



Current Measurement for Electric Vehicle Charger Test

GMW*Associates*

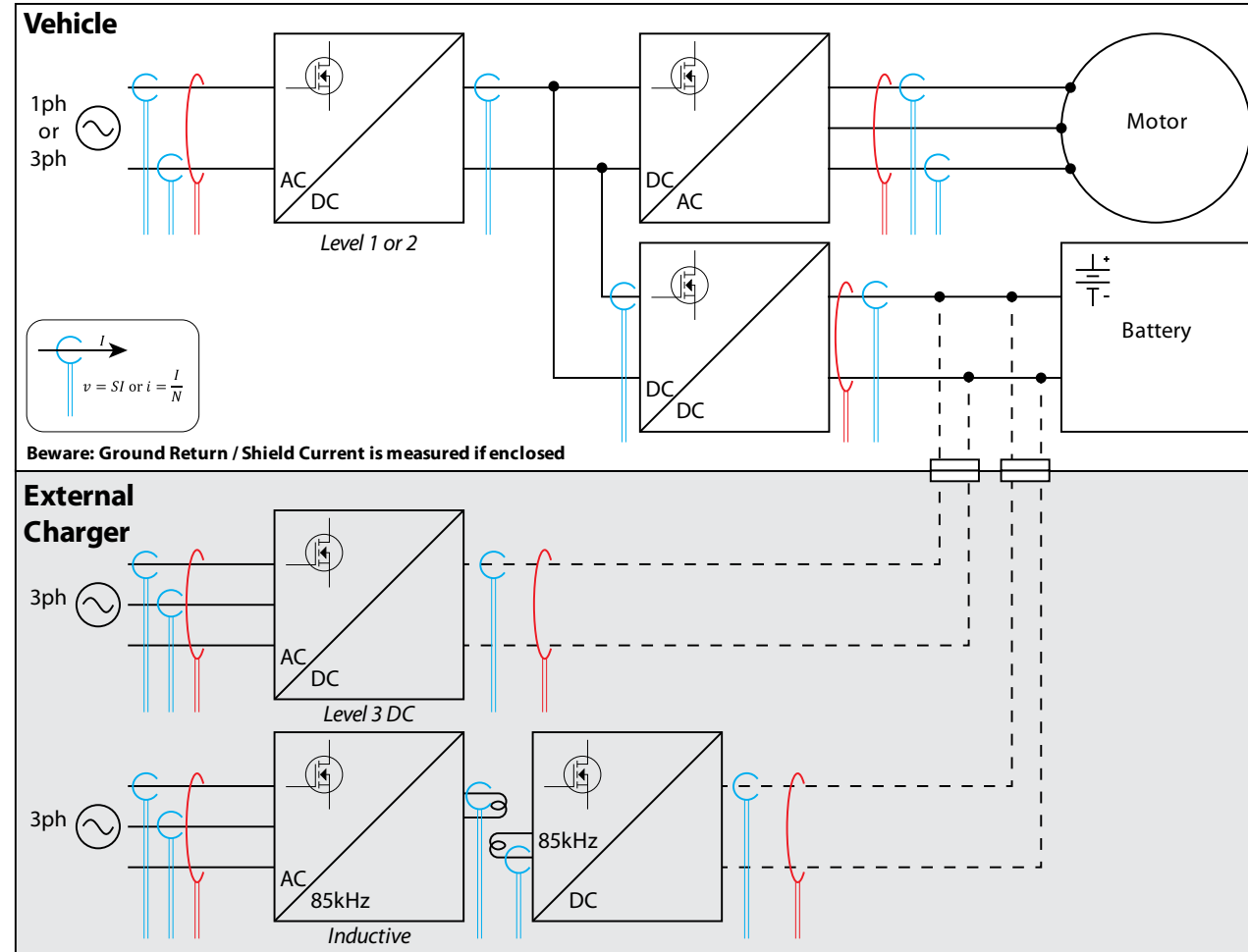
Presented by:

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VP Marketing
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ben@gmw.com

Overview

Current Probe Connections in Electric Vehicle Chargers

Current Probe Connections in Electric Vehicle Chargers

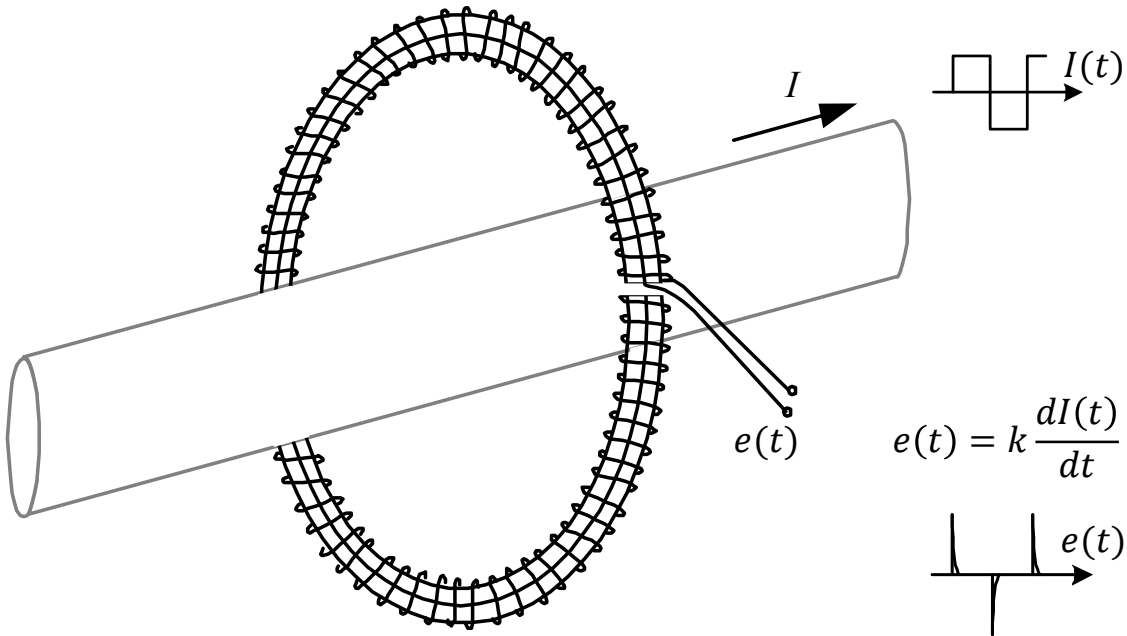


PEM Rogowski Coils

Flexible, Clip-around AC Current Probes with Analog Integrator

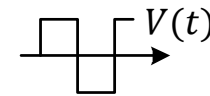
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PEM Flexible, Clip-around AC Current Probes Rogowski Coil with Analog Integrator



Rogowski Coil with no magnetic core

After Analog Integration: $V(t) = \int k \cdot \frac{dI(t)}{dt} \cdot dt = k \cdot k' I(t) = S \cdot I(t)$
 $S = \text{Sensitivity}$

