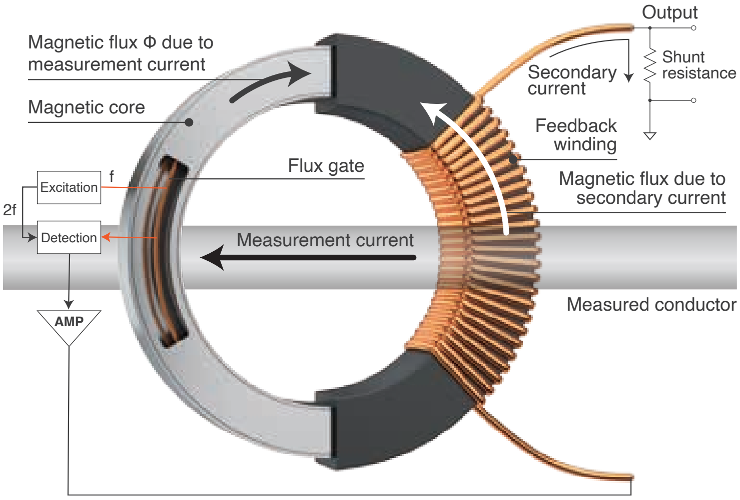
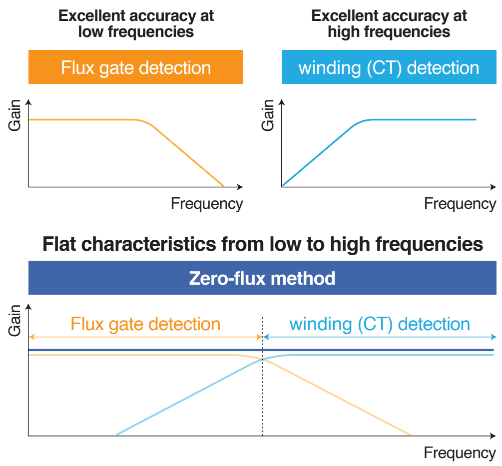
Accurately evaluating power conversion efficiency

Improving power conversion efficiency is a key part of the effort to facilitate the effective use of energy. Devices that operate at high frequencies are increasingly being used to improve efficiency, and evaluation processes undertaken during the development of such devices requires accurate measurement of power at the low frequencies used by in previous devices as well as at high frequencies. Additionally, sensors that can resist noise are necessary since noise becomes stronger as the frequency increases. Hioki offers current sensors that can measure power accurately while providing robust noise resistance over a broad band of frequencies.



High-frequency currents are detected by a winding (CT), while DC to low-frequency currents are detected by a flux gate.

Zero-flux method: achieving stable, wideband measurement from DC to high frequencies



Zero-flux method (flux gate) current sensors


CT6841-05, CT6843-05, CT6844-05


CT6845-05, CT6846-05


CT6862-05, CT6863-05, CT6872, CT6873


CT6875A, CT6876A

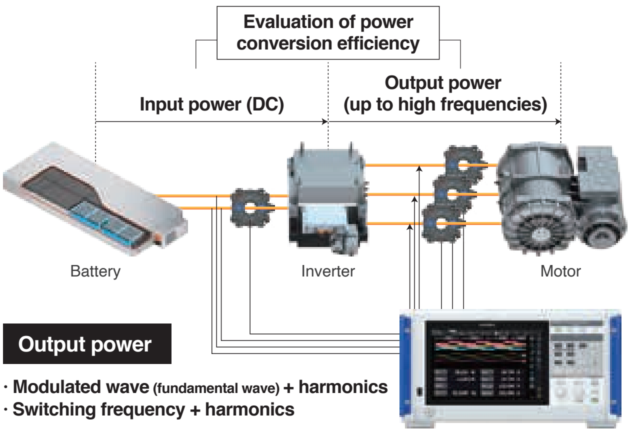

CT6877A


CT6904A

Application

Evaluating the power conversion efficiency of an inverter

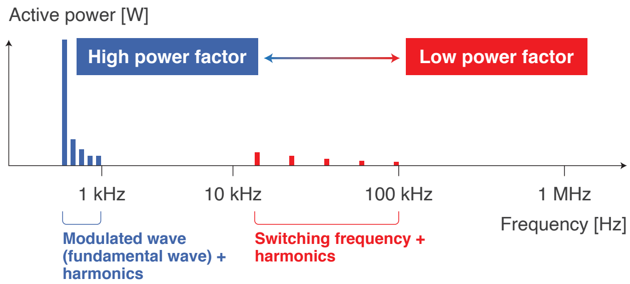
When evaluating the power conversion efficiency of an inverter, the inverter's input and output power are measured and its efficiency is checked. PWM (pulse width modulated) inverter output, which has been widely used in recently years, contains a modulated wave (fundamental wave) and a switching frequency along with their respective harmonic components. Since switching frequencies tend to be high, the process requires wide frequency band current sensors.



