

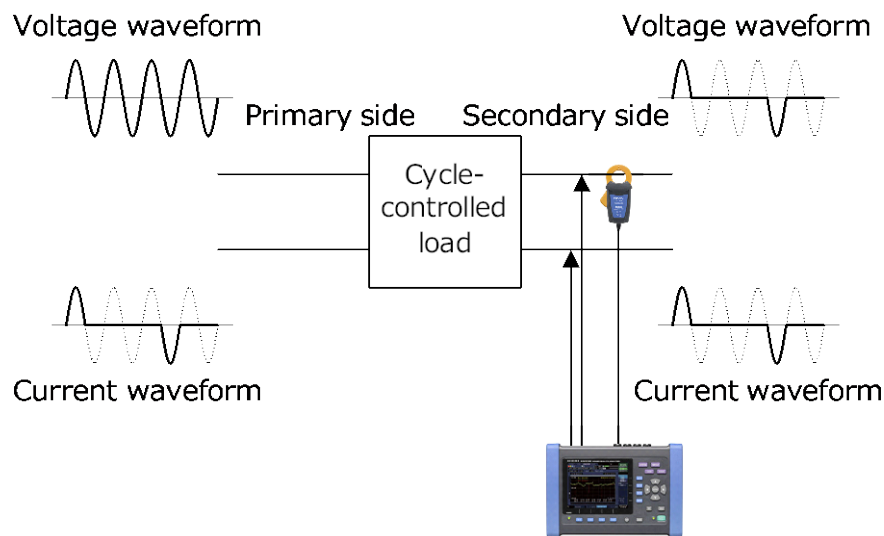
## Voltage, Current, and Power Measurement for Cycle-controlled Loads, Phase-controlled Loads, and Inverters

Please use a suitable power meter for cycle-controlled loads, phase-controlled loads, or inverter measurements for measuring voltage, current, and power.

### 1. Measurement on cycle-controlled loads

-1. Power meters that are suitable for the measurement

As shown in the figure below, an AC/DC type power meter is suitable for measuring cycle-controlled loads in which the voltage waveform is turned on and off at every half-wave.



Cycle-controlled load measurement

Suitable Power Meters AC/DC type		Non-suitable Power Meters AC Type	
Power Analyzers	PW6001, PW3390	Power Meters	3333
Power Meters	PW3337, PW3336, PW3335, 3334	Clamp-on Power Loggers	PW3365
Power Quality Analyzers	PQ3198, PQ3100		PW3360
			3169

-2. AC-type power meter for cycle-controlled loads on the primary-side measurement

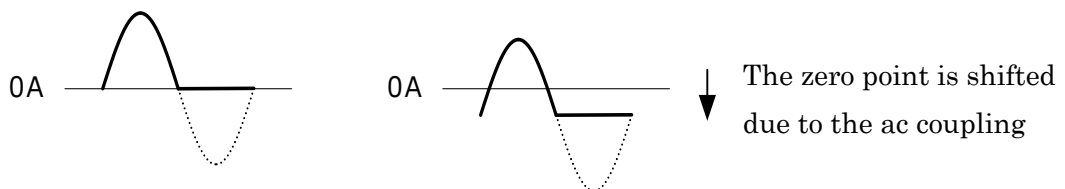
The AC type power meters are also compatible on measuring active power and voltage on the primary side.

(1) Voltage U

Most of the time the voltage waveform on the primary side is a normal AC waveform, so the measurement is possible.

(2) Current I

For the AC type power meter there will be an AC coupling on the measured current waveform. The zero point will be shifted when the waveform is turned on and off at every half-wave. The waveform will look like a DC components superimposed on each other and the RMS value cannot be measured accurately.



The actual current waveform      The AC coupled current waveform

(3) Active Power P

The active power is calculated from voltage and current waveform.

It is calculated from the same frequency component. Even-though there is a DC components superimposed on the current waveform, there is no superimposed components on the voltage waveform. Thus, the active power can be calculated accurately.

(4) Reactive power Q, Apparent power S, Power factor PF

The apparent power S, the reactive power Q and the power factor PF are calculated from the from the RMS value of the voltage and current.

