Test Equipment Solutions Datasheet

Test Equipment Solutions Ltd specialise in the second user sale, rental and distribution of quality test & measurement (T&M) equipment. We stock all major equipment types such as spectrum analyzers, signal generators, oscilloscopes, power meters, logic analysers etc from all the major suppliers such as Agilent, Tektronix, Anritsu and Rohde & Schwarz.

We are focused at the professional end of the marketplace, primarily working with customers for whom high performance, quality and service are key, whilst realising the cost savings that second user equipment offers. As such, we fully test & refurbish equipment in our in-house, traceable Lab. Items are supplied with manuals, accessories and typically a full no-quibble 1 year warranty. Our staff have extensive backgrounds in T&M, totalling over 150 years of combined experience, which enables us to deliver industry-leading service and support. We endeavour to be customer focused in every way right down to the detail, such as offering free delivery on sales, presenting flexible technical + commercial solutions and supplying a loan unit during warranty repair, if available.

As well as the headline benefit of cost saving, second user offers shorter lead times, higher reliability and multivendor solutions. Rental, of course, is ideal for shorter term needs and offers fast delivery, flexibility, try-before-you-buy, zero capital expenditure, lower risk and off balance sheet accounting. Both second user and rental improve the key business measure of Return On Capital Employed.

We are based at Aldermaston in the UK from where we supply test equipment worldwide. Our facility incorporates Sales, Support, Admin, Logistics and our own in-house Lab.

All products supplied by Test Equipment Solutions include:

- No-quibble parts & labour warranty (we provide transport for UK mainland addresses).
- Free loan equipment during warranty repair, if available.
- Full electrical, mechanical and safety refurbishment in our 40GHz in-house Lab.
- Certificate of Conformance (calibration available on request).
- Manuals and accessories required for normal operation.
- Free insured delivery to your UK mainland address (sales).
- Support from our team of seasoned Test & Measurement engineers.
- ISO9001 quality assurance.

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MODELS WT2010/2030 DIGITAL POWER METERS

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We have developed digital power meters equipped with the voltage fluctuation measurement/flicker meter functions based on IEC1000-3-3. WT2010 is a single-phase model and WT2030 a three-phase model. They succeed to their predecessor models 2531 and 2531A. The flicker meter function is designed in near total compliance with IEC868, enabling evaluation of virtually all kinds of flickers occurring due to voltage fluctuations.

INTRODUCTION

Recently, effects of flickers upon the human body due to load variations in electrical equipment have become an issue. European countries are especially active in regulating such effects. More specifically, for any product to be exported to an European Union (EU) country, it is mandatory to have a CE-certification mark indicating the product complies with the EU directives on electro-magnetic compatibility (EMC) and general safety. These directives cover regulations of power-supply harmonics and power-supply voltage fluctuations. These two regulations are scheduled to come into force on June 1, 1998. The conventional 2531/2531A (as well as the WT1000 series) digital power meters had only the evaluation function complying with the power-supply harmonics regulation. We have therefore added the evaluation function complying with the power-supply fluctuations regulation in order to meet market needs. With the addition of the latest precision, high-grade WT2010/2030 digital power meters, which support standards-based measurement, to the existing popular general-purpose lowcost WT110/130 and also general-purpose but medium-grade WT1000 series power meters, all the planned series of digital power meters have become complete. This lineup has enabled us to meet virtually all needs of the power meter market.

This paper focuses on the regulation of power-supply voltage fluctuations and the evaluation function complying with the regulation. Figure 1 is the external view of a model in the WT2000 series.

FEATURES

(1) High Accuracy

The WT2010/2030 (hereinafter referred to as the WT2000 series) are based on the conventional highest-grade 2531 power meter, though they have improved fundamental accuracy (from 0.1% to 0.08% for power measurement) and bandwidth (from 300 kHz to 500 kHz for voltage/current measurement). In addition, the maximum number of analyzable orders of harmonics has been made variable from 1 to 50 and the harmonics window for analysis has been made selectable. A major improvement has also been made to the

