DC-CT-1000I-S22DA
Compact and Low Power 200 ppm 1000 A Current Transducer

The DC-CT-1000I-S22DA is a compact and accurate 1000 A zero-flux current transducer based on ISOTEL proprietary technology and the patented Platiše Flux Sensor (PFS).

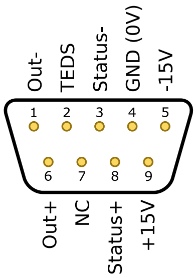
It features a typical DSUB interface with a 22 mm opening in an aluminium chassis delivering 500 kHz of flat bandwidth, 100 ppm linearity, and a total offset including hysteresis below 100 ppm FS. It boasts a low standby power consumption of 0.5 W with a flexible unipolar/bipolar power supply and differential current output.

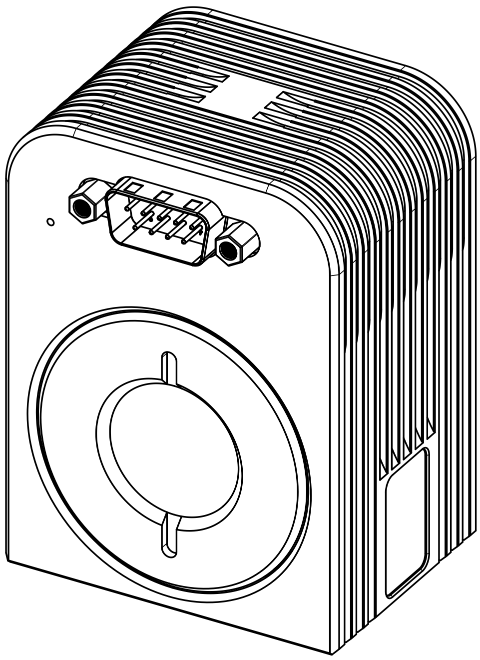
Applications

- Test and measuring equipment
- DC and AC metering
- Power quality analysis in mains
- Stable precision power supplies
- Battery management systems
- Electrical vehicle chargers

Key Specifications

- Round opening 22 mm diameter
- Rated primary current I_P =1000 A_{DC}, 700 A_{AC}
- Linearity <100 ppm
- Typical offset including hysteresis <100 mA RTI
- Bandwidth 500 kHz @ -0.5 dB
- Immunity <50 mA RTI at 5 mT in any direction
- CMRR <TBD μA/V @ 100 kHz
- TEDS (Current Loop Output Sensors Template)
- Range OK signal
- Power supply: unipolar 30 V or bipolar ±15 V with floating current output
- Standby power consumption 0.5 W
- Typical power consumption 6.6 W at rated I_P
- Withstands rated DC/AC primary currents without being powered
- Operational range -40 to 85 °C





1 Electrical Characteristics

Description	Symbol	Min	Typ	Max	Unit	Fig
DC Accuracy						
Rated/Nominal Measuring Current DC	I_P	-1000	..	$+1000$	A	
Rated/Nominal Measuring Current AC RMS	$I_{P(AC)}$		..	700	A	
Max Measuring Current Range	I_{Pmax}	TBD	..	TBD	A	
Max Overloading Current	I_{POV}		TBD		kA	
Nominal Secondary Current at I_P	I_S	-595.238	..	$+595.238$	mA	
Nominal Burden Resistance		0	1	3	Ω	20
Transformer Ratio	N		1680		turns	
Transformer/Gain Off-Center Error			< 20	< 50	ppm	7,8
Gain Linearity at rated 1000 A range	G_ϵ		83	< 100	ppm	5
Offset, including Hysteresis RTI	I_H		65	< 100	mA	6
Long Term Stability at $I_P = 700$ A$_{RMS}$			TBD	TBD	ppm	
AC Accuracy						
Frequency Bandwidth @ -0.5 dB, $I_P = 0.8$ A$_{RMS}$	$f_{-0.5dB}$		500		kHz	
Frequency Bandwidth @ -3 dB, $I_P = 0.7$ A$_{RMS}$	f_{-3dB}		750		kHz	
AC Flatness			TBD			
Phase Shift			TBD			
RMS Noise at 10 kHz and entire T_A		0.4	0.6	1.3	mA	13
... 100 kHz and entire T_A		0.8	1.2	2.0	mA	14
... 1 MHz and entire T_A		5.4	5.5	6.5	mA	15
Platiše Flux Sensor Frequency (seen as ripple)	f_{PFS}		220		kHz	15..18
D-Class Switching Frequency (seen as ripple)	f_{DClass}		750		kHz	15..18
Signal Integrity						
Tracking Current dI/dt			TBD		A/μs	
Time to Out of Range Detection to Status Deasserted			300		μs	
Power-up Time to Status Asserted			100	< 150	ms	21
Primary to Secondary Maximum Difference RTI	I_{MD}		± 1500		mA	
Status Open Collector Max Current			25	50	mA	
Status Open Collector Max Voltage		-5	60	80	V	
Immunity						
Common Mode Rejection @ 100 kHz RTI			TBD		μA/V	