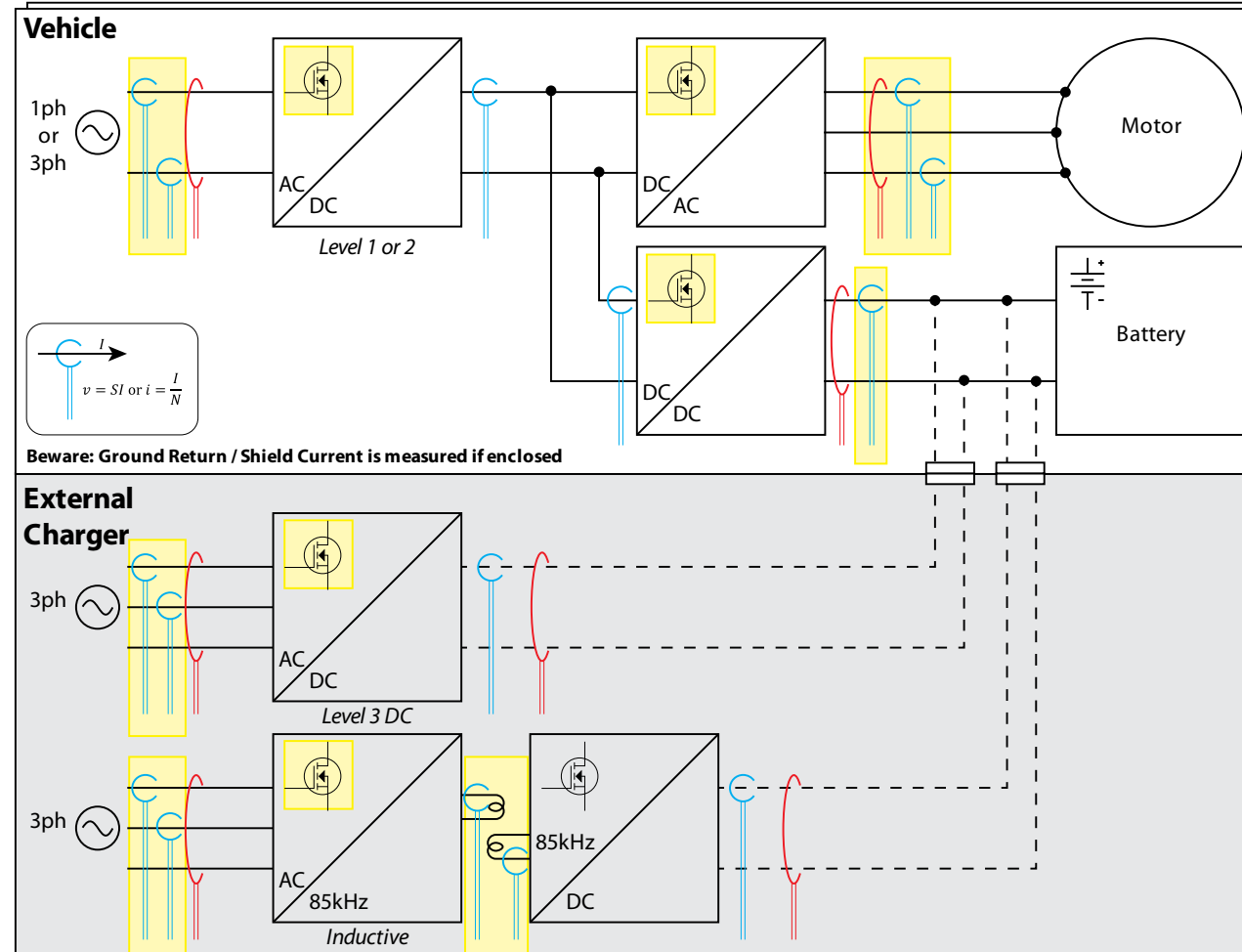


Current Sensitivity (S):	200mV/A to 0.02mV/A
Current Range:	±30A to ±300kA
Frequency Range:	0.03Hz to 50MHz
Amplitude Accuracy:	~±1%
Phase Shift:	< 1° at mid-range
Insertion Impedance:	<1pH
Operating Temp (coil):	-20°C to +100°C (can be wider range)
Sensitivity Temp Coeff:	-150ppm/°C to -200ppm/°C

Source: PEM

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Current Probe Connections in Electric Vehicle Chargers - PEM CWT Rogowski Coils

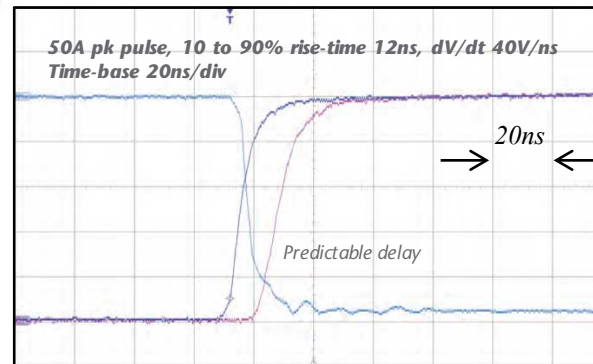


PEM Current Probes - CWT Mini50HF



Clip-around,
shielded Rogowski coil

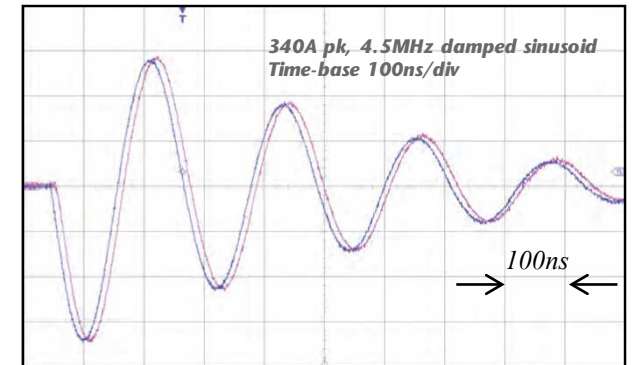
Current Sensitivity (S):	10mV/A	5mV/A
Current Range:	±0.6kA	±1.2kA
Noise (primary current):	1.5Ap-p	3Ap-p
Frequency Range (LF):	12Hz	6Hz
(HF):	50MHz	50MHz
Coil Lengths:	100mm or 200mm	
Coil Cross-section:	3.5mm	
Current Sensitivity (S):	10mV/A	5mV/A



Ch1 - (2GHz) Co-axial shunt (10A/div)

Ch2 - CWTMini50HF/3/B/1/100/2 - 10mV/A, peak current 600A (10A/div)

Ch3 - Voltage close to the coil - 100V/div



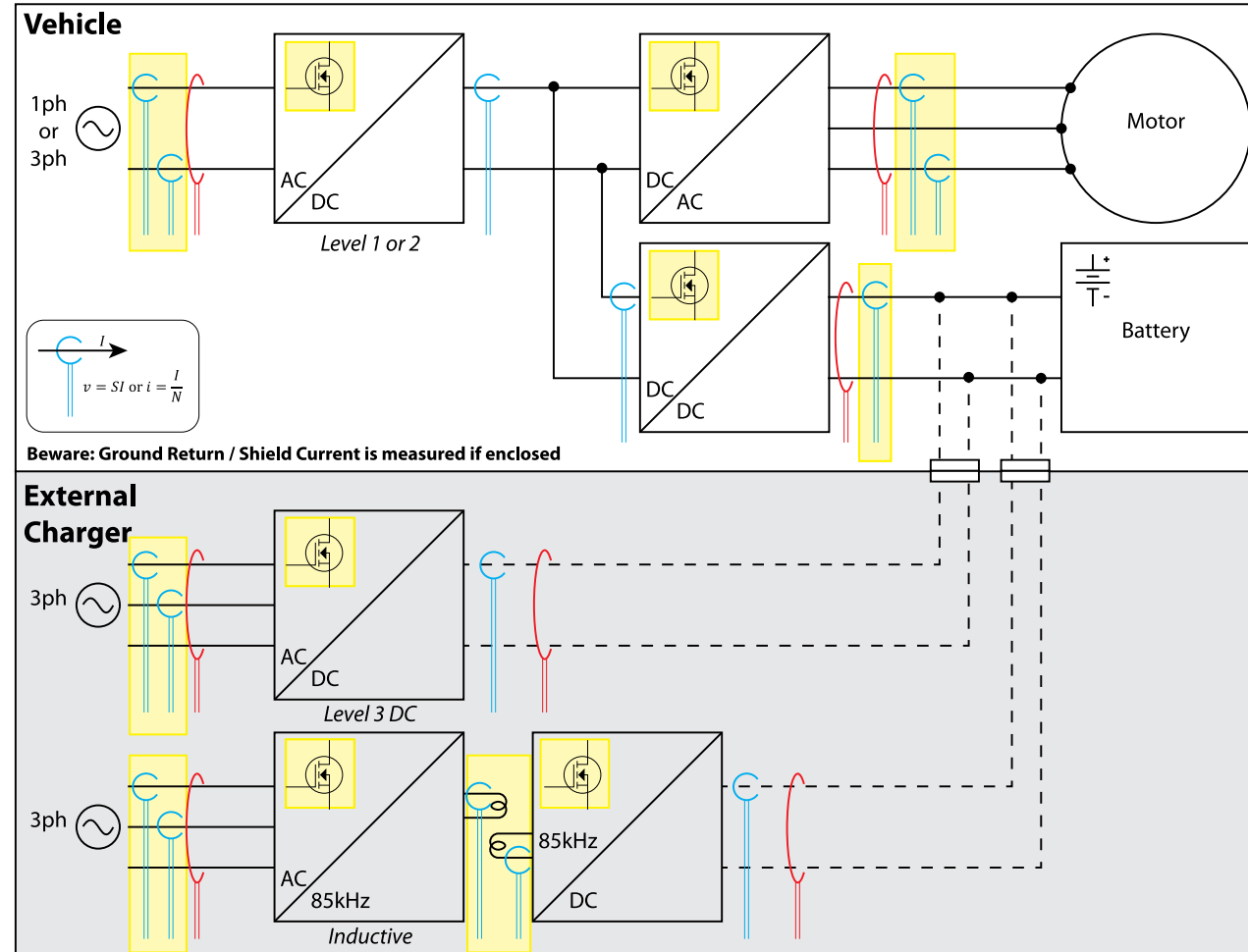
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Current Probe Connections in Electric Vehicle Chargers - PEM CWT Mini50HF



