

Application Note

Long-Term Power Assessment in Grid-Disturbed Renewables

Market: Renewable energy, grid connection, power conditioners
DL950 ScopeCorder



1. Introduction

As the adoption of renewable energy advances, grid disturbances sometimes occur. This refers to a phenomenon in which voltage or frequency fluctuates rapidly in a power grid, potentially having a significant impact on power quality. Especially when a large amount of output from solar photovoltaic (PV) panels or wind power generators is connected to the power grid, there are concerns that these disturbances may occur frequently. For example, disconnecting (isolating) such power outputs all at once can significantly affect power quality.

In power generation systems that utilize renewable energy, such as PV power generation systems that feature mega-scale solar systems and wind power generation systems, it is necessary to efficiently convert and supply the generated power. This conversion efficiency has been improving year by year, and the reduction of conversion losses has become an important indicator for improving market competitiveness. To minimize conversion losses, fault ride through (FRT) capability that allows operation to continue even during momentary voltage drops is crucial. In addition, the development of FRT requirements for distributed energy resources (DERs), which are necessary for maintaining power quality during grid disturbances, continues to progress. The methods for evaluating conversion efficiency include voltage fluctuation and frequency fluctuation tests, as well as temperature rise tests. Indeed, tests involving power measurement using power meters, measurement of instantaneous waveform fluctuations using waveform measuring instruments, or measurement of temperatures, are underway in various countries around the world.

As renewable energy adoption continues to make headway, the technical efforts to address these challenges during grid disturbances are rising in urgency. For example, as DERs increase in number and expand, the implementation of real-time monitoring systems to maintain stability right across the grid is making progress. As such, it is becoming possible to rapidly grasp fluctuations in the generation output of each power plant, allowing for proper maintenance of the supply-demand balance.

2. Challenges

The power generated by renewable energy facilities often fluctuates due to natural conditions, and rapid increases in generation capacity can destabilize the power grid. Additionally, the power grid can be affected by lightning strikes, causing the power generation systems to disconnect simultaneously.

As such, there is a demand to capture and closely examine fluctuations in active power, reactive power, voltage, frequency, power factors, and efficiency when phenomena like these happen.

In addition, the primary purpose of waveform measuring instruments is to continuously monitor the grid over extended periods and capture abnormal waveform data. But observing waveforms over the long term produces enormous volumes of data that make locating the concerning or abnormal waveforms difficult. The need to solve this problem is spurring demand for equipment that measures both numerical and waveforms from power meters over an extended period on the same time axis to monitor data and identify abnormalities data.

3. Solutions provided by DL950

- A variety of plug-in modules
- Dual capture function
- Real time math and power math
- Comparison of power measurement functions for each measuring instrument
- Time-synchronized measurement based on IEEE 1588
- Example of measurement applications for DERs

4. Proposals provided by DL950

4.1 A variety of plug-in modules

We offer a variety of plug-in modules for high-speed and high-precision voltage measurement, as well as for measuring temperature, acceleration, strain, frequency, logic, and CAN/CAN FD/LIN/SENT in-vehicle serial communication data. These modules can be inserted into the eight slots of the DL950, allowing for flexible configurations to meet your measurement needs.

Moreover, up to four subunits can be connected to a single main unit using fiber optic cables, enabling expansion to a maximum of 160 channels. This configuration allows for synchronization of measurement start/stop, trigger timing, and a sample clock.



Figure 1. DL950 ScopeCorder



Figure 2. A variety of plug-in modules

4.2 Dual capture function

In endurance tests and similar situations, data is collected using low-speed sampling to capture long-term trends. However, sudden high-speed transient phenomena need to be measured using high-speed sampling. The dual capture function allows two independent sampling processes to be performed simultaneously.

This function is registered in the application menu, providing easy setup and execution.

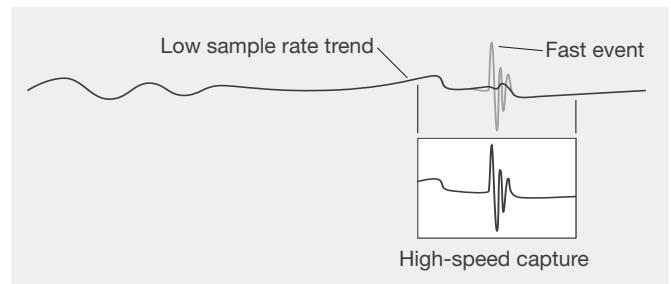


Figure 3. Image of waveform acquisition by the dual capture function

4.3 Real time math and power math

The real time math function (/G03 option) runs various calculations on captured signals and displays the results in real time as trend graphs. This function enables you to set triggers on calculation results or perform automatic waveform parameter and cursor measurements. You can also apply filters to both the input signals and calculation results. In addition, since the real time math function is independent of the input channels, real time calculation results for 32 input channels and additional 16 channels can be displayed and analyzed simultaneously.