The Apparent power  $S = \text{Voltage RMS value } U \text{ (primary side value)} \times \text{Current RMS Value } I$

Reactive Power  $Q = \sqrt{(\text{Apparent Power } S^2 - \text{Active Power } P^2)}$

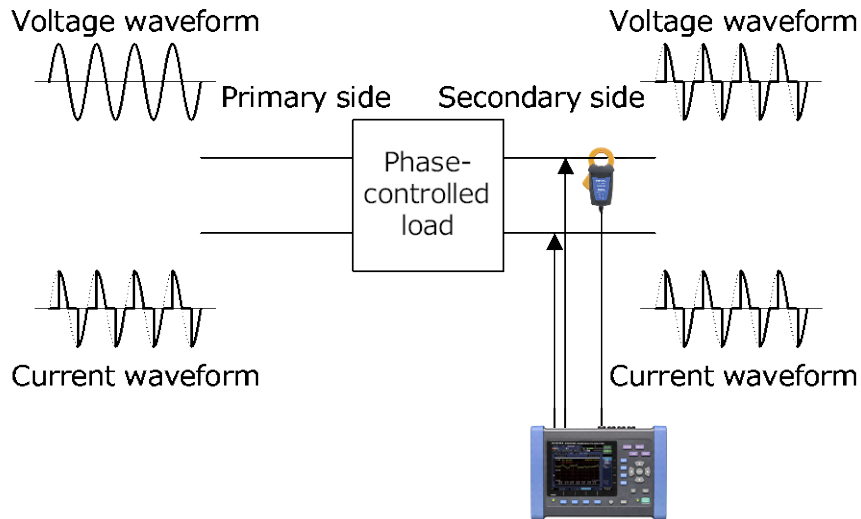
Power Factor  $PF = \text{Active Power } P / \text{Apparent Power } S$

Since the apparent power S, the reactive power Q and the power factor PF are calculated from the from the RMS value of the voltage and current, this will not give you an accurate measurement.

2. Phase-controlled loads measurement

-1. Power meters that are suitable for the measurement

As shown in the figure below, an AC/DC type power meter (with AC/DC current sensors) is suitable for measuring phase-controlled loads.



Phase-controlled loads measurement

Suitable power meters AC/DC type		Non-suitable power meter AC Type	
Power analyzers	PW6001, PW3390	Power meter	3333
Power meters	PW3337, PW3336, PW3335, 3334	Clamp-on power meters	PW3365 PW3360 3169
Power quality analyzers	PQ3198, PQ3100		

-2. AC-type power meter (with AC type current sensors) for cycle-controlled loads on the primary-side measurement

Depends on the measurement conditions, the AC-type power meter (with AC type current sensors) is also suitable for this kind of loads.

Measurement of phase-controlled loads with AC-type power meters

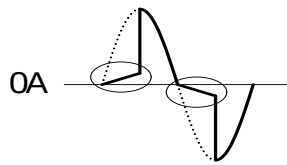
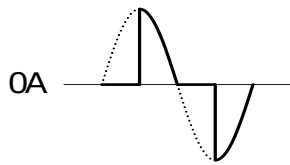
Voltage U	Current I	Active Power P	Reactive Power Q	Apparent Power S	Power Factor PF
Yes	Cautions	Yes	Cautions	Cautions	Cautions

(1) Voltage U

The primary side is a normal AC waveform, so there is no problem for voltage measurement. When measuring voltage on the secondary side of the phase-controlled loads, check on the waveform screen to see if the measured voltage waveform reproduces at the actual waveform before measuring it.

(2) Current I

When measuring current of the phase-controlled loads, check on the waveform screen to see if the measured current waveform reproduces the actual waveform before measuring it. Due to the low frequency characteristics of the current sensor (less than 40Hz is out of the frequency response range, etc.), the OFF section where the current is at 0A, the waveform may not be flat and will produce error in measurement.



The current measurement might not be measured accurately during the OFF condition (0A)

The actual current waveform

The abnormal current waveform

(3) Active Power P

The active power can be measured, but if there current waveform cannot be measured accurately this will also effect the measurement value of the active power.

(4) Reactive Power Q, Apparent Power S, Power Factor PF

The apparent power S, the reactive power Q and the power factor PF are calculated from the from the RMS value of the voltage and current.

