AC Current Transformer

User's Manual

Rev. 5.4

Record of updates

Version	Date	Updates performed
2.1	05/2008	p.3 - General Description: Parts numbers Reference to new High-Resolution and Wideband versions Output polarity: examples p.7 - Specifications High-Resolution specifications Wideband version specifications
3.1	01/2017	New release of the manual Reference to new specifications
4.0	03/2018	Review of the full manual. Obsoletes all former releases
5.0	06/2019	ACCT-E-RM-3R description and specifications added Option -3M added
5.1	06/2019	Modification of the cover page and creation of the distributors' page
5.2	01/2020	p.8 - Correction of one formula in "Operating Principle" chapter
5.3	02/2021	Removal of the In-Air ACCT dimensions with MSH option (no more available) Update of the drawing in the "INSTALLATION OVER A VACUUM CHAMBER" chapter
5.4	04/2021	Modification of the calibration winding option and ACCT-E-RM-3R to add systematically calibration winding on sensor when chosen

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INITIAL INSPECTION

It is recommended that the shipment be inspected immediately upon delivery. If it is damaged in any way, contact Bergoz Instrumentation or your local distributor. The content of the shipment should be compared to the items listed on the invoice. Any discrepancy should be notified to Bergoz Instrumentation or its local distributor immediately. Unless promptly notified, Bergoz Instrumentation will not be responsible for such discrepancies.

WARRANTY

Bergoz Instrumentation warrants its beam current monitors to operate within specifications under normal use for a period of 12 months from the date of shipment. Spares, repairs and replacement parts are warranted for 90 days. Products not manufactured by Bergoz Instrumentation are covered solely by the warranty of the original manufacturer. In exercising this warranty, Bergoz Instrumentation will repair, or at its option, replace any product returned to Bergoz Instrumentation or its local distributor within the warranty period, provided that the warrantor's examination discloses that the product is defective due to workmanship or materials and that the defect has not been caused by misuse, neglect, accident or abnormal conditions or operations. Damages caused by ionizing radiations are specifically excluded from the warranty. Bergoz Instrumentation and its local distributors shall not be responsible for any consequential, incidental or special damages.

ASSISTANCE

Assistance in installation, use or calibration of Bergoz Instrumentation beam current monitors is available from Bergoz Instrumentation, 01630 Saint Genis Pouilly, France. It is recommended to send a detailed description of the problem by email to info@bergoz.com.

SERVICE PROCEDURE

Products requiring maintenance should be returned to Bergoz Instrumentation or its local distributor. Bergoz Instrumentation will repair or replace any product under warranty at no charge. The purchaser is only responsible for transportation charges.

For products in need of repair after the warranty period, the customer must provide a purchase order before repairs can be initiated. Bergoz Instrumentation can issue fixed price quotations for most repairs. However, depending on the damage, it may be necessary to return the equipment to Bergoz Instrumentation to assess the cost of repair.

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RETURN PROCEDURE

All products returned for repair should include a detailed description of the defect or failure, name and fax number of the user. Contact Bergoz Instrumentation or your local distributor to determine where to return the product. Returns must be notified by email to info@bergoz.com or to its local distributor prior to shipment.

Return should be made prepaid. Bergoz Instrumentation will not accept freight-collect shipment. Shipment should be made via UPS, FedEx or DHL. Within Europe, the transportation service offered by the Post Offices "EMS" (Chronopost, Datapost, etc.) can be used. The delivery charges or customs clearance charges arising from the use of other carriers will be charged to the customer.

SAFETY INSTRUCTIONS

This instrument is operated from the mains power supply. For safe operation, it must be grounded by way of the grounding conductor in the power cord. Use only the fuse specified. Do not remove cover panels while the instrument is powered. Do not operate the instrument without the cover panels properly installed.

Chassis originally shipped to U.S. or Canada feature AC mains power entry modules where the Phase is fused and the Neutral unfused, as is the rule.

Chassis to other destinations but U.S. and Canada feature AC mains power entry modules where both Phase and Neutral are fused.

When a chassis with unfused Neutral is used outside the U.S. and Canada, both Phase and Neutral should be fused:
The Power entry module must be opened, the Neutral fuse must be removed, the fuse holder must be flipped; its reverse side presents two slots where two new fuses must be inserted, one in each slot.
The fuses rating must be same as the Neutral fuse that was removed.

The Toroid sensor contains materials such as cobalt and iron. Those materials may become radioactive when exposed to high energy particle beams. Follow applicable radiation-safety procedures when the Toroid sensor must be moved out of controlled areas.

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GENERAL DESCRIPTION

The ACCT is specifically designed to measure charged particle beams.
It measures macropulse current down to 1 mAac full scale, with less than 2 μArms noise and <2 %/ms output droop.

