



## Power Efficiency Measurement at 1000 V and Above

### Safely Measure High Voltages up to 5000 V

Inverters used in rail and power system applications convert high-voltage power. To measure the efficiency of such conversions, it's necessary to measure voltages of 1000 V and above. The VT1005 divides voltages of up to 5000 V and outputs them to a power analyzer.

- Max. Input 5000 V<sup>(\*)</sup>, 2000 V CAT II, 1500 V CAT III

\*1:  $\pm 7100$  V<sub>peak</sub>, no measurement category, anticipated transient overvoltage of 0 V

### Detect Efficiency Improvement Effects on the Order of 0.1%

In order to measure the efficiency of high-efficiency inverters with a high degree of precision, you need to be able to accurately measure power from DC to high frequencies. Thanks to its excellent frequency flatness, the VT1005 makes possible accurate measurement at frequencies ranging from the fundamental wave to switching-frequency components.

- Measurement Accuracy:  $\pm 0.08\%$  (DC),  $\pm 0.04\%$  (50/60 Hz),  $\pm 0.17\%$  (50 kHz)

- Frequency Flatness:  $\pm 0.1\%$  Amplitude Band 200 kHz Typical,  $\pm 0.1^\circ$  Phase Band 500 kHz Typical<sup>(\*)</sup>

- Measurement Band: DC to 4 MHz (-3 dB)

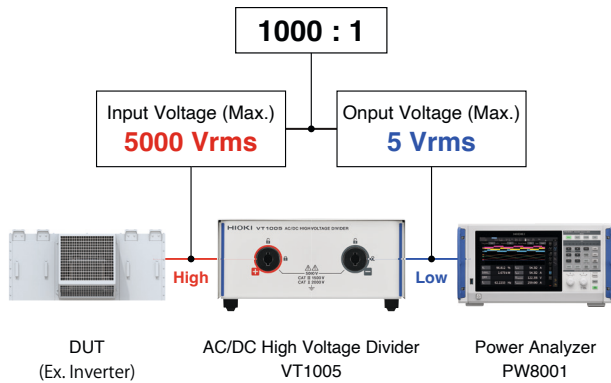
- Noise Resistance: CMRR 80 dB Typical (100 kHz), Differential Input Method

\*2: After phase correction by the power analyzer

# Safely Measure High Voltages up to 5000 V

Max. Input 5000 V <sup>(\*)</sup>, 2000 V CAT II, 1500 V CAT III

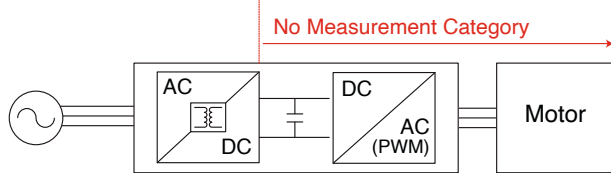
Measure voltages of up to 5000 V <sup>(\*)</sup>, 2000 V CAT II, or 1500 V CAT III. Measured voltages are divided (1000:1) and output to the power analyzer.



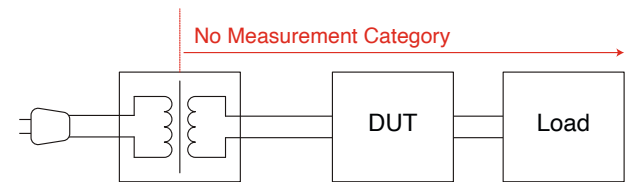
	PW8001 & VT1005	PW8001 Standalone <sup>(*)4</sup>
Rated Voltage	AC/DC 5000 V ±7100 V peak	AC 1000 V <sup>(*)5</sup> ±2000 V peak
Measurement Category	AC/DC 5000 V <sup>(*)1</sup> AC/DC 2000 V CAT II <sup>(*)2</sup> AC/DC 1500 V CAT III <sup>(*)3</sup>	AC 1000 V CAT II <sup>(*)6</sup> AC 600 V CAT III <sup>(*)6</sup>

