Highly stable evaluation of multi-MPPT inverter conversion efficiency

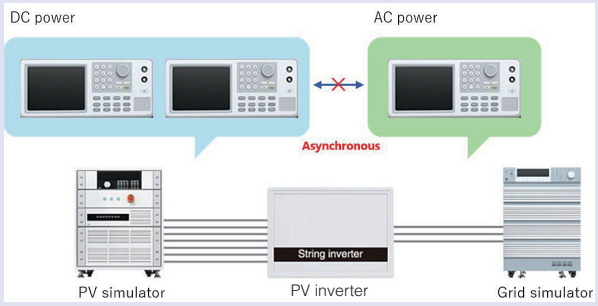
Introduction

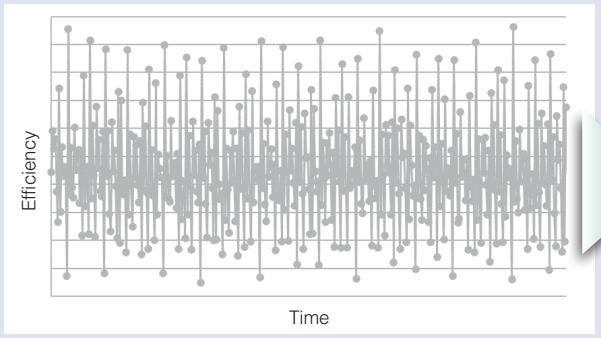
Maximizing the amount of electricity generated by photovoltaic (PV) systems is critical for owners of the systems as well as those installing them. Because the energy produced by PV modules is rife with variability, the power generation must be monitored and controlled to maximize it at all times. This is the job of Maximum Power Point Tracking (MPPT) inverters.
This application note shows how the Hioki M7103's Synchronization Source Sharing Function is particularly useful in measuring the power conversion efficiency of multiple MPPT inverters (a.k.a. string inverters).

Challenge

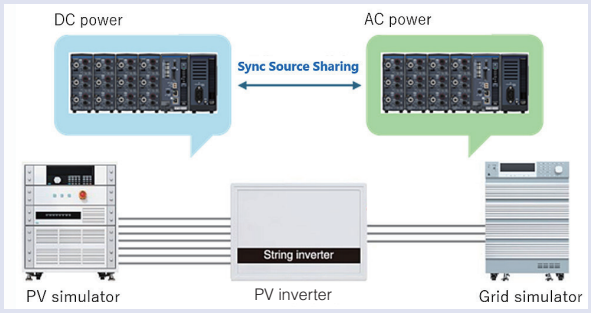
As the capacity of PV inverters increases, the number of DC input strings also increases. This means that many power meters must be used to measure and calculate the power conversion efficiency of all strings. However, it is difficult to align the calculation interval between each power meter, making it impossible to measure efficiency in a stable manner. As a result, it is not rare for evaluation of high-efficiency inverters to render practically impossible efficiency exceeding 100%. This is a very concerning situation, given that accurate and stable measurement of efficiency is essential for improving the quality and reliability of PV inverters.

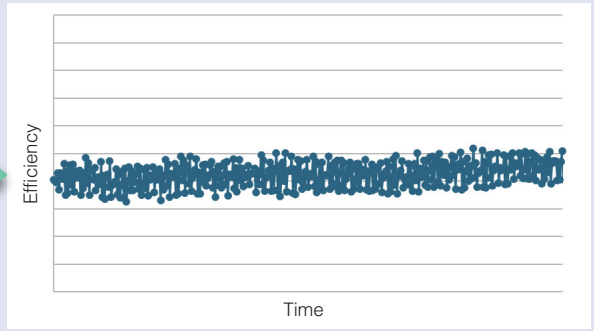
Typical setup





Hioki proposal: M7103's Synchronization Source Sharing Function





Effect of the Synchronization source sharing function
(This graph is intended for illustrative purposes only. Actual measurement data may vary.)

