iTEC2021

Coreless Clip-On & Clamp-On Current Probes for Test Stand & In-Vehicle Current Monitoring

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Overview & Specifications

Coreless Clip-On & Clamp-On Current Probes

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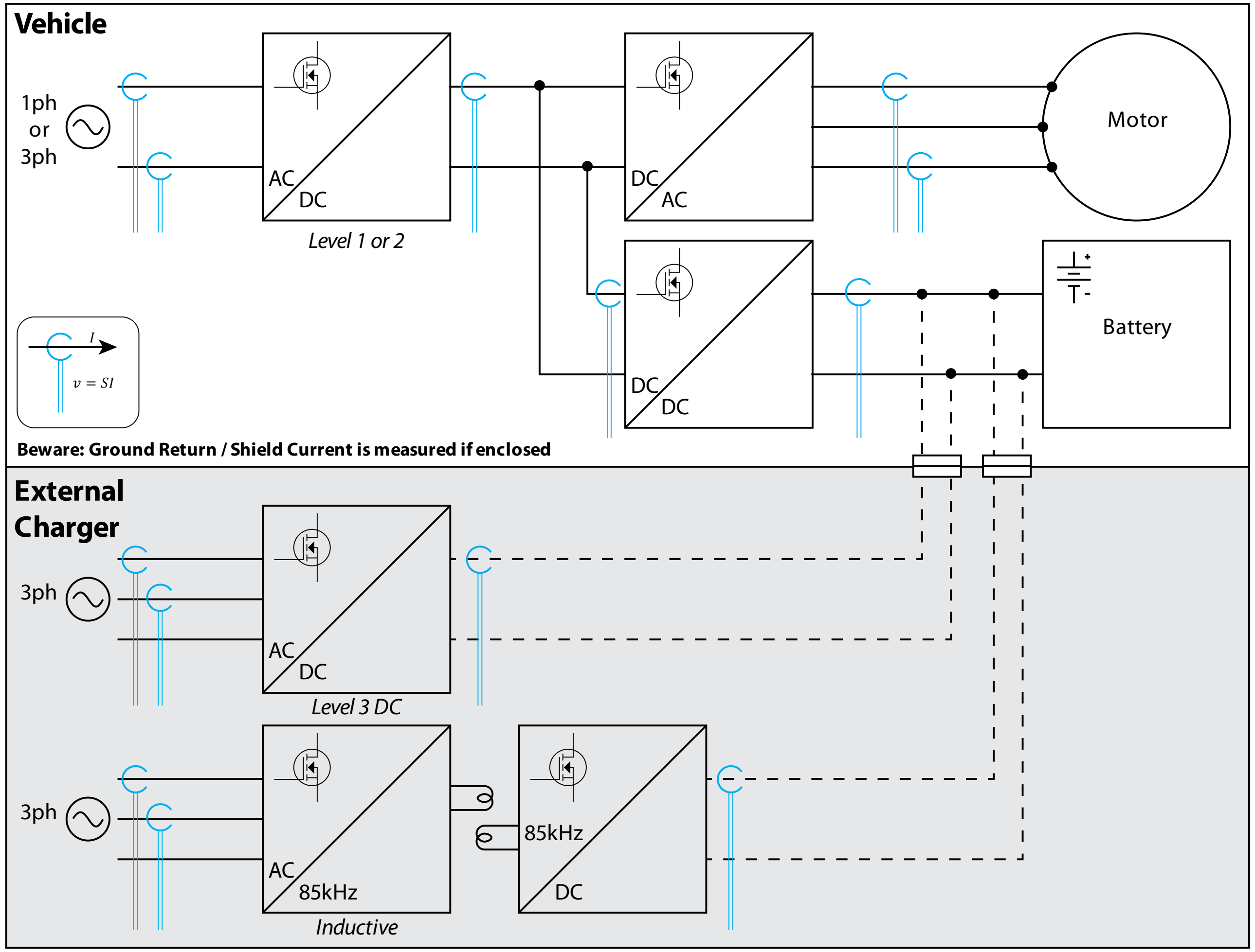
Coreless Clip-On & Clamp-On Current Probes

Potential Measurement Locations



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Coreless Clip-On & Clamp-On Current Probes

The potential locations for current measurement in a modern electric or hybrid vehicle are difficult to access.