The toroid sensor contains no electronics; the electronics is installed in a small external box.
ACCT set includes:
- AC Current Transformer
- ACCT-E-RM-xxxmA or ACCT-E-RM-3R-xxxmA/yyymA/zzzmA external electronics box, where xxxmA/yyymA/zzzmA are the full scale primary current. It can be mounted on a 35-mm normalized DIN rail. It includes active electronics. It must be supplied +15V and -15V to its screw terminal.
- ACCT to ACCT electronics interconnect cable. Maximum cable length without degradation of the ACCT specifications is 20 meters:
  - ACCT-C-XX is the standard cable, where xx is the cable length in meters. Cable is twisted pair RG108 with PVC jacket.
    or
  - ACCT-RHC-XX is the radiation-tolerant shielded twisted pair cable in Siltem (R.I. >7), where xx is the cable length in meters.
- PS-1515 by MinMax, power supply unit mounted on a normalized 35-mm DIN rail.

Note: ACCT is delivered without coaxial output cable.

The output voltage is highly linear. It features < 2uA rms noise and excellent dynamic response. This makes it an ideal instrument to measure long pulses or pulse trains.

The core is in Co-based amorphous alloy specifically annealed for this application.
ACCT is available in two packaging styles: In-flange models or In-air models.

In-flange ACCT with ACCT-E-RM and power supply

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In-flange models

In-flange models are current transformers whose core(s) are embedded in a pair of flanges. Flanges can be Conflat, ISO, KF, Dependex, EVAC or specials with usual inner diameters. ACCT are UHV compatible down to 1e-9 mbar. Soap or alcohol cleaning before installation is however recommended; to reach pressure down to 1e-11 mbar, adequate pumping and cleaning, e.g. plasma, are required.

100°C (212°F) should never be exceeded at any time during bake out or operation unless it is made from a selection of higher temperature alloys and materials:
- Option BK150C allows bake out at 150°C (300°F)
- Option BK185C allows bake out at 185°C (365°F)
- Option BK200C allows bake out at 200°C (392°F)

ACCT wall current break ("gap") is a ceramic ring (Al_2O_3 99.7%) brazed onto two Kovar transition sleeves.
Standard models are made from AISI 304 steel, AISI 316LN is available on option.

In-flange ACCTs have the syntax hereafter:

In-flange ACCT	
-CFx"-	x" is the CF flanges OD [inch]
-xx.x-	xx.x is the sensor ID [mm]
-xx-	xx is the sensor axial length [mm]
-UHV-	UHV: Sensor UHV compatible with brazed ceramic wall current break; As delivered down to 1e-9 mbar After adequate cleaning down to 1e-11 mbar
Example: ACCT-CF6"-60.4-40-UHV	
Available options for In-flange ACCT	
-ARBxx-	In-flange ACCT sensor with special arbitrary aperture, 50mm axial length
-316LN-	In-flange ACCT sensor in AISI316LN instead of 304
-BK150C-	In-flange ACCT sensor bakeable at 150°C (300°F)
-BK185C-	In-flange ACCT sensor bakeable at 185°C (365°F)
-BK200C-	In-flange ACCT sensor bakeable at 185°C (365°F)
-SH2L-	2-layer embedded shield option
-SH4L-	4-layer embedded shield option
-H	Radiation-tolerant sensor option, all components R.I.>6
-CAW1_50	One turn calibration winding option, loaded 50Ω (0.25W), insulated, SMA connector

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In-air models

In-air models are current transformers whose core(s) are potted in a copper toroidal casing. In-air ACCT are typically installed over a vacuum chamber whose wall current flow is interrupted by a user-supplied break ("gap") protected from stress by bellows. The wall current is diverted by a user-supplied wall current bypass. A user-supplied shield prevents the RF leaking out of the gap from radiating over.

In-air ACCT should not be heated above 100°C (212°F) at any time.
In-air ACCT should not be placed in vacuum, they might burst open.
Specially degassed In-air ACCT with option -VAC can be placed in mild vacuum (1e-4 mbar).

In-air models have the syntax hereafter:

In-air ACCT	
-S-	
-xxx-	xxx is the sensor ID [mm]
Example: ACCT-S-055	
Options for In-air ACCT	
-VAC-	In-air ACCT sensor degassed
-SH2L-	2-layer embedded shield option
-SH4L-	4-layer embedded shield option
-H	Radiation-tolerant sensor option, all components R.I.>6
-CAW1_50	One turn calibration winding option, loaded 50Ω (0.25W), insulated, SMA connector
-VAC	Sensor degassing option, for vacuum > 10^{-4} mbar

In-Air ACCT

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ACCT electronics model

ACCT electronics have to be connected to the ACCT sensor output with a twisted pair cable fitted with BNO connectors and common-mode filters.

BNO connector

It is available in two versions:
a) ACCT-E-RM with a single full-scale range
ACCT-E-RM output signal is a high-impedance bipolar voltage.
Output voltage is proportional to current thru the ACCT aperture: ±10 V output full scale.
Example: ACCT-E-RM-10mA has -10 V output when passing -10 mA thru ACCT aperture.

b) ACCT-E-RM-3R with 3 selectable full-scale ranges. It presents the following additional features:
- 3 selectable full scale ranges
- 3 outputs: High impedance, 50 Ω and Differential
- Integrated calibrated current source (applicable when ACCT sensor is equipped with option -CAW1_50)
- TTL controllable
- 1-turn calibration winding with BNO connector mounted on the sensor

ACCT-E-RM and ACCT-E-RM-3R are both powered with +15 V and -15 V to its screw terminal. It is recommended to use the ACCT-PS-1515 power supply provided by Bergoz Instrumentation. They guarantee both electronics output noise specifications.