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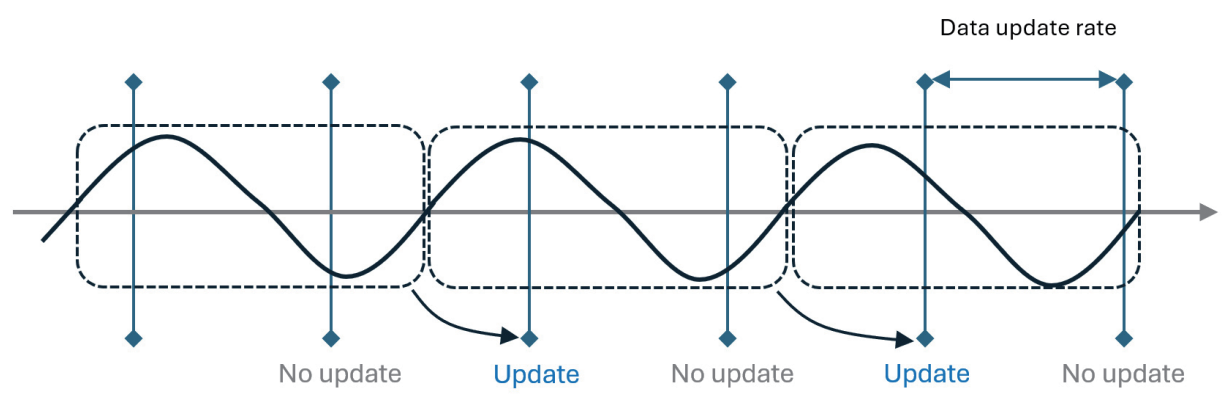
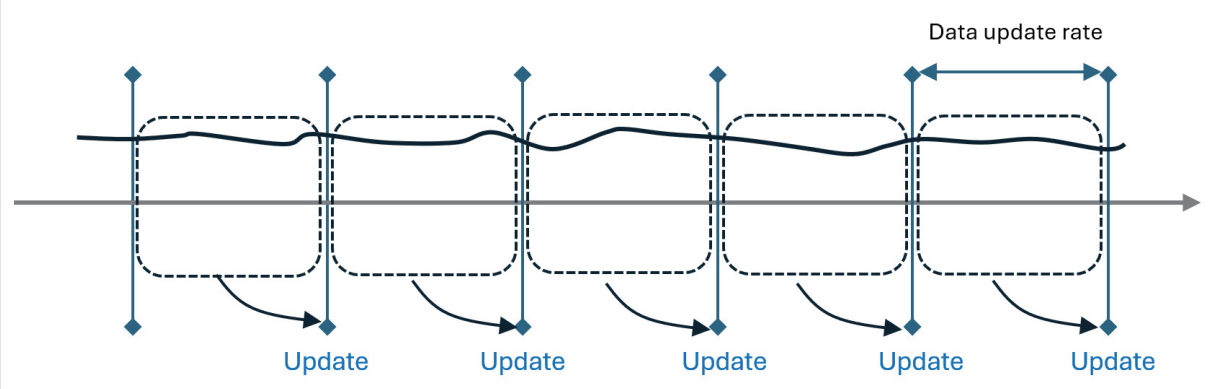
What to know about power measurement

Update-timing of power meters

When a power meter's synchronization source is set to AC current or AC voltage instead of DC, the update (and calculation of power, efficiency, etc.,) happens at each of the device's data update timings that occur after one or more complete waveform periods of the synchronization source. If a full period cannot be detected within the data update interval, the measured value is not updated.



When the synchronization source is set to DC, the value is always updated at the power meter's data update timing, and it calculates using the waveform that results between each data update.



Users can set the synchronization source (AC current, AC voltage or DC) from the power meter's settings.