\*1: ±7100 Vpeak, no measurement category, anticipated transient overvoltage of 0 V  
 \*2: Anticipated transient overvoltage of 12000 V  
 \*3: Anticipated transient overvoltage of 10000 V  
 \*4: When using the U7001 input unit  
 \*5: DC 1500 V  
 \*6: DC 1500 V CAT II, DC 1000 V CAT III, Anticipated transient overvoltage of 8000 V

Example of No Measurement Category



The secondary side of location isolated inside the DUT

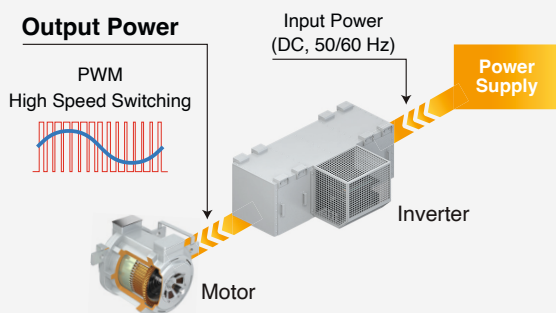


The power supply is internally isolated, for example, load power supplies used in testing. Power supply and DUT are not connected directly.

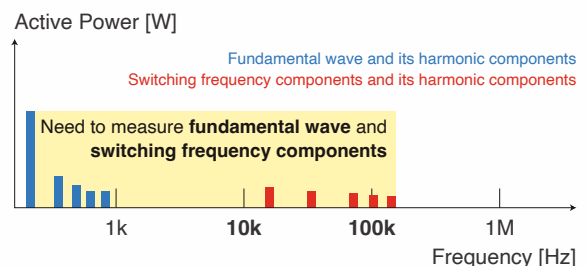
## Key Considerations for Accurately Measuring Efficiency

**?** Can you accurately measure power from fundamental to switching-frequency components?

Active power on the output side of inverters includes not only the fundamental component, but also switching components. To measure accurate efficiency, you must be able to accurately measure not only the fundamental component, but also switching components.



Active Power Spectrogram for an Inverter's Output Power



# Detect Efficiency Improvement Effects on the Order of 0.1%

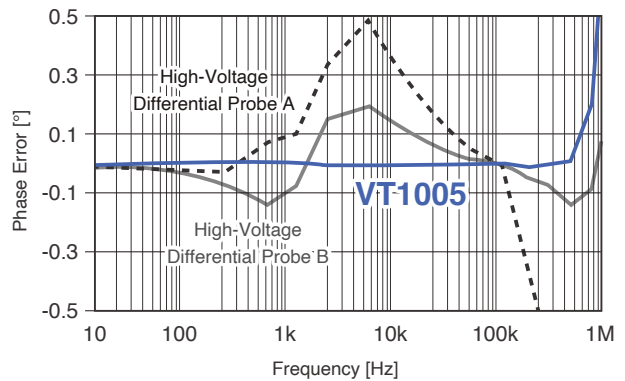
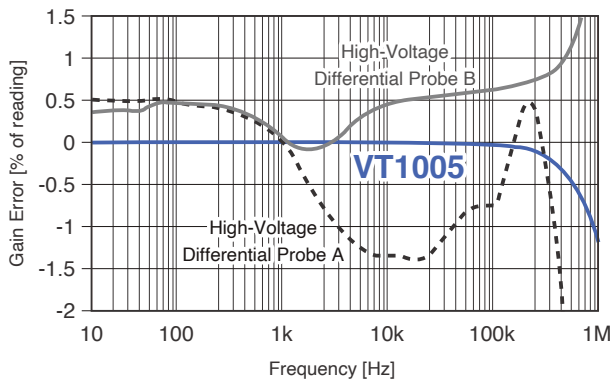
Measurement Accuracy:  $\pm 0.08\%$  (DC),  $\pm 0.04\%$  (50/60 Hz),  $\pm 0.17\%$  (50 kHz)

Frequency Flatness:  $\pm 0.1\%$  Amplitude Band 200 kHz Typical,  $\pm 0.1^\circ$  Phase Band 500 kHz Typical (\*)

The VT1005 can measure voltage with excellent accuracy across a broad band of frequencies. Accuracy is 0.1% or less at DC and commercial frequencies (50/60 Hz). In addition, the device can measure the most commonly used switching frequencies (10 kHz or less) and the switching frequencies of inverters that use SiC power devices (from 10 kHz to 50 kHz) with a high degree of accuracy.

