PZ4000 POWER ANALYZER

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We have developed the power analyzer PZ4000 for power measurement and waveform observation. This new concept power analyzer features a trend display for the measurement of transient power and a span measurement function. Despite having a wide bandwidth of DC-2 MHz which facilitates the accurate measurement of switching control waveforms or fluctuating power and a fast sampling rate of 5 MS/s, it is capable of precise measurements at an accuracy of (±0.1% of reading + 0.025% of range). It can analyze wide band distorted waveforms with a maximum harmonic analysis order of 500th. This paper contains an overview of the instrument.

INTRODUCTION

Recently, there has been growing demand for energy-saving instruments in a view of global environmental issues and the necessity for the effective use of energy resources. However, to obtain better instrument efficiency and further miniaturization through increases in power conversion frequencies inside instruments, wider frequency bandwidth and greater power measurement accuracy is required. In addition, more efficient use of power energy requires more complicated power control by power converters and accurate measurement of power at each conversion stage. The PZ4000 power analyzer is based on a new set of concepts that targets power consumption measurement or analysis at the design phases of instruments. Figure 1 shows an external view of the PZ4000.

BASIC CONFIGURATION

Figure 2 shows PZ4000's basic configuration. It consists of the input, memory, CPU/DSP, and display sections.

Input Section

The input section consists of the voltage input block and current input block that are separated and electrically insulated from each other. Input voltage and current signals are normalized by an operational amplifier (OP AMP) and passed to an A/D converter and a zero crossing detector. The A/D converter samples the voltage and current signals at a fixed clock frequency (sampling rate that is normally 5 MS/s),which are supplied by the logic circuit, and converts them to digital data. On the other hand, the zero crossing detector converts the signals to zero crossing signals by converting them to high/low level signals judged by the central value of input amplitude. The outputs from the A/D converter and the zero crossing detector are then transferred to the memory section through a photo isolator (ISO). Figure 3 shows frequency characteristics of the input section.

Figure 1 PZ4000 Power Analyzer

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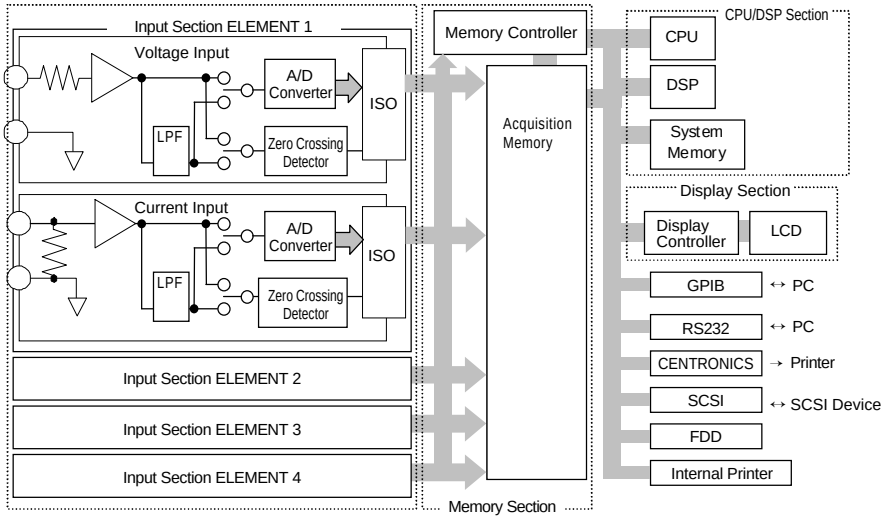

Figure 2 Block Diagram of PZ4000

Memory Section

The A/D-converted data for up to eight channels and zero crossing data that were transferred to the memory section are stored in acquisition memory with the states of external triggers and external clock. The standard acquisition memory is 100 K words and can be extended to a maximum of 4 M words optionally.

The sampling rate is automatically determined depending on the size of the acquisition memory and observation time. When the observation time is too long, the memory controller does not sample all the data and lowers the constant sampling rate. The memory controller can set triggers at levels of the A/D-converted digital data, at zero crossing points, and at external trigger points. When a trigger condition is satisfied, it stores data collected during the observation time in the acquisition memory and finishes acquiring data.

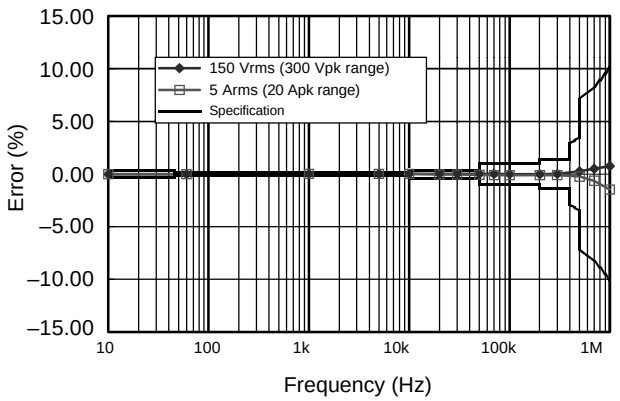

Figure 3 Frequency Characteristics of Voltage and Current

CPU/DSP Section

The CPU/DSP section reads data of a preset span from the acquisition memory to compute measurement values such as active power values, true RMS values and rectified mean values calibrated to the RMS values of the voltage and current, by calculating the average amount of data in a span. Then it computes apparent power, reactive power, power factors, phase angles, impedance, resistance, and reactance. The average amount of data in a span can be calculated in the following three ways.

