *f* = 50 Hz** | | | | | |
| 120 | 0,5 | 0,3 | 7,2 | 8,3 | 0,1 | 0,0 |
| 100 | 0,6 | 0,3 | 7,2 | 8,3 | 0,1 | 0,0 |
| 20 | 0,5 | 0,4 | 7,2 | 8,3 | 0,1 | 0,1 |
| 5 | 1,4 | 0,9 | 8,1 | 9,2 | 0,2 | 0,1 |
| 1 | 1,4 | 1,4 | 9,5 | 10,6 | 0,1 | 0,1 |
| | **Ratio 500 A / 1 A; *f* = 50 Hz** | | | | | |
| 120 | 1,3 | 2,4 | 8,6 | 9,2 | 0,2 | 0,3 |
| 100 | 1,3 | 2,5 | 8,6 | 9,2 | 0,1 | 0,3 |
| 20 | 0,9 | 2,6 | 8,6 | 9,2 | 0,1 | 0,3 |
| 5 | 1,6 | 2,9 | 9,5 | 10,6 | 0,2 | 0,3 |
| 1 | 1,7 | 3,0 | 11,0 | 11,6 | 0,2 | 0,3 |
| | **Ratio 5 000 A / 1 A; *f* = 50 Hz** | | | | | |
| 120 | 0,3 | -0,8 | 9,5 | 10,6 | 0,0 | -0,1 |
| 100 | 0,4 | -0,8 | 9,5 | 10,6 | 0,0 | -0,1 |
| 20 | -0,1 | -0,8 | 9,5 | 10,6 | 0,0 | -0,1 |
| 5 | 0,7 | -0,5 | 10,8 | 11,8 | 0,1 | 0,0 |

| | | | | | | |
|---|---|---|---|---|---|---|
| 1 | 0,7 | -0,1 | 12,1 | 13,1 | 0,1 | 0,0 |
| | **Ratio 10 000 A / 1 A; *f* = 50 Hz** | | | | | |
| 120 | 0,3 | -2,7 | 9,9 | 11,4 | 0,0 | -0,2 |
| 100 | 0,4 | -2,7 | 9,9 | 11,4 | 0,0 | -0,2 |
| 20 | 0,4 | -2,7 | 9,9 | 11,4 | 0,0 | -0,2 |
| 5 | 1,0 | -2,5 | 11,2 | 12,7 | 0,1 | -0,2 |
| 1 | 1,9 | -2,4 | 12,6 | 14,0 | 0,1 | -0,2 |
| | **Ratio 20 000 A / 1 A; *f* = 50 Hz** | | | | | |
| 120 | 0,3 | -1,9 | 13,0 | 14,5 | 0,0 | -0,1 |
| 100 | 0,3 | -1,9 | 13,0 | 14,5 | 0,0 | -0,1 |
| 20 | 0,3 | -1,5 | 13,0 | 14,5 | 0,0 | -0,1 |
| 5 | 1,0 | -1,6 | 14,4 | 15,8 | 0,1 | -0,1 |
| 1 | 2,3 | -1,7 | 15,8 | 17,2 | 0,1 | -0,1 |
| | **Ratio 50 000 A / 1 A; *f* = 50 Hz** | | | | | |
| 120 | 0,4 | -2,2 | 14,9 | 16,3 | 0,0 | -0,1 |
| 100 | 0,6 | -2,2 | 14,9 | 16,3 | 0,0 | -0,1 |
| 20 | -0,1 | -1,9 | 14,9 | 16,3 | 0,0 | -0,1 |
| 5 | 0,6 | -1,5 | 16,3 | 17,2 | 0,0 | -0,1 |
| 1 | 0,9 | -1,2 | 17,7 | 19,1 | 0,1 | -0,1 |



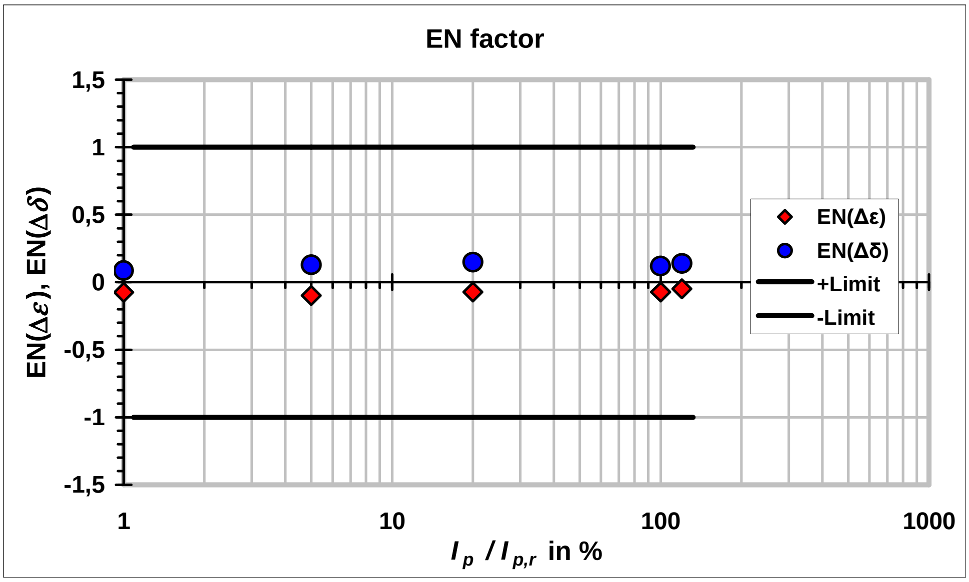
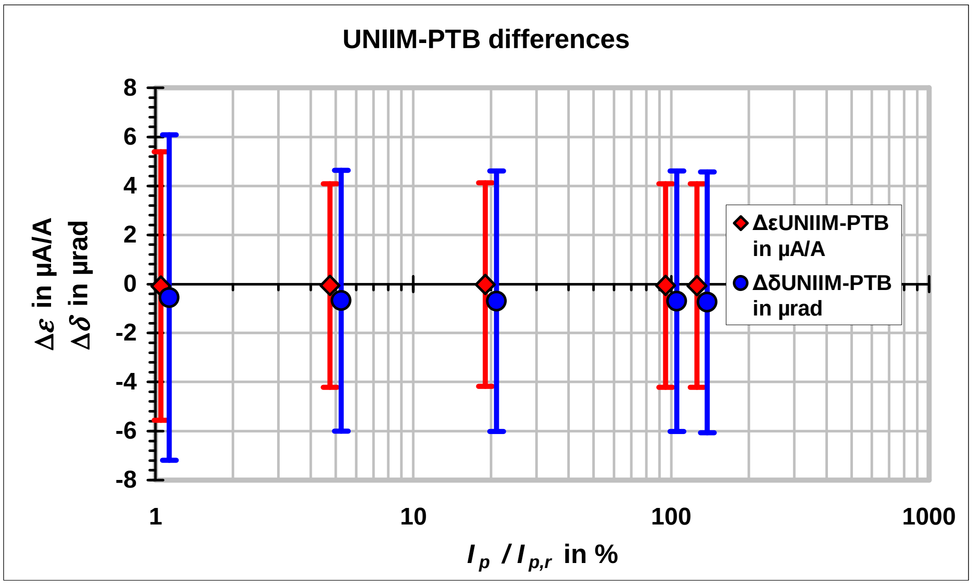




Figure 25: Ratio 5 A / 5 A; $I$ / $I_n$ = 1… 120 %; 50 Hz. Current ratio error differences (Δε) and phase displacement differences (Δδ) between UNIIM and PTB are shown in the upper part of the figure. The bars represent the combined measurement uncertainties ($k$ = 2). The EN factor for the current ratio error difference EN(Δεi) and for the phase displacement difference EN(Δδi) are shown in the lower part of the figure.



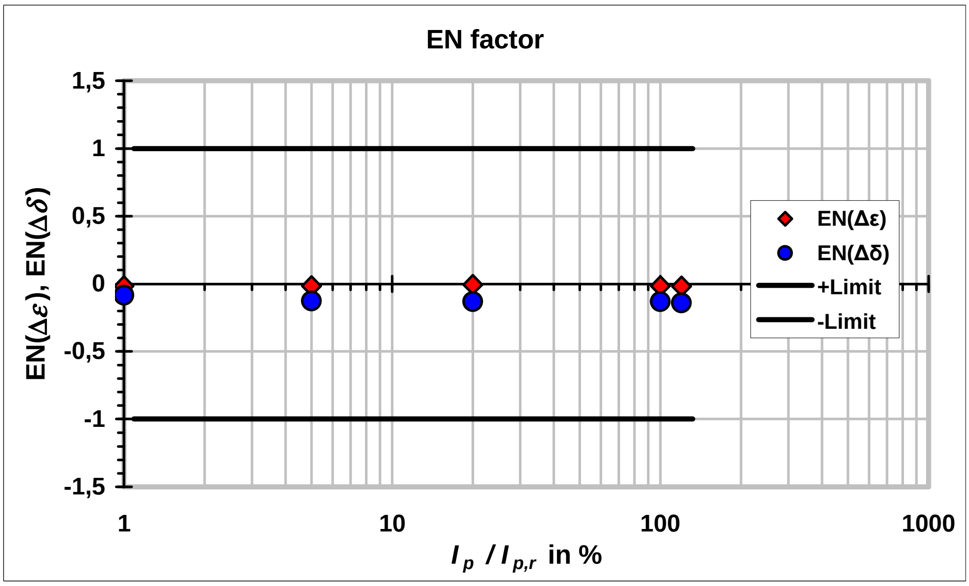
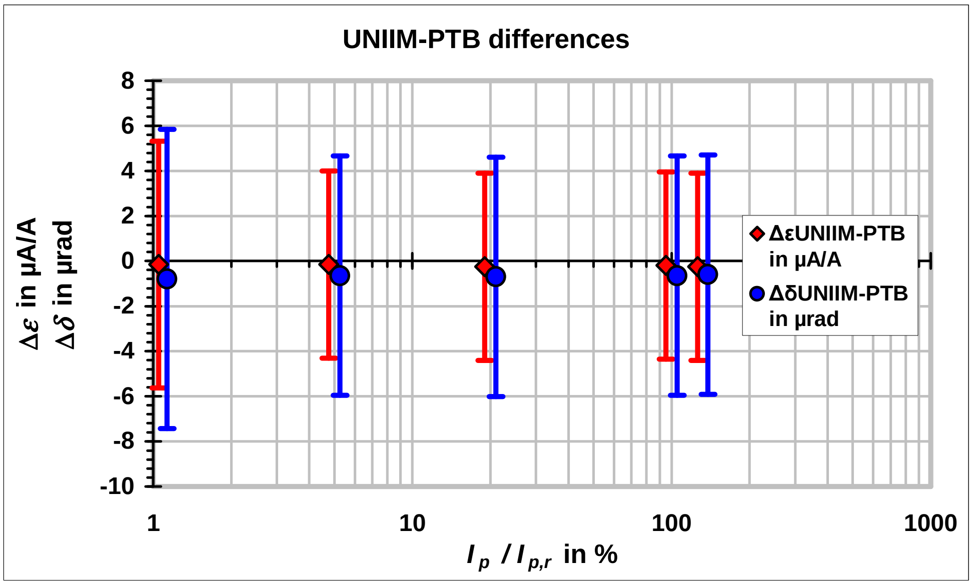




Figure 26: Ratio 20 A / 5 A; $I$ / $I_n$ = 1… 120 %; 50 Hz. Current ratio error differences (Δε) and phase displacement differences (Δδ) between UNIIM and PTB are shown in the upper part of the figure. The bars represent the combined measurement uncertainties ($k$ = 2). The EN factor for the current ratio error difference EN(Δεi) and for the phase displacement difference EN(Δδi) are shown in the lower part of the figure.



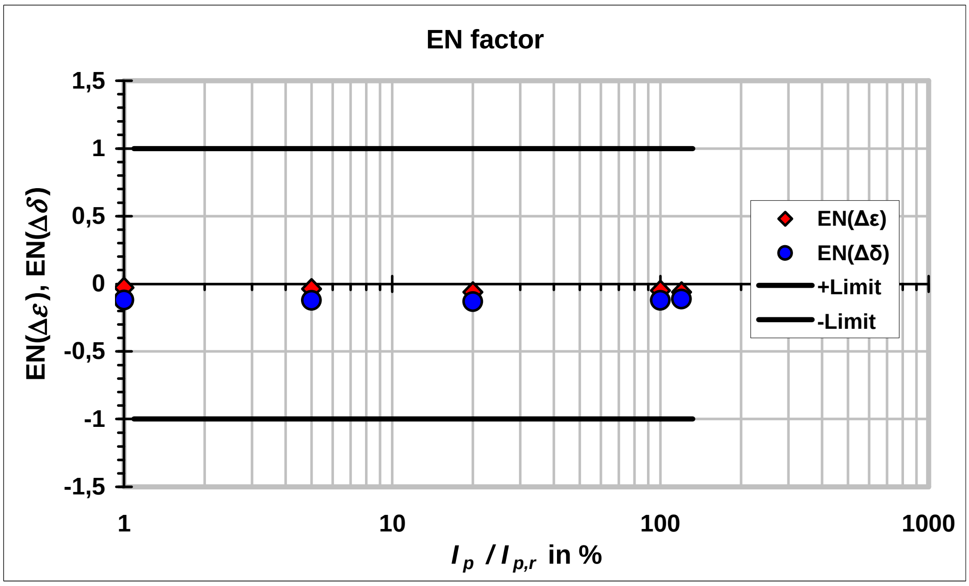
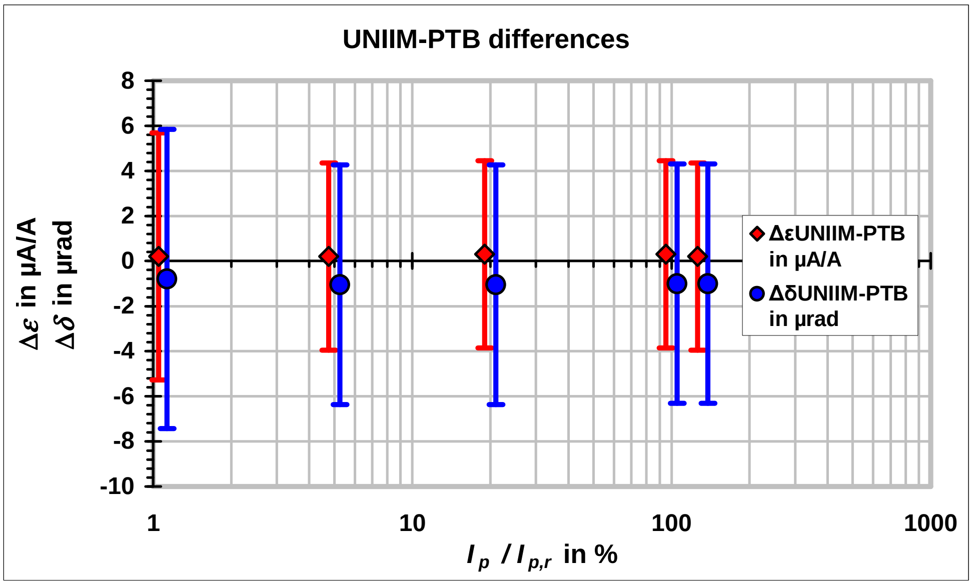




Figure 27: Ratio 50 A / 5 A; $I$ / $I_n$ = 1… 120 %; 50 Hz. Current ratio error differences (Δε) and phase displacement differences (Δδ) between UNIIM and PTB are shown in the upper part of the figure. The bars represent the combined measurement uncertainties ($k$ = 2). The EN factor for the current ratio error difference EN(Δεi) and for the phase displacement difference EN(Δδi) are shown in the lower part of the figure.



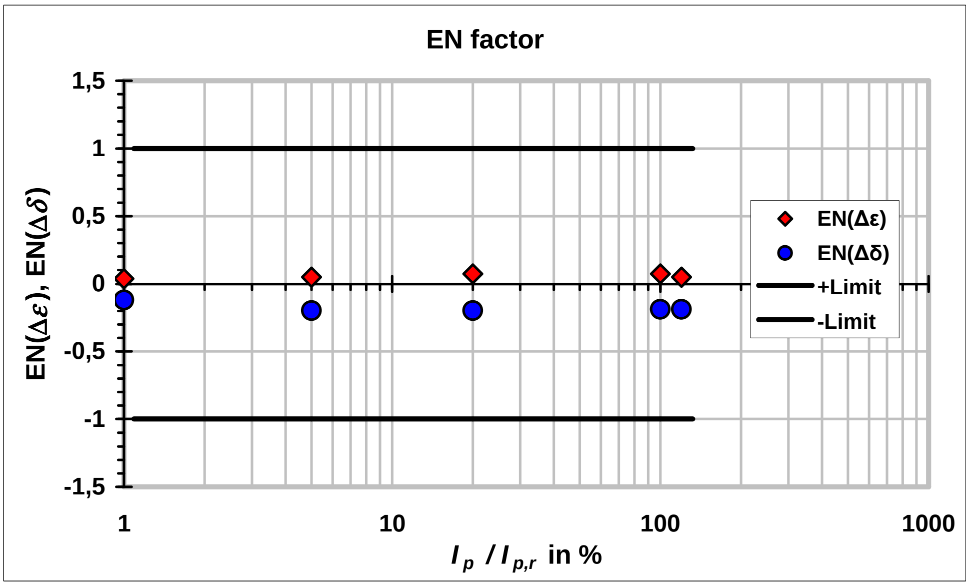
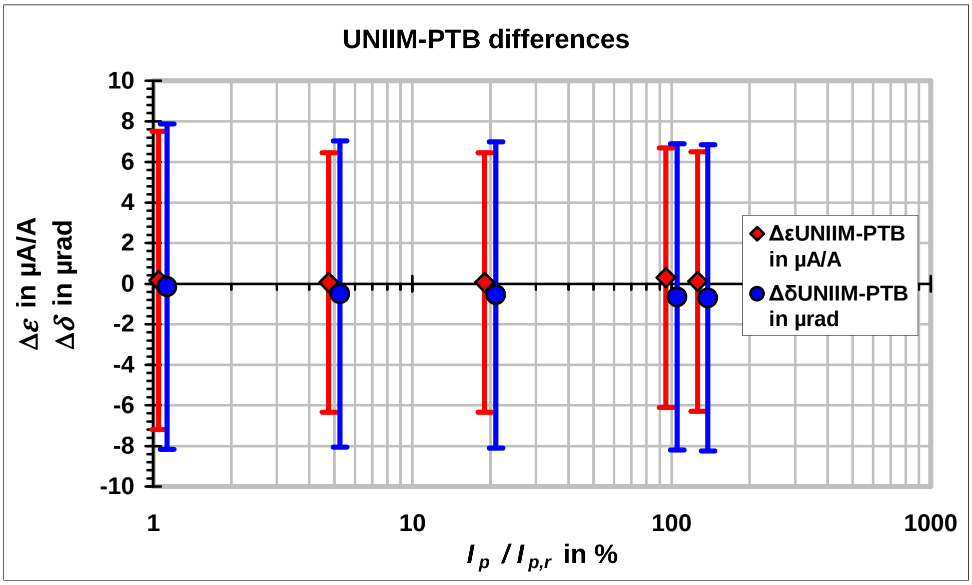




Figure 28: Ratio 100 A / 5 A; $I$ / $I_n$ = 1… 120 %; 50 Hz. Current ratio error differences (Δε) and phase displacement differences (Δδ) between UNIIM and PTB are shown in the upper part of the figure. The bars represent the combined measurement uncertainties ($k$ = 2). The EN factor for the current ratio error difference EN(Δεi) and for the phase displacement difference EN(Δδi) are shown in the lower part of the figure.



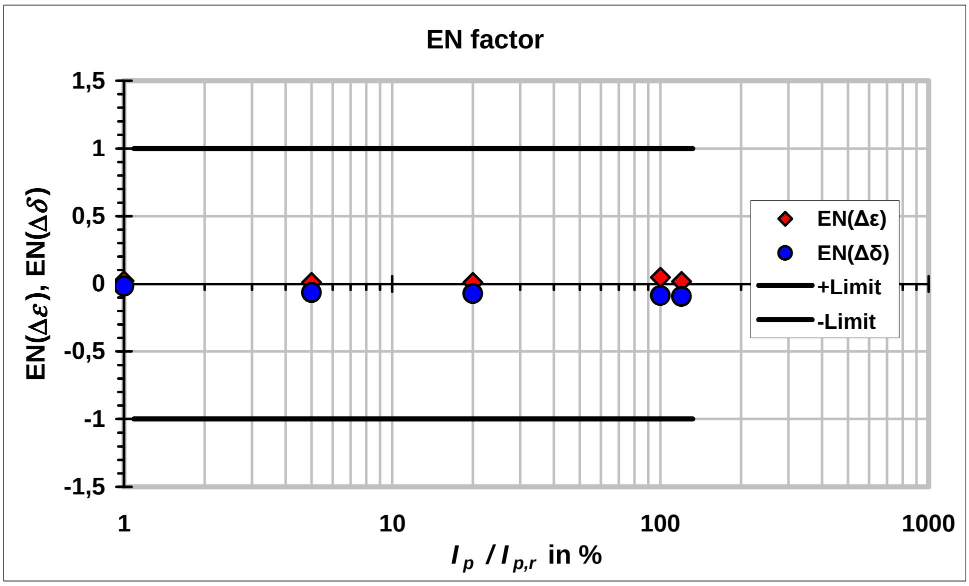




Figure 29: Ratio 500 A / 5 A; $I$ / $I_n$ = 1… 120 %; 50 Hz. Current ratio error differences (Δε) and phase displacement differences (Δδ) between UNIIM and PTB are shown in the upper part of the figure. The bars represent the combined measurement uncertainties ($k$ = 2). The EN factor for the current ratio error difference EN(Δεi) and for the phase displacement difference EN(Δδi) are shown in the lower part of the figure.

