Standby Power

Primer

Tektronix®

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What is Standby Power?

Standby power refers to the electric power consumed by electronic appliances while they are switched off or in a standby mode. Lawrence Berkeley National Laboratory (LBNL) has defined standby power as “Standby power is the power used while an electrical device is in its lowest power mode.” Devices such as a TV or a microwave oven offer remote controls and digital clock features to the user when in standby. Other devices, such as power adapters for laptop computers, tablets and phones consume power without offering any visible features when in standby mode. These and many other devices are users of standby power.

Why is Standby Power Important?

The standby power of household electronic devices is typically very small, but the sum of all such devices within the household becomes significant. Standby power makes up a portion of homes offices and factories’ steadily rising miscellaneous electric load, which also includes small appliances, security systems, and other small power draws.

For example a typical microwave oven consumes more electricity powering its digital clock than it does heating food. For while heating food requires more than 100 times as much power as running the clock, most microwave ovens stand idle—in “standby” mode—more than 99% of the time.

Standby power is typically 1 or 2 Watts for a household appliance, less for computing devices. Although the power needed for functions like displays, indicators, and remote control functions is relatively small, the fact that the devices are continuously plugged in, and the number of such devices in the average household means that the energy usage can reach up to 22 percent of all appliance consumption, and 5 to 10 percent of total residential consumption (see the references for the latest information).

The costs of standby power are:

- Personal (around $100 each year per USA household).
- In wasted electricity generation and transmission infrastructure.
- Political in terms of energy security by contributing to energy imports. (See the U. S. EISA 2007 Energy Independence and Security Act that minimizes standby power for federal procurements).
- Global (an estimated 1% of C02 emissions are due to standby power).

Many programs are already in place to reduce standby power including ENERGY STAR and the EU Eco Directive. The scope of these programs continues to grow and the level of standby power in Watts necessary to achieve compliance steadily falls. For example the European Community (EC) mobile device charger 5-star rating requires a standby power consumption of less than 30mW.

How to Measure Standby Power

Requirements for a Measurement

Standby power is measured with a suitable wattmeter or power analyzer. Unfortunately it is often not a simple measurement of power in Watts and the following measurement cautions should be observed.

Standby Measurement Challenges

- Low power and current.
- Highly distorted waveforms since power supplies operating at low load often draw very high crest-factor current.
- At low power factor because the current may be predominantly capacitive, through the power supply EMC filter.
- When the power supply is in burst mode, drawing power irregularly rather than continuously.

Measuring Low Power and Current

The power analyzer must have a suitable range on which to measure the current. In general, measurements below 5% of a current range will not be reliable.

Example: Measure 100mW at 230V and power factor 1.

Watts = Volts x Amps x PF

So

Amps = Watts / (Volts x PF)

= 0.1 / (230 x 1) = 0.4mA

The power analyzer should operate on a range that is 2mA or lower.

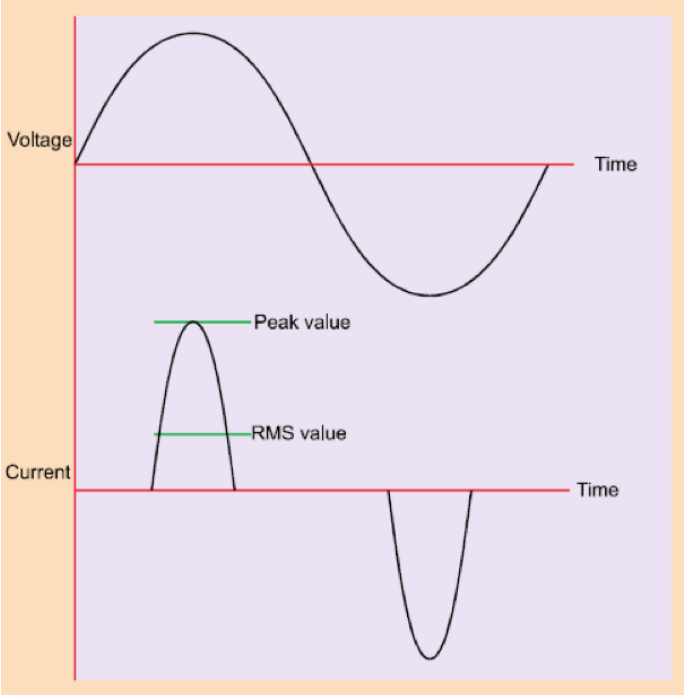


Figure 1. Crest Factor.

High Crest Factor Waveforms

At low load, the current is often at its most distorted. Current is drawn only at the peak of the voltage to charge the power supply's reservoir capacitors and appears as a short pulse.

$$Crest\ factor = \frac{Peak\ value}{RMS\ value}$$

The power analyzer must measure without clipping or reduction in accuracy when the crest factor is greater than 3, possibly up to 10.

