

HIOKI

PW8001 Power Analyzer

Accurate power measurement – Even when it gets challenging

Future proof power measurement solutions



Power Analyzer PW8001 version 2.0



Current Sensor Series

Agenda

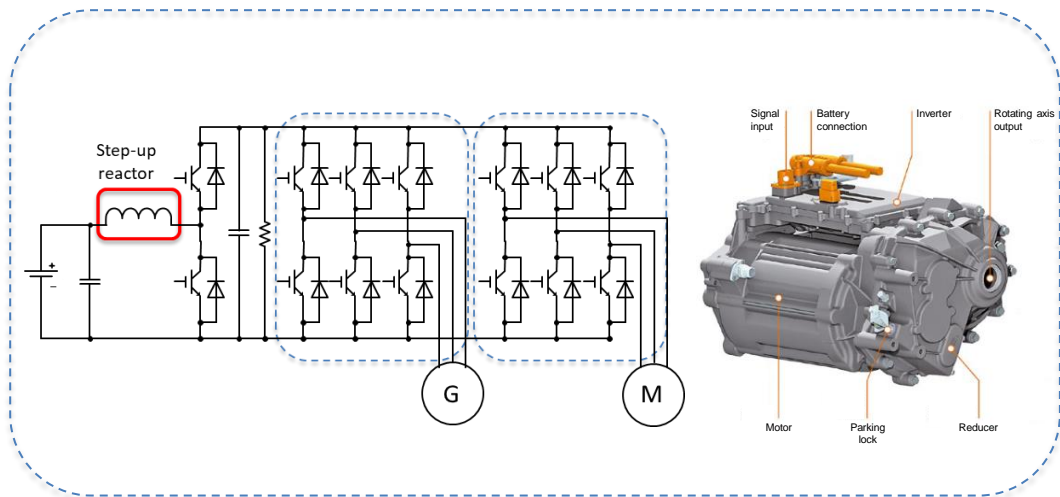
- **Challenges and solutions in accurate power measurement**
 - Use of wide-bandgap semiconductors
- **Product overview**
 - Features overview
 - Optional solutions
 - Current sensors
- **Application examples**



The use of wide-bandgap semiconductors

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Why are wide-bandgap semiconductors becoming so popular?



- Increase degree of freedom in design
- Reduce resource consumption
- Increase power density of devices



- **High-speed switching (100kHz) of wide-bandgap semiconductors is driving downsizing**
- **High-speed switching makes accurate power measurement more challenging**

Challenges in high-switching inverter output power measurement

The influence of phase errors

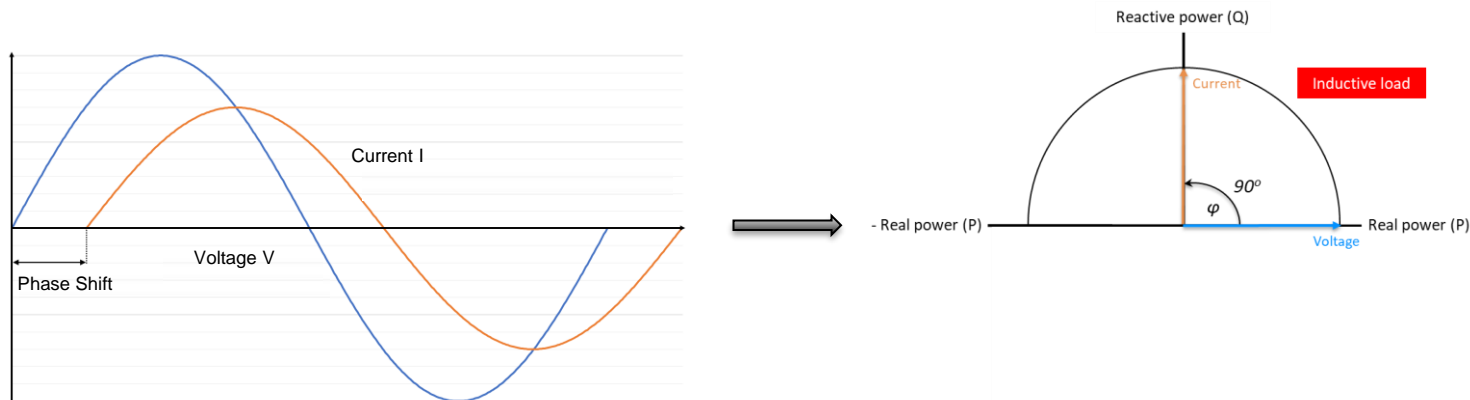
The influence of high switching frequency noise

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Challenge 1: the influence of phase error (1)

Phase Shift φ

The phase shift refers to the different times of zero crossings of 2 signals (current and voltage), even though they have the same frequency.



$\varphi = 0^\circ \rightarrow$ Ohmic resistance: voltage and current are in phase

$0^\circ > \varphi > 90^\circ \rightarrow$ Inductance: Voltage leads current

$0^\circ < \varphi < -90^\circ \rightarrow$ Capacity: Voltage lags behind current

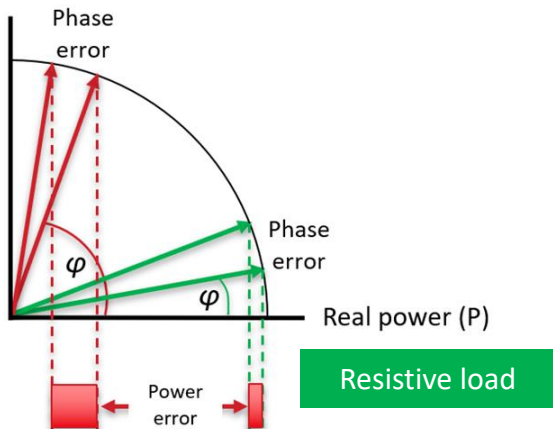
(Phase angle (deg) $\phi = \text{time delay } \Delta t \times \text{frequency } f \times 360^\circ$)

Challenge 1: the influence of phase error (2)

