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APPLICATION NOTE - 015

Standby Power Measurement – IEC62301

Estimates of the typical household energy wasted by electronic equipment in standby mode range from 5% to 15% of total household power consumption. There is now International awareness of the financial and environmental cost of this wasted energy. This recognition has resulted in standards that force manufacturers of electronic products to reduce the power that their devices consume when not in normal operation

International Standards

There are an increasing number of domestic standards that specify the power limit associated with particular product groups or categories within a product group. Domestic standards include:

Energy Star, Blue Angel, EcoDesign, Top Runner and Nordic Swan.

However, the internationally recognised standard for the measurement technique and measurement accuracy for standby power is IEC62301. The IEC (International Electrotechnical Commission) is a worldwide organization for standardization comprising all national electrotechnical committees (IEC National Committees). Any regulatory body that wishes to use a different technique to that defined by the IEC must separately define the differences, so in most cases, regulatory bodies have chosen to adopt the IEC 62301 standard.

In the following table there are example limits for power adapters, in the following document we will explore what challenges power analyzer designers are met with when undertaking the measurement of standby power and how we overcome these challenges.

Example Limits – Power Adaptors

Example regulatory bodies who define domestic limits for compliance with power consumption limits	
EPA (U.S.A. Environmental Protection Agency) [Control the Energy Star program in the USA]	**DOE** (U.S.A. Department of Energy)
CEC (California Energy Commission)	**EU** (European Union)
CECP (China Certification Centre for Energy Conservation Product)	**KEMCO** (Korea Energy Management Corporation)

Table 1, Minimum Energy Performance Classification – Power Adaptors

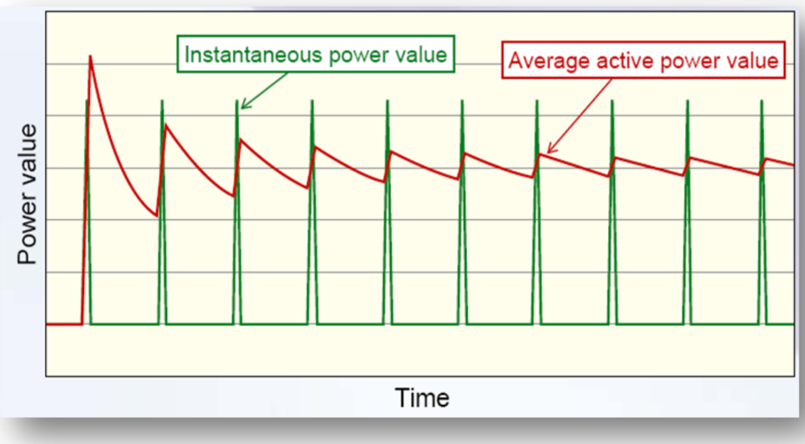
Efficiency Level Mark	Performance Requirements				
	Nameplate Power Output (Pno)	Required No-Load Input Power	Nameplate Power Output (Pno)	Required Average Active Efficiency	Power Factor
I	Used if none of the other criteria are met				Not Applicable
II	1 to <=10 W 10 to 250 W	<=0.75 W <=1.0 W	0 to 1 W >1 to 49 W >49 to 250 W	>=0.39 x Pno >=0.107 x Ln(Pno) + 0.39 >=0.82	
III	0 to < 10 W 10 to 250 W	<=0.5 W <=0.75 W	0 to 1 W >1 to 49 W >49 to 250 W	>=0.49 x Pno >=0.090 x Ln(Pno) + 0.49 >=0.84	
IV	0 to 250 W	<=0.5 W	0 to 1 W >1 to 51 W >51 to 250 W	>=0.50 x Pno >=0.090 x Ln(Pno) + 0.50 >=0.85	
V	0 to < 50 W 50 to 250 W	<=0.5 W for ac-ac <=0.3 W for ac-dc <=0.5 W	0 to 1 W >1 to 49 W >49 to 250 W	Vo > 6V: >=0.480 x Pno + 0.140 Vo <= 6V: <= 0.497 x Pno + 0.067 Vo > 6V: 0.0626 x Ln(Pno) + 0.622 Vo <= 6V: 0.0750 x Ln(Pno) + 0.561 Vo > 6V: >= 0.87 Vo <= 6V: <= 0.86	Power supplies with 100W or greater input power must have a true power factor of 0.90 or greater at 100% load when tested at 115Vac, 60 Hz.

Typical Power Analyzer Weaknesses

Many power analyzer manufacturers claim to have a 'solution' to IEC 62301 testing but generally, these products have weaknesses.

