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IEC 61000-4-30, Ed. 3 Compliance Report¹

Power Quality Measurement Methods

Power Standards Lab
PQube[®]3 Power Quality and Energy Analyzer

U_{din} : 230 V, 50 Hz

¹ *To be read in combination with IEC 61000-4-30, Ed. 2 Compliance Report*

November 2014

Summary of Results
Power Standards Lab, PQube®3
IEC 61000-4-30, Ed. 3 compliance
 when equipped with the following accessories or options:
 None

NOTE: the PQube®3 is certified for 61000-4-30 performance
 at $U_{din} = 230 \text{ V}$, 50 Hz.

Table 1: Summary of Results – PQube®3
 at 230 V L-N U_{din} (equivalent to 398 V L-L V_{rms}), 50 Hz
 when equipped with the following accessories:
 None

61000-4-30, Ed. 3 Section	Power Quality Parameter	Class A Compliance	Class S Compliance	Remarks
5.3	Flicker	Pass	Pass	
5.11	Rapid voltage changes	Pass	Pass	
5.13	Current	Pass	Pass	
Annex C	2 kHz - 150 kHz conducted emissions	Pass	N/A	Annex C is informative

Signed:  _____

Alex McEachern
 President, Power Standards Lab
 November 2014

Equipment under Test

EUT Manufacturer: Power Standards Lab
EUT Model: PQube3-PQ-E08N-0000
EUT S/N: P3001356
EUT Firmware version: 3.1.16R11
Accessories included in test: None (EUT powered from POE connection)

Test standard

IEC 61000-4-30 Ed. 3/FDIS © IEC:2014

Test parameters

Test location: Power Standards Lab, Alameda, California, U.S.A.
Test dates: November 2014
Supervising engineer: A. McEachern
Other participants: M. Muh

U_{din} selected by PSL for this report: **$U_{\text{din}} = 230 \text{ V}_{\text{rms}}$ at $f_{\text{nom}} = 50 \text{ Hz}$**

5.3 Flicker

Summary of 5.3 Flicker Conformance Results

Flicker measurements conform to Class A requirements	Yes
Flicker measurements conform to Class S requirements	Yes

Per IEC 61000-4-30, Ed. 3, Section 5.3.1, all tests were performed with reference to IEC 61000-4-15, Ed 2.0

Lamp response specification for this series of tests: 230 V, 50 Hz

Table 5.3 Class A – Summary of 61000-4-30, Ed. 3 Flicker Results

	61000-4-30 section	Flicker requirement	EUT conforms to Class A	Remarks
Engineering review	¶5.3.3, and IEC61000-4-15, ¶4.7	Verify P_{st} , P_{it} , P_{inst} values are available	Yes	Pass See Ed. 2 report.
Engineering review	Table 1 Line 3	EUT specifications meet required range for flicker	Yes	Pass See Ed. 2 report.
PSL Test 5.3(a)	IEC 61000-4-15, ¶5, Table 5, Line 4	Simple P_{inst} , P_{st} , P_{it} flicker measurement	Yes	Pass See Ed. 2 report.
PSL Test 5.3(b)	IEC 61000-4-15, ¶5.7.3	P_{it} aggregation	Yes	Pass See Ed. 2 report.
PSL Test 5.3(c)	¶6.2	Verify P_{inst} accuracy with sinusoidal and rectangular changes	Yes	Pass
PSL Test 5.3(d)	¶6.3	Verify P_{st} accuracy with rectangular voltage changes	Yes	Pass See Ed. 2 report.
PSL Test 5.3(e)	¶6.4	Verify accuracy with combined frequency and voltage changes	Yes	Pass
PSL Test 5.3(f)	¶6.5	Verify accuracy with distorted voltage	Yes	Pass
PSL Test 5.3(g)	¶6.6	Verify input bandwidth	Yes	Pass Input bandwidth is greater than 450 Hz.
PSL Test 5.3(h)	¶6.7	Verify accuracy with phase jumps	Yes	Pass
PSL Test 5.3(i)	¶6.8	Verify accuracy with rectangular voltage changes with duty ratio	Yes	Pass
PSL Test 5.3(j)	Table 1 Line 3	Measurement uncertainty over range of influence quantities	Yes	Pass See Ed. 2 report.

Table 5.3 Class S – Summary of 61000-4-30, Ed. 3 Flicker Results

	61000-4-30 section	Flicker requirement	EUT conforms to Class S	Remarks
Engineering review	¶5.3.3, and IEC61000-4-15, ¶4.7	Verify P_{st} , P_{fl} , P_{inst} values are available	Yes	Pass See Ed. 2 report.
Engineering review	Table 1 Line 3	EUT specifications meet required range for flicker	Yes	Pass See Ed. 2 report.
PSL Test 5.3(a)	IEC 61000-4-15, ¶5, Table 5, Line 4	Simple P_{inst} , P_{st} , P_{fl} flicker measurement	Yes	Pass See Ed. 2 report.
PSL Test 5.3(b)	IEC 61000-4-15, ¶5.7.3	P_{fl} aggregation	Yes	Pass See Ed. 2 report.
PSL Test 5.3(c)	¶6.2	Verify P_{inst} accuracy with sinusoidal and rectangular changes	Yes	Pass
PSL Test 5.3(d)	¶6.3	Verify P_{st} accuracy with rectangular voltage changes	Yes	Pass See Ed. 2 report.
PSL Test 5.3(j)	Table 1 Line 3	Measurement uncertainty over range of influence quantities	Yes	Pass See Ed. 2 report.

