Application Note

# Analysis of Power Consumption Fluctuations in AI Data Centers

**Market: Generative AI data centers, server power supplies, power supply blades, UPS**
**WT5000 Precision Power Analyzer**

## 1. Introduction

Generative AI is a type of artificial intelligence that creates new content such as text, images, and audio. This technology leverages deep learning and vast amounts of data to generate new outputs. And as generative AI becomes more widespread, data centers are playing an increasingly vital role.
AI data centers provide high-performance computing resources for training and inference of generative AI models. In particular, training large-scale generative AI models demands immense computational power. This requires the use of high-performance GPUs and TPUs*, which consume significant amounts of power. AI data centers are also equipped with high-speed networks, large-capacity storage, and advanced cooling technologies, all of which contribute to substantial power consumption.
In this context, enhancing the energy efficiency of AI data centers requires conducting a thorough analysis of power consumption. Because accurately measuring power usage is a key step in optimizing energy efficiency and lowering operational costs, real-time monitoring and efficient power management are becoming increasingly vital for minimizing energy waste and pinpointing opportunities for improvement in cooling and power supply systems.

* GPU: Graphics Processing Unit
* TPU: Tensor Processing Unit

## 2. Challenges

In AI data centers, measuring power consumption often requires monitoring the current flowing through power cables that are already in place. However, installing a high-accuracy feed-through current sensor is typically unfeasible in such environments. This necessitates the use of a removable, high-precision sensor capable of measuring both AC and DC high current. The CT1000S AC/DC split-core current sensor, when paired with the WT5000 precision power analyzer, enables high accuracy multi-channel power measurement. The CT1000S is easy to remove while maintaining high-precision current measurement, and the WT5000 enables accurate collection and analysis of multi-channel power data. This combination makes it possible to closely monitor power consumption within AI data centers, helping to improve energy efficiency and reduce operating costs.

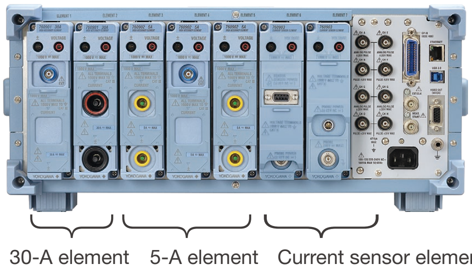
## 3. Solutions the WT5000 provides

- Highly accurate power measurement with a basic power accuracy of ±0.03%
- High-precision efficiency measurement for AC/DC and DC/DC conversion
- CT1000S features a user-friendly open/close mechanism for easy installation
- The CT1000S main unit design for easy attachment to sheet metal
- Measurement of integrated electrical energy and current
- Excellent noise immunity in both the power meter and current sensor
- Continuous power and waveform measurements enable prompt detection of abnormalities
- Development and manufacturing support with additional measurement instruments, including the DL950, DLM3000HD, AQ6370E, and AQ6150B

# 4. Proposal for using the WT5000

## 4.1 Highly accurate power measurement with a basic power accuracy of ±0.03%

The WT5000 offers a total measurement accuracy of ±0.03% (50/60 Hz), which is among the highest in the world. When measuring currents with high RMS wave heights, minimizing range error is important. This is why the WT5000 provides a minimum range error and a power accuracy of ±(0.01% of reading + 0.02% of range) (50/60 Hz), ensuring highly precise power measurements. Thanks to its modular design, the WT5000 allows you to replace or add your own input modules. The system offers three different input options (dedicated current sensor input, 30-A rated input, or 5-A rated input), enabling flexible measurement of a wide range of current amplitudes with a single unit.




Example of mounting a mixture of 30-A, 5-A, and current sensor elements

Figure 1. WT5000 input elements (3 types) mounted

## 4.2 High-precision efficiency measurement of AC/DC and DC/DC conversion

AI data center power supplies typically contain several conversion circuits. Suppressing harmonics is crucial because they are connected to a standard AC commercial power supply, and suppression is achieved by including a power factor correction (PFC) circuit. Additionally, a DC/DC converter is used to regulate the DC voltage level. These conversion circuits require designs that minimize power loss, and the WT5000, with its multi-channel input capability, is ideal for measuring the efficiency of each circuit with precision. This ensures optimal performance.

Figure 2. Example of connecting WT5000 and CT1000S units

## 4.3 Open/close mechanism for easy installation

The CT1000S is a high-precision AC/DC current sensor equipped with an open/close mechanism, allowing for non-invasive current measurements. This feature makes it easy to remove the sensor without the need to cut or disturb the cables being measured. In addition, you can remove the sensor without disassembling the entire measurement system.