Figure 1 External View of a Model in Series of WT2000 Digital Power Meters

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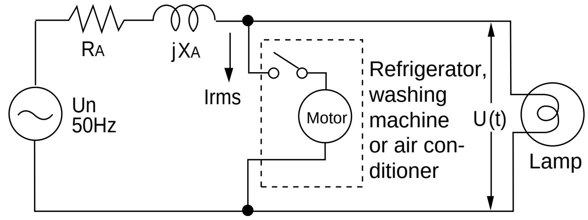

Figure 2 Mechanism of Flickering

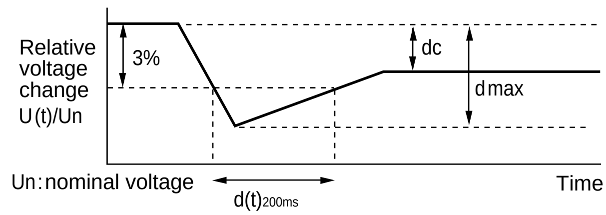

Figure 3 Relative Voltage Changes

Table 1 Parameters under Regulation and Their Limits

Parameter under Regulation	Limits by Standards
Relative steady-state voltage change (dc)	3% maximum
Maximum relative voltage change(dmax)	4% maximum
Duration for the relative voltage change to exceed 3% ($d(t)_{200ms}$)	200 ms maximum
Short-term flicker indicator (Pst)	1.0 maximum
Long-term flicker indicator (Plt)	0.65 maximum

transmission rate, enabling output of 36 data items at a maximum speed of 250 ms.

Fundamental accuracy:
0.04% of reading + 0.04% of range (50/60 Hz, power measurement)
0.03% of reading + 0.03% of range (50/60 Hz, voltage/current measurement)
Bandwidth: DC, 2 Hz to 500 kHz
Error in power factor: 0.1% of range (50/60 Hz, power factor = 0)
Measuring ranges:
Voltage: 10, 15, 30, 60, 100, 150, 300 or 600 V
Current: Direct input: 1, 2, 5, 10, 20 or 30 A; external shunt input: 50, 100 or 200 mV
Functions: Current- and power-based integration (with capability of polarity-based integration)
Harmonics analysis function complying with IEC1000-3-2 (optional); voltage fluctuations/flicker measurement function complying with IEC1000-3-3 (optional); built-in printer; manual/automatic printing (optional); 14-channel D/A output (optional)

(2) Voltage Fluctuations/Flicker Measurement Function
Measured parameters: Voltage fluctuations = dc, dmax and $d(t)_{200\ ms}$
Flicker = Pst and Plt
Scaling for flicker: Logarithmic separation of 0.01-6,400 P.U. range into 1,024 divisions
Accuracy: Half-period rms value = ±(0.1% of reading + 0.1% of range)
Pst, Plt = ±5% (when Pst = 1)
Judgment function: Judges the pass/fail for all measured data items by comparison with the given limits
Printout: Interval-by-interval measured data, judgment result, CPF (cumulative probability function) graph and comprehensive judgment result

REGULATION OF POWER-SUPPLY VOLTAGE FLUCTUATIONS

The tolerance limits of voltage fluctuations and flickers are duly prescribed in the IEC1000-3-3 international standard. Flickers are defined as the degree of uncomfortableness due to fluctuations in the brightness (flickering of light) felt by the human. One of the reasons for flickering is that as shown in Figure 2, a large current flows when, for example, a motor starts, the voltage drops due to the impedance along the distribution line, and then a lighting device in a room darkens. The IEC1000-3-3 standard sets limits on the five parameters summarized in Table 1. The following paragraphs explain these parameters in detail.

- Relative steady-state voltage change (dc) and maximum relative voltage change (dmax)

  The rms values of a voltage waveform are determined on a half-period basis, where the characteristics of voltage changes between two steady states are defined by function ΔU(t). The difference between the maximum and minimum of function ΔU(t) is called the maximum voltage change—ΔUmax. The difference in voltage between the two steady states is called the steady-state voltage change—ΔUc. Given the nominal voltage Un, the parameters concerning relative voltage changes are represented as (Figure 3):

  Relative voltage change characteristic(d(t)): ΔU(t)/Un
  Maximum relative voltage change (dmax): ΔUmax/Un
  Relative steady-state voltage change: ΔUc/Un

- Short-term flicker indicator (Pst)

  Pst, the short-term flicker indicator is determined statistically. Pst = 1 means the degree of voltage fluctuation at which a lamp flickers, causing 50% of people to feel uncomfortable. Pst is defined for 10-minute observation and measured using an instrument based on the design specifications of flicker meters indicated in IEC868 (direct method of flicker measurement). This method has become a standard in evaluating flickers for every kind of voltage fluctuation.