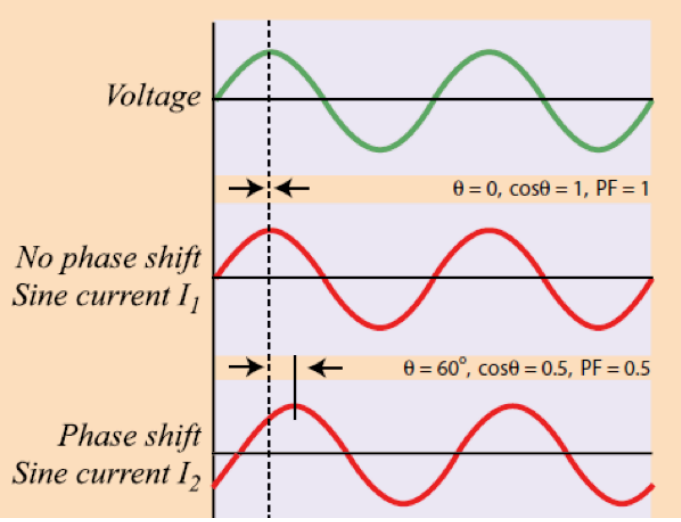


Figure 2. Current Phase Shift.

Figure 3. Standby Test Run.

Low Power Factor

Under standby conditions the input current may be dominated by current in the capacitors used for EMC filtering, especially the X2 rated capacitors fitted across line and neutral.

In this case, the current is phase shifted by up to 90 degrees. This is an area where not all power analyzers will measure accurately.

Burst Mode Operation

Operating at no or low load the power supply's own control and power circuits still operate to maintain a regulated output voltage. This control power may be in excess of the desired standby power so many power supplies switch to a burst mode.

In this mode, the power switching devices inside the power supply stop operating and the output voltage is maintained exclusively by the output smoothing capacitors. When the output voltage falls to a pre-determined level then the power supply switching starts again to top up the output capacitors.

In this mode current is drawn in bursts from the AC line. The bursts of current are irregular and vary in duration and size.

In addition, the power drawn by the product under test may simply change due to temperature or further power saving features.

For measurements of power in this circumstance the power analyzer must:

- Sample power continuously so as not to miss any power.
- Take an average of the power over a period of time long enough to provide a stable result.

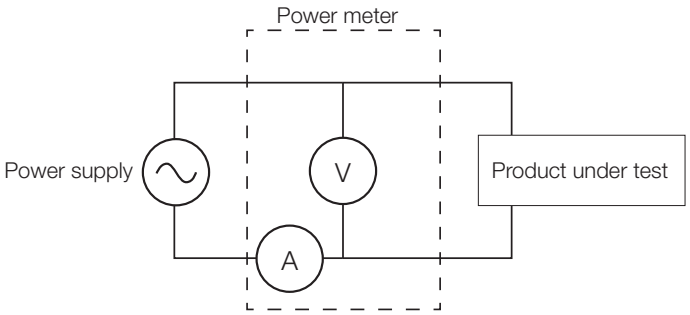


Figure 4. Connection for measuring power in normal mode.

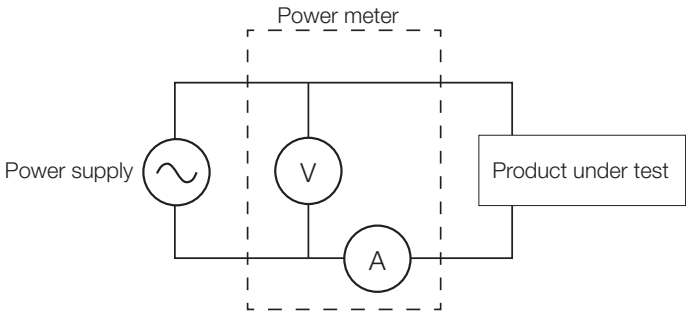


Figure 5. Connection measuring standby power.

Making Connections

- The power analyzer will sample the voltage and current waveforms simultaneously in order to calculate power. Connections should be safe and secure.
- Voltage is measured by connecting the voltage terminals in parallel.
- Current is measured by connecting current terminals in series. In general, a directly connected resistive current shunt (as opposed to a current transformer) is required to achieve reasonable measurements.
- For standby power measurements the voltage connection is made the source or supply side of the circuit.
- During normal power measurements the current and power in the voltmeter circuit of the power analyzer is very much less than that of the current shunt.
- For standby power measurements the current and power in the voltmeter circuit can be significant and that of the current shunt very small. So for standby measurements the voltage is connected on the supply side of the current shunt.

Making a Basic Measurement

Set up the power analyzer to measure Watts. Conditions should be:

- Continuous sampling
- Recording Watts at a rate faster than 1 a second
- Averaging over a selectable time.

