Application Note

High precision measurement of Standby power

Industry: Appliance & Lighting

Precision Power Analyzer WT5000, WT1800E
Digital Power Analyzer WT310E

Overview

Standby power refers to the power consumed by electric devices, such as refrigerators, water heaters, televisions, air conditioners and telephones, when they are in power off state or standby mode. Although the standby power consumption of an individual electric appliance is small, it is said that the total standby power consumption of appliances in a household accounts for several percent of the total power consumption of that household. The total standby power consumed in homes, offices, factories, and society is a very large and wasteful amount of electricity.

Standards for power reduction include IEC 62301: 2011 (Ed. 2.0) *, ErP Directive **, and Energy Star. These standards specify how to measure power consumption in standby power mode and require highly accurate power measurement.

This document introduces four methods and accompanying challenges for reducing standby power, and key points of high accuracy power measurement.

* IEC 62301 Ed 2.0 is a reference standard in the EN 50564: 2011 Directive. The corresponding Japanese Industrial Standard is JIS C 62301.

** The measurement method for power consumption is based on IEC 62301: Household Electrical Appliances - Measurement of Standby Power.

Challenges

The methods for reducing standby power include (1) Reduction of power/current, (2) Shortening of current flow time, (3) Intermittent current flow, and (4) Phase shift between voltage and current.

Each method has the following challenges in terms of measuring the standby power with high accuracy.

(1) Reduction of power/current

Close attention needs to be paid to the power resolution and minimum current range of the power analyzer to be used and to the connection so as to prevent electrical noise.

(2) Shortening of current flow time

Since the load is small, the current waveform is distorted, resulting in a short pulse. The ratio of the peak value to the root mean square (RMS) value of a waveform is called the crest factor (CF), and on a power analyzer, it indicates the maximum multiple of the measurement range that can be applied as a peak value. You must select the measurement range and crest factor to avoid overloading.

IEC 62301 requires measurement conditions with a crest factor of 3 or more.

(3) Intermittent current flow

In this method, even if the instantaneous power is averaged over the voltage period, the measured value of active power may vary depending on the averaging period. In such a case, it is effective to use the integrated average function of the power analyzer.

(4) Phase shift between voltage and current

This is a method to reduce standby power by shifting the phase between voltage and current to intentionally lower the power factor. Since the phase difference between the voltage and the current is 90 degrees, that is, the power factor is close to 0, and a small phase difference greatly affects the measured accuracy, it is necessary to use a high precision power analyzer with little influence of the power factor error that guarantees an effective input range from 0.

Solutions

YOKOGAWA's WT series offers an optimal measurement solution for standby power measurement.

Selecting Crest Factor and Current Range

Use the following procedure to select the crest factor and current range.

1. Set the current range to auto range and make measurements. For the voltage range, select the range of voltage to be input.
2. Check the current peak value and RMS value, and then based on the ratio between the two, select the Crest Factor from CF3, CF6, and CF6A*.
3. Select the current range based on the current peak value and the selected crest factor using the formula below.

$$Current\ range \geq \frac{Current\ peak}{Crest\ factor}$$

* CF6A: the range-increase condition is changed as follows, as compared to CF6. This prevents frequent range changes while measuring a distorted waveform in auto range mode.
- Condition for increasing the range in auto range mode
  The voltage or current RMS value exceeds 220%** of the measurement range.
- Condition that causes an overload indication ("- - O L - -")
  The measured voltage or current exceeds 280%** of the measurement range.

** WT310E: 260% and 600%, respectively

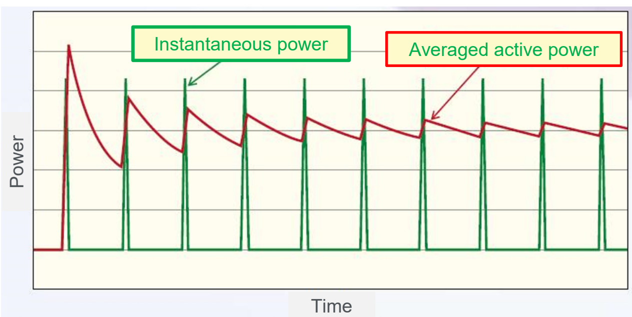
Calculation of average power

In IEC 62301, stability is considered to be achieved and power is determined as the average of two measurements, if, after 30 minutes of equipment warm-up, the difference in average power between the two adjacent measurement periods is:

- For products with input power of 1 W or less: 10 mW/h
- For products with input power greater than 1 W: 1% of the measured input power per hour

Average power can be calculated either by the power average method (simple average function), which takes a simple average of measured values, or by the integrated average method (integrated average function, averaged active power), which divides the integrated power (watt hours) by the integration time.

