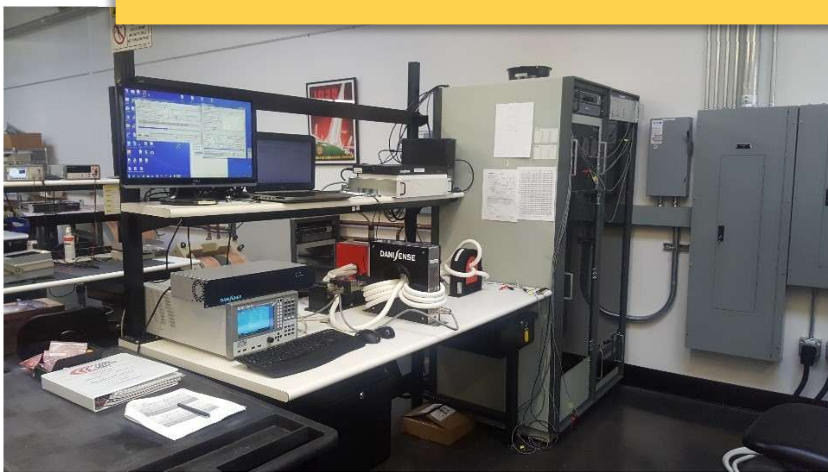
Application Note: Low-Current AC Measurements with Danisense DCCTs

Filippos Toufexis, PhD



Overview

Danisense DCCTs offer excellent precision and high dynamic range. Although most customers use these sensors to measure hundreds or thousands of amperes, we often receive questions about measuring down to single-digit amperes or even below 1 A. This Application Note shows AC 60 Hz measurements at low current up to 3 A with a DS50ID and DN1000ID, rated at 50 Arms and 1000 Arms, respectively.

Since this current range is too low for the GMW 17025 Accredited Calibration Station, we created the setup shown in Figure 1. A Variac with a current-limiting resistor is used to generate AC 60 Hz test currents between 100 mA and 3 A. The current going through the aperture of the DUT and the output of the DUT are directly measured on a 2-channel Zimmer LMG640 Power Analyzer that has accuracy of 0.015% of measured value + 0.01% of range.

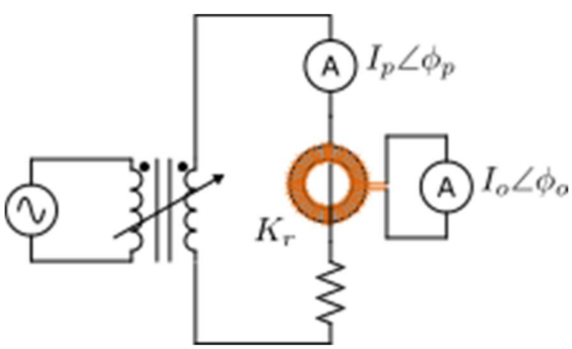


Figure 1: Measurement Setup Schematic.

Equipment

- Danisense Current Transducer
- Measurement Instrument such as a Power Analyzer

Applications

- Current Measurements requiring High Dynamic Range.

Measurements

Using the test setup of Figure 1, we measured the primary current amplitude I_P, the secondary (transducer's output) current amplitude I_o, and the phase difference or Phase Displacement Error $\Delta\phi = \phi_o - \phi_p$. From these measurements, we can calculate the Transformer Ratio Error

$$\epsilon = \frac{K_r - K}{K} = \frac{K_r I_o}{I_p} - 1, \tag{1}$$

where K_r is the rated transducer ratio and K is the actual, yet unknown, transducer ratio. At each primary current point we took 50 measurements, calculated the statistics, and performed uncertainty calculations. Figure 2 shows the Transformer Ratio Error and its Uncertainty versus primary current for the two transducers. Figure 3 shows the Phase Displacement Error and its Uncertainty versus primary current for the two transducers.