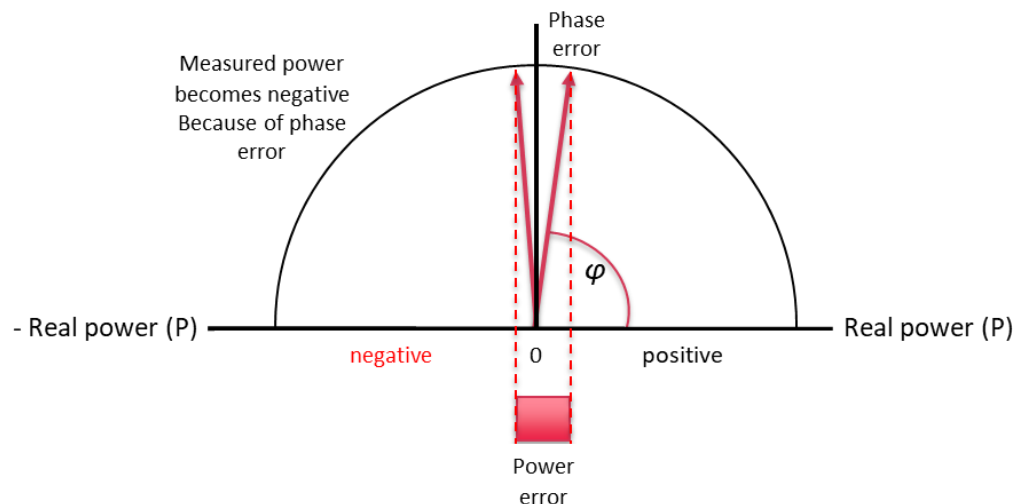
$$Power = V_{rms} \cdot I_{rms} \cdot \cos\phi$$

Inductive load

Reactive power (Q)

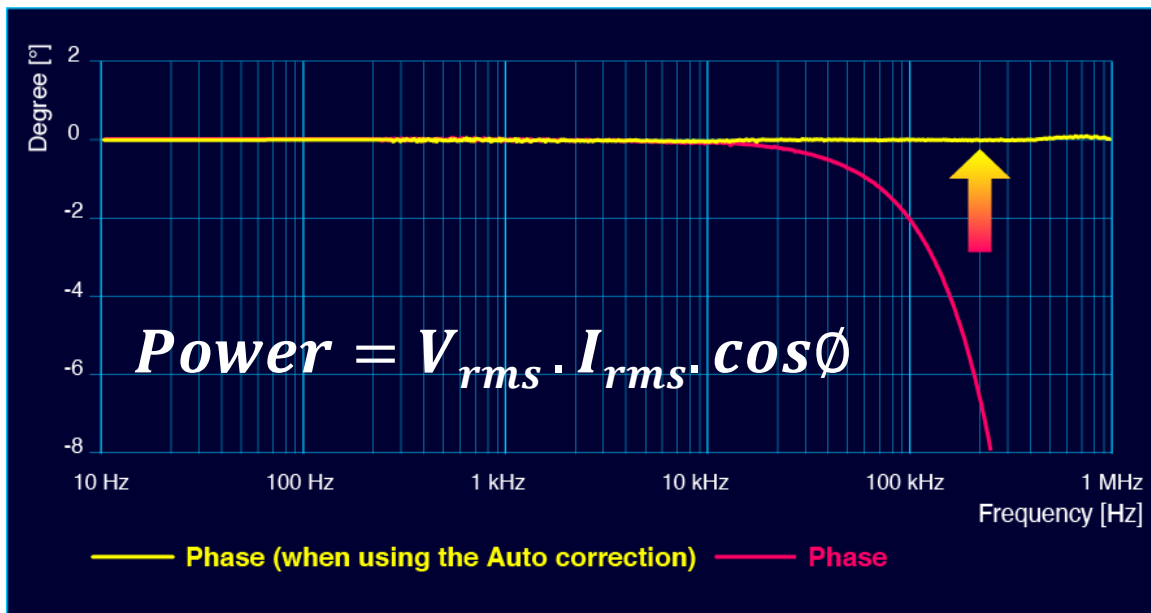


Reactive power (Q)



Power error has much more influence when inductance is dominant and can even cause negative power results!

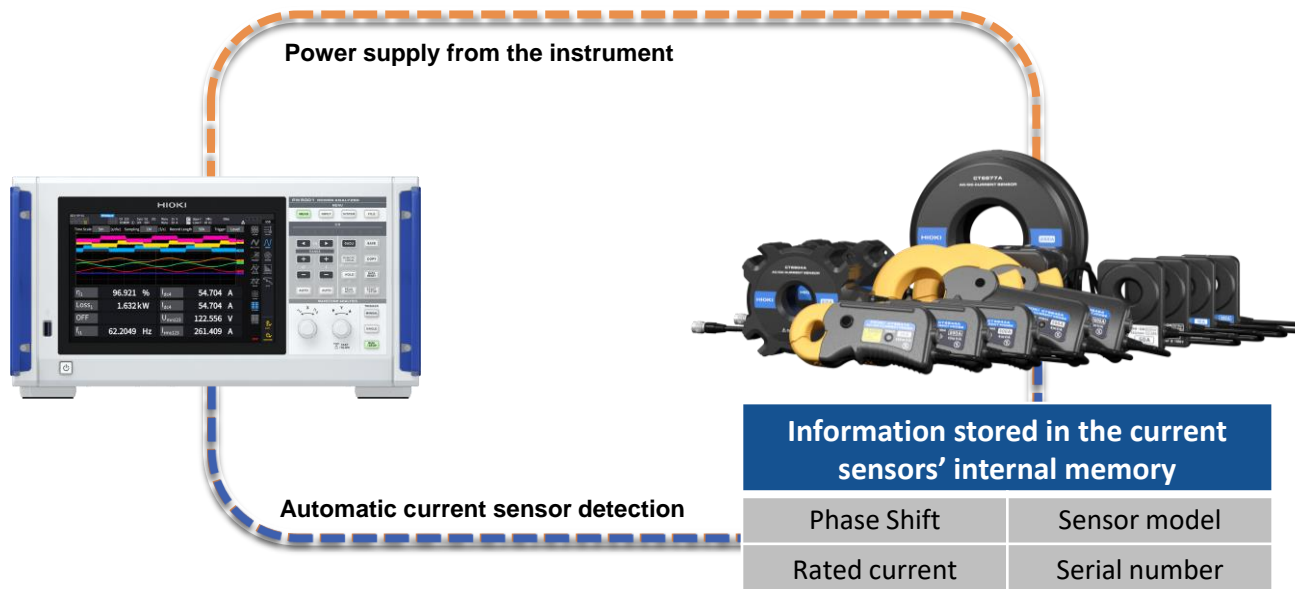
Solution 1: Phase correction (1)