ACCT-E-RM, ACCT-E-RM-3R and ACCT-PS-1515 can be mounted on a 35-mm normalized DIN rail.

ACCT electronics have the syntax hereafter:

ACCT electronics	
ACCT-E-RM-xxxmA	Full scale range of xxxmA.
ACCT-E-RM-3R-xxxmA/yyymA/zzzmA	Three full scale range selectable of xxxmA, yyymA and zzzmA.
Example: ACCT-E-RM-20mA or ACCT-E-RM-3R-1mA/10mA/100mA	
Available options for ACCT electronics	
-3M	Bandwidth extended to 3MHz Maximum cable length is then limited to 2m

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ACCT ADVANTAGES COMPARED TO OTHER CTs

The ACCT can measure low AC currents accurately. Other current transformers cannot do it for the following reasons:
- A passive CT capable of passing say 50-60 Hz with less than 1% error must have a -3dB lower cutoff frequency below a few Hertz. This imposes a large number of turns, typically 500 turns. Therefore, the sensitivity is in the order of 0.1 V/A in a high impedance load.
- If 10 mA current is measured with this transformer, the output is a mere 1mV, which cannot be measured on an oscilloscope or voltmeter. The situation is not much better at 100 mA current.
- Amplifying the signal from this CT does not help much, because the noise is amplified as well.

Therefore, the ACCT is much superior to other CTs for pulses longer than tens of μs: It measures accurately down to 10 mA full scale, even down to 1 mA. It delivers a strong voltage signal, with accuracy better than 1%.
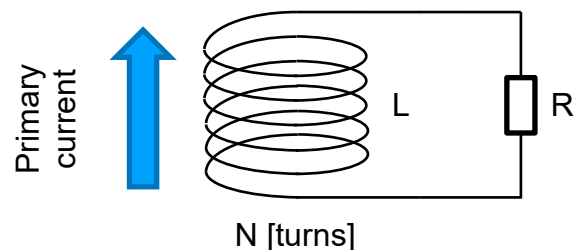
OPERATING PRINCIPLE

The ACCT measures low frequency current, from 3 Hertz to 1 Megahertz. It is not simply a transformer with an amplified output, because such a combination is unable to measure low currents at low frequency.
The lower frequency cutoff (-3 dB) of a transformer is given by:

$$f_L = \frac{R}{2\pi \cdot L}$$

Where:
- L is the core winding inductance
- R is the winding load

To obtain a low value for f_L, either R must be decreased, or L must be increased.
The inductance L cannot be increased beyond a certain value because physics laws and economics prevent it. The inductance is given by:

$L = f \{\mu_r, A, N^2, l^{-1}\}$ where μ_r is the core alloy relative permeability
A is the core magnetic cross section
l is the magnetic path length (core average circumference)
N is the number of winding turns

μ_r is a characteristic of the magnetic alloy and annealing process. The ACCT uses cobalt-based alloys specifically annealed for this application. High temperature bake-out models use iron-based nanocrystalline alloys. They feature very high permeability.

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A is limited by the size of the sensor and the economics (high performance alloys are expensive).
l is imposed by the sensor sized.
N is the only parameter which the designer can vary significantly.

When N is increased, L increases with N^2, which is very favorable for the low frequency response.
But at the same time, the sensitivity decreases by N, hence the signal level decreases and becomes too close to the noise floor to make meaningful measurements.

This is why the ACCT has a moderate number of turns ($\approx$100, depending on the model) and – instead of increasing L for low frequency response– is designed with a very low R load value.

Already Hereward proposed in 1960 an active transformer with very low impedance load.

