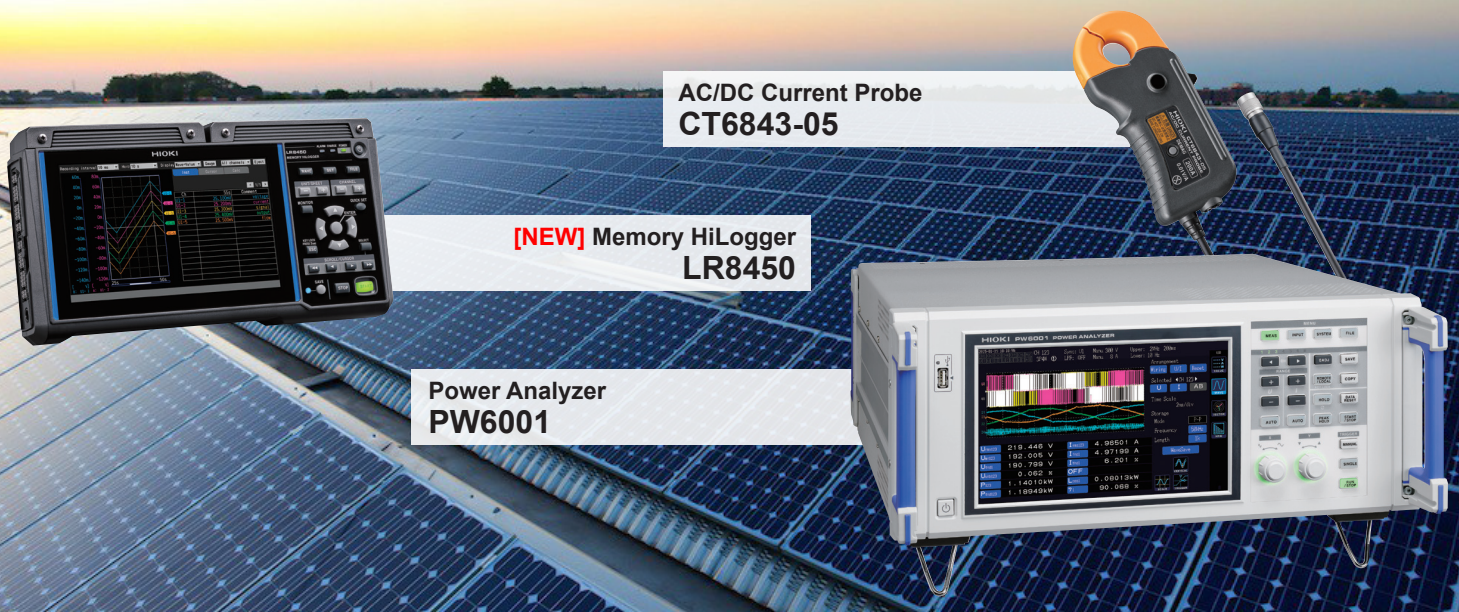


Application Note

HIOKI DATA LOGGER LR8450 AND POWER ANALYZER PW6001 FOR SOLAR PHOTOVOLTAIC POWER MEASUREMENT & MONITORING



AC/DC Current Probe
CT6843-05

[NEW] Memory HiLogger
LR8450

Power Analyzer
PW6001

What is Solar Photovoltaic (PV)?

Solar PV is a technology made up of a few main components^[1] – Solar PV Cells, Battery Storage Cells, Solar Power Conditioning Unit (PCU), DC and AC Isolators, AC Main Switchboard Panel and Revenue meter (Figure 1.0).