Example with a Tektronix PA1000 or PA4000

1. Connect the analyzer as above
   (Use the 1A shunt input for best accuracy)
2. Reset defaults.
   (Menu > User Configuration>Load Default Configuration
3. Select the 1A shunt
   (Menu > Inputs > Shunt > 1A)
4. Select Standby Mode
   (Menu > Modes > Select Mode > Standby)

Figure 6. Mode Selection.

Figure 7. Power Measurements.

The analyzer will now make accurate standby measurements, auto-ranging for crest factors up to 10, sampling continuously at 1MHz without gaps and averaging the power measurement (watts) over the default 10 seconds. No further set up is required for this quick basic measurement.

This is an ideal basic measurement intended for continuous use in everyday product design and development.

If required, the averaging time can be changed in the menu system (Menu > Mode > Setup > Standby). 10 seconds is typical but if the measurement is unstable, increase the averaging time to suit. In case of difficulty use the full compliance measurement ability of the PA1000 or PA4000.

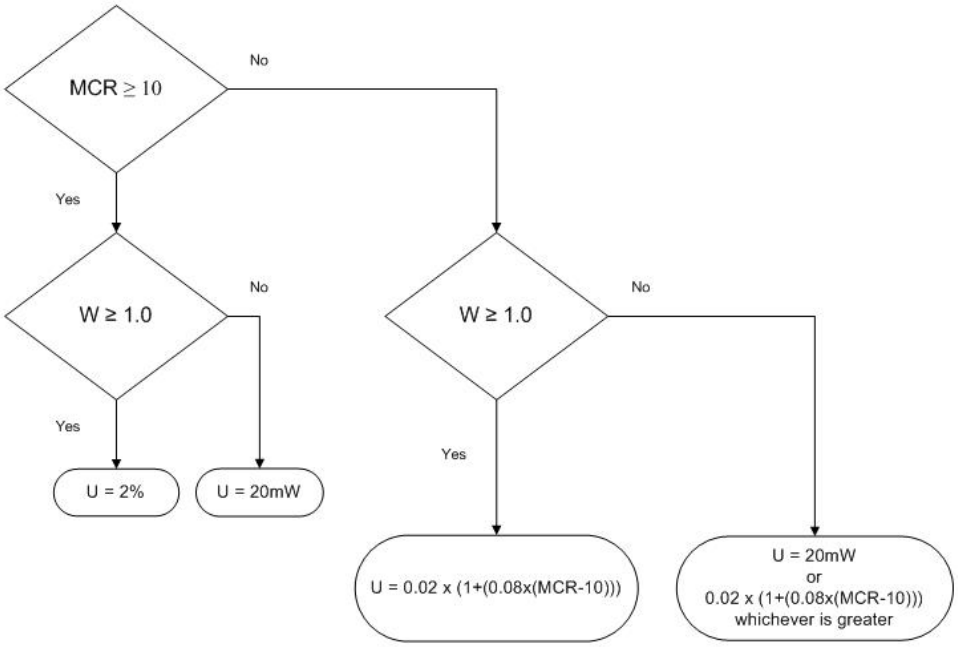


Figure 8. Making Measurements Flowchart.

Making Measurements to IEC62301 Ed.2:2011 and EN50564:2011

Tektronix PA1000 and PA4000 power analyzer will also make measurements in full compliance to the above standards. This means that the analyzers meet the strict requirements for measurement methodology as well as accuracy.

IEC62301 Ed2 is important because this is the definitive measurement method reference by ENERGY STAR and the European regulation No 1275/2008 Standby and off mode electric power consumption of electrical and electronic household and office equipment.

Requirements of IEC62301 Ed.2

Please refer to the latest edition of the standard and confirm details before making compliance measurements.

Supply Voltage (IEC62310 Ed.2 Section 4.3)

- Nominal voltage and frequency for the region may be used but must be stable +/- 1%
- The total harmonic content (THC) must not exceed 2%. (THC is a modified THD or total harmonic distortion including the first 13 harmonics only).
- Crest factor of the voltage (ratio of peak to RMS) must be between 1.34 and 1.49.
- Since any variation in these parameters will influence the standby power measurement they must be measured and confirmed simultaneously with each power measurement during the test. Simultaneous RMS and harmonic measurements are required.
- The normal AC line supply may meet these criteria, especially if the test connection is made close to the incoming supply or distribution transformer. If the supply does not meet the requirements than a synthetic AC source or line conditioner must be used.

Measurement Uncertainty (IEC62310 Ed.2 Section 4.4)

The IEC standard takes into account the difficulties discussed above and defines a measurement uncertainty that is based on both the level of power to be measured and the distortion and phase shift of the waveform.

To take into account both distortion and phase shift, Maximum Current Ratio (MCR) is defined.

MCR = Crest Factor / Power Factor

The required level of uncertainty, “U” can then be determined as in Figure 8.