Hereward transformer principle (1960)
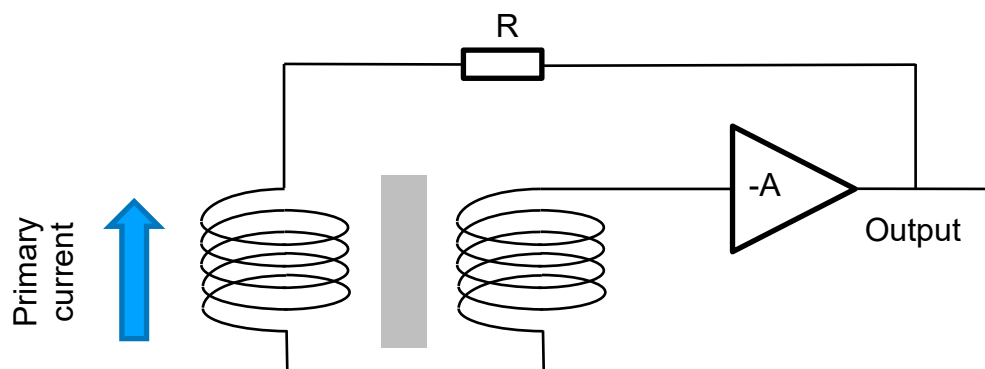
To provide the AC response of the first DCCT ever built, K. Unser in 1969 improved and simplified Hereward's circuit diagram:
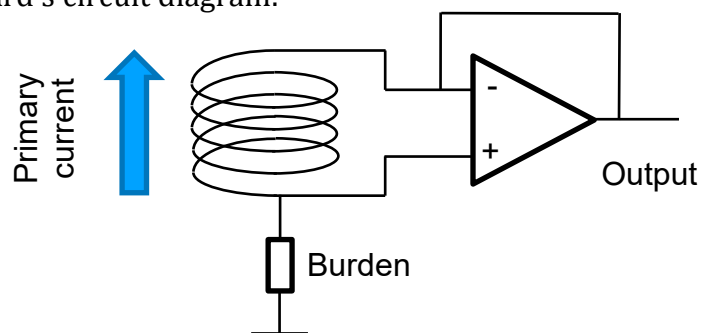
In this circuit, the impedance seen by the winding is close to 0 Ω, because the operational amplifier maintains at all times the voltage difference between its inputs very close to zero. The ACCT implements this principle.

The ACCT incorporates another innovative technique to null the operational amplifier's offset. As a result, the ACCT offset voltage is very close to zero when no primary current flows thru the sensor.

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ELECTRICAL CONNECTIONS

Connectors on the ACCT sensor

Output
BNC female connector.
Grounded connector to sensor body.

Connectors on ACCT-E-RM

Input
To be connected to the ACCT sensor output with a twisted pair cable fitted with BNO connectors (twin BNC) and common-mode filters.

Output
BNC connector, to be read in high impedance input.
-10 V to +10 V proportional to the selected range full scale.
Maximum output current drive: 32 mA source or sink.

Power Supply
ACCT-E-RM is powered with +15 V and -15 V, 15 W.
It is recommended to use the ACCT-PS-1515 power supply provided by Bergoz Instrumentation. They guarantee the ACCT-E-RM output noise specifications.
It is recommended to uses a twisted wires cable for the power supply wires. Passing the wires thru a common-mode choke is advisable.

Connectors on ACCT-E-RM-3R

Controls, Status, Ext. PS
DB9 connector
Optocoupled I/O

Input
BNO input connector
from ACCT sensor

CAL output
BNO output connector
to ACCT sensor CAL input

Trigger CAL
BNC input connector
from Beam Timing controls

Power Supply
Screw terminal

50 Ω output
BNC connector

1 MΩ output
BNC connector

Differential output
BNO connector

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Input
To be connected to the ACCT sensor output with a twisted pair cable fitted with BNO connectors and common-mode filters.

CAL output
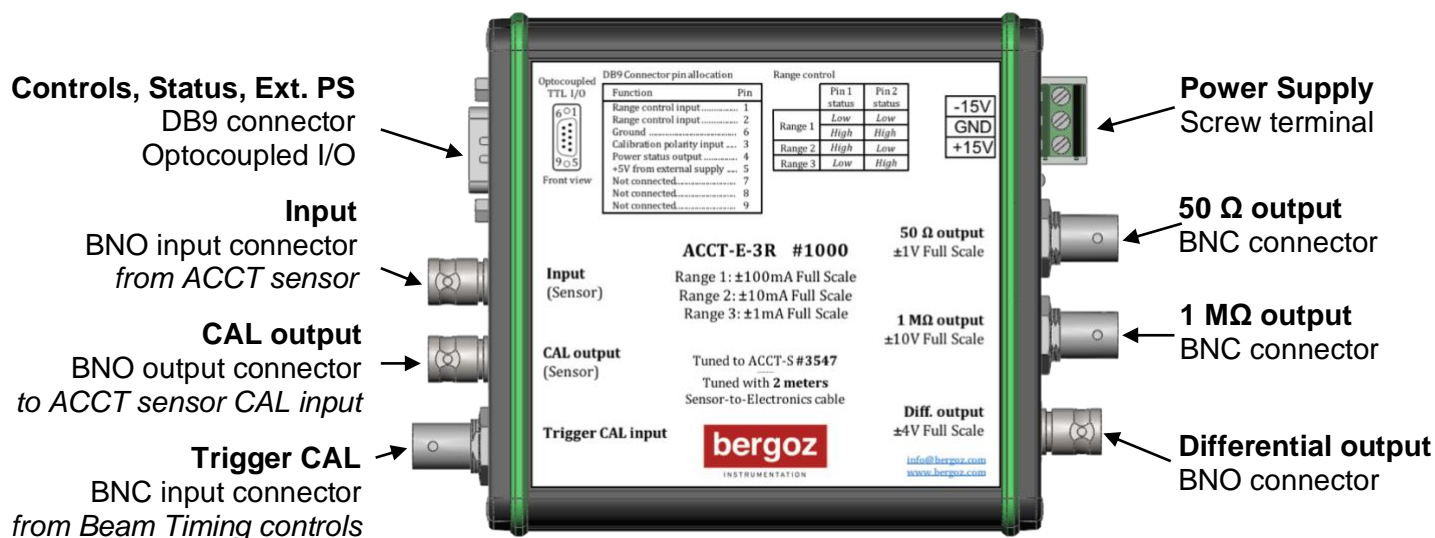To be connected to the ACCT sensor calibration winding output with a twisted pair cable fitted with BNO connectors and common-mode filters.
The calibrated pulse is generated by the ACCT-E-RM-3R electronics and injected into the sensor calibration winding via the sensor CAL input connector.
The calibrated pulse amplitude is adjusted to be 50% of the full scale of the selected range.
E.g., when the range selected is 10 mA, the amplitude of the calibrated current pulse is 5 mA.
The calibrated current pulse length is defined by the Trigger CAL signal length.