- Measurements with current sensors that have known frequency characteristics enables phase correction

Solution 1: Phase correction (2)

Automatic detection of current sensor phase shift



- PW8001 supports automatic phase correction

Solution 1: Phase correction (3)

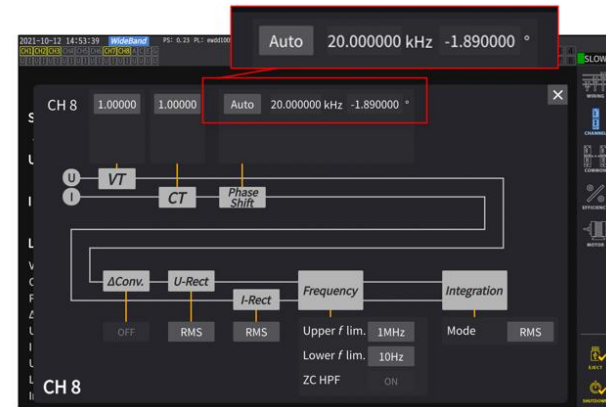
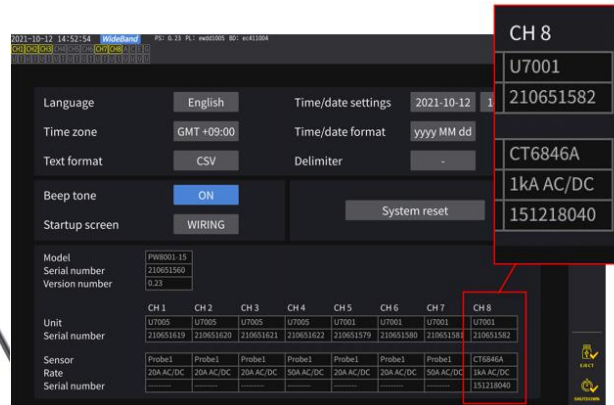
Plug & Play current sensor connection



PW8001
Power Analyzer

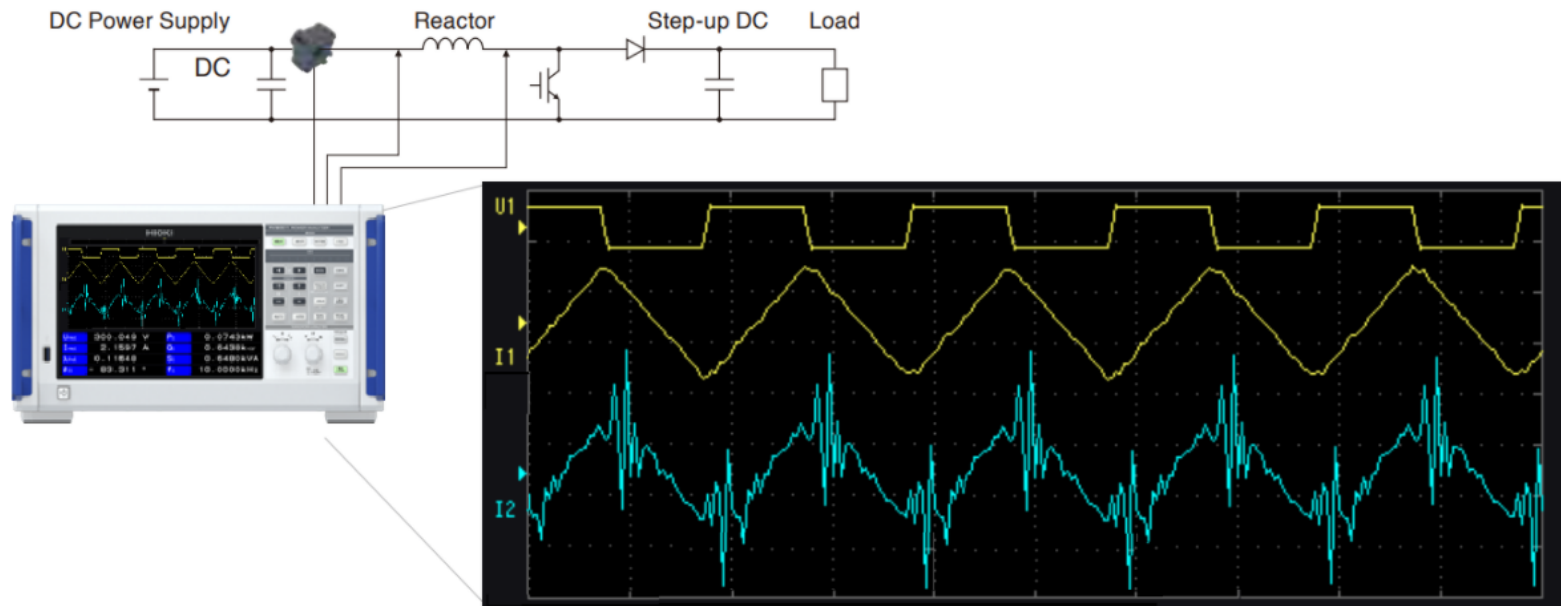


CT6846A
1000A AC/DC Current Probe



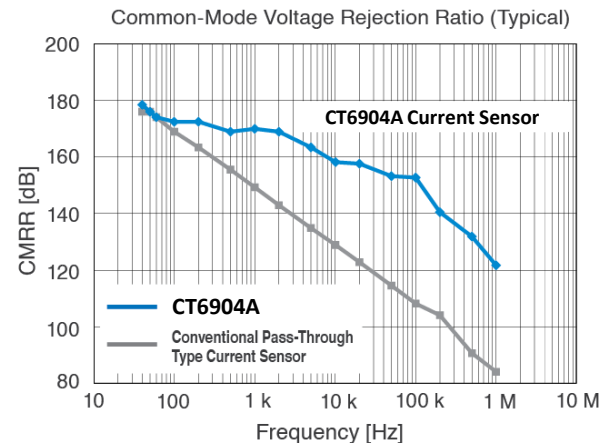
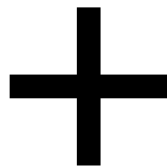
- Current sensors have defined phase characteristics
- Phase shift information is stored in the current sensor
- Phase shift error is compensated with the automatic phase shift correction

Challenge 2: The influence of high switching frequency noise



- Switching noise can have substantial influence on the measurement!