Watts Measurement Procedure (IEC62301 Ed.2 Section 5.3)

There are three possible methods for determining the power in Watts

1. Direct Method

"This method shall not be used for verification purpose"

This is the basic power analyzer front panel method described earlier. It is intended for rapid prototyping measurements on products that draw very stable power only.

2. Average Reading Method

This method is a modified version of that used by previous versions of the standard (Ed.1). Since the measurement takes a minimum 20 minutes and does not apply to all product modes, the sampling method described below is preferred.

1. For two measurement periods of not less than 10 minutes each the average power is determined.
2. The power measurements are checked for stability by calculating the rate of change of power (mW /h) between the two measurements. Only if the stability criteria are met is the measurement valid. If stability cannot be achieved the sampling method must be used.

3. Sampling Method

This is the method recommended by the IEC. It is the fastest and applies to all possible product modes.

1. Power and other measurements are recorded at a rate faster than 1 / second.
2. The product under test is energized for a minimum 15 minutes
3. The first third of the data (5 minutes) is discarded
4. Stability of the measurement is determined from a least-squares linear regression through all the power measurements. Stability is established when the slope of the straight-line regression is either less tha 10mW/h (input power <= 1W) or less than 1% of the power if the power is greater than 1W.

Test Report (IEC62301 Ed.2 Section 6)

The test report must contain details of the product, the test environment and the test laboratory as well as the measured data and measurement method.

General Power Analyzer Requirements (IEC62301 Ed.2 Section B.2)

1. Determine all measurements (Volts, Amps, crest factors, THC as well as Watts) and record them simultaneously at an interval of less than 1 second.
2. Sample continuously without gaps.
3. Have a power resolution of 1mW or better
4. Rated measurements at crest factor of 3, preferably 10
5. Minimum current range of less than 10mA
6. Signal over-range
7. Ability to switch auto-ranging off.
8. Frequency response of at least 2kHz

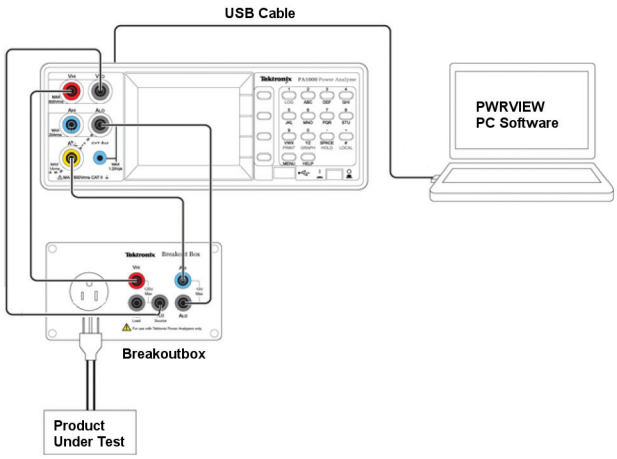


Figure 9. Power Measurement Setup.

Making a Compliant Standby Power Measurement

Equipment Required

1. AC Supply

   Meeting the requirements discussed in section Supply Voltage (IEC62310 Ed.2 Section 4.3). For a test lab, this is normally a programmable AC Source that allows various voltage and frequency combinations to be certified.

2. Power analyzer that meets the requirements of IEC62310 Ed.2 for uncertainty, measurement procedure and general characteristics as described earlier.

   - Tektronix PA4000 or PA1000

3. Method to connect the test circuit (AC supply, power analyzer and product under test) safely and in accordance with IEC62301 Ed.2 Section B.4

   A Tektronix BreakOut Box satisfies this requirement and is fitted with 4mm safety sockets for simple 1:1 connection to a Tektronix power analyzer.

4. Method to record and report the measurement as required by IEC62301 Ed.2 Section 6.

   A laptop with Tektronix PWRVIEW installed and a USB connection.

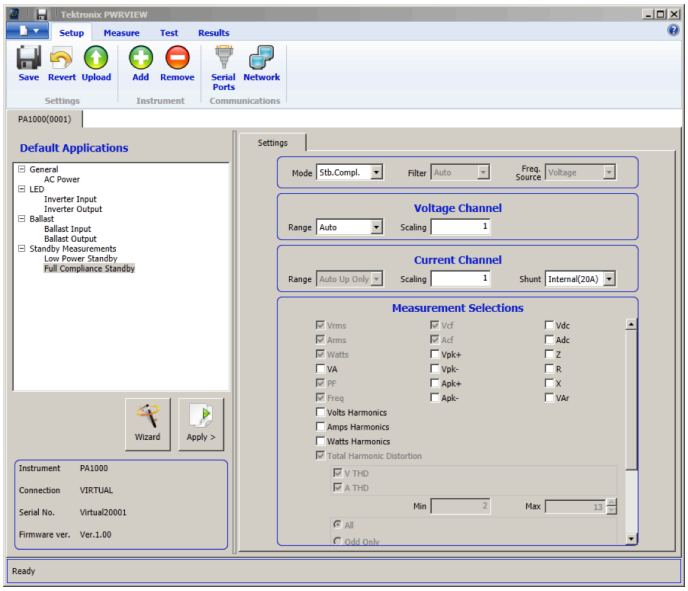


Figure 10. Default Applications.