PEM Current Probes with Tailored Frequency Response

CMC Common-Mode AC Current Probe

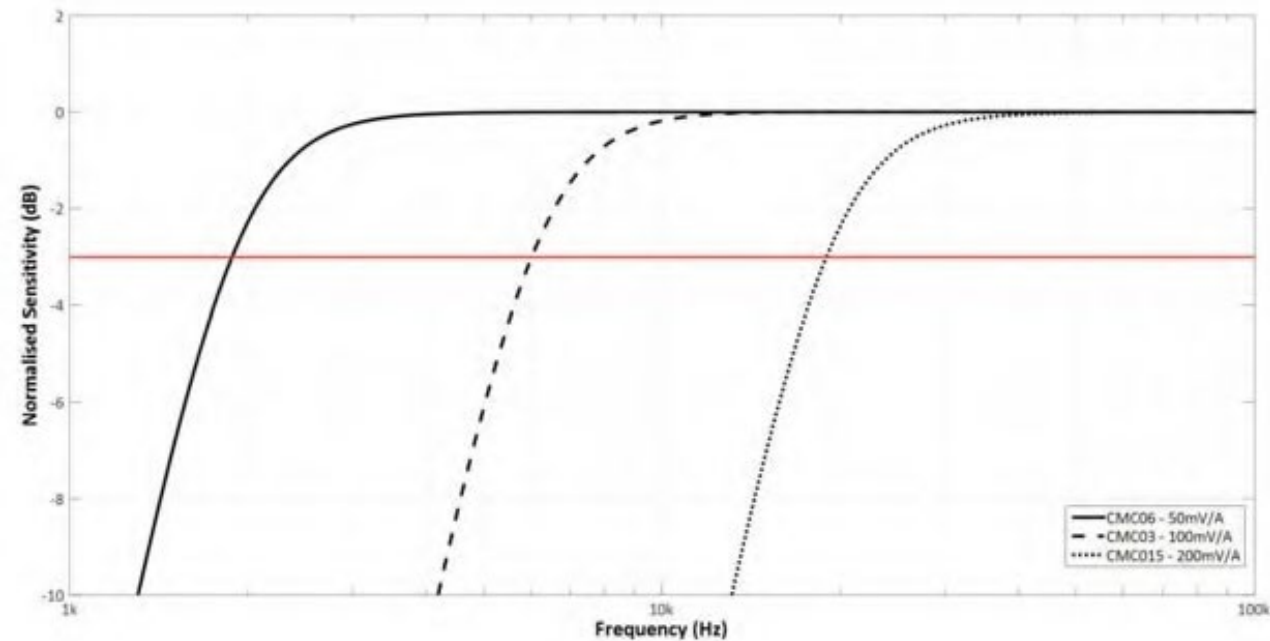
Optimized for high S/N for the high frequency current generated by the Variable Speed Drive Voltage Spikes

Current Sensitivity (S):	200mV/A	100mV/A	50mV/A
Current Range:	±37.5A	±75A	±150A
Frequency Range (LF):	19kHz	6kHz	1.9kHz
(HF):	11MHz	13MHz	14MHz

CWT MiniHF 85kHz AC Current Probe

Optimized for 85kHz inductive power transfer measurements

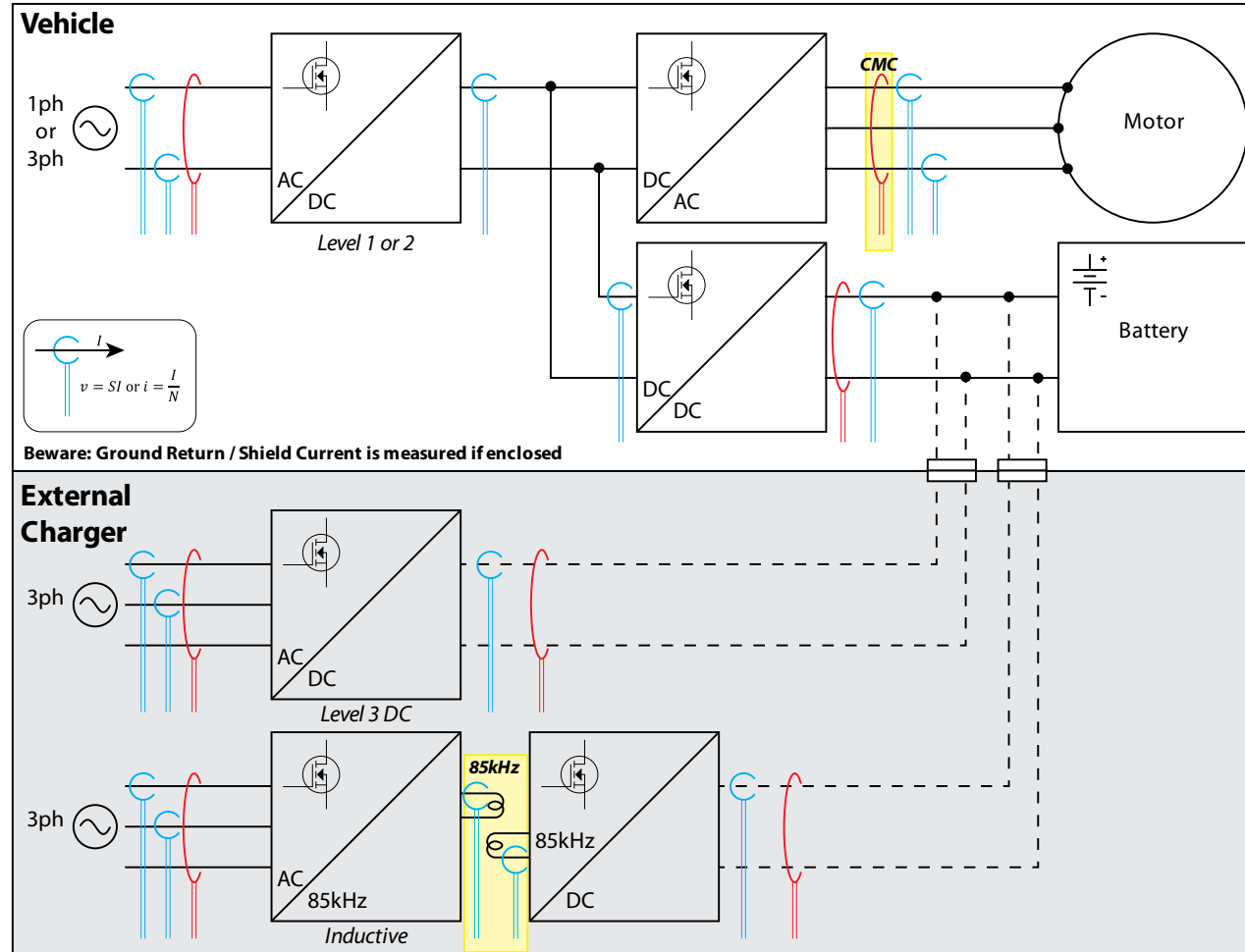
Current Sensitivity (S):	20mV/A
Current Range:	±300A
Frequency Range (LF):	530Hz
(HF):	30MHz
Amplitude Accuracy (85kHz)	±0.5%
Phase Accuracy (85kHz)	<±1°



Source: PEM

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Current Probe Connections in Electric Vehicle Chargers – Tailored Frequency Response (CMC, CWT MiniHF 85kHz)