Description	Symbol	Min	Typ	Max	Unit	Fig
Immunity to external magnetic field, 5 mT in any direction RTI	I_{XB}		± 30	< 50	mA	
Noise Injection into Primary						
Induced RMS voltage on primary conductor at $I_P = 0$			32		μV	
Induced RMS voltage on primary conductor during Search			1223		μV	
Power Supply						
Power Supply Voltage between pin 9 and 5		24	30	35	V	
Power Supply Maximum In-rush/working current @ 30 V				< 0.5	A	21
500 A Range Power Supply Voltage		12	30	35	V	
Standby (Idle) Power Consumption			0.56	0.7	W	
Power Consumption at $I_P = 500$ A and Burden 3 Ω				3	W	
... at $I_P = 1000$ A and Burden 1 Ω			6.6	8	W	
... at $I_P = 1000$ A and Burden 3 Ω			7.6	9	W	
Environmental Conditions						
Isolation CAT II / CAT III non-insulated wire			1000/600		V	
Isolation CAT II / CAT III insulated wire			1000		V	
Clearance / Creepage			12		mm	
Weight	m			500	g	
Storage and Operating Temperature	T_A	-40		$+85$	°C	

1.1 Accuracy

1.1.1 Linearity and Offset due to Hysteresis

The following typical characteristics have been obtained at a nominal power supply of ±15 V (NGE100), a burden resistor of 1 Ω, a cable length between DC-CT and a burden resistor of 5 m, DMM Keithley DMM7510, the IN2000S reference current sensor, an ambient temperature T_A of 23 ±5 $^\circ C$, a primary conductor of a square bar 15x15 mm in the center position, and a total measurement uncertainty of the system of 21 mA @ 1000 A. Before each measurement, DC-CT-1000I was restarted.

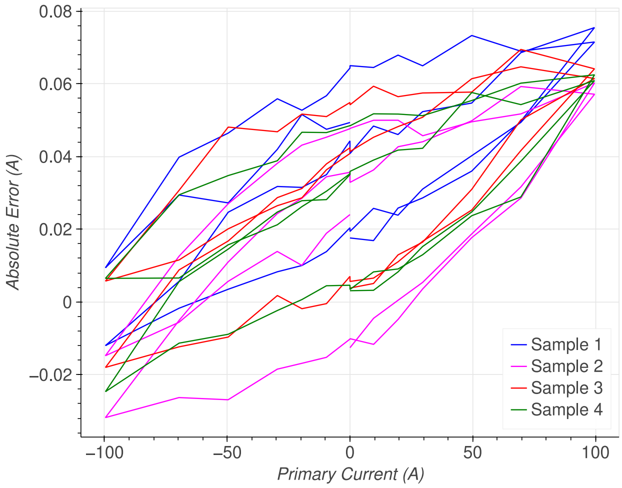


Figure 1: Typical Accuracy at I_P=±100 A

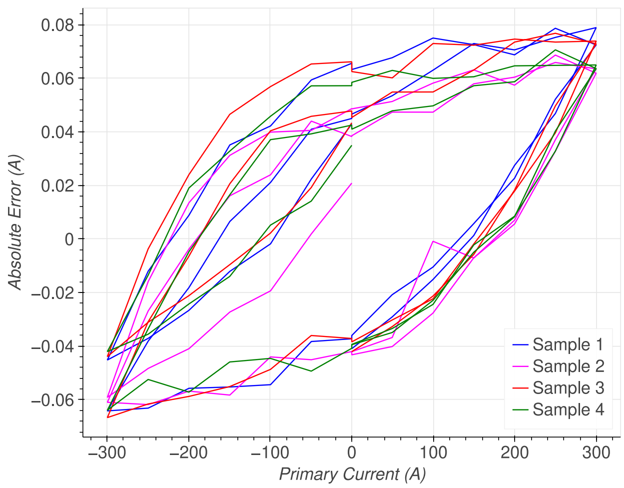


Figure 2: Typical Accuracy at I_P=±300 A

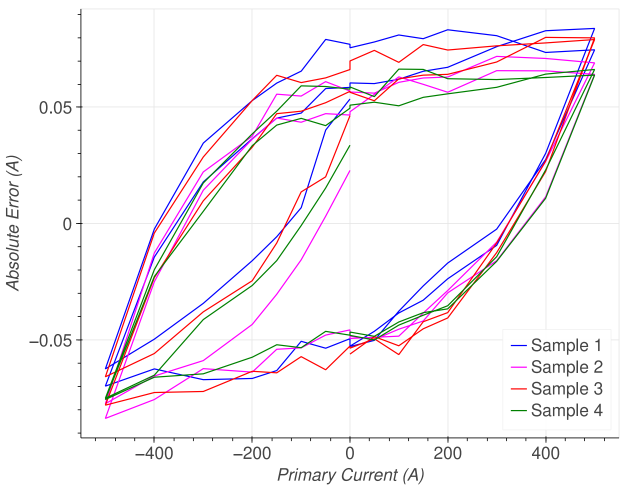


Figure 3: Typical Accuracy at I_P=±500 A

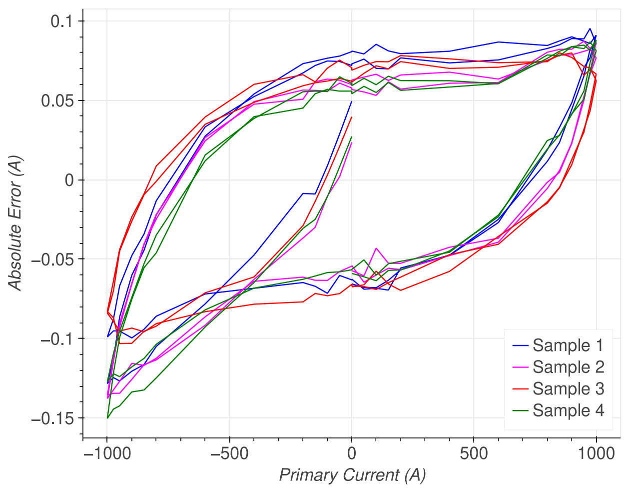


Figure 4: Typical Accuracy at I_P=±1000 A

The following two figures represent non-linearity as the maximum distance from the BFSL (best-fit-straight-line) vs primary current and peak-to-peak hysteresis amplitude vs primary current, calculated from the given ±100 A, ±300, ±500, and ±1000 A characteristics above.

