

Power Quality Analyzer PQ3100

Ken Sakai

Engineering Division 1, Engineering Department 1

Abstract—The Power Quality Analyzer PQ3100 is an IEC 61000-4-30-compliant measuring instrument for analyzing issues such as power line anomalies and problems. Hioki improved the legacy model's operability in response to a high level of interest in power quality measurement to make the product as accessible as possible to end-users. This paper provides an overview of the PQ3100 while describing its architecture and response characteristics.

I. INTRODUCTION

Power quality is the general term given to a group of indicators that express the magnitude of the effect on the operation of customer equipment when a power supply's amplitude, frequency, phase, or waveform deviate from the designated range. Growing interest in power quality reflects concerns that the recent liberalization of the electricity market in Japan may lead to a decline in power quality as well as widespread adoption of distributed power systems. It is likely that the number of people who are called upon to measure power quality despite having never used a power quality analyzer will increase as a result of these developments.

The Power Quality Analyzer PQ3100 is the first instrument of its kind to incorporate functionality for helping users configure settings (in the form of Hioki's Quick Set function) and for checking instrument connections as originally featured in power meters designed to measure energy savings. This functionality makes products that are perceived as being difficult to operate easier to use while helping ensure that measurements are carried out with appropriately configured settings. In addition, Hioki accommodated user feedback by developing a new desktop application with enhanced statistics and report functionality.

II. OVERVIEW AND FEATURES

The PQ3100 delivers the following functionality, which has won praise from users of the Power Quality Analyzer PW3198:

- Simultaneous measurement of all parameters
- Easy-to-read TFT color LCD
- Compact, lightweight design
- Remote operation using an HTTP server function

In addition, Hioki has added the new functionalities described below to make the instrument even more convenient to use.



PQ3100 external appearance.

A. Event Waveform Recording for 11.2 s

Abruptly taking a high-capacity, grid-tied photovoltaic system offline introduces disturbances into the power grid that have a significant and adverse impact on power quality. To prevent this issue, the regulations governing such grid-tied systems have been updated to require photovoltaic equipment to incorporate fault ride-through (FRT) functionality.

FRT functionality allows photovoltaic systems to continue operating even if the grid experiences a period of reduced voltage lasting 1 s or less. When the FRT function operates, it is necessary to observe the voltage waveform for about 5 s after the drop in order to verify the stability of the grid, and the PQ3100's ability to record waveforms for up to 11.2 s before and after events is useful in order to meet this requirement.

B. Power Supply for Current Sensors

Users now need only wire the PQ3100 for power since the instrument can supply power to current sensors such as flexible sensors and AC/DC sensors that require drive power. In addition, automatic detection of the sensor model eliminates the potential for improperly configured settings.

C. AC/DC Measurement

Demand for DC measurement is growing due to factors such as widespread adoption of photovoltaic systems and data center operators' transition to DC power. The PQ3100 can measure AC and DC input across all of its channels.