PEM Current Probes with Tailored Frequency Response

CMC Common-Mode AC Current Probe

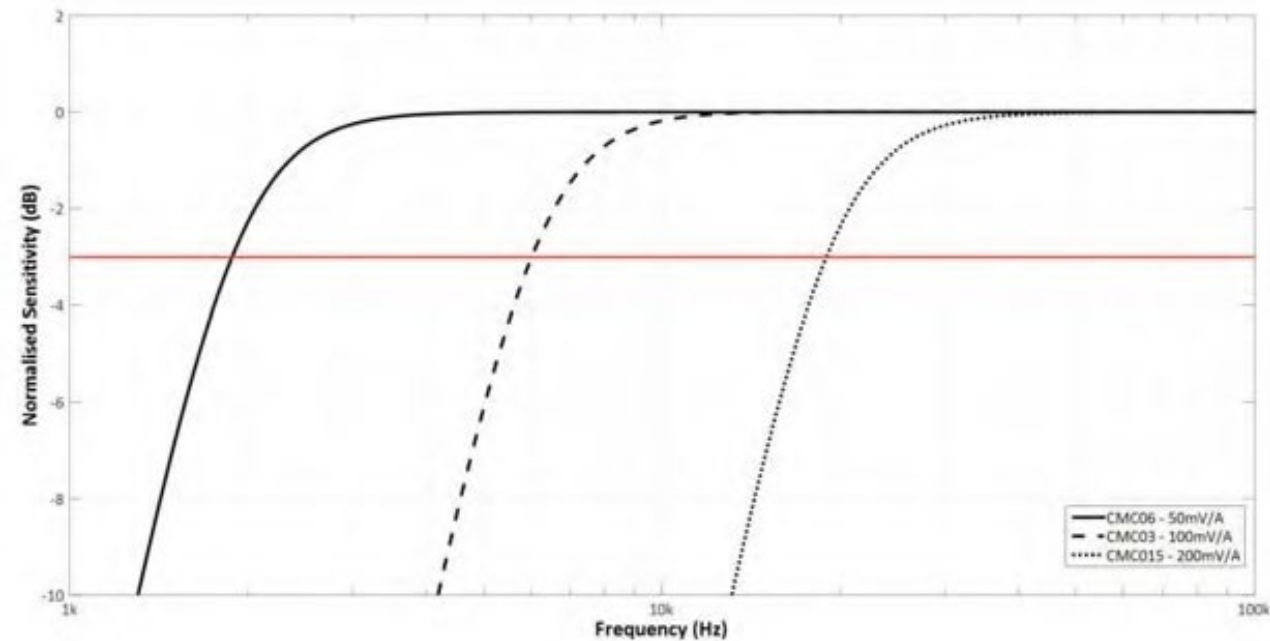
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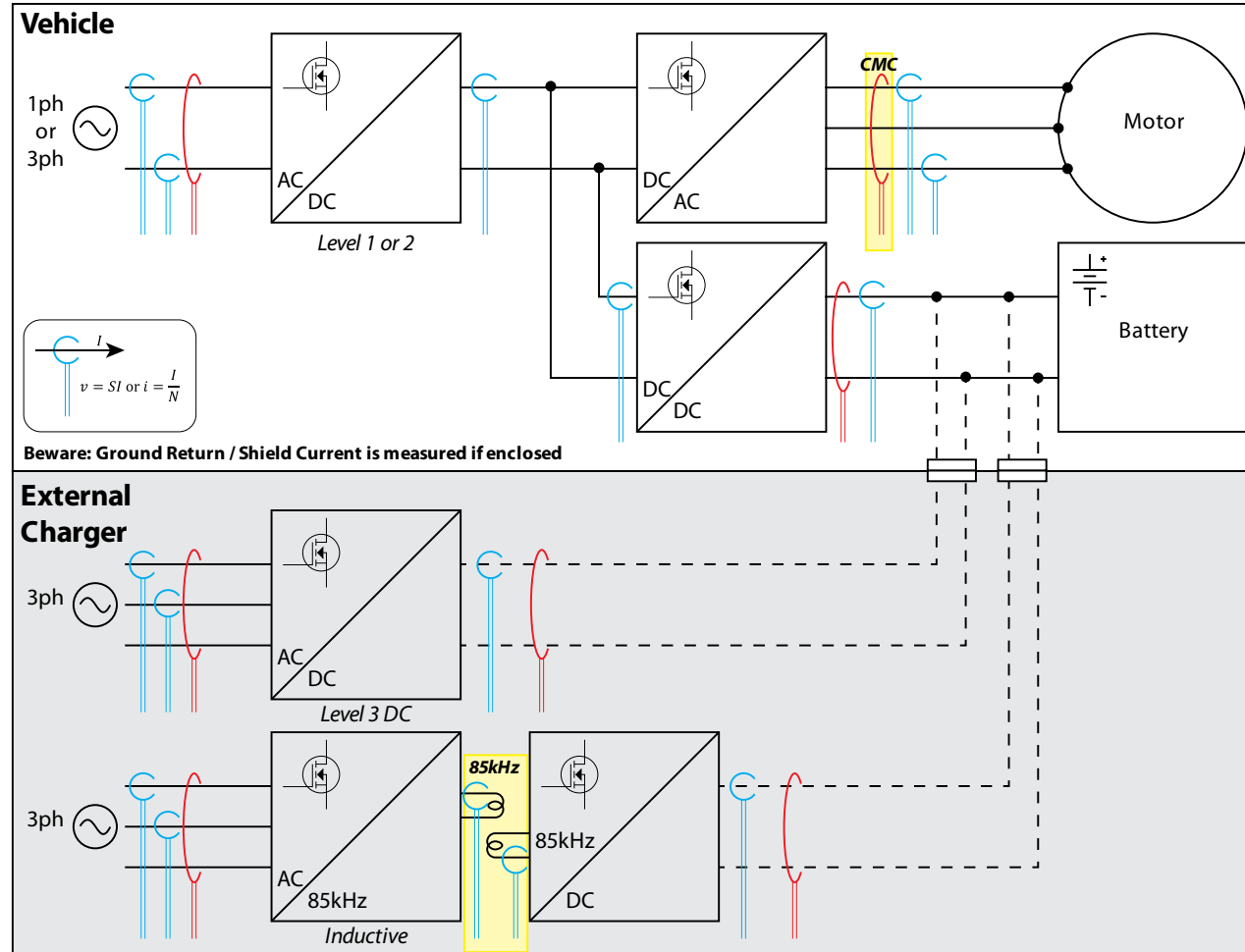
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Current Probe Connections in Electric Vehicle Chargers – Tailored Frequency Response (CMC, CWT MiniHF 85kHz)