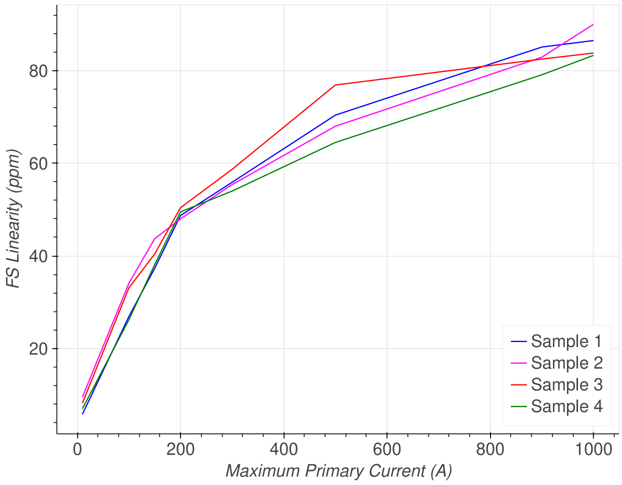


Figure 5: Linearity Referred to Full Scale I_P=1000 A

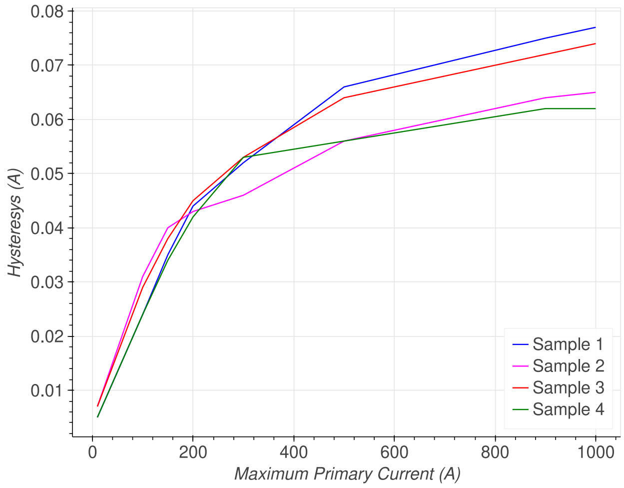


Figure 6: Offset (Hysteresis) vs. I_P

1.1.2 Off-Center Error

The following figures show the effect of the position of the primary conductor on the accuracy versus current in the primary conductor.

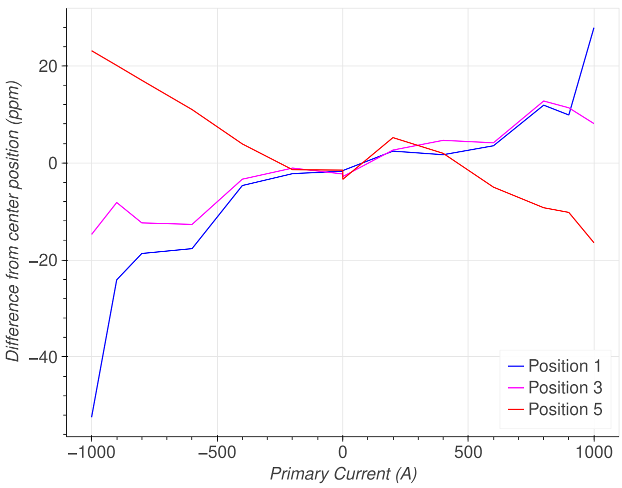


Figure 7: Position Error vs Test Location relative to Location 0

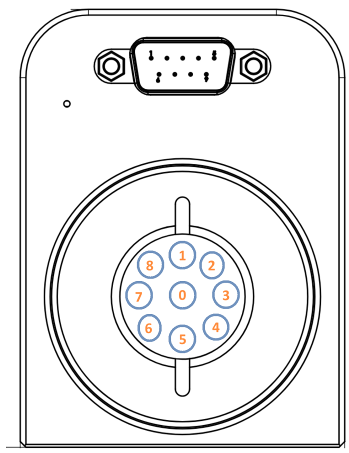


Figure 8: Position Error Test Locations

1.1.3 2000 A Peak-to-Peak Cycling Test

The following test shows a sequence test with current cycling, representing the primary current and the absolute error:

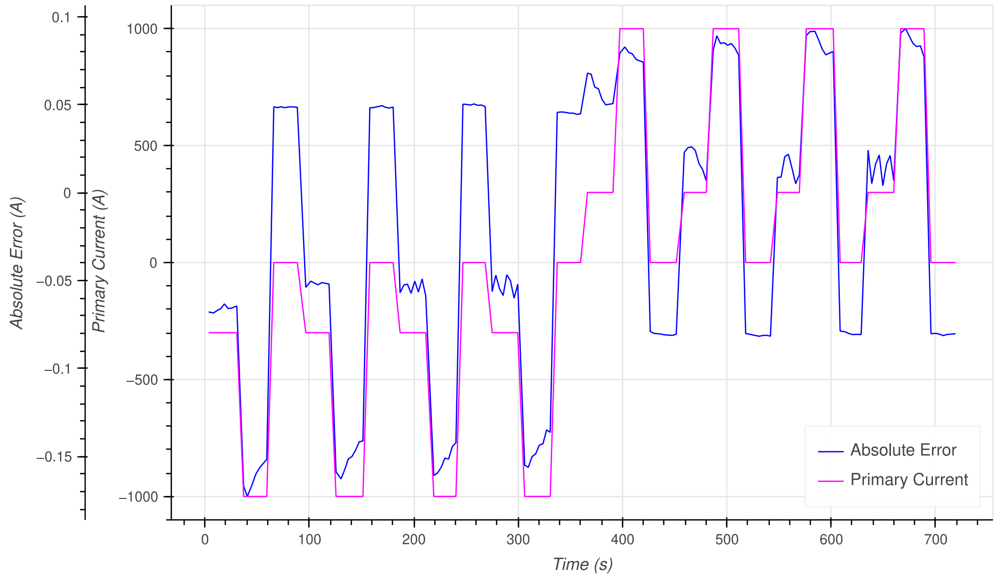


Figure 9: Cycling Test at $T_A = 23 \pm 5\ ^{\circ}C$

1.1.4 AC Response

Figure 8 depicts the typical small signal response at 0.8 A_{RMS}. The large signal response up to 1500 Hz is TBD.

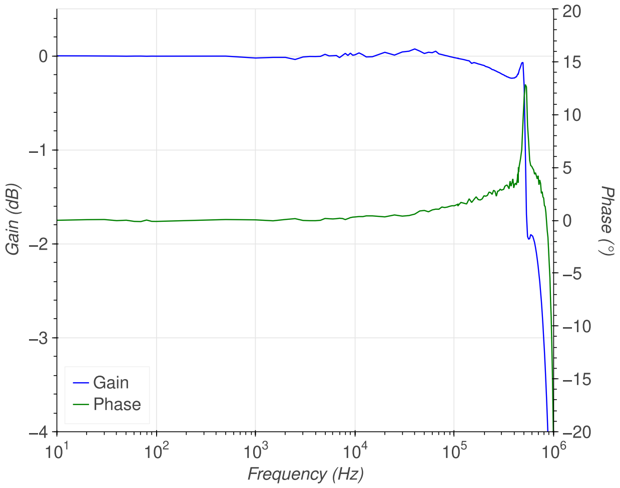


Figure 10: Small Signal AC Response at $I_P \approx 0.8$ A_{RMS}

1.2 Temperature Drift

1.2.1 Offset Drifting

The following two tests were performed using a burden resistor 2.5 Ω and the current source reference is Fluke 5502A. The first chart represents the sensor output at I_P=0 A and the intentionally magnetized core (offset) to the maximum possible value. The second chart represents the drift from -35 $^\circ C$ and magnetized cores at a constant current of 100 A. It has been determined that temperature stress in whatever direction reduces the offset resulting from the hysteresis.

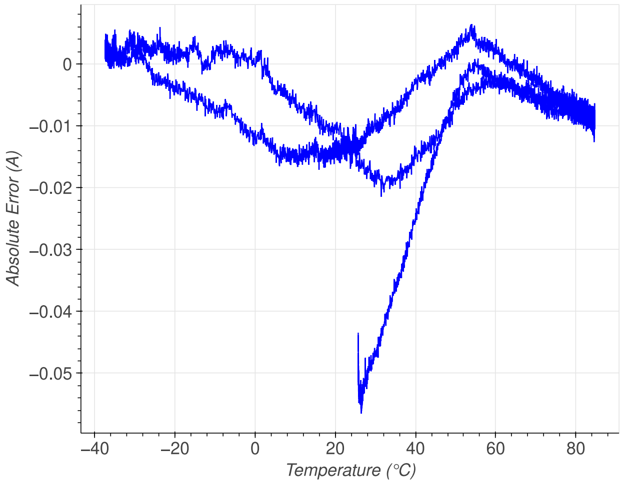


Figure 11: Temperature Drift at I_P= 0 A

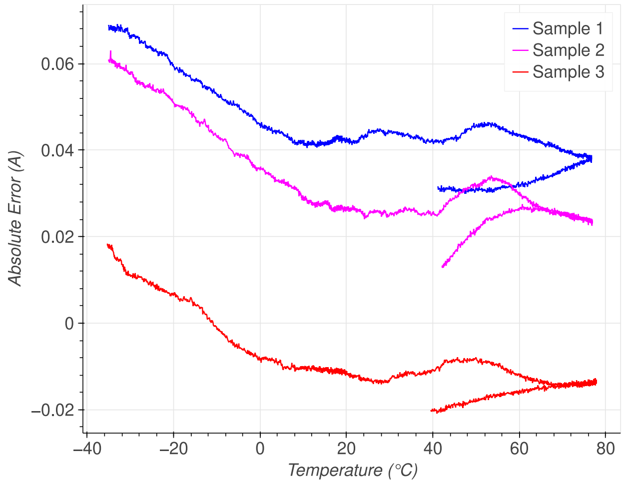


Figure 12: Temperature Drift at I_P= 100 A

1.3 Noise

Noise was evaluated using the INA849 amplifier with G=501, 2.5 Ω burden resistor and R&S RTO1004, and a primary current I_P of 0 A.

