WT3000 PRECISION POWER ANALYZER

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We have developed the WT3000 Precision Power Analyzer, which features the world's highest measurement accuracy of ±0.02% of reading and a measurement bandwidth of 0.1 Hz to 1 MHz as well as DC signals. The WT3000 can be equipped with four input elements, as against three with its predecessor, the WT2000. Also, it is possible to measure the efficiency of a DC-input three-phase inverter with one WT3000 unit, thereby enabling highly accurate measurement of the efficiency of inverters installed on electric vehicles and so on. Its predecessor used a conventional LED, but the WT3000 uses a large-sized LCD enabling the WT3000 to display measured values in various forms, including waveform, for greater operability. This paper outlines these key features.

INTRODUCTION

In recent years, the demand for energy-efficient machinery and equipment designed to address global environmental problems and to effectively utilize energy resources has been increasing. In Japan, the Law Concerning Rational Use of Energy was revised in response to the Conference of Parties III (COP3) conference on global warming, which was hosted by Kyoto in December 1997. The Japanese Government ratified the Kyoto Protocol in June 2002. Internationally, the Energy Star Program was launched in 1995. The energy efficiency standard of this program applies to home appliances and OA equipment. Now that hybrid automobiles, inverter-driven refrigerators and air conditioners are widespread, greater accuracy is needed in power measurement.

The recently developed WT3000 meets the demands of the high-accuracy power measurement market by offering the world's highest accuracy for power measurement. Figure 1 shows an external view of the WT3000.

FEATURES

(1) High-accuracy and Broad Bandwidth
The basic accuracy, or the accuracy of measurements at commercial frequencies of 50/60 Hz, is ± (0.02% of reading and + 0.04% of range). The frequency bandwidth covers 0.1 Hz to 1 MHz as well as DC signals.

Figure 1 External View of the WT3000

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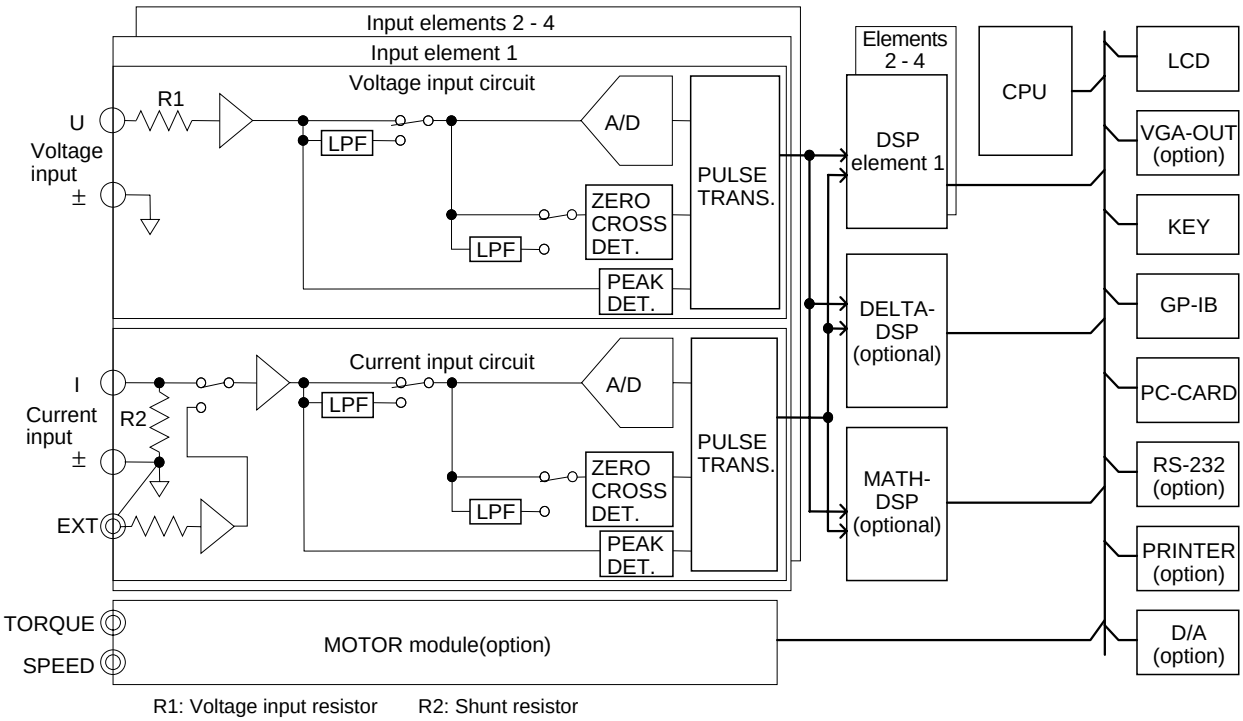