Solution 2: High Common Mode voltage Rejection Ratio (CMRR)



U7005 High Bandwidth Power Module
CMRR 110 dB @ 100 kHz

CT6904A AC/DC 500A current sensor
CMRR 120 dB @ 1 MHz

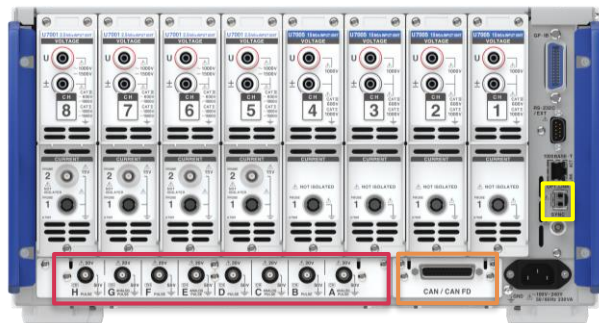


- It is important that not only the power analyzer has a high CMRR, but the current sensors as well.

Features overview

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Power Analyzer PW8001



Optical link synchronization

Motor analysis

CAN/CAN FD output

- **Highest number of power channels**
 - Up to 8 power power modules
 - Selectable power module to suit your application

- **Highest accuracy (U7005 High Bandwidth Power Module)**
 - Basic power accuracy: $\pm 0.03\%$
 - Accuracy for DC power: $\pm 0.05\%$
 - 15MHz, 18bit high speed A/D converter

- **DC 1500V CAT II (U7001 High Voltage Power Module)**
 - High-voltage, high accuracy ideal for development and shipping inspection

- **Automatic Phase Shift Correction**
Significantly reduces time spent on configuration and provides error-free power measurement

Two types of modules depending on the application

2.5 MS/s INPUT UNIT

U7001

Basic accuracy: $\pm 0.07\%$
Accuracy for DC power: $\pm 0.07\%$
1500 V DC CAT II

Ideal for solar inverter evaluations

15 MS/s INPUT UNIT

U7005

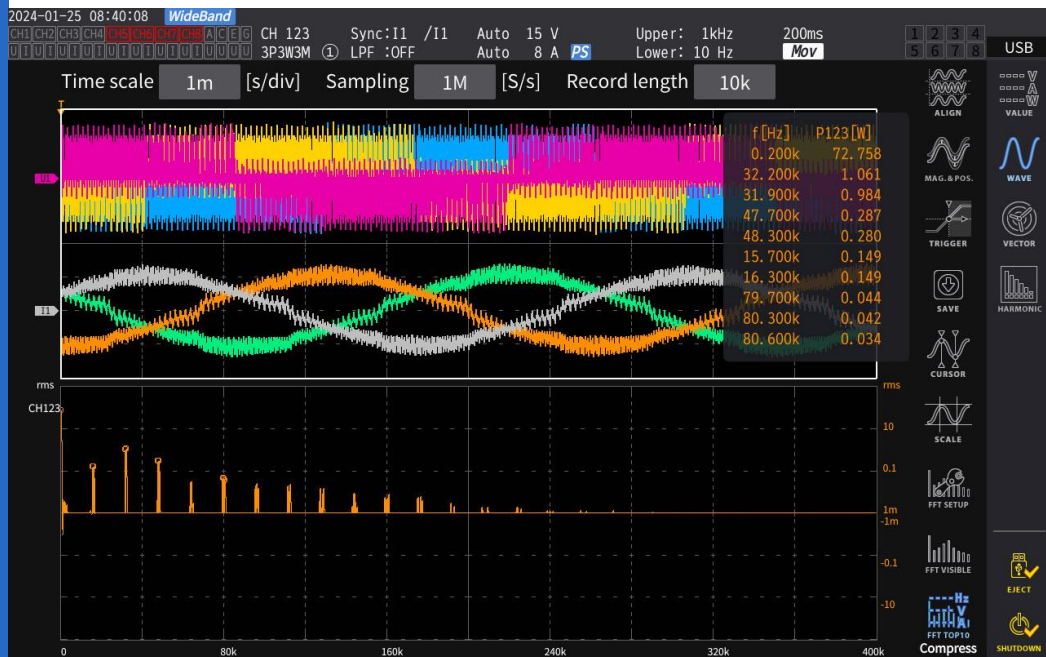
Basic accuracy: $\pm 0.03\%$
Accuracy for DC Power: $\pm 0.05\%$

Ideal for evaluations of SiC/GaN inverter efficiency and reactor loss evaluations

- **Highest number of power channels**

Combine the two types of input modules to create a measurement system in one instrument which realizes the optimum fit for your application.

Power Spectrum analysis



Power Spectrum Analysis...

... allows to visualize power loss measurement over a wide frequency bandwidth up to 6MHz

... provides easy-to access information for development engineers to further improve their designs

... is unique for HIOKI

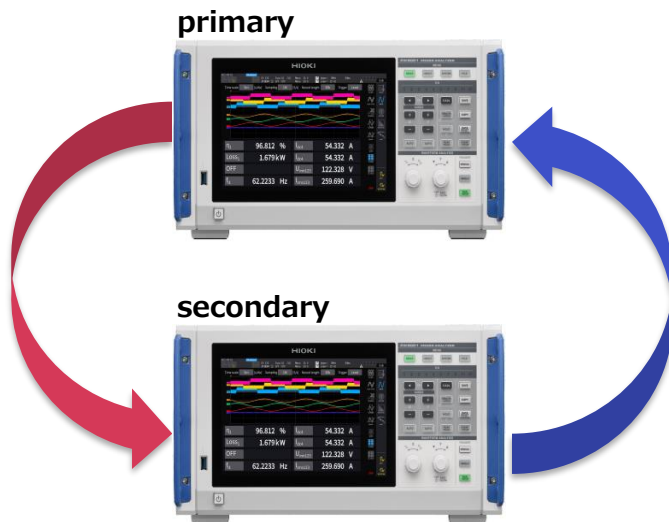
... is available with the free-of-charge firmware version 2.0 or higher