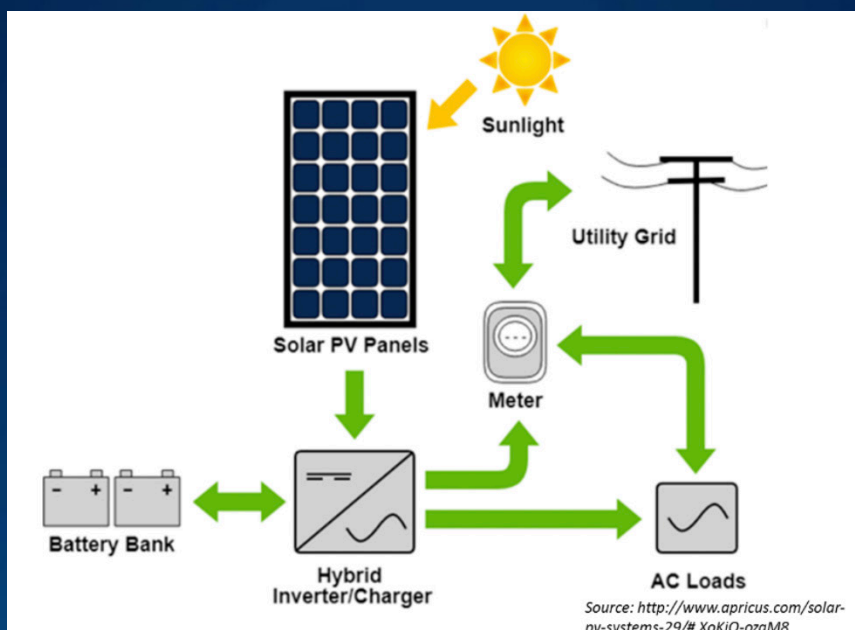


Figure 1.0 Main Components of a Grid-Connected to Battery PV-System

The build material of solar PV cells, mainly from crystalline silicones^[2] (N-type and P-type silicones), produces a voltage output in response to incident lights (any light source). Sunlight carries tiny packets of energy called photon as it shines^[3]. The electrons of the silicon atoms in the solar PV Cells absorb energy from the photon energy of the sunlight. When sufficient energy is absorbed, it allows free moving electrons which results in electrical potential energy difference, or direct current (DC) voltage (Figure 2.0).

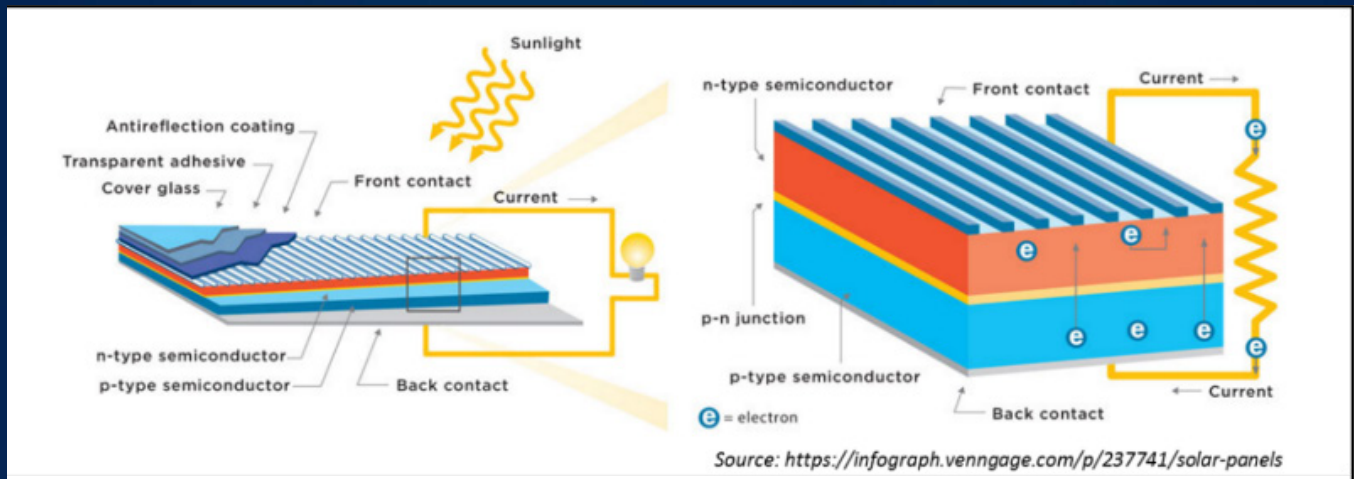


Figure 2.0 Solar PV Cells Working Principle

The PV cells are electrically connected to form a PV module, and multiple PV modules are then connected to form a PV panel to increase the electricity output as a single PV cell only generates 1 to 2 watts of electricity. The DC voltage can be converted to alternating current (AC) by a PCU for direct consumer use or stored in the battery cells via a battery charger.