Figure 2 Block Diagram of the WT3000

The basic accuracy and the measurement bandwidth of the WT3000 are much greater than those of its predecessor, the WT2000[(2)].

With these improved features, the WT3000 serves various applications for high-accuracy power measurement.

(2) Maximum of Four Input Elements

Since the WT3000 can be equipped with a maximum of four input elements, one WT3000 unit can measure the inputs and outputs of a three-phase inverter. With two units, multi-channel power measurement can be performed on a synchronized basis.

(3) Common-mode Voltage: 1000 V

The WT3000's predecessor employed a photocoupler to insulate the input circuit, and its rated common-mode voltage was 600 V. The WT3000 employs a newly developed pulse transformer for input circuit insulation. By maintaining a sufficient insulation distance, a common-mode voltage of 1000 V was achieved. This enables measurement of ever-increasing inverter drive voltage.

(4) High-speed Data Updating

The maximum data updating period of the WT3000 is 50 ms, which is five times the speed of its predecessor.

This feature is useful in evaluating the characteristics of the motor (torque, rotation speed, and the like). It is also effective in measuring phenomena that tend to change in a relatively short period of time such as ramp current and the secondary voltage of lighting that changes at high frequencies.

(5) Motor Evaluation (optional)

The analog or pulse output of the torque and the rotation speed can be input directly from the torque meter to the WT3000. Torque and rotation speed readings as well as motor output, synchronous speed, sliding, motor input/output efficiency, and inverter input/motor output efficiency are calculated to measure the total efficiency of the inverter and the motor. Just one WT3000 unit can perform comprehensive measurements such as these.

BASIC CONFIGURATION AND OPERATION MECHANISM

Figure 2 shows the basic configuration of the WT3000. The main components are the DSP, the CPU, and input elements 1 to 4, which are composed of the voltage and current input circuits. Other components include the LCD for display, the KEY for operation, and the GP-IB for communication.

The voltage input circuit is of the resistance-voltage-division type, and the current input circuit of the shunt-resistor type. Inputs into each type are normalized and in turn entered into the A/D converter by the operational amplifier. The conversion rate is approximately 5 μs.

The input resistance of the voltage input circuit is 10MΩ, which is five times larger than that of the WT3000's predecessor. Due to this improvement, instrument loss is reduced, and the effects of self-heating caused by high-voltage input are minimized. To increase the measurement bandwidth while maintaining the input resistance at 10MΩ, input resistor shield cases are used so that capacitors are formed between their terminals.