(1) Averaging by means of zero crossing data or external clock (see Figure 4)
The active power and true RMS values of voltage and current can be calculated by averaging sampled data for one or several sycles. The acquisition memory stores zero crossing data of the voltage and current and the external clock signal. The accurate active power and the true RMS value of the voltage and current can be determined by calculating the average of the first to the last rising edge of the zero crossing data during the observation time. Which rising edge averaging to synchronize to is selectable for each element from zero crossing data of the voltage or current and the external clock signal.

(2) Averaging by means of external trigger input in memory
With this method, only a high or low zone of the external trigger inputs from sampled data in memory is averaged.

(3) Averaging over a period specified by cursor on waveform display
With this method, sampled data specified by start and stop points of the cursor on the waveform display is averaged.

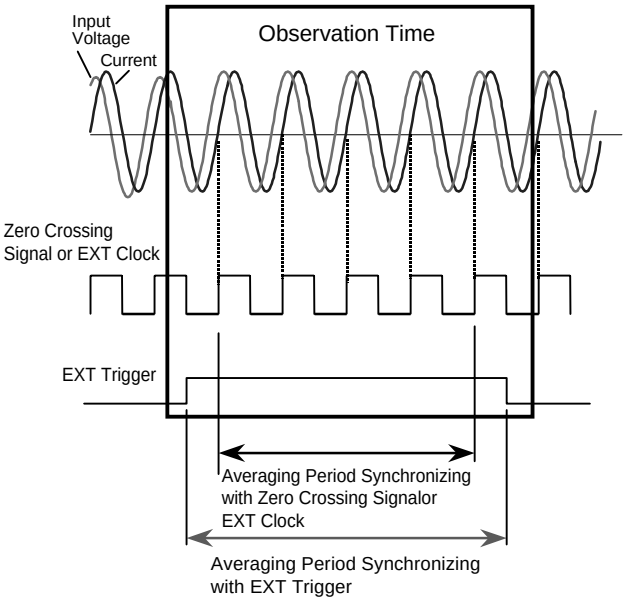

Figure 4 Measuring Principal

FEATURES

The PZ4000 offers the following advantages:

(1) Basic Performance
PZ4000's basic accuracy, measured at 50/60 Hz, is ((0.1% of reading + 0.025% of range) and it has an unprecedented measurement bandwidth of DC-2 MHz. Furthermore, its sampling rate is 5 MS/s, which is far greater than any conventional digital-sampling type power meter.

(2) Maximum of 4 Element Modules
PZ4000's input section has a module structure that allows users to incorporate up to four element modules into it. This enables the evaluation of three-phase I/Os with only one instrument. The input module has the following ranges:
Voltage input: 30 Vpeak to 2000 Vpeak
(max. input: 1000 Vrms)
Current input: 100 mA peak to 10 A peak
(max. input: 5 Arms),
1 A peak to 100 Apeak (max. input: 50 Arms)
External current sensor input: 100 mVpeak to 1 Vpeak

(3) Waveform Analysis
The PZ4000 can show instantaneous waveforms of the voltage and current on a color LCD by storing all sampled data in memory using the data acquisition method. The adoption of the waveform magnifying function of digital oscilloscopes allows it to display instantaneous power waveforms, active power per cycle, trends of true RMS values of the voltage and current using waveform calculations. In addition, it can measure power, voltage, and current in any period of waveforms. These functions assist the capture of sudden changes in power to allow for analysis of power fluctuation and transient power.

(4) Trigger Function
The PZ4000 has triggers to synchronize the start of measurement with input signals, which makes measurement or waveform observation synchronized with inputs possible. Edge and window detection triggers are available depending on input levels. To prevent triggers being operated normally when observing noisy waveforms or PWM (Pulse Width Modulation) inverter waveforms, signals can be triggered by their rising or falling edges after they are processed by a filter that is only available for the trigger function.

(5) Word Access Memory
The PZ4000 has standard 100-K word internal memory that can be extended to a maximum of 4 M words for fast sampling and measurement over a long period. The waveform observation time can be set to specific values between 10 µs to 1000 s, such as 10 µs, 20 µs, 40 µs, 100 µs, 200 µs, 400 µs, 1 ms, 2 ms, 4 ms, and so on, to select optimum time depending on the measured object. The sampling rate is automatically determined depending on the size of the acquisition memory and observation time. The PZ4000 allows long-time measurement even for high-speed sampling. When the sampling rate is set to the maximum 5 MS/s, measurement can last 20 ms for 100-K word memory and 400 ms for extended 4-M word memory.

