WT110/WT130 DIGITAL POWER METER

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We have developed sampling power meters which can measure DC and AC signals from 10Hz to 50Hz. The WT110 is a single-phase model and the WT130 is a 3-phase model. They are the successors to our earlier models, the 2534/2535, which were put on the market in 1992. To satisfy market demand, the surge resistance and noise immunity have been improved, and the meters have various functions. This paper provides an overview of the meters.

INTRODUCTION

Among its various power meters, this company's Model 2885 Standard Watt Converter and Model 2533 Digital Power Meter are employed around the world, and they are used in a wide range of applications from standard equipment to general-purpose uses. Model 2532, the first model to use a digital sampling system, first appeared on the market in 1991. The following year, the general-purpose Model 2534 and 2535 Digital Power Meters, which used the total-averaging method based on digital sampling, were introduced. Although these models met the market need for a low price and were highly praised, especially in the electric appliance market, the need arose in the market for new products with a greater noise immunity, surge resistance, and efficiency. As the successors to these instruments, the presently developed WT110 and WT130 are superior in every way: on the performance side, with a greater measurement range; on the function side, with harmonic wave analysis; and on the operational side, with improved insulation between voltage and current.

Furthermore, since these are successors to earlier models, the design specifications were based on minute analyses of those models, and new functions and performance features were incorporated, while low prices were maintained. In addition, the development time from planning to sales was just one short year, even though the complex parts were designed for interchangeability and reuse.

The WT110 is a single-phase model and the WT130 is a 3-phase model. Figure 1 is an external view of the models. (The following is a description of the WT100 series.)

FEATURES

The main functions and features of the WT100 series are as follows.

(1) Large LED display

We focused on the display functions for this development, and took clear visibility and ease of use into consideration. Since visibility is one of the key elements during wiring and panel installation, an LED display as large as one in the enhanced

Figure 1 External View of the WT100 Series

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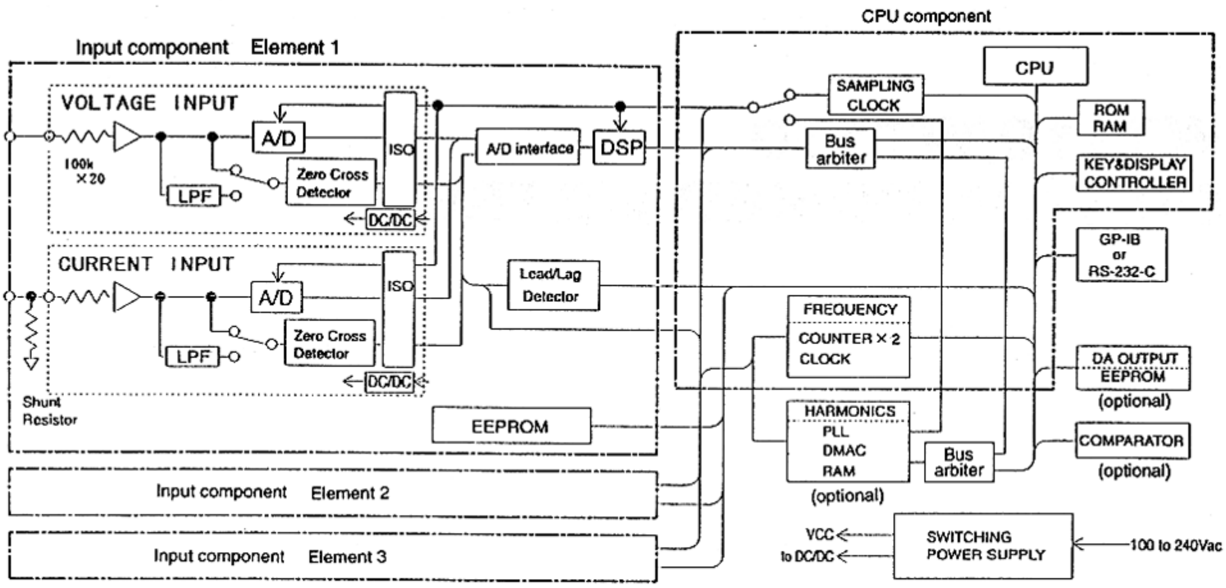

Figure 2 WT130 Block Diagram

models was adopted. The operation keys were designed to function in the same manner as other models, and consideration was given to their layout and operation.

