

WT210/WT230 DIGITAL POWER METERS

NAKANISHI Hirofumi*1 NISHIGAKI Naoya*1 TACHIBANA Katsuya*1 SHINAGAWA Takano*1

We have developed the WT210/WT230 high accuracy and wide-bandwidth power meters, which can measure DC and AC signals from 0.5 Hz to 100 kHz with a fundamental accuracy of 0.2%. The WT210/WT230 models succeed the former WT200/WT130 models, with the WT210 being a single-phase model and the WT230 being a three-phase model. In addition to having the functions of the former power meters, the WT210/WT230 have improved basic functions and implemented higher accuracy and wider frequency and input ranges.

This paper outlines the WT210/WT230 power meters.

INTRODUCTION

From the viewpoint of global environmental problems and the efficient use of energy resources, there has been a growing demand recently for saving on energy consumed by equipment.

In Japan, with the December 1997 Kyoto Conference on the Prevention of Global Warming (also known as COP3) as a turning point, the Japanese government has revised the Law concerning the Rational Use of Energy. In June 2002, the Kyoto Protocol was ratified. Internationally, there are the energy-saving standards of the US's Energy Star Program (1995) and consumer electric appliances and office automation equipment are under the regulations of these standards. In order to achieve these energy-saving standards, it is necessary to improve efficiency and reduce stand-by power consumption of equipment. This necessity has led to the market demand for precisely measuring equipment's efficiency and extremely low stand-by power levels.

Under these circumstances, the WT210 (single-phase)/WT230 (three-phase) digital power meters that we have developed recently feature dramatically improved basic performance, such as accuracy, and bandwidth and input range, as compared with their predecessors. These power meters are intended for accurately measuring the high power levels and marginally low stand-by power levels of such equipment as

inverters. Figure 1 shows the external views of these power meters.

FEATURES

The main features of the WT210/WT230 are as follows:

(1) High Accuracy and Broad Bandwidth

The WT210/WT230 feature a basic accuracy (accuracy of power measurement at the 50/60 Hz commercial frequencies) of $\pm (0.1\% \text{ of reading} + 0.1\% \text{ of range})$ and a bandwidth of 0.5 Hz to 100 kHz, including DC signals. These features mark significant improvements from the basic accuracy and bandwidth ratings of $\pm (0.2\% \text{ of reading} + 0.1\% \text{ of range})$ and



Figure 1 External Views of WT210/WT230

*1 T&M Business Div.