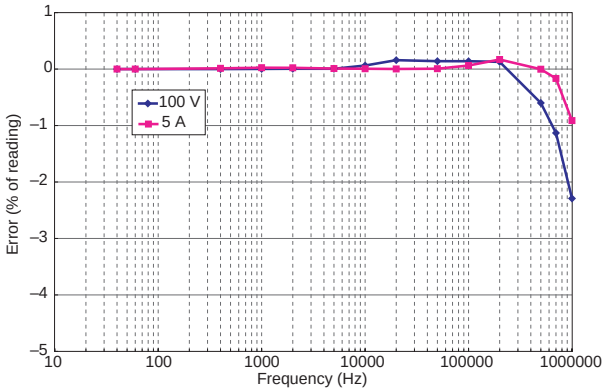

Figure 3 Voltage and Current Error Curves of the WT3000 with Respect to Frequency

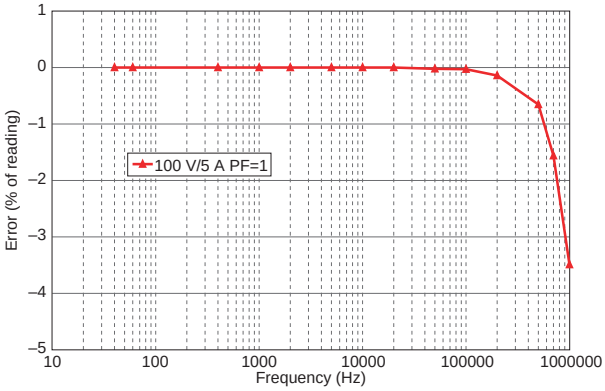

Figure 4 Power Error Curve of the WT3000 with Respect to Frequency

The shunt resistor of the current input circuit employs a coaxial structure to increase the measurement bandwidth. The shunt resistance of such a structure tends to fluctuate greatly with changes in applied power. Our development efforts aimed at minimizing changes in shunt resistance.

Outputs of the A/D converter are insulated by the pulse transformers and input into the DSP, which calculates measurements of voltage rms, current rms, effective power, etc. Real-time performance of this calculation contributes to the reduction of dead time in power measurement. The DELTA-DSP performs the calculation for Δ–Y conversion at the time of three-phase connection. The MATH-DSP executes computation for harmonic wave analysis.

The values measured by the DSP are processed by the CPU for display, communication, D/A output, and the like.

Figure 3 presents voltage and current error curves of the WT3000 with respect to frequency. Figure 4 shows a power error curve of the WT3000 with respect to frequency.

FUNCTIONS

The characteristic functions of the WT3000 are as follows:

(1) Simultaneous Measurement of Normal and Harmonic Waves

To measure harmonic waves using the WT3000's predecessor, the WT2000, it was necessary to change to a dedicated harmonic wave measurement mode. For users who wish to acquire measurement data related to harmonic waves such as THD (distortion factor) in addition to voltage, current, and power, changing measurement modes not only lowers throughput but also, causes a loss of the synchronicity of measured data.

The WT3000 employs a 200-kHz sampling clock which is normally used for measurement. For data acquisition, the number of pulses generated by the sampling clock is reduced, so that the generated signals are nearly equal to the PLL clock signals of the input sources. The FFT calculation is executed using the dedicated DSP concurrently with data acquisition.

To comply with international standard IEC61000-3-2, the point of the FFT is 9000. The 9000-point FFT calculation function does not have a proper library, so we developed a calculation function on our own for faster processing which has enabled harmonic voltage and current waves to be measured for a maximum of four elements within the available time.

(2) Combined Use of Digital Filtering Method and Total-averaging Method

The WT3000's predecessor adopted a digital filtering method in which multiple exponential averaging is executed for sampled instantaneous values. The accuracy of this method is greater than that of the total-averaging method, in which instantaneous values in the measured section are summed for averaging. However, the accuracy of digital filter processing is low for data updating periods below 250 ms when the frequency of data input is mainly in the commercial frequency range.

The 50-ms and 100-ms data updating periods are difficult to achieve with the digital filtering method. Therefore, the WT3000 also adopts the total-averaging method for these periods to meet the needs of users who require high-speed responses, even if the accuracy must be compromised to a certain extent.

To enable measurement at frequencies above 0.1 Hz, the maximum data updating period is set at 20 s. Therefore, the data updating periods of the WT3000 are 50 ms, 100 ms, 250 ms, 1 s, 2 s, 5 s, 10 s, and 20 s.