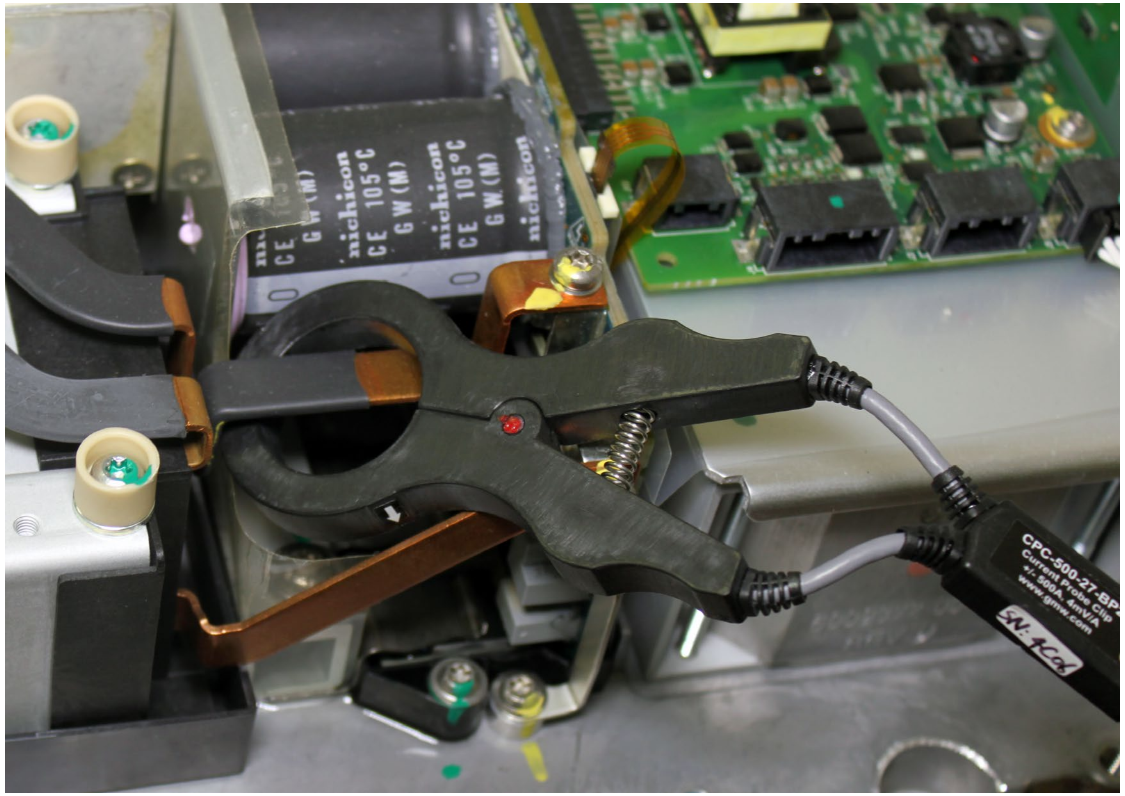
A Clamp-On Current Probe designed for safe, Hand-Held current measurements is typically large and will not withstand vibration, moisture/ice, or temperature cycling from -40°C to +85°C.

Coreless Clip-On & Clamp-On Current Probes

GMW CPC Clip-On DC-AC Current Probes
Current probes with no magnetic core and current ranges from ±250A to ±2000A.

No hysteresis, no damage from primary current overload with recovery to linear operation within 10 μs of primary current within range. The CPC Current Probe can be used to monitor the “low current” recovery after a high current overload.

27mm Aperture Clip-on Current Probe



Small size enables installation in difficult locations

Coreless Clip-On & Clamp-On Current Probes

Specifications: GMW CPC Clip-On DC-AC Current Probes

Signal Output	0±2V
Current Sensitivity	8mV/A to 1mV/A
Current Ranges	±250A, ±500A, ±1000A, ±2000A
Frequency Range	DC to 75kHz (-3dB)
Sensitivity Error	<±1%
Output Change, Magnetic Field	<0.2% of range for 40mT(1)
Response Time	<2μs
Insertion Impedance	<1pH
Operating Temperature	-40°C to +100°C
Moisture Resistance	Sealed, NEMA 5
Aperture	27mm (1.06”)
Mass	<30g (1 oz)
Power Supply	3.5V to 5.5V, <85mA, USB Port

(1) A current of 10kA generates a field of 40mT at a radius of 0.05m (~2”).

Coreless Clip-On & Clamp-On Current Probes

GMW CPCO Clamp-On DC-AC Current Probes
Large aperture Current Probes with no magnetic core and current ranges from ±500A to ±16kA. Suitable for earth moving, marine and aerospace high current applications.

77mm (3.03”) or 160mm (6.3”) aperture with a full 180° opening short 19mm (0.75”) axial length enables installation on cables or bus bars with close spacing.

Small cross-section and sealed enclosure enables long-term, reliable operation in harsh environments.

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Coreless Clip-On & Clamp-On Current Probes

Specifications: GMW CPCO Clamp-On DC-AC Current Probes

Signal Output Options	5V±5V, 05±5V, 0V±10V, 12mA±8mA, RMS 0-3V
Current Ranges	±500A, ±1kA, ±2kA, ±4kA, ±8kA, ±16kA
Frequency Range	DC to 40kHz (-3dB)
Sensitivity Error	<±1%
Output Change, Magnetic Field	<0.2% of range for 18mT to 267mT (range dependent) (1)
Response Time	<10µs
Insertion Impedance	<1pH
Operating Temperature	-40°C to +85°C
Moisture Resistance	Sealed, NEMA 5
Aperture	77mm (3.03”) or 160mm (6.3”)
Mass	120g (0.26 lb) or 300g (0.66 lb)
Power Supply	±11V to ±31V, <0.8W

(1) A current of 10kA generates a field of 40mT at a radius of 0.05m (~2”).