The two most common weaknesses are:

1. Long integration required to obtain a stable power reading



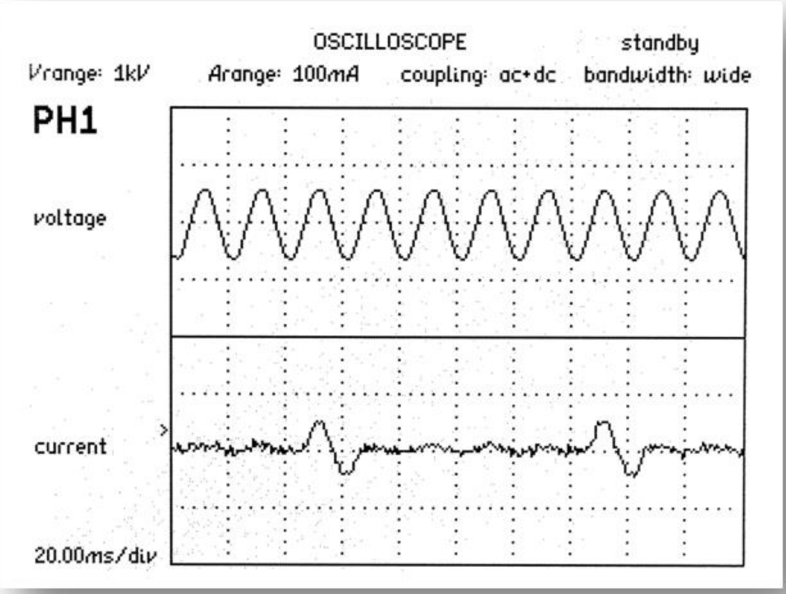
If the measured power is not stable, the IEC permits long measurement periods in order to provide a stable reading. However, the instability is due to the power analyzer not the DUT.

High performance power analyzers can achieve measurement stability with a short measurement time; therefore, minimum test time can be achieved.

2. External shunts are required to measure low current

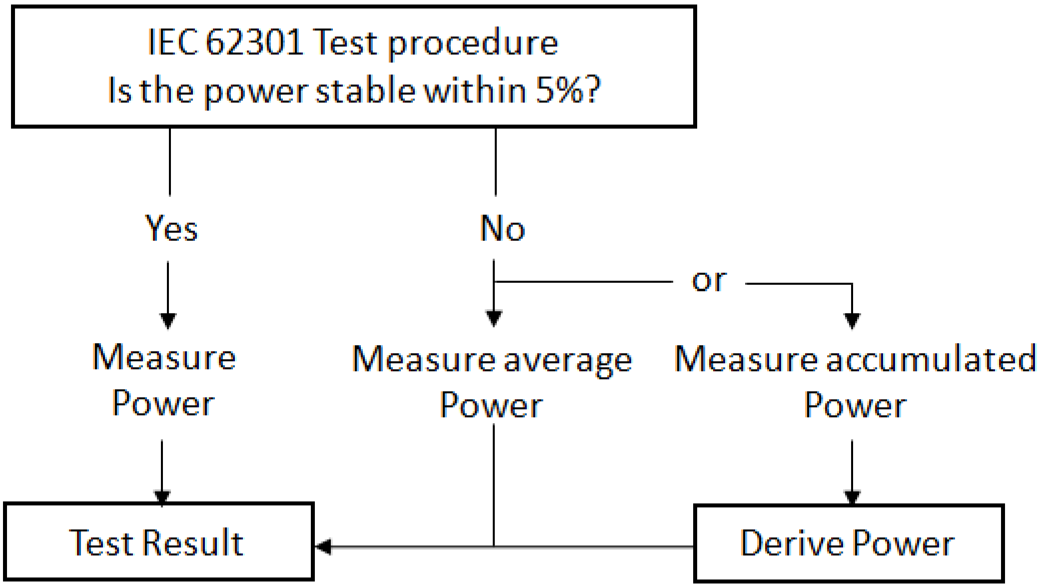
For measurement applications with current down to 1mA, external current shunts can be helpful, but this should NOT be necessary for IEC 62301 testing. External shunts add complication and add error stages to the system. The best power analyzers can test to IEC62301 using only the internal current shunts.

High quality power analyzers with a good dynamic range do not require an external shunt to measure standby power. Here, a PPA5500 power analyzer with 300Apk and 30Arms direct inputs easily measures a low duty cycle standby power waveform with 24mApk and 8.5mArms.



IEC62301 Testing

As described previously, the Energy Star program along with all major standards that are associated with standby power now recognize IEC 62301 as the reference for measurement techniques and accuracy.



Statement from Energy Star Program

"It is also desirable for measurement instruments to be able to average power accurately over any user selected time..." and
"As an alternative, the measurement instrument would have to be capable of integrating energy over any user selected time interval with an energy resolution of less than or equal to 0.1 mWh and integrating time displayed with a resolution of 1 second or less."

Is Standby Power Periodic?

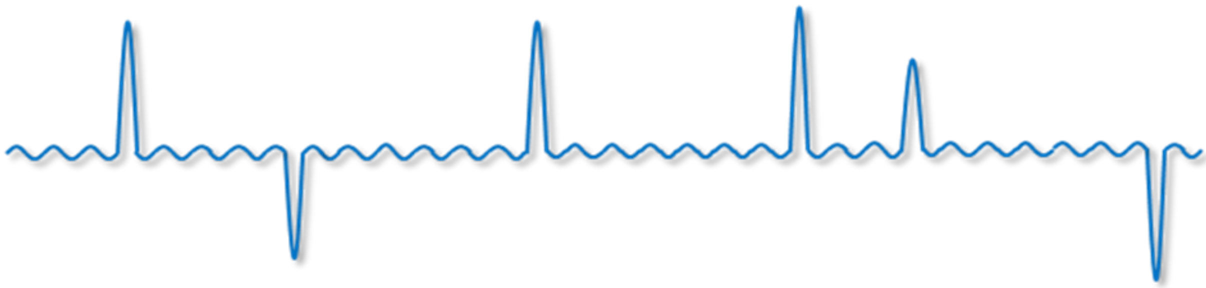
Under low power conditions, it is clearly important that the measurement instrument being used has a current measurement channel with sufficient sensitivity to measure the minimum expected current.