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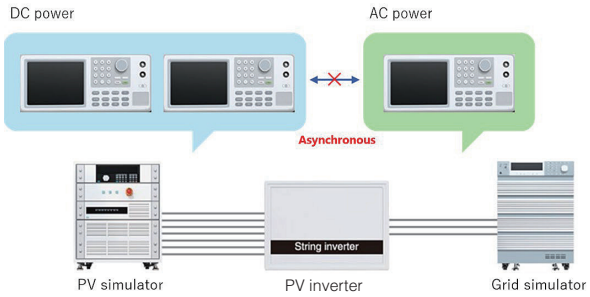
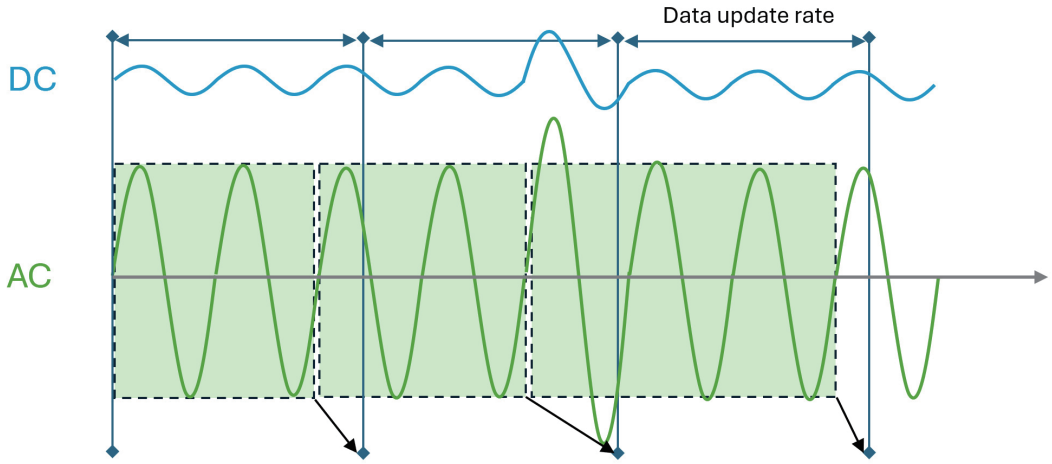
Causes of unstable efficiency values

When multiple power meters are used, however, the power is measured, and efficiency is calculated at the data update timing of each meter. This creates variation in measured values between power analyzers, making it impossible to obtain stable efficiency values. Therefore, it is important to align the data update timing of each power meter. However, there are cases in which aligning data update timing alone is not sufficient. The reasons for this are explained below.



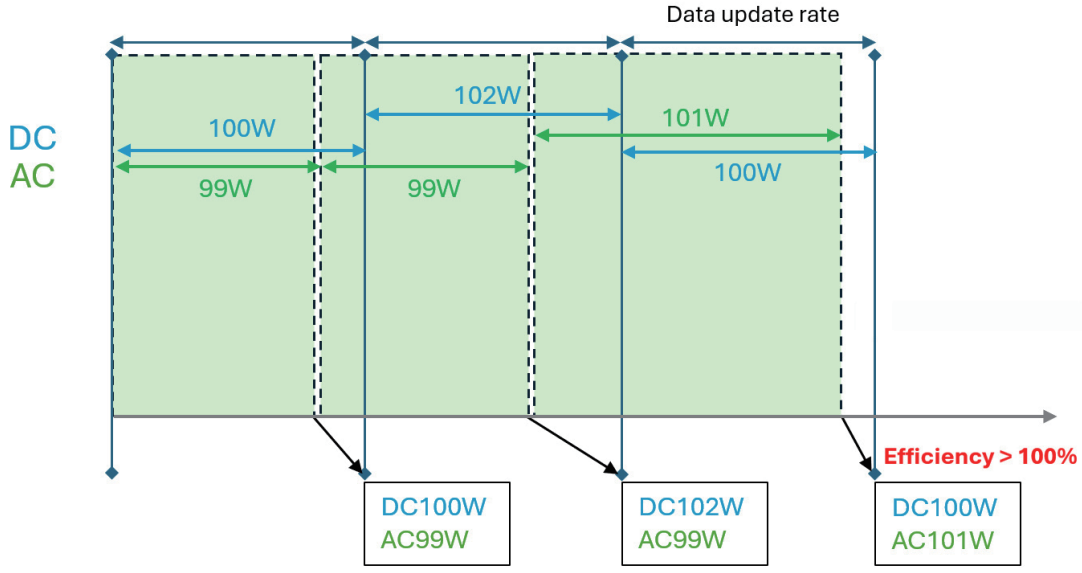
When a power meter's synchronization source is set to AC current or voltage, the AC power is calculated from the waveform extracted from between zero-crossing timings that result in one or more periods as shown in the figure below. The measurement values are updated at the next data update timing. When there is a DC synchronization source, the DC power is simply calculated from the waveform within the data update interval, and the measurement values are updated at each data update timing.