Figure 3. Image of CT1000S opening and closing operation

## 4.4 Main unit design for easy attachment to sheet metal

The CT1000S features six M4 screw holes in its main unit, allowing for secure attachment of the sensor main unit to sheet metal. While current sensors with an open/close mechanism are often more challenging to fix in place compared to conventional feed-through types, the CT1000S overcomes this limitation. Figure 4 demonstrates an example of the CT1000S fixed to a wall. The sensor can be positioned midair, which would otherwise typically be impossible. Figure 5 shows how the CT1000S can be mounted in a rack for three-phase current measurements, taking full advantage of its design. By ensuring that the screw holes and locking lever are easily accessible, this setup facilitates both stable measurements and straightforward maintenance management.

Figure 4 CT1000S fixing example

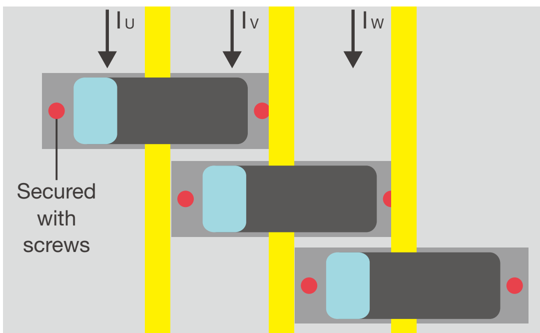



Figure 5. Rack layout for three-phase current measurement

## 4.5 Measurement of integrated electrical energy and current

The WT5000 is equipped with an integration function that measures the total amount of electric power (Wh) and current (Ah) consumed over extended periods. This totalization function includes: active power totalization (watt-hours), current totalization (ampere-hours), apparent power totalization (apparent watt-hours), and reactive power totalization (reactive watt-hours).

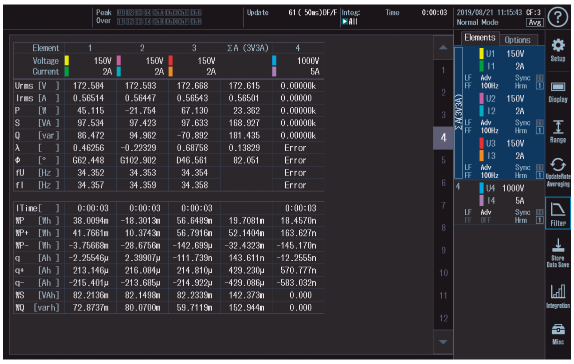


Figure 6. Example of the integrated power and current measurement screen

## 4.6 Excellent noise immunity in both the power meter and current sensor

AI data centers rely on a wide range of power supplies, with switching power supplies being particularly common. While switching power supplies deliver efficient power, they can also generate significant noise, which may interfere with high-precision power measurements. To ensure highly accurate measurements, effective noise suppression techniques are essential in both power measurement and current sensors. In environments like DC/DC converters and inverters, which rely on high-frequency switching to control operations, using current sensors with high bandwidth capabilities and high-performance power meters that offer precise measurements even in noisy conditions is crucial. This combination enables accurate data collection and analysis, leading to better energy efficiency and lower operating costs in AI data centers.

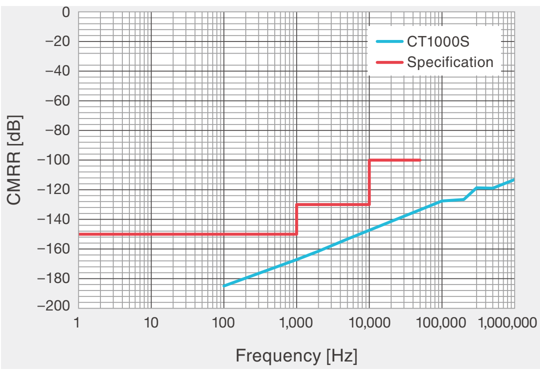



Figure 7. High-precision measurement even in harsh noise environments

## 4.7 Continuous power and waveform measurements enable prompt detection of abnormalities

When monitoring voltage, current, or power data over extended periods is necessary, the IS8000 integrated measurement software platform allows you to track and save power parameter trends in real time. In addition, the WT5000's data streaming function (/DS option) enables both numerical power data and waveform data to be observed and saved simultaneously. For instance, by zooming in on an abnormal power value, you can examine the waveform data at that point directly on a single WT5000 unit.