With a sinusoidal current waveform, this may be relatively easy but with peaky current demand such as that pictured above that produces a high crest factor, this becomes more difficult.

The problem is complicated further with a DUT that exhibits low duty cycle current pulses.

A common mistake made by many instrument vendors is the assumption that a standby power profile is periodic and therefore can be accurately quantified with gaps between measurements by integration over a long period of time, but this not true.

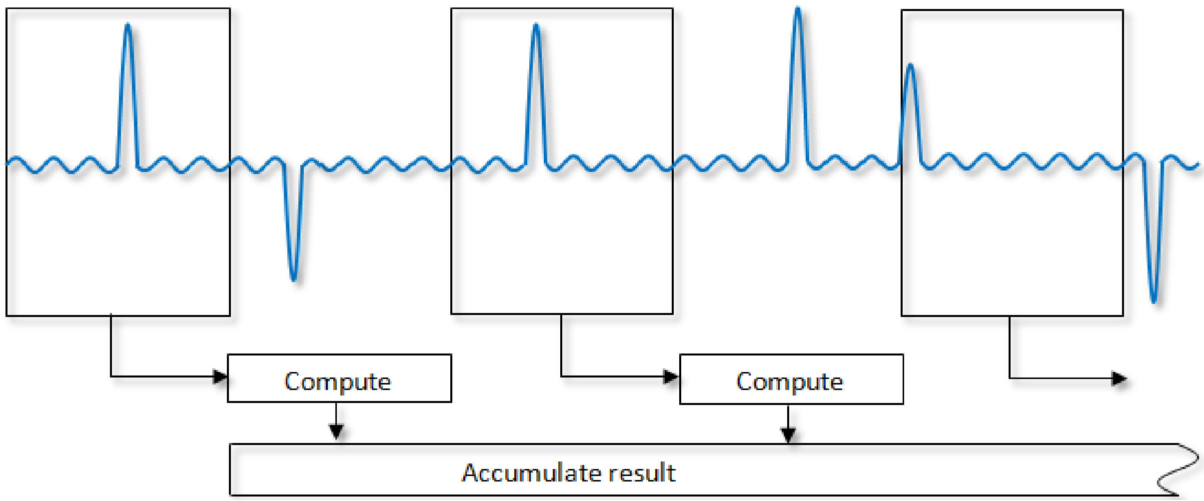
Measuring Real Standby Power



The above waveform is closer to what would be encountered by a power analyzer which is measuring standby power.

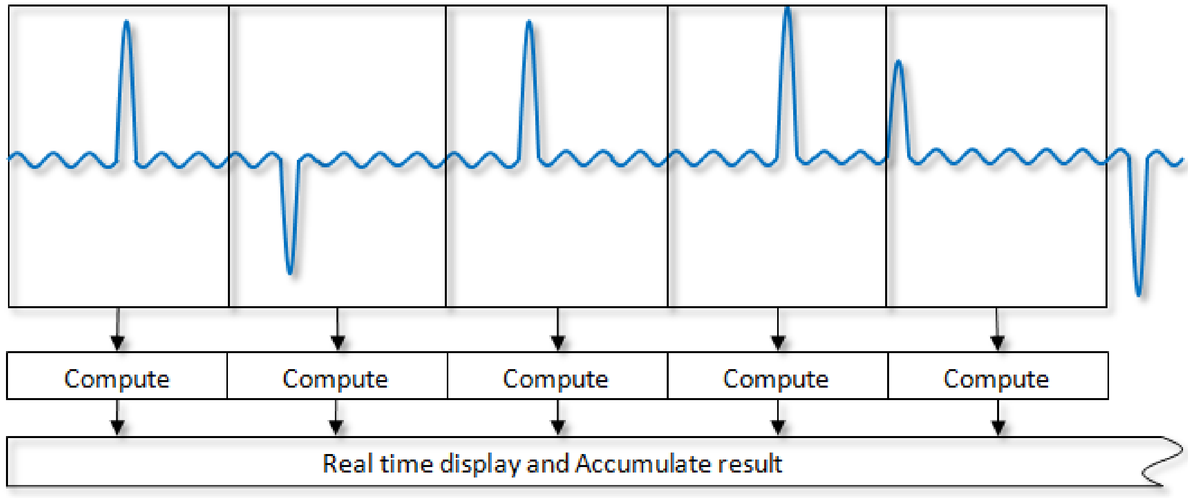
In practice, low duty cycle standby modes are usually not symmetrical and in fact, this is also true of more traditional power supply designs with continuous cycle by cycle power consumption. To obtain the true standby power, an ideal power analyzer would measure continuously so that no event is missed. However, most power analyzers have a gap between measurement windows and therefore the greatest cause of instability in measured power is often the power measurement equipment, not the DUT.