The Apparent power  $S = \text{Voltage RMS value } U \text{ (primary side value)} \times \text{Current RMS Value } I$

Reactive Power  $Q = \sqrt{(\text{Apparent Power } S^2 - \text{Active Power } P^2)}$

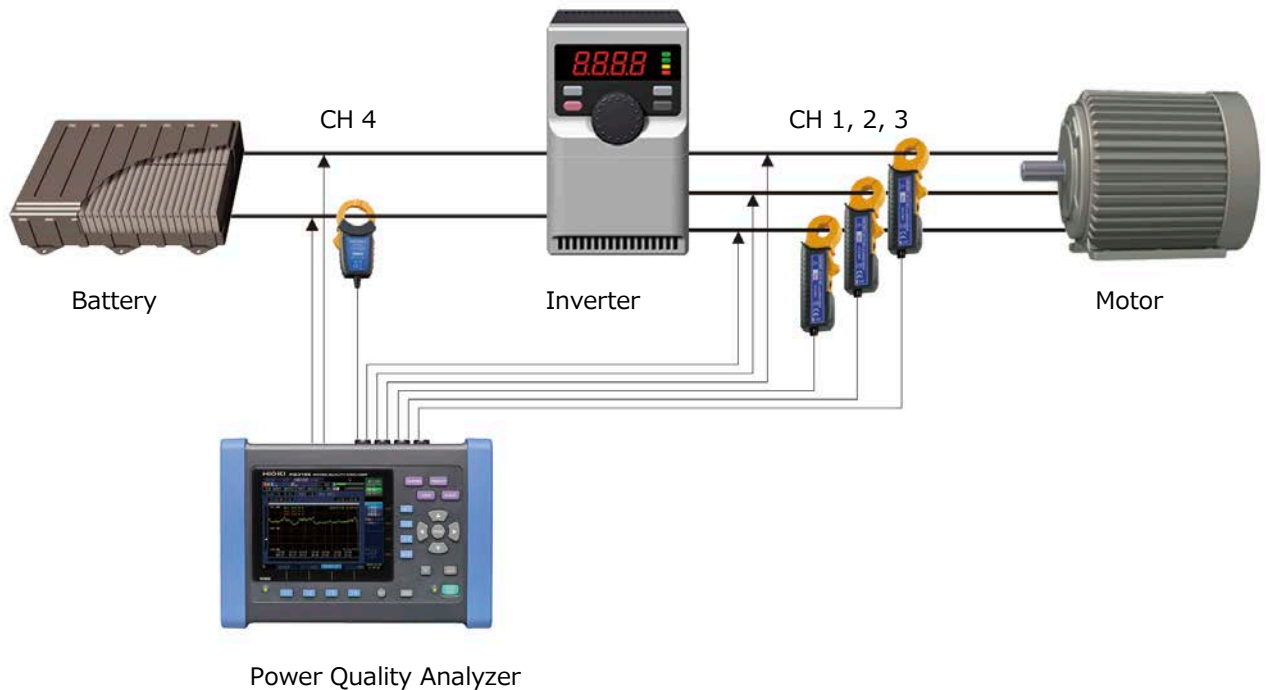
Power Factor  $PF = \text{Active Power } P / \text{Apparent Power } S$

Since the apparent power S, the reactive power Q and the power factor PF are calculated from the from the RMS value of the voltage and current, this will not give you an accurate measurement, when the current value is not calculated accurately.

### 3. Inverter measurement

For inverter measurement Hioki recommended to use power analyzers like PW6001 and PW3390, and power meters like PW3335, PW3336 and PW3337.

Depends on the measurement frequency, the power quality analyzers can sometime do the measurement too.



#### [Cautions]

- Due to differences in measurement bands in the instruments, the harmonic component of the carrier frequency measured in each instruments might effects the voltage RMS values. The current RMS and power values are quite close for all instruments in case the current waveform are close to the fundamental waveform.
- PW6001, PW3390, PW3337, PQ3198 can be used to measure the power transmission between the primary and secondary side of an inverter with a single unit.
- The PQ3198 and PQ3100 cannot measure the average value of voltage and current in terms of rectification RMS value. It is possible to measure only the RMS and fundamental components.