1.3.1 100 kHz Bandwidth Noise

These charts represent the worst-case noise from 3 samples at different temperatures for 10 and 100 kHz bandwidth.

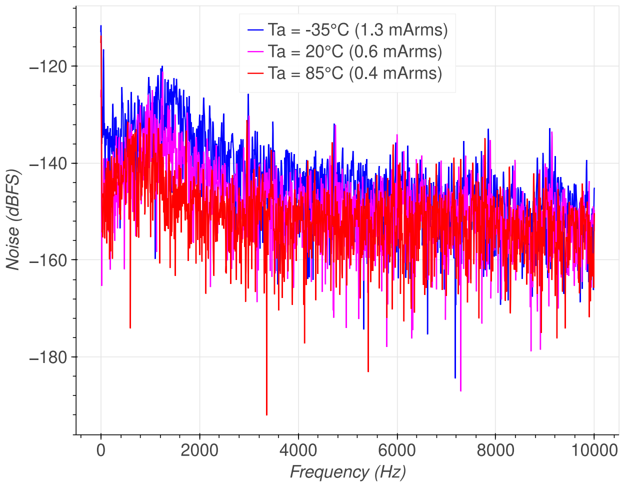


Figure 13: Noise spectrum vs T_A up to 10 kHz

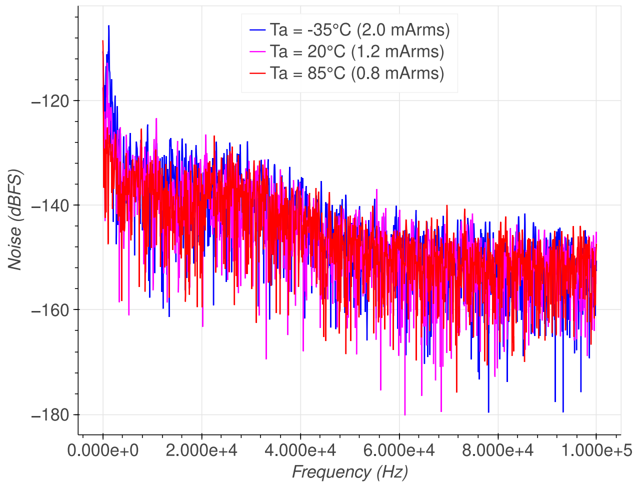


Figure 14: Noise spectrum vs T_A up to 100 kHz

1.3.2 1 MHz Bandwidth Noise and Ripple

As most of the noise and ripple lies in the upper band above 200 kHz, the first chart represents the worst-case spectrum at different temperatures at 1 MHz bandwidth. The subsequent three charts represent the averaged spectrums at different temperatures to represent the ripple from different internal switching sources.