Typical Power Analysis

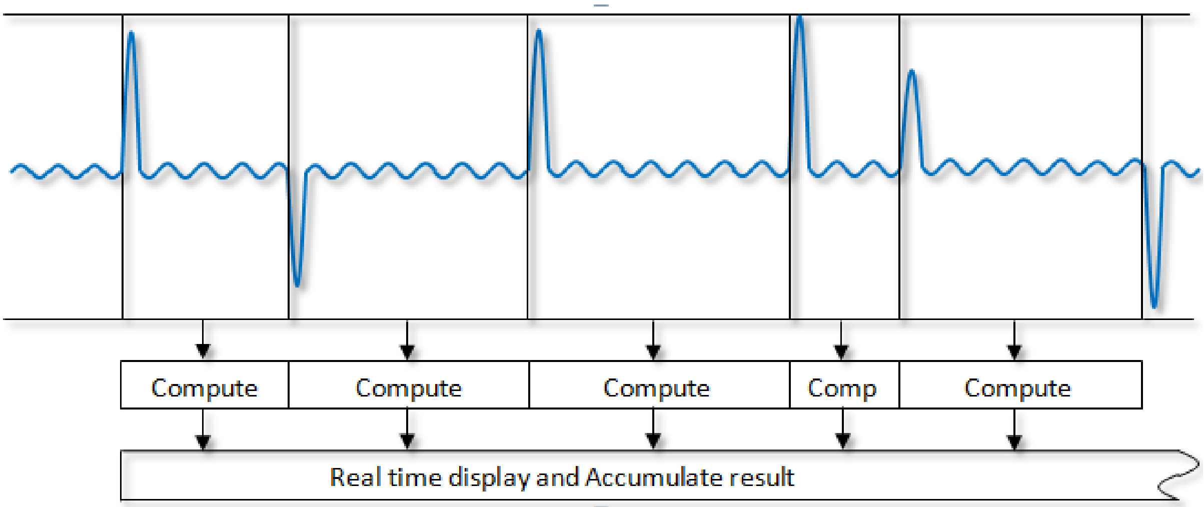


Most power analyzers have gaps between measurement windows, with non periodic current demand or multiple stage standby, such techniques may miss events and provide only an 'average approximation' rather than a 'true' measurement.

If an instrument with no measurement gap is selected, the consumed power measurement can include all events. Given the peaky nature of most standby current profiles, it is common to think only about the current pulses, but it is very important to accurately measure the residual current between peaks because this often represents a significant proportion of the total standby power.



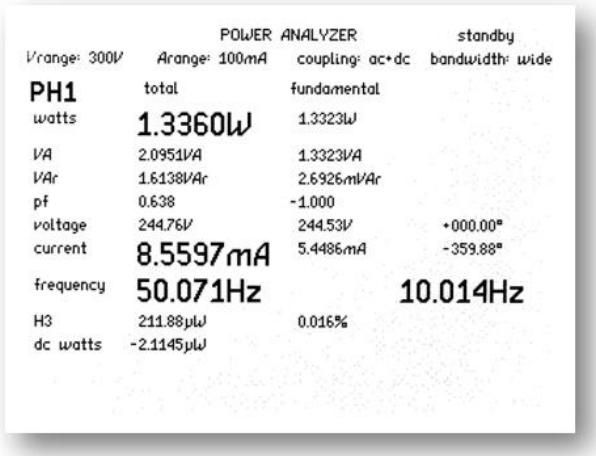
Ideal Solution

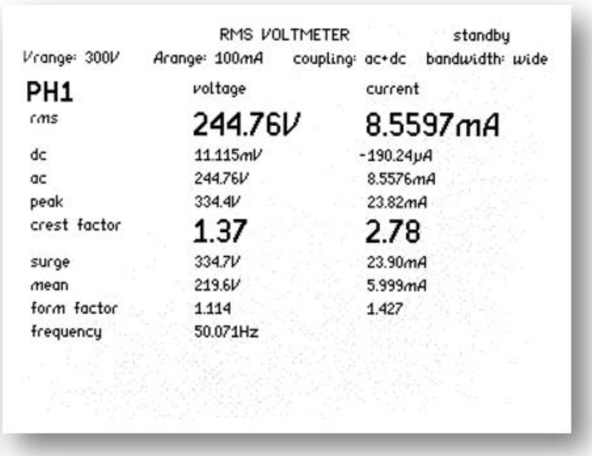


The ideal solution would have continuously variable measurement windows that automatically fit to the changing current pulse period. In this way, the power measurement will quickly reflect the true standby power.