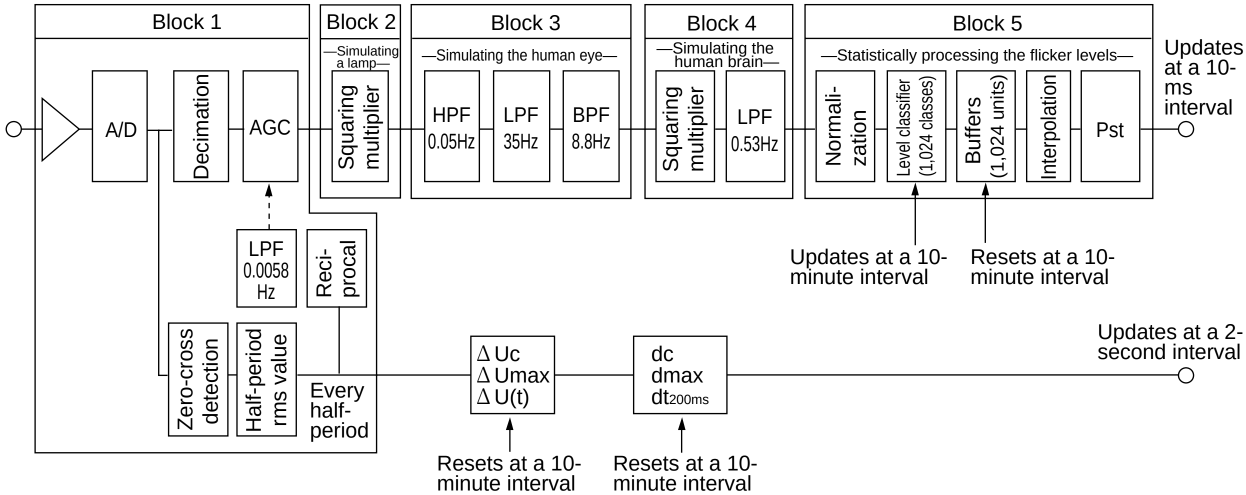

Figure 4 Block Diagram of Flicker Meter Section

CONFIGURATION AND FUNCTIONALITY OF FLICKER METER SECTION OF WT2000 SERIES

Signal processing in the flicker meter section of the WT2000 series of power meters is implemented software-wise using digital signal processors (DSP's). The WT2000 series can simultaneously calculate the flicker indicator and half-period rms value. Thus, the power meter can measure the flicker indicator, relative steady-state voltage change, maximum relative voltage change, and so on, all at one time. Since each separate DSP is allocated to each input element, it is possible to measure three input elements at one time for three-phase, four-wire equipment. This method is materialized using the configuration illustrated in Figure 4.