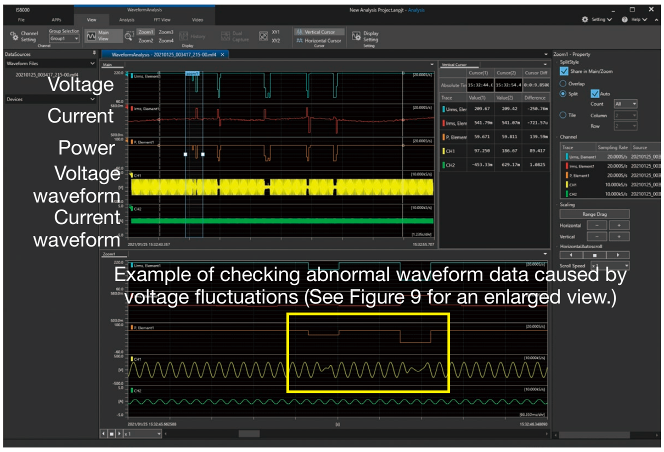



Figure 8. Voltage, current, and power trend display in the IS8000

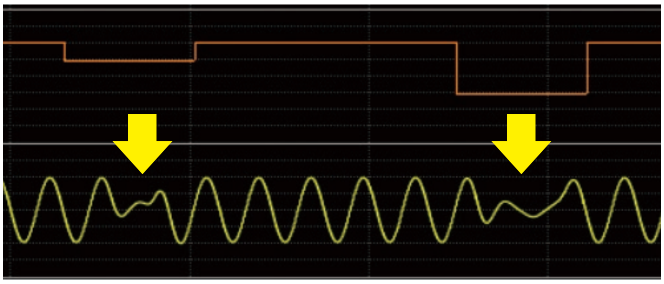


Figure 9. Confirmation of abnormal waveforms by zooming in on areas with power fluctuations

## 4.8 Development and manufacturing support with additional measurement instruments

### DL950: Long-duration data recording and high-speed measurement at signal abnormality

The DL950 ScopeCorder, a multi-channel isolated waveform recorder, features a dual capture function that allows simultaneous recording at different sampling rates. This enables the acquisition of data at a low sampling rate for long-term trends while capturing sudden transients at a high sampling rate. When paired with the IS8000 integrated measurement software platform, the DL950's waveform data can be synchronized with numerical power data from the WT5000 via IEEE1588 and displayed. This synchronization provides a detailed observation of waveform during power fluctuations.

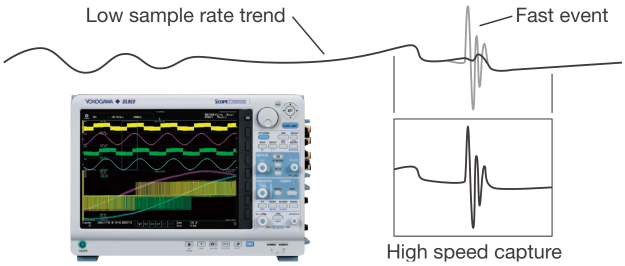



Figure 10. Example of measurement using the DL950's dual capture function

### DLM3000HD/DLM5000HD: Waveform observation of PFC circuits

The DLM3000HD, a high-definition oscilloscope optimized for ease of use and high performance for waveform observation, and the DLM5000HD with its eight analog channel inputs, are ideal for monitoring the operation of power supplies and power factor correction (PFC) circuits.

Figure 11. Example of DLM3000HD dual-unit synchronous connection

### Optical transceiver testing in AI data centers

In a generative AI data center, optical network equipment plays an important role in processing large amounts of data at high speed and efficiency. Optical network equipment converts electrical signals into optical signals and transmits data through optical fiber, which enables high-speed communication in and out of the data center and streamlines exchanges of the vast amount of data required for training and inference of generative AI.
Optical transceivers are responsible for converting electrical signals to optical signals in optical network equipment. Optical transceivers are devices that interconvert electrical and optical signals and function as part of the optical network equipment. This allows data to be transmitted at high speeds through optical fiber.
Yokogawa's optical spectrum analyzers (OSA) and wavelength meters are used to test optical transceivers. The OSA analyzes the spectrum of the optical signal and measures important parameters such as wavelength, power level, and SMSR. A wavelength meter, on the other hand, measures the exact wavelength of an optical signal.
Combining these instruments allows for highly accurate evaluation of optical transceiver performance and contributes to quality improvement

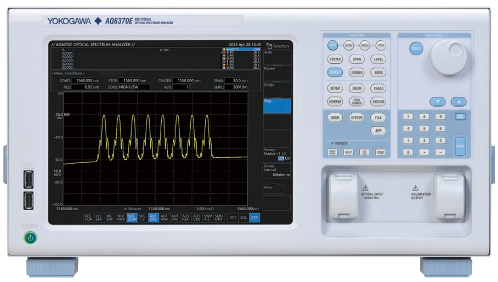


Figure 12. Optical spectrum analyzer AQ6370E

Figure 13. Optical wavelength meter AQ6150B

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**YOKOGAWA TEST & MEASUREMENT CORPORATION**
*Global Sales Dept.* /E-mail: tm@cs.jp.yokogawa.com


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