Importance of Monitoring Solar PV Parameters

Although Solar PV generated energy is a renewable, easily-available, and cleaner energy source compared to fossil fuel, the installation cost is high while the energy yield is very weather dependent (sunlight irradiation). Hence, the system needs to monitor and ensure maximized power output production for the Return of Investment (ROI)^[4], which translates to the power efficiency of the overall Solar PV system.

Measurement accuracy can also impact the ROI for a Solar PV system. The measurement of large-scale solar energy power consumption could be in MWh or GWh ranges. However, the requirement for the revenue meter accuracy is only Class 0.5% and above, while a power analyzer has a higher accuracy (Power Accuracy - 0.02%). For example, a lower accuracy power analyzer measures Power Consumption at 138,800MWh, while Hioki's high accuracy Power Analyzer PW6001 measures Power Consumption at 138,813MWh. The difference of 13MWh has a significant cost impact for countries charging high energy tariffs. Therefore, a high accuracy power analyzer is highly recommended for checking the solar power consumption at the customer's load side.

Another important factor of using Hioki's Power Analyzer is the fact that it can measure the Solar PV voltage supply up to 1500Vdc. This unique measurement feature allows the Power Analyzer to measure accurately on the power efficiency of the PCU.

Solar PV Parameters Measurements with Hioki Power Analyzer PW6001 and Data Logger LR8450

A small-scale Solar PV system setup, as shown in Figure 3.0, is used for Solar PV measurement using Hioki's Power Analyzer PW6001, and Data Logger LR8450.