Output power

· **Modulated wave** (fundamental wave) **+ harmonics**
· **Switching frequency + harmonics**

Inverter output: principal active power components

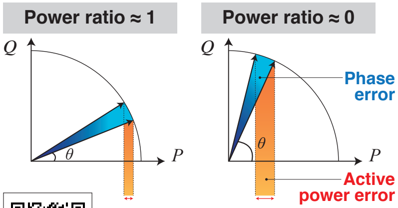


Since the power factor decreases with harmonics, current sensors' phase measurement accuracy becomes key (see right).

Phase measurement accuracy and correction: accurately measuring power at low power factors

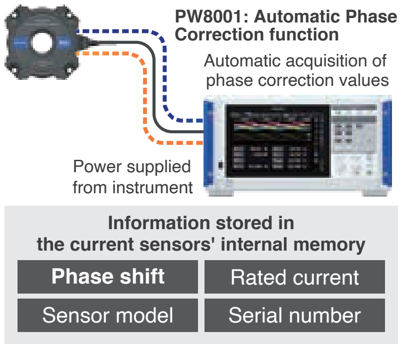
For typical current sensors, phase measurement accuracy is not defined. However, phase measurement precision is important in applications where power must be measured with a high degree of accuracy. Power can be measured more accurately by selecting a current sensor for which phase measurement accuracy is defined in the measurement band.

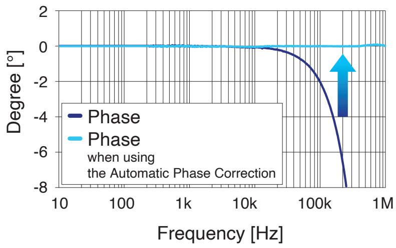
At low power factors, phase error has a significant effect on power error.



Access the QR Code to view the technical documentation on phase correction.

The power factor decreases in the high-frequency range of the switching frequencies and other frequency components. At low power factors, phase error has a significant effect on power measured values.



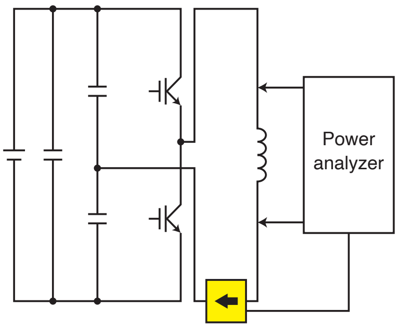


Example of the Automatic Phase Correction for the CT6904A AC/DC current sensor

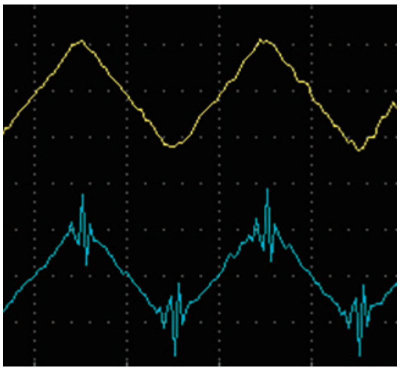
For typical sensors, phase error increases with frequency. Since Hioki has developed both current sensors and the measuring instruments, current sensors' phase characteristics can be corrected by the instruments, allowing accurate power values to be calculated.

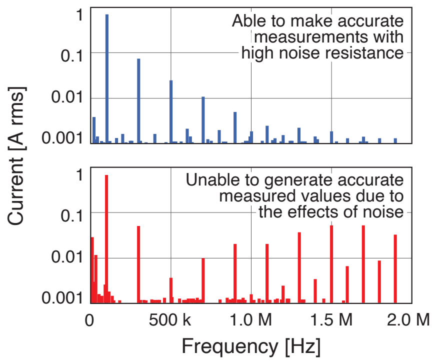
Common-mode voltage rejection ratio: measuring current values accurately in noisy environments

In high-frequency measurement, sensors' resistance to noise is critical. A sensor's ability to remove noise is expressed by its common-mode rejection ratio (CMRR). Sensors with a high CMRR reject more noise and therefore can make more accurate measurements.