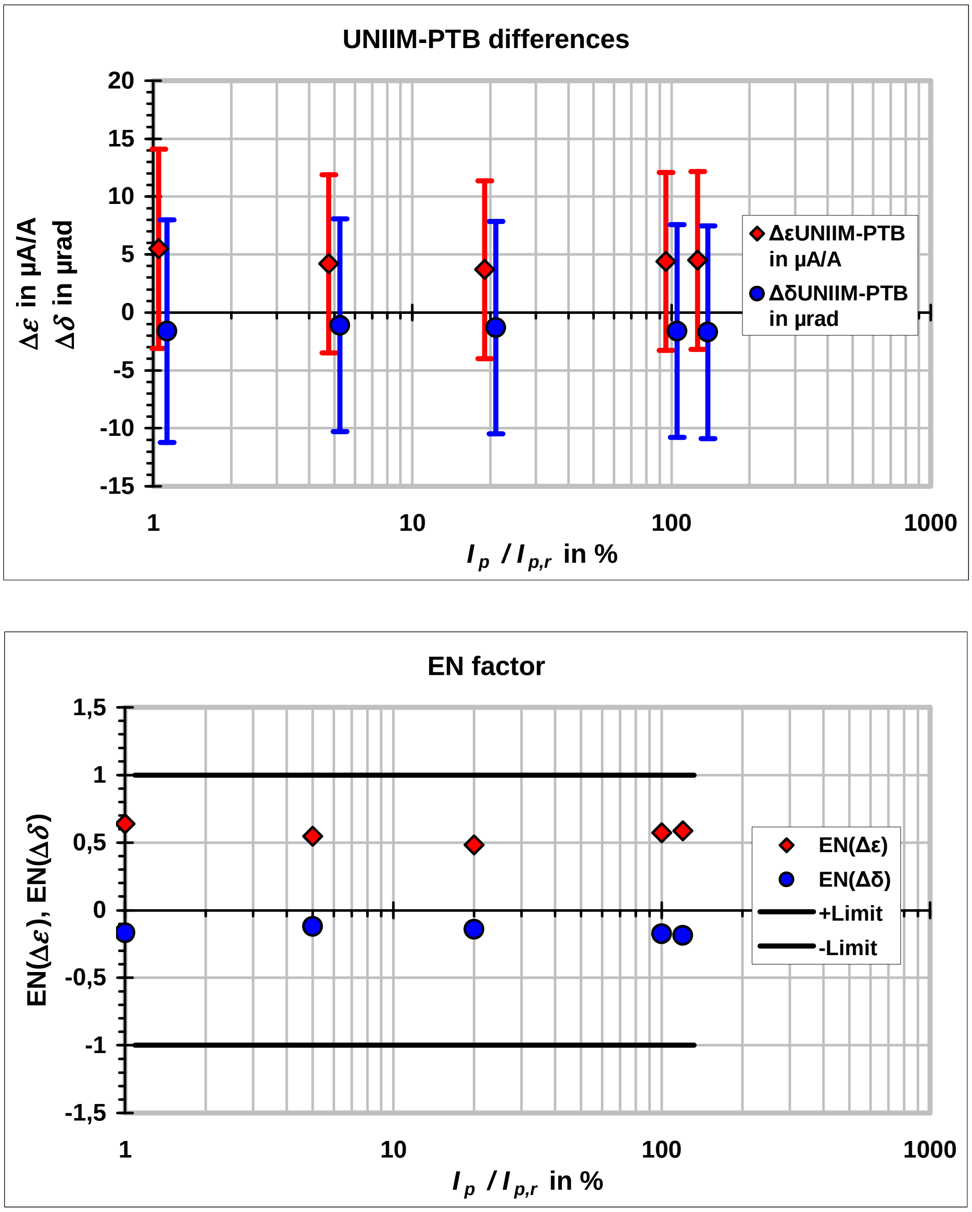



Figure 30: Ratio 1 000 A / 5 A; $I$ / $I_n$ = 1… 120 %; 50 Hz. Current ratio error differences (Δε) and phase displacement differences (Δδ) between UNIIM and PTB are shown in the upper part of the figure. The bars represent the combined measurement uncertainties ($k$ = 2). The EN factor for the current ratio error difference EN(Δεi) and for the phase displacement difference EN(Δδi) are shown in the lower part of the figure.

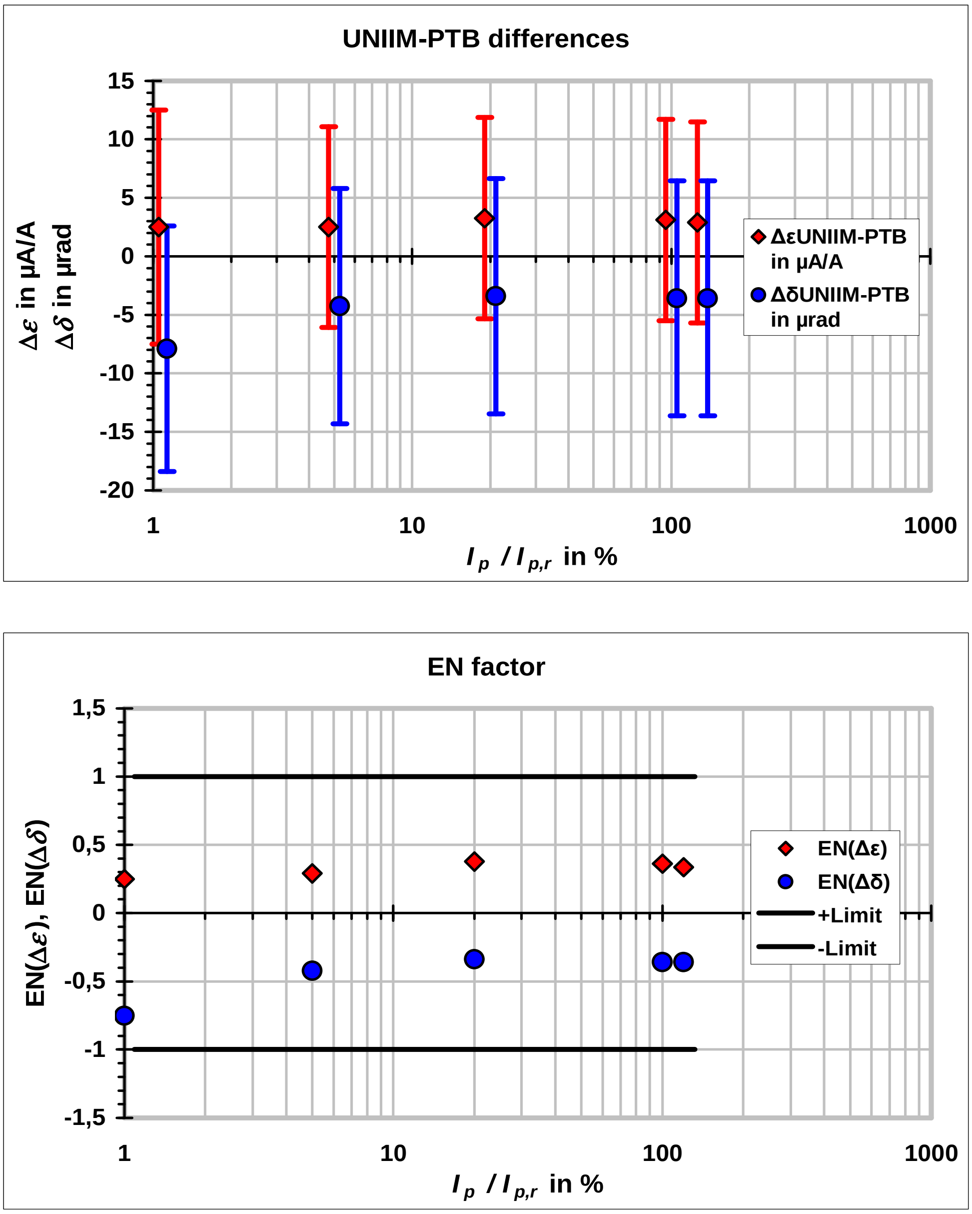
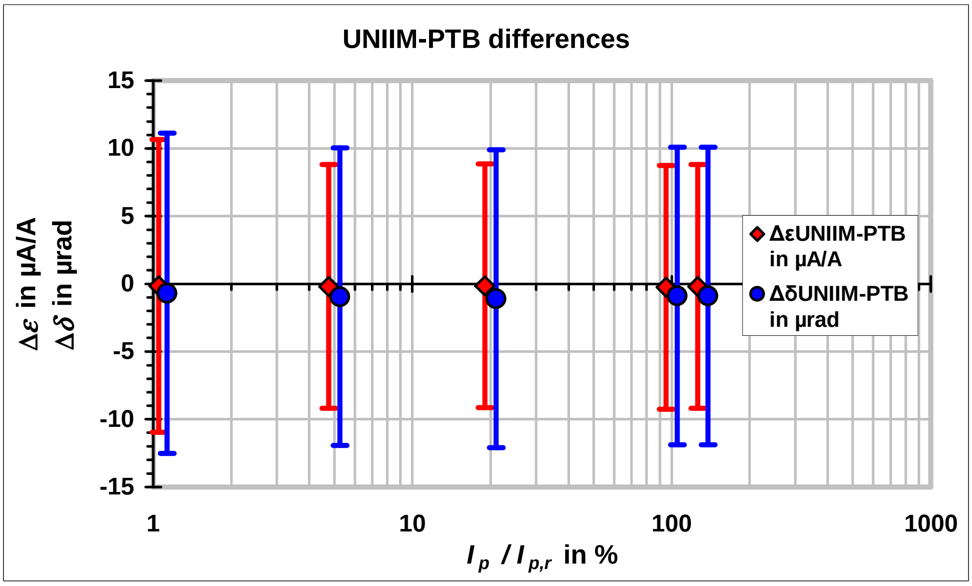



Figure 31: Ratio 3 000 A / 5 A; $I$ / $I_n$ = 1… 120 %; 50 Hz. Current ratio error differences (Δε) and phase displacement differences (Δδ) between UNIIM and PTB are shown in the upper part of the figure. The bars represent the combined measurement uncertainties ($k$ = 2). The EN factor for the current ratio error difference EN(Δεi) and for the phase displacement difference EN(Δδi) are shown in the lower part of the figure.



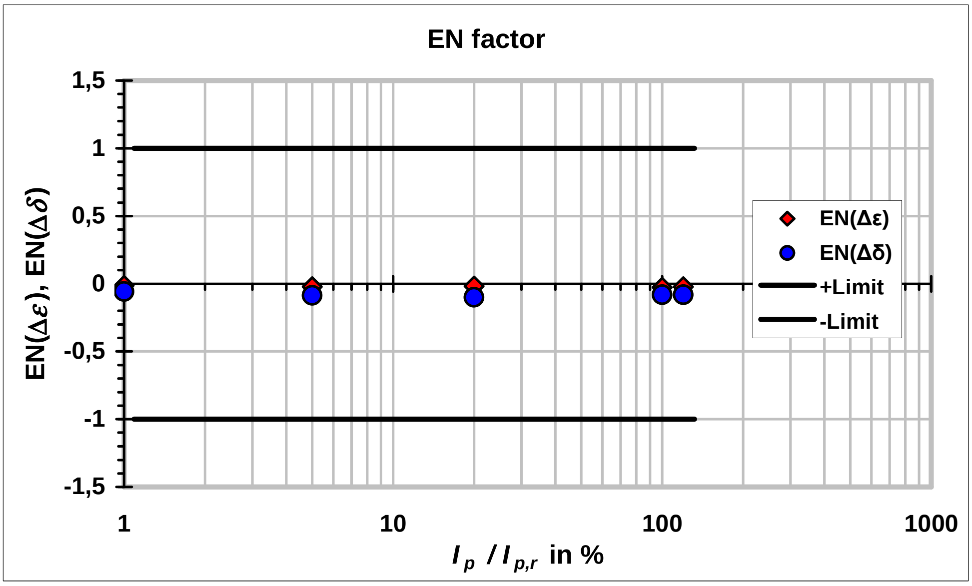
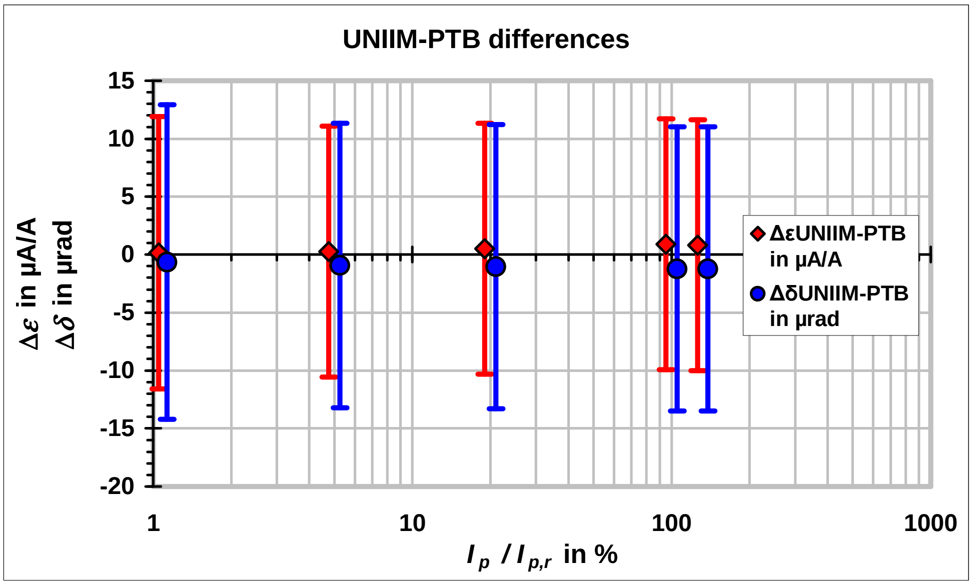




Figure 32: Ratio 10 000 A / 5 A; $I$ / $I_n$ = 1… 120 %; 50 Hz. Current ratio error differences (Δε) and phase displacement differences (Δδ) between UNIIM and PTB are shown in the upper part of the figure. The bars represent the combined measurement uncertainties ($k$ = 2). The EN factor for the current ratio error difference EN(Δεi) and for the phase displacement difference EN(Δδi) are shown in the lower part of the figure.



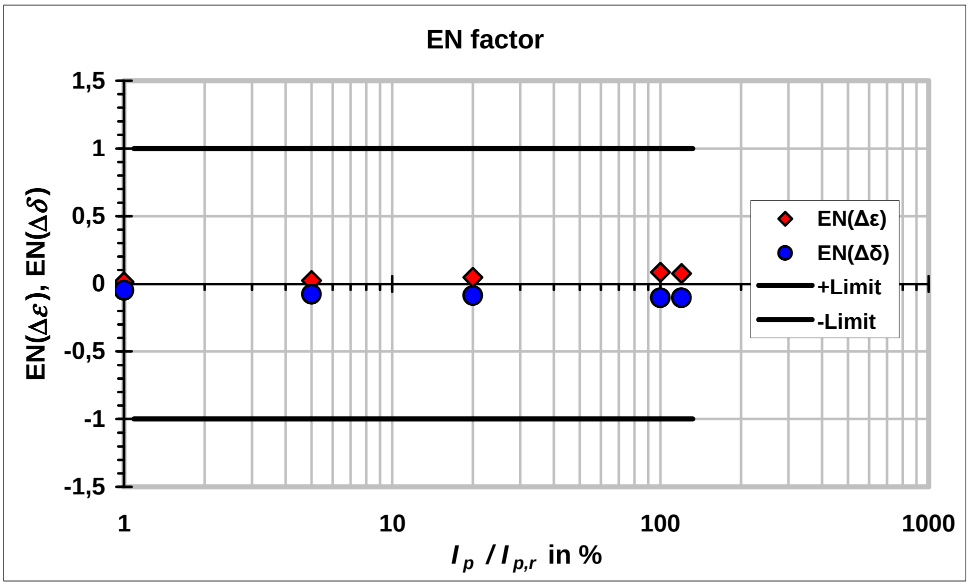
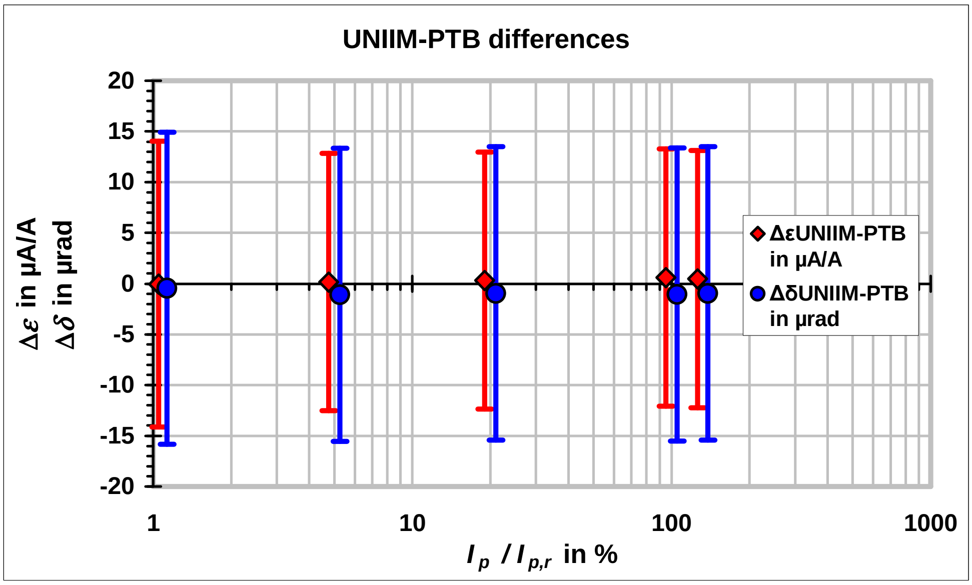




Figure 33: Ratio 30 000 A / 5 A; $I$ / $I_n$ = 1… 120 %; 50 Hz. Current ratio error differences (Δε) and phase displacement differences (Δδ) between UNIIM and PTB are shown in the upper part of the figure. The bars represent the combined measurement uncertainties ($k$ = 2). The EN factor for the current ratio error difference EN(Δεi) and for the phase displacement difference EN(Δδi) are shown in the lower part of the figure.



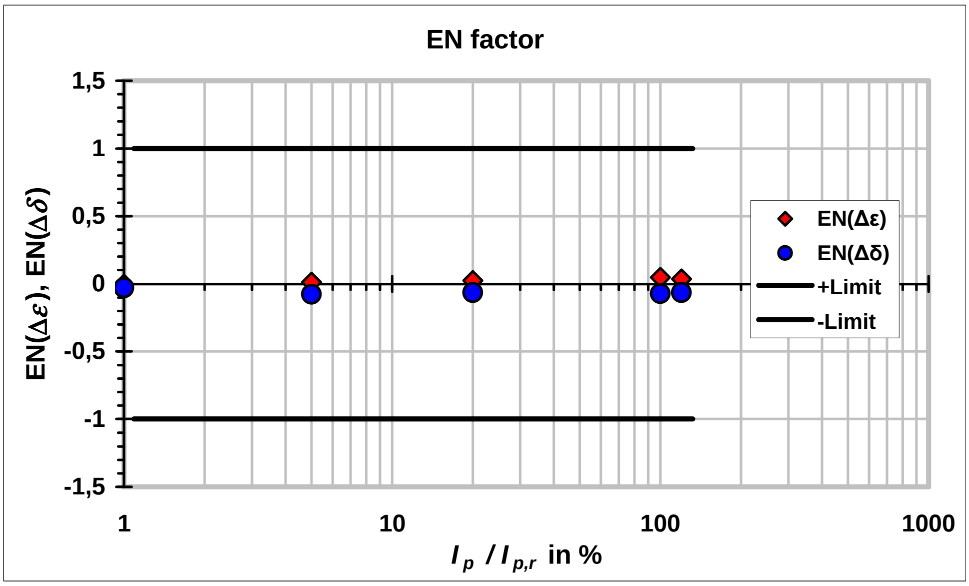
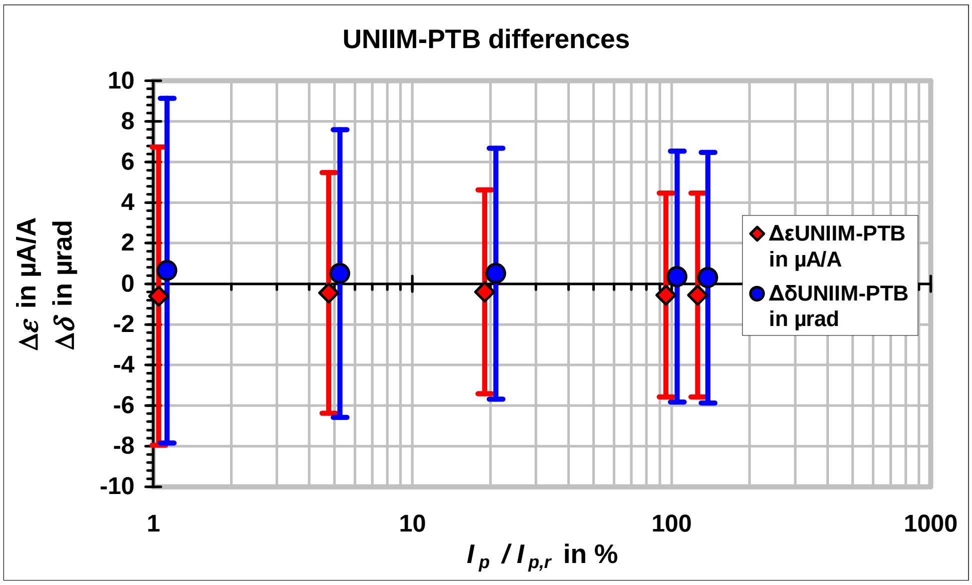




Figure 34: Ratio 50 000 A / 5 A; $I$ / $I_n$ = 1… 120 %; 50 Hz. Current ratio error differences (Δε) and phase displacement differences (Δδ) between UNIIM and PTB are shown in the upper part of the figure. The bars represent the combined measurement uncertainties ($k$ = 2). The EN factor for the current ratio error difference EN(Δεi) and for the phase displacement difference EN(Δδi) are shown in the lower part of the figure.



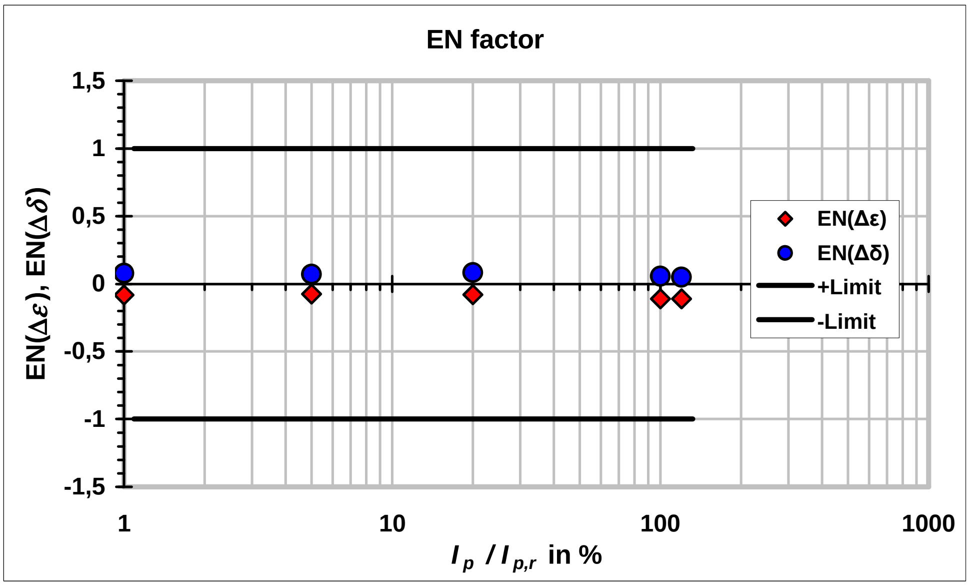




Figure 35: Ratio 1 A / 1 A; $I$ / $I_n$ = 1… 120 %; 50 Hz. Current ratio error differences (Δε) and phase displacement differences (Δδ) between UNIIM and PTB are shown in the upper part of the figure. The bars represent the combined measurement uncertainties ($k$ = 2). The EN factor for the current ratio error difference EN(Δεi) and for the phase displacement difference EN(Δδi) are shown in the lower part of the figure.