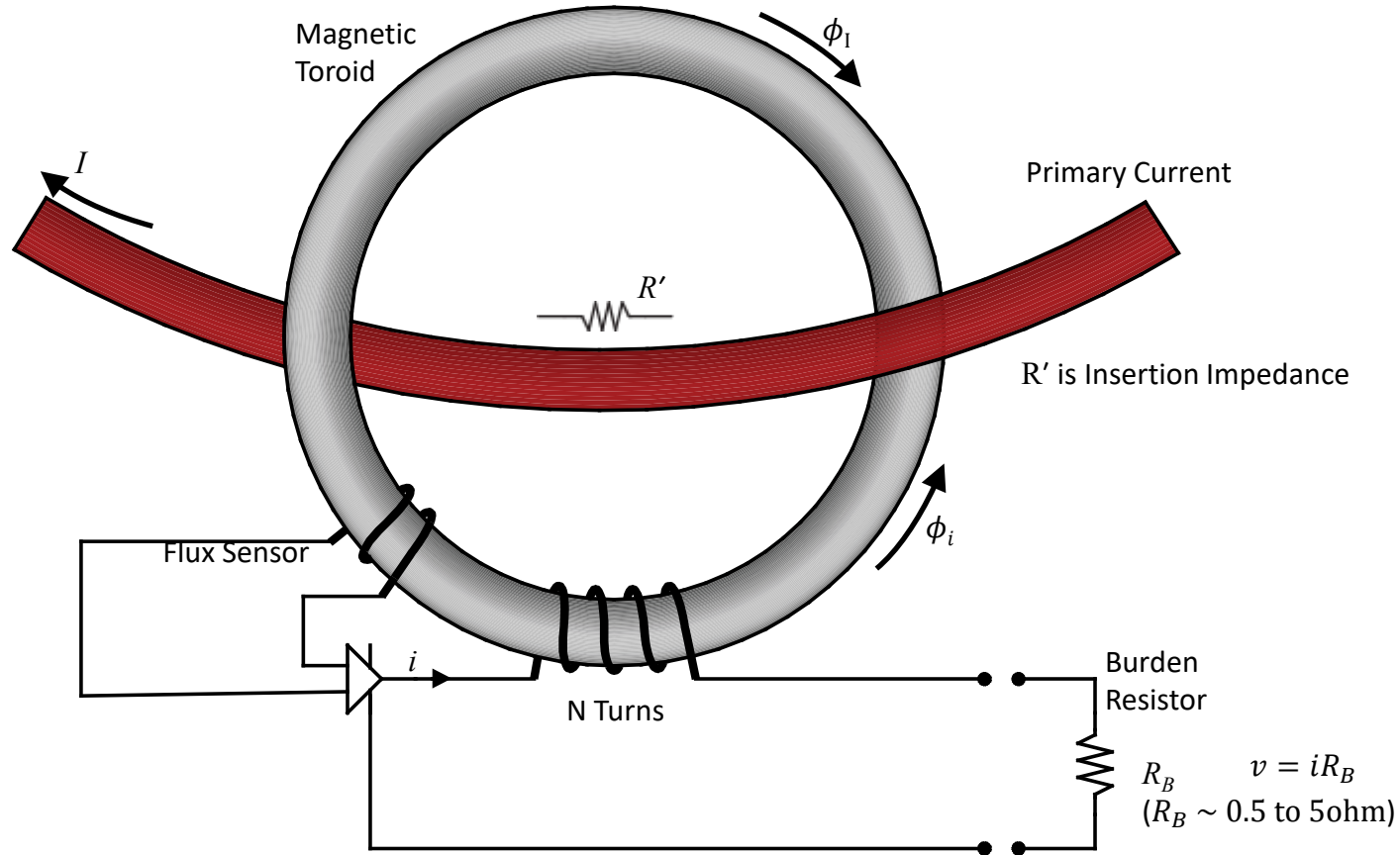
Danisense Current Transducers

DC-AC Zero Flux, Fluxgate Current Transducers

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 **TEC2021**

Danisense Zero Flux, Fluxgate Current Transducers



If $\phi_i = \phi_1$ (zero flux in the magnetic toroid),
 $Ni = I$ and $i = I/N$ ($N \sim 200$ to 5000).

If there is no power lost in the Current Transducer,
 $I^2 R' \sim i^2 R_B$, $I^2 R' \sim \frac{I^2}{N^2} R_B$ or $R' \sim \frac{R_B}{N^2}$

For $R_B \sim 1\text{ohm}$, $N \sim 1000$, $R' \sim 1\mu\text{ohm}$.

For $I \sim 1000\text{A}$, $N \sim 1000$, $\text{Power} \sim 1\text{W}$

Danisense Zero Flux, Fluxgate Current Transducers

Product Range Overview

Output Type	Product Family	Primary Current (Arms)										
		50	200	300	400	500	600	1000	1200	2000	5000	10000
Current	DP	PCB Mount, Programmable, 12.5/25/50Arms										
	DS											
	DQ											
	DC											
	DM											
	DL											
	DR											
Voltage	DS											
	DM											
	DL											
	DR											



DP series



DQ series



DC series



DM series



DS series



DR series



DL series



Unpackaged



DSSIU System Interface

Danisense Zero Flux, Fluxgate Current Transducers

Specifications, selected models

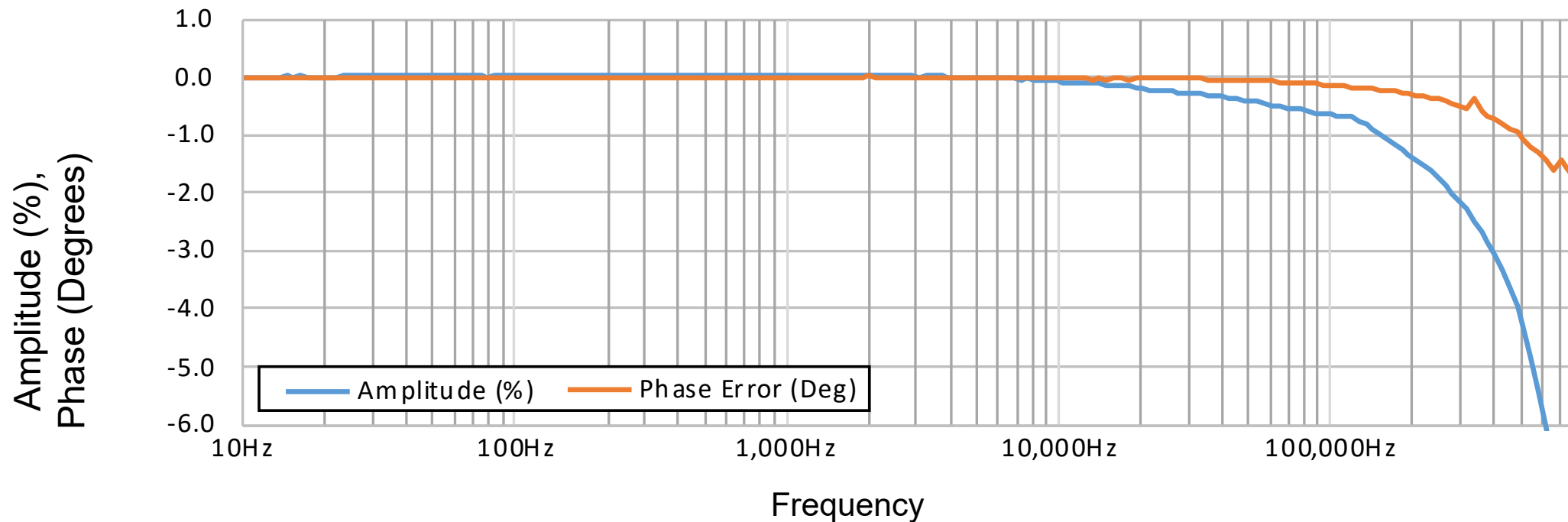
	DS200ID	DS1200ID-CD3000
Current Ratio, N	500	1500
Current Range	$\pm 370\text{A}$	$\pm 1500\text{A}$
Output Signal	2mA/A	0.666mA/A
Zero Offset (equiv. primary)	$< \pm 6\text{mA}$	$< \pm 18\text{mA}$
Zero Offset Stability (equiv. primary)	$< \pm 0.06\text{mA/month}$	$< \pm 0.15\text{mA/month}$
Offset Change, Magnetic Field (equiv. primary)	$< \pm 3\text{mA/mT}^{(1)}$	$< \pm 3\text{mA/mT}^{(1)}$
Amplitude Error, dc to 5kHz	$< \pm 0.01\%$	$< 0.01\%^{(2)}$
Phase Error, dc to 5kHz	$< \pm 0.1 \text{ degree}$	$< \pm 0.1 \text{ degree}^{(2)}$
Calibration Winding	—	3000 turns ⁽²⁾ $500\text{mA} \cdot 3000t = 1500\text{A} \cdot t$
Case Type	Al (ES Shield)	Al (ES Shield)
Aperture	27.6mm (~1.1")	45mm (~1.77")

(1) A current of 500A generates a field of 1mT at a radius of 0.1m (~4").