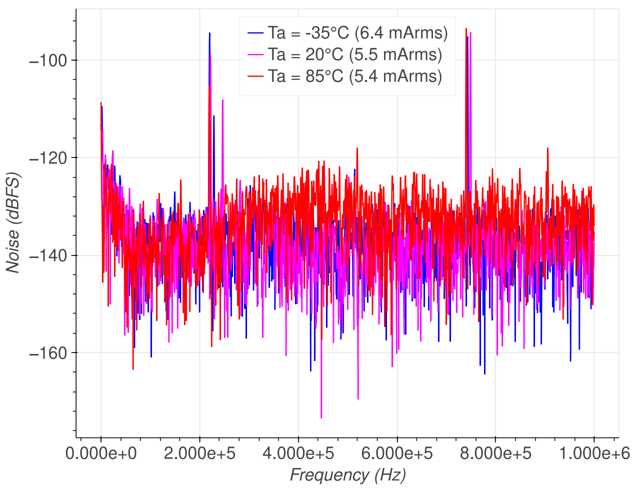


Figure 15: Noise spectrum vs T_A up to 1 MHz

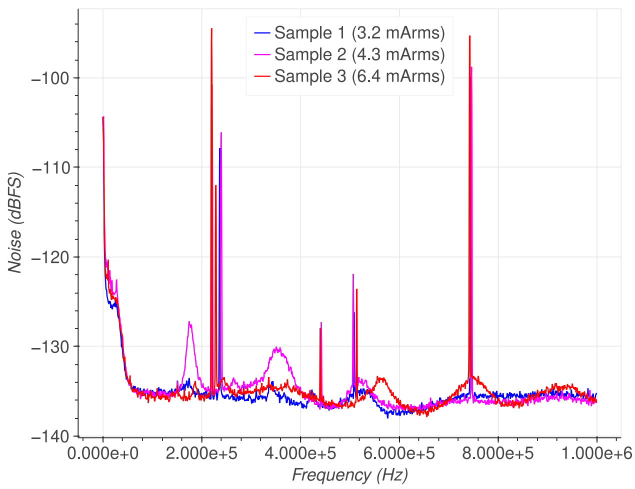


Figure 16: Averaged noise spectrum at T_A= -35 °C

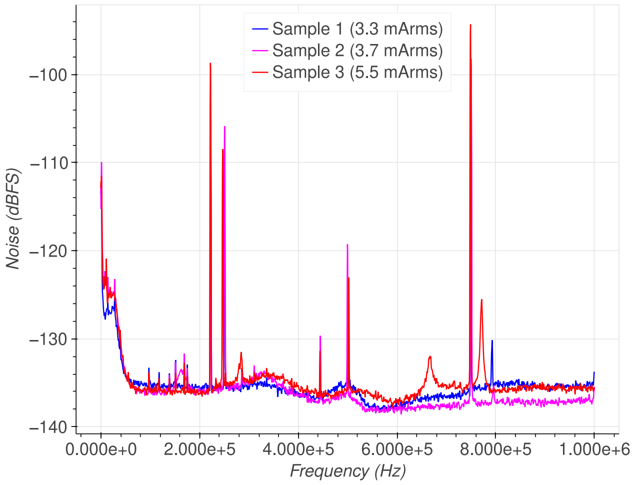


Figure 17: Averaged noise spectrum at $T_A = 20\ ^{\circ}C$

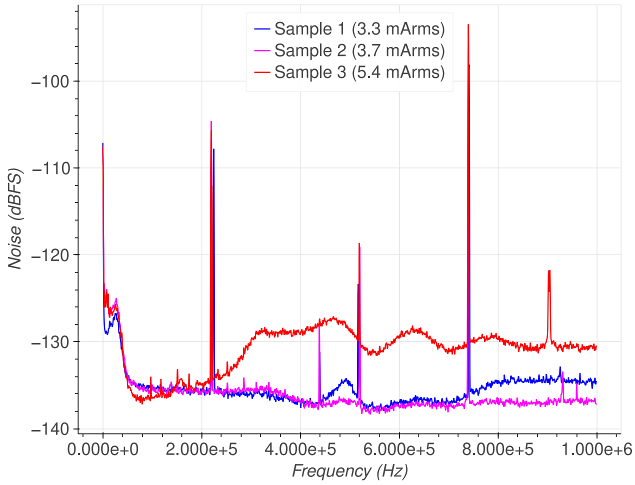


Figure 18: Averaged noise spectrum at $T_A = 85\ ^{\circ}C$

2 Connection and Operation of the Transducer

Figure 19 presents a block diagram of the DC-CT-1000I.

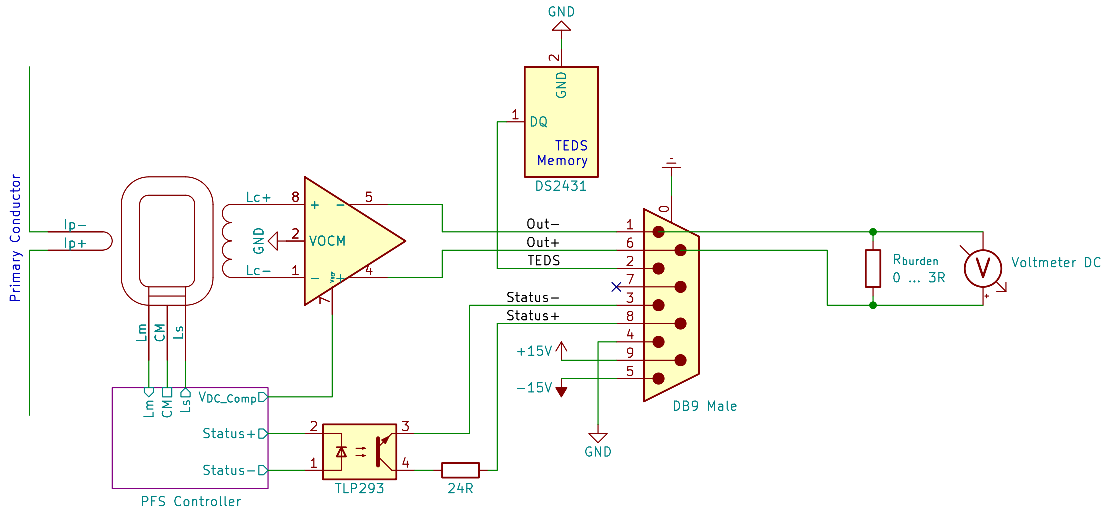


Figure 19: Maximum Burden Resistance vs T_A

It consists of the following key components:

1. Magnetic core with an opening for a primary conductor, with built-in
2. Platiše Flux Sensor, an innovative low-power sensitive residual flux meter, which measures the absolute value of the magnetic flux inside the core, reports the valid Status, and drives
3. active compensation via secondary compensation winding, which transforms high bandwidth AC signals and compensates the DC component with the help of the Platiše Sensor. The burden resistor must be provided by the user.
4. Flexible unipolar/bipolar power supply with a floating measurement ground, the output common mode potential,
5. and the TEDS.

2.1 Powering the Unit

The power supply can be either:

1. bipolar: pin 9 (15 V), pin 5 (-15 V) and pin 4 (0 V) or
2. unipolar: pin 9 (30 V) and pin 5 (0 V)

For best CMRR performance, the units should be earthed via the screw on the bottom or the back plate. Note that the D-SUB connector is also earthed, but may create a ground loop with the chassis. It is therefore important to make sure that if the chassis is earthed, the cable of the D-SUB connector is not earthed.

The maximum in-rush current is internally limited below 0.5 A as shown in Figure 21.

2.2 Differential Current Output and Status Signal

The DC-CT-1000I provides a differential current output with a common voltage set by pin 4 and scaled down for the number of turns N as the output signal on pins 1 and 6. The user must connect a burden resistor with a maximum resistance vs temperature as provided in Figure 19.