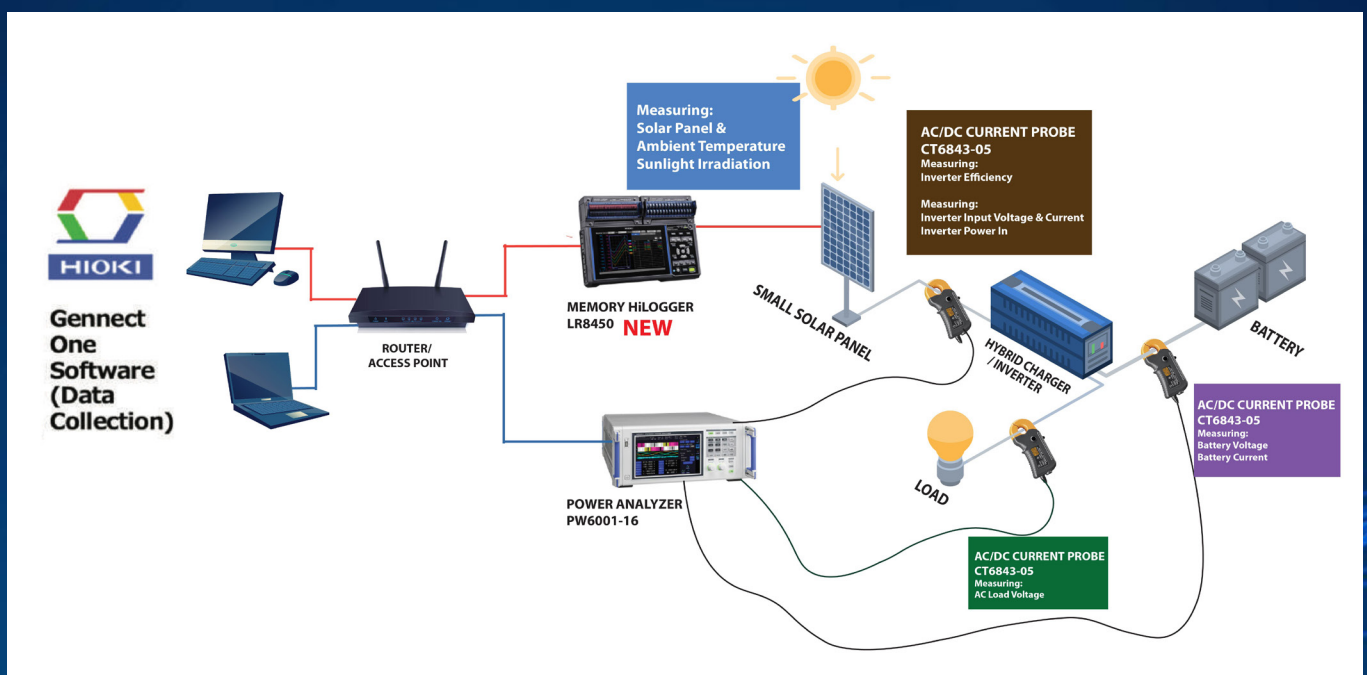


Figure 3.0 Small Scale Solar PV Setup for Demonstration

The following are test run data from a small-scale Solar PV model with the correlations as seen between some of the parameters.

1) Solar PV Panel

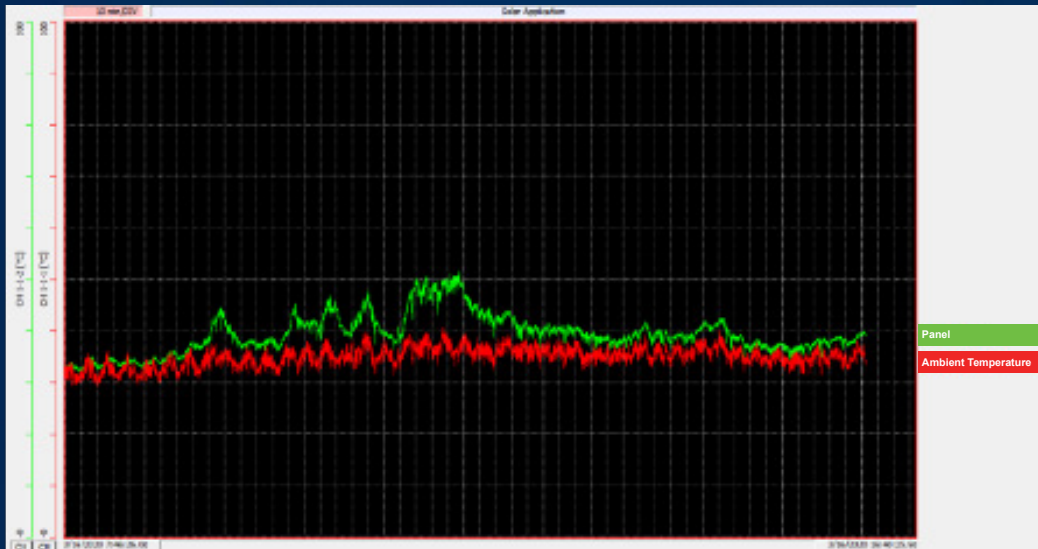


Figure 4.0 Panel and Ambient Temperature

A) Panel temperature and ambient temperature (Hioki Data Logger LR8450)
Figure 4.0 shows the panel temperature and ambient temperature trend over time.