For reactors, higher frequencies mean lower current values. The image to the right shows a waveform obtained by measuring reactor current at high frequency along with variations in current values that accompany variations in the frequency.

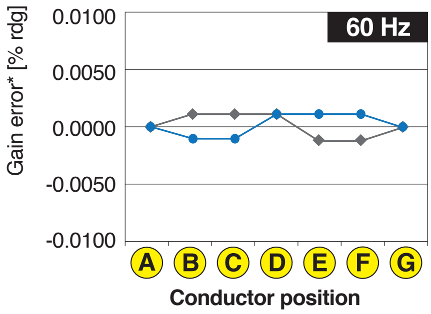


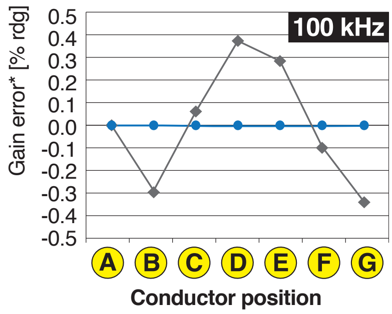


Top: CT6904A CMRR 120 dB or greater (100 Hz); bottom: sensor with a low CMRR

Effects of conductor position: stable, highly reproducible sensing

In general, speaking, the effects of conductor position increase with frequency. Since the position of the conductor inside the clamp core affects the measurement accuracy, resulting the reproducibility of measurement reduces. Sensors are designed the effects of conductor position, highly reproducible measurements are possible since conductor position does not affect measured values.





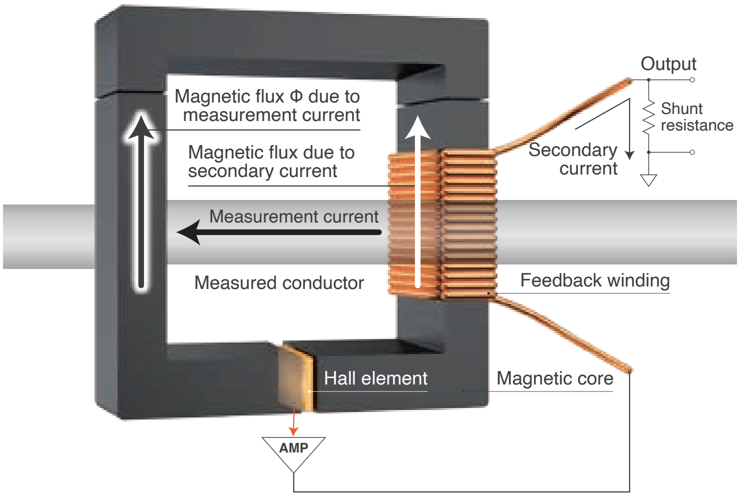
CT6904A — Sensors designed without accounting for conductor position

deviation from center

When using a sensor designed with the effects of conductor position, measured values are not affected when the conductor's position changes.

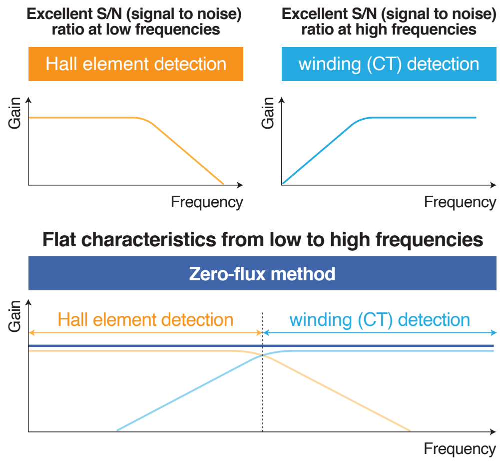
Clearly observing current waveforms

The magnitude of the currents that flow in power-saving devices during operation and control currents that flow in automotive accessory components have reduced to 1 mA or less. At the same time, reliance on high-speed switching operation for device control is resulting in increased noise. Wideband current probes that are highly resistant to noise are essential in order to clearly observe low-current waveforms without losing them in noise. Hioki offers current probes that enable clear waveform observation while providing robust noise resistance over a broad band of frequencies.