Test Data

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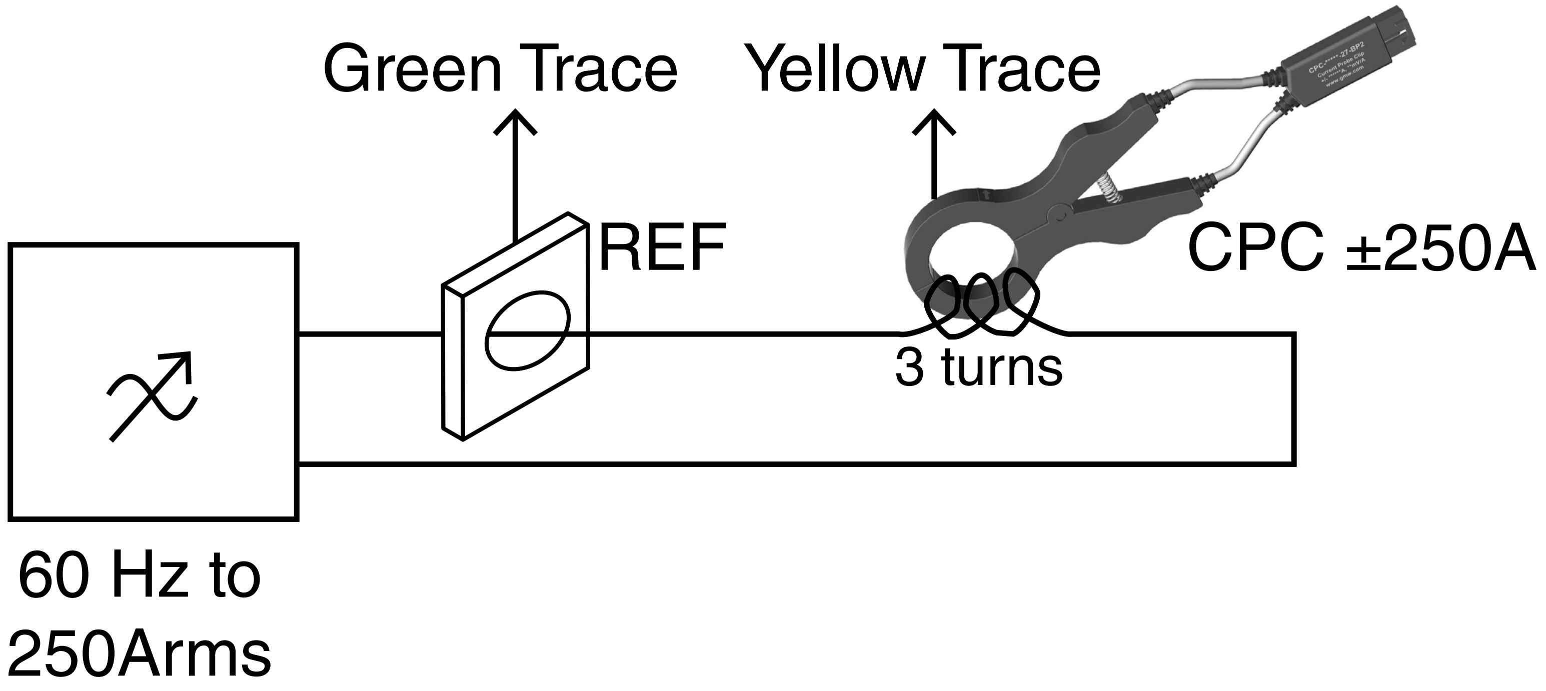
Coreless Clip-On & Clamp-On Current Probes

Recovery from Overload Current – Test Setup



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Coreless Clip-On & Clamp-On Current Probes

With 4x primary overload current the CPC shows:

- No electrical saturation and the correct sign with no overshoot
- No ringing
- No zero-crossing phase shift after overload
- No damage