Trigger CAL input
Trigger signal controlling the calibrated current pulse.
The trigger signal has to be TTL level.
The calibrated current pulse length is equal to the trigger pulse length.

Power Supply
The ACCT-E-RM-3R is powered with +15 V and -15 V, 15 W.
It is recommended to use the ACCT-PS-1515 power supply provided by Bergoz Instrumentation. They guarantee the ACCT-E-RM-3R output noise specifications.
It is recommended to uses a twisted wires cable for the power supply wires. Passing the wires thru a common-mode choke is advisable.

50 Ω output
BNC connector, 50 Ω output impedance.
To be read in 50 Ω impedance input.
-1 V to +1 V proportional to the selected range full scale.
Maximum output current drive: 70 mA source or sink.

1 MΩ output
BNC connector, 50 Ω output impedance.
To be read in high impedance input.
-10 V to +10 V proportional to the selected range full scale.
Maximum output current drive: 32 mA source or sink.

Differential output
BNO connector, 50 Ω single-ended output impedance (100 Ω differential output impedance).
-4 V to +4 V proportional to the selected range full scale, when read in high impedance.
-2 V to +2 V proportional to the selected range full scale, when read in 50 Ω impedance.
Maximum output current drive: 40 mA source or sink.

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DB9 Connector pin allocation

Function	*Pin*
Range Control input	1
Range Control input	2
Ground	6
Calibration Polarity input	3
Power Status output	4
+5V from external power supply	5
Not connected	7
Not connected	8
Not connected	9

DB9 connector input and output signals are TTL levels.

Range Control input (pin 1 & 2)

Pin 1 status	*Pin 2 status*	*Range*
Low	Low	Range 1
High	High	Range 1
High	Low	Range 2
Low	High	Range 3

Calibration Polarity input (pin 3)

Low	Positive calibration pulse
High	Negative calibration pulse

Power Status output (pin 4)
High when ACCT-E-3R is powered.
Low when ACCT-E-3R is not powered.

Since this output is optocoupled, +5 V must be provided on pin 5 of the DB9 connector to activate this functionality.

Ground (input, pin 6)
Reference of the TTL signals and +5V EXT (pin 5).

+5V from external power supply (input, pin 5)
+5V (referenced to Ground, pin 6) must be applied to activate the Power Status functionality.

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OUTPUT SIGNAL POLARITY

The ACCT is bipolar.
Arrows are printed on the outer surface of the toroid.

Positive charges e.g., protons crossing the aperture in the direction of the arrow give positive output.
Negative charges e.g., electrons crossing the aperture in the direction of the arrow give negative output.

COAXIAL OUTPUT CABLE SELECTION

Unless specially requested, no output coaxial cable is supplied with the ACCT.
The ACCT signal is a baseband signal up to 1 MHz.

In environments with high RFI, a double-shielded cable is required if low currents are measured. In high EMI environments, it is recommended to pass the coaxial cable through common-mode filters of two types:
- MnZn ferrite cores, tubes or beads for high-frequency noise rejection
- Soft-annealed nano-crystalline cores for low-frequency noise rejection

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SPECIFICATIONS

Full scale range	Any value from ±1mA to ± 2A, factory preset range.
Ratio accuracy error	<0.1% FS
Lower cutoff (-3dB)	<3Hz
Droop	<2%/ms
Upper cutoff (-3dB)	1MHz
Risetime	350ns (10% - 90%)
Noise at 10mA F.S.	≈1.5µArms
Noise at 100mA F.S.	<5µArms