High-frequency currents are detected by the winding (CT), while DC to low-frequency currents are detected by the Hall element.

Zero-flux method: realizing stable, wideband measurement from DC to high frequencies



Zero-flux method (hall element) current probes


CT6710, CT6711


CT6700, CT6701

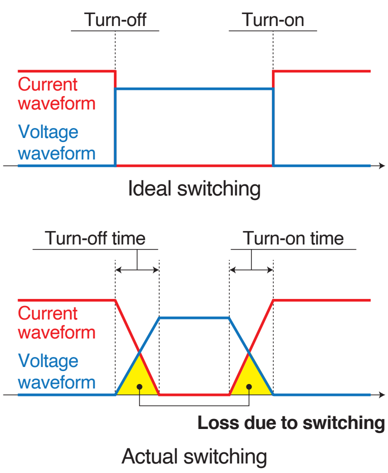

3273-50, 3276

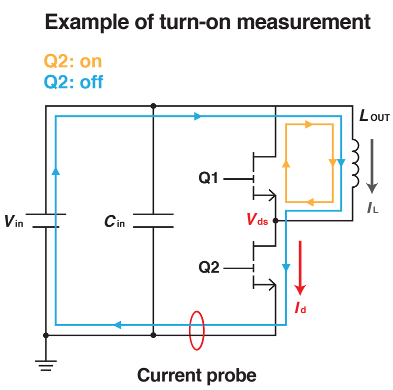

3274, 3275

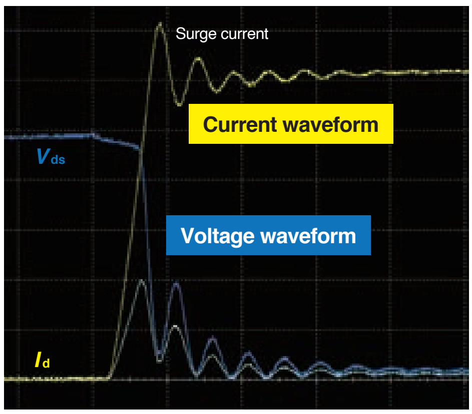
Application

Evaluating the response performance of switching devices

Switching devices control equipment by turning the power on and off. The response performance of switching devices is evaluated by observing fluctuations of current and voltage when the device cycles the power on and off. Capturing current fluctuations caused by high-speed switching operation requires current probes with a broad frequency band. Additionally, noise resistance is important since switching operation generates noise.





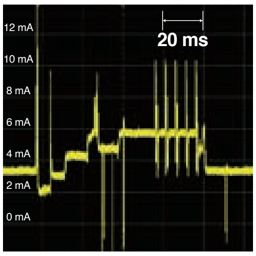


Observing waveforms from minuscule currents to large currents: evaluating the control design of ECUs and accessory components

The control systems used in ECUs and accessory components carry currents of a variety of magnitudes according to the vehicle's operation, from control currents to inrush currents. Using a current probe that can switch current ranges makes it possible to observe current waveforms associated with an array of operating conditions with a single probe.

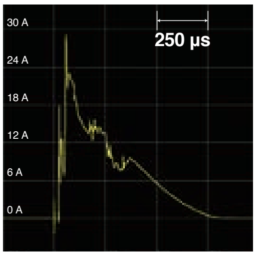
CT6710/CT6711
0.5 A, 5 A, 30 A
range switching

0.5 A range



Observing a minuscule current waveform
(current consumption of a power-saving device)

30 A range



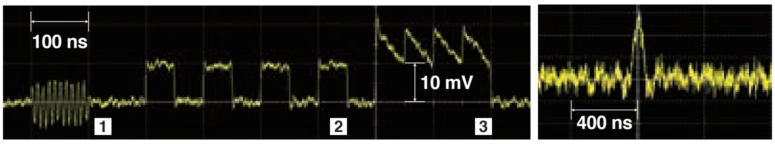
Observing a large current waveform
(inrush current)

Observing currents of a variety of magnitudes,
from minuscule currents to large currents, with a single probe