As the unit is powered up, the sequence includes the ramping up of power supplies, the microprocessor boot sequence, followed by the signal search until ready. A typical power-up sequence takes less than 100 ms. During the power-up and signal search, the Status signal is deasserted as shown in Figure 20; once the signal is valid, the Status is asserted.

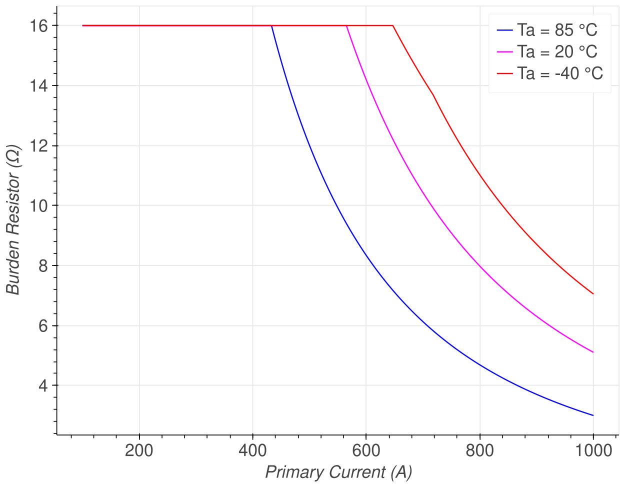


Figure 20: Maximum Burden Resistance vs T_A

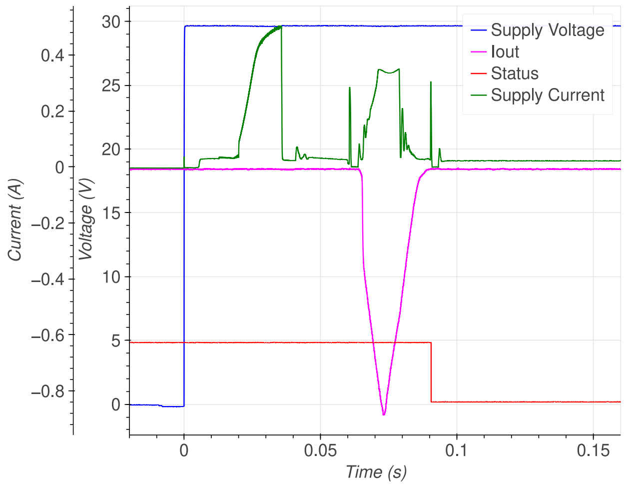


Figure 21: Power-Up Supply, Output Current, Status and Supply Current

Whenever the signal is lost, typically due to out-of-range and inability to track the primary signal, the Status signal is de-asserted within 300 μs and the signal Search procedure begins. As soon as the primary current is successfully tracked within the I_{MD}, the status signal is reasserted.

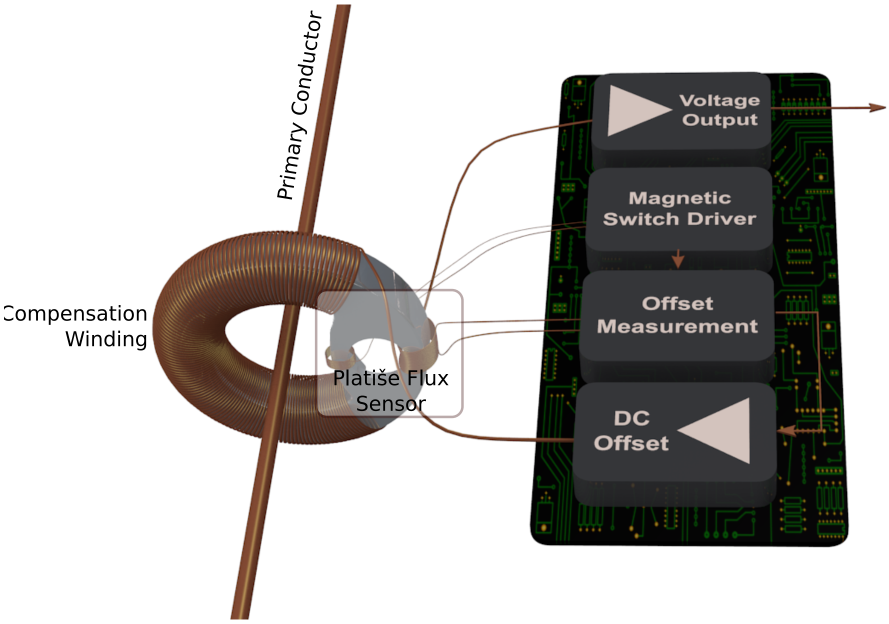
2.3 About the Innovative Platiše Flux Sensor

For many decades, the most popular DC transducers have relied on flux-gate or Hall principles. The former, flux-gate, requires a complex three-core structure to achieve the highest accuracy down to a few ppm and good AC flatness, while the Hall-based ones hardly reach 0.5% accuracy and have limited frequency bandwidth. Some lower-cost, single chip versions of flux-gate and giant magnetoresistance (GMR) sensors do exist, however, both need to cut the magnetic core to measure the flux.

The Platiše Flux Sensor uses a single core, like the Hall one, a single-chip flux-gate and GMR implementations, but without the air gap, enabling it to perform nearly as well as the most accurate flux-gate sensors. Due to the simplified construction of the magnetic core, the overall solution is small and thus represents the highest accuracy at the lowest form factor. The Platiše Sensor therefore provides a solution for a wide range of applications requiring accuracies from 0.01% to 0.1%.