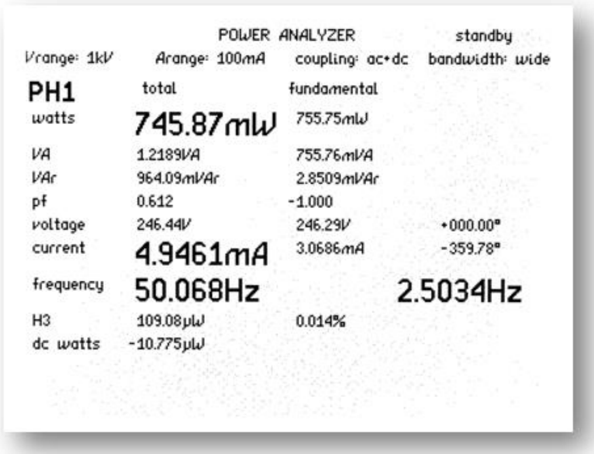
PPA Series standby mode – 1 in 5 cycles

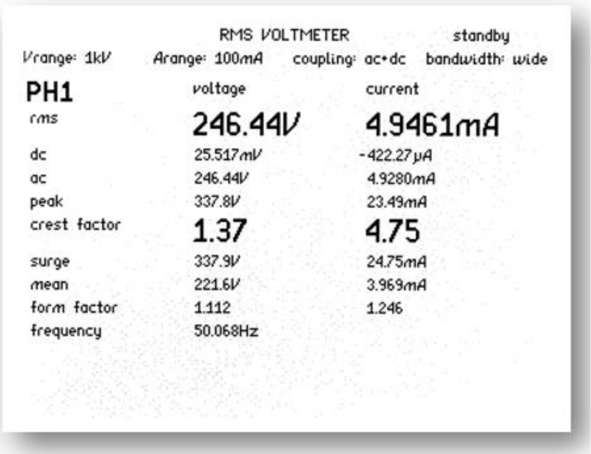
Here and in the following pages, we illustrate the measurement of three different low duty cycle standby modes using direct connection to the standard Voltage and Current inputs of a PPA series power analyzer.



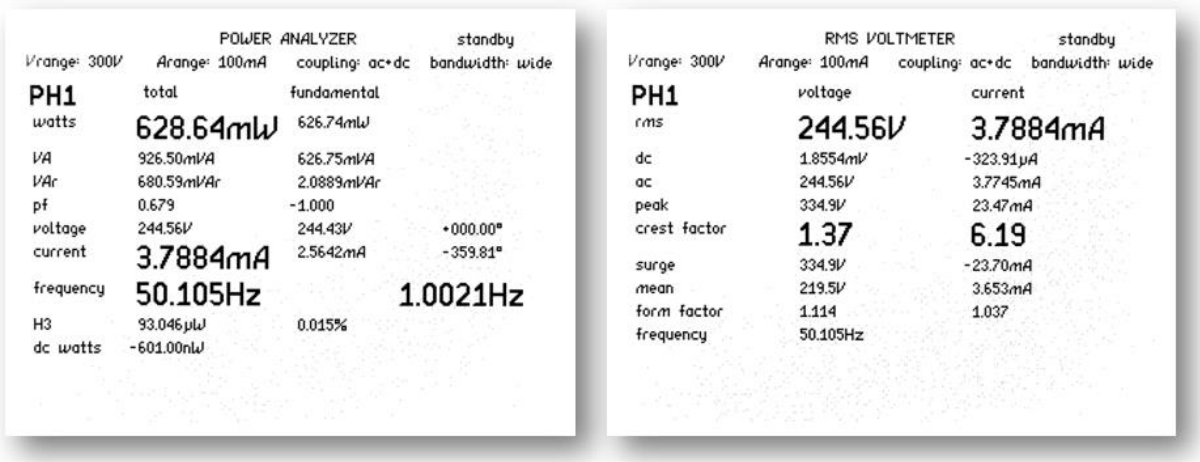


Duty cycle 1 - 5 Standby period 10Hz Note: 23.82mApk / 8.5597mArms = 2.78 CF





Duty cycle 1 - 20 Standby period 2.5Hz Note: 23.48mApk / 4.9461mArms = 4.75 CF



Duty cycle 1 - 50   Standby period 1Hz   Note: 23.47mApk / 3.7884mArms = 6.19 CF

Class leading frequency range, sample rate and crest factor combined with unique current shunt technology and no-gap analysis, the PPA series provides the best possible measurements for standby power to IEC62301.

Accuracy to IEC62301 and EnergyStar

Compliance to IEC62301 requires the ability to maintain defined measurement accuracy when measuring any DUT in standby mode. PPA series power analyzers provide complete assurance by being well within the required accuracy.

Required Watts accuracy @ > 0.5W =   2.0%

PPA2530 Measured accuracy is within   0.2%

Required Watts accuracy @ < 0.5W =   0.01W

PPA2530 Measured accuracy within   0.001W

The standard states that approved meters will include a “Power resolution of 1mW or better” and also that “Measurements of power of less than 0.5 W shall be made with an uncertainty of less than or equal to 0.01 W at the 95% confidence level”. The ideal measurement solution will therefore provide a resolution of 0.0001W.

Note: IEC62301 also specifies test conditions under which power measurements should be made. Total Harmonic Content of the supply voltage (up to and including the13th harmonic) must be less than 2%. Voltage Crest Factor should be between 1.34 and 1.49.

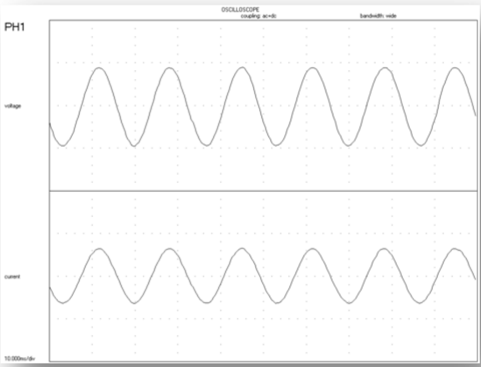
<u>Can you prove the power accuracy?</u>

Due to the complex nature of standby power, it is common for statements of accuracy to be made with little supporting evidence. However, in common with other areas of metrology, power accuracy can be proven by comparison of measurement results with a known or calculable reference.