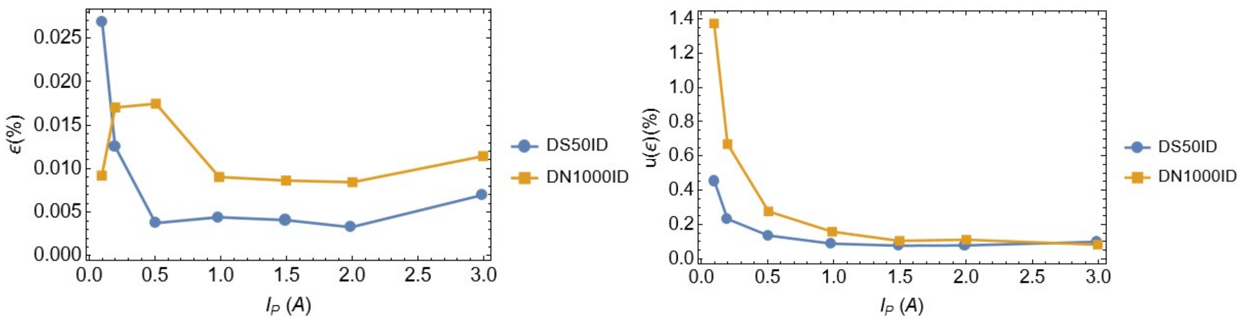


Figure 2: Error Ratio and its Uncertainty.

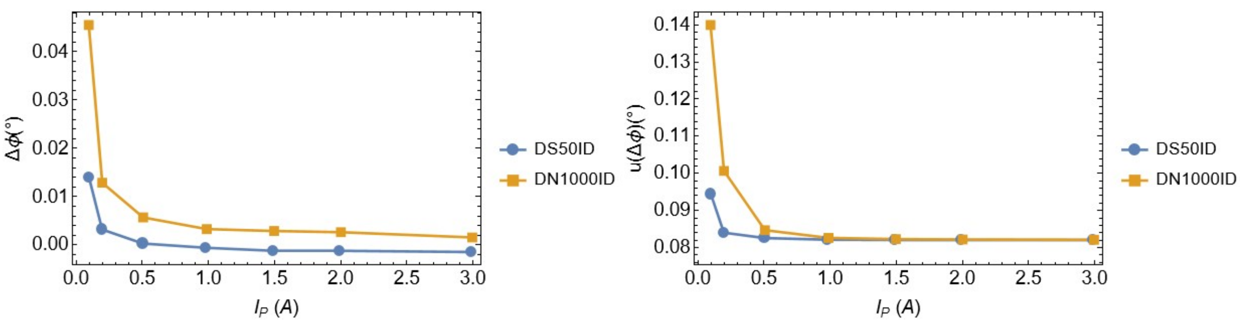


Figure 3: Phase Displacement Error and its Uncertainty.

We can clearly see that both transducers remain accurate even below 1 A, both in terms of amplitude and phase. We can observe that uncertainty does increase with reduced primary current as it is dominated by noise. The DS50ID behaves better than the DN1000ID that is expected given the difference in nominal current rating. Note that we are effectively trying to measure quantities near zero for both the Transformer Ratio Error and Phase Displacement Error, and therefore it is normal for the uncertainty to be larger than the measurand.

Attachments

- DS50ID AC 60 Hz Accredited Calibration Certificate.
- DN1000ID AC 60 Hz Accredited Calibration Certificate.

GMW Associates

ACCREDITED CERT #4349.01

ISO 17025 Accredited Certificate of Calibration

Customer Details

Customer	GMW Calibration Lab	**Order Number**	ILC-000058
Address	955 Industrial Road		
City, State	San Carlos, CA 94070, USA		

Instrument Details

Manufacturer	Danisense	**Date Received**	Nov 12, 2025
Model	DS50ID	**Controller Model**	N/A
Serial Number	24190492010	**Controller SN**	N/A
Description	Current Transducer		

Calibration Details

Certificate #	GMW-CT-13377	**Calibration Date**	Nov 12, 2025
Calibration Level	Accredited	**Next Due Date**	N/A
Incoming Condition		**Outgoing Condition**	
New		New	

Test Details

Test Frequency	60 Hz	**Actual Frequency***	60 Hz
Temperature	21 °C	**Humidity**	57 %
REF Prim. Turns	1	**DUT Prim. Turns**	1
REF Meas. Instr. SN	06902402	**Channel / Input**	Ch. 1 / Current
DUT Meas. Instr. SN	06902402	**Channel / Input**	Ch. 2 / Current
Calibration Site	GMW Associates, 955 Industrial Rd, San Carlos, CA 94070		

Calibrated by	**Authorized by**
Miguel Llamas	Filippos Toufexis
Senior Electro-Mechanical Technician	VP of Engineering
Nov 12, 2025	Nov 12, 2025

Notes

The customer is obligated to have the equipment calibrated at appropriate intervals.