\*1: After phase correction by the power analyzer

## Comparison of High-Voltage Differential Probe and VT1005



High-voltage differential probes have a broad frequency band, but measurement error on the order of several percent occurs within that band. Thanks to high accuracy and excellent frequency flatness within its frequency band, the VT1005 makes it possible to detect efficiency improvement effects on the order of 0.1%, a task that has been impossible until now.

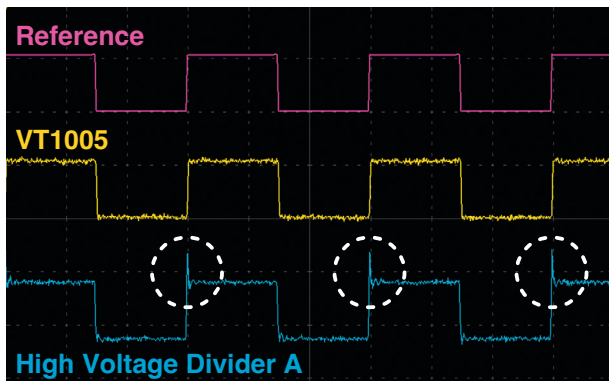
How is it possible to accurately measure frequencies up to switching components?  
**Phase correction by the Power Analyzer PW8001**

Thanks to the combination of the VT1005's flat frequency characteristics and the PW8001's phase correction function, it's possible to accurately measure power across a wider band.

Correction of the VT1005's phase error by the PW8001's phase correction function

Noise Resistance: CMRR 80 dB Typical (100 kHz), Differential Input Method

The VT1005 is highly resistant to both common-mode and high-frequency noise, allowing it to measure voltage accurately even in noisy environments. Since conversion devices like inverters are sources of noise, noise resistance is important in efficiency evaluation.



## Comparing the noise resistance measurement result of an inverter's secondary side.

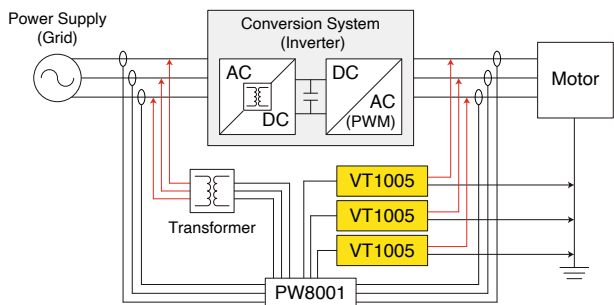
SiC power devices are characterized by fast voltage rise and fall time, and their output waveforms contain numerous high-frequency components. Some companies' dividers are sensitive to out of band high-frequency noise.

When a divider such as this is used, significant ringing that is not actually occurring can be erroneously observed, potentially increasing measurement error and causing the measurement results to exhibit greater variability due to differences in the effects of noise depending on device placement.

Output voltage waveform during 50 kHz switching from an inverter that uses SiC power devices

# Accurately Measures High Power at High Voltages in a Variety of Applications

VT1005 measurement method is differential input. Therefore, in addition to 3P4W wiring as shown in the figure, a line-to-line voltage can also be measured as 3P3W3M wiring.