The power math function (/G05 option) calculates up to 118 types of power parameters for each cycle in real time, including RMS values, effective power, integrated power, and harmonics. It simultaneously displays both the voltage and current signals being measured, as well as the trend waveform of the computed power parameters in real time. You can also set triggers on trend waveforms of the power parameters.

* The power math option includes the real time math option.

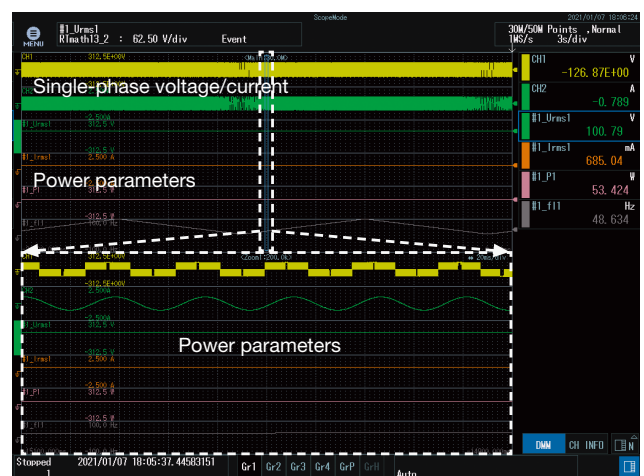


Figure 4. Example of single-phase voltage/current waveforms and power parameter math

4.4 Comparison of power measurement functions for each measuring instrument

To measure power, you can use either a dedicated power meter capable of high-precision measurement or an oscilloscope's calculation functions. Each has its own advantages and disadvantages. The DL950's power math function (/G05 option) is optimal for measuring power comprehensively together with temperatures or vibrations.

	ScopeCorder	Power Meter	Oscilloscope
Representative model (option)	DL950 /G05 Power math option 	WT5000 	DLM5000/DLM5000HD /G03 Power analysis option 
Power measurement function	- Up to two 3-phase systems can be computed simultaneously - Wiring system: 1P2W, 1P3W, 3P3W, 3P3W (3V3A), 3P4W	- Up to three 3-phase systems can be computed simultaneously - Wiring system: 1P2W, 1P3W, 3P3W, 3P3W (4V4A), 3P4W	- Automatically measures power parameters for voltage/current waveforms of up to four systems - Capable of statistical processing and computations
Other functions	- Harmonic analysis - Synchronized channel filter	- Simultaneous harmonic analysis - IEC harmonic/flicker measurement - Motor evaluation function - DA output	Power supply analysis function: Switching loss, safe operation range, harmonic analysis, Joule integral, auto deskew function
Number of channels	Up to 16	Up to 7 (Voltage and current pairs)	8 (4 channels model available) *4/2 channels for DLM3000
Number of synchronized units	Up to 5	Up to 4	Up to 2
Voltage/current waveform observation	Yes	/DS option (Max. 2 MS/s)	Yes
Sampling rate	Max. 200 MS/s*	10 MS/s	2.5 GS/s
ADC resolution	12/14/16 bits*	18 bits	DLM5000: 8 bit DLM5000HD: 12 bit
Max. input voltage	1000 V (DC + ACpeak)	1000 V, 1.5 kVdc	300 Vrms/400 Vpeak
Application scenarios	- Evaluation of large power fluctuations - Integrated measurement of temperature, vibrations, in-vehicle bus data etc.	High-precision power measurement	Evaluation of rough characteristics combined with waveform observation with high-speed sampling

* Depends on the modules used.

The PX8000 Precision Power Scope features a high sampling speed of up to 100 MS/s and measurement frequency bandwidth of 20 MHz, enabling measurement and analysis of transient voltage, current, and power.