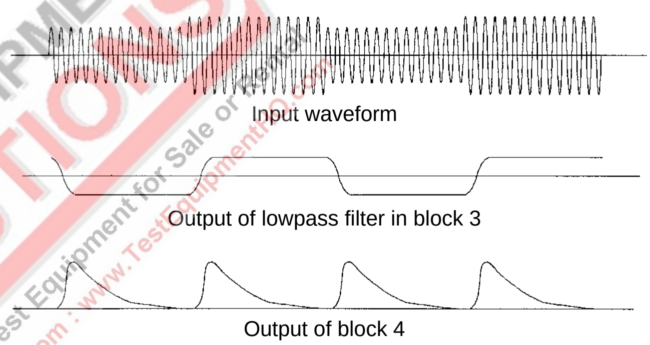

Figure 5 Output Waveforms

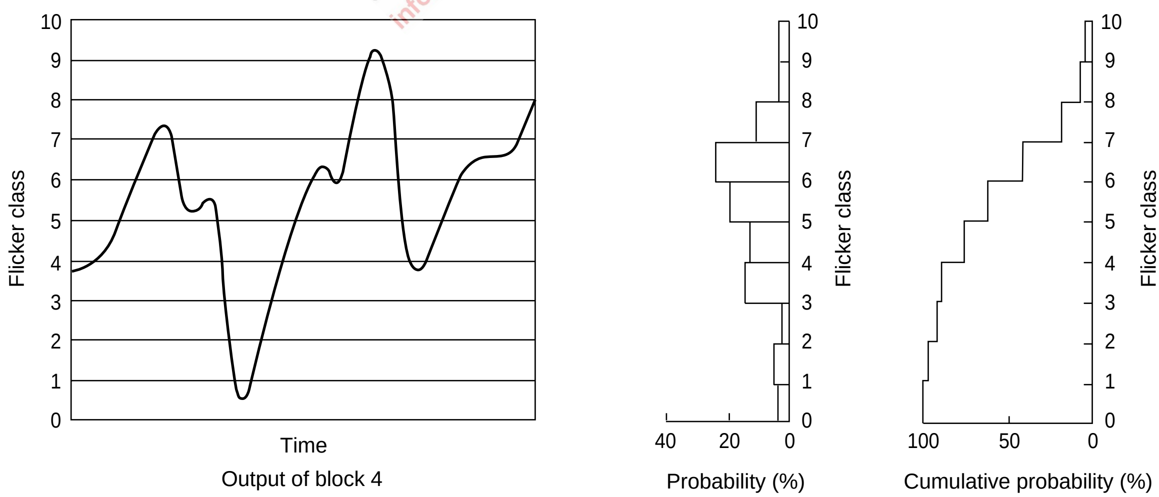

Figure 6 Determination of Cumulative Probability Function (Example When the Range of Classes is Limited to 10)

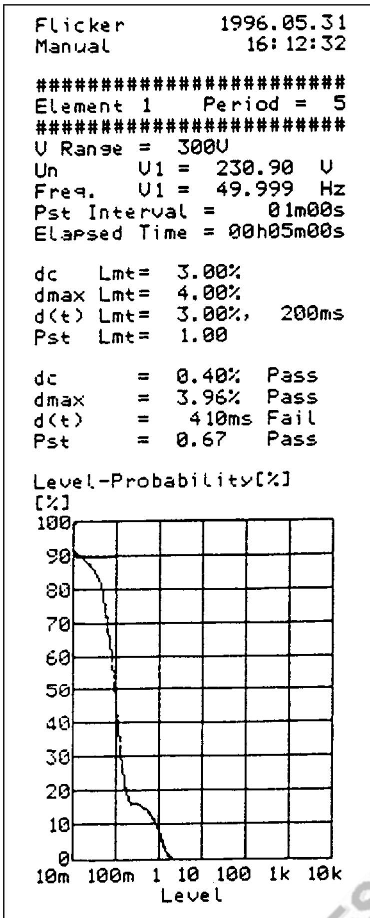

Figure 7 Printout

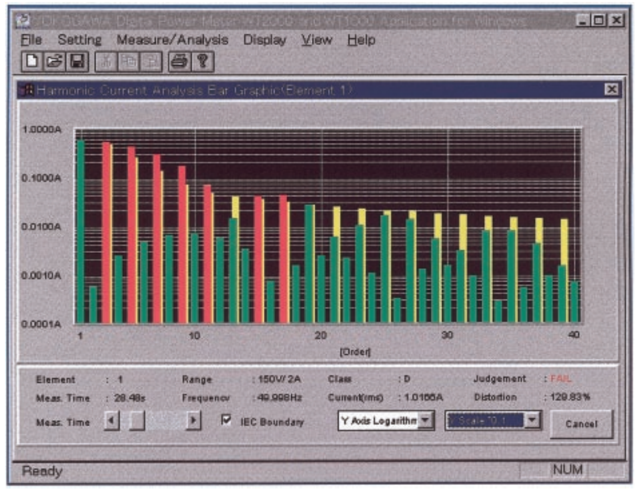

Figure 8 Bar-Graph View of Measurement Results

The following paragraphs explain the configuration and functionality of the flicker meter section.

1. Calculation of Short-Term Flicker Indicator Pst

The flicker meter section calculates the short-term flicker indicator Pst by processing signals through its five circuit blocks.

Block 1 comprises a voltage adapter that keeps the input voltage amplitude constant. For a step input of rms values, the automatic gain control (AGC) used with the voltage adapter has a 60-second response against a 10%-to-90% change in terms of the final value.