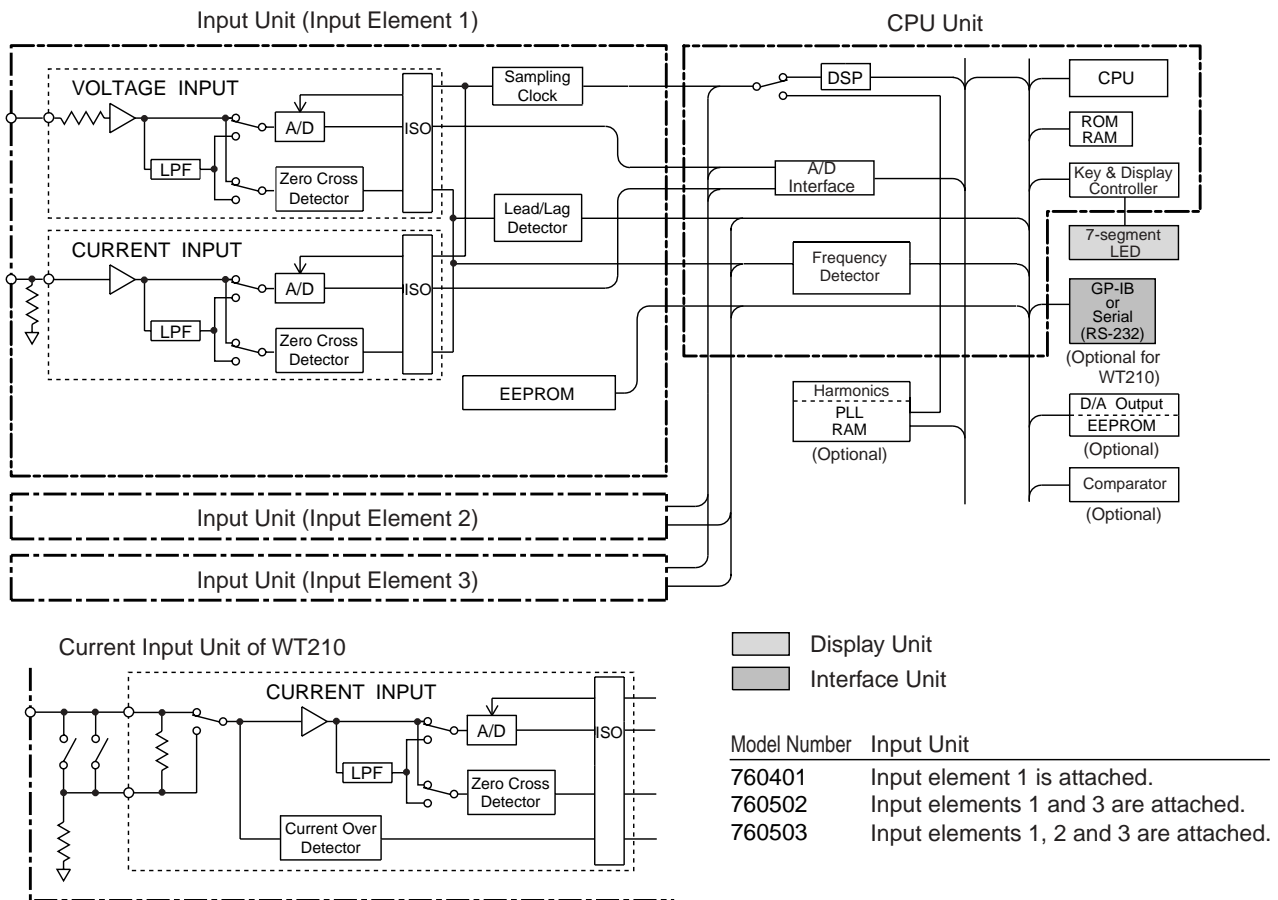


Figure 2 Block Diagram of WT210/WT230

from DC signals of +10 Hz to 20 kHz of the WT100 series predecessors. Thus, it is now possible to evaluate for example, elevator motors driven at low frequencies or high-frequency inverters.

(2) Wide Choice of Measurement Ranges

The measurement ranges cover 15 to 600 V on the voltage input side and 0.5 to 20 A on the current input side. The WT210 is further equipped with low-current ranges to cover 5 to 200 mA. This means that the user can precisely measure both marginal currents turned on in the stand-by mode and large currents turned on during operation, with just one meter. The meter is thus capable of responding to a wide variety of power measurement needs.

(3) Wide Input Ranges

The accuracy-guaranteed ranges of voltage and current inputs are as wide as from 1% to 130%, which is a substantial improvement from the previous 10% to 130% range of the WT100 series.

Now assume that we select the 5 mA range of the WT210, for example. Since this range is accuracy-guaranteed for 50 μ A input and has a read-out resolution of 0.1 μ A, it is extremely useful for measuring, for example, equipment's marginal stand-by power levels.

Moreover, the accuracy-guaranteed input range is so wide that the WT210/WT230 can measure equipment with large load variations even during an integration interval in which the range is fixed.

(4) Deadtime-free Measurement of Integrated Wattage

The WT210/WT230 employ the method of continuously integrating instantaneous wattage (i.e., the product of instantaneous voltage and current values sampled at approximately 51 kHz). Unlike the WT100 series' method of integrating active power that is determined for each display update interval, this method is deadtime-free. Therefore, the WT210/WT230 can measure integrated wattage with high fidelity against transient wattage variations.

(5) Waveform Output Function

Obtaining dynamic voltage and current waveforms when measuring equipment's wattage is effective for knowing the condition of the equipment. The WT210/WT230 have a waveform output function whereby the meters can output the waveform data of voltage/current signals being input through the communication port. By creating graphs according to this data, it is possible to visually check the magnitudes, phases and periods of the voltage and current signals that are being input.