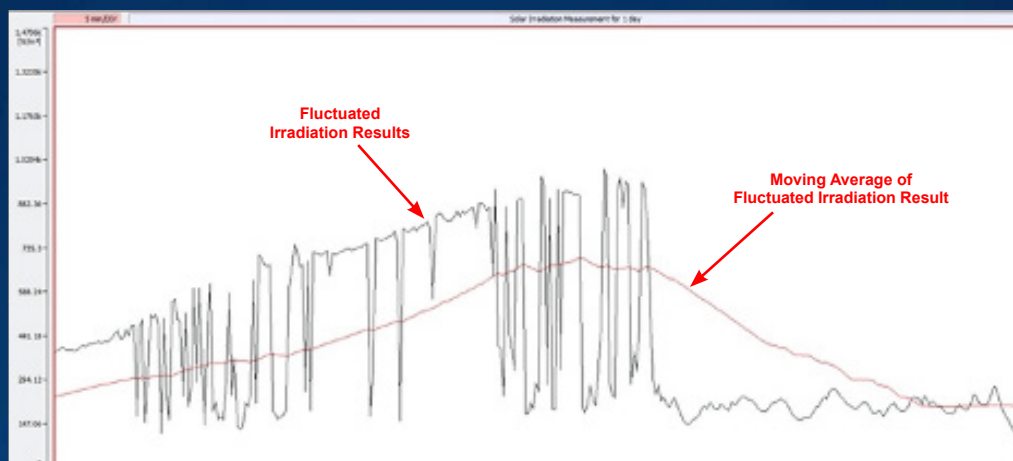


Figure 5.0 Sunlight Irradiation

B) Sunlight irradiation (Hioki Data Logger LR8450 and a pyranometer)
Figure 5.0 shows constant irradiation fluctuation due to the cloud movement that blocks the sunlight to the pyranometer.

2) Inverter (Hioki Power Analyzer PW6001)

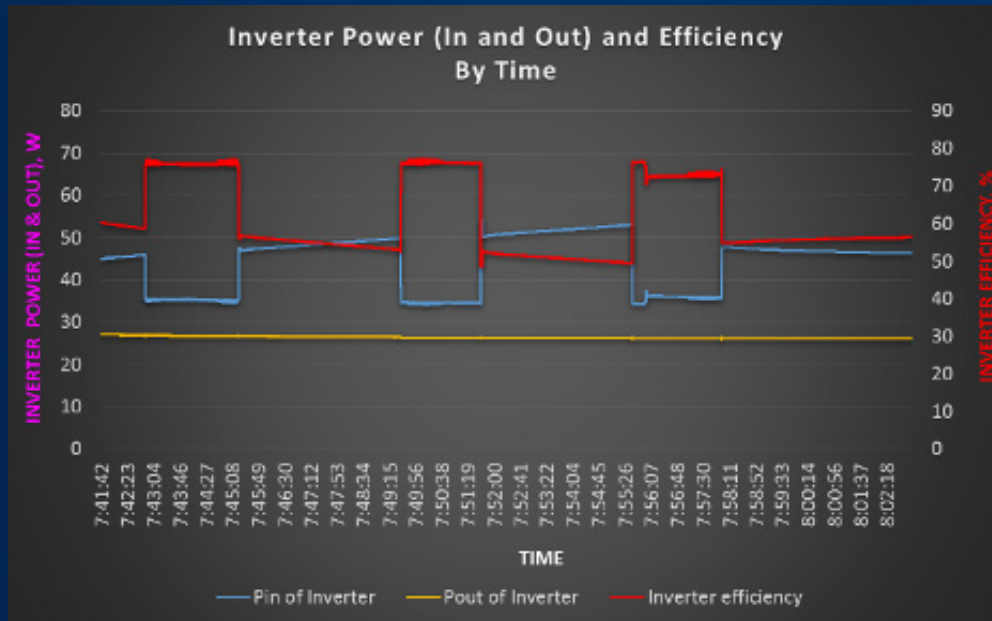


Figure 6.0 Inverter Power and Efficiency

A) Power in, power out and inverter efficiency

The input power, which is highly dependent on sunlight, is observed to be in inverse proportion to the inverter efficiency. This highly accurate-to-seconds measurement (Figure 6.0) is only achievable through a high accuracy Power Analyzer.

Disclaimer: This measurement data might not represent the actual case of a large-scale Solar PV installation as shown in Figure 7.0.