Compared to the power average method, the integrated average method can provide active power with less variation.

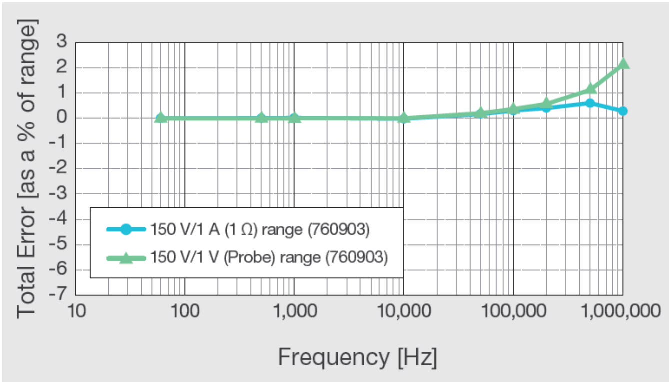


Measurement of low power factor equipment

The error of power analyzer is broken down as: reading error + range error + phase error. The phase error in the third term is expressed by “power reading W x tan (voltage-current phase difference deg) x (influence when λ = 0 %), meaning that as the phase difference between voltage and current becomes larger, that is, as the power factor becomes lower, the phase error increases in proportion to the trigonometric function tangent.

For this reason, it is desirable to use a power analyzer with little influence of power factor error that guarantees an effective input range from 0%.

The WT 5000 has an effective input range of 0% to ± 130%, enabling highly accurate measurements even when measuring the standby power of low power factor equipment.



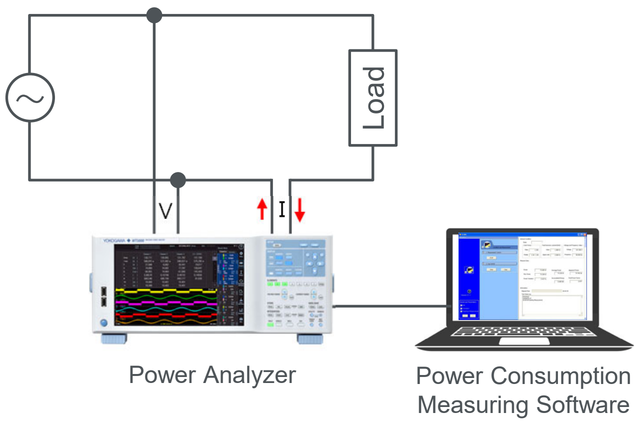
WT5000 Frequency versus power at zero power factor

Connection to power analyzer

A current clamp or current sensor cannot be used to measure small currents, so they are directly input to a power analyzer.

Adapters may be introduced to simplify wiring, but this is not recommended because of the measurement errors caused by the adapters.

The power consumption measuring software (free) makes standards-compliant standby power measurements easy.

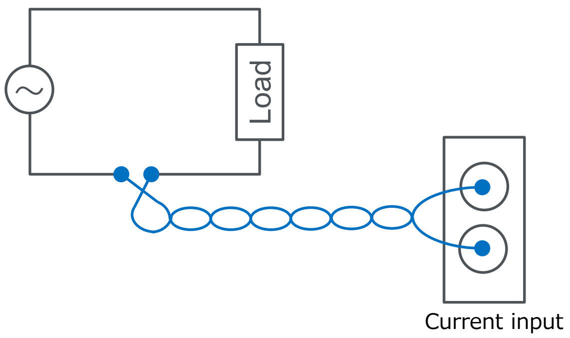


Elimination of extraneous noise

When connecting wires from the device to be measured for direct input to a power analyzer, use safety terminals or the like to prevent electric shock and damage to the instrument.

In this case, the ratio of noise current due to extraneous noise becomes relatively large, so wiring that is less susceptible to noise is required.