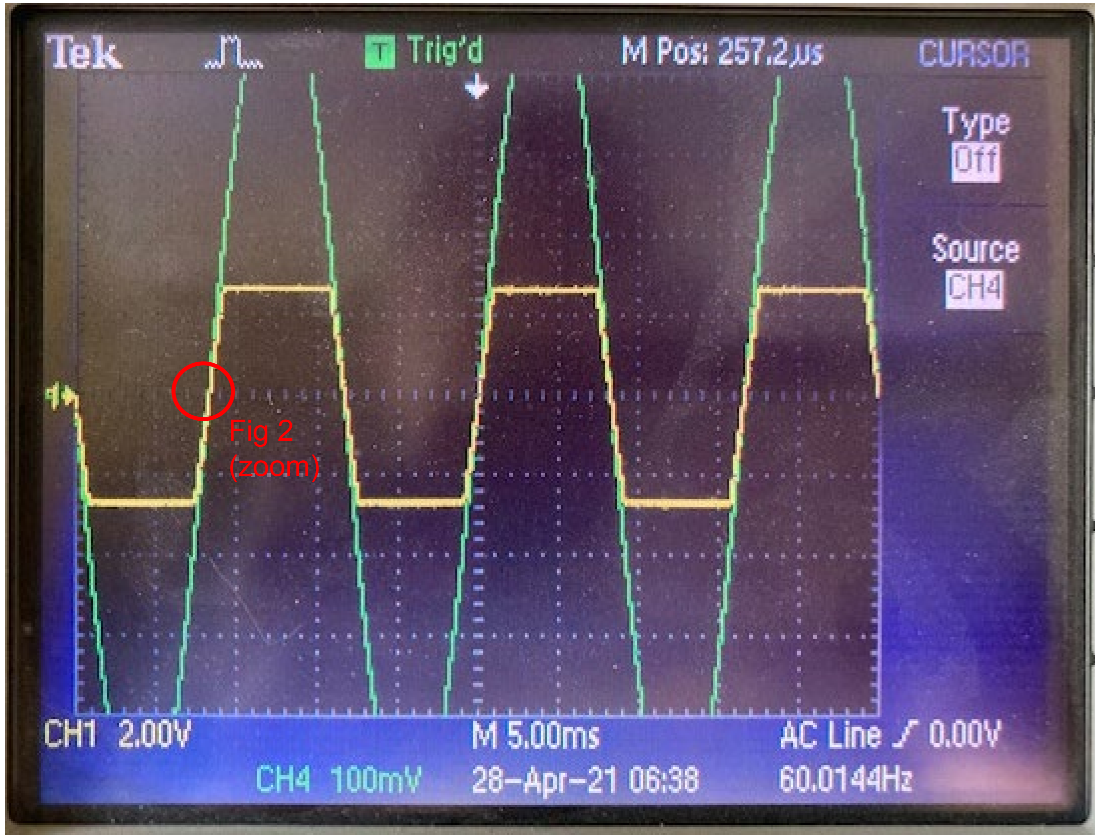

Fig 1: CPC ±250A fs with 750Arms Primary Current (yellow trace), or ±1060A. Approx. 4x full scale.

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Coreless Clip-On & Clamp-On Current Probes

With 4x primary overload current the CPC shows:

- No electrical saturation and the correct sign with no overshoot
- No ringing
- No zero-crossing phase shift after overload
- No damage

Fig 2: CPC ±250A fs as in Fig 1 but with high vertical sensitivity. No measurable zero crossing shift at 5µs/div.

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Coreless Clip-On & Clamp-On Current Probes

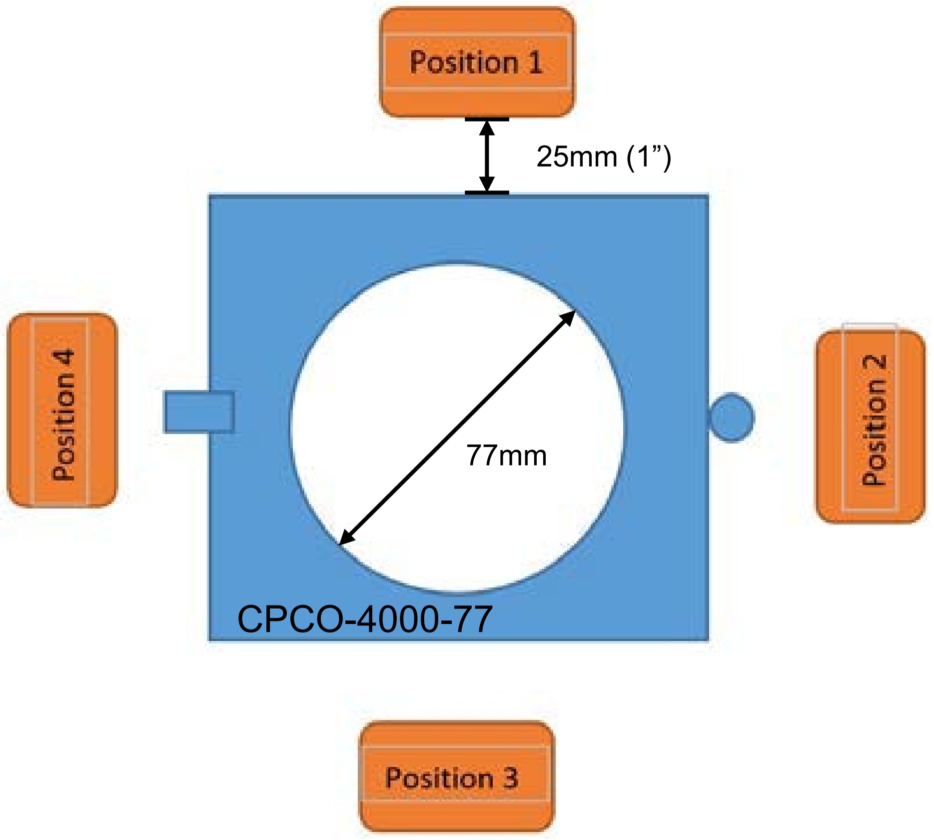
High rejection of external magnetic fields arising from external currents or steel cabinets.

Test arrangement:

- GMW CPCO-4000-77 (±4000A, 77mm aperture)
- External Conductor 1000A at 25mm from surface

Change in Zero Offset:

Position 1: 0.5% full-scale
Position 2: 0.52% full-scale
Position 3: 0.61% full-scale
Position 4: 0.25% full-scale