Figure 7.0 Example of a Large-Scale Solar PV Installation

2) Inverter (Hioki Power Analyzer PW6001)

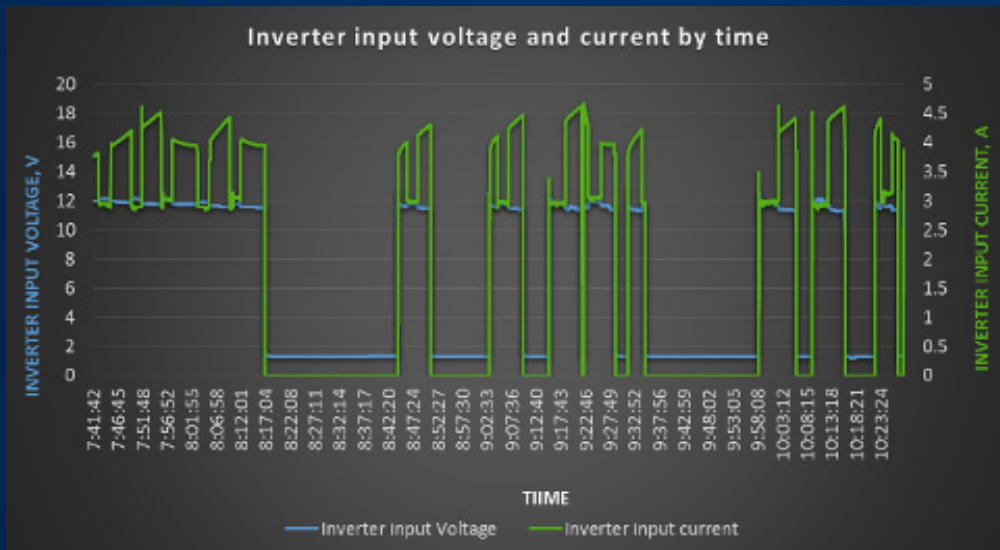


Figure 8.0 Inverter Input and Battery Voltage Response to Load

B) Inverter input voltage and current

The inverter input voltage and current drops when the AC load is removed (Figure 8.0).

3) Battery Charging

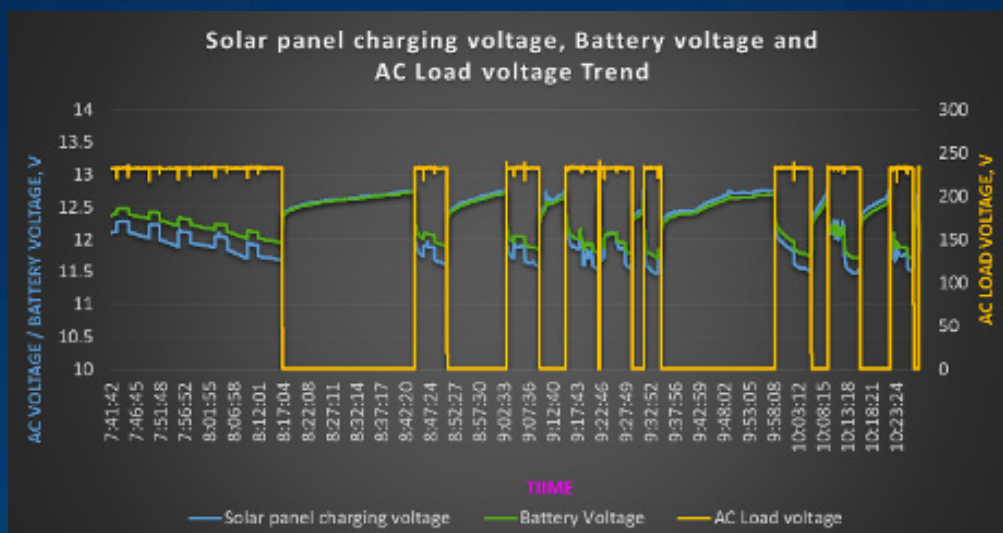


Figure 9.0 Solar Panel Charging Voltage and Battery Voltage

A) Solar panel charging voltage and battery voltage (Hioki Power Analyzer PW6001)

Solar panel charging voltage increases and equates to battery voltage value when there's no AC load running (Figure 9.0).

Below are some screenshots of actual measurement of a Solar PV inverter using Hioki Power Analyzer PW6001 (Figure 10.0 and Figure 11.0).