Instantaneous waveform



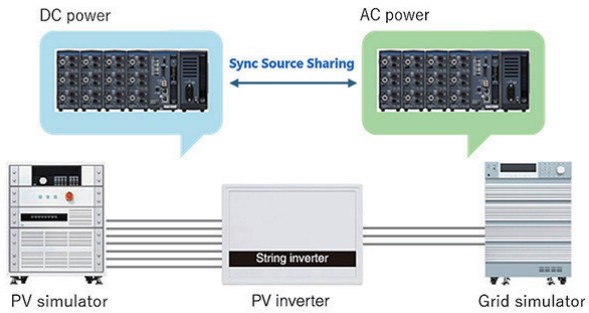
In the waveform above, both the DC and AC waveforms momentarily fluctuate. However, this momentary fluctuation is calculated from different time periods. Even though data is updated at the same time, this difference results in the efficiency exceeding 100%. Thus, simply aligning the data update timing is not enough to accurately and stably measure efficiency.

Active power

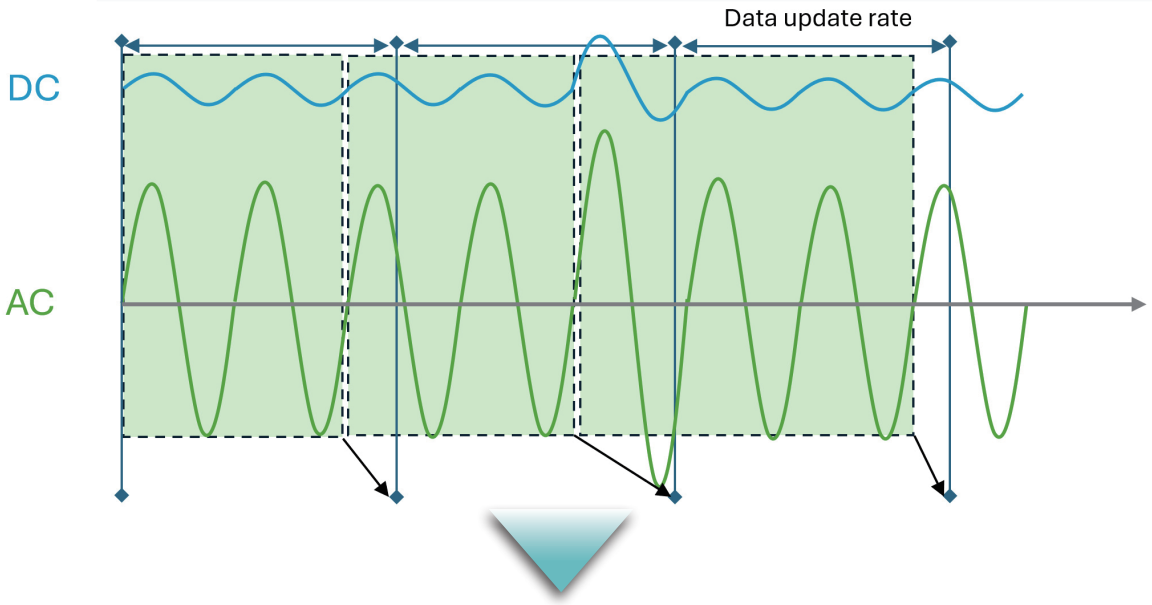


NEW Synchronization source sharing function

The Synchronization Source Sharing function was developed to solve this issue. When the Synchronization Source Sharing function is used to synchronize the calculation interval between each power meter, the calculation intervals for DC and AC power are matched. As a result, efficiency can be accurately and stably measured.