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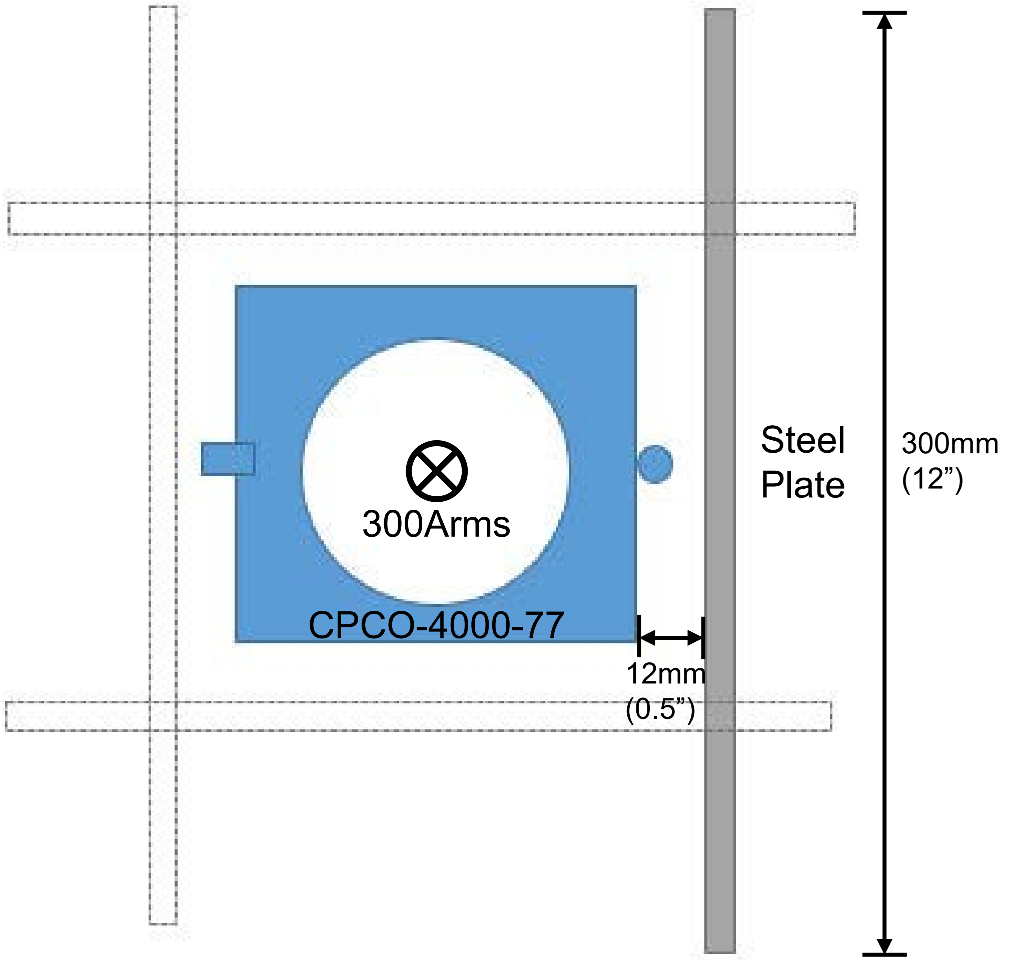
Coreless Clip-On & Clamp-On Current Probes

High rejection of external magnetic fields arising from external currents or steel cabinets.

Test arrangement:
Steel place 100mm x 300mm x 6mm (4” x 12” x ¼”) placed about 12mm (0.5”) from the outer surface of the CPCO at four positions. The output signal for a 300Arms, 60Hz was measured.

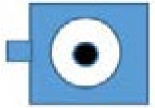
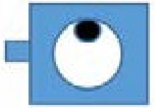
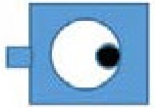
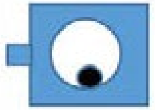
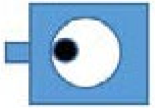
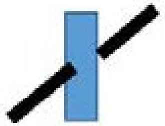
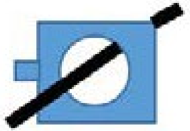
The change in the output signal was <0.1% of the signal for the steel place in any position.



Coreless Clip-On & Clamp-On Current Probes

Signal Output essentially independent of current position within aperture.

The output signal for a CPCO-4000-77 (77mm aperture) is measured for a 60Hz 230Arms current in a 10mm diameter conductor with variations in the measured current as shown.

Conductor Position	Measured Current (Arms)	Deviation (%)
	230	0.%
	228	-0.9%
	228	-0.9%
	232	0.9%
	233	1.3%
 	233	1.3%

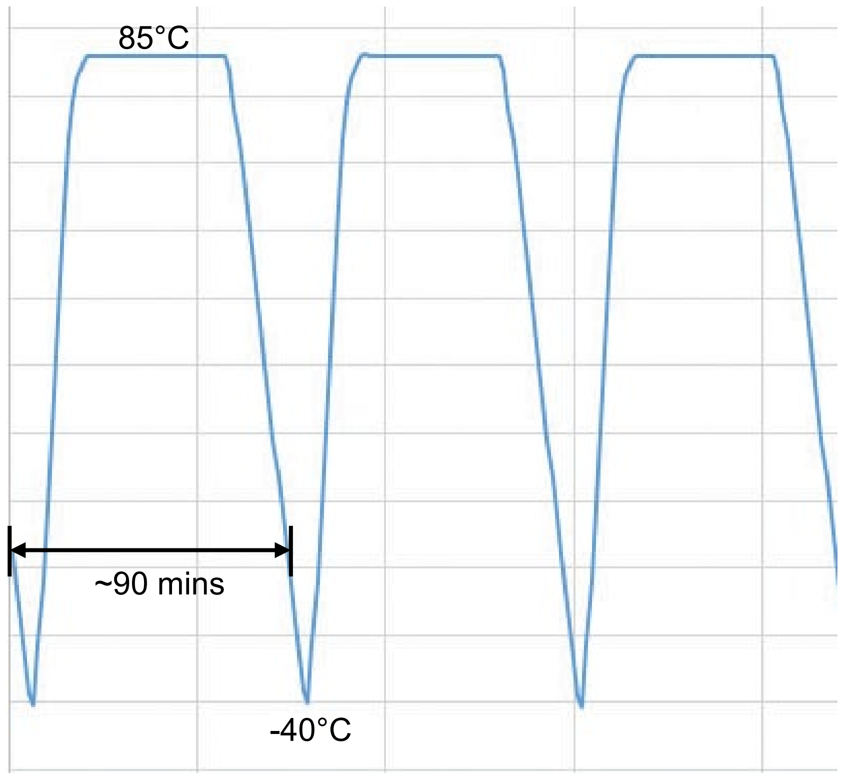
Coreless Clip-On & Clamp-On Current Probes