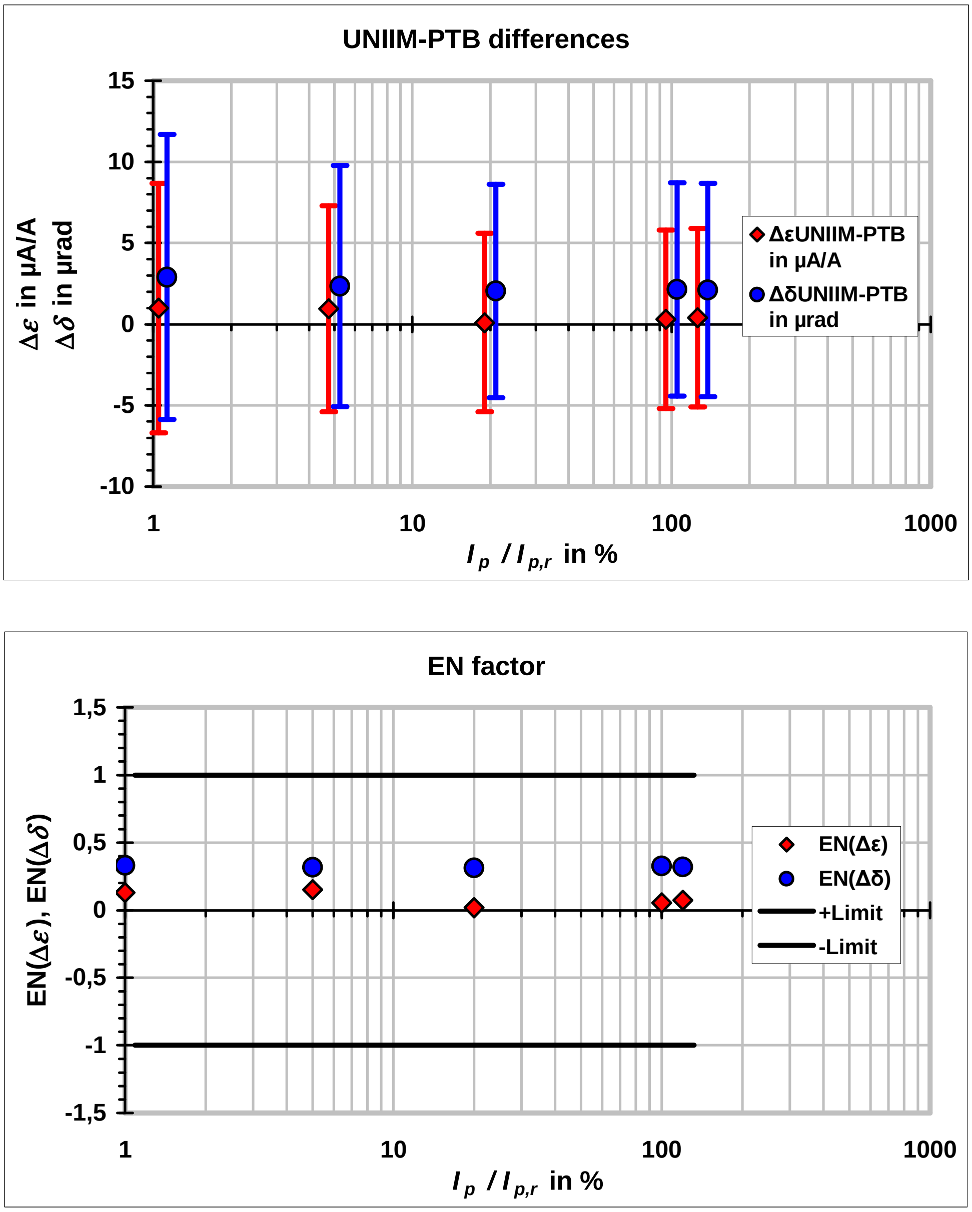
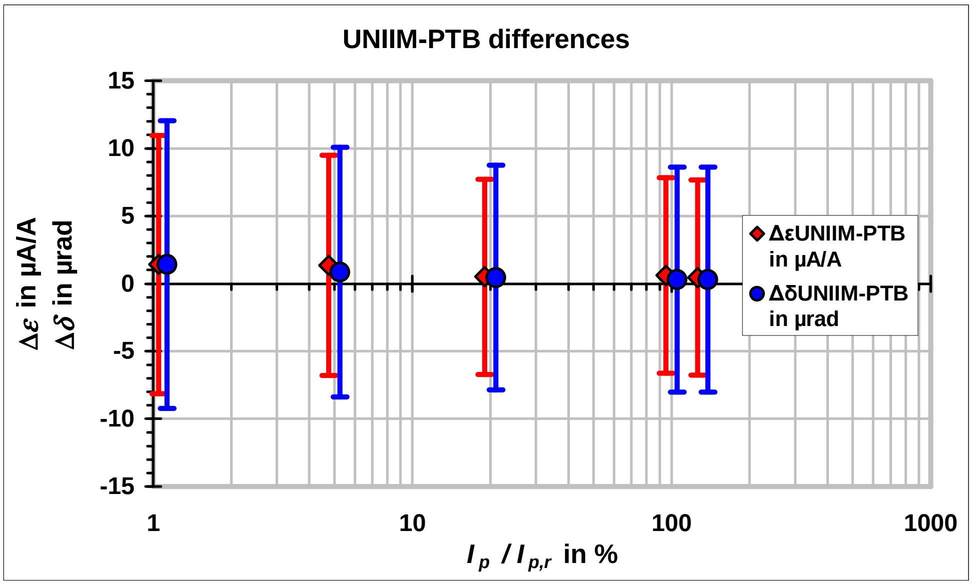



Figure 36: Ratio 10 A / 1 A; $I$ / $I_n$ = 1… 120 %; 50 Hz. Current ratio error differences (Δε) and phase displacement differences (Δδ) between UNIIM and PTB are shown in the upper part of the figure. The bars represent the combined measurement uncertainties ($k$ = 2). The EN factor for the current ratio error difference EN(Δεi) and for the phase displacement difference EN(Δδi) are shown in the lower part of the figure.



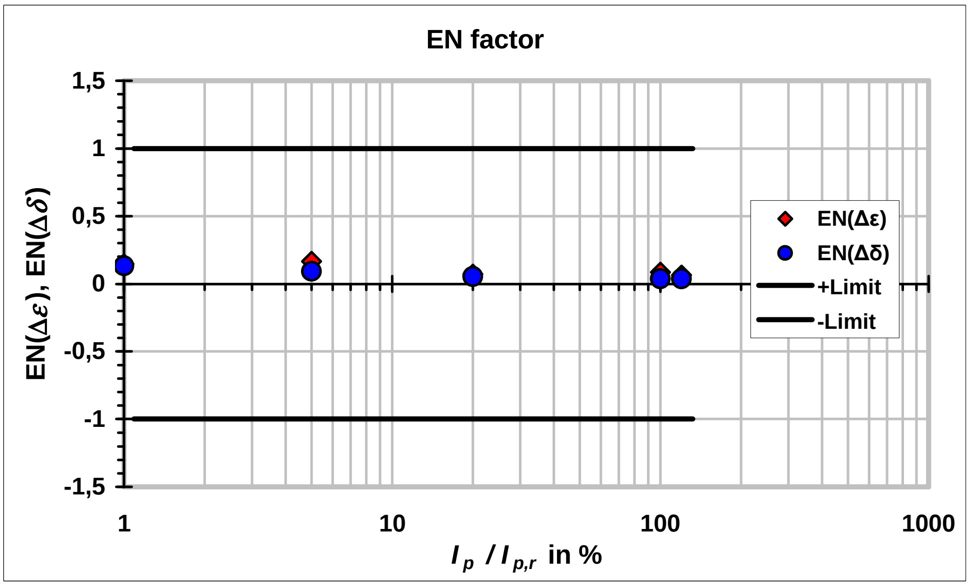
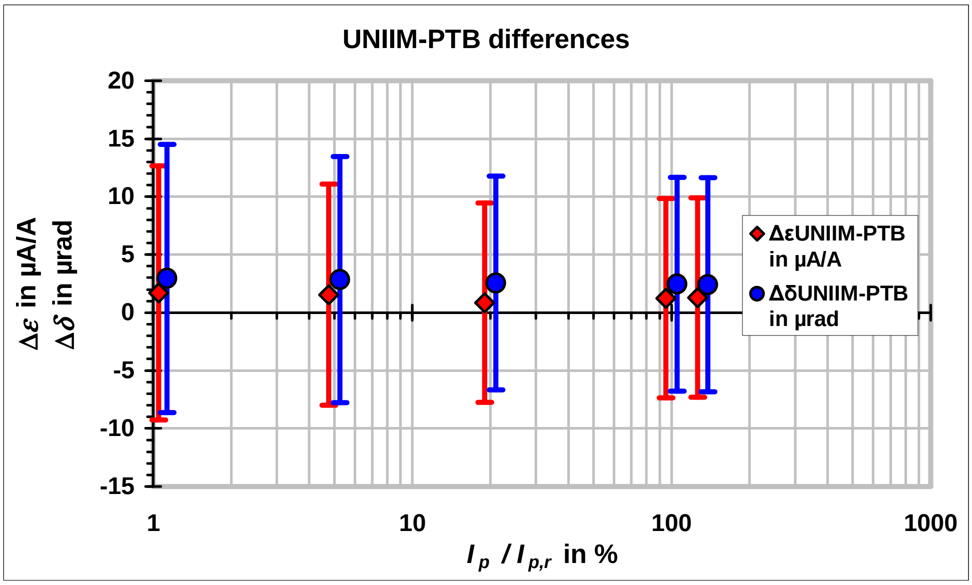




Figure 37: Ratio 100 A / 1 A; $I$ / $I_n$ = 1… 120 %; 50 Hz. Current ratio error differences (Δε) and phase displacement differences (Δδ) between UNIIM and PTB are shown in the upper part of the figure. The bars represent the combined measurement uncertainties ($k$ = 2). The EN factor for the current ratio error difference EN(Δεi) and for the phase displacement difference EN(Δδi) are shown in the lower part of the figure.



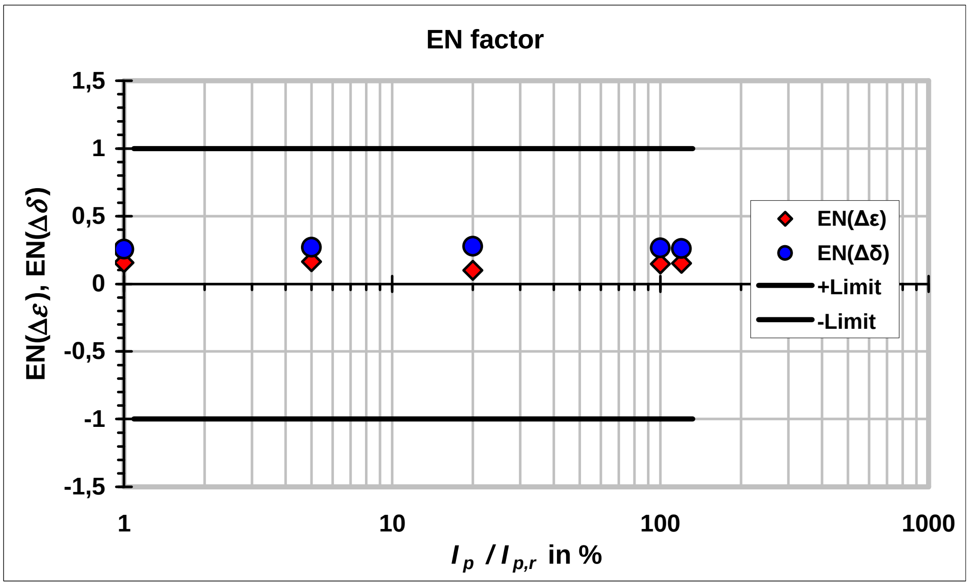




Figure 38: Ratio 500 A / 1 A; $I$ / $I_n$ = 1… 120 %; 50 Hz. Current ratio error differences (Δε) and phase displacement differences (Δδ) between UNIIM and PTB are shown in the upper part of the figure. The bars represent the combined measurement uncertainties ($k$ = 2). The EN factor for the current ratio error difference EN(Δεi) and for the phase displacement difference EN(Δδi) are shown in the lower part of the figure.

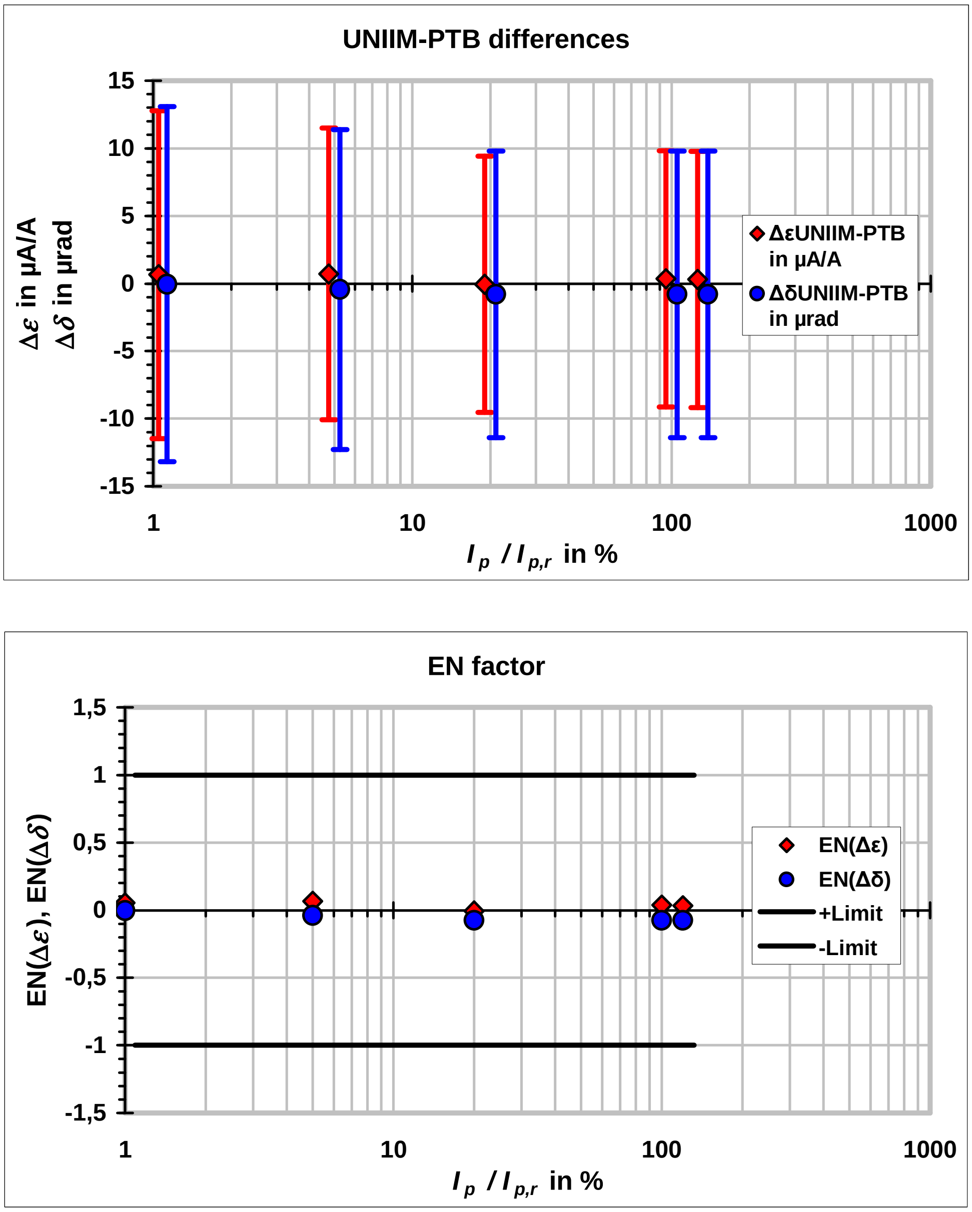
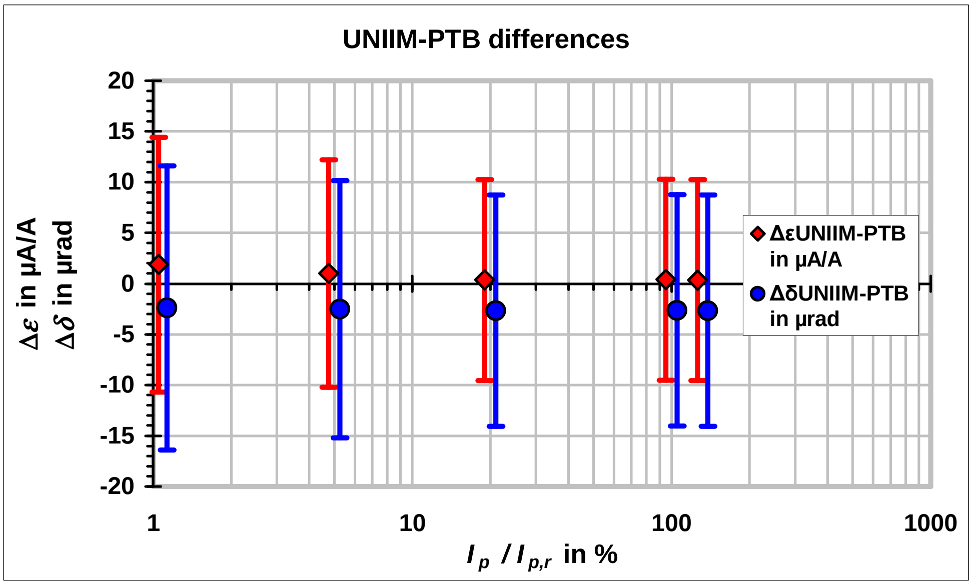



Figure 39: Ratio 5 000 A / 1 A; $I$ / $I_n$ = 1… 120 %; 50 Hz. Current ratio error differences (Δε) and phase displacement differences (Δδ) between UNIIM and PTB are shown in the upper part of the figure. The bars represent the combined measurement uncertainties ($k$ = 2). The EN factor for the current ratio error difference EN(Δεi) and for the phase displacement difference EN(Δδi) are shown in the lower part of the figure.



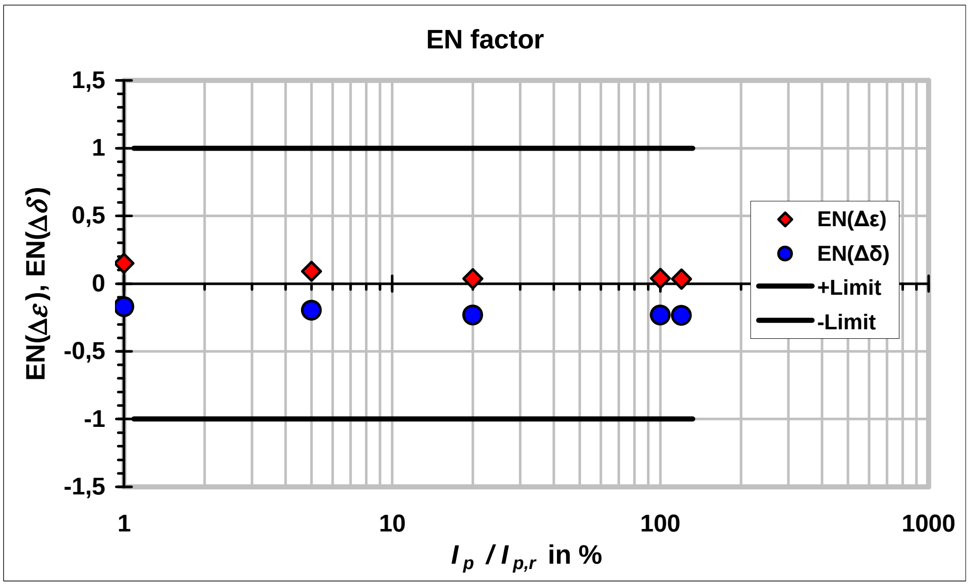
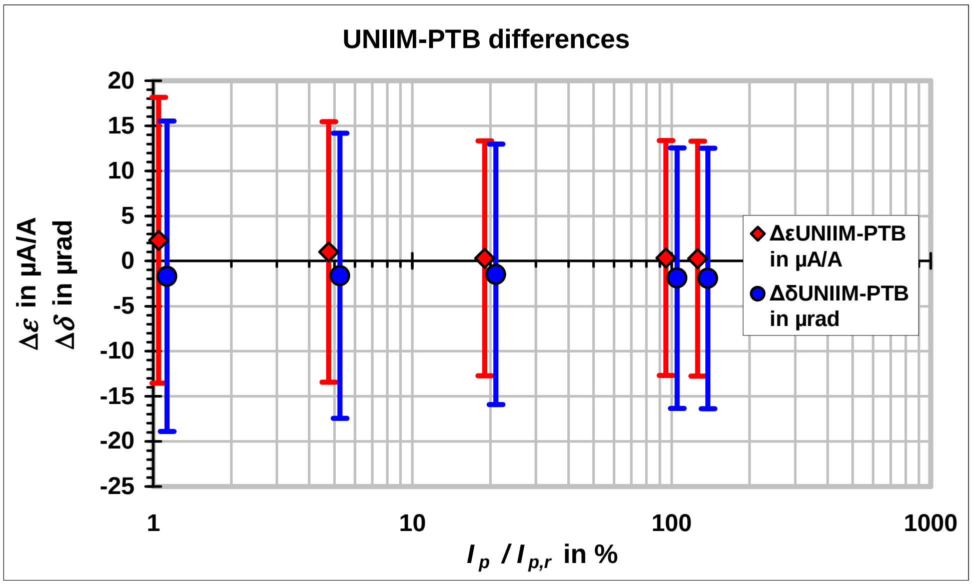




Figure 40: Ratio 10 000 A / 1 A; $I$ / $I_n$ = 1… 120 %; 50 Hz. Current ratio error differences (Δε) and phase displacement differences (Δδ) between UNIIM and PTB are shown in the upper part of the figure. The bars represent the combined measurement uncertainties ($k$ = 2). The EN factor for the current ratio error difference EN(Δεi) and for the phase displacement difference EN(Δδi) are shown in the lower part of the figure.



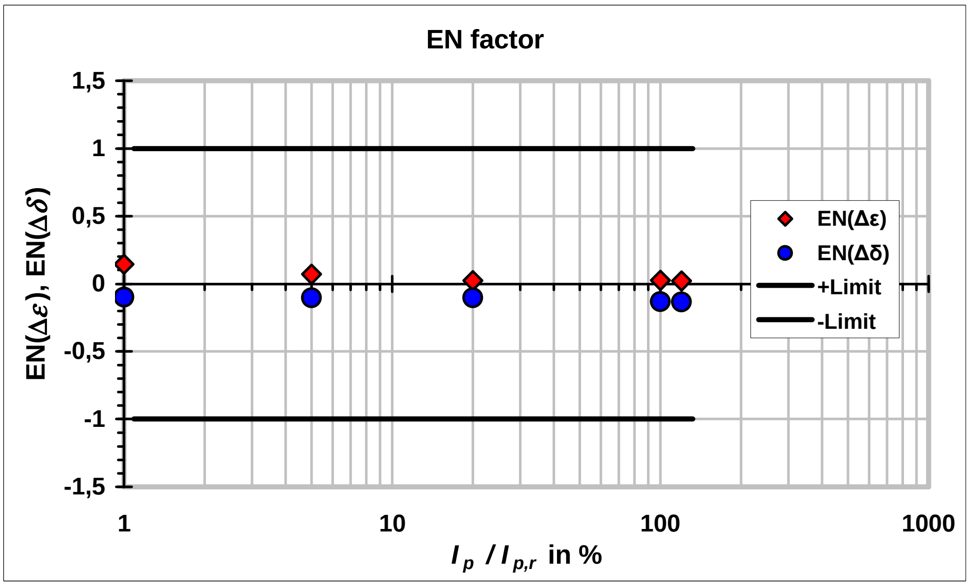
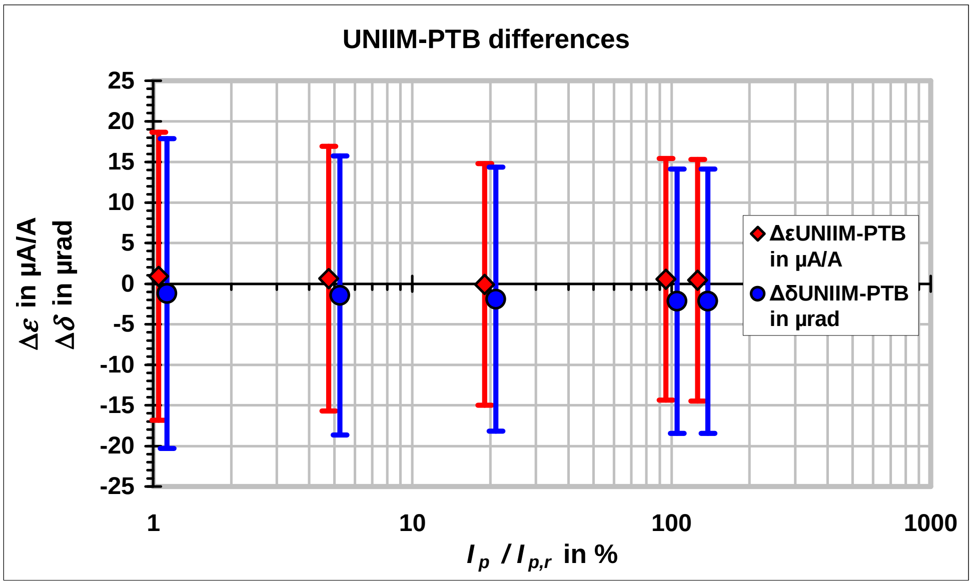




Figure 41: Ratio 20 000 A / 1 A; $I$ / $I_n$ = 1… 120 %; 50 Hz. Current ratio error differences (Δε) and phase displacement differences (Δδ) between UNIIM and PTB are shown in the upper part of the figure. The bars represent the combined measurement uncertainties ($k$ = 2). The EN factor for the current ratio error difference EN(Δεi) and for the phase displacement difference EN(Δδi) are shown in the lower part of the figure.