In this case, three controllable elements are required:

1. Upper signal level – representing the 'pulse' (on period)
2. Lower signal level – representing the 'dead band' (off period)
3. A selectable duty cycle between the two levels

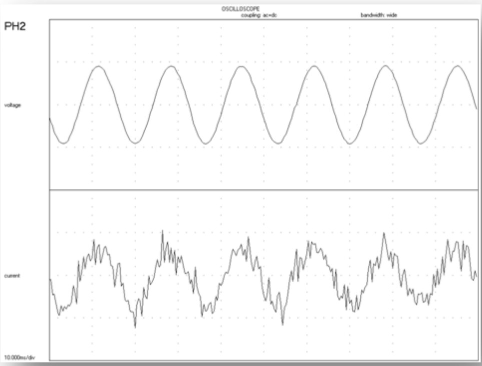
When each signal is constant, measurement of the respective power at upper and lower signal levels is quite straight forward. Deriving the correct power for a composite signal of defined duty cycle is then a simple ratio computation.



POWER ANALYZER

PH1	total	fundamental	
watts	2.7561W	2.7555W	
VA	2.7562VA	2.7555VA	
VAr	22.819mVAr	-1.0865mVAr	
pf	999.97m	1	
voltage	109.95V	109.93V	+000.000°
current	25.068mA	25.065mA	-000.023°
frequency	59.992Hz		
H3	5.1700µW	187.62µ%	
dc watts	-17.583nW		
V ph-ph	385.28mV	1.2598mV	-330.700°

External shunt (0.47mΩ 3Arms 30Apk)



POWER ANALYZER

PH2	total	fundamental	
watts	2.7561W	2.7554W	
VA	2.7617VA	2.7554VA	
VAr	176.79mVAr	-1.9445mVAr	
pf	997.95m	1	
voltage	109.94V	109.93V	+000.000°
current	25.120mA	25.065mA	-000.040°
frequency	59.992Hz		
H3	5.0539µW	183.42µ%	
dc watts	5.4920µW		
V ph-ph	109.93V	109.92V	-000.030°

Internal shunt (0.01mΩ 30Arms 300Apk)

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From the power measurements of pulse on and pulse off periods, we can calculate standby power simulations as follows:

Continuous Power = 2.75W   Off Power = 0.121W

1:4 Power = 1/5 on + 4/5 off
= 0.55W + 0.097 = **0.647W**

1:19 Power = 1/20 on + 19/20 off
= 0.1375W + 0.115 = **0.252W**

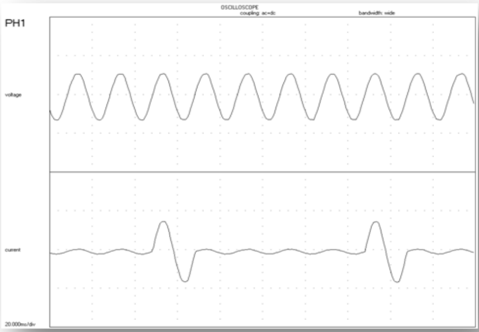
1:49 Power = 1/50 on + 49/50 off
= 0.055W + 0.119 = **0.174W**

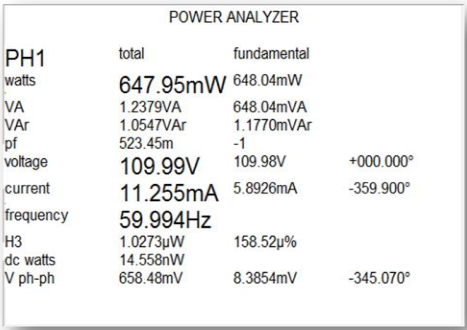
1 in 5 Standby Power Real Test

We will now use the same power supply measure in the previous pages and set it to 1 in 5 standby power mode.

Previously calculated 1 in 5 standby power from On and Off periods

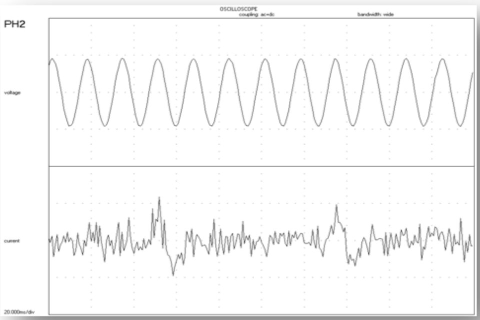
1:4 Power 0.55W+0.097= **0.647W**

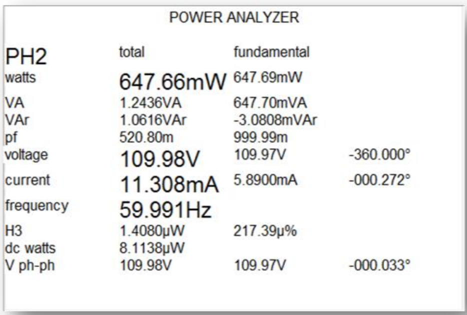



POWER ANALYZER

PH1	total	fundamental	
watts	647.95mW	648.04mW	
VA	1.2379VA	648.04mVA	
VAr	1.0547VAr	1.1770mVAr	
pf	523.45m	-1	
voltage	109.99V	109.98V	+000.000°
current	11.255mA	5.8926mA	-359.900°
frequency	59.994Hz		
H3	1.0273µW	158.52µ%	
dc watts	14.558nW		
V ph-ph	658.48mV	8.3854mV	-345.070°