Power Quality Analyzer PQ3100

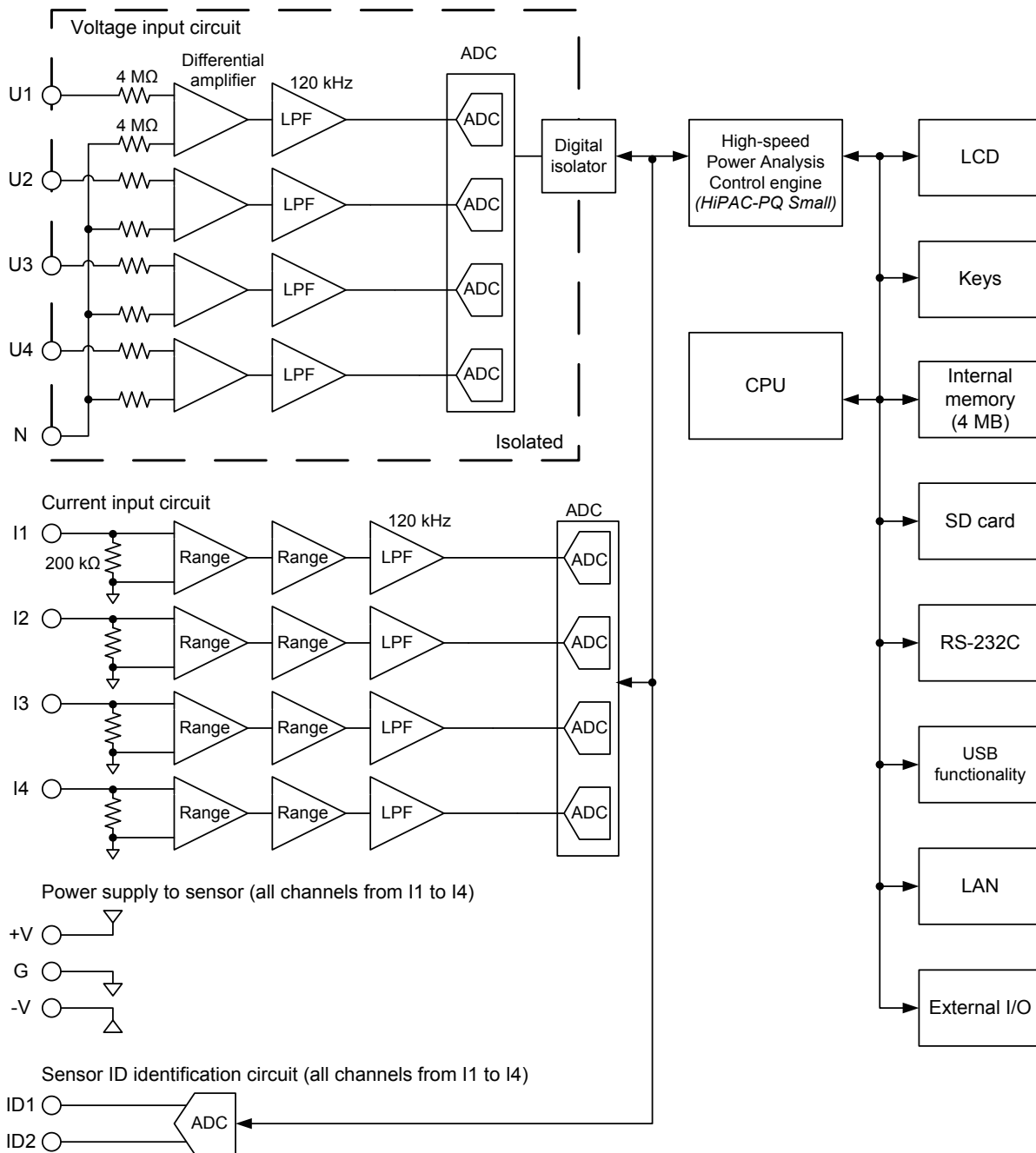


Fig. 1. PQ3100 block diagram.

D. Safe, CAT III (1000 V) Compliant Design

Power conditioners used in megasolar installations have a primary-side voltage of 1000 V. The PQ3100 can safely measure such devices since it can accommodate CAT III (1000 V) circuits.

E. Demand Measurement Function

The PQ3100 lets users monitor power quality while simultaneously checking energy-saving results.

F. Compliance with IEC 61000-4-30:2015

The third edition of IEC 61000-4-30, an international standard that sets forth power quality measurement methods and functional and performance requirements for measuring instruments, was adopted in 2015. Compliant instruments must perform calculations using data that is updated every half-cycle for current just as for voltage, and provisions concerning rapid voltage change (RVC) events have been moved from the appendix to the main text of the standard, which means compliant instruments are now required to offer that functionality. The PQ3100 is designed to accommodate these and other changes in the standard.

III. ARCHITECTURE

A. Voltage and Current Input Circuits

Fig. 1 provides a block diagram for the PQ3100. The instrument's input circuit consists of four voltage and four current channels.

The voltage input unit utilizes the same differential input design as the legacy product, and the primary side of the unit is isolated from the secondary-side circuit by means of digital isolators positioned downstream from A/D conversion.