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This report cannot be used to claim product endorsement by A2LA or any other agencies.

*Non-Accredited Quantity.

Calibration Procedure

Reference Transducer Comparison Method: the customer's transducer (DUT) is compared against a reference transducer (REF).

Calibration Results Summary

Transformer Ratio[1,2]	$K = 500.01\,\mathrm{A}_{RMS}/\mathrm{A}_{RMS}$ (Primary/Output)
Linear Fit[1,3]	$X_o\,(\mathrm{A}_{RMS}) = -0.000000758822 + 0.00199996 I_P\,(\mathrm{A}_{RMS})$ with $R^2 = 1$.
Linearity Error[1]	$\epsilon_L = 0.00023\,\%$
Accredited Data	Refer to Tables 1 and 2, and Figures 1, 2, and 3.
Past Data[4]	No past data available.

[1] Non-Accredited quantity.
[2] Inferred from the Linear Fit.
[3] Performed on the data of Table 1.
[4] From GMW's archive for current transducer SN 24190492010.

Definitions

The **Transformer Ratio Error** ϵ, or simply **Ratio Error**, is defined as:

$$\epsilon = \frac{K_r - K}{K} = \frac{K_r X_o - I_P}{I_P}$$

and is expressed in %. K_r is the Rated Transformer Ratio per the manufacturer, K is the measured Transformer Ratio, X_o is the current transducer output, and I_P is the primary current (including primary turns).

The **Linearity Error** ϵ_L is defined as the RMS deviation of the data points from the identified linear fit, i.e. a line with slope $1/K$ and some offset, normalized to nominal current.

The **Phase Displacement** $\Delta\phi$ is defined as the difference between the phase of the transducer output and the phase of the primary current.

Measurement Uncertainty

The estimated uncertainties of the Ratio Errors $u(\epsilon)$ and Phase Displacements $u(\Delta\phi)$ listed in Tables 1 and 2 are expanded uncertainties for a coverage factor $k = 2$ that corresponds to confidence interval of approximately 95%, and includes Type A uncertainty and the Type B uncertainty of the GMW Calibration System. The uncertainty due to the effect of non-symmetrical primary return conductors is not included.

Statement of Traceability

This calibration was conducted using standards traceable to the International System of Units (SI) through either an accredited ISO laboratory or National Measurement Institute (NMI).

Calibration Instruments & Standards

Serial Number	Manufacturer	Model	Recall Date
17260290060	Danisense	DS2000ICLA	Aug 07, 2026
E27674	Dracal Technologies Inc	VCP-TRH450-CAL	Oct 27, 2026
06902402	ZES Zimmer	LMG641	Mar 03, 2026

Table 1: Accredited Calibration Ratio Error Results for the Danisense DS50ID with SN 24190492010.

Primary Current[1,2] (A_{RMS})	Output[2] (A_{RMS})	Ratio[2] K	Ratio Error ϵ (%)	$\pm u(\epsilon)$ (%)
10.9036	0.021806	500.026	−0.0052	0.053
19.1634	0.038326	500.014	−0.0028	0.05
29.0179	0.058033	500.028	−0.0056	0.05
39.1552	0.078309	500.01	−0.002	0.05
48.9576	0.097912	500.015	−0.0029	0.05

[1] Calculated using the reference transducer.
[2] Non-Accredited quantity.

Figure 1: Output versus Primary Current.