(2) Compact and lightweight

The existing 3-phase power meters are regular-size meters, but the WT100 series was developed at half the size for portability. As a result, the total weight of a single meter was kept below 5 kg, so the unit is easy to carry, and two of the meters can be installed together on a rack mount.

(3) Greater surge resistance

Reconsideration was given to the construction of the existing shunt resistor, and a board shape that had a superior surge resistance was adopted, while the allowable error was increased and the trimming process was eliminated. As a result, a significantly improved surge resistance (300 Arms/20 ms) was realized, and costs were cut in half.

(4) Input component

This component serves as insulation between modules and it separates the voltage from the current within the same module. It has a 2-layer insulation construction based on the IEC1010 standard.

(5) Harmonic wave analysis function (optional)

Recently, with the implementation of power harmonic wave regulations, market demand regarding harmonic waves has increased. These units are suitable for the measurement of regular harmonic waves and were designed to take measurements easily and at low cost.

(6) Comparator output (optional)

A 4-channel relay contact output was provided for GO/NO-GO determination in production and inspection lines. Single-mode and dual-mode outputs are available, and by combining them, 5 types of determinations can be made. This option is also equipped with a DA output.

(7) Display value adjustment by user

ISO-based measurement control is important to users of meters. Conventional power meters cannot be easily adjusted or calibrated by users, but with the WT100 series, display value adjustments can be made manually or via telecommunications. This allows users to reduce maintenance costs.

BASIC CONSTRUCTION

The basic construction of the WT130 is shown in Figure 2. The WT130 is made up of an input component, CPU, display component, I/F component, and power supply.

1. Input Component

The input component consists of voltage and current circuits, an A/D converter, and a DSP and DC/DC converter power supply. Both the voltage and current circuits are insulated. The A/D converter is a 12-bit/100 kHz general-purpose converter. The DSP, like that in the existing models, is a 16-bit fixed-point arithmetic general-purpose component. The construction is double-insulated, with the assumption that it is CE certified, and it has parts that can withstand insulation values greater than 3700 V.

The voltage input component has a 2 MΩ input resistance consisting of 20 100 kΩ chip resistors. In the earlier models, a high withstanding voltage and high-accuracy resistance were used because the input component's resistance divided a high voltage of 600 V. But in the newest models, the voltage applied to 1 unit was reduced by lining up the chip resistors, so regular chip resistors could be used. This allowed the cost of the component to fall to 1/10th that of the one in the existing models. And for safety during a separate breakdown, which is required by