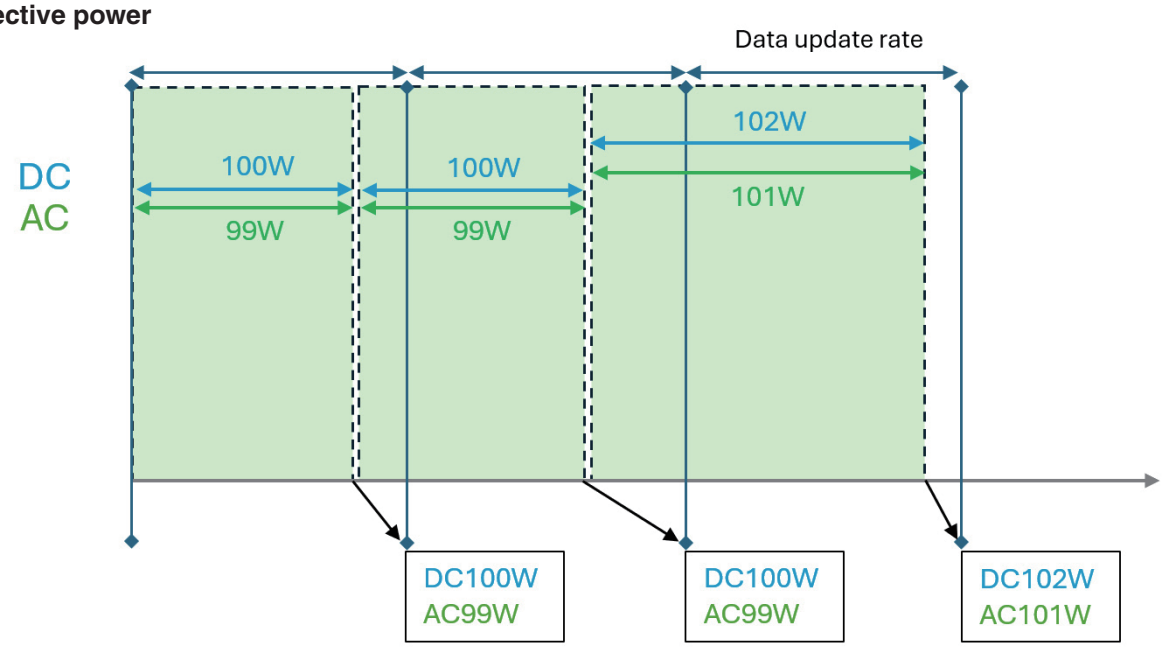


Instantaneous waveform



By using the Synchronization source sharing function, even in the case of instantaneous waveform fluctuations, both the DC and AC power can be calculated from the same time period, so the efficiency never exceeds 100%.

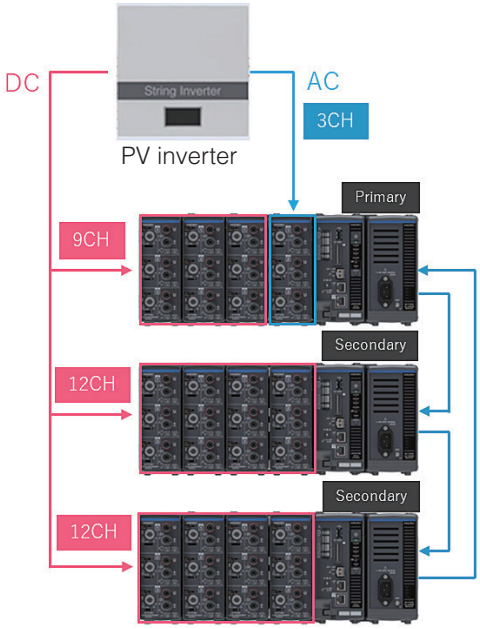
Effective power



Synchronization Source Sharing function application example

The M7103's Synchronization Source Sharing Function's stable power measurement especially shines in scenarios where two or more power meters are required. It provides an ideal solution for applications where multi-point power measurement is required, such as multi-MPPT inverters.

36-channel rack installation



Optical Connection Cable
L6101 (1 m) or L6102 (10 m)

(The Synchronization Source Sharing Function requires use of the Data Logger LR8102, Power Supply Module M1110, and Optical Connection Cable L6101 or L6102)

Product Configuration

To measure power, the main data logger unit requires a power supply module and a power measurement module.

3 channels

Standard Model
(without Synchronization Source Sharing function)

Advanced Model
(with Synchronization Source Sharing function)

Power Measurement Modules (up to 4)

Data Logger (main unit)

Power Supply Module

External dimensions

LR8102 + M1100 + M7103

When 4 units of the Power Measurement Module M7103 are installed

General specifications of the Power Measurement Module M7103

Measurable frequency band	DC, 0.1 Hz to 100 kHz
Basic accuracy (U, I)	0.02% of reading + 0.03% of range
Basic Precision (P)	0.02% of reading + 0.05% of range
Number of measurement channels	3
Voltage range	6 to 1500 V
Current range	40 mA to 2000 A (current sensors are used)
Data update interval	5, 50, 200 ms
Maximum input voltage	AC 1000 V, DC 2000 V

Integrate power and temperature measurement at high accuracy

The system can be combined with optional voltage/temperature modules to integrate highly accurate measurement of power and temperature. This provides comprehensive data on temperature, power consumption, and power conversion efficiency. Ideal for system-integration applications, this is a must-have solution for evaluating energy-saving products.

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