Block 2 squares the input voltage to simulate the characteristics of a lighting device.

Block 3 comprises three filters, the first one removes dc components, the second eliminates components having a frequency twice that of the power supply frequency, and the third, which is a bandpass filter of 8.8-Hz peak frequency, simulates a frequency response for voltage fluctuations in the lighting device, accounting for the effects of the human visual system. Using bilinear s-z transformation, the WT2000 series materializes the transfer function of the bandpass filter given in IEC868 by two second-order digital filters.

Block 4 squares signals with the squaring multiplier to simulate the nonlinear human perception through the eyes to the brain; the filter that follows the calculator simulates the memory effect of the human brain. The output of block 4 represents the instantaneous flickering sensation. The incoming voltage waveform thus processed is processed further as shown in Figure 5.

Block 5 normalizes the output of block 4 and then classifies it with the level classifier. At the end of a measurement interval, the block derives a probability density function for flicker levels from a sum of the counts of all classes and the count of each class. The block then obtains a cumulative probability function from the probability density function (Figure 6) and calculates Pst using the following equations.

$$Pst = \sqrt{0.0314P_{0.1} + 0.0525P_{1S} + 0.0657P_{3S} + 0.28P_{10S} + 0.08P_{50S}},$$

$$P1S = (P_{0.7} + P_1 + P_{1.5})/3,$$

$$P3S = (P_{2.2} + P_3 + P_4)/3,$$

$$P10S = (P_6 + P_8 + P_{10} + P_{13} + P_{17})/5 \text{ and}$$

$$P_{50S} = (P_{30} + P_{50} + P_{80})/3,$$

where, Pk represents a flicker level above the cumulative probability of k%. Pk is calculated using interpolation based on the cumulative probability function where the range of flicker levels from 0.01 to 6,400 P.U. is segmented into 1,024 divisions using a logarithmic scale. The relationship between flicker levels thus classified and their classes is that the 6,400 P.U. flicker level corresponds to class 1,024 and the 0.01 P.U. flicker level corresponds to class 0.

Using these processes, the flicker meter section of the WT2000 series calculates the short-term flicker indicator Pst which is one of the flicker-related parameters under regulation.

2. Calculation of Long-Term Flicker Indicator Plt

The observation interval for the long-term flicker indicator Plt is two hours. Plt is calculated from 12 values of Pst using the following equation.

$$Pst = \sqrt[3]{(Pst_1^3 + Pst_2^3 \ldots + Pst_{12}^3)/12}$$

3. Calculation of dc, dmax and d(t)$_{200ms}$

The rest of the parameters under regulation, dc, dmax and d(t)$_{200ms}$, is evaluated according to the half-period rms value. The rms value is calculated by first determining a square-root sum of sample values between the zero-cross points of an input signal, then dividing the sum by the number of samples, and finally finding the square root of the quotient.

4. Printout of the Results of Measurement

The WT2000 series can print the results of measurement thus performed with the built-in printer (optional). This feature makes recording and storage of the results extremely easy. Figure 7 shows a printout example.

SUPPORT OF IEC-STANDARDS TESTING

Yokogawa Electric is planning to release software used to run IEC-standards tests (harmonic current/voltage fluctuations) by connecting the WT2000 series power meter to a personal computer via a GP-IB interface. Using the software, the operator can both measure harmonics and acquire the results during harmonics analysis. Upon completion of measurement, the operator can display the trends of each order of harmonics for any desired 2.5-minute time slot within the measurement interval, compare the class-by-class limits with the measured values, and make a pass/fail judgment (Figure 8). In addition, the operator can view the given results on a personal computer during the measurement of voltage fluctuations/flicker, output them to a printer, and make a file of data for use with other application software.

CONCLUDING REMARKS

In this paper, we have focused on the flicker meter and voltage fluctuation measurement functions which are representative of the WT2000 series' functionality. With the validation of the EU's regulation of power-supply voltage fluctuations near at hand, we expect users to take advantage of the WT2000 series' wealth of functions in evaluating power supplies used with varying types of equipment and use the instrument in a wide range of applications. ◆

REFERENCES

(1) IEC1000-3-3 1994-12
(2) IEC868 1986 AMENDMENT 1 1990-07