Optical link synchronization

Unique features of the Optical link synchronization (9-16 channel measurement)

Control with primary

- Change secondary wiring setting from primary
- Change secondary channel and motor settings from primary
- Starting, Stopping, and Integrator Resetting



Data transfer to primary

- Save numerical data from secondary on USB drive primary
- Use secondary data for the primary UDF or Efficiency
- Show numerical data from secondary on the display of primary

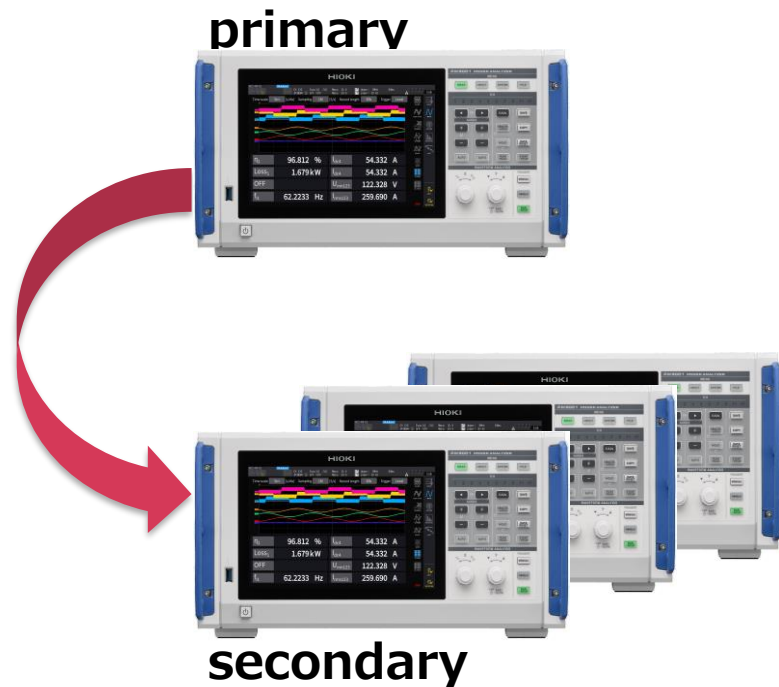
Create your 16-ch precision power analyzer easily.

BNC synchronization

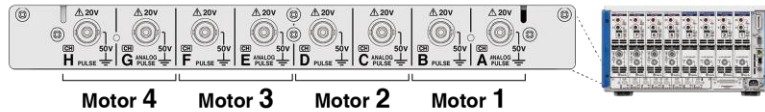
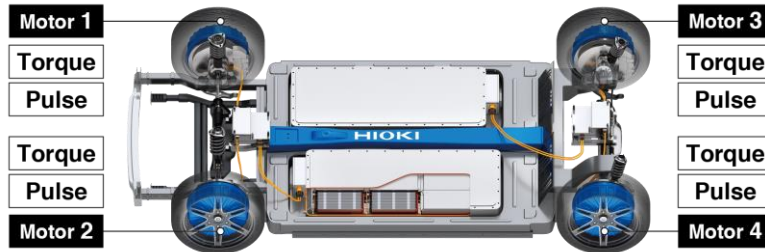
Functionality of the BNC synchronization

Control with primary

- Internal Operations and data refresh
- Starting, Stopping, and Integrator Resetting
- Zero adjustment
- 17 to 32 channels



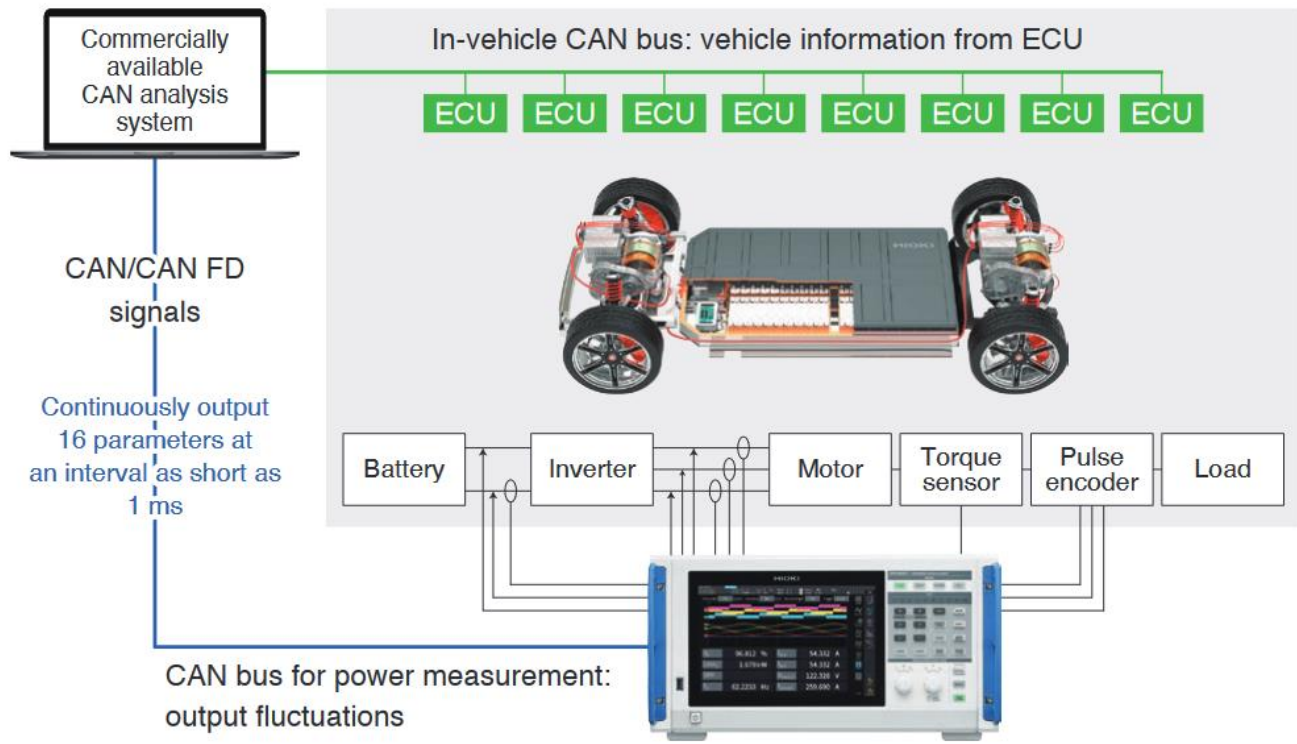
4-Motor analysis function



■ Ideal for complex motor efficiency analysis

- The motor analysis option allows you to measure the torque and rotational speed of four motors. This enables you to measure the efficiency of up to 4 motors like e-Axle motors, in-wheel motors, drones and industrial robots