External Shunt




POWER ANALYZER

PH2	total	fundamental	
watts	647.66mW	647.69mW	
VA	1.2436VA	647.70mVA	
VAr	1.0616VAr	-3.0808mVAr	
pf	520.80m	999.99m	
voltage	109.98V	109.97V	-360.000°
current	11.308mA	5.8900mA	-000.272°
frequency	59.991Hz		
H3	1.4080µW	217.39µ%	
dc watts	8.1138µW		
V ph-ph	109.98V	109.97V	-000.033°

Internal Shunt

The above pictures show the instrument measured very accurately the 1 in 5 standby power.

1 in 20 Standby Power

POWER ANALYZER

PH1	total	fundamental	
watts	252.76mW	252.77mW	
VA	627.87mVA	252.77mVA	
VAr	574.74mVAr	1.5574mVAr	
pf	402.57m	-999.98m	
voltage	109.99V	109.98V	+000.000°
current	5.7082mA	2.2983mA	-359.650°
frequency	59.992Hz		
H3	283.62nW	112.21µ%	
dc watts	315.02nW		
V ph-ph	492.13mV	6.8207mV	-359.820°

Internal Shunt

POWER ANALYZER

PH2	total	fundamental	
watts	252.94mW	252.96mW	
VA	639.27mVA	252.96mVA	
VAr	587.11mVAr	-1.1257mVAr	
pf	395.67m	999.99m	
voltage	109.99V	109.98V	-000.000°
current	5.8123mA	2.3002mA	-000.255°
frequency	59.993Hz		
H3	-120.44nW	-47.613µ%	
dc watts	1.6256µW		
V ph-ph	109.98V	109.97V	-000.031°

External Shunt

1:19 Power
= 1/20 on + 19/20 off
= 0.1375W + 0.115
= **0.252W**

1 in 50 Standby Power

POWER ANALYZER

PH1	total	fundamental	
watts	173.69mW	173.68mW	
VA	408.05mVA	173.68mVA	
VAr	369.23mVAr	1.6114mVAr	
pf	425.66m	-999.96m	
voltage	109.99V	109.97V	+000.000°
current	3.7100mA	1.5793mA	-359.470°
frequency	59.992Hz		
H3	125.29nW	72.138µ%	
dc watts	83.865nW		
V ph-ph	371.07mV	5.5310mV	-355.790°

Internal Shunt

POWER ANALYZER

PH2	total	fundamental	
watts	174.20mW	174.24mW	
VA	414.59mVA	174.26mVA	
VAr	376.21mVAr	2.7036mVAr	
pf	420.18m	-999.88m	
voltage	109.98V	109.97V	-000.001°
current	3.7697mA	1.5846mA	-359.110°
frequency	59.992Hz		
H3	1.3261µW	761.09µ%	
dc watts	-19.493µW		
V ph-ph	109.97V	109.96V	-000.037°

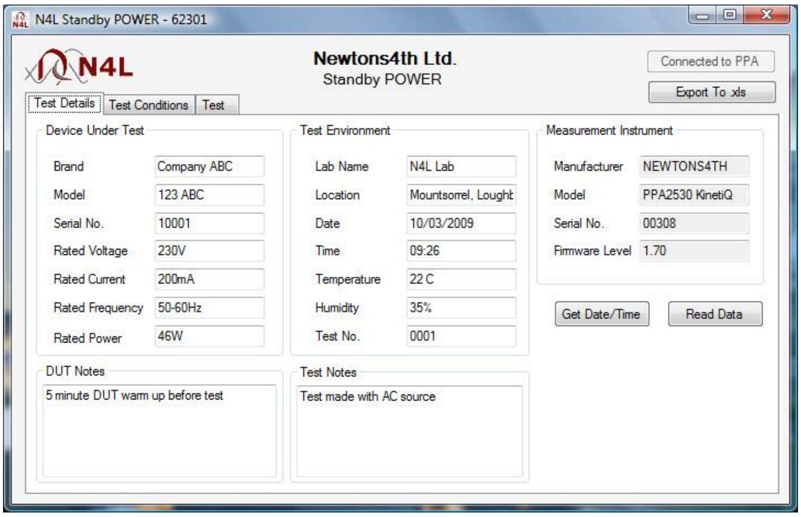
External Shunt

N4L complete solution to IEC62301

The 'Standby POWER' program makes testing that is compliant to IEC62301 a simple 4 step process.