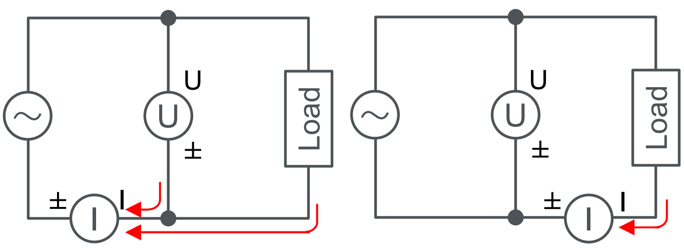
1. Keep the measurement target, wiring cables, and power analyzer away from the equipment generating noise.
2. Shorten the wiring length as much as possible.
3. Reduce the current loop area formed by the wiring cables. Make the wiring cables into a twisted pair.



Wiring position of voltage input and current input

When the voltage measurement terminal is wired between the current measurement terminal and the load as shown in Fig. (a), the current measurement circuit receives the sum of the current flowing through the load and the current flowing through the input resistance of the voltage measurement circuit, resulting in a large error in the current measurement value.

When the measured current is small and the connection in Fig. (b) is made, only the current flowing through the load flows through the current measurement circuit and there is no effect of the current flowing through the voltage measurement circuit. However, if the connection shown in Fig. (b) is made when the measured current is large, the voltage drop due to the current flowing through the shunt resistor of the current measurement circuit is added to the voltage applied to the load and input to the voltage measurement circuit, resulting in a large error in the voltage measurement value.



(a) When the measured current is relatively large

(b) When the measured current is relatively small

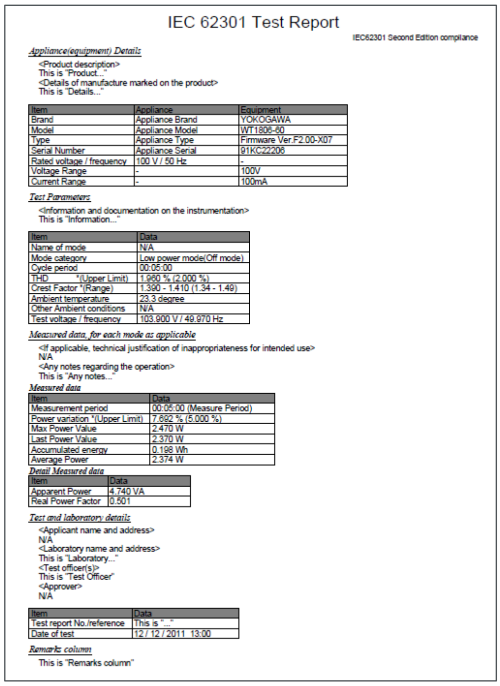
Software

The free Power Consumption Measuring Software, connected with a YOKOGAWA WT series power meter/power analyzer, enables easy measurement according to IEC 62301 Ed 2.0 (2011) and ErP Directive Lot 6.

- You can perform measurements in accordance with IEC 62301 Ed 1.0 and Ed 2.0 by switching the measurement conditions.

  NOTE: In IEC 62301 Ed 2.0 (2011), the algorithm and measurement pattern to obtain stable measurement results have been significantly changed from Ed 1.0.

- Power measurement can be made by entering the required information.
- Reports of measurement results can be generated and output.



IEC 62301 Test Report

IEC62301 Second Edition compliance

Appliance(equipment) Details

<Product description>
This is "Product..."
<Details of manufacture marked on the product>
This is "Details..."

Item	Appliance	Equipment
Brand	Appliance Brand	YOKOGAWA
Model	Appliance Model	WT1806-60
Type	Appliance Type	Firmware Ver.F2.00-X07
Serial Number	Appliance Serial	91KC22206
Rated voltage / frequency	100 V / 50 Hz	-
Voltage Range	-	100V
Current Range	-	100mA

Test Parameters

<Information and documentation on the instrumentation>
This is "Information..."

Item	Data
Name of mode	N/A
Mode category	Low power mode(Off mode)
Cycle period	00:05:00
THD *(Upper Limit)	1.960 % (2.000 %)
Crest Factor *(Range)	1.390 - 1.410 (1.34 - 1.49)
Ambient temperature	23.3 degree
Other Ambient conditions	N/A
Test voltage / frequency	103.900 V / 49.970 Hz

Measured data, for each mode as applicable

<If applicable, technical justification of inappropriateness for intended use>
N/A
<Any notes regarding the operation>
This is "Any notes..."