High Stability with thermal cycling.

Several different CPC and CPCO models with different current ranges have been temperature cycled for 50 cycles over 70 hours.

The maximum changes observed:

Zero Offset: ±0.2% of full-scale
Sensitivity: ±0.5%



1 cycle ~ 90 minutes, -40°C to +85°C.
Repeated for 50 cycles.

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Operating Principle

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Coreless Clip-On & Clamp-On Current Probes

<u>Operating Principle:</u>
Ampere's Circuital Law

In SI units:

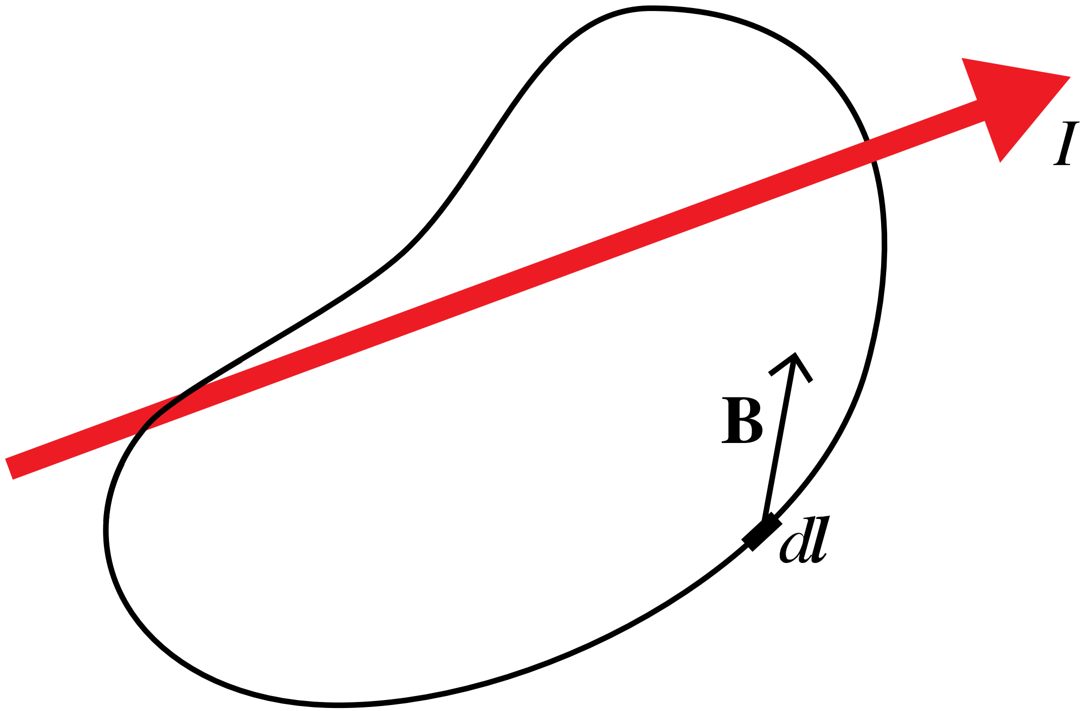
$$\oint_C \mathbf{B} \cdot \mathrm{d}\boldsymbol{l} = \mu_0 I_{enc}$$

$\mathbf{B}$ is the magnetic flux density in Tesla.

μ_0 is the permeability of a vacuum.

I is the current enclosed in Ampere.

Note that the line integral is independent of the position of the current.



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<u>Operating Principle:</u>
Ampere's Circuital Law