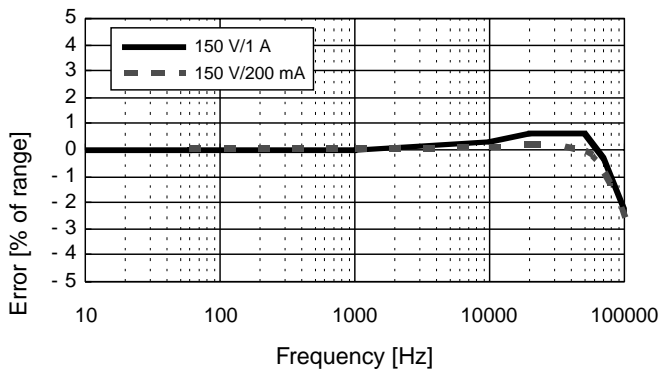


Figure 3 Frequency Responses to Input Power

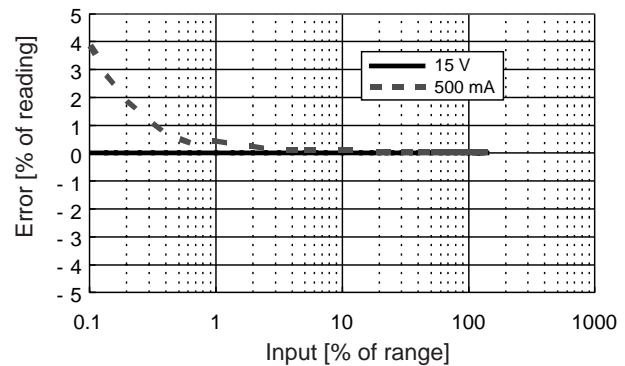


Figure 4 Linearity Error

(6) Compact, Lightweight and Economical

Like the WT100 series, the WT210/WT230 are compact, being half the rack-mount size. The meters are lightweight, weighing only 3 kg (WT210) and 5 kg (WT230), thus being easily transportable. Moreover, thanks to thorough cost reductions, the WT210/WT230 remain priced as low as the former models, in spite of improvements in their basic performance and functionality.

(7) Value-added Application Software Package

An application software package has been developed and is being offered as a tool for increasing measurement efficiency. This package includes 1) a waveform display function that graphs waveform data, 2) a multi-parameter display function that concurrently shows the waveforms of those parameters which cannot be shown with the main unit alone, and 3) a harmonic analysis function that presents a bar graph view of harmonic analysis results.

BASIC HARDWARE CONFIGURATION AND THE PRINCIPLES OF OPERATION

Basic Hardware Configuration

Figure 2 shows the circuit diagrams of the WT210/WT230.

The WT210/WT230 are basically comprised of an input unit, a CPU unit, a display unit, and an interface unit. The input unit consists of the voltage and current input units, which are electrically isolated from the housing. The voltage input unit is based on resistance voltage division, while the current input unit is based on current division with resistors.

Principles of Operation

(1) Flow of Signal Processing

The waveforms of voltage and current applied to the input unit are normalized as voltage signals and converted to digital signals with the A/D converters. These signals are then supplied through the photoisolators to the CPU unit.

In the CPU unit, the DSP performs averaging calculations on waveform data in real time, in order to determine the values of voltage, current and active power. The DSP also calculates the values of other parameters, such as apparent power,

reactive power and phase angle. The values thus measured are then sent to the display unit, interface unit, and other destinations for output.

(2) Averaging Method

The WT210/WT230 use the total-averaging method to average waveform data.

They detect the period of the duration of waveforms with the zero-cross detector to determine the interval over which sampled waveform data should be averaged. This determination is carried out in real time immediately after the start of measurement and continues thereafter. This strategy prolongs the interval applied to the averaging calculation associated with the display update interval, i.e., extends the interval over which the waveform data is averaged. Thus, the WT210/WT230 achieves both high accuracy and fast display updating.

(3) High Accuracy, Broad Bandwidth and Wide Input Ranges

As discussed in the FEATURES section, the WT210/WT230 significantly outperforms the WT100 series. We have achieved the broad bandwidth by optimizing constants associated with each unit of the circuitry and by reengineering components, for example, speeding-up the analog switches, without changing the basic configuration of the input unit. Figure 3 shows the frequency responses of the WT210/WT230. We have also improved the measurement resolution by using 16-bit A/D converters and ensuring 32-bit accuracy in averaging calculations.

Another point to note is that a design review has been made regarding the patterns of the printed circuit boards. By reducing noise from the isolated power supply and thereby improving the S/N ratios of the head amplifier units, we have succeeded in broadening the measurement bandwidth, while simultaneously achieving high accuracy and widened input ranges. Figure 4 is a graph of linearity errors.

FUNCTIONS

This section describes the functions characteristic of the WT210/WT230 digital power meters.