The current input unit is isolated by means of voltage output-type current sensors. Input signals are ranged from $1\times$ to $100\times$, affording users a range selection with coverage extending from 0.05 A to 5000 A, depending on the specific combination of sensor and instrument range selected.

The A/D conversion unit simultaneously samples the instrument's four voltage channels and four current channels by means of voltage- and current-side A/D converters (ADCs), which perform 16-bit sampling at a speed of 200 kS/s.

B. High-Speed Power Analysis Engine

Fig. 2 provides a block diagram for the PQ3100's high-speed power analysis engine. The engine delivers the same processing performance as the PW3198's engine in a more compact footprint. Thanks to this design, the PQ3100 uses less power and operates longer on battery power despite delivering the computing power needed for power quality analysis at the same level of performance as the PW3198.

1) *Power calculation and zero-cross detection:* Zero-cross synchronized calculation with 200 kS/s sampling is used to calculate power. Zero-cross detection digitally processes all signals including waveform shaping. Thanks to a fixed sampling rate and zero-cross detection that utilizes all-digital processing, the PQ3100 can calculate stable measured values even during power outages, with low levels of input, and in environments characterized by large amounts of high-frequency noise, ensuring it can provide the same level of performance for power quality analysis as the PW3198.

2) *Harmonic calculations:* After converting the 200 kS/s sampling waveform to 2048 data points at 200 ms (10 cycles for a 50 Hz power system or 12 cycles for a 60 Hz power system), the PQ3100 performs harmonic analysis. Since the sampling rate decreases as a result of the sampling conversion, the instrument utilizes a digital antialiasing filter (AAF) to limit the band in advance.

3) *Transient voltage measurement:* The PQ3100 uses the same 200 kS/s sampling waveform data as is used in power calculation to measure transient voltages. After using a digital high-pass filter (HPF) to extract high-frequency components from the 200 kS/s sampling waveform, the

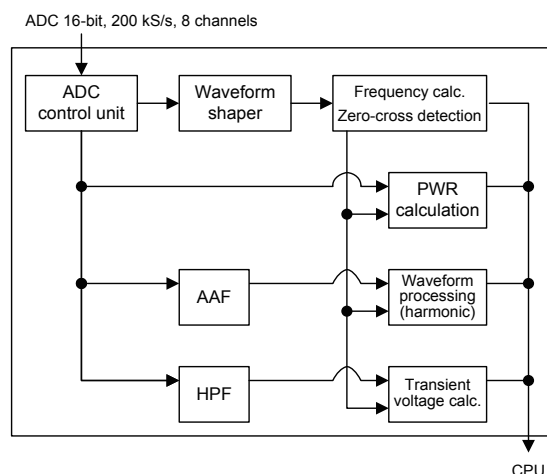


Fig. 2. High-speed power analysis engine block diagram.

instrument measures the waveform peak value. The HPF allows the instrument to detect transient voltages within the range of 5 kHz to 40 kHz. By recording the uncompressed 200 kHz waveform for 3 ms, the instrument allows users to check transient voltages at a high level of detail.

C. Firmware

The PQ3100 incorporates a number of new features designed to make it easier to use for people who have never used a power quality analyzer. It is the first instrument of its kind to incorporate Hioki's Quick Set function, a popular feature from instruments such as the Clamp On Power Logger PW3360. In addition, the instrument supports Japanese, English, simplified Chinese, traditional Chinese, Korean, German, French, Italian, Spanish, Turkish, and Polish. Even without an SD card, certain measurement data can be recorded to its 4 MB internal memory.

1) *Quick Set function:* The Quick Set function prevents configuration errors by augmenting Hioki's existing wiring check function with new functionality for automatically detecting connected current sensors. In addition, the PQ3100 adds an auto-zero adjustment function to facilitate more accurate measurement. A current sensor automatic detection function detects model information for sensors that support Hioki's PL14 connector and applies that information to the PQ3100's sensor model settings. This capability eliminates the need for users to manually input the information for each sensor while simultaneously preventing configuration errors.

The instrument's auto-zero adjustment function adjusts voltage and current offsets to facilitate high-precision measurement.