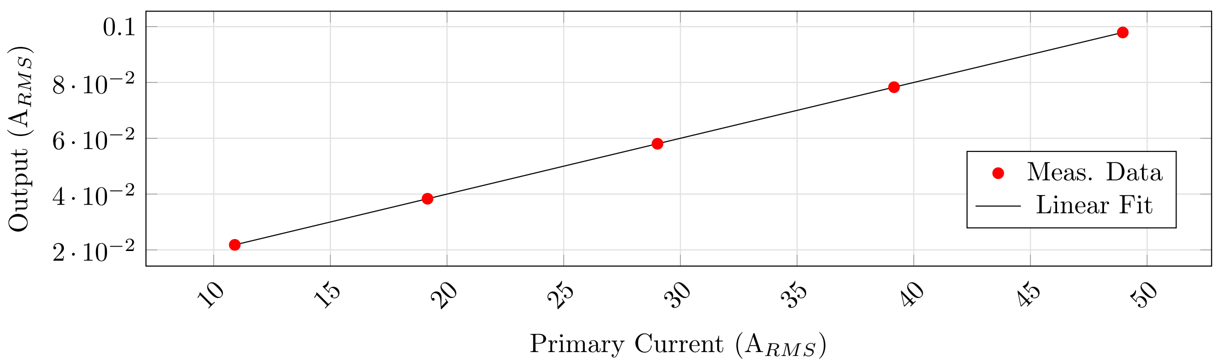


Figure 2: Transformer Ratio Error versus Primary Current.

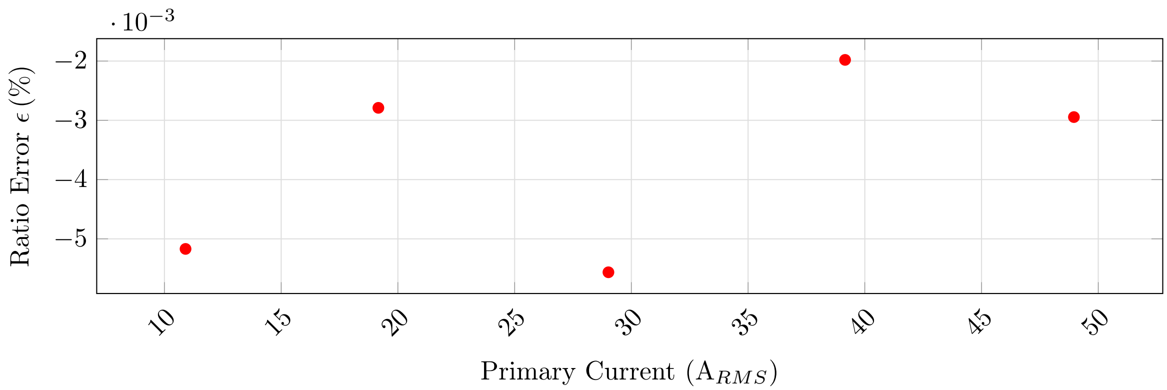
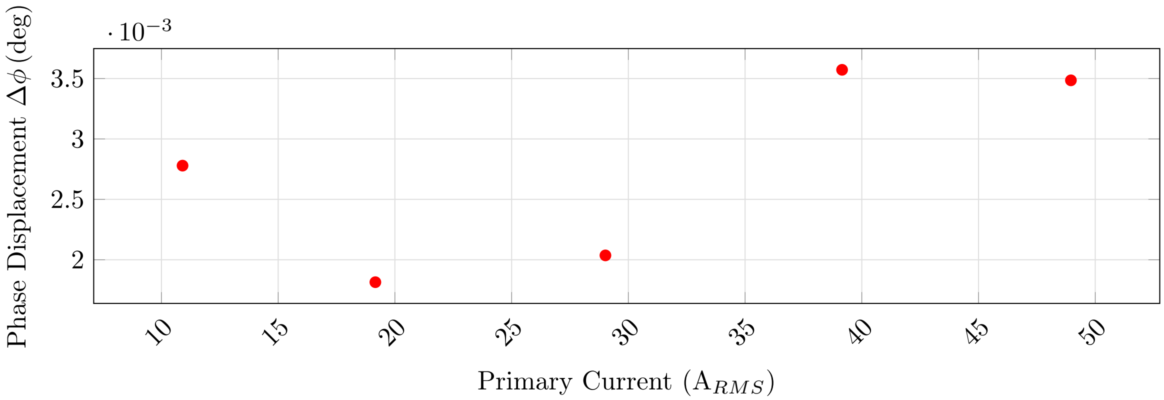


Table 2: Accredited Calibration Phase Displacement Results for the Danisense DS50ID with SN 24190492010.