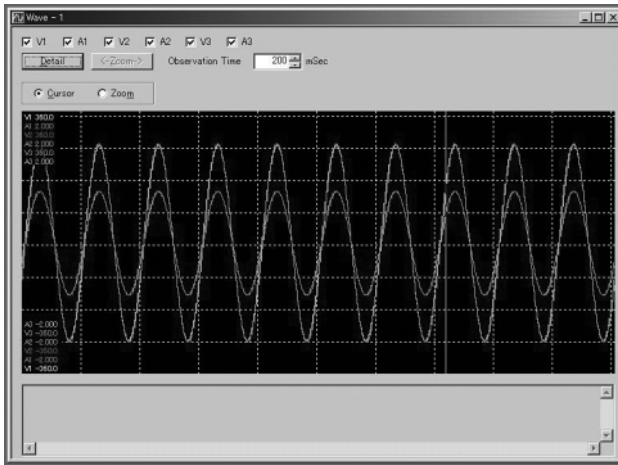


Figure 5 Example of Waveform Display

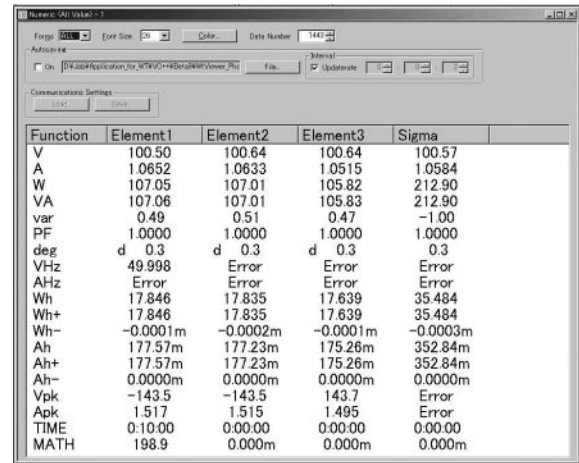


Figure 6 Example of Numeric Data Display

User-selectable Display Update Intervals

Unlike the WT100 series with the fixed, 0.25 sec. display update interval, the WT210/WT230 allow the user to select from the 0.1, 0.25, 0.5, 1, 2 and 5 sec. display update interval options. Data being measured is updated once per selected display update interval. The user can shorten the interval to lock onto the waveform of comparatively quick load variations seen in high-frequency equipment, including inverters. Conversely, the user can also lengthen the interval to characterize cycloconverters or motors in their start-up sequence. In this characterization, the user can acquire sampled data equivalent to several periods of a signal, even in the case of signals with relatively low frequencies.

Waveform Data Output

With the WT210/WT230, it is possible to output not only various numeric data available by calculation but also the waveform data of an input signal using communication means, which was not possible with the WT100 series. The waveform data is P-P compressed (i.e., data points as represented by pairs of the maximum and minimum values are determined) for each specific interval in the time-axis direction, according to sampled data that has been acquired during the display update interval. Thus, as many data points (1,002 points for normal measurement and 1,024 points for harmonics measurement) as necessary to show waveforms on the application software screen are collected in a time-series manner.

Accordingly, by plotting pairs of outputted waveform data points on the time axis, it is possible for the user to visually check the input waveform. Figure 5 shows an example of waveform display.

For the duration of waveform observation (in milliseconds), the user can freely change the time axis setpoint within the limits of the current display update interval.

Higher-speed Communication Output

Unlike the WT100 series whose various numeric data output

via communication means is limited to ASCII format only, the WT210/WT230 support binary format as well. The ASCII format requires a maximum of 12 byte for each data item, while the binary format permits outputting numeric data in the 4-byte, IEEE single-precision floating-point format. This means that the WT210/WT230 can output larger amounts of numeric data using fewer transferred bytes. Figure 6 shows an example of numeric data display.

Moreover, the user can add information for conversion to ASCII, such as the data status, the decimal point's position, and an auxiliary unit of measure (m, k or M), to individual data items. Thus, even if the data in question is binary-format numeric data, the user can reproduce the data as ASCII-character data.

CONCLUSION

In this article, we have discussed the operating principles, functions and features of the WT210/WT230 digital power meters.

The WT210/WT230 feature superior basic performance, wide input ranges, and a variety of functions.

This means that the user can measure both high power consumed by such equipment as inverters and extremely low stand-by power consumed by consumer electric appliances or office automation equipment, with just one meter. Accordingly, we expect these power meters will be used in a wide range of power measurement applications. ◆

REFERENCES

- (1) Kazumi Masahiro, et al, "WT110/WT130 Digital Power Meters," Yokogawa Technical Report, No. 22, 1996, pp. 19-22
- (2) Iwase Hisashi, et al, "WT1600 Digital Power Meter," Yokogawa Technical Report, Vol. 46, No. 1, 2002, pp. 27-30, (in Japanese)