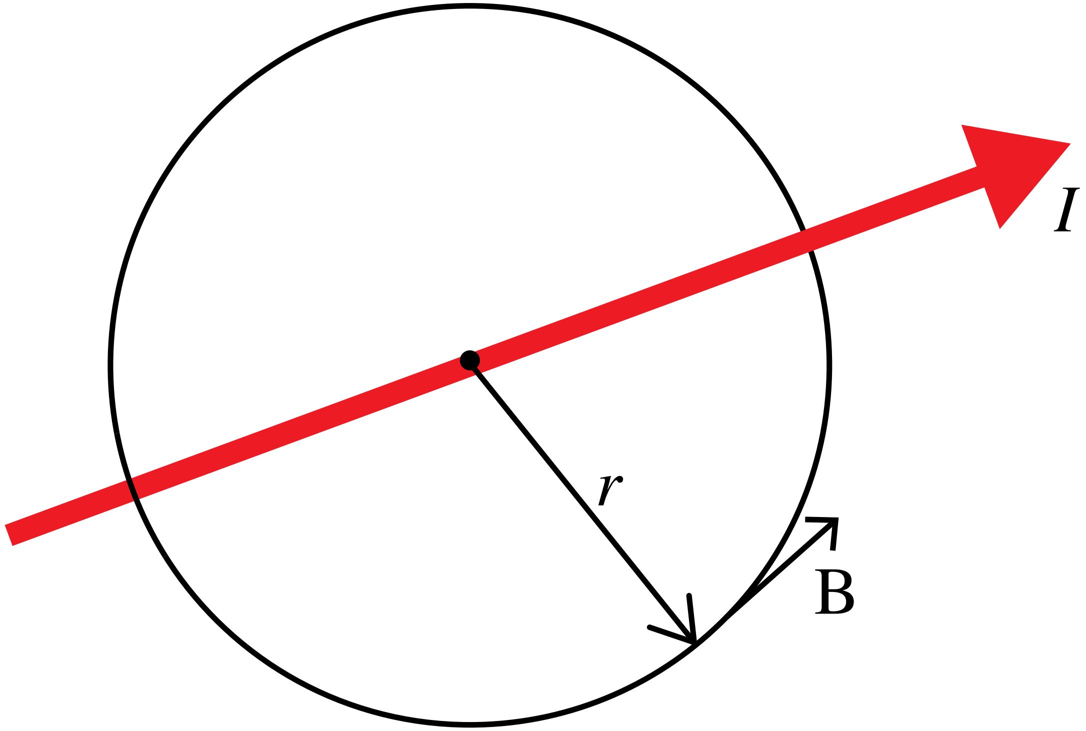
For a circle of radius r enclosing a current I with the current perpendicular to the plane of the circle, $\mathbf{B}$ is tangential to the circle at all points on the circle and the relationship becomes:

$$\mathrm{B} \cdot 2\pi r = \mu_0 I$$

or

$$I = \frac{2\pi r \mathrm{B}}{r}$$

Only in the absence of any other currents or magnetic fields can the current be determined by measuring $\mathbf{B}$ at one point.



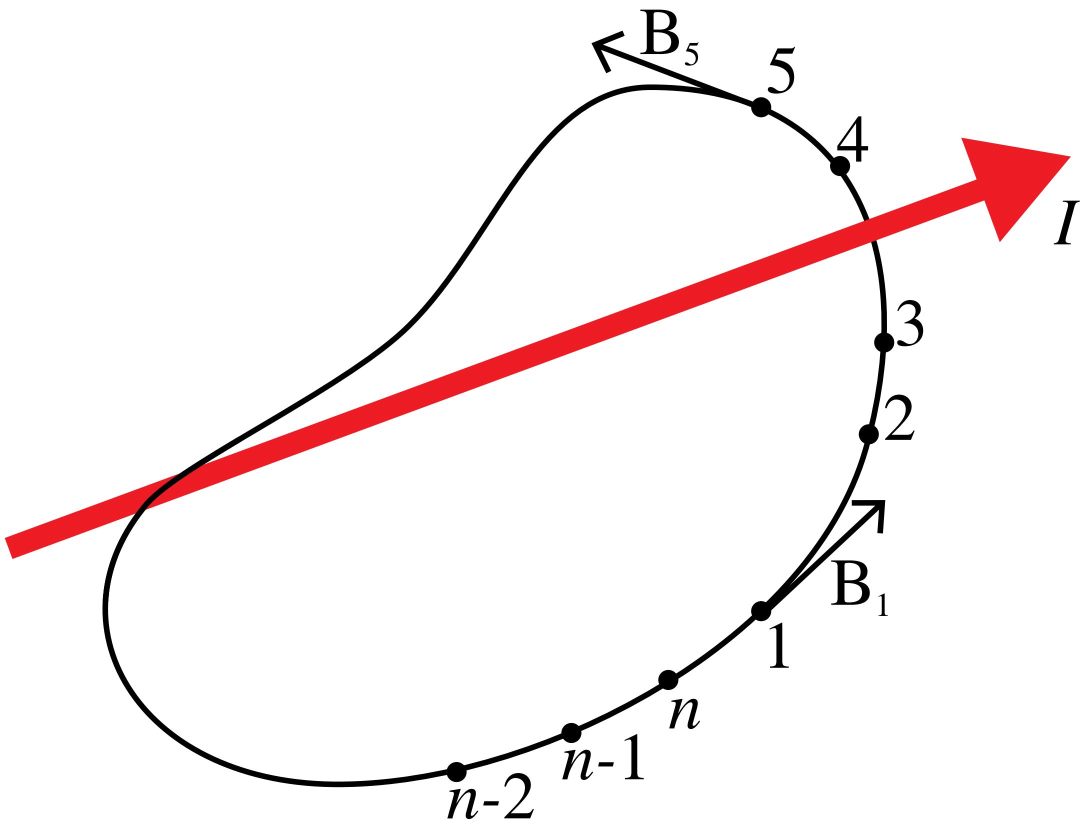
Coreless Clip-On & Clamp-On Current Probes

Approximating Ampere's Circuital Law with a Summation instead of a Line Integral

For "point" magnetic sensors providing an output signal proportional to $\mathbf{B}$, the Line Integral can be approximated by a summation:

$$I = \frac{1}{\mu_0}\int \mathbf{B}\cdot d\boldsymbol{l} \sim \frac{1}{\mu_0}\sum_{r=1}^{n} C_r \cdot B_r$$

Where B_r is the field component along the tangent to the enclosing line and C_r are constants that can be determined by magnetic modeling.