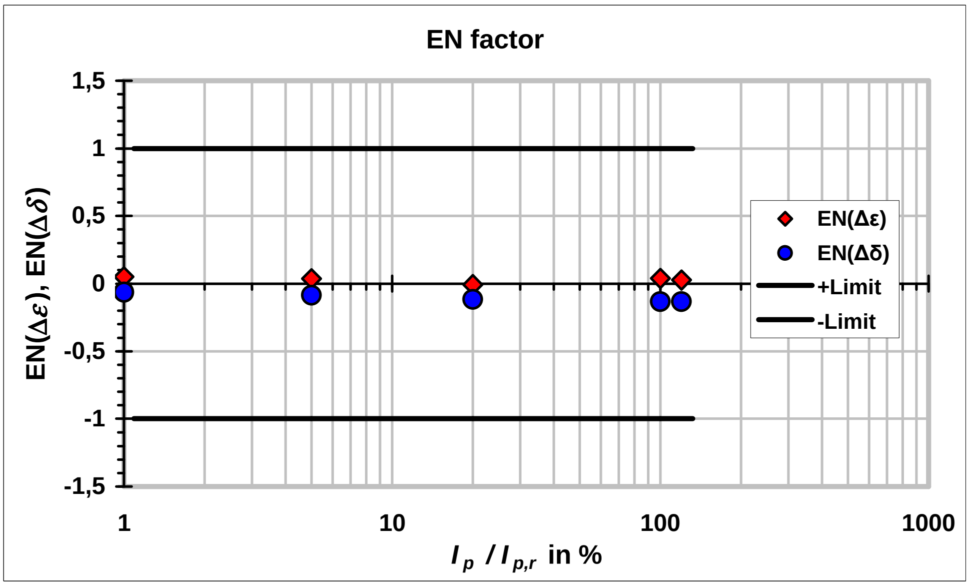




Figure 42: Ratio 50 000 A / 1 A; $I$ / $I_n$ = 1… 120 %; 50 Hz. Current ratio error differences (Δε) and phase displacement differences (Δδ) between UNIIM and PTB are shown in the upper part of the figure. The bars represent the combined measurement uncertainties ($k$ = 2). The EN factor for the current ratio error difference EN(Δεi) and for the phase displacement difference EN(Δδi) are shown in the lower part of the figure.

## CONCLUSIONS

For all of the current ratio error measurements and the phase displacement measurements there is a close agreement between PTB (Germany) and UNIIM (Russia). Extensive measurements with the travelling standards were carried out at 18 different current ratios and at 5 different test points (1 %; 5 %; 20 %, 100 % and 120 %) each. The range of tested primary currents was from 10 mA to 60 kA. It can therefore be concluded that the results of each laboratory agree very well within the calculated measurement uncertainties. No outliers were observed. Considering especially the EN factors, the calculated uncertainties seem to be too conservative to some extent. Here there is the possibility to slightly improve the uncertainty budgets in the future if there is a need.

The worst EN factors are within ± 0.6 at 1 kA / 5 A (see Figure 30), or ± 0.8 at 3 kA (see Figure 31). The current comparator "IW 32" from PTB may have caused that. This was subsequently confirmed. The primary current induced a small voltage in the compensation winding. This problem has now been solved.

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# 10 APPENDIX

## 10.1 UNCERTAINTY BUDGETS OF PTB

**Table 4: PTB uncertainty budget for the current ratio error and the phase displacement for rated primary currents from 5 A to 500 A. The secondary current is 5 A. The test points vary from 1 % to 120 % and the frequency is 50 Hz or 60 Hz.**

| **uncertainty budget**<br>**50/60 Hz; (5A - 500A) / 5A; $I_p / I_{p,r}$ = 1%... 120%** | | **PTB Braunschweig**<br>**working group 2.35 "Instrument transformer"** | | |
|---|---|---|---|---|
| | | **current ratio error $\varepsilon_x$** | | |
| **quantity $x_i$** | **limits in µA / A** | **type** | **distribution** | **standard uncertainty $u(x_i)$** |
| $s(\varepsilon_{Bridge})$ (SEKAM II; $n$ = 10) | 2 | A | normal | 0,37 |
| $\varepsilon_{Bridge}$ (SEKAM II) | 0,5 | B | normal | 0,25 |
| $\varepsilon_{N1}$ (standard CT1 - IW33) | 0 | B | normal | 0,00 |
| $\varepsilon_{N2}$ (standard CT2 - IW51) | 0,5 | B | normal | 0,25 |
| $\varepsilon_{N3}$ (standard CT3 - ZW51) | 0 | B | normal | 0,00 |
| $\varepsilon_B$ (influence of burden) | 0,2 | B | rectangular | 0,12 |
| $\varepsilon_F$ (influence of frequency) | 0,5 | B | rectangular | 0,29 |
| $\varepsilon_{Circuit}$ (influence of circuit configuration) | 1 | B | rectangular | 0,58 |
| | | | **standard uncertainty $u(\varepsilon_x)$ =** | **0,83 µA / A** |
| | | | **round off - expanded measurement uncertainty ($k$ = 2) $U_{PTB}(\varepsilon_x)$ =** | **2,0 µA / A** |
| | | | | |
| | | **phase displacement $\delta_x$** | | |
| **quantity $x_i$** | **limits in µrad** | **type** | **distribution** | **standard uncertainty $u(x_i)$** |
| $s(\delta_{Bridge})$ (SEKAM II; $n$ = 10) | 2 | A | normal | 0,37 |
| $\delta_{Bridge}$ (SEKAM II) | 0,5 | B | normal | 0,25 |
| $\delta_{N1}$ (standard CT1 - IW33) | 0 | B | normal | 0,00 |
| $\delta_{N2}$ (standard CT2 - IW51) | 0,7 | B | normal | 0,35 |
| $\delta_{N3}$ (standard CT3 - ZW51) | 0 | B | normal | 0,00 |
| $\delta_B$ (influence of burden) | 0,3 | B | rectangular | 0,17 |
| $\delta_F$ (influence of frequency) | 0,5 | B | rectangular | 0,29 |
| $\delta_{Circuit}$ (influence of circuit configuration) | 1 | B | rectangular | 0,58 |
| | | | **standard uncertainty $u(\delta_x)$ =** | **0,88 µA / A** |
| | | | **round off - expanded measurement uncertainty ($k$ = 2) $U_{PTB}(\delta_x)$ =** | **2,0 µA / A** |

**Table 5: PTB uncertainty budget for the current ratio error and the phase displacement for rated primary currents from 5 A to 500 A. The secondary current is 1 A. The test points vary from 1 % to 120 % and the frequency is 50 Hz or 60 Hz.**

| **uncertainty budget**<br>**50/60 Hz; (5A - 500A) / 1A; Ip / Ip,r = 1%... 120%** | | **PTB Braunschweig**<br>**working group 2.35 "Instrument transformer"** | | |
|---|---|---|---|---|
| **current ratio error $\varepsilon_x$** | | | | |
| **quantity $x_i$** | **limits in µA / A** | **type** | **distribution** | **standard uncertainty $u(x_i)$** |
| $s(\varepsilon_{Bridge})$ (SEKAM II; $n$ = 10) | 2 | A | normal | 0,37 |
| $\varepsilon_{Bridge}$ (SEKAM II) | 0,5 | B | normal | 0,25 |
| $\varepsilon_{N1}$ (standard CT1 - IW33) | 0 | B | normal | 0,00 |
| $\varepsilon_{N2}$ (standard CT2 - IW51) | 0,5 | B | normal | 0,25 |
| $\varepsilon_{N3}$ (standard CT3 - ZW51) | 0,5 | B | normal | 0,25 |
| $\varepsilon_B$ (influence of burden) | 0,2 | B | rectangular | 0,12 |
| $\varepsilon_F$ (influence of frequency) | 0,5 | B | rectangular | 0,29 |
| $\varepsilon_{Circuit}$ (influence of circuit configuration) | 1,5 | B | rectangular | 0,87 |
| | | | **standard uncertainty $u(\varepsilon_x)$ =** | **1,08 µA / A** |
| | | | **round off - expanded measurement uncertainty ($k$ = 2) $U_{PTB}(\varepsilon_x)$ =** | **3,0 µA / A** |
| | | | | |
| **phase displacement $\delta_x$** | | | | |
| **quantity $x_i$** | **limits in µrad** | **type** | **distribution** | **standard uncertainty $u(x_i)$** |
| $s(\delta_{Bridge})$ (SEKAM II; $n$ = 10) | 2 | A | normal | 0,37 |
| $\delta_{Bridge}$ (SEKAM II) | 0,5 | B | normal | 0,25 |
| $\delta_{N1}$ (standard CT1 - IW33) | 0 | B | normal | 0,00 |
| $\delta_{N2}$ (standard CT2 - IW51) | 0,7 | B | normal | 0,35 |
| $\delta_{N3}$ (standard CT3 - ZW51) | 0,7 | B | normal | 0,35 |
| $\delta_B$ (influence of burden) | 0,3 | B | rectangular | 0,17 |
| $\delta_F$ (influence of frequency) | 0,5 | B | rectangular | 0,29 |
| $\delta_{Circuit}$ (influence of circuit configuration) | 1,5 | B | rectangular | 0,87 |
| | | | **standard uncertainty $u(\delta_x)$ =** | **1,14 µA / A** |
| | | | **round off - expanded measurement uncertainty ($k$ = 2) $U_{PTB}(\delta_x)$ =** | **3,0 µA / A** |

**Table 6: PTB uncertainty budget for the current ratio error and the phase displacement for rated primary currents from 500 A to 3 kA. The secondary current is 5 A. The test points vary from 1 % to 120 % and the frequency is 50 Hz or 60 Hz.**

| **uncertainty budget**<br>**50/60 Hz; (500A - 3kA) / 5A; Ip / Ip,r = 1%... 120%** | | **PTB Braunschweig**<br>**working group 2.35 "Instrument transformer"** | | |
|---|---|---|---|---|
| **current ratio error $\varepsilon_x$** | | | | |
| **quantity $x_i$** | **limits in µA / A** | **type** | **distribution** | **standard uncertainty $u(x_i)$** |
| $s(\varepsilon_{Bridge})$ (SEKAM II; $n$ = 10) | 2 | A | normal | 0,37 |
| $\varepsilon_{Bridge}$ (SEKAM II) | 0,5 | B | normal | 0,25 |
| $\varepsilon_{N1}$ (standard CT1 - IW33) | 0 | B | normal | 0,00 |
| $\varepsilon_{N2}$ (standard CT2 - IW32) | 2 | B | normal | 1,00 |
| $\varepsilon_{N3}$ (standard CT3 - ZW51) | 0 | B | normal | 0,00 |
| $\varepsilon_B$ (influence of burden) | 0,2 | B | rectangular | 0,12 |
| $\varepsilon_F$ (influence of frequency) | 0,5 | B | rectangular | 0,29 |
| $\varepsilon_{Circuit}$ (influence of circuit configuration) | 1 | B | rectangular | 0,58 |
| | | | **standard uncertainty $u(\varepsilon_x)$ =** | **1,28 µA / A** |
| | | | **round off - expanded measurement uncertainty ($k$ = 2) $U_{PTB}(\varepsilon_x)$ =** | **3,0 µA / A** |
| | | | | |
| **phase displacement $\delta_x$** | | | | |
| **quantity $x_i$** | **limits in µrad** | **type** | **distribution** | **standard uncertainty $u(x_i)$** |
| $s(\delta_{Bridge})$ (SEKAM II; $n$ = 10) | 2 | A | normal | 0,37 |
| $\delta_{Bridge}$ (SEKAM II) | 0,5 | B | normal | 0,25 |
| $\delta_{N1}$ (standard CT1 - IW33) | 0 | B | normal | 0,00 |
| $\delta_{N2}$ (standard CT2 - IW32) | 3 | B | normal | 1,50 |
| $\delta_{N3}$ (standard CT3 - ZW51) | 0 | B | normal | 0,00 |
| $\delta_B$ (influence of burden) | 0,3 | B | rectangular | 0,17 |
| $\delta_F$ (influence of frequency) | 0,5 | B | rectangular | 0,29 |
| $\delta_{Circuit}$ (influence of circuit configuration) | 1 | B | rectangular | 0,58 |
| | | | **standard uncertainty $u(\delta_x)$ =** | **1,70 µA / A** |
| | | | **round off - expanded measurement uncertainty ($k$ = 2) $U_{PTB}(\delta_x)$ =** | **4,0 µA / A** |

**Table 7: PTB uncertainty budget for the current ratio error and the phase displacement for rated primary currents from 500 A to 3 kA. The secondary current is 1 A. The test points vary from 1 % to 120 % and the frequency is 50 Hz or 60 Hz.**

| **uncertainty budget**<br>**50/60 Hz; (500A - 3kA) / 1A; Ip / Ip,r = 1%... 120%** | | **PTB Braunschweig**<br>**working group 2.35 "Instrument transformer"** | | |
|---|---|---|---|---|
| | | **current ratio error $\varepsilon_x$** | | |
| **quantity $x_i$** | **limits in µA / A** | **type** | **distribution** | **standard uncertainty $u(x_i)$** |
| $s(\varepsilon_{Bridge})$ (SEKAM II; $n$ = 10) | 2 | A | normal | 0,37 |
| $\varepsilon_{Bridge}$ (SEKAM II) | 0,5 | B | normal | 0,25 |
| $\varepsilon_{N1}$ (standard CT1 - IW33) | 0 | B | normal | 0,00 |
| $\varepsilon_{N2}$ (standard CT2 - IW32) | 2 | B | normal | 1,00 |
| $\varepsilon_{N3}$ (standard CT3 - ZW51) | 0,5 | B | normal | 0,25 |
| $\varepsilon_B$ (influence of burden) | 0,2 | B | rectangular | 0,12 |
| $\varepsilon_F$ (influence of frequency) | 0,5 | B | rectangular | 0,29 |
| $\varepsilon_{Circuit}$ (influence of circuit configuration) | 1,5 | B | rectangular | 0,87 |
| | | | **standard uncertainty $u(\varepsilon_x)$ =** | **1,45 µA / A** |
| | | | **round off - expanded measurement uncertainty ($k$ = 2) $U_{PTB}(\varepsilon_x)$ =** | **3,0 µA / A** |
| | | | | |
| | | **phase displacement $\delta_x$** | | |
| **quantity $x_i$** | **limits in µrad** | **type** | **distribution** | **standard uncertainty $u(x_i)$** |
| $s(\delta_{Bridge})$ (SEKAM II; $n$ = 10) | 2 | A | normal | 0,37 |
| $\delta_{Bridge}$ (SEKAM II) | 0,5 | B | normal | 0,25 |
| $\delta_{N1}$ (standard CT1 - IW33) | 0 | B | normal | 0,00 |
| $\delta_{N2}$ (standard CT2 - IW32) | 3 | B | normal | 1,50 |
| $\delta_{N3}$ (standard CT3 - ZW51) | 0,7 | B | normal | 0,35 |
| $\delta_B$ (influence of burden) | 0,3 | B | rectangular | 0,17 |
| $\delta_F$ (influence of frequency) | 0,5 | B | rectangular | 0,29 |
| $\delta_{Circuit}$ (influence of circuit configuration) | 1,5 | B | rectangular | 0,87 |
| | | | **standard uncertainty $u(\delta_x)$ =** | **1,85 µA / A** |
| | | | **round off - expanded measurement uncertainty ($k$ = 2) $U_{PTB}(\delta_x)$ =** | **4,0 µA / A** |

**Table 8: PTB uncertainty budget for the current ratio error and the phase displacement for rated primary currents from 5 kA to 50 kA. The secondary current is 5 A. The test points vary from 1 % to 120 % and the frequency is 50 Hz or 60 Hz.**

| **uncertainty budget**<br>**50/60 Hz; (5kA - 50kA) / 5A; Ip / Ip,r = 1%... 120%** | | **PTB Braunschweig**<br>**working group 2.35 "Instrument transformer"** | | |
|---|---|---|---|---|
| **current ratio error $\varepsilon_x$** | | | | |
| **quantity $x_i$** | **limits in µA / A** | **type** | **distribution** | **standard uncertainty $u(x_i)$** |
| $s(\varepsilon_{Bridge})$ (SEKAM II; $n$ = 10) | 2 | A | normal | 0,37 |
| $\varepsilon_{Bridge}$ (SEKAM II) | 0,5 | B | normal | 0,25 |
| $\varepsilon_{N1}$ (standard CT1 - IW33) | 3 | B | normal | 1,50 |
| $\varepsilon_{N2}$ (standard CT2 - IW51) | 0,5 | B | normal | 0,25 |
| $\varepsilon_{N3}$ (standard CT3 - ZW51) | 0 | B | normal | 0,00 |
| $\varepsilon_B$ (influence of burden) | 0,2 | B | rectangular | 0,12 |
| $\varepsilon_F$ (influence of frequency) | 0,5 | B | rectangular | 0,29 |
| $\varepsilon_{Circuit}$ (influence of circuit configuration) | 1,5 | B | rectangular | 0,87 |
| | | | **standard uncertainty $u(\varepsilon_x)$ =** | **1,83 µA / A** |
| | | | **round off - expanded measurement uncertainty ($k$ = 2) $U_{PTB}(\varepsilon_x)$ =** | **4,0 µA / A** |
| | | | | |
| **phase displacement $\delta_x$** | | | | |
| **quantity $x_i$** | **limits in µrad** | **type** | **distribution** | **standard uncertainty $u(x_i)$** |
| $s(\delta_{Bridge})$ (SEKAM II; $n$ = 10) | 2 | A | normal | 0,37 |
| $\delta_{Bridge}$ (SEKAM II) | 0,5 | B | normal | 0,25 |
| $\delta_{N1}$ (standard CT1 - IW33) | 5 | B | normal | 2,50 |
| $\delta_{N2}$ (standard CT2 - IW51) | 0,7 | B | normal | 0,35 |
| $\delta_{N3}$ (standard CT3 - ZW51) | 0 | B | normal | 0,00 |
| $\delta_B$ (influence of burden) | 0,3 | B | rectangular | 0,17 |
| $\delta_F$ (influence of frequency) | 0,5 | B | rectangular | 0,29 |
| $\delta_{Circuit}$ (influence of circuit configuration) | 1,5 | B | rectangular | 0,87 |
| | | | **standard uncertainty $u(\delta_x)$ =** | **2,73 µA / A** |
| | | | **round off - expanded measurement uncertainty ($k$ = 2) $U_{PTB}(\delta_x)$ =** | **6,0 µA / A** |

**Table 9: PTB uncertainty budget for the current ratio error and the phase displacement for rated primary currents from 5 kA to 50 kA. The secondary current is 1 A. The test points vary from 1 % to 120 % and the frequency is 50 Hz or 60 Hz.**

| uncertainty budget<br>50/60 Hz; (5kA - 50kA) / 1A; Ip / Ip,r = 1%... 120% | | PTB Braunschweig<br>working group 2.35 "Instrument transformer" | | |
|---|---|---|---|---|
| **current ratio error $\varepsilon_x$** | | | | |
| **quantity $x_i$** | **limits in µA / A** | **type** | **distribution** | **standard uncertainty $u(x_i)$** |
| $s(\varepsilon_{Bridge})$ (SEKAM II; $n$ = 10) | 2 | A | normal | 0,37 |
| $\varepsilon_{Bridge}$ (SEKAM II) | 0,5 | B | normal | 0,25 |
| $\varepsilon_{N1}$ (standard CT1 - IW33) | 3 | B | normal | 1,50 |
| $\varepsilon_{N2}$ (standard CT2 - IW51) | 0,5 | B | normal | 0,25 |
| $\varepsilon_{N3}$ (standard CT3 - ZW51) | 0,5 | B | normal | 0,25 |
| $\varepsilon_{B}$ (influence of burden) | 0,2 | B | rectangular | 0,12 |
| $\varepsilon_{F}$ (influence of frequency) | 0,5 | B | rectangular | 0,29 |
| $\varepsilon_{Circuit}$ (influence of circuit configuration) | 2 | B | rectangular | 1,15 |
| | | | **standard uncertainty $u(\varepsilon_x)$ =** | **2,00 µA / A** |
| | | | **round off - expanded measurement uncertainty ($k$ = 2) $U_{PTB}(\varepsilon_x)$ =** | **5,0 µA / A** |
| | | | | |
| **phase displacement $\delta_x$** | | | | |
| **quantity $x_i$** | **limits in µrad** | **type** | **distribution** | **standard uncertainty $u(x_i)$** |
| $s(\delta_{Bridge})$ (SEKAM II; $n$ = 10) | 2 | A | normal | 0,37 |
| $\delta_{Bridge}$ (SEKAM II) | 0,5 | B | normal | 0,25 |
| $\delta_{N1}$ (standard CT1 - IW33) | 5 | B | normal | 2,50 |
| $\delta_{N2}$ (standard CT2 - IW51) | 0,7 | B | normal | 0,35 |
| $\delta_{N3}$ (standard CT3 - ZW51) | 0,7 | B | normal | 0,35 |
| $\delta_{B}$ (influence of burden) | 0,3 | B | rectangular | 0,17 |
| $\delta_{F}$ (influence of frequency) | 0,5 | B | rectangular | 0,29 |
| $\delta_{Circuit}$ (influence of circuit configuration) | 2 | B | rectangular | 1,15 |
| | | | **standard uncertainty $u(\delta_x)$ =** | **2,85 µA / A** |
| | | | **round off - expanded measurement uncertainty ($k$ = 2) $U_{PTB}(\delta_x)$ =** | **6,0 µA / A** |