Single range electronics

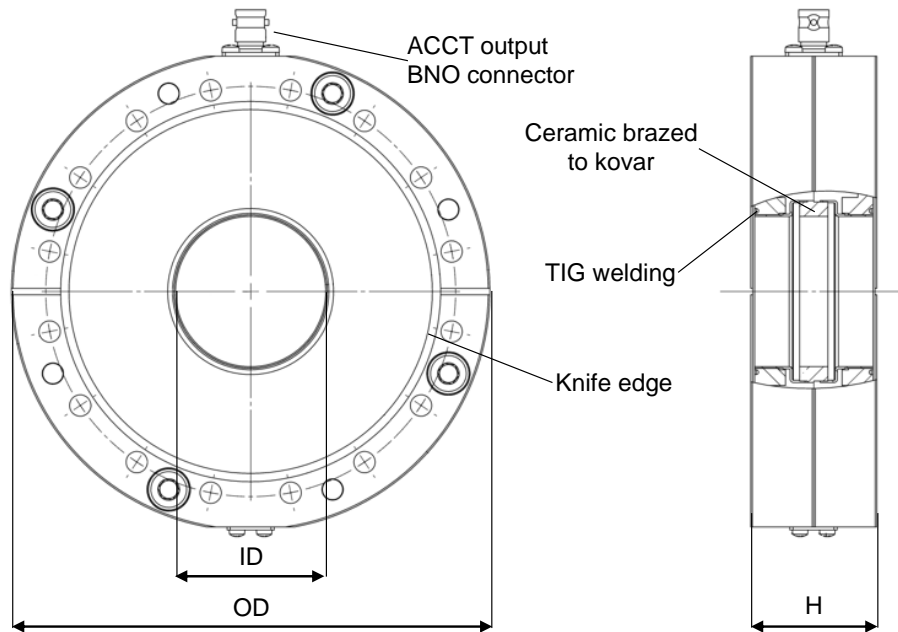|	
1MΩ output full scale	-10V … +10V in high impedance
Output offset	0.5mV max.
Output current limit	20mA max.
Connectors	Electronics input: BNO (Twin BNC) Electronics output: BNC

3-ranges electronics

1MΩ output full scale	-10V … +10V in high impedance
50Ω output full scale	-1V … +1V in 50Ω
Differential output FS	-4V … +4V in high impedance
Output offset	50Ω output: <0.5mV 1MΩ output: <0.5mV Differential output: <1mV
Output current limit	50Ω output: 70mA max. 1MΩ output: 32mA max. Differential output: 40mA max.
CAL output	Output pulse amplitude equal to 50% of the full scale of the selected range Output pulse length defined by the Trigger CAL input signal length (TTL)
Connectors	Electronics input: BNO (Twin BNC) Electronics CAL output: BNO (Twin BNC) Electronics Trigger CAL input: BNC Electronics 50Ω output: BNC Electronics 1MΩ output: BNC Electronics Differential output: BNO

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Others

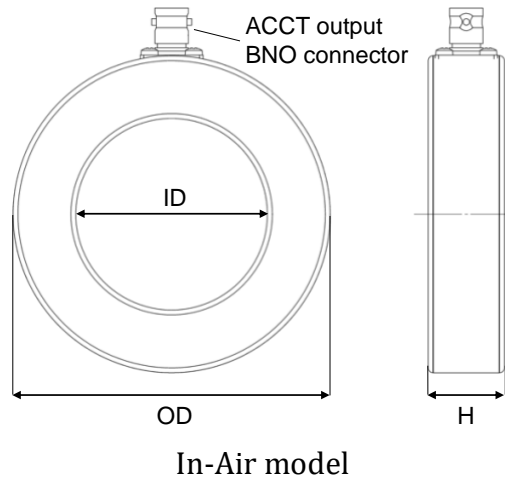|	
Power supply	+15Vdc and -15Vdc, 100mA ea.
Power supply unit	ACCT-PS-1515 recommended Mains voltage 95-125Vac / 215-245Vac
Calibration winding	1-turn calibration winding, loaded 50Ω (0.25W), insulated
Connectors	Sensor winding: BNO (Twin BNC) Sensor CAL winding: SMA; BNO with ACCT-E-RM-3R
Sensor cable	Twisted pair Up to 20 meters Above 20 meters overshoot may appear and rise time may increase
CAL winding cable	Twisted pair
Destructive level	DC current: Unlimited Spikes >100mC AC current >20Arms

Sensor saturation	External magnetic field:
	    Transverse to sensor axis: 2mT max
	    Collinear with sensor axis: 10mT max
	Can be exceeded with optional
	embedded shielding, options SH2L/SH4L

Temperature drift	Negligible

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MECHANICAL DIMENSIONS AND DRAWINGS

In-flange models

In-flange ACCT sensor order code	ACCT OD (inch)	Pipe OD (inch)	Mating flange	ACCT ID (mm)	ACCT H (mm)
ACCT-CF3"3/8-22.2-40-UHV	3.375"	1"	DN/NW50CF	22.2	40
ACCT-CF4"1/2-34.9-40-UHV	4.5"	1.5"	DN/NW63CF	34.9	40
ACCT-CF4"1/2-38.0-40-UHV	4.5"	40 mm	DN/NW63CF	38.0	40
ACCT-CF6"-47.7-40-UHV	6"	2"	DN/NW100CF	47.7	40
ACCT-CF6"-60.4-40-UHV	6"	2.5"	DN/NW100CF	60.4	40
ACCT-CF6"3/4-96.0-40-UHV or ACCT-CF8"-96.0-40-UHV	6.75" 8"	4"	DN/NW130CF DN160/NW150CF	96.0	40
ACCT-CF10"-147.6-40-UHV	10"	6"	DN/NW200CF	147.6	40
ACCT-CF12"-198.4-40-UHV	12"	8"	DN/NW250CF	198.4	40