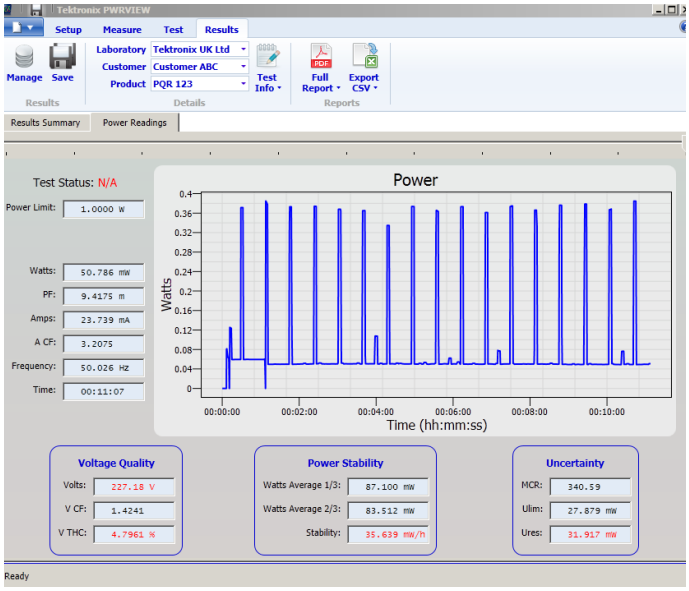


Figure 11. Standby Test Run.

Measurement Procedure

1. Connect the supply, load and power analyzer using the Tektronix Breakout Box.
   - Remember to use the VLO SOURCE connection on the Breakout Box.
2. Apply the desired AC supply (e.g. 230V, 50Hz) and switch on the product under test.
3. Switch on the power analyzer, connect the computer via USB and open the PWRVIEW application.
4. Set up or wait until the product under test enters the desired standby mode.
5. In PWRVIEW, select the ‘Full Compliance Standby’ wizard to confirm the test set up or simply click ‘Apply’.
   - All the measurements required by IEC62301 Ed.2 are selected automatically.
6. Now click on the ‘Test’ tab and the “Start” in the ribbon.
   - The compliance testing will begin.
7. The graph scales automatically and shows the power in watts on against the time of the measurement.
8. Results are updated and displayed at a rate faster than the required 1/sec and recorded for reporting at the end of the test.
9. The test duration should be a minimum of 15 minutes, extended if the requirements for stability are not met.

Measurements
Every measurement is recorded simultaneously with a time stamp.

PASS / FAIL

Details of the test laboratory, the customer and the product may be entered here.

Voltage Quality
Voltage harmonics and THC recorded during the test.

Stability
The slope of the least-squares linear regression through the second 2/3 of the power measurements is displayed in real time.

Uncertainty
The required uncertainty U LIM and the actual uncertainty of the measurement U RES are calculated and displayed in real time.