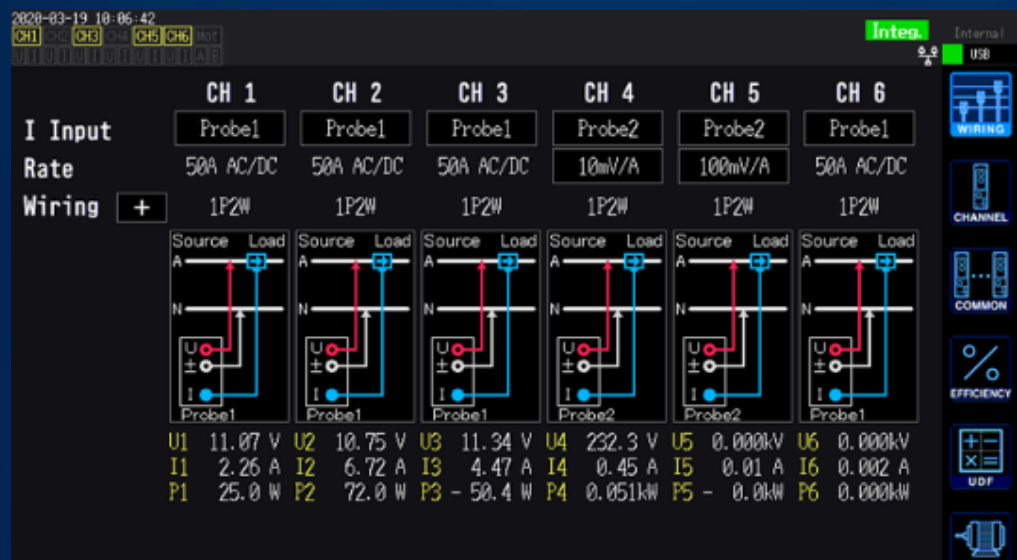


Figure 10.0 Inverter Voltage, Current and Power Measurements by Channels with Wiring Scheme



Figure 11.0 Inverter Power In, Power Out and Efficiency

In conclusion, it is important to check on the overall power efficiency of your Solar PV installation, as well as the energy cost by cross referencing with the revenue meter. Hioki's high accuracy Power Analyzer PW6001 and Data Logger LR8450 can help to optimize on the overall efficiency of the Solar PV system and ROI.

The measured data for Power Analyzer PW6001 can be retrieved wirelessly via Bluetooth and pairing with Hioki Data Logger LR8410, while Data Logger LR8450 has built-in HTTP Remote Server to configure and monitor the instrument via a browser, as well as FTP server functions for remote data retrieval. Solar PV panels are usually mounted on top of the roof or specially constructed structures at a widespread area (solar farm) to maximize exposure of sun. Hence, these features offer easy and convenient measurement data retrieval.

For more product information, please click on the links below:

- [Memory HiLogger LR8450 \(NEW\)](#)
- [Power Analyzer PW6001](#)
- [AC/DC Current Probe CT6843-05](#)

References

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HEADQUARTERS

81 Koizumi
Ueda, Nagano 386-1192 JAPAN
www.hioki.com

HIOKI SINGAPORE PTE. LTD.

(For South East Asia, Oceania & Bangladesh markets)
33 Ubi Avenue 3, #03-02 Vertex, S408868
TEL: +65-6634-7677
www.hioki.com.sg
www.facebook.com/HiokiSingapore

Thailand Representative Office

202 9th Floor, Room 906, Le Concorde Tower
Ratchadapisek Road, Huay kwang
Bangkok 10310, Thailand
TEL +66-2-051-5323
www.hioki.com.sg
www.facebook.com/HiokiThai

PT HIOKI ELECTRIC INSTRUMENT

Gedung Graha MIR, 1st Floor, Zone C
Jl. Pemuda No. 9, Rawamangun, Pulogadung
Jakarta Timur 13220, Indonesia
TEL +62-21-2956-9853
www.hioki.com.sg
www.facebook.com/HiokiIndonesia