(2) Calibration Winding Option limits AC operation to 1kHz

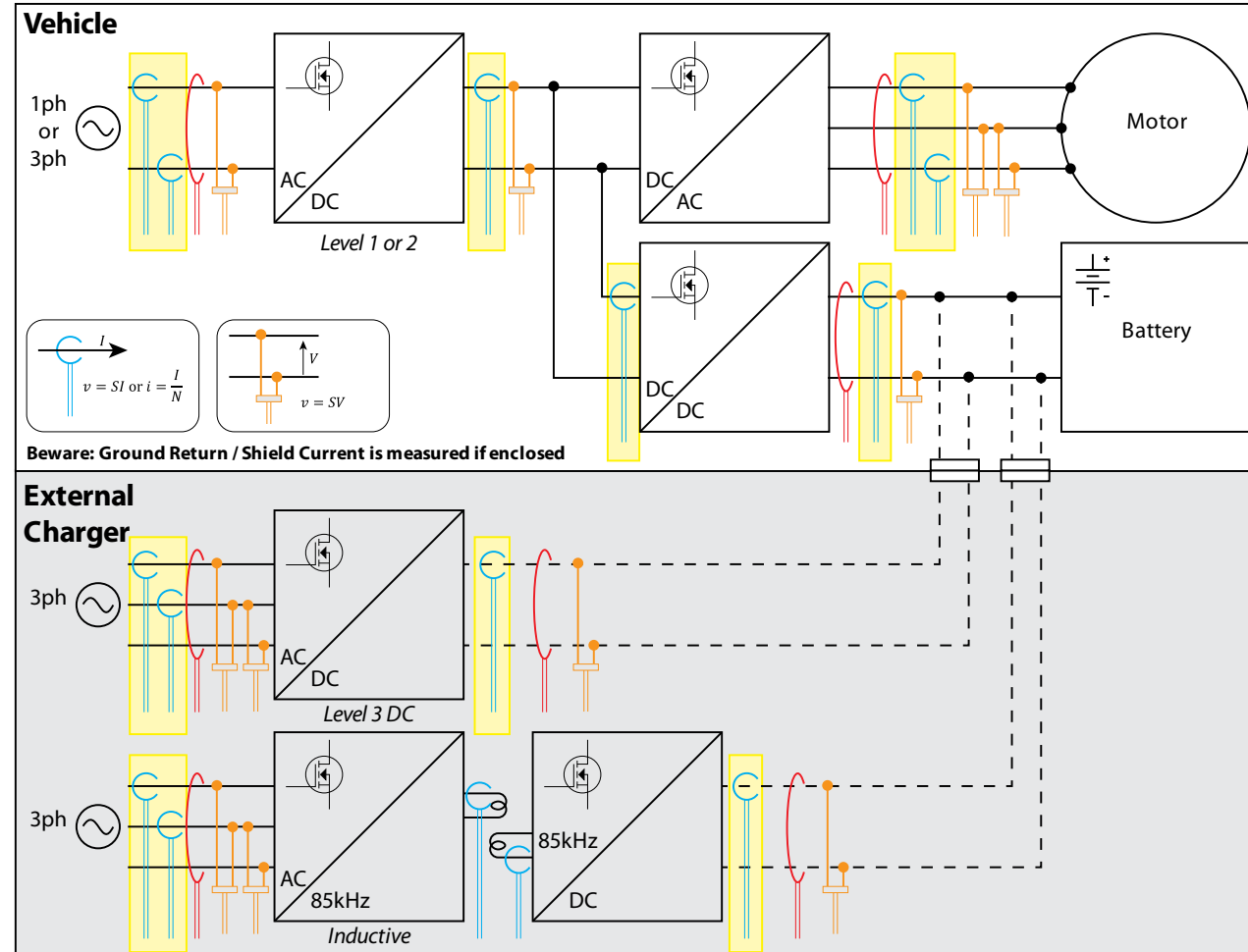
Danisense Zero Flux, Fluxgate Current Transducers

DS200ID, Amplitude and Phase



- Excellent amplitude and phase response to 10kHz
- No resonant behavior in amplitude or phase response at high frequency

Current and Voltage Probe Connections in Electric Vehicle Chargers – Danisense Current Transducers



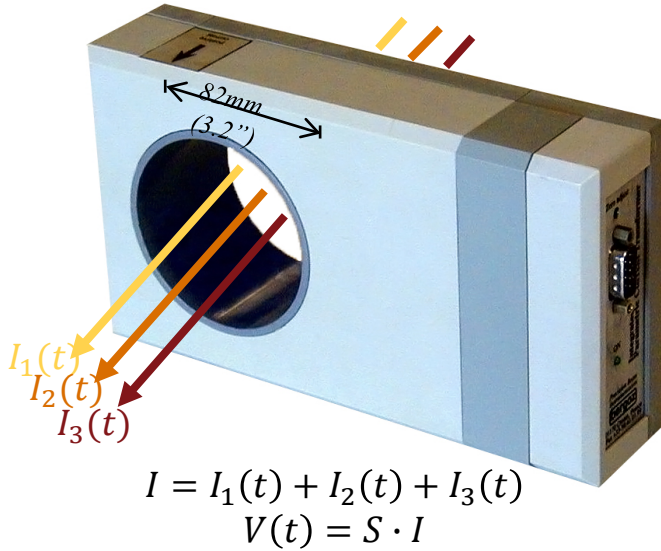
Bergoz IPCT

DC-AC High Resolution Current Transducer

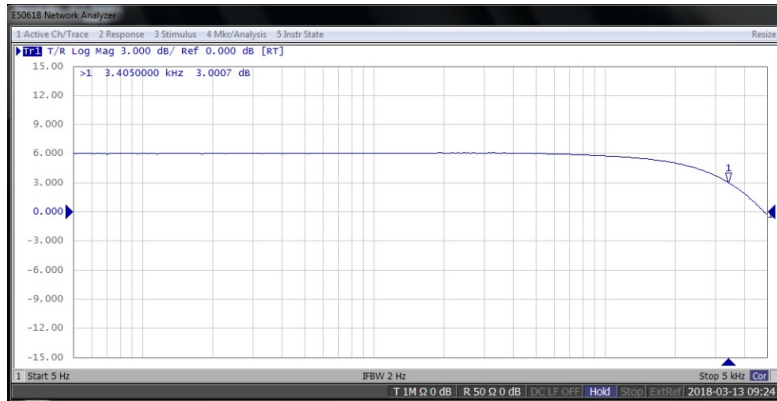
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The logo for iTEC2021, featuring a stylized 'i' with a green and blue bar, followed by 'TEC2021' in blue.