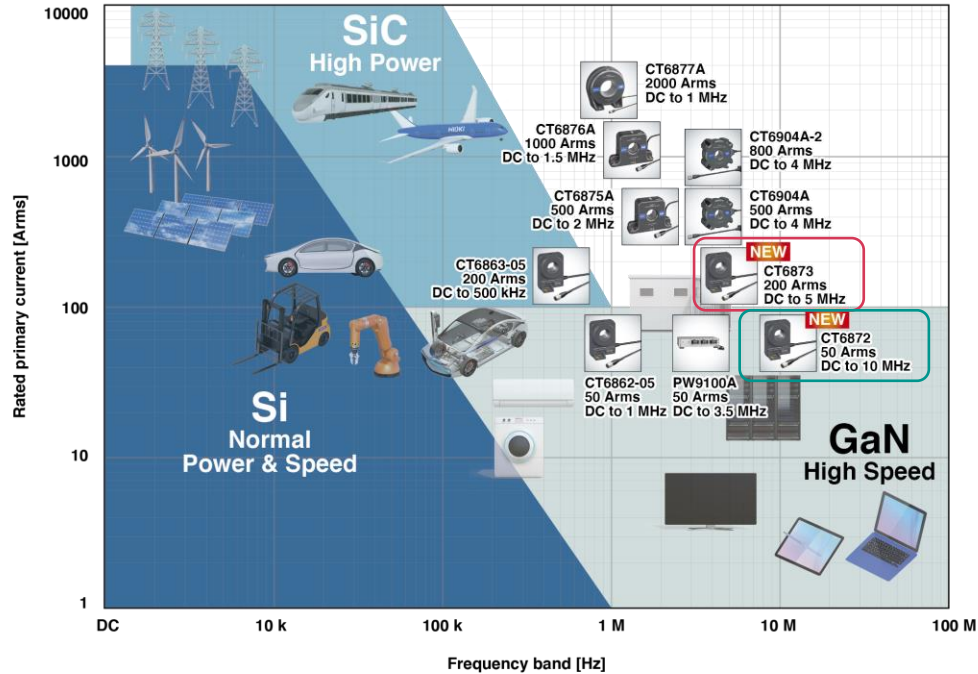
CAN or CAN FD output function



Current Sensors

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Pass-through current sensors line-up



New sensor models



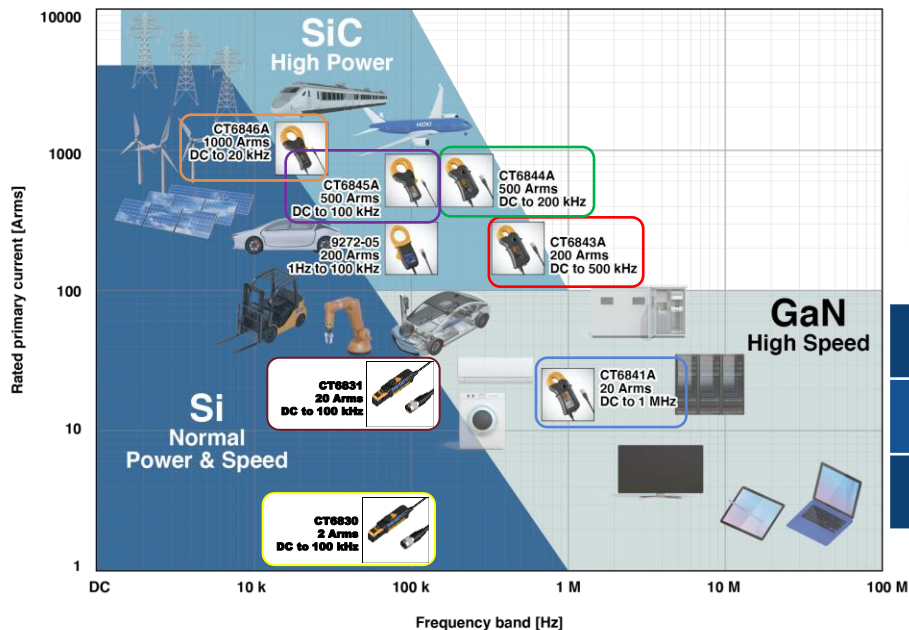
High accuracy
0.03% rdg + 0.007% f.s.

Automatic sensor recognition

Phase shift	Sensor model
Rated current	Serial number

Model	<u>CT6873</u>	<u>CT6872</u>
Rated current	200A	50A
Frequency band	10MHz	10MHz

Clamp-on current sensors line-up



CT684xA series

High accuracy
0.2% rdg + 0.01% f.s.



Automatic sensor recognition

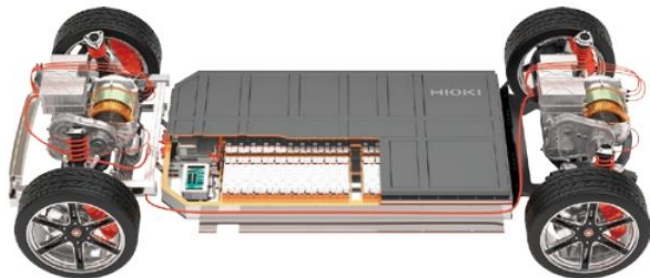
Phase shift	Sensor model
Rated current	Serial number

Model	<u>CT6830</u>	<u>CT6831</u>	<u>CT6841A</u>	<u>CT6843A</u>	<u>CT6844A</u>	<u>CT6845A</u>	<u>CT6846A</u>
Rated current	2A	20A	20A	200A	500A	500A	1000A
Frequency band	100kHz	100kHz	1MHz	500kHz	200kHz	100kHz	20kHz