Measured data

Item	Data
Measurement period	00:05:00 (Measure Period)
Power variation *(Upper Limit)	7.692 % (5.000 %)
Max Power Value	2.470 W
Last Power Value	2.370 W
Accumulated energy	0.198 Wh
Average Power	2.374 W

Detail Measured data

Item	Data
Apparent Power	4.740 VA
Real Power Factor	0.501

Test and laboratory details

<Applicant name and address>
N/A
<Laboratory name and address>
This is "Laboratory..."
<Test officer(s)>
This is "Test Officer"
<Approver>
N/A

Item	Data
Test report No./reference	This is "..."
Date of test	12 / 12 / 2011 13:00

Remarks column

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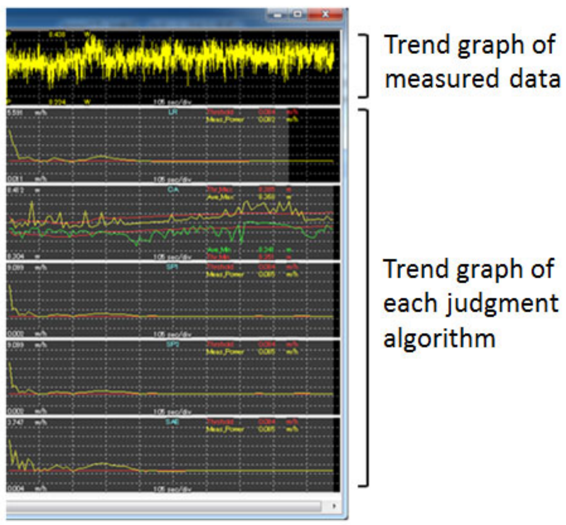
- When IEC 62301 Ed 2.0 (Auto) is specified, the trend graphs of the measurement data and the judgement data can be displayed on the measurement screen.



High-precision standby power measurement

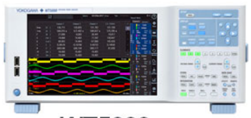
The WT series meets standards such as IEC 62301, ErP Directive, and Energy Star for measuring standby power, and provides high-precision standby power measurement.

IEC major requirements		WT5000 Specification
Measurement capability of active power, true rms voltage and rms current, peak current	✓	Active power P, rms voltage Urms, rms current Irms, peak current I+pk
Power resolution: < 1 mW	✓	0.00001mW
Crest factor: > 3	✓	CF3/CF6/CF6A
Min. current range: < 10 mA	✓	2.5mA range
Data update rate: < 1s	✓	10ms
Harmonic Distortion (THD): <2% (13 order)	✓	Harmonic measurement: 2 to 13 order
Power accuracy: < 0.5%	✓	±0.03%

Example of standby power measurement of Blu-ray Disc Recorder using WT5000

- Display power parameters and voltage/current waveforms
- Observe the variation in amplitude on the current waveforms (green)

WT series Line-up

Major Specifications	 WT5000	 WT1800E	 WT310E
Number of input channels	1 to 7 (Modular)	1, 2, 3, 4, 5, 6	1
Basic Power Accuracy (% of reading + % of range)	±0.03% ±(0.01%+0.02%)	±0.1% ±(0.05%+0.05%)	±0.15% ±(0.1%+0.05%)
Effective input range (Power, DC meas.)	0 to ±130%	0 to ±110%	±0.001 to ±130%
Influence of Power Factor λ (50/60Hz, λ=0)	±0.02% of S	±0.07% of S	±0.1% of S
Resolution of power	0.00001mW	0.0001mW	0.0001mW
Minimum current range (Direct input)	5mA (CF3) 2.5mA (CF6, CF6A)	10mA (CF3) 5mA (CF6, CF6A)	5mA (CF3) 2.5mA (CF6, CF6A)
Data update rate (second)	10m/50m/100m/200m/ 500m/1/2/5/10/20	50m/100m/200m/500m/ 1/2/5/10/20/Auto	100m/250m/500m/ 1/2/5/10/20/Auto

YOKOGAWA

https://tmi.yokogawa.com/ YMI-KS-MI-SE08

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