Bergoz IPCT – DC-AC High Resolution Current Transducer



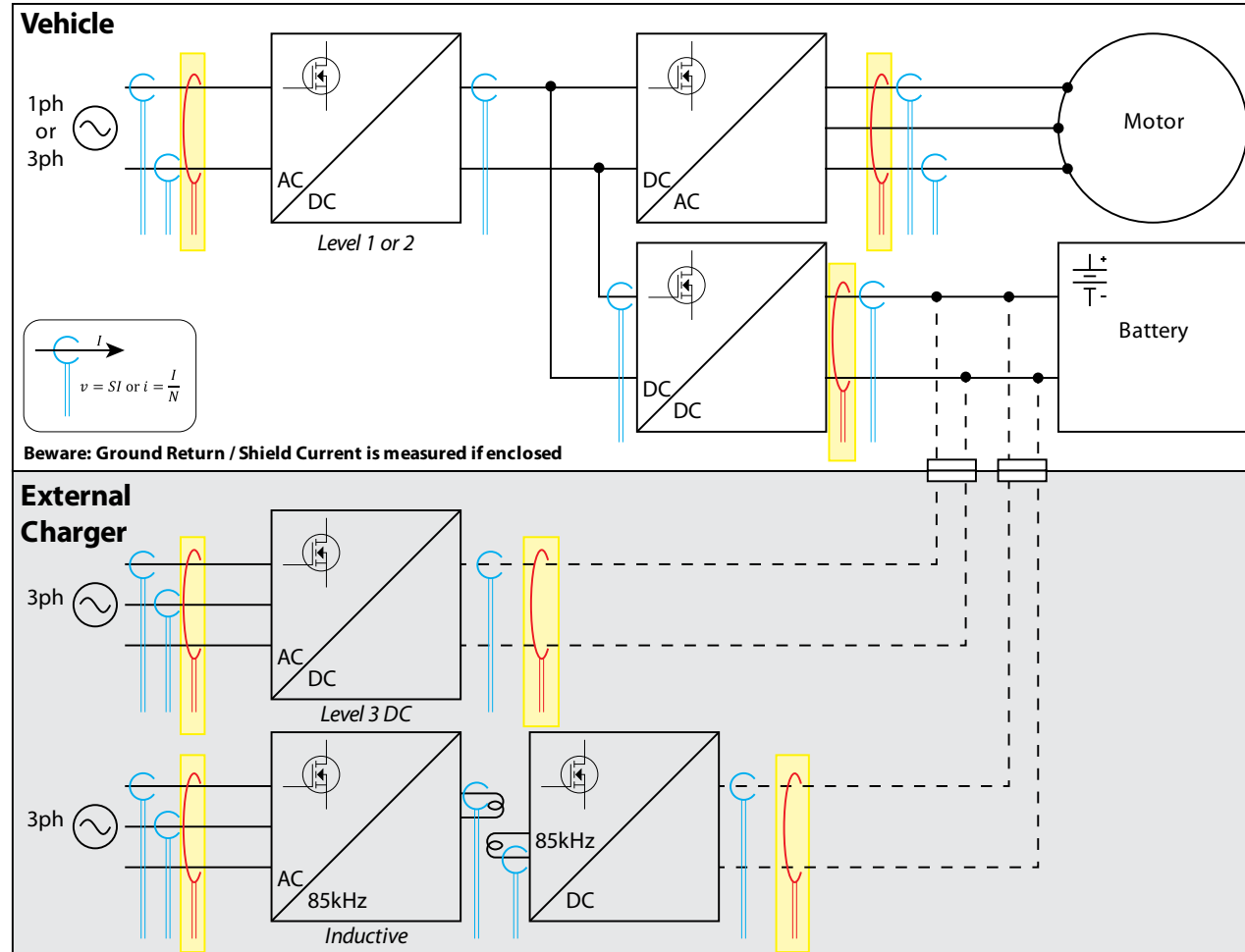
IPCT-0100mA-82 Amplitude v. Frequency



	IPCT	LP-IPCT
Current Range	±1mA to ±20A	±1mA to ±2A
Output Signal, $V(t)$	±10V	±10V
Zero Offset	Adjustable, 20 turn pot.	Adjustable, 20 turn pot.
Frequency Response	DC to 2.5kHz (-3dB)	DC to 1kHz (-3dB)
Noise (equiv. primary)	$1\mu\text{Arms}/\sqrt{Hz}$ to $50\mu\text{Arms}/\sqrt{Hz}$	—
Resolution	30μA at ±2A Full-Scale	3μA at ±2A Full-Scale
Recovery after overload (1000x)	< 10ms	< 20ms
Aperture	82mm (3.2")	30mm (1.18")
Mass	0.5kg	0.2kg
Dimensions	200 x 112 x 50mm	105 x 52 x 55mm

(1) A current of 500A generates a field of 1mT at a radius of 0.1m (~4").

Current Probe Connections in Electric Vehicle Chargers – Bergoz IPCT



GMW CPC

Clip-on DC-AC Coreless Current Probes

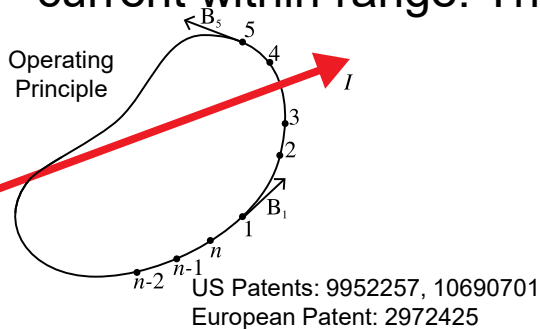
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GMW CPC – Clip-on DC-AC Coreless Current Probes

For System diagnostics and long-term monitoring, Current Probes with no magnetic core.

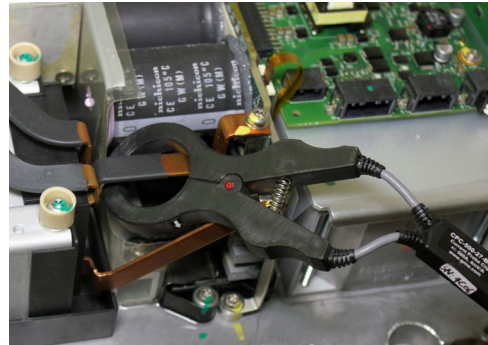
No hysteresis, no damage from primary current overload with recovery to linear operation within 10 μ S of primary current within range. The CPC can be used to monitor the “low current” recovery after a high current overload.



CPC-xxxx-27



CPCO – Current Probe, Clamp-on
Probe based on same technology and
design with larger aperture, in use at an
electrochemical plant.

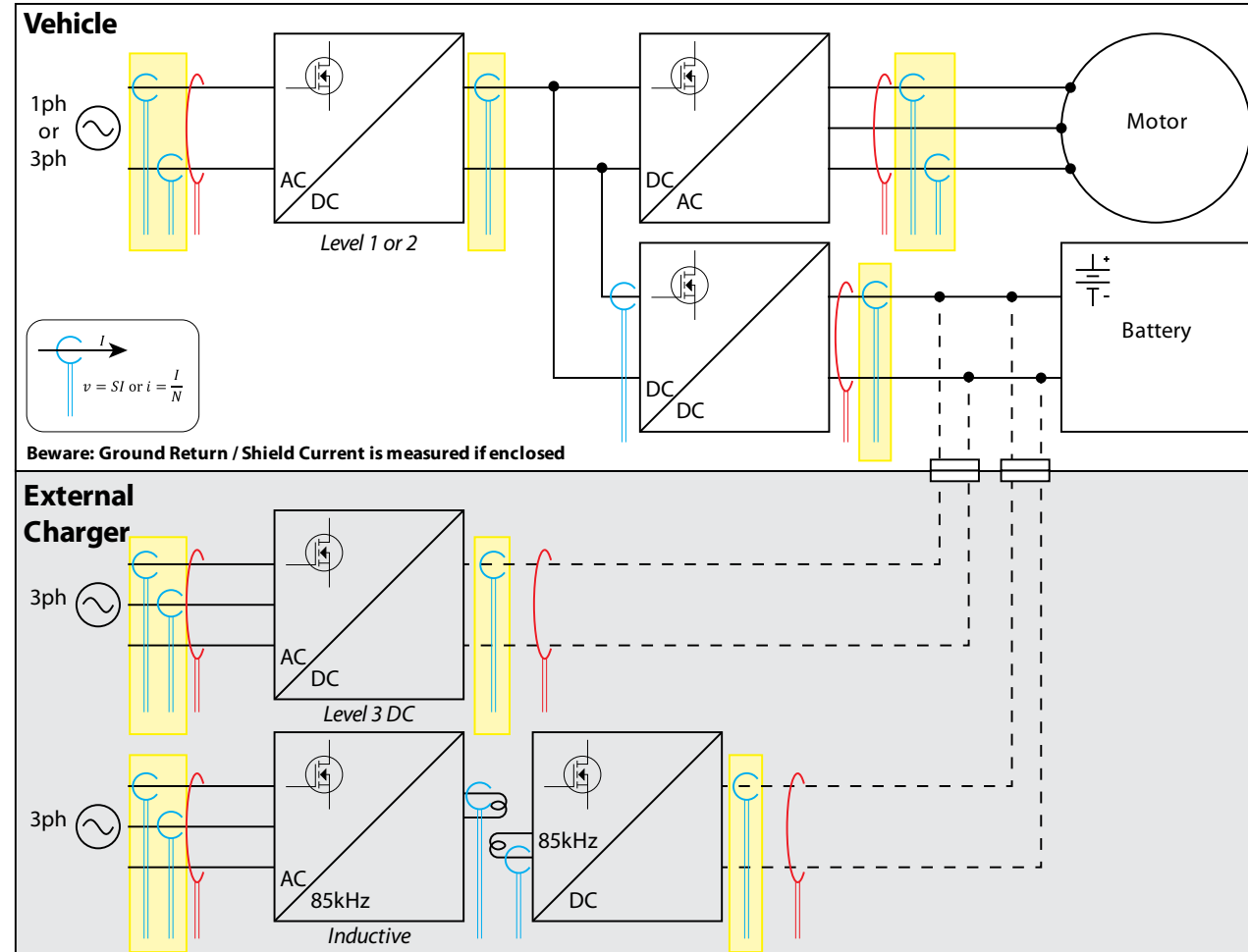


CPC – small size enables installation in
difficult locations.

Current Sensitivity	8mV/A to 1mV/A
Current Range	± 250 A to ± 2000 A
Frequency Range	dc to 75kHz (-3dB)
Amplitude Error	$< \pm 1\%$
Output Change, Magnetic Field	$< 0.2\%$ of range for 40mT ⁽¹⁾
Response Time	$< 2\mu$ s
Insertion Impedance	$< 1\text{pH}$
Operating Temperature	-40°C to +100°C
Moisture Resistance	Sealed, NEMA 5
Aperture	27mm (1.06")
Mass	< 30 g (1 oz)
Power Supply	3.5V to 5.5V, < 85 mA, USB Port

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

Current Probe Connections in Electric Vehicle Chargers – GMW CPC DC-AC Current Probes