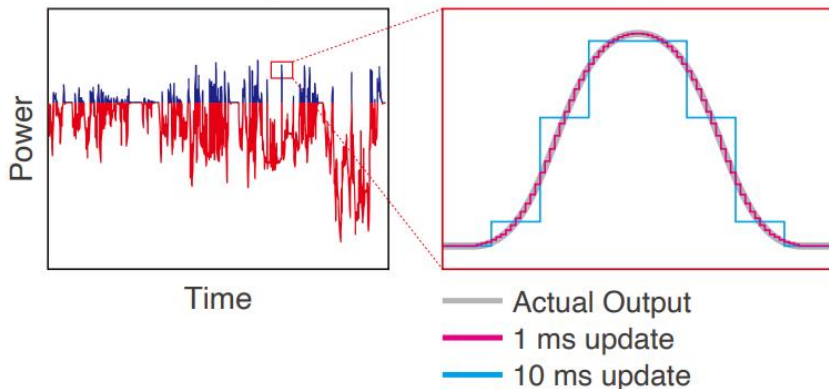
Application examples

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Battery discharge/charge monitoring



Battery charging and discharging

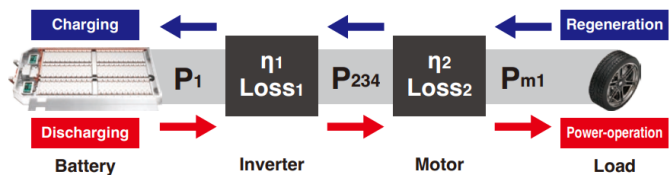


Key features

Accuracy 0.05% @ DC 0.03% @ 50/60 Hz 0.2% @ 50 kHz	8-channel combined with Motor analysis	Extensive range of current sensors
Automatic Phase Shift Correction	Power Spectrum Analysis	High-speed data update every 1ms
High noise resistivity	User-defined calculations	Flexible efficiency calculations
Optical link synchronization	BNC synchronization	CAN/CAN FD output
Wideband harmonic analysis	IEC Harmonic and flicker measurement	

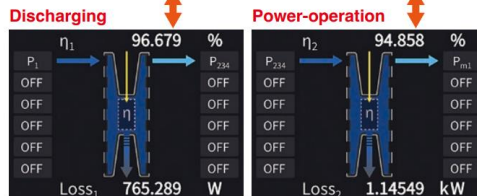
Continuous power conversion efficiency and loss detection

η : Power efficiency Loss: Power loss



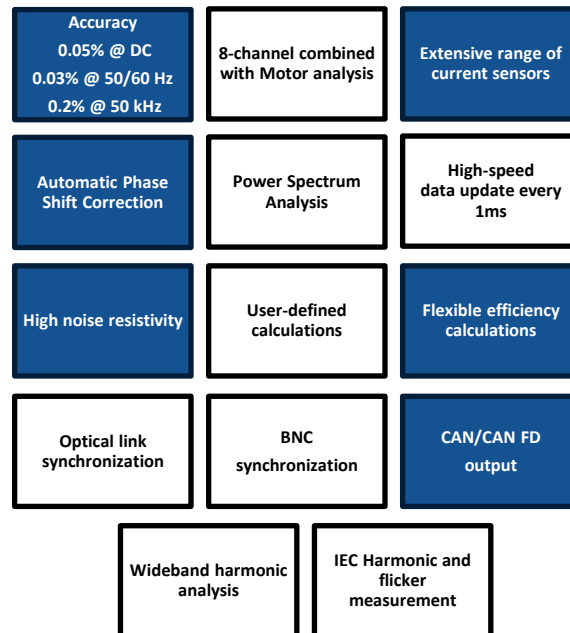
Auto mode	Inverter		Motor	
	η_1 [%]	Loss1 [W]	η_2 [%]	Loss2 [W]
Charging Regeneration	IP1/IP234x100	IP234-IP1	IP234/IPm1x100	IPm1-IP234
Discharging Power-operation	IP234/IP1x100	IP1-IP234	IPm1/IP234x100	IP234-IPm1

PW8001 detects charging/discharging and power operation/regeneration driving states and switches equations automatically

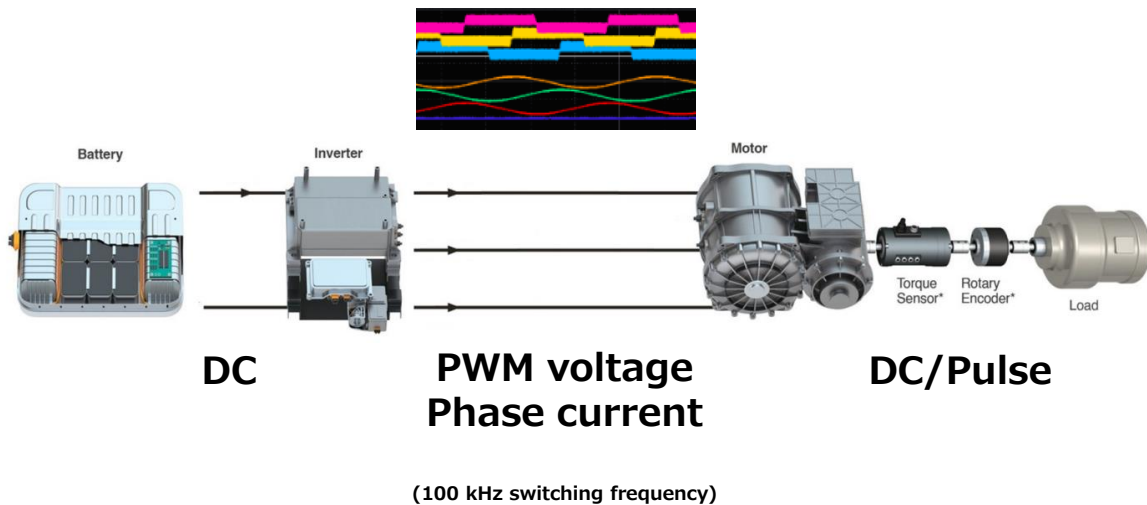


PW8001 detects charging/discharging and power-operation/regeneration driving states and switches direction of energy flows automatically