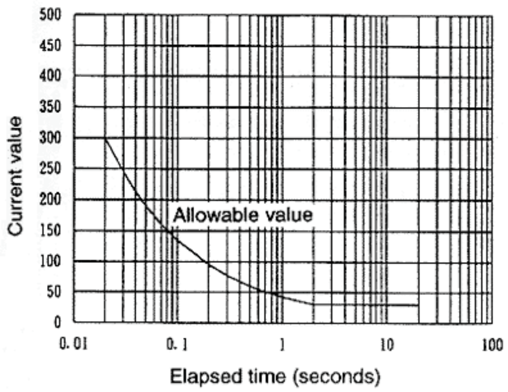

Figure 3 Current Surge Resistance Properties

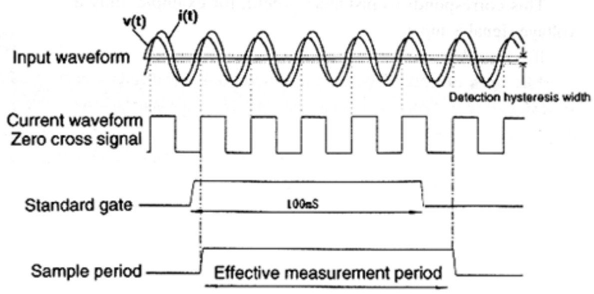

Figure 4 Measuring Principle

safety regulations in all countries, variation of the input resistance stops at 5%, even if one of the chip resistors short-circuits, and fuses or other safety devices are not required.

The current input component consists of a 5 mΩ shunt resistor and an amplifier. The previous wide-band precision shunt resistor for current detection had a low surge resistance and was susceptible to burnout and other problems. In order to solve these problems, the resistor was given a board shape, the trimming to adjust the resistance value was eliminated, and the shape was redesigned to improve further the frequency properties. Figure 3 shows the current surge resistance properties of the shunt resistor.

2. Effective Power Measuring Principle

The measuring principle is described in the following.

Instantaneous data obtained by sampling are added over a set interval. This total is divided by the number of samples taken and measurement data are obtained, standardized with the total-averaging method. This set interval is determined by synchronizing the input signal cycle. And the standardization process is done in real time with a 16-bit DSP within a display update cycle of 250ms.

The DSP is used to compute the effective power and the voltage and current root-mean-square (rms) values, according to the following equations.

$$\text{Effective power} = \frac{1}{N}\sum_{K=1}^{N} v(k)\cdot i(k) \quad \cdots\cdots (1)$$

$$\text{Voltage rms} = \sqrt{\frac{1}{N}\sum_{K=1}^{N} v(k)^2} \quad \cdots\cdots (2)$$

$$\text{Current rms} = \sqrt{\frac{1}{N}\sum_{K=1}^{N} i(k)^2} \quad \cdots\cdots (3)$$

where

v(k) = the voltage instantaneous value due to k number of samples
i (k) = the current instantaneous value due to k number of samples
n = an integer
N = the number of samples synchronized with the input cycle

The effective measurement period is generated by the hardware, and the number of samples N is then determined. The effective measurement period obtained by synchronizing the input signal is described in the following.

Figure 4 shows the principle by which the effective measurement period is determined. The current's input waveform is converted to a square-wave zero-cross signal by a zero-cross detector. The period in which the reference gate is synchronized with the start of this zero-cross signal is the effective measurement period synchronized with the current signal. A similar zero-cross detector is equipped on the voltage side, and the measurement period synchronized with the voltage signal is obtained by the same principle as that of the current signal.

With the DSP, the sampling period is modified according to the equipment in which measurement is taking place, the input conditions, or other conditions, and the following 3 measurement values are obtained at all times.

(a) value after synchronizing the current signal;
(b) value after synchronizing the voltage signal;
(c) value in a fixed cycle (200 ms)

Any of these measurement values can be selected as the real measured value, depending on the following conditions.

If (a) is selected:

* If the effective measurement periods obtained after synchronizing the voltage and current signals are both within the display update cycle

* If the effective measurement period obtained after synchronizing the voltage signal is longer than the display update cycle

In the case of normal current measurement, this refers to the determination made after synchronizing the current signal.

If (b) is selected:

* If only the effective measurement period obtained after synchronizing the voltage signal is within the display update cycle

This corresponds to instances where, for example, only a voltage signal is input.

If (c) is selected:

* If both effective measurement periods obtained after synchronizing the voltage and current signals are longer than the display update cycle

This corresponds to instances where the input signal cycle is lower than the measurement frequency range or where the respective input signal levels are lower than the standard level.

Final determination of which computation results are to be used as the real computation results is made after computation of the 3 measurement periods has been completed, not after the measurement period has been determined as described above. This allows data to be sampled within the optimum measurement period, regardless of the input waveform, and prevents a lengthening of the input response time.