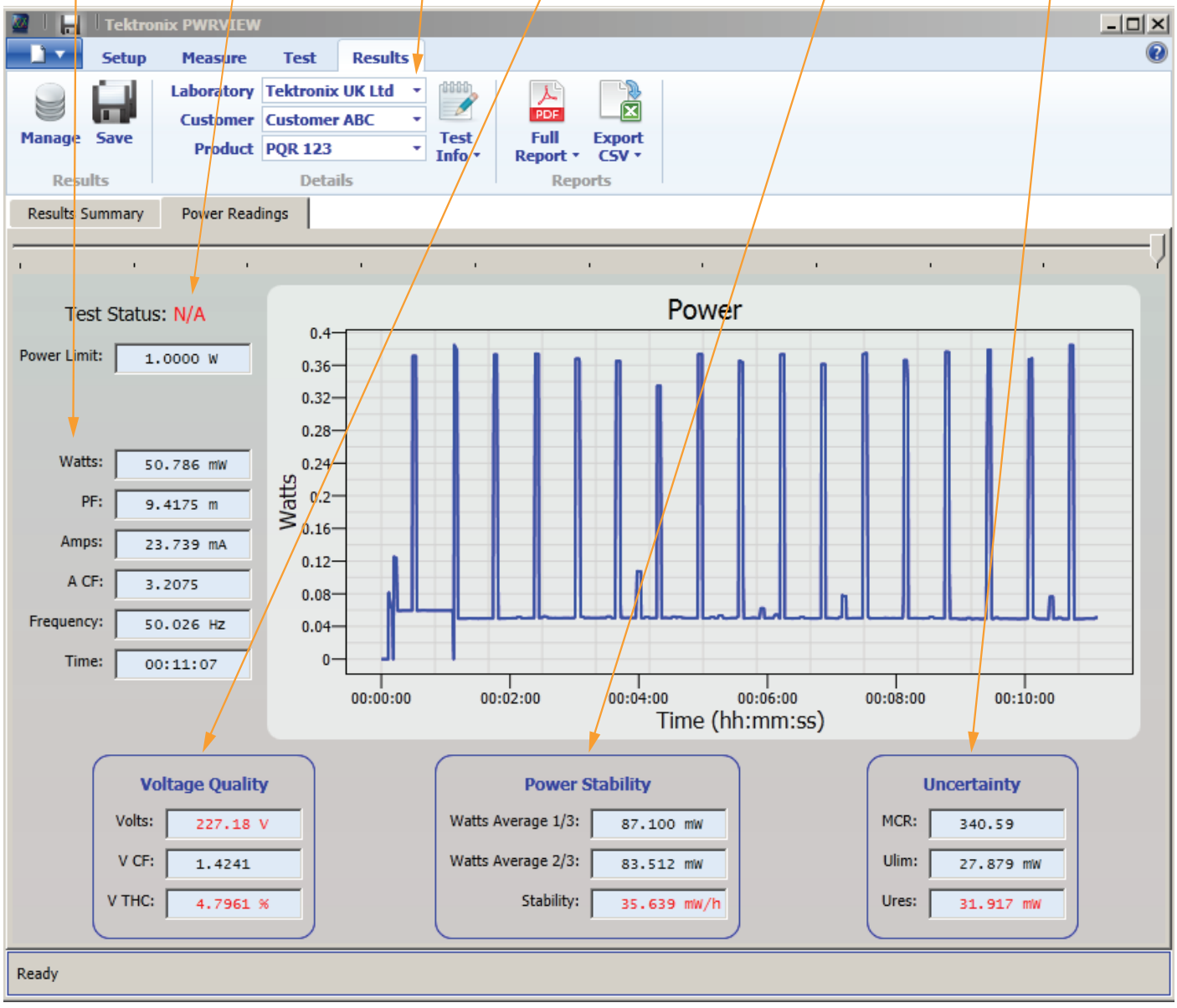


Figure 12. Standby Test Run.