The patented measurement principle, as invented by Uroš Platiše, relies on an embedded element inside a magnetic circuit, patented as Current Controlled Variable Reluctance, which allows flux redirection inside the magnetic core. Being able to redirect fluxes, the constant (DC) flux is easily converted into a measurable AC signal, at a rate defined by the Platiše Flux Sensor frequency. Since the built-in element inside the magnetic core is not merely passive, but becomes active with external stimuli, the Platiše Sensor is temperature independent. The temperature variations are purely a result of the magnetic material itself and improve with time as the magnetic material improves.

In addition, the DC-CT-1000I implements a zero-flux or null method to achieve the highest accuracy and compensates for the non-linearities caused by the magnetic material in a similar way as other closed-loop DC-CT sensors. The key blocks are presented in the following Figure.

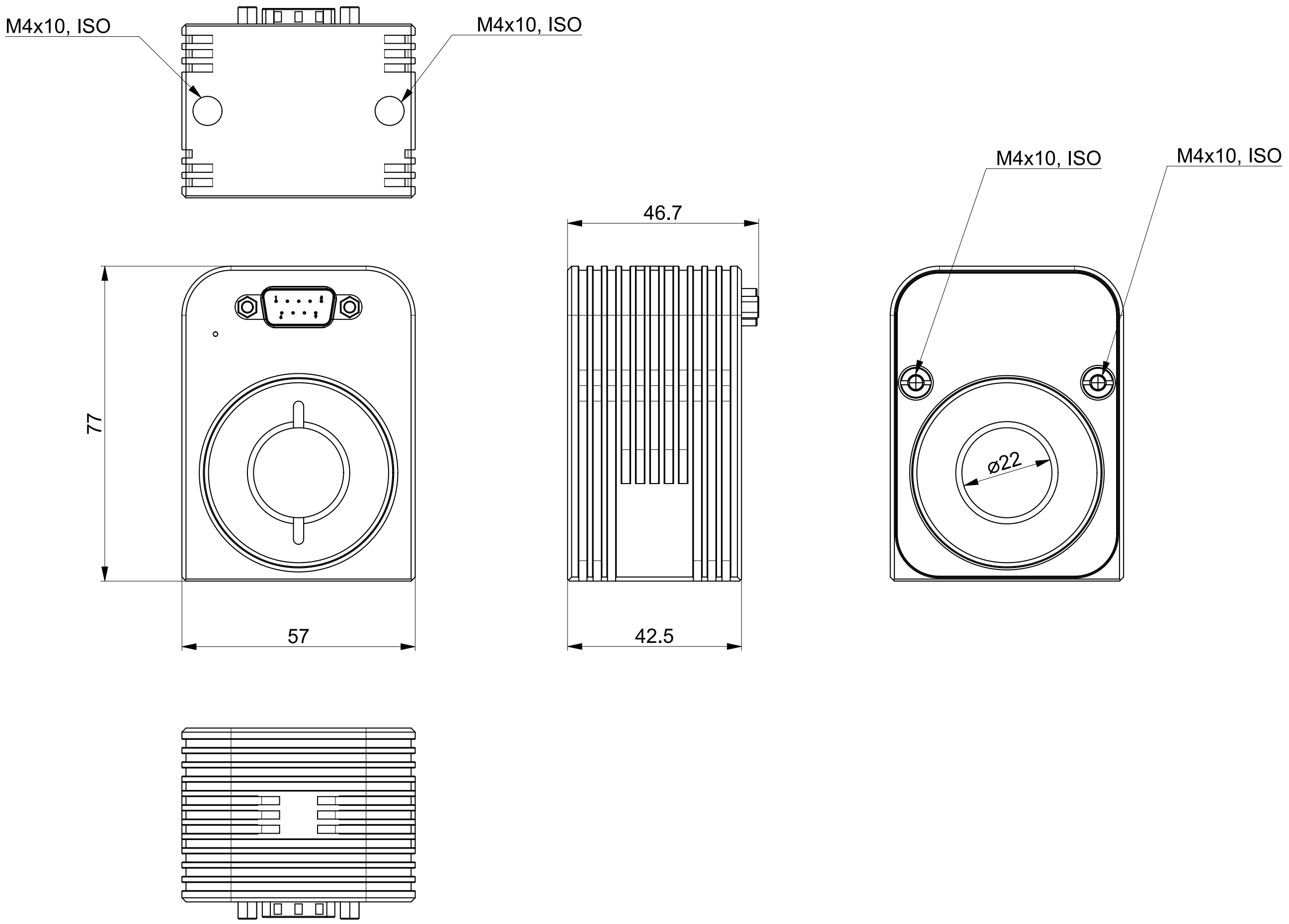


The primary current flows through the magnetic core wound by a secondary compensating winding of N turns, defining a current transformation ratio. Additional modulating winding is added to a small part of the magnetic core, driven by a magnetic switch driver and sensing winding, sensed by offset measurement circuitry. The residual flux is integrated by the output amplifier to compensate for the DC component, while the AC component of the DC-CT passes through the sensor, directly to the output.

More information about the technology can be found at www.dc-ct.com.

DC-CTs that use this new patented principle of operation are branded under the DOT brand.

3 Dimensions



4 Ordering Information

Ordering Code	Description
DC-CT-1000I-S22DA	1000A, Standalone, 22 mm Opening, D-SUB, Analog Current Output

Disclaimer