(3) Various Forms of Display

The WT3000 employs a large-sized LCD for the display part. A maximum of 104 data can be displayed at one time. The number of parameters to be displayed can be chosen from “4 parameters,” “8 parameters,” “16 parameters,” and “ALL.” The number of parameters and data to be displayed can be arbitrarily combined by the user.

Also, the WT3000 can display a waveform of an input signal (Figure 5) and the trends of measured data in time series (Figure 6). It can also display a list, bar graph, and vector of harmonic waves. In addition, the WT3000 can display a waveform during integration, which has not been possible in the past.

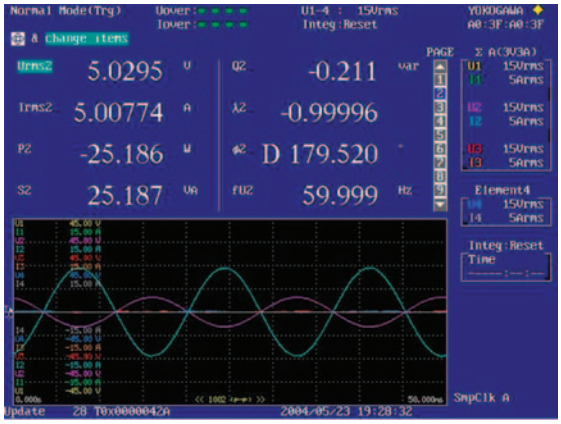

Figure 5 Waveform Display

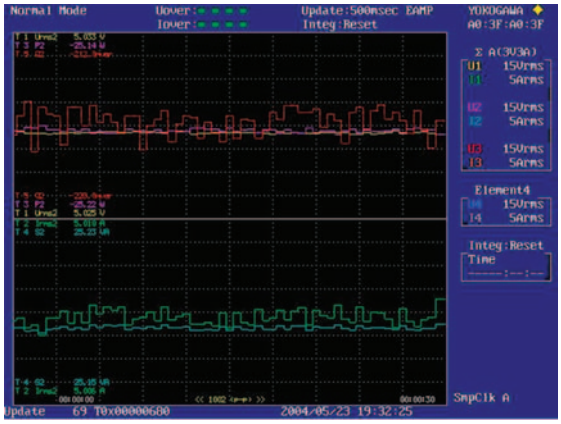

Figure 6 Display of Measured Data Trends

(4) Excellent Communication Interfaces

The WT3000 is equipped with a GP-IB interface. RS232C, Ethernet, and USB interfaces are optional. For the Ethernet interface, in addition to a control function using the IEEE488.2 command, the FTP server/client function is also provided.

Measured data stored in a PC card of the WT3000 can be transferred to a PC using the interface function. USB communication enables measured data storage, keyboard connection for file name typing, and outputting to the printer.

DEDICATED PC SOFTWARE APPLICATIONS

We offer the following dedicated PC software applications:

- WTViewer software
  It is possible to read measured numerical values and waveform data into the PC via communications, display numerical data and waveforms, and convert them into a specified data format and store them.
- Harmonic wave measurement software
  Pass/fail judgment can be made for harmonic waves according to the classifications A, B, C, D, of international standard IEC61000-3-2.
- Flicker software
  Voltage change and flicker can be measured according to international standard EN61000-3-3 (Ed1: 1995).
- LabVIEW driver
  This driver is a library that can be used with the National Instruments Corporation's LabVIEW.

CONCLUSION

The mechanism, functions, and features of the WT3000 Precision Power Analyzer are discussed above. We expect that this instrument will be utilized in power measurement for numerous purposes, ranging from high-accuracy measurement for inverters and motors to the evaluation of transformers for which high-accuracy measurement is required and standard power measurement calibration systems. ◆

REFERENCES

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(2) Shioda Toshiaki, et al., “Models WT2010/2030 Digital Power Meters”, Yokogawa Technical Report, No. 24, 1997, pp. 10-14

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