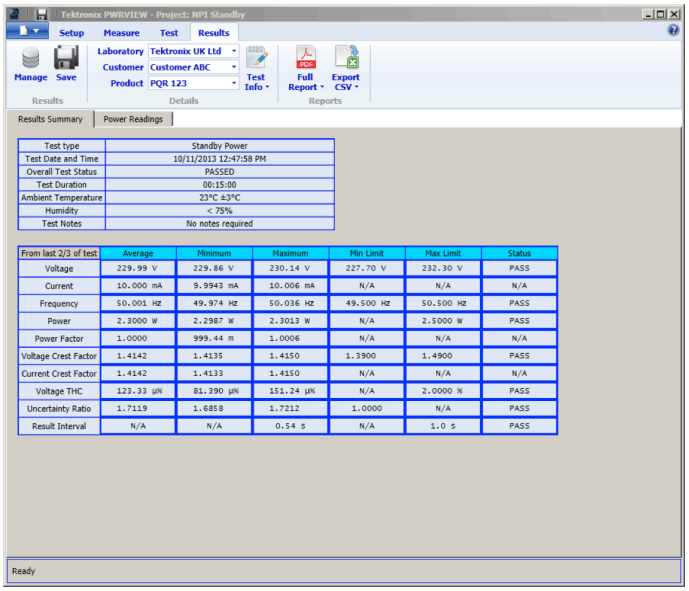


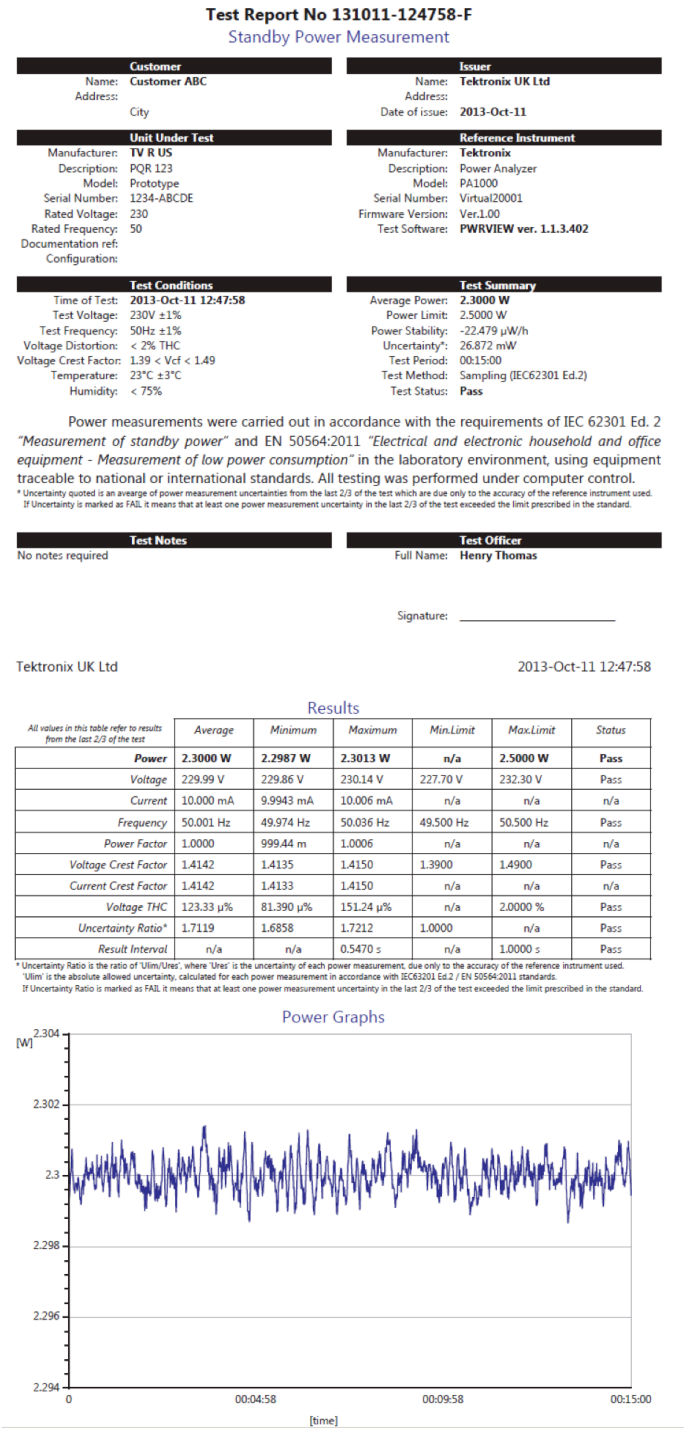
Figure 13. Reporting.

Reporting

PWRVIEW provides powerful methods to review the measured data including Microsoft Excel compatible data export.

Click in the “Results” tab then select the data required by clicking the “Manage” symbol.

A full compliance report, including all certification notes may also be created as a pdf.



Test Report No 131011-124758-F

Standby Power Measurement

Customer		Issuer	
Name:	Customer ABC	Name:	Tektronix UK Ltd
Address:		Address:	
	City	Date of issue:	2013-Oct-11

Unit Under Test		Reference Instrument	
Manufacturer:	TV R US	Manufacturer:	Tektronix
Description:	PQR 123	Description:	Power Analyzer
Model:	Prototype	Model:	PA1000
Serial Number:	1234-ABCDE	Serial Number:	Virtual20001
Rated Voltage:	230	Firmware Version:	Ver.1.00
Rated Frequency:	50	Test Software:	PWRVIEW ver. 1.1.3.402
Documentation ref:			
Configuration:			

Test Conditions		Test Summary	
Time of Test:	2013-Oct-11 12:47:58	Average Power:	2.3000 W
Test Voltage:	230V ±1%	Power Limit:	2.5000 W
Test Frequency:	50Hz ±1%	Power Stability:	-22.479 µW/h
Voltage Distortion:	< 2% THC	Uncertainty*:	26.872 mW
Voltage Crest Factor:	1.39 < Vcf < 1.49	Test Period:	00:15:00
Temperature:	23°C ±3°C	Test Method:	Sampling (IEC62301 Ed.2)
Humidity:	< 75%	Test Status:	Pass

Power measurements were carried out in accordance with the requirements of IEC 62301 Ed. 2 *"Measurement of standby power"* and EN 50564:2011 *"Electrical and electronic household and office equipment - Measurement of low power consumption"* in the laboratory environment, using equipment traceable to national or international standards. All testing was performed under computer control.

* Uncertainty quoted is an average of power measurement uncertainties from the last 2/3 of the test which are due only to the accuracy of the reference instrument used.
If Uncertainty is marked as FAIL it means that at least one power measurement uncertainty in the last 2/3 of the test exceeded the limit prescribed in the standard.

Test Notes	Test Officer	
No notes required	Full Name:	Henry Thomas

Signature: _____

Tektronix UK Ltd 2013-Oct-11 12:47:58

Results

All values in this table refer to results from the last 2/3 of the test	Average	Minimum	Maximum	Min.Limit	Max.Limit	Status
Power	**2.3000 W**	**2.2987 W**	**2.3013 W**	**n/a**	**2.5000 W**	**Pass**
Voltage	229.99 V	229.86 V	230.14 V	227.70 V	232.30 V	Pass
Current	10.000 mA	9.9943 mA	10.006 mA	n/a	n/a	n/a
Frequency	50.001 Hz	49.974 Hz	50.036 Hz	49.500 Hz	50.500 Hz	Pass
Power Factor	1.0000	999.44 m	1.0006	n/a	n/a	n/a
Voltage Crest Factor	1.4142	1.4135	1.4150	1.3900	1.4900	Pass
Current Crest Factor	1.4142	1.4133	1.4150	n/a	n/a	n/a
Voltage THC	123.33 µ%	81.390 µ%	151.24 µ%	n/a	2.0000 %	Pass
Uncertainty Ratio*	1.7119	1.6858	1.7212	1.0000	n/a	Pass
Result Interval	n/a	n/a	0.5470 s	n/a	1.0000 s	Pass