(6) Harmonic Analysis
The PZ4000 allows for harmonic analysis up to 500th order, which has made analysis of the effects of converter switching or noise possible.

(7) Graphical Displays
Simultaneous display, bar graphs during harmonic analysis, vector diagrams during harmonic analysis for three-phase power, and other graphical display functions contribute to an increase in the efficiency of analysis.

(8) External I/O
The PZ4000 supports external I/O signals including external triggers, an external clock to allow for synchronized measurement with two instruments or more and sampling based on the external clock. It can also synchronize power measurement time with external inputs, in other words, synchronize span measurement with a control signal of a measured object.

(9) Support for a Variety of Interfaces
The standard PZ4000 incorporates GP-IB and RS-232 interfaces, as well as Centronics to facilitate the output of screen images to an external printer. PZ4000 settings, waveform data, measured values, and screen image files can be stored on a floppy disk through its built-in floppy drive. Stored waveform data can be loaded on the PZ4000 for later analysis and if a large amount of data needs to be stored, the optional SCSI interface is available for external storage on hard disks, MOs etc.

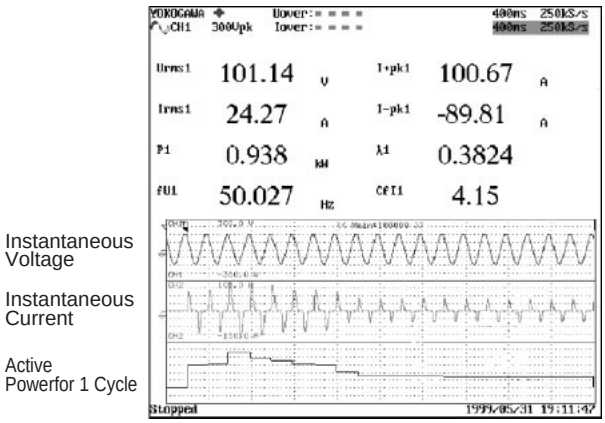

Figure 5 Trend Display Function of Transient Power

FUNCTIONS

Based on new concepts, the PZ4000 was developed with the following functions:

Transient Power Measurement

Figure 5 shows a measurement example of a home appliance with variable power consumption. In this example, a trigger is used to capture a point where current values increase, to measure decreasing current values. Numerals in the upper half of the screen give measured values. They include true RMS values of the voltage and current, active power, voltage frequencies, peak current values, power factors, and current crest factors (ratio of true RMS values to peak values) over 19 power cycles that start with the first rising edge and end with the last rising edge of the measured voltage. Waveforms in the lower half of the screen show instantaneous voltages and currents, and a trend display of active power for one power cycle. These allow users to obtain a visual interpretation of changes in waveforms of input voltages and currents, as well as active power, and thus are useful for the measurement of maximum power consumption or transient power.

Power Measurement For A Period

Power measurement is possible for any span defined by start and stop cursors in the waveform screen. This allows users to capture phenomena as waveforms and analyze in detail the power consumption of photocopiers or other devices with large fluctuations in power values, for each operation state.

In addition, because the PZ4000 can receive a control signal of the measured object as an external input, measurement is possible over a period when the control signal is on, or when measurement is synchronized with on/off cycles of the control signal.

Harmonic Analysis

In response to growing concern about suppressing harmonic power, recent releases of digital power meters facilitate harmonic analysis. With conventional models, we restricted measurement objects to commercial frequency bandwidth and to a maximum analysis order of a 500th. However, digital power meters have been increasingly used for evaluation of the effects of inverter switching and quality of outputs from power converters, but have been unable to offer frequencies or analysis orders for these situations.

We therefore enhanced harmonic analysis for the PZ4000 to offer a maximum analysis order of a 500th for the wide range of basic frequencies, 20 Hz to 6.4 KHz. This product can analyze voltage, current, active power, apparent power, and reactive power for every analysis order. At the same time, it can measure power loss when actual load is applied to electronic components because of the capability of computing impedance per order, resistance per order, and reactance per order. Since values obtained from analysis with up to 500th orders are massive, the PZ4000 not only lists measured values, but also shows the results as bar graphs to allow for a visual interpretation of the components of each order.

Moreover, the PZ4000 can store in memory data obtained from measurements over a long period (about 20-60s for 4-M word memory, depending on input cycles) and apply harmonic analysis to any point on displayed waveforms, by taking advantage of word access memory and waveform display.

CONCLUSION

The PZ4000 incorporates many useful functions including waveform display and waveform analysis that enhance the basic performance of wide measurement bandwidth and current input range, and facilitate high-speed sampling. We believe that this product can be used for many applications including the measurement of the outputs of inverter motor drives, inverter lighting and equipment with fluctuating power. ◆

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