3. Other Measurement Items

Based on the DSP computation results, the CPU is used to compute apparent power, reactive power, the power factor, phase angle, and integrating value. The integrating value consists of a power integrating value and a current integrating value, either of which can give positive-negative polarity differentiation results. The integrating value is the time-converted value of the DSP computation results of the effective power value and current value, added according to the different symbols. The addition of the effective measurement period of the measurement results may give different results than those obtained with meters with different working principles.

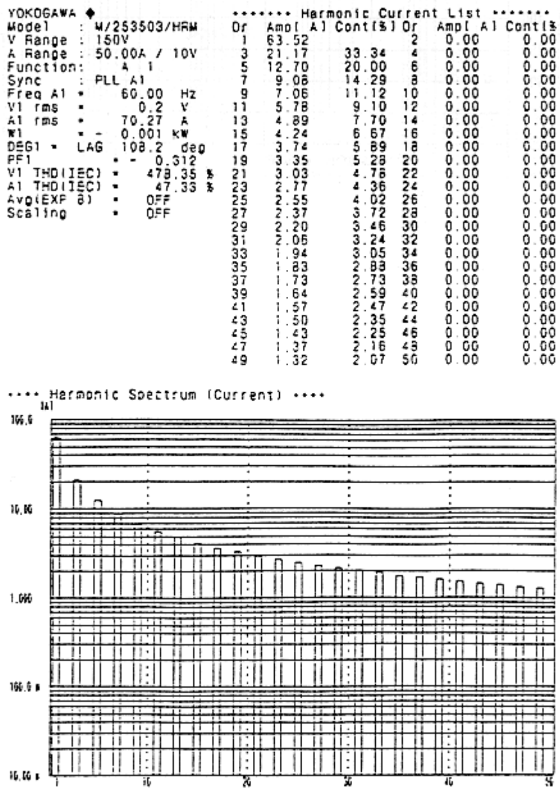

Figure 5 Example of the Block Output of Harmonic Wave Analysis Results

FUNCTION

1. Harmonic Wave Analysis and External Output

Guidelines for measures against harmonic waves established by the Ministry of Trade and Industry indicate that concerns regarding measurement of the harmonic wave current are mounting, even in Japan.

This meter is equipped with an optional harmonic wave analysis function that can be added inexpensively. The hardware needed to add this function consists of a PLL synchronous circuit, DMA controller, and 32 k bytes of RAM.

The instantaneous data of a 1-cycle portion of the basic frequency obtained at the sampling clock, where the basic input signal is multiplied 512 times by the PLL synchronous circuit, are stored in RAM by the DMA controller, via the DSP. Then, up to the 50th FFT analysis is performed with the main CPU. The content factor, distortion factor, phase angle for each degree of basic wave, and other data needed for harmonic wave control measures are obtained.

The analysis results can be output as communication output to a plotter or printer. An example of a plotter output is shown in Figure 5.

2. Comparator Function

The 4 relay contact outputs allow setting of individual measurement functions and determination values, and if a measured value exceeds a determination value, the contacts can be changed. By combining these outputs with 2 channels, the high-low limit, high-high limit, and low-low limit can be set, which is advantageous for GO/NO-GO determinations in production and inspection lines.

CONCLUSION

The WT100 series' measuring principle, functions, and features were described above. These meters are used principally for the measurement of power consumed by household appliances, such as air conditioners, automated office equipment, and other appliances, and they can be applied partially to the measurement of the output of invertor equipment. These meters are equipped with a rich array of functions: a comparator function, which is needed at production sites, and harmonic wave analysis, to which a lot of attention has been given. They can, therefore, be expected to be applied to a wide variety of services.

Our line of power meters was made even more complete by the introduction of the WT100 series. Future power meters should be thought of as new products developed from the WT series. ◆