## 10.2 UNCERTAINTY BUDGETS OF UNIIM

**Table 10: UNIIM uncertainty budget for the current ratio error and the phase displacement for rated primary currents of 1 A and 10 A. The secondary current is 1 A. The test points vary from 1 % to 120 % and the frequency is 50 Hz.**

| Current error uncertainty, ratio 1/1, 10/1, I/In = 20-120% | | | | | | |
|---|---|---|---|---|---|---|
| Source of uncertainty | Value, ppm | Type | Prob.Distr. | Divisor | $C_i$ | $u_i(y)$, ppm |
| Calibration of current comparator | 4 | B | normal | 2 | 1 | 2,00 |
| Calibration of test set | 0,4 | B | rectangular | 1,7321 | 1 | 0,23 |
| Influence of burden(±0,5%) | 0,1 | B | rectangular | 1,7321 | 1 | 0,06 |
| Influence of I/In(0,01·I/In) | 0,2 | B | rectangular | 1,7321 | 1 | 0,12 |
| Influence of frequency(±0,1Hz) | 0,1 | B | rectangular | 1,7321 | 1 | 0,06 |
| Reproducibility | 1 | B | rectangular | 1,7321 | 1 | 0,58 |
| Circuit configuration | 0,1 | B | normal | 2 | 1 | 0,05 |
| Uncertainty type A (n=10) | 0,1 | A | normal | 1 | 1 | 0,10 |
| Influence of εi and δi(±0,01·(εi or δi) | 0,06 | B | rectangular | 1,7321 | 1 | 0,03 |
| Combined uncertainty | | | | | | *2,10* |
| Expanded uncertainty | | | k=2 | | | *4,20* |

| Current error uncertainty, ratio 1/1, 10/1, I/In = 5% | | | | | | |
|---|---|---|---|---|---|---|
| Source of uncertainty | Value, ppm | Type | Prob.Distr. | Divisor | $C_i$ | $u_i(y)$, ppm |
| Calibration of current comparator | 5 | B | normal | 2 | 1 | 2,50 |
| Calibration of test set | 0,8 | B | rectangular | 1,7321 | 1 | 0,46 |
| Influence of burden(±0,5%) | 0,1 | B | rectangular | 1,7321 | 1 | 0,06 |
| Influence of I/In(0,01·I/In) | 0,3 | B | rectangular | 1,7321 | 1 | 0,17 |
| Influence of frequency(±0,1Hz) | 0,1 | B | rectangular | 1,7321 | 1 | 0,06 |
| Reproducibility | 1,5 | B | rectangular | 1,7321 | 1 | 0,87 |
| Circuit configuration | 0,2 | B | normal | 2 | 1 | 0,10 |
| Uncertainty type A (n=10) | 0,3 | A | normal | 1 | 1 | 0,30 |
| Influence of εi and δi(±0,01·(εi or δi) | 0,1 | B | rectangular | 1,7321 | 1 | 0,06 |
| Combined uncertainty | | | | | | *2,71* |
| Expanded uncertainty | | | k=2 | | | *5,42* |

| Current errort uncertainty, ratio 1/1, 10/1, I/In = 1% | | | | | | |
|---|---|---|---|---|---|---|
| Source of uncertainty | Value, ppm | Type | Prob.Distr. | Divisor | $C_i$ | $u_i(y)$, ppm |
| Calibration of current comparator | 6 | B | normal | 2 | 1 | 3,00 |
| Calibration of test set | 1,2 | B | rectangular | 1,7321 | 1 | 0,69 |
| Influence of burden(±0,5%) | 0,1 | B | rectangular | 1,7321 | 1 | 0,06 |
| Influence of I/In(0,01·I/In) | 0,5 | B | rectangular | 1,7321 | 1 | 0,29 |
| Influence of frequency(±0,1Hz) | 0,1 | B | rectangular | 1,7321 | 1 | 0,06 |
| Reproducibility | 2 | B | rectangular | 1,7321 | 1 | 1,15 |
| Circuit configuration | 0,3 | B | normal | 2 | 1 | 0,15 |
| Uncertainty type A (n=10) | 0,6 | A | normal | 1 | 1 | 0,60 |
| Influence of εi and δi(±0,01·(εi or δi) | 0,2 | B | rectangular | 1,7321 | 1 | 0,12 |
| Combined uncertainty | | | | | | *3,36* |
| Expanded uncertainty | | | k=2 | | | *6,72* |

**Table: (continued)**

| Phase displacement uncertainty, ratio 1/1, 10/1, I/In = 20-120% | | | | | | |
|---|---|---|---|---|---|---|
| Source of uncertainty | Value, µrad | Type | Prob.Distr. | Divisor | $C_i$ | $u_i(y)$, µrad |
| Calibration of current comparator | 5 | B | normal | 2 | 1 | 2,50 |
| Calibration of test set | 0,6 | B | rectangular | 1,7321 | 1 | 0,35 |
| Influence of burden(±0,5%) | 0,1 | B | rectangular | 1,7321 | 1 | 0,06 |
| Influence of I/In(0,01·I/In) | 0,2 | B | rectangular | 1,7321 | 1 | 0,12 |
| Influence of frequency(±0,1Hz) | 0,1 | B | rectangular | 1,7321 | 1 | 0,06 |
| Reproducibility | 1 | B | rectangular | 1,7321 | 1 | 0,58 |
| Circuit configuration | 0,1 | B | normal | 2 | 1 | 0,05 |
| Uncertainty type A (n=10) | 0,1 | A | normal | 1 | 1 | 0,10 |
| Influence of εi and δi(±0,01·(εi or δi) | 0,04 | B | rectangular | 1,7321 | 1 | 0,02 |
| Combined uncertainty | | | | | | *2,60* |
| Expanded uncertainty | | | k=2 | | | *5,19* |

| Phase displacement uncertainty, ratio 1/1, 10/1, I/In = 5% | | | | | | |
|---|---|---|---|---|---|---|
| Source of uncertainty | Value, µrad | Type | Prob.Distr. | Divisor | $C_i$ | $u_i(y)$, µrad |
| Calibration of current comparator | 6 | B | normal | 2 | 1 | 3,00 |
| Calibration of test set | 1 | B | rectangular | 1,7321 | 1 | 0,58 |
| Influence of burden(±0,5%) | 0,1 | B | rectangular | 1,7321 | 1 | 0,06 |
| Influence of I/In(0,01·I/In) | 0,3 | B | rectangular | 1,7321 | 1 | 0,17 |
| Influence of frequency(±0,1Hz) | 0,1 | B | rectangular | 1,7321 | 1 | 0,06 |
| Reproducibility | 1,5 | B | rectangular | 1,7321 | 1 | 0,87 |
| Circuit configuration | 0,2 | B | normal | 2 | 1 | 0,10 |
| Uncertainty type A (n=10) | 0,3 | A | normal | 1 | 1 | 0,30 |
| Influence of εi and δi(±0,01·(εi or δi) | 0,1 | B | rectangular | 1,7321 | 1 | 0,06 |
| Combined uncertainty | | | | | | *3,20* |
| Expanded uncertainty | | | k=2 | | | *6,39* |

| Phase displacement uncertainty, ratio 1/1, 10/1, I/In = 1% | | | | | | |
|---|---|---|---|---|---|---|
| Source of uncertainty | Value, µrad | Type | Prob.Distr. | Divisor | $C_i$ | $u_i(y)$, µrad |
| Calibration of current comparator | 7 | B | normal | 2 | 1 | 3,50 |
| Calibration of test set | 1,5 | B | rectangular | 1,7321 | 1 | 0,87 |
| Influence of burden(±0,5%) | 0,1 | B | rectangular | 1,7321 | 1 | 0,06 |
| Influence of I/In(0,01·I/In) | 0,5 | B | rectangular | 1,7321 | 1 | 0,29 |
| Influence of frequency(±0,1Hz) | 0,1 | B | rectangular | 1,7321 | 1 | 0,06 |
| Reproducibility | 2 | B | rectangular | 1,7321 | 1 | 1,15 |
| Circuit configuration | 0,3 | B | normal | 2 | 1 | 0,15 |
| Uncertainty type A (n=10) | 0,5 | A | normal | 1 | 1 | 0,50 |
| Influence of εi and δi(±0,01·(εi or δi) | 0,2 | B | rectangular | 1,7321 | 1 | 0,12 |
| Combined uncertainty | | | | | | *3,84* |
| Expanded uncertainty | | | k=2 | | | *7,67* |

**Table 11: UNIIM uncertainty budget for the current ratio error and the phase displacement for rated primary currents of 100 A. The secondary current is 1 A. The test points vary from 1 % to 120 % and the frequency is 50 Hz.**

| Current error uncertainty, ratio 100/1 I/In = 20-120% | | | | | | |
|---|---|---|---|---|---|---|
| Source of uncertainty | Value, ppm | Type | Prob.Distr. | Divisor | $C_i$ | $u_i(y)$, ppm |
| Calibration of current comparator | 6,2 | B | normal | 2 | 1 | 3,10 |
| Calibration of test set | 0,4 | B | rectangular | 1,7321 | 1 | 0,23 |
| Influence of burden(±0,5%) | 0,1 | B | rectangular | 1,7321 | 1 | 0,06 |
| Influence of I/In(0,01·I/In) | 0,2 | B | rectangular | 1,7321 | 1 | 0,12 |
| Influence of frequency(±0,1Hz) | 0,1 | B | rectangular | 1,7321 | 1 | 0,06 |
| Reproducibility | 1,5 | B | rectangular | 1,7321 | 1 | 0,87 |
| Circuit configuration | 0,3 | B | normal | 2 | 1 | 0,15 |
| Uncertainty type A (n=10) | 0,1 | A | normal | 1 | 1 | 0,10 |
| Influence of εi and δi(±0,01·(εi or δi) | 0,06 | B | rectangular | 1,7321 | 1 | 0,03 |
| Combined uncertainty | | | | | | *3,24* |
| Expanded uncertainty | | | k=2 | | | *6,47* |

| Current error uncertainty, ratio 100/1 I/In = 5% | | | | | | |
|---|---|---|---|---|---|---|
| Source of uncertainty | Value, ppm | Type | Prob.Distr. | Divisor | $C_i$ | $u_i(y)$, ppm |
| Calibration of current comparator | 7 | B | normal | 2 | 1 | 3,50 |
| Calibration of test set | 0,8 | B | rectangular | 2 | 1 | 0,40 |
| Influence of burden(±0,5%) | 0,1 | B | rectangular | 1,7321 | 1 | 0,06 |
| Influence of I/In(0,01·I/In) | 0,3 | B | rectangular | 1,7321 | 1 | 0,17 |
| Influence of frequency(±0,1Hz) | 0,1 | B | rectangular | 1,7321 | 1 | 0,06 |
| Reproducibility | 2 | B | rectangular | 1,7321 | 1 | 1,15 |
| Circuit configuration | 0,5 | B | normal | 2 | 1 | 0,25 |
| Uncertainty type A (n=10) | 0,3 | A | normal | 1 | 1 | 0,30 |
| Influence of εi and δi(±0,01·(εi or δi) | 0,1 | B | rectangular | 1,7321 | 1 | 0,06 |
| Combined uncertainty | | | | | | *3,73* |
| Expanded uncertainty | | | k=2 | | | *7,47* |

| Current error uncertainty, ratio 100/1 I/In = 1% | | | | | | |
|---|---|---|---|---|---|---|
| Source of uncertainty | Value, ppm | Type | Prob.Distr. | Divisor | $C_i$ | $u_i(y)$, ppm |
| Calibration of current comparator | 8 | B | normal | 2 | 1 | 4,00 |
| Calibration of test set | 1,2 | B | rectangular | 2 | 1 | 0,60 |
| Influence of burden(±0,5%) | 0,1 | B | rectangular | 1,7321 | 1 | 0,06 |
| Influence of I/In(0,01·I/In) | 0,5 | B | rectangular | 1,7321 | 1 | 0,29 |
| Influence of frequency(±0,1Hz) | 0,1 | B | rectangular | 1,7321 | 1 | 0,06 |
| Reproducibility | 2,5 | B | rectangular | 1,7321 | 1 | 1,44 |
| Circuit configuration | 0,7 | B | normal | 2 | 1 | 0,35 |
| Uncertainty type A (n=10) | 0,6 | A | normal | 1 | 1 | 0,60 |
| Influence of εi and δi(±0,01·(εi or δi) | 0,2 | B | rectangular | 1,7321 | 1 | 0,12 |
| Combined uncertainty | | | | | | *4,36* |
| Expanded uncertainty | | | k=2 | | | *8,72* |

**Table: (continued)**

| Source of uncertainty | Value, µrad | Type | Prob.Distr. | Divisor | $C_i$ | $u_i(y)$, µrad |
|---|---|---|---|---|---|---|
| Phase displacement uncertainty, ratio 100/1 I/In = 20-120% | | | | | | |
| Calibration of current comparator | 7 | B | normal | 2 | 1 | 3,50 |
| Calibration of test set | 0,6 | B | rectangular | 1,7321 | 1 | 0,35 |
| Influence of burden(±0,5%) | 0,1 | B | rectangular | 1,7321 | 1 | 0,06 |
| Influence of I/In(0,01·I/In) | 0,2 | B | rectangular | 1,7321 | 1 | 0,12 |
| Influence of frequency(±0,1Hz) | 0,1 | B | rectangular | 1,7321 | 1 | 0,06 |
| Reproducibility | 1,5 | B | rectangular | 1,7321 | 1 | 0,87 |
| Circuit configuration | 0,3 | B | normal | 2 | 1 | 0,15 |
| Uncertainty type A (n=10) | 0,1 | A | normal | 1 | 1 | 0,10 |
| Influence of εi and δi(±0,01·(εi or δi) | 0,04 | B | rectangular | 1,7321 | 1 | 0,02 |
| Combined uncertainty | | | | | | *3,63* |
| Expanded uncertainty | | | k=2 | | | *7,26* |
| | | | | | | |
| Phase displacement uncertainty, ratio 100/1 I/In = 5% | | | | | | |
| Source of uncertainty | Value, µrad | Type | Prob.Distr. | Divisor | $C_i$ | $u_i(y)$, µrad |
| Calibration of current comparator | 8 | B | normal | 2 | 1 | 4,00 |
| Calibration of test set | 1 | B | rectangular | 2 | 1 | 0,50 |
| Influence of burden(±0,5%) | 0,1 | B | rectangular | 1,7321 | 1 | 0,06 |
| Influence of I/In(0,01·I/In) | 0,3 | B | rectangular | 1,7321 | 1 | 0,17 |
| Influence of frequency(±0,1Hz) | 0,1 | B | rectangular | 1,7321 | 1 | 0,06 |
| Reproducibility | 2 | B | rectangular | 1,7321 | 1 | 1,15 |
| Circuit configuration | 0,5 | B | normal | 2 | 1 | 0,25 |
| Uncertainty type A (n=10) | 0,3 | A | normal | 1 | 1 | 0,30 |
| Influence of εi and δi(±0,01·(εi or δi) | 0,1 | B | rectangular | 1,7321 | 1 | 0,06 |
| Combined uncertainty | | | | | | *4,22* |
| Expanded uncertainty | | | k=2 | | | *8,43* |
| | | | | | | |
| Phase displacement uncertainty, ratio 100/1 I/In = 1% | | | | | | |
| Source of uncertainty | Value, µrad | Type | Prob.Distr. | Divisor | $C_i$ | $u_i(y)$, µrad |
| Calibration of current comparator | 9 | B | normal | 2 | 1 | 4,50 |
| Calibration of test set | 1,5 | B | rectangular | 2 | 1 | 0,75 |
| Influence of burden(±0,5%) | 0,1 | B | rectangular | 1,7321 | 1 | 0,06 |
| Influence of I/In(0,01·I/In) | 0,5 | B | rectangular | 1,7321 | 1 | 0,29 |
| Influence of frequency(±0,1Hz) | 0,1 | B | rectangular | 1,7321 | 1 | 0,06 |
| Reproducibility | 2,5 | B | rectangular | 1,7321 | 1 | 1,44 |
| Circuit configuration | 0,7 | B | normal | 2 | 1 | 0,35 |
| Uncertainty type A (n=10) | 0,6 | A | normal | 1 | 1 | 0,60 |
| Influence of εi and δi(±0,01·(εi or δi) | 0,2 | B | rectangular | 1,7321 | 1 | 0,12 |
| Combined uncertainty | | | | | | *4,85* |
| Expanded uncertainty | | | k=2 | | | *9,69* |

**Table 12: UNIIM uncertainty budget for the current ratio error and the phase displacement for rated primary currents of 500 A. The secondary current is 1 A. The test points vary from 1 % to 120 % and the frequency is 50 Hz.**

| Current error uncertainty, ratio 500/1 I/In = 20-120% | | | | | | |
|---|---|---|---|---|---|---|
| Source of uncertainty | Value, ppm | Type | Prob.Distr. | Divisor | $C_i$ | $u_i(y)$, ppm |
| Calibration of current comparator | 7,3 | B | normal | 2 | 1 | 3,65 |
| Calibration of test set | 0,4 | B | rectangular | 2 | 1 | 0,20 |
| Influence of burden(±0,5%) | 0,1 | B | rectangular | 1,7321 | 1 | 0,06 |
| Influence of I/In(0,01·I/In) | 0,2 | B | rectangular | 1,7321 | 1 | 0,12 |
| Influence of frequency(±0,1Hz) | 0,1 | B | rectangular | 1,7321 | 1 | 0,06 |
| Reproducibility | 1,5 | B | rectangular | 1,7321 | 1 | 0,87 |
| Circuit configuration | 0,8 | A | normal | 2 | 1 | 0,40 |
| Uncertainty type A (n=10) | 0,1 | A | normal | 1 | 1 | 0,10 |
| Influence of εi and δi(±0,01·(εi or δi) | 0,06 | B | rectangular | 1,7321 | 1 | 0,03 |
| Combined uncertainty | | | | | | *3,78* |
| Expanded uncertainty | k=2 | | | | | *7,56* |

| Current error uncertainty, ratio 500/1 I/In = 5% | | | | | | |
|---|---|---|---|---|---|---|
| Source of uncertainty | Value, ppm | Type | Prob.Distr. | Divisor | $C_i$ | $u_i(y)$, ppm |
| Calibration of current comparator | 8 | B | normal | 2 | 1 | 4,00 |
| Calibration of test set | 0,8 | B | rectangular | 2 | 1 | 0,40 |
| Influence of burden(±0,5%) | 0,1 | B | rectangular | 1,7321 | 1 | 0,06 |
| Influence of I/In(0,01·I/In) | 0,3 | B | rectangular | 1,7321 | 1 | 0,17 |
| Influence of frequency(±0,1Hz) | 0,1 | B | rectangular | 1,7321 | 1 | 0,06 |
| Reproducibility | 2,5 | B | rectangular | 1,7321 | 1 | 1,44 |
| Circuit configuration | 1,5 | A | normal | 2 | 1 | 0,75 |
| Uncertainty type A (n=10) | 0,3 | A | normal | 1 | 1 | 0,30 |
| Influence of εi and δi(±0,01·(εi or δi) | 0,1 | B | rectangular | 1,7321 | 1 | 0,06 |
| Combined uncertainty | | | | | | *4,35* |
| Expanded uncertainty | k=2 | | | | | *8,70* |

| Current error uncertainty, ratio 500/1 I/In = 1% | | | | | | |
|---|---|---|---|---|---|---|
| Source of uncertainty | Value, ppm | Type | Prob.Distr. | Divisor | $C_i$ | $u_i(y)$, ppm |
| Calibration of current comparator | 9 | B | normal | 2 | 1 | 4,50 |
| Calibration of test set | 1,2 | B | rectangular | 2 | 1 | 0,60 |
| Influence of burden(±0,5%) | 0,1 | B | rectangular | 1,7321 | 1 | 0,06 |
| Influence of I/In(0,01·I/In) | 0,5 | B | rectangular | 1,7321 | 1 | 0,29 |
| Influence of frequency(±0,1Hz) | 0,1 | B | rectangular | 1,7321 | 1 | 0,06 |
| Reproducibility | 3 | B | rectangular | 1,7321 | 1 | 1,73 |
| Circuit configuration | 2 | A | normal | 2 | 1 | 1,00 |
| Uncertainty type A (n=10) | 0,6 | A | normal | 1 | 1 | 0,60 |
| Influence of εi and δi(±0,01·(εi or δi) | 0,2 | B | rectangular | 1,7321 | 1 | 0,12 |
| Combined uncertainty | | | | | | *5,01* |
| Expanded uncertainty | k=2 | | | | | *10,01* |

**Table: (continued)**

| Phase displacement uncertainty, ratio 500/1 I/In = 20-120% | | | | | | |
|---|---|---|---|---|---|---|
| Source of uncertainty | Value, μrad | Type | Prob.Distr. | Divisor | $C_i$ | $u_i(y)$, μrad |
| Calibration of current comparator | 8 | B | normal | 2 | 1 | 4,00 |
| Calibration of test set | 0,6 | B | rectangular | 2 | 1 | 0,30 |
| Influence of burden(±0,5%) | 0,1 | B | rectangular | 1,7321 | 1 | 0,06 |
| Influence of I/In(0,01·I/In) | 0,2 | B | rectangular | 1,7321 | 1 | 0,12 |
| Influence of frequency(±0,1Hz) | 0,1 | B | rectangular | 1,7321 | 1 | 0,06 |
| Reproducibility | 1,5 | B | rectangular | 1,7321 | 1 | 0,87 |
| Circuit configuration | 0,8 | A | normal | 2 | 1 | 0,40 |
| Uncertainty type A (n=10) | 0,1 | A | normal | 1 | 1 | 0,10 |
| Influence of εi and δi(±0,01·(εi or δi) | 0,04 | B | rectangular | 1,7321 | 1 | 0,02 |
| Combined uncertainty | | | | | | *4,13* |
| Expanded uncertainty | | | k=2 | | | *8,25* |

| Phase displacement uncertainty, ratio 500/1 I/In = 5% | | | | | | |
|---|---|---|---|---|---|---|
| Source of uncertainty | Value, μrad | Type | Prob.Distr. | Divisor | $C_i$ | $u_i(y)$, μrad |
| Calibration of current comparator | 9 | B | normal | 2 | 1 | 4,50 |
| Calibration of test set | 1 | B | rectangular | 2 | 1 | 0,50 |
| Influence of burden(±0,5%) | 0,1 | B | rectangular | 1,7321 | 1 | 0,06 |
| Influence of I/In(0,01·I/In) | 0,3 | B | rectangular | 1,7321 | 1 | 0,17 |
| Influence of frequency(±0,1Hz) | 0,1 | B | rectangular | 1,7321 | 1 | 0,06 |
| Reproducibility | 2,5 | B | rectangular | 1,7321 | 1 | 1,44 |
| Circuit configuration | 1,5 | A | normal | 2 | 1 | 0,75 |
| Uncertainty type A (n=10) | 0,3 | A | normal | 1 | 1 | 0,30 |
| Influence of εi and δi(±0,01·(εi or δi) | 0,1 | B | rectangular | 1,7321 | 1 | 0,06 |
| Combined uncertainty | | | | | | *4,82* |
| Expanded uncertainty | | | k=2 | | | *9,65* |

| Phase displacement uncertainty, ratio 500/1 I/In = 1% | | | | | | |
|---|---|---|---|---|---|---|
| Source of uncertainty | Value, μrad | Type | Prob.Distr. | Divisor | $C_i$ | $u_i(y)$, μrad |
| Calibration of current comparator | 10 | B | normal | 2 | 1 | 5,00 |
| Calibration of test set | 1,5 | B | rectangular | 2 | 1 | 0,75 |
| Influence of burden(±0,5%) | 0,1 | B | rectangular | 1,7321 | 1 | 0,06 |
| Influence of I/In(0,01·I/In) | 0,5 | B | rectangular | 1,7321 | 1 | 0,29 |
| Influence of frequency(±0,1Hz) | 0,1 | B | rectangular | 1,7321 | 1 | 0,06 |
| Reproducibility | 3 | B | rectangular | 1,7321 | 1 | 1,73 |
| Circuit configuration | 2 | A | normal | 2 | 1 | 1,00 |
| Uncertainty type A (n=10) | 0,6 | A | normal | 1 | 1 | 0,60 |
| Influence of εi and δi(±0,01·(εi or δi) | 0,2 | B | rectangular | 1,7321 | 1 | 0,12 |
| Combined uncertainty | | | | | | *5,48* |
| Expanded uncertainty | | | k=2 | | | *10,96* |