Senis 3DACMT

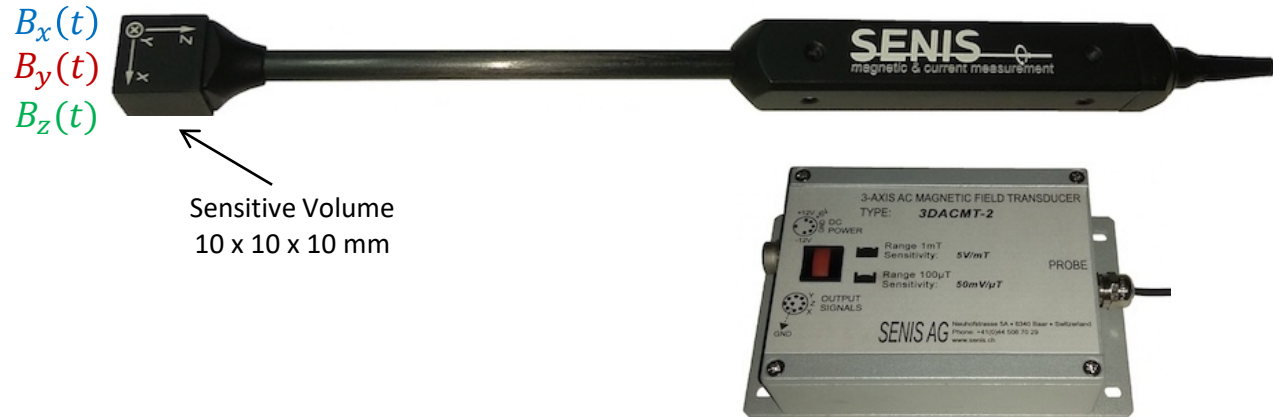
Three-Component AC Magnetic Field Transducer

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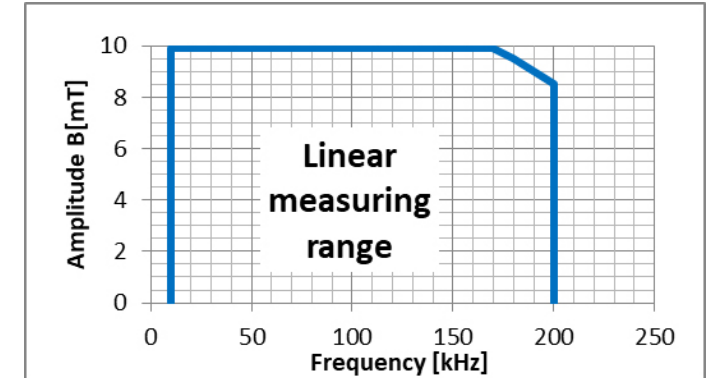
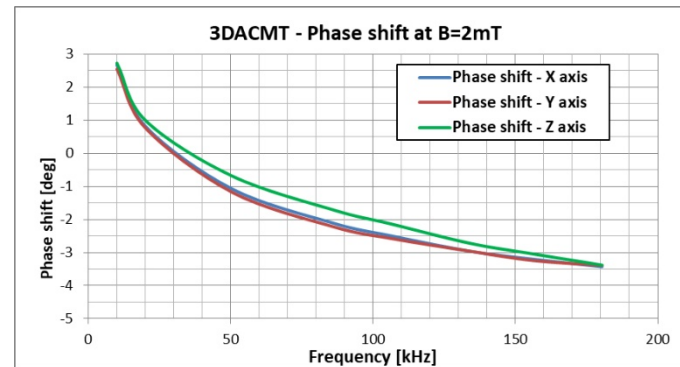
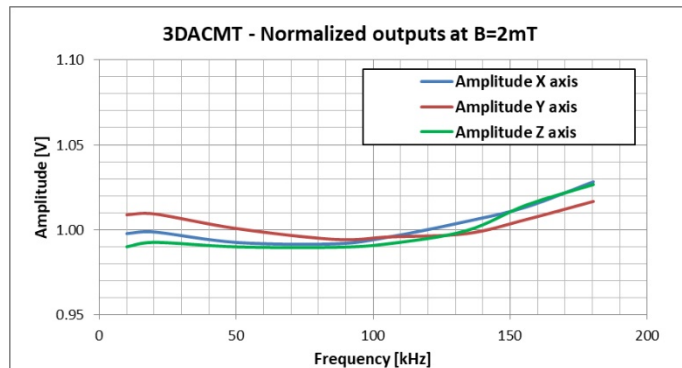
 **TEC2021**

Senis 3DACMT – Three-Component AC Magnetic Field Transducer

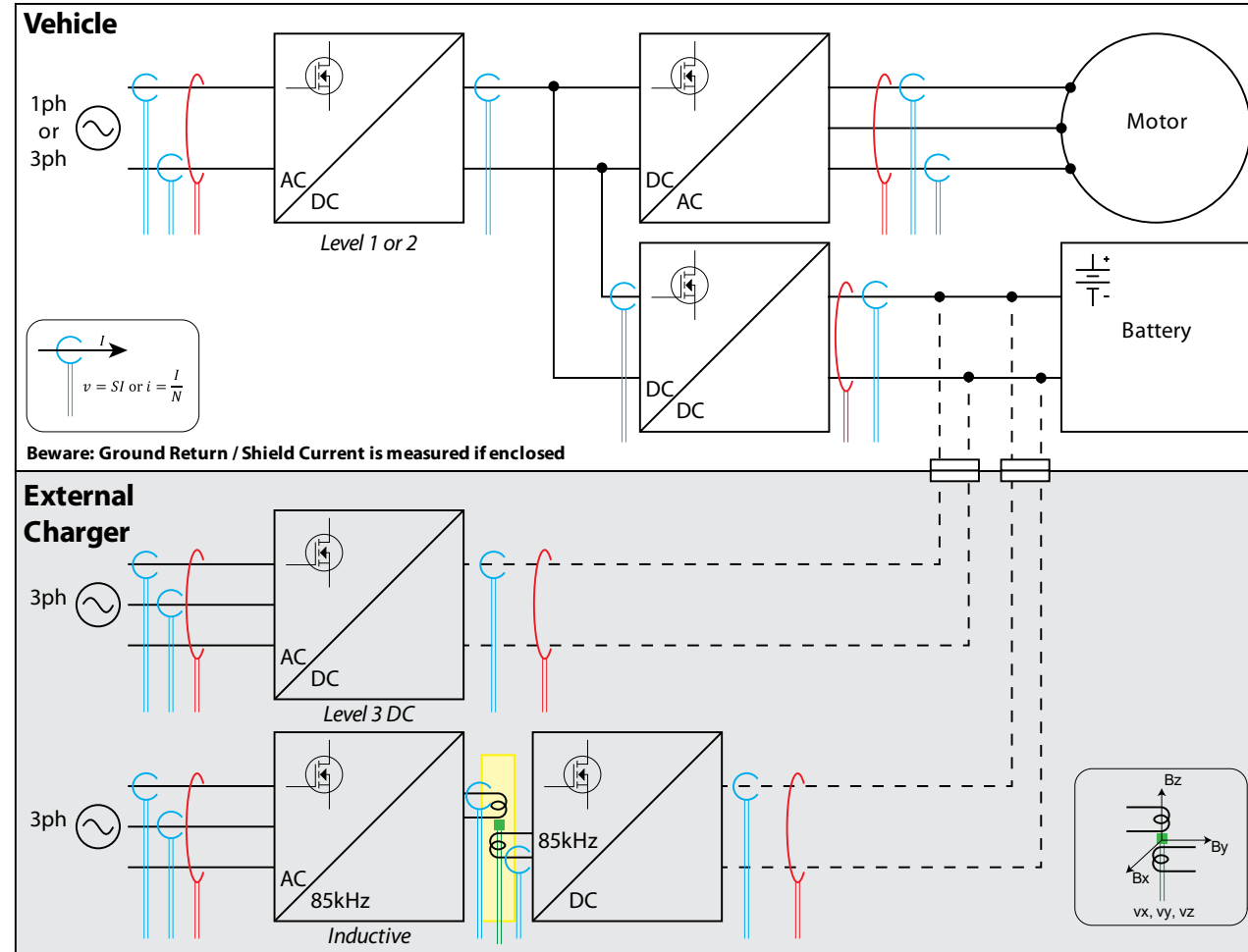
Small size enables field mapping between coils. High resolution for fringe field mapping.



Field Components	$B_x(t), B_y(t), B_z(t)$
Output Signals	$V_x(t), V_y(t), V_z(t)$
Sensitivity, S_x, S_y, S_z	500mV/mT
Field Range	± 10 mT
Field Resolution	$< 1.5\mu$ Trms
Signal Nonlinearity	$< 1\%$, $f < 100$ kHz
Frequency Range (LF)	10kHz
(HF)	200kHz
Phase Shift	$< 3^\circ$ at 85kHz



Field Measurement Points in Electric Vehicle Chargers – Senis Magnetic Field Transducer



Thank You!



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