Evaluation of the Efficiency of Inverters that use SiC Power Devices in Electrical Railways  
Example of VT1005 and PW8001 connection

## Applications

- Evaluation of the Efficiency of Inverters that use SiC Power Devices in Industrial Equipment
- Evaluation of the Efficiency of Solar Inverters that Support High-Voltage Input
- Evaluation of Loss in Transformers and Reactors Designed for Use in High-Voltage Circuits
- Evaluation of the Efficiency of Wireless Power Transfer (WPT) Systems



Learn more Applications

## Specification

Product warranty period: 3 years Accuracy guarantee period: 1 year

Maximum rated voltage	5000 V rms, $\pm 7100$ V peak <sup>(*)1</sup>
Maximum rated voltage (line-to-ground)	No measurement category: 5000 V AC/DC <sup>(*)2</sup> Measurement category II: 2000 V AC/DC <sup>(*)3</sup> Measurement category III: 1500 V AC/DC <sup>(*)4</sup>
Measurement accuracy	$\pm 0.08\%$ (DC), $\pm 0.04\%$ (50 Hz/60 Hz), $\pm 0.17\%$ (50 kHz)
Frequency flatness	Band where amplitude falls within $\pm 0.1\%$ range: 200 kHz (typical) Band where phase falls within $\pm 0.1^\circ$ range: 500 kHz (typical) <sup>(*)5</sup>
Measurement bandwidth	DC to 4 MHz (Amplitude and phase accuracy specified up to 1 MHz)
Voltage dividing ratio	1000 : 1
Common-mode voltage rejection ratio (CMRR)	50 Hz/60 Hz: 90 dB (typical), 100 kHz: 80 dB (typical)
Operating temperature and humidity range	-10°C to 50°C (14°F to 122°F), 80% RH or less (non-condensing)
Standards	Safety: EN 61010, EMC: EN 61326 Class A
Power supply	100 V to 240 V AC (50/60 Hz)
Dimensions (W x H x D)	Approx. 195.0 x 83.2 x 346.0 mm (7.68 x 3.28 x 13.62 in.)
Weight	Approx. 2.2 kg (77.6 oz.)
Measurement method	Differential input
Connectable products	Power Analyzer PW8001, PW6001, PW3390
Included accessories	- L1050-01 Voltage Cord (1.6 m/ 5.25 ft) - L9217 Connection Cord (insulated BNC, 1.6 m/ 5.25 ft) - 9704 Conversion Adapter (insulated-female BNC-to-banana plug) - Power cord

\*1: Provided this falls within the frequency derating curve illustrated

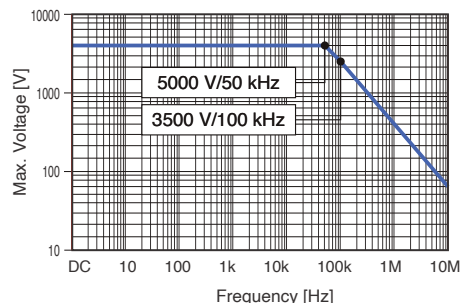
\*2:  $\pm 7100$  V peak, Anticipated transient overvoltage 0 V

\*3: Anticipated transient overvoltage 12000 V

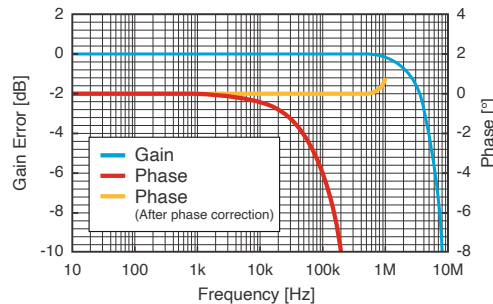
\*4: Anticipated transient overvoltage 10000 V

\*5: After phase correction by the power analyzer

Frequency derating curve



Frequency characteristics (typical value)



## Options



Voltage Cord

L1050-01 (1.6 m, 5.25 ft)  
L1050-03 (3.0 m, 9.84 ft)



Connection Cord

L9217 (1.6 m, 5.25 ft)  
L9217-01 (3.0 m, 9.84 ft)  
L9217-02 (10 m, 32.81 ft)



Conversion Adapter

9704  
BNC-to-banana plug

## AC/DC HIGH VOLTAGE DIVIDER

Order code: VT1005



Learn more

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