**Table 13: UNIIM uncertainty budget for the current ratio error and the phase displacement for rated primary currents of 5 kA. The secondary current is 1 A. The test points vary from 1 % to 120 % and the frequency is 50 Hz.**

| Current error uncertainty, ratio 5k/1 I/In = 20-120% | | | | | | |
|---|---|---|---|---|---|---|
| Source of uncertainty | Value, ppm | Type | Prob.Distr. | Divisor | $C_i$ | $u_i(y)$, ppm |
| Calibration of current comparator | 7 | B | normal | 2 | 1 | 3,50 |
| Calibration of test set | 0,4 | B | rectangular | 2 | 1 | 0,20 |
| Influence of burden(±0,5%) | 0,1 | B | rectangular | 1,7321 | 1 | 0,06 |
| Influence of I/In(0,01·I/In) | 0,2 | B | rectangular | 1,7321 | 1 | 0,12 |
| Influence of frequency(±0,1Hz) | 0,1 | B | rectangular | 1,7321 | 1 | 0,06 |
| Reproducibility | 1,5 | B | rectangular | 1,7321 | 1 | 0,87 |
| Circuit configuration | 2 | B | normal | 2 | 1 | 1,00 |
| Uncertainty type A (n=10) | 0,1 | A | normal | 1 | 1 | 0,10 |
| Influence of εi and δi(±0,01·(εi or δi) | 0,06 | B | rectangular | 1,7321 | 1 | 0,03 |
| Combined uncertainty | | | | | | *3,75* |
| Expanded uncertainty | | | k=2 | | | *7,50* |

| Current error uncertainty, ratio 5k/1 I/In = 5% | | | | | | |
|---|---|---|---|---|---|---|
| Source of uncertainty | Value, ppm | Type | Prob.Distr. | Divisor | $C_i$ | $u_i(y)$, ppm |
| Calibration of current comparator | 8 | B | normal | 2 | 1 | 4,00 |
| Calibration of test set | 0,8 | B | rectangular | 2 | 1 | 0,40 |
| Influence of burden(±0,5%) | 0,1 | B | rectangular | 1,7321 | 1 | 0,06 |
| Influence of I/In(0,01·I/In) | 0,3 | B | rectangular | 1,7321 | 1 | 0,17 |
| Influence of frequency(±0,1Hz) | 0,1 | B | rectangular | 1,7321 | 1 | 0,06 |
| Reproducibility | 2,5 | B | rectangular | 1,7321 | 1 | 1,44 |
| Circuit configuration | 3 | B | normal | 2 | 1 | 1,50 |
| Uncertainty type A (n=10) | 0,3 | A | normal | 1 | 1 | 0,30 |
| Influence of εi and δi(±0,01·(εi or δi) | 0,1 | B | rectangular | 1,7321 | 1 | 0,06 |
| Combined uncertainty | | | | | | *4,54* |
| Expanded uncertainty | | | k=2 | | | *9,08* |

| Current error uncertainty, ratio 5k/1 I/In = 1% | | | | | | |
|---|---|---|---|---|---|---|
| Source of uncertainty | Value, ppm | Type | Prob.Distr. | Divisor | $C_i$ | $u_i(y)$, ppm |
| Calibration of current comparator | 9 | B | normal | 2 | 1 | 4,50 |
| Calibration of test set | 1,2 | B | rectangular | 2 | 1 | 0,60 |
| Influence of burden(±0,5%) | 0,1 | B | rectangular | 1,7321 | 1 | 0,06 |
| Influence of I/In(0,01·I/In) | 0,5 | B | rectangular | 1,7321 | 1 | 0,29 |
| Influence of frequency(±0,1Hz) | 0,1 | B | rectangular | 1,7321 | 1 | 0,06 |
| Reproducibility | 3 | B | rectangular | 1,7321 | 1 | 1,73 |
| Circuit configuration | 4 | B | normal | 2 | 1 | 2,00 |
| Uncertainty type A (n=10) | 0,6 | A | normal | 1 | 1 | 0,60 |
| Influence of εi and δi(±0,01·(εi or δi) | 0,2 | B | rectangular | 1,7321 | 1 | 0,12 |
| Combined uncertainty | | | | | | *5,30* |

**Table: (continued)**

| Phase displacement uncertainty, ratio 5k/1 I/In = 20-120% | | | | | | |
|---|---|---|---|---|---|---|
| Source of uncertainty | Value, μrad | Type | Prob.Distr. | Divisor | $C_i$ | $u_i(y)$, μrad |
| Calibration of current comparator | 8 | B | normal | 2 | 1 | 4,00 |
| Calibration of test set | 0,6 | B | rectangular | 2 | 1 | 0,30 |
| Influence of burden(±0,5%) | 0,1 | B | rectangular | 1,7321 | 1 | 0,06 |
| Influence of I/In(0,01·I/In) | 0,2 | B | rectangular | 1,7321 | 1 | 0,12 |
| Influence of frequency(±0,1Hz) | 0,1 | B | rectangular | 1,7321 | 1 | 0,06 |
| Reproducibility | 1,5 | B | rectangular | 1,7321 | 1 | 0,87 |
| Circuit configuration | 2 | B | normal | 2 | 1 | 1,00 |
| Uncertainty type A (n=10) | 0,1 | A | normal | 1 | 1 | 0,10 |
| Influence of εi and δi(±0,01·(εi or δi) | 0,04 | B | rectangular | 1,7321 | 1 | 0,02 |
| Combined uncertainty | | | | | | *4,23* |
| Expanded uncertainty | | | k=2 | | | *8,45* |
| | | | | | | |
| Phase displacement uncertainty, ratio 5k/1 I/In = 5% | | | | | | |
| Source of uncertainty | Value, μrad | Type | Prob.Distr. | Divisor | $C_i$ | $u_i(y)$, μrad |
| Calibration of current comparator | 9 | B | normal | 2 | 1 | 4,50 |
| Calibration of test set | 1 | B | rectangular | 2 | 1 | 0,50 |
| Influence of burden(±0,5%) | 0,1 | B | rectangular | 1,7321 | 1 | 0,06 |
| Influence of I/In(0,01·I/In) | 0,3 | B | rectangular | 1,7321 | 1 | 0,17 |
| Influence of frequency(±0,1Hz) | 0,1 | B | rectangular | 1,7321 | 1 | 0,06 |
| Reproducibility | 2,5 | B | rectangular | 1,7321 | 1 | 1,44 |
| Circuit configuration | 3 | B | normal | 2 | 1 | 1,50 |
| Uncertainty type A (n=10) | 0,3 | A | normal | 1 | 1 | 0,30 |
| Influence of εi and δi(±0,01·(εi or δi) | 0,1 | B | rectangular | 1,7321 | 1 | 0,06 |
| Combined uncertainty | | | | | | *5,00* |
| Expanded uncertainty | | | k=2 | | | *9,99* |
| | | | | | | |
| Phase displacement uncertainty, ratio 5k/1 I/In = 1% | | | | | | |
| Source of uncertainty | Value, μrad | Type | Prob.Distr. | Divisor | $C_i$ | $u_i(y)$, μrad |
| Calibration of current comparator | 10 | B | normal | 2 | 1 | 5,00 |
| Calibration of test set | 1,5 | B | rectangular | 2 | 1 | 0,75 |
| Influence of burden(±0,5%) | 0,1 | B | rectangular | 1,7321 | 1 | 0,06 |
| Influence of I/In(0,01·I/In) | 0,5 | B | rectangular | 1,7321 | 1 | 0,29 |
| Influence of frequency(±0,1Hz) | 0,1 | B | rectangular | 1,7321 | 1 | 0,06 |
| Reproducibility | 3 | B | rectangular | 1,7321 | 1 | 1,73 |
| Circuit configuration | 4 | B | normal | 2 | 1 | 2,00 |
| Uncertainty type A (n=10) | 0,5 | A | normal | 1 | 1 | 0,50 |
| Influence of εi and δi(±0,01·(εi or δi) | 0,2 | B | rectangular | 1,7321 | 1 | 0,12 |
| Combined uncertainty | | | | | | *5,74* |
| Expanded uncertainty | | | k=2 | | | *11,47* |

Table 14: **UNIIM uncertainty budget for the current ratio error and the phase displacement for rated primary currents of 10 kA. The secondary current is 1 A. The test points vary from 1 % to 120 % and the frequency is 50 Hz.**

| Current error uncertainty, ratio 10k/1 I/In = 20-120% | | | | | | |
|---|---|---|---|---|---|---|
| Source of uncertainty | Value, ppm | Type | Prob.Distr. | Divisor | $C_i$ | $u_i(y)$, ppm |
| Calibration of current comparator | 8 | B | normal | 2 | 1 | 4,00 |
| Calibration of test set | 0,4 | B | rectangular | 2 | 1 | 0,20 |
| Influence of burden(±0,5%) | 0,1 | B | rectangular | 1,7321 | 1 | 0,06 |
| Influence of I/In(0,01·I/In) | 0,2 | B | rectangular | 1,7321 | 1 | 0,12 |
| Influence of frequency(±0,1Hz) | 0,1 | B | rectangular | 1,7321 | 1 | 0,06 |
| Reproducibility | 1,5 | B | rectangular | 1,7321 | 1 | 0,87 |
| Circuit configuration | 2 | B | normal | 2 | 1 | 1,00 |
| Uncertainty type A (n=10) | 0,1 | A | normal | 1 | 1 | 0,10 |
| Influence of εi and δi(±0,01·(εi or δi) | 0,06 | B | rectangular | 1,7321 | 1 | 0,03 |
| Combined uncertainty | | | | | | *4,22* |
| Expanded uncertainty | k=2 | | | | | *8,44* |

| Current error uncertainty, ratio 10k/1 I/In = 5% | | | | | | |
|---|---|---|---|---|---|---|
| Source of uncertainty | Value, ppm | Type | Prob.Distr. | Divisor | $C_i$ | $u_i(y)$, ppm |
| Calibration of current comparator | 9 | B | normal | 2 | 1 | 4,50 |
| Calibration of test set | 0,8 | B | rectangular | 2 | 1 | 0,40 |
| Influence of burden(±0,5%) | 0,1 | B | rectangular | 1,7321 | 1 | 0,06 |
| Influence of I/In(0,01·I/In) | 0,3 | B | rectangular | 1,7321 | 1 | 0,17 |
| Influence of frequency(±0,1Hz) | 0,1 | B | rectangular | 1,7321 | 1 | 0,06 |
| Reproducibility | 2,5 | B | rectangular | 1,7321 | 1 | 1,44 |
| Circuit configuration | 3 | B | normal | 2 | 1 | 1,50 |
| Uncertainty type A (n=10) | 0,3 | A | normal | 1 | 1 | 0,30 |
| Influence of εi and δi(±0,01·(εi or δi) | 0,1 | B | rectangular | 1,7321 | 1 | 0,06 |
| Combined uncertainty | | | | | | *4,99* |
| Expanded uncertainty | k=2 | | | | | *9,97* |

| Current error uncertainty, ratio 10k/1 I/In = 1% | | | | | | |
|---|---|---|---|---|---|---|
| Source of uncertainty | Value, ppm | Type | Prob.Distr. | Divisor | $C_i$ | $u_i(y)$, ppm |
| Calibration of current comparator | 10 | B | normal | 2 | 1 | 5,00 |
| Calibration of test set | 1,2 | B | rectangular | 2 | 1 | 0,60 |
| Influence of burden(±0,5%) | 0,1 | B | rectangular | 1,7321 | 1 | 0,06 |
| Influence of I/In(0,01·I/In) | 0,5 | B | rectangular | 1,7321 | 1 | 0,29 |
| Influence of frequency(±0,1Hz) | 0,1 | B | rectangular | 1,7321 | 1 | 0,06 |
| Reproducibility | 3 | B | rectangular | 1,7321 | 1 | 1,73 |
| Circuit configuration | 4 | B | normal | 2 | 1 | 2,00 |
| Uncertainty type A (n=10) | 0,6 | A | normal | 1 | 1 | 0,60 |
| Influence of εi and δi(±0,01·(εi or δi) | 0,2 | B | rectangular | 1,7321 | 1 | 0,12 |
| Combined uncertainty | | | | | | *5,73* |
| Expanded uncertainty | k=2 | | | | | *11,46* |

**Table: (continued)**

| Phase displacement uncertainty, ratio 10k/1 I/In = 20-120% | | | | | | |
|---|---|---|---|---|---|---|
| Source of uncertainty | Value, µrad | Type | Prob.Distr. | Divisor | $C_i$ | $u_i(y)$, µrad |
| Calibration of current comparator | 9 | B | normal | 2 | 1 | 4,50 |
| Calibration of test set | 0,6 | B | rectangular | 2 | 1 | 0,30 |
| Influence of burden(±0,5%) | 0,1 | B | rectangular | 1,7321 | 1 | 0,06 |
| Influence of I/In(0,01·I/In) | 0,2 | B | rectangular | 1,7321 | 1 | 0,12 |
| Influence of frequency(±0,1Hz) | 0,1 | B | rectangular | 1,7321 | 1 | 0,06 |
| Reproducibility | 1,5 | B | rectangular | 1,7321 | 1 | 0,87 |
| Circuit configuration | 2 | B | normal | 2 | 1 | 1,00 |
| Uncertainty type A (n=10) | 0,1 | A | normal | 1 | 1 | 0,10 |
| Influence of εi and δi(±0,01·(εi or δi) | 0,04 | B | rectangular | 1,7321 | 1 | 0,02 |
| Combined uncertainty | | | | | | *4,70* |
| Expanded uncertainty | | | k=2 | | | *9,41* |

| Phase displacement uncertainty, ratio 10k/1 I/In = 5% | | | | | | |
|---|---|---|---|---|---|---|
| Source of uncertainty | Value, µrad | Type | Prob.Distr. | Divisor | $C_i$ | $u_i(y)$, µrad |
| Calibration of current comparator | 10 | B | normal | 2 | 1 | 5,00 |
| Calibration of test set | 1 | B | rectangular | 2 | 1 | 0,50 |
| Influence of burden(±0,5%) | 0,1 | B | rectangular | 1,7321 | 1 | 0,06 |
| Influence of I/In(0,01·I/In) | 0,3 | B | rectangular | 1,7321 | 1 | 0,17 |
| Influence of frequency(±0,1Hz) | 0,1 | B | rectangular | 1,7321 | 1 | 0,06 |
| Reproducibility | 2,5 | B | rectangular | 1,7321 | 1 | 1,44 |
| Circuit configuration | 3 | B | normal | 2 | 1 | 1,50 |
| Uncertainty type A (n=10) | 0,3 | A | normal | 1 | 1 | 0,30 |
| Influence of εi and δi(±0,01·(εi or δi) | 0,1 | B | rectangular | 1,7321 | 1 | 0,06 |
| Combined uncertainty | | | | | | *5,45* |
| Expanded uncertainty | | | k=2 | | | *10,90* |

| Phase displacement uncertainty, ratio 10k/1 I/In = 1% | | | | | | |
|---|---|---|---|---|---|---|
| Source of uncertainty | Value, µrad | Type | Prob.Distr. | Divisor | $C_i$ | $u_i(y)$, µrad |
| Calibration of current comparator | 11 | B | normal | 2 | 1 | 5,50 |
| Calibration of test set | 1,5 | B | rectangular | 2 | 1 | 0,75 |
| Influence of burden(±0,5%) | 0,1 | B | rectangular | 1,7321 | 1 | 0,06 |
| Influence of I/In(0,01·I/In) | 0,5 | B | rectangular | 1,7321 | 1 | 0,29 |
| Influence of frequency(±0,1Hz) | 0,1 | B | rectangular | 1,7321 | 1 | 0,06 |
| Reproducibility | 3 | B | rectangular | 1,7321 | 1 | 1,73 |
| Circuit configuration | 4 | B | normal | 2 | 1 | 2,00 |
| Uncertainty type A (n=10) | 0,5 | A | normal | 1 | 1 | 0,50 |
| Influence of εi and δi(±0,01·(εi or δi) | 0,2 | B | rectangular | 1,7321 | 1 | 0,12 |
| Combined uncertainty | | | | | | *6,18* |
| Expanded uncertainty | | | k=2 | | | *12,36* |

**Table 15: UNIIM uncertainty budget for the current ratio error and the phase displacement for rated primary currents of 20 kA. The secondary current is 1 A. The test points vary from 1 % to 120 % and the frequency is 50 Hz.**

| Current error uncertainty, ratio 20k/1 I/In = 20-120% | | | | | | |
|---|---|---|---|---|---|---|
| Source of uncertainty | Value, ppm | Type | Prob.Distr. | Divisor | $C_i$ | $u_i(y)$, ppm |
| Calibration of current comparator | 11 | B | normal | 2 | 1 | 5,50 |
| Calibration of test set | 0,4 | B | rectangular | 2 | 1 | 0,20 |
| Influence of burden(±0,5%) | 0,1 | B | rectangular | 1,7321 | 1 | 0,06 |
| Influence of I/In(0,01·I/In) | 0,2 | B | rectangular | 1,7321 | 1 | 0,12 |
| Influence of frequency(±0,1Hz) | 0,1 | B | rectangular | 1,7321 | 1 | 0,06 |
| Reproducibility | 2 | B | rectangular | 1,7321 | 1 | 1,15 |
| Circuit configuration | 3 | B | normal | 2 | 1 | 1,50 |
| Uncertainty type A (n=10) | 0,1 | A | normal | 1 | 1 | 0,10 |
| Influence of εi and δi(±0,01·(εi or δi) | 0,06 | B | rectangular | 1,7321 | 1 | 0,03 |
| Combined uncertainty | | | | | | *5,82* |
| Expanded uncertainty | | | k=2 | | | *11,65* |

| Current error uncertainty, ratio 20k/1 I/In = 5% | | | | | | |
|---|---|---|---|---|---|---|
| Source of uncertainty | Value, ppm | Type | Prob.Distr. | Divisor | $C_i$ | $u_i(y)$, ppm |
| Calibration of current comparator | 12 | B | normal | 2 | 1 | 6,00 |
| Calibration of test set | 0,8 | B | rectangular | 2 | 1 | 0,40 |
| Influence of burden(±0,5%) | 0,1 | B | rectangular | 1,7321 | 1 | 0,06 |
| Influence of I/In(0,01·I/In) | 0,3 | B | rectangular | 1,7321 | 1 | 0,17 |
| Influence of frequency(±0,1Hz) | 0,1 | B | rectangular | 1,7321 | 1 | 0,06 |
| Reproducibility | 3 | B | rectangular | 1,7321 | 1 | 1,73 |
| Circuit configuration | 4 | B | normal | 2 | 1 | 2,00 |
| Uncertainty type A (n=10) | 0,3 | A | normal | 1 | 1 | 0,30 |
| Influence of εi and δi(±0,01·(εi or δi) | 0,1 | B | rectangular | 1,7321 | 1 | 0,06 |
| Combined uncertainty | | | | | | *6,58* |
| Expanded uncertainty | | | k=2 | | | *13,16* |

| Current error uncertainty, ratio 20k/1 I/In = 1% | | | | | | |
|---|---|---|---|---|---|---|
| Source of uncertainty | Value, ppm | Type | Prob.Distr. | Divisor | $C_i$ | $u_i(y)$, ppm |
| Calibration of current comparator | 13 | B | normal | 2 | 1 | 6,50 |
| Calibration of test set | 1,2 | B | rectangular | 2 | 1 | 0,60 |
| Influence of burden(±0,5%) | 0,1 | B | rectangular | 1,7321 | 1 | 0,06 |
| Influence of I/In(0,01·I/In) | 0,5 | B | rectangular | 1,7321 | 1 | 0,29 |
| Influence of frequency(±0,1Hz) | 0,1 | B | rectangular | 1,7321 | 1 | 0,06 |
| Reproducibility | 4 | B | rectangular | 1,7321 | 1 | 2,31 |
| Circuit configuration | 5 | B | normal | 2 | 1 | 2,50 |
| Uncertainty type A (n=10) | 0,6 | A | normal | 1 | 1 | 0,60 |
| Influence of εi and δi(±0,01·(εi or δi) | 0,2 | B | rectangular | 1,7321 | 1 | 0,12 |
| Combined uncertainty | | | | | | *7,39* |
| Expanded uncertainty | | | k=2 | | | *14,79* |

**Table: (continued)**

| Phase displacement uncertainty, ratio 20k/1 I/In = 20-120% | | | | | | |
|---|---|---|---|---|---|---|
| Source of uncertainty | Value, μrad | Type | Prob.Distr. | Divisor | $C_i$ | $u_i(y)$, μrad |
| Calibration of current comparator | 12 | B | normal | 2 | 1 | 6,00 |
| Calibration of test set | 0,6 | B | rectangular | 2 | 1 | 0,30 |
| Influence of burden(±0,5%) | 0,1 | B | rectangular | 1,7321 | 1 | 0,06 |
| Influence of I/In(0,01·I/In) | 0,2 | B | rectangular | 1,7321 | 1 | 0,12 |
| Influence of frequency(±0,1Hz) | 0,1 | B | rectangular | 1,7321 | 1 | 0,06 |
| Reproducibility | 2 | B | rectangular | 1,7321 | 1 | 1,15 |
| Circuit configuration | 3 | B | normal | 2 | 1 | 1,50 |
| Uncertainty type A (n=10) | 0,1 | A | normal | 1 | 1 | 0,10 |
| Influence of εi and δi(±0,01·(εi or δi) | 0,04 | B | rectangular | 1,7321 | 1 | 0,02 |
| Combined uncertainty | | | | | | *6,30* |
| Expanded uncertainty | | | k=2 | | | *12,60* |

| Phase displacement uncertainty, ratio 20k/1 I/In = 5% | | | | | | |
|---|---|---|---|---|---|---|
| Source of uncertainty | Value, μrad | Type | Prob.Distr. | Divisor | $C_i$ | $u_i(y)$, μrad |
| Calibration of current comparator | 13 | B | normal | 2 | 1 | 6,50 |
| Calibration of test set | 1 | B | rectangular | 2 | 1 | 0,50 |
| Influence of burden(±0,5%) | 0,1 | B | rectangular | 1,7321 | 1 | 0,06 |
| Influence of I/In(0,01·I/In) | 0,3 | B | rectangular | 1,7321 | 1 | 0,17 |
| Influence of frequency(±0,1Hz) | 0,1 | B | rectangular | 1,7321 | 1 | 0,06 |
| Reproducibility | 3 | B | rectangular | 1,7321 | 1 | 1,73 |
| Circuit configuration | 4 | B | normal | 2 | 1 | 2,00 |
| Uncertainty type A (n=10) | 0,3 | A | normal | 1 | 1 | 0,30 |
| Influence of εi and δi(±0,01·(εi or δi) | 0,1 | B | rectangular | 1,7321 | 1 | 0,06 |
| Combined uncertainty | | | | | | *7,04* |
| Expanded uncertainty | | | k=2 | | | *14,09* |

| Phase displacement uncertainty, ratio 20k/1 I/In = 1% | | | | | | |
|---|---|---|---|---|---|---|
| Source of uncertainty | Value, μrad | Type | Prob.Distr. | Divisor | $C_i$ | $u_i(y)$, μrad |
| Calibration of current comparator | 14 | B | normal | 2 | 1 | 7,00 |
| Calibration of test set | 1,5 | B | rectangular | 2 | 1 | 0,75 |
| Influence of burden(±0,5%) | 0,1 | B | rectangular | 1,7321 | 1 | 0,06 |
| Influence of I/In(0,01·I/In) | 0,5 | B | rectangular | 1,7321 | 1 | 0,29 |
| Influence of frequency(±0,1Hz) | 0,1 | B | rectangular | 1,7321 | 1 | 0,06 |
| Reproducibility | 4 | B | rectangular | 1,7321 | 1 | 2,31 |
| Circuit configuration | 5 | B | normal | 2 | 1 | 2,50 |
| Uncertainty type A (n=10) | 0,6 | A | normal | 1 | 1 | 0,60 |
| Influence of εi and δi(±0,01·(εi or δi) | 0,2 | B | rectangular | 1,7321 | 1 | 0,12 |
| Combined uncertainty | | | | | | *7,85* |
| Expanded uncertainty | | | k=2 | | | *15,70* |