Key features



Wide-bandgap semiconductor inverter drives development



Key features

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Automatic Phase Shift Correction	Power Spectrum Analysis	High-speed data update every 1ms
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Coil/Transformer loss measurements

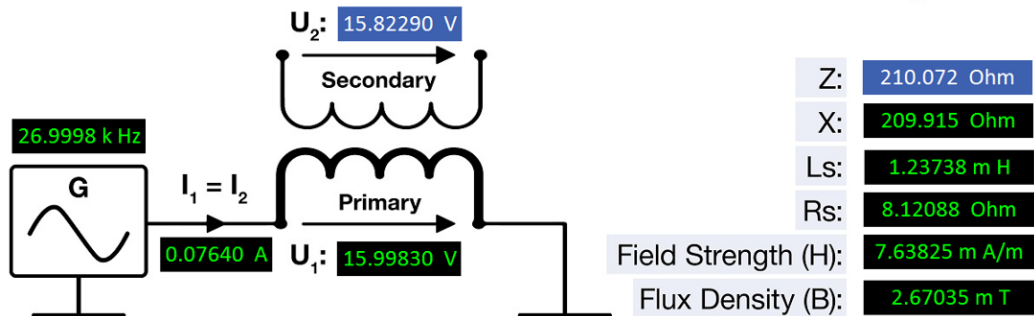
APSC ON

Total loss = Core loss + Copper loss

45.51230 m

2.10126 mW

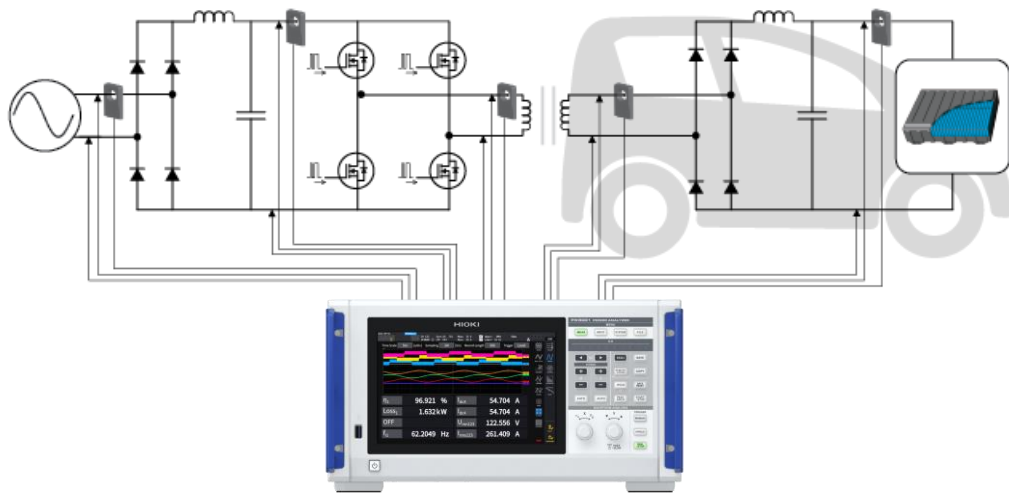
43.41110 m



Key features

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Automatic Phase Shift Correction	Power Spectrum Analysis	High-speed data update every 1ms
High noise resistivity	User-defined calculations	Flexible efficiency calculations
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Wideband harmonic analysis	IEC Harmonic and flicker measurement	

Applications – Wireless Power Transfer (WPT)



Electric vessels



Electric vehicles

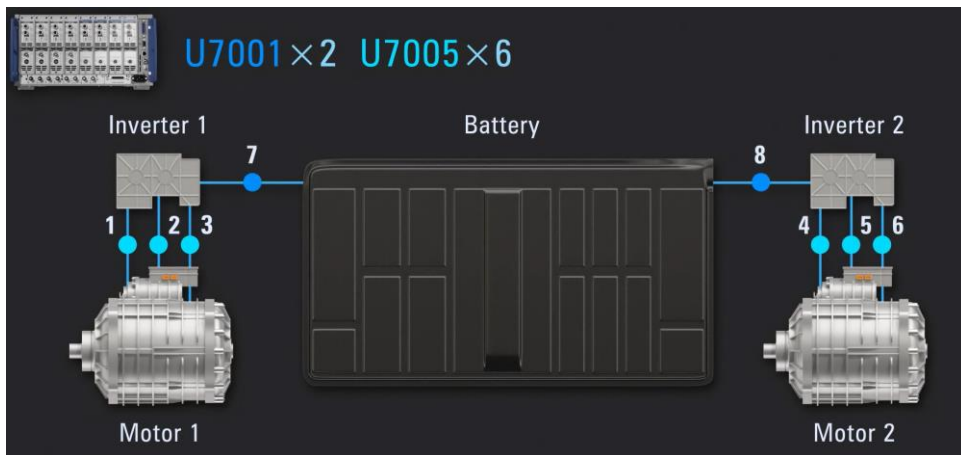


Automated guided vehicles

Key features

Accuracy 0.05% @ DC 0.03% @ 50/60 Hz 0.2% @ 50 kHz	8-channel combined with Motor analysis	Extensive range of current sensors
Automatic Phase Shift Correction	Power Spectrum Analysis	High-speed data update every 1ms
High noise resistivity	User-defined calculations	Flexible efficiency calculations
Optical link synchronization	BNC synchronization	CAN/CAN FD output
Wideband harmonic analysis	IEC Harmonic and flicker measurement	

Dual motor drive train



- Dual-motor systems, such as those used in EVs, use two inverters to drive each motor, and an 8-channel power module can be used to evaluate the entire dual-motor system simultaneously

Key features

Accuracy 0.05% @ DC 0.03% @ 50/60 Hz 0.2% @ 50 kHz	8-channel combined with Motor analysis	Extensive range of current sensors
Automatic Phase Shift Correction	Power Spectrum Analysis	High-speed data update every 1ms
High noise resistivity	User-defined calculations	Flexible efficiency calculations
Optical link synchronization	BNC synchronization	CAN/CAN FD output
Wideband harmonic analysis	IEC Harmonic and flicker measurement	

Complete power analysis solutions

For all industries in pursuit of power conversion efficiency



[Click here for more application information](#)



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