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In-air models

In-Air model

In-air ACCT sensor order code	ID (mm)	OD (mm)	H (mm)	Mass (g)
Unshielded models				
ACCT-S-016	16	42	22	60
ACCT-S-028	28	64	22	115
ACCT-S-055	55	91	22	175
ACCT-S-082	82	118	22	250
ACCT-S-122	122	156	22	320
ACCT-S-178	178	226	22	700

Drawings

Drawings in .pdf can be found on our website:
www.bergoz.com >> Products >> ACCT >> Downloads >> Technical drawings

Dimensions missing on the website can be obtained asking info@bergoz.com

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INSTALLATION

In-flange models

In-flange ACCT mechanical parts are in direct electrical contact with the vacuum chamber. Its output connector body, hence the cable shield is also in direct electrical contact.
It is therefore of paramount importance to equip every section of the coaxial cable with common mode filters to mitigate ground loops. A cable section is any length of cable which connector body is grounded at both ends, e.g., through a patch panel.

In-flange ACCT bolts must be tightened at the recommended torque according to the flange type, but not beyond.

In-air models

In-air ACCT must be installed over the vacuum chamber, not too far away from the wall current gap. It is recommended to install bellows to avoid stress on the gap, wall current bypass and RF overall shield to prevent RF leaking outside are recommended.

The output connector body is in direct electrical contact with the In-air ACCT copper shell. Therefore, to prevent ground loops, it is recommended that the In-air ACCT shell is electrically isolated from the vacuum chamber.

Common mode filters

Common mode filters must be installed at both ends of each cable segments. Each filter must comprise one MnZn ferrite tube, core or bead, and one iron-based nanocrystalline core, e.g., Hitachi Metals' Finemet alloy FT-3KL.

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INSTALLATION OVER A VACUUM CHAMBER

The installation of an In-air ACCT on the outside of a vacuum chamber requires some precautions.

a) The electrical conductivity of the vacuum chamber must be interrupted in the vicinity of the ACCT, otherwise the wall current will flow thru the ACCT aperture and cancel the beam current.

b) The wall current higher frequencies must be diverted around the ACCT thru a low impedance path.

c) A fully-enclosing shield must be installed over the ACCT and vacuum chamber electrical break to avoid RF interference emission.

d) The enclosing shield forms a cavity. Cavity ringing at any of the beam harmonics must be avoided.

e) The ACCT must be protected from being heated beyond 100°C (212°F) during vacuum chamber bake-out.

f) The higher harmonics of the beam should be prevented from escaping the vacuum chamber, because (1) they are not "seen" by the ACCT therefore unnecessary, (2) they heat the ACCT and any other conductive material inside the cavity, (3) they cause various ringing modes in the cavity.

Note: The ACCT does not need to be protected from external magnetic fields. When it is exposed to external magnetic fields it may saturate; this causes the droop to increase up to a factor of 2. It has no effect on the ACCT linearity.

Wall current break or "gap"

When installing an In-air ACCT over a vacuum chamber, a break or "gap" must be installed in order to stop the wall current.

If vacuum pressure is 1e-7 mbar or above, a polymer gasket O-ring can be used between two flanges to assure the desired galvanic isolation.
For vacuum pressures below 1e-7 mbar, a ceramic ring brazed to the vacuum chamber is indicated.

Thermal protection of the In-air ACCT

The ACCT must not be heated beyond 100°C (212°F). If the vacuum chamber requires bake out, a thermal shield must be installed between the vacuum chamber (or the heating sleeves) and the ACCT.
The thermal shield can be a simple copper cylinder cooled by water circulating in a copper tube brazed onto the cylinder.

The water circuit must not pass thru the ACCT aperture. It must enter and go out on the same side of the ACCT, otherwise it makes a shorting loop around the ACCT toroid.

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Keeping high harmonics of the beam out of the In-air ACCT cavity

The transformer, the gap capacitance and the wall current bypass form together a cavity. It is important to prevent unnecessary harmonics from entering the cavity:

The beam current flows thru the vacuum chamber.
The wall current follows the conductive vacuum chamber walls.
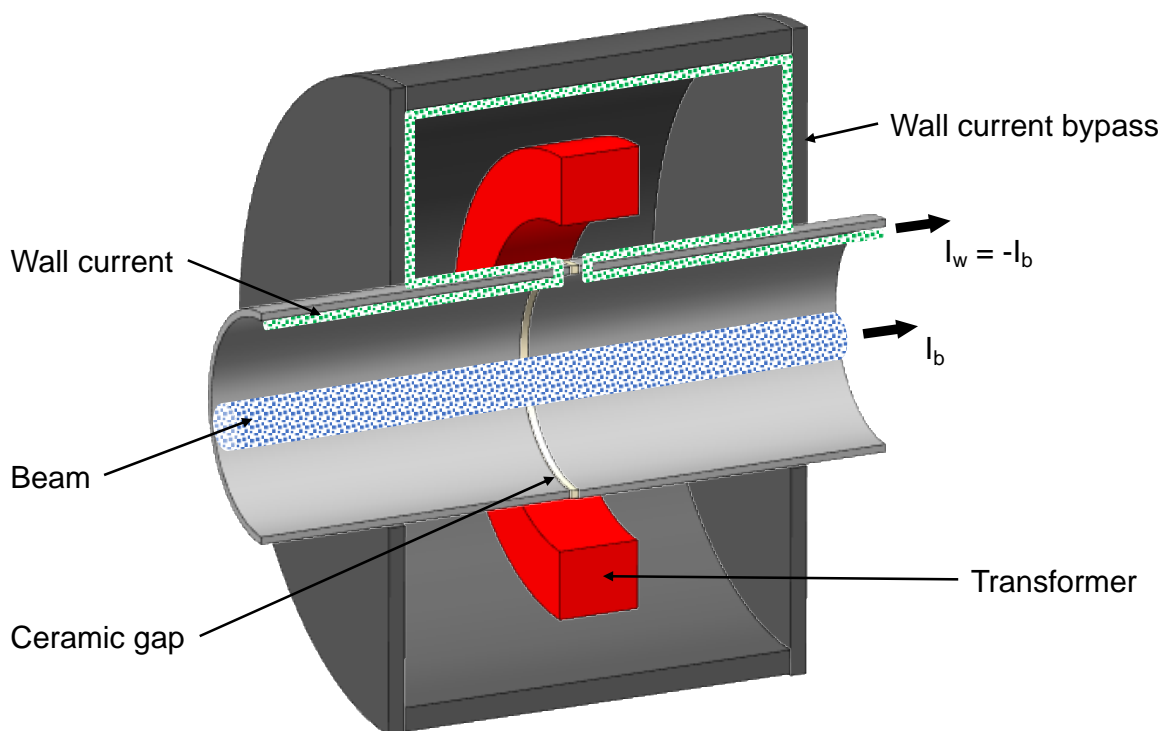
The transformer "sees" the wall current I_w. The higher frequencies of the wall current pass thru the capacitance of the ceramic gap, while the lower frequencies enter the cavity and induce a flux in the transformer core.

Optionally, a wall current bypass can be installed over the gap, option -BYP, when the beam bunches are very short. Recommended when bunch length is lower than 1 ps rms.

Note that the full charge of the wall current pulse passes thru the cavity, irrespective of the value of the gap capacitance.

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ACCT-S SENSOR RADIATION RESISTANCE

ACCT-S sensor contains material which may be damaged by ionizing radiations.
There are listed hereafter:

Organic and radiation-sensitive materials used in the "Standard" sensor:

The "Standard" sensor is supplied when the "Rad-Hard" option is not ordered.

Component		Material	Radiation resistance[1]
Wiring insulation		Polyvinyl chloride PVC	2×10^5 Gy
		Fiber glass	$> 10^8$ Gy
		with rubber adhesive	$> 10^6$ Gy
		Silicon rubber tape SIR	5×10^5 Gy
		Silicon rubber SIR	2×10^5 Gy
Output connector	Twin BNC	ETFE "Tefzel"	10^6 Gy
Calibration connector	SMA	PTFE "Teflon"	$< 10^3$ Gy

Organic and radiation-sensitive materials used in the "Rad-Hard" sensor:

The "Rad-Hard" sensor is supplied when the "Rad-Hard" option is ordered. The ordering code and model number are then terminated by -H.

Component		Material	Radiation resistance[1]
Wiring isolation		Polyether-ether-ketone PEEK	6×10^7 Gy
		Fiber glass	$> 10^8$ Gy
		with rubber adhesive	$> 10^6$ Gy
Stress absorbent		Polyurethane foam PU	5×10^6 Gy
		Polyurethane rubber PUR	5×10^6 Gy
Output connector	Twin BNC	ETFE Tefzel	10^6 Gy
Calibration connector	SMA	Polyether-ether-ketone PEEK	6×10^7 Gy

The above radiation resistance values are indicative only. They do not imply any guarantee of whatever nature of the manufacturer.
The manufacturer specifically declines any responsibility for any damage, direct or consequential, caused by ionizing radiations.

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[1] *Source: Compilation of Radiation Damage Test Data, H. Schönbacher et al.,*
CERN 79-04: http://cds.cern.ch/record/133188/files/CERN-HS-RP-038-YR-PARTI.pdf?version=1
CERN 79-08: http://cds.cern.ch/record/141784/files/CERN-HS-RP-093.pdf?version=1
CERN 82-10: http://cds.cern.ch/record/141784/files/CERN-HS-RP-093.pdf?version=1
CERN 89-12: http://cds.cern.ch/record/205520/files/CERN-89-12.pdf?version=1

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ACKNOWLEDGEMENT

ACCT is derived from the early design by H.G. Hereward at CERN.
K. Unser, also at CERN, simplified it by using the readout winding as feedback winding too.

Hervé Bayle at Bergoz Instrumentation made it a truly universal instrument with low noise, extended bandwidth and excellent immunity to the EMI and RFI background around particle accelerators.

Last revised April 2021