In addition, the instrument makes it easy for users to recognize wiring connections and measurement parameters by displaying settings graphically based on the selection cursor for wiring diagrams and event information displays (Fig. 3).

Power Quality Analyzer PQ3100

2) *Communications interfaces:* The PQ3100 provides three communications interfaces: LAN, RS-232C, and USB.

Supported functionality for the LAN interface includes control using communication commands, remote operation, FTP server/client, and email functionality. In addition, the instrument's HTTP server function lets users check measured values and change settings via an Internet browser.

The instrument's FTP server function lets users download files stored on the SD card or in the internal memory to a PC via a LAN connection. The FTP client function can automatically send measurement data over the network or to an FTP server running on a remotely located PC while data is being recorded.

The RS-232C interface can be used to control the instrument using communication commands or to connect the Wireless Logging Station LR8410 or the Wireless Heat Flow Logger LR8416 (available only in Japan) by means of a compatible Bluetooth® dongle (LR8410 LINK).

The USB port allows the instrument to be connected to a PC to download data from its SD card.

3) *Event data:* In response to a high level of demand for the ability to save large amounts of event data on SD cards, Hioki has made available an optional 8 GB SD memory card.

The PQ3100 can record up to 9999 event data points, a significant increase from the PW3198's 1000-point capacity. The instrument's ability to handle a large volume of event data allows it to record up to 1 s of waveform data before each event and up to 10 s of waveform data after each event.

D. Construction

The PQ3100 uses the same chassis as the PW3198 to ensure consistency of design while delivering the same rugged construction and resistance to being dropped as its predecessor.

To improve ease of use, function keys have been grouped together in a design that allows settings to be configured with fewer keystrokes. Like the PW3360, separate keys have been provided for frequently used tasks such as accessing Quick Set and configuring and checking wiring for superior ease of use.

In addition, keys used to display the MONITOR and TREND screens light up so that the user knows at a glance which screen is being displayed.

E. PQ ONE

Along with the PQ3100, Hioki developed PQ ONE, a power quality analysis software package. The application replaces the PQA HiVIEW PRO 9624-50, which is a separately purchased option for the PW3198. This section describes the principal functionality provided by PQ ONE.

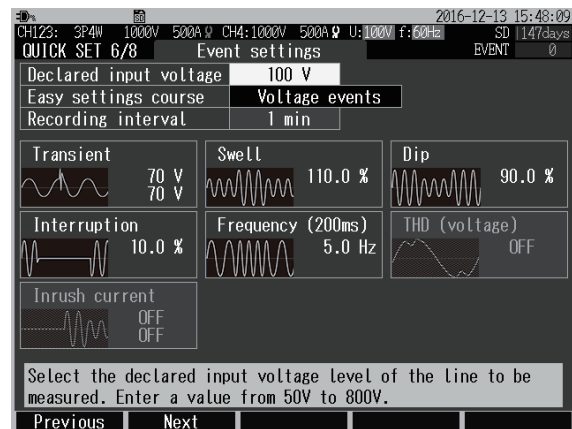


Fig. 3. Quick Set event display screen.

1) *Event statistics functionality:* Event statistics functionality tracks the times at which events occur by day or by hour and displays the resulting data in graph form. By ascertaining trends in event timing and comparing that information to equipment operating data, the causes of power supply issues can be more easily identified.

2) *Trend graph analysis and report functionality:* PQ ONE can display three phases of trend data on a single graph to facilitate efficient data analysis. In addition, since the range of times covered by the trend data can be freely adjusted, it is possible to create reports covering standard time ranges (one day, one week, one month, etc.) or custom, user-defined time ranges.

3) *Event waveform display:* PQ ONE can be used to analyze event waveforms of up to 11.2 s in duration as recorded by the PQ3100 (including 1 s before each event and 10 s after). In addition, a mouse can be used to freely enlarge the waveform, facilitating analysis of events ranging from instantaneous changes to comparatively longer-term changes on the order of seconds.