* Uncertainty Ratio is the ratio of 'Ulim/Ures', where 'Ures' is the uncertainty of each power measurement, due only to the accuracy of the reference instrument used.
'Ulim' is the absolute allowed uncertainty, calculated for each power measurement in accordance with IEC63201 Ed.2 / EN 50564:2011 standards.
If Uncertainty Ratio is marked as FAIL it means that at least one power measurement uncertainty in the last 2/3 of the test exceeded the limit prescribed in the standard.

Power Graphs

Figure 14. Example IEC62301 Ed.2 Full Compliance Test Report.

Tektronix Solutions

To make an accurate measurement of standby power, the following factors must be considered:

- The low levels of power and current.
- Highly distorted waveforms with high crest factors
- Low power factor.
- Burst mode operation

Tektronix PA4000 and PA1000 power analyzers are engineered to provide accurate measurements in these circumstances. In fact they are completely capable of fully complaint standby power measurements to IEC62310 Ed.2.

Meeting the Standard

How the PA4000 and PA1000 meet the requirements of IEC61000-3-2 Ed.2.

1. Accuracy / Uncertainty

Both the PA4000 and the PA1000 feature a 1A current input as standard. The minimum range is 2mA. (IEC62301 Ed.2 requires a minimum of 10mA or less)

2. High Crest Factors

The Tektronix power analyzers auto-range to a value determined by the peak values in a waveform. This guarantees measurements up to a crest factor of 10. If an over-range occurs, it is clearly signaled.

3. Low Power Factor

The MCR ratio of Current Crest Factor to Power Factor is determined in real time for each measurement.

The required uncertainty U LIM is calculated according to the requirements and the actual power analyzer uncertainty U RES is calculated from the actual measurement conditions including range and power factor.

The required and actual uncertainties are clearly displayed and reported to ensure compliance.

4. Burst Mode Operation

IEC62301 Ed.2 requires that a stable measurement is achieved and specifies stability exactly for various conditions.

The Tektronix PA4000 and PA1000 analyzers and PWRVIEW software:

- Sample continuously without gaps
- Report all measurements including watts and power quality simultaneously at intervals of less than 1 second
- Calculate stability using least square regression as specified

Conclusion

The measurement of standby power is important to the engineer designing, testing and certifying power supplies and everyday domestic and office appliances.

Tektronix PA4000 and PA1000 Power Analyzers, together with the PWRVIEW pc software, provide flexible and powerful tools to measure standby power.

- During prototyping the analyzers 1-click standby mode can be used to provide a 10-second measurement.
- During design qualification and certification the full compliance abilities of the analyzers and PWRVIEW may be used to provide full compliance certification to IEC62301 Ed 2.

Contact Tektronix:

ASEAN / Australia (65) 6356 3900
Austria* 00800 2255 4835
Balkans, Israel, South Africa and other ISE Countries +41 52 675 3777
Belgium* 00800 2255 4835
Brazil +55 (11) 3759 7627
Canada 1 (800) 833-9200
Central East Europe and the Baltics +41 52 675 3777
Central Europe & Greece +41 52 675 3777
Denmark +45 80 88 1401
Finland +41 52 675 3777
France* 00800 2255 4835
Germany* 00800 2255 4835
Hong Kong 400-820-5835
Ireland* 00800 2255 4835
India +91-80-30792600
Italy* 00800 2255 4835
Japan 0120-441-046
Luxembourg +41 52 675 3777
Macau 400-820-5835
Mongolia 400-820-5835
Mexico, Central/South America & Caribbean 52 (55) 56 04 50 90
Middle East, Asia and North Africa +41 52 675 3777
The Netherlands* 00800 2255 4835
Norway 800 16098
People's Republic of China 400-820-5835
Poland +41 52 675 3777
Portugal 80 08 12370
Puerto Rico 1 (800) 833-9200
Republic of Korea +822-6917-5000
Russia +7 495 664 75 64
Singapore +65 6356-3900
South Africa +27 11 206 8360
Spain* 00800 2255 4835
Sweden* 00800 2255 4835
Switzerland* 00800 2255 4835
Taiwan 886-2-2656-6688
United Kingdom* 00800 2255 4835
USA 1 (800) 833-9200

* **If the European phone number above is not accessible, please call +41 52 675 3777**

Contact List Updated June 2013

For Further Information
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