Coreless Clip-On & Clamp-On Current Probes

Approximating Ampere's Circuital Law with a Summation instead of a Line Integral

For a current I' outside the loop:

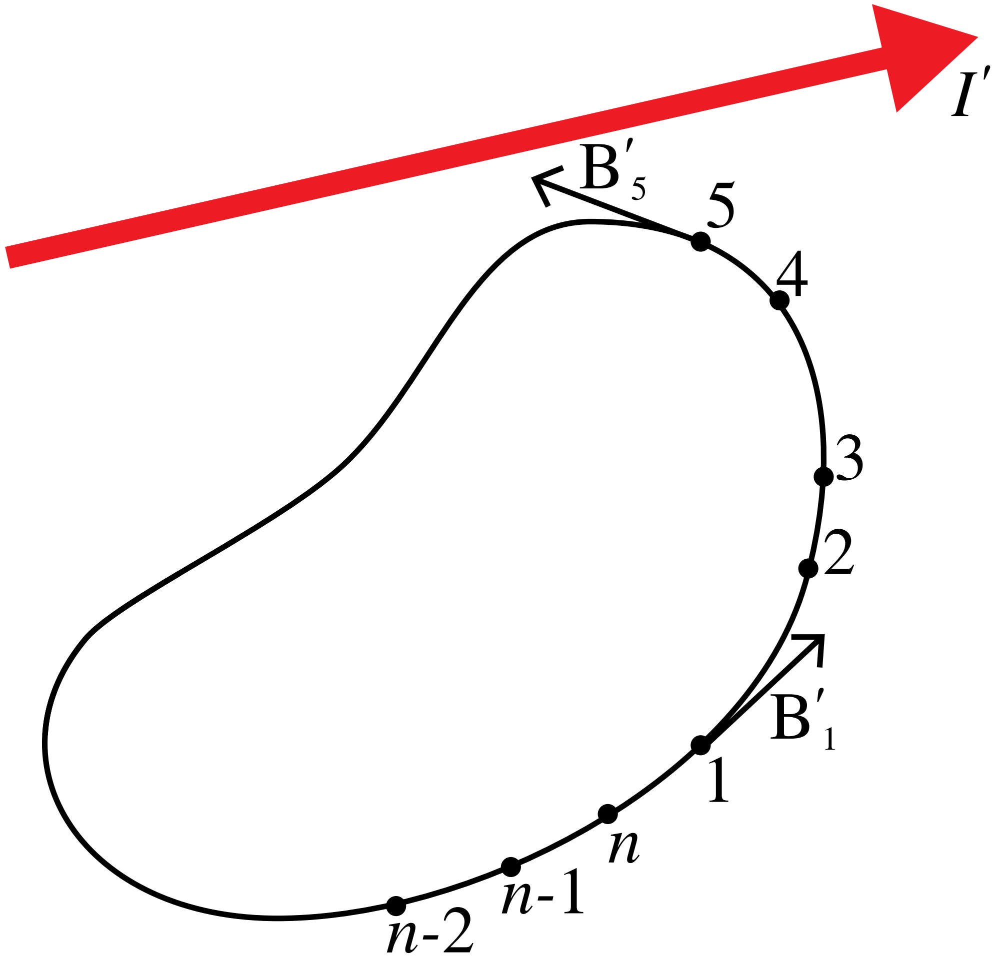
$$\frac{1}{\mu_0}\int \mathbf{B}'\cdot d\boldsymbol{l} = 0$$

and

$$\frac{1}{\mu_0}\sum_{r=1}^{n} C_r \cdot B_r' \sim 0$$

External currents and magnetic fields are rejected by the summation approximation.

US Patents: 9952257, 10690701
European Patent: 2972425



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Coreless Clip-On & Clamp-On Current Probes

Ampere's Circuital Law applies to any closed line. The CSS-SO DC/AC "Slip-on" Current Probe can measure the current of any shape conductor that can fit within the open U-shape.

Signal Output	0±2V
Current Sensitivity	4mV/A to 0.166mV/A
Current Ranges	±400A, ±1kA, ±2kA, ±4kA, ±8kA, ±12kA
Frequency Range	DC to 1kHz (-3dB)
Sensitivity Error	<±1%
Response Time	<2μs
Insertion Impedance	<1pH
Operating Temperature	-40°C to +85°C
Moisture Resistance	Sealed, NEMA5
Aperture, U-shape	102mm x 30.2mm (4.0" x 1.2")
Mass	<65g (2.3 oz)
Power Supply	3.5V to 5.5V, 150mA, USB Port

A U-shape, "Slip-On" Current Sensor with a relatively narrow opening works well.

CSS-SO-xxxx-BP2

Thank You!

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