Key features

- Power calculation for the section specified by the cursor
- Trend power calculation for each cycle
- Harmonic analysis up to the 500th order
- FFT waveform analysis
- User-defined computation functions



PX8000 Precision Power Scope

4.5 Time-synchronized measurement based on IEEE 1588

IEEE 1588 is a standard for the Precision Time Protocol (PTP), a protocol used for high-precision time synchronization of measuring instruments and control systems connected to a network. It provides highly accurate clock synchronization with an error of less than 1 μ s between measuring instruments or control systems connected via a LAN. By supplying the reference clock from GPS satellites to each measuring instrument through a PTP grandmaster, you can synchronize not only the instruments within the network but also those located remotely. Since the DL950 ScopeCorder comes equipped with the PTP master function*, it can achieve high-precision clock synchronization among compatible measuring instruments within a local network even when a PTP grandmaster is not available. Additionally, the IS8000 also has the capability to combine simultaneously measured data from these clock-synchronized measuring instruments into a single window.

* Requires the /C40 IEEE 1588 master function option.

* The DL950, DLM5000, and WT5000 come equipped with IEEE 1588 slave functionality as a standard feature.

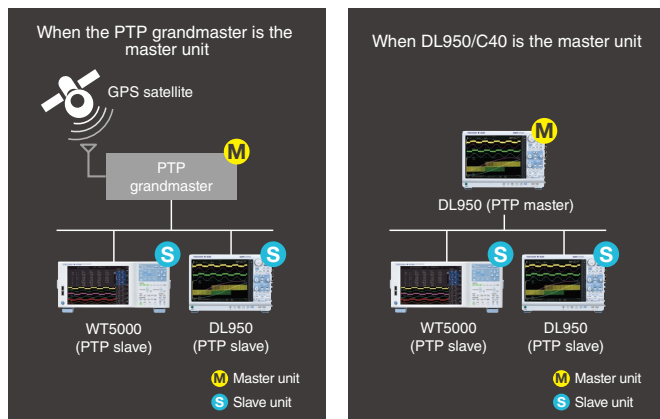


Figure 5. Image of synchronized measurement

4.6 Examples of measurement applications for DERs

Consider renewable energy sources such as hydroelectric power, PV power, and wind power connected to the power grid, helping to bring about a sustainable society. The DL950 supports this with its long-term power recording and analysis capabilities. For example, wind turbine power generation requires monitoring of generation efficiency at multiple locations with time synchronization, which can be achieved with high precision using GPS* or IRIG signals*.

In addition, the efficiency of DC/AC conversion for feeding direct-current power generated by solar panels into the grid can be measured with high precision using the WT5000 high-precision power analyzer. This data can be comprehensively verified along with the power analysis from the DL950 using the IS8000.

* Requires the /C35 IRIG, GPS interface option.

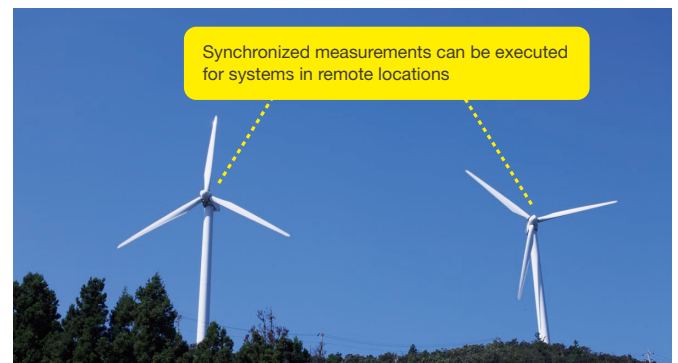
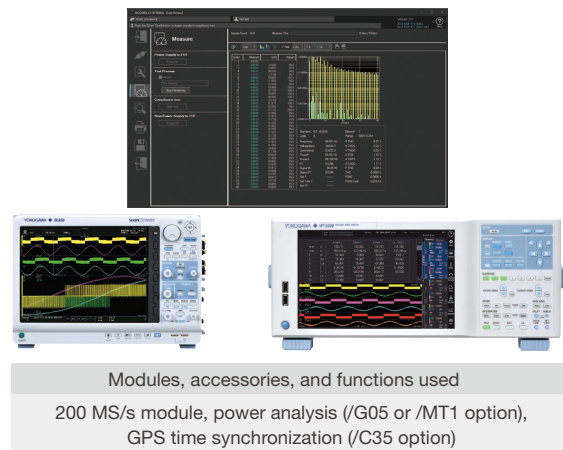


Figure 6. Example of synchronized measurement using the IS8000, DL950, and WT5000

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