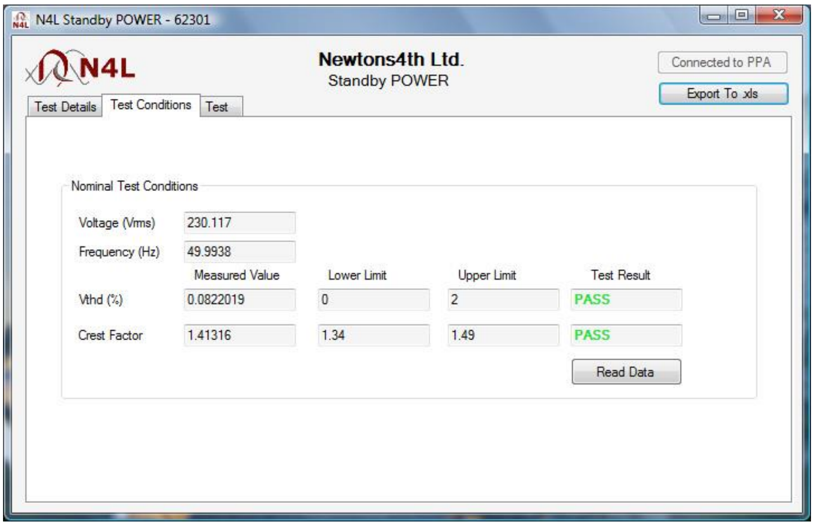
Step 1:

Enter details of DUT and Test Environment: Date, Time and Measurement Instrument details are entered buy a button click.



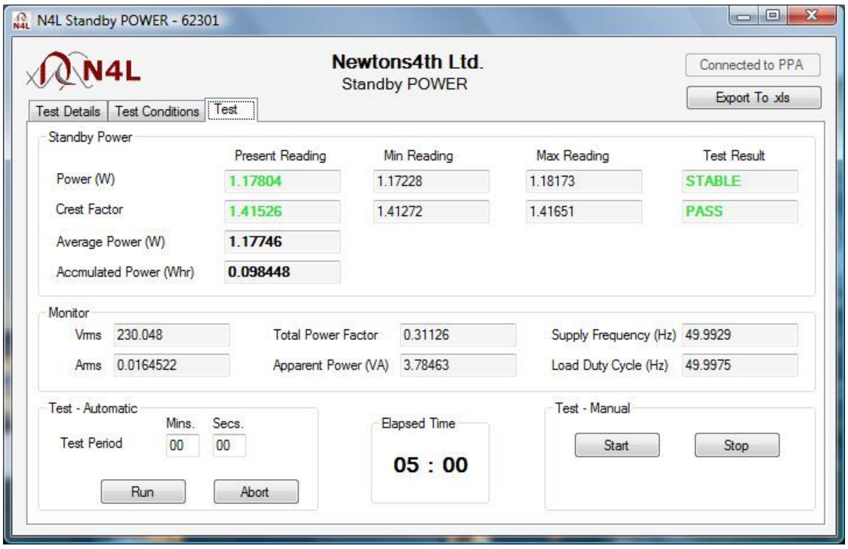
Step 2:

Nominal test conditions are tested by clicking on a 'read data' button. All values will be measured against the required limits.



Step 3:

Start a test with either manual ‘start’ – ‘stop’ buttons or set a test period, then ‘run’ and the standby power test will start, count down the requested time and then stop.



Step 4:

At the end of a manual or automatic test, click on the ‘Export to .xls’ button and a spreadsheet will open with all test details, test conditions and test results automatically entered. The spreadsheet can be saved to any file and is pre-formatted for direct printing.

See the following page for an example of the test report

Example Standby Power Test report in accordance with IEC62301

N4L - Standby Power Test Report - IEC 62301				
Test Details				
Device Under Test				
Brand	Company ABC			
Model	123 ABC			
Serial No.	10001			
Rated Voltage (Vrms)	230V			
Rated Current (Arms)	200mA			
Rated Frequency (Hz)	50-60Hz			
Rated Power (W)	46W			
DUT Notes	5 minute DUT warm up before test			
Test Environment				
Lab Name	N4L Lab			
Location	Mountsorrel, Loughborough, LE12 7AT, UK			
Date	10/03/2009			
Time	09:26			
Temperature	22 C			
Humidity	35%			
Test No.	1			
Test Notes	Test made with AC source			
Measurement Instrument				
Manufacturer	NEWTONS4TH			
Model	PPA2530 KinetiQ			
Serial No.	308			
Firmware Level	1.70			
Nominal Test Conditions				
Voltage (V)	230.117			
Frequency (Hz)	49.9938			
	Measured Value	Lower Limit	Upper Limit	Test Result
Vthd (%)	0.0822019	0	2	PASS
Crest Factor	1.41316	1.34	1.49	PASS
Test Results				
Monitor				
Vrms	230.048			
Arms	0.01645			
Total Power Factor	0.31126			
Apparent Power (VA)	3.78463			
Supply Frequency (Hz)	49.9929			
Load Duty Cycle (Hz)	49.9975			
Elapsed Time (mm:ss)	05:00			
Standby Power				
	Measured Value	Lower Limit	Upper Limit	Test Result
Power (W)	**1.17804**	1.17228	1.18173	STABLE
Crest Factor	1.41526	1.41272	1.41651	PASS
Average Power (W)	1.17746			
Accmulated Power (Whr)	0.098448			