IV. RESPONSE CHARACTERISTICS

Figs. 4 through 11 illustrate the characteristics of the PQ3100 when combined with a current sensor. The characteristics illustrate reference data obtained by measuring with a sample instrument owned by Hioki and as such represent response characteristics for a single instrument.

V. CONCLUSION

Responding to growing interest worldwide in power quality, Hioki developed a power quality analyzer that provides the functionality needed to measure power quality in a way that complies with the latest standards and with needs deriving from the growing adoption of distributed power systems. The company hopes that the PQ3100 will play a useful role for people worldwide who need to measure power quality.

Yuka Shima¹, Hirotaka Kenmochi¹, Shinji Tabuchi¹,
Risa Sakai¹, Toshiki Takahashi¹

TRADEMARK

- Bluetooth® is a registered trademark of Bluetooth SIG, Inc.(USA). The trademark is used by HIOKI E.E. CORPORATION under license.

REFERENCES

- [1] H. Yoda, "Power Quality Analyzer PW3198," *Hioki Giho*, vol. 33, no. 1, pp. 33-40, 2012. (Japanese).
- [2] IEC61000-4-30 Ed.2, Electromagnetic compatibility (EMC)-Part 4-30: Testing and measurement techniques-Power quality measurement methods, 2015.
- [3] S. Miyajima, "Clamp On Power Logger PW3360," *Hioki Giho*, vol. 35, no. 1, pp. 21-28, 2014. (Japanese).

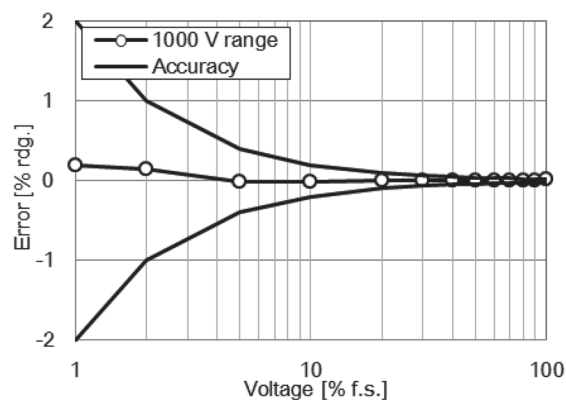


Fig. 4. Voltage linearity (50 Hz).

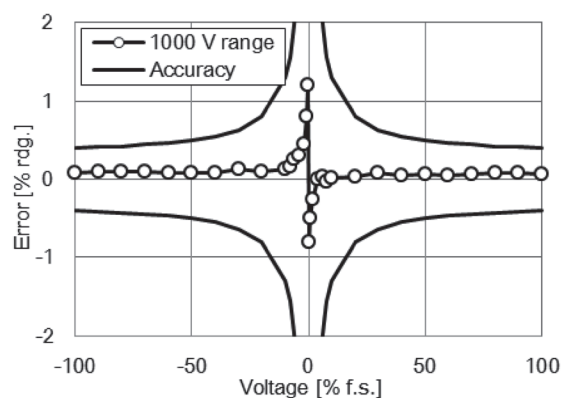


Fig. 5. Voltage linearity (DC).

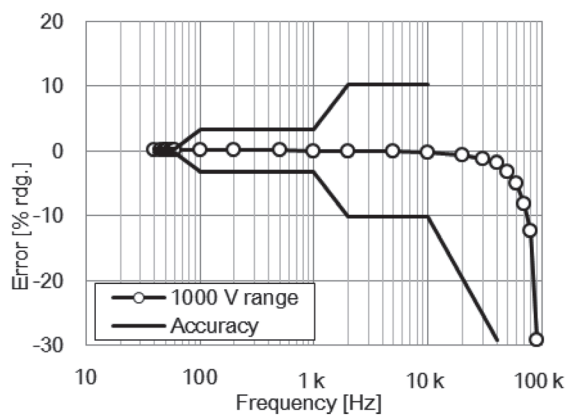


Fig. 6. Voltage frequency characteristics (750 V input).