**Table 16: UNIIM uncertainty budget for the current ratio error and the phase displacement for rated primary currents of 50 kA. The secondary current is 1 A. The test points vary from 1 % to 120 % and the frequency is 50 Hz.**

| Current error uncertainty, ratio 50k/1 I/In = 20-120% | | | | | | |
|---|---|---|---|---|---|---|
| Source of uncertainty | Value, ppm | Type | Prob.Distr. | Divisor | $C_i$ | $u_i(y)$, ppm |
| Calibration of current comparator | 13 | B | normal | 2 | 1 | 6,50 |
| Calibration of test set | 0,4 | B | rectangular | 2 | 1 | 0,20 |
| Influence of burden(±0,5%) | 0,1 | B | rectangular | 1,7321 | 1 | 0,06 |
| Influence of I/In(0,01·I/In) | 0,2 | B | rectangular | 1,7321 | 1 | 0,12 |
| Influence of frequency(±0,1Hz) | 0,1 | B | rectangular | 1,7321 | 1 | 0,06 |
| Reproducibility | 2 | B | rectangular | 1,7321 | 1 | 1,15 |
| Circuit configuration | 3 | B | normal | 2 | 1 | 1,50 |
| Uncertainty type A (n=10) | 0,1 | A | normal | 1 | 1 | 0,10 |
| Influence of εi and δi(±0,01·(εi or δi) | 0,06 | B | rectangular | 1,7321 | 1 | 0,03 |
| Combined uncertainty | | | | | | *6,78* |
| Expanded uncertainty | | | k=2 | | | *13,55* |

| Current error uncertainty, ratio 50k/1 I/In = 5% | | | | | | |
|---|---|---|---|---|---|---|
| Source of uncertainty | Value, ppm | Type | Prob.Distr. | Divisor | $C_i$ | $u_i(y)$, ppm |
| Calibration of current comparator | 14 | B | normal | 2 | 1 | 7,00 |
| Calibration of test set | 0,8 | B | rectangular | 2 | 1 | 0,40 |
| Influence of burden(±0,5%) | 0,1 | B | rectangular | 1,7321 | 1 | 0,06 |
| Influence of I/In(0,01·I/In) | 0,3 | B | rectangular | 1,7321 | 1 | 0,17 |
| Influence of frequency(±0,1Hz) | 0,1 | B | rectangular | 1,7321 | 1 | 0,06 |
| Reproducibility | 3 | B | rectangular | 1,7321 | 1 | 1,73 |
| Circuit configuration | 4 | B | normal | 2 | 1 | 2,00 |
| Uncertainty type A (n=10) | 0,3 | A | normal | 1 | 1 | 0,30 |
| Influence of εi and δi(±0,01·(εi or δi) | 0,1 | B | rectangular | 1,7321 | 1 | 0,06 |
| Combined uncertainty | | | | | | *7,50* |
| Expanded uncertainty | | | k=2 | | | *15,01* |

| Current error uncertainty, ratio 50k/1 I/In = 1% | | | | | | |
|---|---|---|---|---|---|---|
| Source of uncertainty | Value, ppm | Type | Prob.Distr. | Divisor | $C_i$ | $u_i(y)$, ppm |
| Calibration of current comparator | 15 | B | normal | 2 | 1 | 7,50 |
| Calibration of test set | 1,2 | B | rectangular | 2 | 1 | 0,60 |
| Influence of burden(±0,5%) | 0,1 | B | rectangular | 1,7321 | 1 | 0,06 |
| Influence of I/In(0,01·I/In) | 0,5 | B | rectangular | 1,7321 | 1 | 0,29 |
| Influence of frequency(±0,1Hz) | 0,1 | B | rectangular | 1,7321 | 1 | 0,06 |
| Reproducibility | 4 | B | rectangular | 1,7321 | 1 | 2,31 |
| Circuit configuration | 5 | B | normal | 2 | 1 | 2,50 |
| Uncertainty type A (n=10) | 0,6 | A | normal | 1 | 1 | 0,60 |
| Influence of εi and δi(±0,01·(εi or δi) | 0,2 | B | rectangular | 1,7321 | 1 | 0,12 |
| Combined uncertainty | | | | | | *8,29* |
| Expanded uncertainty | | | k=2 | | | *16,57* |

**Table: (continued)**

| Phase displacement uncertainty, ratio 50k/1 I/In = 20-120% | | | | | | |
|---|---|---|---|---|---|---|
| Source of uncertainty | Value, µrad | Type | Prob.Distr. | Divisor | $C_i$ | $u_i(y)$, µrad |
| Calibration of current comparator | 14 | B | normal | 2 | 1 | 7,00 |
| Calibration of test set | 0,6 | B | rectangular | 2 | 1 | 0,30 |
| Influence of burden(±0,5%) | 0,1 | B | rectangular | 1,7321 | 1 | 0,06 |
| Influence of I/In(0,01·I/In) | 0,2 | B | rectangular | 1,7321 | 1 | 0,12 |
| Influence of frequency(±0,1Hz) | 0,1 | B | rectangular | 1,7321 | 1 | 0,06 |
| Reproducibility | 2 | B | rectangular | 1,7321 | 1 | 1,15 |
| Circuit configuration | 3 | B | normal | 2 | 1 | 1,50 |
| Uncertainty type A (n=10) | 0,1 | A | normal | 1 | 1 | 0,10 |
| Influence of εi and δi(±0,01·(εi or δi) | 0,06 | B | rectangular | 1,7321 | 1 | 0,03 |
| Combined uncertainty | | | | | | *7,26* |
| Expanded uncertainty | | | k=2 | | | *14,52* |

| Phase displacement uncertainty, ratio 50k/1 I/In = 5% | | | | | | |
|---|---|---|---|---|---|---|
| Source of uncertainty | Value, µrad | Type | Prob.Distr. | Divisor | $C_i$ | $u_i(y)$, µrad |
| Calibration of current comparator | 15 | B | normal | 2 | 1 | 7,50 |
| Calibration of test set | 1 | B | rectangular | 2 | 1 | 0,50 |
| Influence of burden(±0,5%) | 0,1 | B | rectangular | 1,7321 | 1 | 0,06 |
| Influence of I/In(0,01·I/In) | 0,3 | B | rectangular | 1,7321 | 1 | 0,17 |
| Influence of frequency(±0,1Hz) | 0,1 | B | rectangular | 1,7321 | 1 | 0,06 |
| Reproducibility | 3 | B | rectangular | 1,7321 | 1 | 1,73 |
| Circuit configuration | 4 | B | normal | 2 | 1 | 2,00 |
| Uncertainty type A (n=10) | 0,3 | A | normal | 1 | 1 | 0,30 |
| Influence of εi and δi(±0,01·(εi or δi) | 0,1 | B | rectangular | 1,7321 | 1 | 0,06 |
| Combined uncertainty | | | | | | *7,98* |
| Expanded uncertainty | | | k=2 | | | *15,95* |

| Phase displacement uncertainty, ratio 50k/1 I/In = 1% | | | | | | |
|---|---|---|---|---|---|---|
| Source of uncertainty | Value, µrad | Type | Prob.Distr. | Divisor | $C_i$ | $u_i(y)$, µrad |
| Calibration of current comparator | 16 | B | normal | 2 | 1 | 8,00 |
| Calibration of test set | 1,5 | B | rectangular | 2 | 1 | 0,75 |
| Influence of burden(±0,5%) | 0,1 | B | rectangular | 1,7321 | 1 | 0,06 |
| Influence of I/In(0,01·I/In) | 0,5 | B | rectangular | 1,7321 | 1 | 0,29 |
| Influence of frequency(±0,1Hz) | 0,1 | B | rectangular | 1,7321 | 1 | 0,06 |
| Reproducibility | 4 | B | rectangular | 1,7321 | 1 | 2,31 |
| Circuit configuration | 5 | B | normal | 2 | 1 | 2,50 |
| Uncertainty type A (n=10) | 0,6 | A | normal | 1 | 1 | 0,60 |
| Influence of εi and δi(±0,01·(εi or δi) | 0,2 | B | rectangular | 1,7321 | 1 | 0,12 |
| Combined uncertainty | | | | | | *8,75* |
| Expanded uncertainty | | | k=2 | | | *17,51* |

**Table 17: UNIIM uncertainty budget for the current ratio error and the phase displacement for rated primary currents from 5 A to 100 A. The secondary current is 5 A. The test points vary from 1 % to 120 % and the frequency is 50 Hz.**

| Current error uncertainty, ratio 5/5, 20/5, 50/5,100/5, I/In = 5-120% | | | | | | |
|---|---|---|---|---|---|---|
| Source of uncertainty | Value, ppm | Type | Prob.Distr. | Divisor | $C_i$ | $u_i(y)$, ppm |
| Calibration of current comparator | 3 | B | normal | 2 | 1 | 1,50 |
| Calibration of test set | 0,4 | B | rectangular | 1,7321 | 1 | 0,23 |
| Influence of burden(±0,5%) | 0,1 | B | rectangular | 1,7321 | 1 | 0,06 |
| Influence of I/In(0,01·I/In) | 0,2 | B | rectangular | 1,7321 | 1 | 0,12 |
| Influence of frequency(±0,1Hz) | 0,1 | B | rectangular | 1,7321 | 1 | 0,06 |
| Reproducibility | 1 | B | rectangular | 1,7321 | 1 | 0,58 |
| Circuit configuration | 0,1 | B | normal | 2 | 1 | 0,05 |
| Uncertainty type A (n=10) | 0,1 | A | normal | 1 | 1 | 0,10 |
| Influence of εi and δi(±0,01·(εi or δi) | 0,06 | B | rectangular | 1,7321 | 1 | 0,03 |
| Combined uncertainty | | | | | | *1,63* |
| Expanded uncertainty | | | k=2 | | | *3,27* |

| current error uncertainty, ratio 5/5, 20/5, 50/5,100/5, I/In = 1% | | | | | | |
|---|---|---|---|---|---|---|
| Source of uncertainty | Value, ppm | Type | Prob.Distr. | Divisor | $C_i$ | $u_i(y)$, ppm |
| Calibration of current comparator | 4 | B | normal | 2 | 1 | 2,00 |
| Calibration of test set | 0,8 | B | rectangular | 1,7321 | 1 | 0,46 |
| Influence of burden(±0,5%) | 0,1 | B | rectangular | 1,7321 | 1 | 0,06 |
| Influence of I/In(0,01·I/In) | 0,3 | B | rectangular | 1,7321 | 1 | 0,17 |
| Influence of frequency(±0,1Hz) | 0,1 | B | rectangular | 1,7321 | 1 | 0,06 |
| Reproducibility | 2 | B | rectangular | 1,7321 | 1 | 1,15 |
| Circuit configuration | 0,2 | B | normal | 2 | 1 | 0,10 |
| Uncertainty type A (n=10) | 0,3 | A | normal | 1 | 1 | 0,30 |
| Influence of εi and δi(±0,01·(εi or δi) | 0,1 | B | rectangular | 1,7321 | 1 | 0,06 |
| Combined uncertainty | | | | | | *2,38* |
| Expanded uncertainty | | | k=2 | | | *4,77* |

**Table: (continued)**

| Phase displacement uncertainty, ratio 5/5, 20/5, 50/5,100/5, I/In = 5-120% | | | | | | |
|---|---|---|---|---|---|---|
| Source of uncertainty | Value, μrad | Type | Prob.Distr. | Divisor | $C_i$ | $u_i(y)$, μrad |
| Calibration of current comparator | 4 | B | normal | 2 | 1 | 2,00 |
| Calibration of test set | 0,6 | B | rectangular | 1,7321 | 1 | 0,35 |
| Influence of burden(±0,5%) | 0,1 | B | rectangular | 1,7321 | 1 | 0,06 |
| Influence of I/In(0,01·I/In) | 0,2 | B | rectangular | 1,7321 | 1 | 0,12 |
| Influence of frequency(±0,1Hz) | 0,1 | B | rectangular | 1,7321 | 1 | 0,06 |
| Reproducibility | 1 | B | rectangular | 1,7321 | 1 | 0,58 |
| Circuit configuration | 0,1 | B | normal | 2 | 1 | 0,05 |
| Uncertainty type A (n=10) | 0,1 | A | normal | 1 | 1 | 0,10 |
| Influence of εi and δi(±0,01·(εi or δi) | 0,04 | B | rectangular | 1,7321 | 1 | 0,02 |
| Combined uncertainty | | | | | | *2,12* |
| Expanded uncertainty | | | k=2 | | | *4,24* |

| Phase displacement uncertainty, ratio 5/5, 20/5, 50/5,100/5, I/In = 1% | | | | | | |
|---|---|---|---|---|---|---|
| Source of uncertainty | Value, μrad | Type | Prob.Distr. | Divisor | $C_i$ | $u_i(y)$, μrad |
| Calibration of current comparator | 5 | B | normal | 2 | 1 | 2,50 |
| Calibration of test set | 1 | B | rectangular | 1,7321 | 1 | 0,58 |
| Influence of burden(±0,5%) | 0,1 | B | rectangular | 1,7321 | 1 | 0,06 |
| Influence of I/In(0,01·I/In) | 0,3 | B | rectangular | 1,7321 | 1 | 0,17 |
| Influence of frequency(±0,1Hz) | 0,1 | B | rectangular | 1,7321 | 1 | 0,06 |
| Reproducibility | 2 | B | rectangular | 1,7321 | 1 | 1,15 |
| Circuit configuration | 0,2 | B | normal | 2 | 1 | 0,10 |
| Uncertainty type A (n=10) | 0,3 | A | normal | 1 | 1 | 0,30 |
| Influence of εi and δi(±0,01·(εi or δi) | 0,1 | B | rectangular | 1,7321 | 1 | 0,06 |
| Combined uncertainty | | | | | | *2,84* |
| Expanded uncertainty | | | k=2 | | | *5,68* |

**Table 18: UNIIM uncertainty budget for the current ratio error and the phase displacement for rated primary currents of 500 A. The secondary current is 5 A. The test points vary from 1 % to 120 % and the frequency is 50 Hz.**

| Current error uncertainty, ratio 500/5 I/In = 5-120% | | | | | | |
|---|---|---|---|---|---|---|
| Source of uncertainty | Value, ppm | Type | Prob.Distr. | Divisor | $C_i$ | $u_i(y)$, ppm |
| Calibration of current comparator | 5,4 | B | normal | 2 | 1 | 2,70 |
| Calibration of test set | 0,4 | B | rectangular | 2 | 1 | 0,20 |
| Influence of burden(±0,5%) | 0,1 | B | rectangular | 1,7321 | 1 | 0,06 |
| Influence of I/In(0,01·I/In) | 0,2 | B | rectangular | 1,7321 | 1 | 0,12 |
| Influence of frequency(±0,1Hz) | 0,1 | B | rectangular | 1,7321 | 1 | 0,06 |
| Reproducibility | 1,5 | B | rectangular | 1,7321 | 1 | 0,87 |
| Circuit configuration | 0,3 | B | normal | 2 | 1 | 0,15 |
| Uncertainty type A (n=10) | 0,1 | A | normal | 1 | 1 | 0,10 |
| Influence of εi and δi(±0,01·(εi or δi) | 0,06 | B | rectangular | 1,7321 | 1 | 0,03 |
| Combined uncertainty | | | | | | *2,85* |
| Expanded uncertainty | | | k=2 | | | *5,70* |
| | | | | | | |
| Current error uncertainty, ratio 500/5 I/In = 1% | | | | | | |
| Source of uncertainty | Value, ppm | Type | Prob.Distr. | Divisor | $C_i$ | $u_i(y)$, ppm |
| Calibration of current comparator | 6 | B | normal | 2 | 1 | 3,00 |
| Calibration of test set | 0,8 | B | rectangular | 2 | 1 | 0,40 |
| Influence of burden(±0,5%) | 0,1 | B | rectangular | 1,7321 | 1 | 0,06 |
| Influence of I/In(0,01·I/In) | 0,3 | B | rectangular | 1,7321 | 1 | 0,17 |
| Influence of frequency(±0,1Hz) | 0,1 | B | rectangular | 1,7321 | 1 | 0,06 |
| Reproducibility | 2,5 | B | rectangular | 1,7321 | 1 | 1,44 |
| Circuit configuration | 0,5 | B | normal | 2 | 1 | 0,25 |
| Uncertainty type A (n=10) | 0,5 | A | normal | 1 | 1 | 0,50 |
| Influence of εi and δi(±0,01·(εi or δi) | 0,1 | B | rectangular | 1,7321 | 1 | 0,06 |
| Combined uncertainty | | | | | | *3,41* |
| Expanded uncertainty | | | k=2 | | | *6,81* |

**Table: (continued)**

| Phase displacement uncertainty, ratio 500/5 I/In = 5-120% | | | | | | |
|---|---|---|---|---|---|---|
| Source of uncertainty | Value, μrad | Type | Prob.Distr. | Divisor | $C_i$ | $u_i(y)$, μrad |
| Calibration of current comparator | 6,2 | B | normal | 2 | 1 | 3,10 |
| Calibration of test set | 0,6 | B | rectangular | 2 | 1 | 0,30 |
| Influence of burden(±0,5%) | 0,1 | B | rectangular | 1,7321 | 1 | 0,06 |
| Influence of I/In(0,01·I/In) | 0,2 | B | rectangular | 1,7321 | 1 | 0,12 |
| Influence of frequency(±0,1Hz) | 0,1 | B | rectangular | 1,7321 | 1 | 0,06 |
| Reproducibility | 1,5 | B | rectangular | 1,7321 | 1 | 0,87 |
| Circuit configuration | 0,3 | B | normal | 2 | 1 | 0,15 |
| Uncertainty type A (n=10) | 0,1 | A | normal | 1 | 1 | 0,10 |
| Influence of εi and δi(±0,01·(εi or δi) | 0,04 | B | rectangular | 1,7321 | 1 | 0,02 |
| Combined uncertainty | | | | | | *3,24* |
| Expanded uncertainty | | | k=2 | | | *6,48* |

| Phase displacement uncertainty, ratio 500/5 I/In = 1% | | | | | | |
|---|---|---|---|---|---|---|
| Source of uncertainty | Value, μrad | Type | Prob.Distr. | Divisor | $C_i$ | $u_i(y)$, μrad |
| Calibration of current comparator | 7 | B | normal | 2 | 1 | 3,50 |
| Calibration of test set | 1 | B | rectangular | 2 | 1 | 0,50 |
| Influence of burden(±0,5%) | 0,1 | B | rectangular | 1,7321 | 1 | 0,06 |
| Influence of I/In(0,01·I/In) | 0,3 | B | rectangular | 1,7321 | 1 | 0,17 |
| Influence of frequency(±0,1Hz) | 0,1 | B | rectangular | 1,7321 | 1 | 0,06 |
| Reproducibility | 2 | B | rectangular | 1,7321 | 1 | 1,15 |
| Circuit configuration | 0,5 | B | normal | 2 | 1 | 0,25 |
| Uncertainty type A (n=10) | 0,3 | A | normal | 1 | 1 | 0,30 |
| Influence of εi and δi(±0,01·(εi or δi) | 0,1 | B | rectangular | 1,7321 | 1 | 0,06 |
| Combined uncertainty | | | | | | *3,75* |
| Expanded uncertainty | | | k=2 | | | *7,49* |

**Table 19: UNIIM uncertainty budget for the current ratio error and the phase displacement for rated primary currents of 1 kA. The secondary current is 5 A. The test points vary from 1 % to 120 % and the frequency is 50 Hz.**

| Current error uncertainty, ratio 1000/5 I/In = 5-120% | | | | | | |
|---|---|---|---|---|---|---|
| Source of uncertainty | Value, ppm | Type | Prob.Distr. | Divisor | $C_i$ | $u_i(y)$, ppm |
| Calibration of current comparator | 6,5 | B | normal | 2 | 1 | 3,25 |
| Calibration of test set | 0,4 | B | rectangular | 2 | 1 | 0,20 |
| Influence of burden(±0,5%) | 0,1 | B | rectangular | 1,7321 | 1 | 0,06 |
| Influence of I/In(0,01·I/In) | 0,2 | B | rectangular | 1,7321 | 1 | 0,12 |
| Influence of frequency(±0,1Hz) | 0,1 | B | rectangular | 1,7321 | 1 | 0,06 |
| Reproducibility | 1,5 | B | rectangular | 1,7321 | 1 | 0,87 |
| Circuit configuration | 0,5 | A | normal | 2 | 1 | 0,25 |
| Uncertainty type A (n=10) | 0,1 | A | normal | 1 | 1 | 0,10 |
| Influence of εi and δi(±0,01·(εi or δi) | 0,06 | B | rectangular | 1,7321 | 1 | 0,03 |
| Combined uncertainty | | | | | | *3,38* |
| Expanded uncertainty | | | k=2 | | | *6,77* |
| | | | | | | |
| Current error uncertainty, ratio 1000/5 I/In = 1% | | | | | | |
| Source of uncertainty | Value, ppm | Type | Prob.Distr. | Divisor | $C_i$ | $u_i(y)$, ppm |
| Calibration of current comparator | 7 | B | normal | 2 | 1 | 3,50 |
| Calibration of test set | 0,8 | B | rectangular | 2 | 1 | 0,40 |
| Influence of burden(±0,5%) | 0,1 | B | rectangular | 1,7321 | 1 | 0,06 |
| Influence of I/In(0,01·I/In) | 0,3 | B | rectangular | 1,7321 | 1 | 0,17 |
| Influence of frequency(±0,1Hz) | 0,1 | B | rectangular | 1,7321 | 1 | 0,06 |
| Reproducibility | 2,5 | B | rectangular | 1,7321 | 1 | 1,44 |
| Circuit configuration | 1 | A | normal | 2 | 1 | 0,50 |
| Uncertainty type A (n=10) | 0,5 | A | normal | 1 | 1 | 0,50 |
| Influence of εi and δi(±0,01·(εi or δi) | 0,1 | B | rectangular | 1,7321 | 1 | 0,06 |
| Combined uncertainty | | | | | | *3,88* |
| Expanded uncertainty | | | k=2 | | | *7,75* |