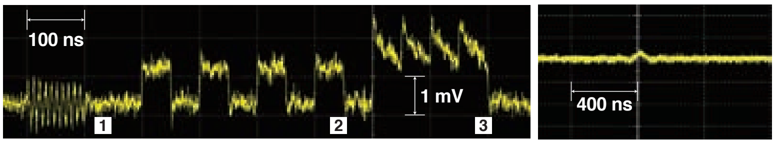
Model	Freq. band	mesurement range	output rate
CT6710	DC to 50 MHz	0.5 A	10 V/A
		5 A	1 V/A
		30 A	0.1 V/A
CT6711	DC to 120 MHz	0.5 A	10 V/A
		5 A	1 V/A
		30 A	0.1 V/A
CT6700	DC to 50 MHz	5 A	1 V/A
CT6701	DC to 120 MHz	5 A	1 V/A
3273-50	DC to 50 MHz	30 A	0.1 V/A
3276	DC to 100 MHz	30 A	0.1 V/A
3274	DC to 10 MHz	150 A	0.01 V/A
3275	DC to 2 MHz	500 A	0.01 V/A

Clearly observing minuscule currents: operating currents of power-saving devices and control currents flowing to accessory components

The magnitude of the currents that flow during operation of power-saving devices like wearables and control currents that flow in automotive accessory components tend to decrease in to 1 mA or less. Using a current probe with a high output rate make you possible for clearly observing minuscule current waveforms.



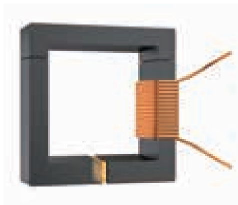
CT6710, CT6711 **Output rate of 10 V/A**
lets you observe clear waveforms with a high S/N ratio.



Earlier model **Output rate of 1 V/A**
precludes observation of accurate waveforms as they are obscured by noise.

1 Sine wave: f = 100 MHz, 1 mA peak-peak
2 Square wave: f = 10 MHz, 1 mA peak-peak
3 Sawtooth wave: f = 20 MHz, 1 mA peak-peak (offset +1 mA)

Noise resistance design: key to increasing output rate

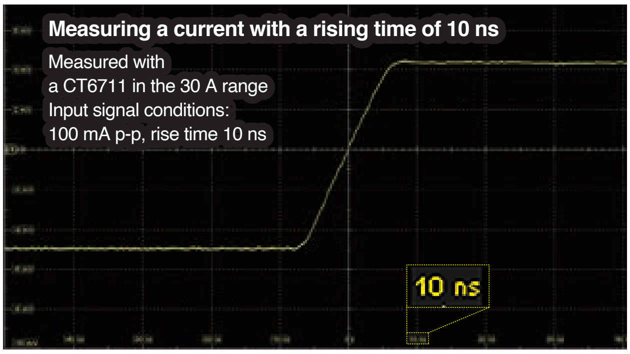


Hioki uses a proprietary thin-film Hall element to reduce the amount of noise generated inside the probe.

Electromagnetic shielding in the sensor improves resistance to environmental noise.

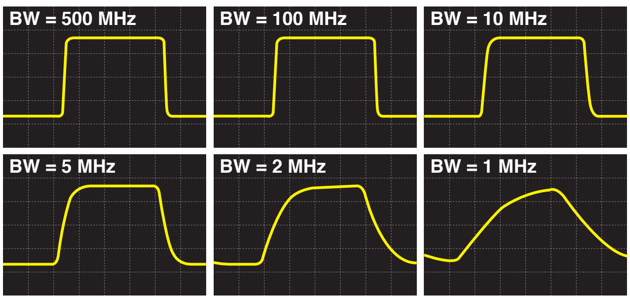
Observing waveforms across a broad band of frequencies: capturing waveforms and pulse waveforms that fluctuate at high speeds

Currents from switching operation of devices such as SiC and GaN inverters and currents that flow momentarily when a power supply is activated fluctuate at high speeds. Using a current probe with a wide frequency band allows you observe current waveforms that fluctuate at high speed. Additionally, such devices allow you observe current waveforms such as pulse waveforms that contain a variety of frequency components.



Current probes with a wide frequency band can capture high-speed current fluctuations with a rising time of 10 ns.

Failure to capture accurate waveforms due to insufficient frequency band
Example of measuring a pulse with a cyclic frequency of 1 MHz using different frequency bands



Current probes with a wide frequency band can accurately capture pulse waveforms.