Primary Current[1] (A_{RMS})	Phase Displacement $\Delta\phi$ (deg)	$\pm u\,(\Delta\phi)$ (deg)
10.9036	0.0028	0.09
19.1634	0.0018	0.09
29.0179	0.002	0.09
39.1552	0.0036	0.09
48.9576	0.0035	0.09

[1] Calculated using the reference transducer, Non-Accredited quantity.

Figure 3: Phase Displacement versus Primary Current.



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GMW Associates

ACCREDITED CERT #4349.01

ISO 17025 Accredited Certificate of Calibration

Customer Details

Customer	GMW Calibration Lab	**Order Number**	ILC-000058
Address	955 Industrial Road		
City, State	San Carlos, CA 94070, USA		

Instrument Details

Manufacturer	Danisense	**Date Received**	Nov 12, 2025
Model	DN1000ID	**Controller Model**	N/A
Serial Number	25280702011	**Controller SN**	N/A
Description	Current Transducer		

Calibration Details

Certificate #	GMW-CT-13378	**Calibration Date**	Nov 12, 2025
Calibration Level	Accredited	**Next Due Date**	N/A
Incoming Condition		**Outgoing Condition**	
New		New	

Test Details

Test Frequency	60 Hz	**Actual Frequency***	59.998 Hz
Temperature	21 °C	**Humidity**	57 %
REF Prim. Turns	1	**DUT Prim. Turns**	1
REF Meas. Instr. SN	06902402	**Channel / Input**	Ch. 1 / Current
DUT Meas. Instr. SN	06902402	**Channel / Input**	Ch. 2 / Current
Calibration Site	GMW Associates, 955 Industrial Rd, San Carlos, CA 94070		

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Calibration Procedure

Reference Transducer Comparison Method: the customer's transducer (DUT) is compared against a reference transducer (REF).

Calibration Results Summary

Transformer Ratio[1,2]	$K = 1{,}500.051\,\mathrm{A}_{RMS}/\mathrm{A}_{RMS}$ (Primary/Output)
Linear Fit[1,3]	$X_o\,(\mathrm{A}_{RMS}) = 0.00000237071 + 0.000666644 I_P\,(\mathrm{A}_{RMS})$ with $R^2 = 1$.
Linearity Error[1]	$\epsilon_L = 0.00056\,\%$
Accredited Data	Refer to Tables 1 and 2, and Figures 1, 2, and 3.
Past Data[4]	No past data available.

[1] Non-Accredited quantity.
[2] Inferred from the Linear Fit.
[3] Performed on the data of Table 1.
[4] From GMW's archive for current transducer SN 25280702011.

Definitions

The **Transformer Ratio Error** ϵ, or simply **Ratio Error**, is defined as:

$$\epsilon = \frac{K_r - K}{K} = \frac{K_r X_o - I_P}{I_P}$$

and is expressed in %. K_r is the Rated Transformer Ratio per the manufacturer, K is the measured Transformer Ratio, X_o is the current transducer output, and I_P is the primary current (including primary turns).

The **Linearity Error** ϵ_L is defined as the RMS deviation of the data points from the identified linear fit, i.e. a line with slope $1/K$ and some offset, normalized to nominal current.

The **Phase Displacement** $\Delta\phi$ is defined as the difference between the phase of the transducer output and the phase of the primary current.

Measurement Uncertainty

The estimated uncertainties of the Ratio Errors $u\,(\epsilon)$ and Phase Displacements $u\,(\Delta\phi)$ listed in Tables 1 and 2 are expanded uncertainties for a coverage factor $k = 2$ that corresponds to confidence interval of approximately 95%, and includes Type A uncertainty and the Type B uncertainty of the GMW Calibration System. The uncertainty due to the effect of non-symmetrical primary return conductors is not included.

Statement of Traceability

This calibration was conducted using standards traceable to the International System of Units (SI) through either an accredited ISO laboratory or National Measurement Institute (NMI).

Calibration Instruments & Standards

Serial Number	**Manufacturer**	**Model**	**Recall Date**
17260290060	Danisense	DS2000ICLA	Aug 07, 2026
E27674	Dracal Technologies Inc	VCP-TRH450-CAL	Oct 27, 2026
06902402	ZES Zimmer	LMG641	Mar 03, 2026

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Table 1: Accredited Calibration Ratio Error Results for the Danisense DN1000ID with SN 25280702011.