**Table: (continued)**

| Phase displacement uncertainty, ratio 1000/5 I/In = 5-120% | | | | | | |
|---|---|---|---|---|---|---|
| Source of uncertainty | Value, μrad | Type | Prob.Distr. | Divisor | $C_i$ | $u_i(y)$, μrad |
| Calibration of current comparator | 7,4 | B | normal | 2 | 1 | 3,70 |
| Calibration of test set | 0,6 | B | rectangular | 2 | 1 | 0,30 |
| Influence of burden(±0,5%) | 0,1 | B | rectangular | 1,7321 | 1 | 0,06 |
| Influence of I/In(0,01·I/In) | 0,2 | B | rectangular | 1,7321 | 1 | 0,12 |
| Influence of frequency(±0,1Hz) | 0,1 | B | rectangular | 1,7321 | 1 | 0,06 |
| Reproducibility | 1,5 | B | rectangular | 1,7321 | 1 | 0,87 |
| Circuit configuration | 0,5 | B | normal | 2 | 1 | 0,25 |
| Uncertainty type A (n=10) | 0,1 | A | normal | 1 | 1 | 0,10 |
| Influence of εi and δi(±0,01·(εi or δi) | 0,04 | B | rectangular | 1,7321 | 1 | 0,02 |
| Combined uncertainty | | | | | | *3,82* |
| Expanded uncertainty | | | k=2 | | | *7,65* |
| | | | | | | |
| Phase displacement uncertainty, ratio 1000/5 I/In = 1% | | | | | | |
| Source of uncertainty | Value, μrad | Type | Prob.Distr. | Divisor | $C_i$ | $u_i(y)$, μrad |
| Calibration of current comparator | 8 | B | normal | 2 | 1 | 4,00 |
| Calibration of test set | 1 | B | rectangular | 2 | 1 | 0,50 |
| Influence of burden(±0,5%) | 0,1 | B | rectangular | 1,7321 | 1 | 0,06 |
| Influence of I/In(0,01·I/In) | 0,3 | B | rectangular | 1,7321 | 1 | 0,17 |
| Influence of frequency(±0,1Hz) | 0,1 | B | rectangular | 1,7321 | 1 | 0,06 |
| Reproducibility | 2 | B | rectangular | 1,7321 | 1 | 1,15 |
| Circuit configuration | 1 | A | normal | 2 | 1 | 0,50 |
| Uncertainty type A (n=10) | 0,3 | A | normal | 1 | 1 | 0,30 |
| Influence of εi and δi(±0,01·(εi or δi) | 0,1 | B | rectangular | 1,7321 | 1 | 0,06 |
| Combined uncertainty | | | | | | *4,24* |
| Expanded uncertainty | | | | | | *8,48* |

**Table 20: UNIIM uncertainty budget for the current ratio error and the phase displacement for rated primary currents from 3 kA. The secondary current is 5 A. The test points vary from 1 % to 120 % and the frequency is 50 Hz.**

| Current error uncertainty, ratio 3000/5 I/In = 5-120% | | | | | | |
|---|---|---|---|---|---|---|
| Source of uncertainty | Value, ppm | Type | Prob.Distr. | Divisor | $C_i$ | $u_i(y)$, ppm |
| Calibration of current comparator | 7,5 | B | normal | 2 | 1 | 3,75 |
| Calibration of test set | 0,4 | B | rectangular | 2 | 1 | 0,20 |
| Influence of burden(±0,5%) | 0,1 | B | rectangular | 1,7321 | 1 | 0,06 |
| Influence of I/In(0,01·I/In) | 0,2 | B | rectangular | 1,7321 | 1 | 0,12 |
| Influence of frequency(±0,1Hz) | 0,1 | B | rectangular | 1,7321 | 1 | 0,06 |
| Reproducibility | 1,5 | B | rectangular | 1,7321 | 1 | 0,87 |
| Circuit configuration | 0,8 | B | normal | 2 | 1 | 0,40 |
| Uncertainty type A (n=10) | 0,1 | A | normal | 1 | 1 | 0,10 |
| Influence of εi and δi(±0,01·(εi or δi) | 0,06 | B | rectangular | 1,7321 | 1 | 0,03 |
| Combined uncertainty | | | | | | *3,88* |
| Expanded uncertainty | | | k=2 | | | *7,76* |
| | | | | | | |
| Current error uncertainty, ratio 3000/5 I/In = 1% | | | | | | |
| Source of uncertainty | Value, ppm | Type | Prob.Distr. | Divisor | $C_i$ | $u_i(y)$, ppm |
| Calibration of current comparator | 8,5 | B | normal | 2 | 1 | 4,25 |
| Calibration of test set | 0,8 | B | rectangular | 2 | 1 | 0,40 |
| Influence of burden(±0,5%) | 0,1 | B | rectangular | 1,7321 | 1 | 0,06 |
| Influence of I/In(0,01·I/In) | 0,3 | B | rectangular | 1,7321 | 1 | 0,17 |
| Influence of frequency(±0,1Hz) | 0,1 | B | rectangular | 1,7321 | 1 | 0,06 |
| Reproducibility | 2,5 | B | rectangular | 1,7321 | 1 | 1,44 |
| Circuit configuration | 1,5 | B | normal | 2 | 1 | 0,75 |
| Uncertainty type A (n=10) | 0,3 | A | normal | 1 | 1 | 0,30 |
| Influence of εi and δi(±0,01·(εi or δi) | 0,1 | B | rectangular | 1,7321 | 1 | 0,06 |
| Combined uncertainty | | | | | | *4,58* |
| Expanded uncertainty | | | k=2 | | | *9,16* |

**Table: (continued)**

| Phase displacement uncertainty, ratio 3000/5 I/In = 5-120% | | | | | | |
|---|---|---|---|---|---|---|
| Source of uncertainty | Value, µrad | Type | Prob.Distr. | Divisor | $C_i$ | $u_i(y)$, µrad |
| Calibration of current comparator | 8,3 | B | normal | 2 | 1 | 4,15 |
| Calibration of test set | 0,6 | B | rectangular | 2 | 1 | 0,30 |
| Influence of burden(±0,5%) | 0,1 | B | rectangular | 1,7321 | 1 | 0,06 |
| Influence of I/In(0,01·I/In) | 0,2 | B | rectangular | 1,7321 | 1 | 0,12 |
| Influence of frequency(±0,1Hz) | 0,1 | B | rectangular | 1,7321 | 1 | 0,06 |
| Reproducibility | 1,5 | B | rectangular | 1,7321 | 1 | 0,87 |
| Circuit configuration | 0,8 | B | normal | 2 | 1 | 0,40 |
| Uncertainty type A (n=10) | 0,1 | A | normal | 1 | 1 | 0,10 |
| Influence of εi and δi(±0,01·(εi or δi) | 0,04 | B | rectangular | 1,7321 | 1 | 0,02 |
| Combined uncertainty | | | | | | *4,27* |
| Expanded uncertainty | | | k=2 | | | *8,54* |

| Phase displacement uncertainty, ratio 3000/5 I/In = 1% | | | | | | |
|---|---|---|---|---|---|---|
| Source of uncertainty | Value, µrad | Type | Prob.Distr. | Divisor | $C_i$ | $u_i(y)$, µrad |
| Calibration of current comparator | 9 | B | normal | 2 | 1 | 4,50 |
| Calibration of test set | 1 | B | rectangular | 2 | 1 | 0,50 |
| Influence of burden(±0,5%) | 0,1 | B | rectangular | 1,7321 | 1 | 0,06 |
| Influence of I/In(0,01·I/In) | 0,3 | B | rectangular | 1,7321 | 1 | 0,17 |
| Influence of frequency(±0,1Hz) | 0,1 | B | rectangular | 1,7321 | 1 | 0,06 |
| Reproducibility | 2 | B | rectangular | 1,7321 | 1 | 1,15 |
| Circuit configuration | 1,5 | B | normal | 2 | 1 | 0,75 |
| Uncertainty type A (n=10) | 0,3 | A | normal | 1 | 1 | 0,30 |
| Influence of εi and δi(±0,01·(εi or δi) | 0,1 | B | rectangular | 1,7321 | 1 | 0,06 |
| Combined uncertainty | | | | | | *4,75* |
| Expanded uncertainty | | | k=2 | | | *9,49* |

**Table 21: UNIIM uncertainty budget for the current ratio error and the phase displacement for rated primary currents from 10 kA. The secondary current is 5 A. The test points vary from 1 % to 120 % and the frequency is 50 Hz.**

| Current error uncertainty, ratio 10k/5 I/In = 5-120% | | | | | | |
|---|---|---|---|---|---|---|
| Source of uncertainty | Value, ppm | Type | Prob.Distr. | Divisor | $C_i$ | $u_i(y)$, ppm |
| Calibration of current comparator | 7,5 | B | normal | 2 | 1 | 3,75 |
| Calibration of test set | 0,4 | B | rectangular | 2 | 1 | 0,20 |
| Influence of burden(±0,5%) | 0,1 | B | rectangular | 1,7321 | 1 | 0,06 |
| Influence of I/In(0,01·I/In) | 0,2 | B | rectangular | 1,7321 | 1 | 0,12 |
| Influence of frequency(±0,1Hz) | 0,1 | B | rectangular | 1,7321 | 1 | 0,06 |
| Reproducibility | 1,5 | B | rectangular | 1,7321 | 1 | 0,87 |
| Circuit configuration | 2 | B | normal | 2 | 1 | 1,00 |
| Uncertainty type A (n=10) | 0,1 | A | normal | 1 | 1 | 0,10 |
| Influence of εi and δi(±0,01·(εi or δi) | 0,06 | B | rectangular | 1,7321 | 1 | 0,03 |
| Combined uncertainty | | | | | | *3,99* |
| Expanded uncertainty | | | k=2 | | | *7,97* |

| Current error uncertainty, ratio 10k/5 I/In = 1% | | | | | | |
|---|---|---|---|---|---|---|
| Source of uncertainty | Value, ppm | Type | Prob.Distr. | Divisor | $C_i$ | $u_i(y)$, ppm |
| Calibration of current comparator | 8,5 | B | normal | 2 | 1 | 4,25 |
| Calibration of test set | 0,8 | B | rectangular | 2 | 1 | 0,40 |
| Influence of burden(±0,5%) | 0,1 | B | rectangular | 1,7321 | 1 | 0,06 |
| Influence of I/In(0,01·I/In) | 0,3 | B | rectangular | 1,7321 | 1 | 0,17 |
| Influence of frequency(±0,1Hz) | 0,1 | B | rectangular | 1,7321 | 1 | 0,06 |
| Reproducibility | 2,5 | B | rectangular | 1,7321 | 1 | 1,44 |
| Circuit configuration | 3 | B | normal | 2 | 1 | 1,50 |
| Uncertainty type A (n=10) | 0,3 | A | normal | 1 | 1 | 0,30 |
| Influence of εi and δi(±0,01·(εi or δi) | 0,1 | B | rectangular | 1,7321 | 1 | 0,06 |
| Combined uncertainty | | | | | | *4,76* |
| Expanded uncertainty | | | k=2 | | | *9,53* |

**Table: (continued)**

| Phase displacement uncertainty, ratio 10k/5 I/In = 5-120% | | | | | | |
|---|---|---|---|---|---|---|
| Source of uncertainty | Value, µrad | Type | Prob.Distr. | Divisor | $C_i$ | $u_i(y)$, µrad |
| Calibration of current comparator | 8 | B | normal | 2 | 1 | 4,00 |
| Calibration of test set | 0,6 | B | rectangular | 2 | 1 | 0,30 |
| Influence of burden(±0,5%) | 0,1 | B | rectangular | 1,7321 | 1 | 0,06 |
| Influence of I/In(0,01·I/In) | 0,2 | B | rectangular | 1,7321 | 1 | 0,12 |
| Influence of frequency(±0,1Hz) | 0,1 | B | rectangular | 1,7321 | 1 | 0,06 |
| Reproducibility | 1,5 | B | rectangular | 1,7321 | 1 | 0,87 |
| Circuit configuration | 2 | B | normal | 2 | 1 | 1,00 |
| Uncertainty type A (n=10) | 0,1 | A | normal | 1 | 1 | 0,10 |
| Influence of εi and δi(±0,01·(εi or δi) | 0,04 | B | rectangular | 1,7321 | 1 | 0,02 |
| Combined uncertainty | | | | | | *4,23* |
| Expanded uncertainty | | | k=2 | | | *8,45* |

| Phase displacement uncertainty, ratio 10k/5 I/In = 1% | | | | | | |
|---|---|---|---|---|---|---|
| Source of uncertainty | Value, µrad | Type | Prob.Distr. | Divisor | $C_i$ | $u_i(y)$, µrad |
| Calibration of current comparator | 9 | B | normal | 2 | 1 | 4,50 |
| Calibration of test set | 1 | B | rectangular | 2 | 1 | 0,50 |
| Influence of burden(±0,5%) | 0,1 | B | rectangular | 1,7321 | 1 | 0,06 |
| Influence of I/In(0,01·I/In) | 0,3 | B | rectangular | 1,7321 | 1 | 0,17 |
| Influence of frequency(±0,1Hz) | 0,1 | B | rectangular | 1,7321 | 1 | 0,06 |
| Reproducibility | 2 | B | rectangular | 1,7321 | 1 | 1,15 |
| Circuit configuration | 3 | B | normal | 2 | 1 | 1,50 |
| Uncertainty type A (n=10) | 0,3 | A | normal | 1 | 1 | 0,30 |
| Influence of εi and δi(±0,01·(εi or δi) | 0,1 | B | rectangular | 1,7321 | 1 | 0,06 |
| Combined uncertainty | | | | | | *4,92* |
| Expanded uncertainty | | | k=2 | | | *9,84* |

**Table 22: UNIIM uncertainty budget for the current ratio error and the phase displacement for rated primary currents from 30 kA. The secondary current is 5 A. The test points vary from 1 % to 120 % and the frequency is 50 Hz.**

| Current error uncertainty, ratio 30k/5 I/In = 5-120% | | | | | | |
|---|---|---|---|---|---|---|
| Source of uncertainty | Value, ppm | Type | Prob.Distr. | Divisor | $C_i$ | $u_i(y)$, ppm |
| Calibration of current comparator | 9 | B | normal | 2 | 1 | 4,50 |
| Calibration of test set | 0,4 | B | rectangular | 2 | 1 | 0,20 |
| Influence of burden(±0,5%) | 0,1 | B | rectangular | 1,7321 | 1 | 0,06 |
| Influence of I/In(0,01·I/In) | 0,2 | B | rectangular | 1,7321 | 1 | 0,12 |
| Influence of frequency(±0,1Hz) | 0,1 | B | rectangular | 1,7321 | 1 | 0,06 |
| Reproducibility | 1,5 | B | rectangular | 1,7321 | 1 | 0,87 |
| Circuit configuration | 2 | B | normal | 2 | 1 | 1,00 |
| Uncertainty type A (n=10) | 0,1 | A | normal | 1 | 1 | 0,10 |
| Influence of εi and δi(±0,01·(εi or δi) | 0,06 | B | rectangular | 1,7321 | 1 | 0,03 |
| Combined uncertainty | | | | | | *4,70* |
| Expanded uncertainty | | | k=2 | | | *9,40* |

| Current error uncertainty, ratio 30k/5 I/In = 1% | | | | | | |
|---|---|---|---|---|---|---|
| Source of uncertainty | Value, ppm | Type | Prob.Distr. | Divisor | $C_i$ | $u_i(y)$, ppm |
| Calibration of current comparator | 10 | B | normal | 2 | 1 | 5,00 |
| Calibration of test set | 0,8 | B | rectangular | 2 | 1 | 0,40 |
| Influence of burden(±0,5%) | 0,1 | B | rectangular | 1,7321 | 1 | 0,06 |
| Influence of I/In(0,01·I/In) | 0,3 | B | rectangular | 1,7321 | 1 | 0,17 |
| Influence of frequency(±0,1Hz) | 0,1 | B | rectangular | 1,7321 | 1 | 0,06 |
| Reproducibility | 2,5 | B | rectangular | 1,7321 | 1 | 1,44 |
| Circuit configuration | 3 | B | normal | 2 | 1 | 1,50 |
| Uncertainty type A (n=10) | 0,3 | A | normal | 1 | 1 | 0,30 |
| Influence of εi and δi(±0,01·(εi or δi) | 0,1 | B | rectangular | 1,7321 | 1 | 0,06 |
| Combined uncertainty | | | | | | *5,44* |
| Expanded uncertainty | | | k=2 | | | *10,89* |

**Table: (continued)**

| Phase displacement uncertainty, ratio 30k/5 I/In = 5-120% | | | | | | |
|---|---|---|---|---|---|---|
| Source of uncertainty | Value, µrad | Type | Prob.Distr. | Divisor | $C_i$ | $u_i(y)$, µrad |
| Calibration of current comparator | 10 | B | normal | 2 | 1 | 5,00 |
| Calibration of test set | 0,6 | B | rectangular | 2 | 1 | 0,30 |
| Influence of burden(±0,5%) | 0,1 | B | rectangular | 1,7321 | 1 | 0,06 |
| Influence of I/In(0,01·I/In) | 0,2 | B | rectangular | 1,7321 | 1 | 0,12 |
| Influence of frequency(±0,1Hz) | 0,1 | B | rectangular | 1,7321 | 1 | 0,06 |
| Reproducibility | 1,5 | B | rectangular | 1,7321 | 1 | 0,87 |
| Circuit configuration | 2 | B | normal | 2 | 1 | 1,00 |
| Uncertainty type A (n=10) | 0,1 | A | normal | 1 | 1 | 0,10 |
| Influence of εi and δi(±0,01·(εi or δi) | 0,04 | B | rectangular | 1,7321 | 1 | 0,02 |
| Combined uncertainty | | | | | | *5,18* |
| Expanded uncertainty | | | k=2 | | | *10,37* |

| Phase displacement uncertainty, ratio 30k/5 I/In = 1% | | | | | | |
|---|---|---|---|---|---|---|
| Source of uncertainty | Value, µrad | Type | Prob.Distr. | Divisor | $C_i$ | $u_i(y)$, µrad |
| Calibration of current comparator | 11 | B | normal | 2 | 1 | 5,50 |
| Calibration of test set | 1 | B | rectangular | 2 | 1 | 0,50 |
| Influence of burden(±0,5%) | 0,1 | B | rectangular | 1,7321 | 1 | 0,06 |
| Influence of I/In(0,01·I/In) | 0,3 | B | rectangular | 1,7321 | 1 | 0,17 |
| Influence of frequency(±0,1Hz) | 0,1 | B | rectangular | 1,7321 | 1 | 0,06 |
| Reproducibility | 2 | B | rectangular | 1,7321 | 1 | 1,15 |
| Circuit configuration | 3 | B | normal | 2 | 1 | 1,50 |
| Uncertainty type A (n=10) | 0,3 | A | normal | 1 | 1 | 0,30 |
| Influence of εi and δi(±0,01·(εi or δi) | 0,1 | B | rectangular | 1,7321 | 1 | 0,06 |
| Combined uncertainty | | | | | | *5,85* |
| Expanded uncertainty | | | k=2 | | | *11,70* |

**Table 23: UNIIM uncertainty budget for the current ratio error and the phase displacement for rated primary currents from 50 kA. The secondary current is 5 A. The test points vary from 1 % to 120 % and the frequency is 50 Hz.**

| Current error uncertainty, ratio 50k/5 I/In = 5-120% | | | | | | |
|---|---|---|---|---|---|---|
| Source of uncertainty | Value, ppm | Type | Prob.Distr. | Divisor | $C_i$ | $u_i(y)$, ppm |
| Calibration of current comparator | 11 | B | normal | 2 | 1 | 5,50 |
| Calibration of test set | 0,4 | B | rectangular | 2 | 1 | 0,20 |
| Influence of burden(±0,5%) | 0,1 | B | rectangular | 1,7321 | 1 | 0,06 |
| Influence of I/In(0,01·I/In) | 0,2 | B | rectangular | 1,7321 | 1 | 0,12 |
| Influence of frequency(±0,1Hz) | 0,1 | B | rectangular | 1,7321 | 1 | 0,06 |
| Reproducibility | 2 | B | rectangular | 1,7321 | 1 | 1,15 |
| Circuit configuration | 3 | B | normal | 2 | 1 | 1,50 |
| Uncertainty type A (n=10) | 0,1 | A | normal | 1 | 1 | 0,10 |
| Influence of εi and δi(±0,01·(εi or δi) | 0,06 | B | rectangular | 1,7321 | 1 | 0,03 |
| Combined uncertainty | | | | | | *5,82* |
| Expanded uncertainty | | | k=2 | | | *11,65* |

| Current error uncertainty, ratio 50k/5 I/In = 1% | | | | | | |
|---|---|---|---|---|---|---|
| Source of uncertainty | Value, ppm | Type | Prob.Distr. | Divisor | $C_i$ | $u_i(y)$, ppm |
| Calibration of current comparator | 12 | B | normal | 2 | 1 | 6,00 |
| Calibration of test set | 0,8 | B | rectangular | 2 | 1 | 0,40 |
| Influence of burden(±0,5%) | 0,1 | B | rectangular | 1,7321 | 1 | 0,06 |
| Influence of I/In(0,01·I/In) | 0,3 | B | rectangular | 1,7321 | 1 | 0,17 |
| Influence of frequency(±0,1Hz) | 0,1 | B | rectangular | 1,7321 | 1 | 0,06 |
| Reproducibility | 3 | B | rectangular | 1,7321 | 1 | 1,73 |
| Circuit configuration | 4 | B | normal | 2 | 1 | 2,00 |
| Uncertainty type A (n=10) | 0,3 | A | normal | 1 | 1 | 0,30 |
| Influence of εi and δi(±0,01·(εi or δi) | 0,1 | B | rectangular | 1,7321 | 1 | 0,06 |
| Combined uncertainty | | | | | | *6,58* |
| Expanded uncertainty | | | k=2 | | | *13,16* |

**Table: (continued)**

| Phase displacement uncertainty, ratio 50k/5 I/In = 5-120% | | | | | | |
|---|---|---|---|---|---|---|
| Source of uncertainty | Value, µrad | Type | Prob.Distr. | Divisor | $C_i$ | $u_i(y)$, µrad |
| Calibration of current comparator | 12 | B | normal | 2 | 1 | 6,00 |
| Calibration of test set | 0,6 | B | rectangular | 2 | 1 | 0,30 |
| Influence of burden(±0,5%) | 0,1 | B | rectangular | 1,7321 | 1 | 0,06 |
| Influence of I/In(0,01·I/In) | 0,2 | B | rectangular | 1,7321 | 1 | 0,12 |
| Influence of frequency(±0,1Hz) | 0,1 | B | rectangular | 1,7321 | 1 | 0,06 |
| Reproducibility | 2 | B | rectangular | 1,7321 | 1 | 1,15 |
| Circuit configuration | 3 | B | normal | 2 | 1 | 1,50 |
| Uncertainty type A (n=10) | 0,1 | A | normal | 1 | 1 | 0,10 |
| Influence of εi and δi(±0,01·(εi or δi) | 0,04 | B | rectangular | 1,7321 | 1 | 0,02 |
| Combined uncertainty | | | | | | *6,30* |
| Expanded uncertainty | | | k=2 | | | *12,60* |

| Phase displacement uncertainty, ratio 50k/5 I/In = 1% | | | | | | |
|---|---|---|---|---|---|---|
| Source of uncertainty | Value, µrad | Type | Prob.Distr. | Divisor | $C_i$ | $u_i(y)$, µrad |
| Calibration of current comparator | 13 | B | normal | 2 | 1 | 6,50 |
| Calibration of test set | 1,2 | B | rectangular | 2 | 1 | 0,60 |
| Influence of burden(±0,5%) | 0,1 | B | rectangular | 1,7321 | 1 | 0,06 |
| Influence of I/In(0,01·I/In) | 0,3 | B | rectangular | 1,7321 | 1 | 0,17 |
| Influence of frequency(±0,1Hz) | 0,1 | B | rectangular | 1,7321 | 1 | 0,06 |
| Reproducibility | 2,5 | B | rectangular | 1,7321 | 1 | 1,44 |
| Circuit configuration | 4 | B | normal | 2 | 1 | 2,00 |
| Uncertainty type A (n=10) | 0,3 | A | normal | 1 | 1 | 0,30 |
| Influence of εi and δi(±0,01·(εi or δi) | 0,1 | B | rectangular | 1,7321 | 1 | 0,06 |
| Combined uncertainty | | | | | | *6,99* |
| Expanded uncertainty | | | k=2 | | | *13,97* |