¹ Engineering Division 1, Engineering Department 1

Power Quality Analyzer PQ3100

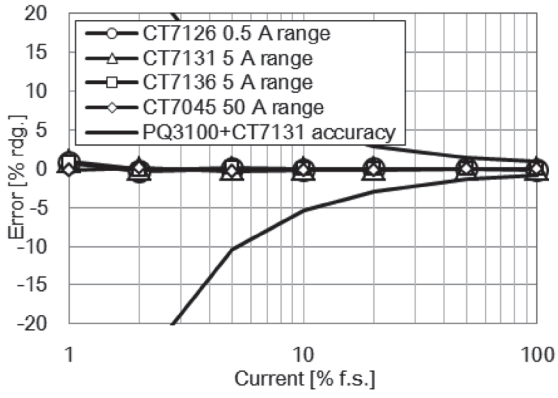


Fig. 7. Current linearity (50 Hz).

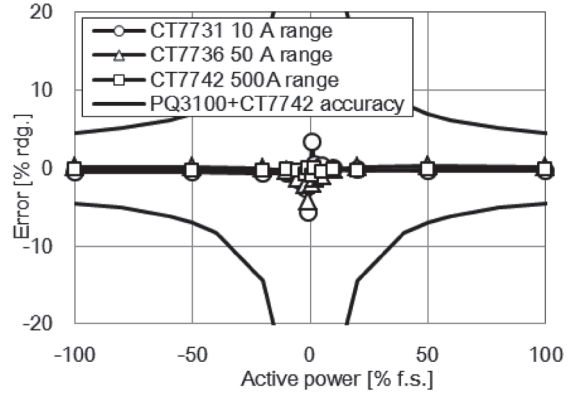


Fig. 10. Active power linearity (DC).

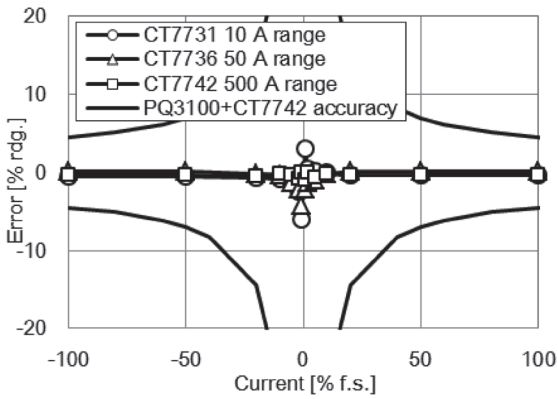


Fig. 8. Current linearity (DC).

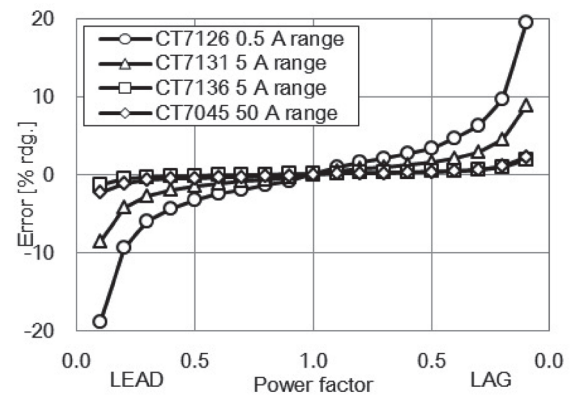


Fig. 11. Power factor effects.

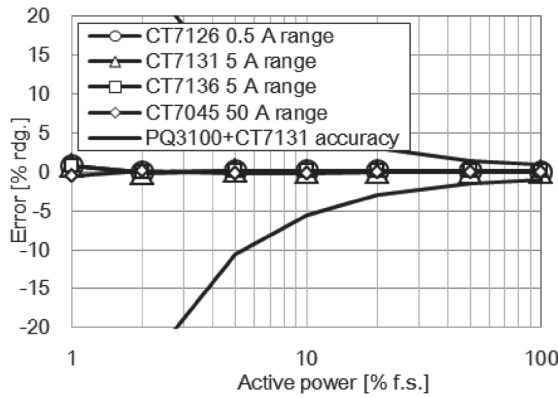


Fig. 9. Active power linearity (50 Hz).