Primary Current[1,2] (A_{RMS})	Output[2] (A_{RMS})	Ratio[2] K	Ratio Error ϵ (%)	$\pm u(\epsilon)$ (%)
200.774	0.133844	1,500.06	−0.0039	0.05
398.985	0.265982	1,500.05	−0.003	0.05
599.203	0.399462	1,500.03	−0.0017	0.05
798.914	0.532599	1,500.03	−0.0019	0.05
999.121	0.666054	1,500.06	−0.0041	0.05

[1] Calculated using the reference transducer.
[2] Non-Accredited quantity.

Figure 1: Output versus Primary Current.

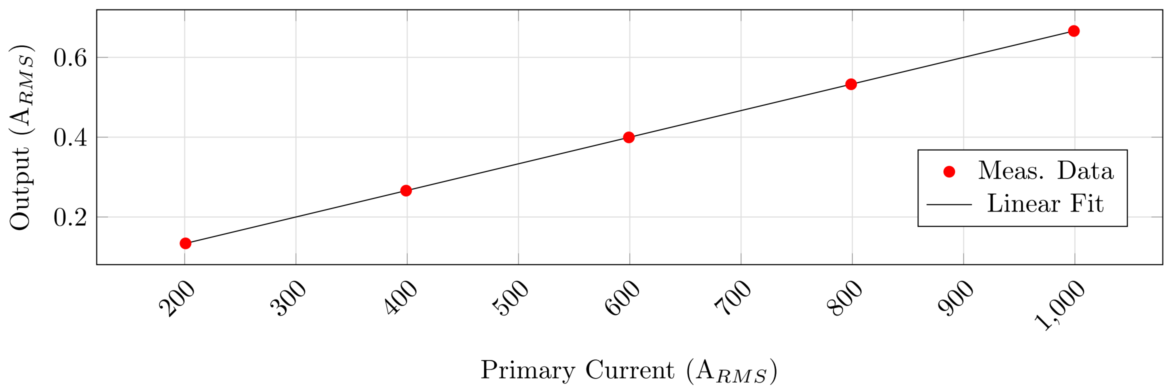

Figure 2: Transformer Ratio Error versus Primary Current.

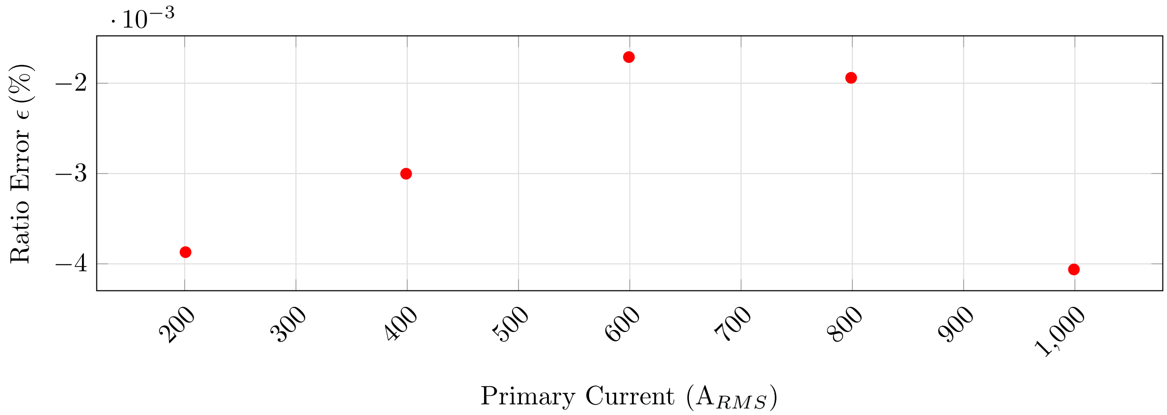

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Table 2: Accredited Calibration Phase Displacement Results for the Danisense DN1000ID with SN 25280702011.

Primary Current[1] (A_{RMS})	Phase Displacement $\Delta\phi$ (deg)	$\pm u\,(\Delta\phi)$ (deg)
200.774	0.00044	0.09
398.985	0.00044	0.09
599.203	0.00029	0.09
798.914	0.00031	0.09
999.121	−0.0013	0.09

[1] Calculated using the reference transducer, Non-Accredited quantity.

Figure 3: Phase Displacement versus Primary Current.