PSL Test Suite 5.3: Flicker

PSL Test 5.3(c) – Verify flicker P_{inst} accuracy with sinusoidal and rectangular voltage changes

Purpose of test: Verifies the measured value of P_{inst} according to Tables 1 and 2 of IEC 61000-4-15, for rectangular and sinusoidal voltage fluctuations. Applied waveforms are sinusoidal, V_{din} nominal, 50 Hz. Pass/fail criteria is $\pm 8\%$ of $P_{inst,max} = 1.00$ for the specified operating ranges and frequencies of the EUT.

Table 5.3(c)

Applied waveform	Expected P_{inst}	EUT $P_{inst,max}$ reading	Remarks	Result
PSL53c1.csv	1.00	1.00	Sinusoidal modulation, 0.5 Hz	Pass
PSL53c2.csv	1.00	1.00	Sinusoidal modulation, 1.5 Hz	Pass
PSL53c3.csv	1.00	1.02	Sinusoidal modulation, 8.8 Hz	Pass
PSL53c4.csv	1.00	1.02	Sinusoidal modulation, 20.0 Hz	Pass
PSL53c5.csv	1.00	1.01	Sinusoidal modulation, 25.0 Hz	Pass
PSL53c6.csv	1.00	1.01	Sinusoidal modulation, 33 1/3 Hz	Pass
PSL53c7.csv	1.00	1.00	Rectangular modulation, 0.5 Hz	Pass
PSL53c8.csv	1.00	1.00	Rectangular modulation, 3.5 Hz	Pass
PSL53c9.csv	1.00	1.01	Rectangular modulation, 8.8 Hz	Pass
PSL53c10.csv	1.00	1.02	Rectangular modulation, 18.0 Hz	Pass
PSL53c11.csv	1.00	1.01	Rectangular modulation, 21.5 Hz	Pass
PSL53c12.csv	1.00	1.01	Rectangular modulation, 25.0 Hz	Pass
PSL53c13.csv	1.00	1.00	Rectangular modulation, 28.0 Hz	Pass
PSL53c14.csv	1.00	1.01	Rectangular modulation, 30.5 Hz	Pass
PSL53c15.csv	1.00	1.00	Rectangular modulation, 33 1/3 Hz	Pass

PSL Test 5.3(e) – Verify flicker P_{inst} accuracy with combined frequency and voltage changes

Purpose of test: Verifies the measured value of $P_{inst,max}$ according to Table 6 of IEC 61000-4-15, for combined frequency and voltage changes. Applied waveforms are sinusoidal, V_{din} nominal, 50 Hz. Pass/fail criteria is $\pm 8\%$ of $P_{inst,max} = 1.00$.

Table 5.3(e)

Applied waveform	Expected P_{inst}	EUT $P_{inst,max}$ reading	Remarks	Result
PSL53e1.csv	1.00	1.02		Pass

PSL Test 5.3(f) – Verify flicker P_{inst} accuracy with distorted voltage with multiple zero crossings

Purpose of test: Verifies the measured value of $P_{inst,max}$ according to Table 8 of IEC 61000-4-15, for a distorted voltage with multiple zero crossings, consisting of the fundamental voltage U and harmonic levels according to Table 7 of IEC 61000-4-15. Distorted voltage is sinusoidally modulated at 8.8 Hz. Pass/fail criteria is $\pm 8\%$ of $P_{inst,max} = 1.00$.

Table 5.3(f)

Applied waveform	Expected P_{inst}	EUT $P_{inst,max}$ reading	Remarks	Result
PSL53f1.csv	1.00	1.01		Pass

PSL Test 5.3(g) – Verify input bandwidth using harmonic and inter-harmonic side band modulation

Purpose of test: Establishes the maximum bandwidth of the EUT using two modulating voltages with frequencies that are 10 Hz apart. To establish the maximum bandwidth, the modulating frequencies are increased in steps of 50 or 60 Hz, starting at the minimum frequencies specified in IEC 61000-4-15, Table 9. The highest frequency, $f_{v,max}$, for which $P_{inst,max} = 1.00$ with a tolerance of $\pm 8\%$ is the input bandwidth of the EUT. $f_{v,max}$ shall be at least 450 Hz. Applied waveforms are sinusoidal, V_{din} nominal, 50/60 Hz.

Table 5.3(g)

Applied waveform	Applied f_v	EUT measured $P_{inst,max}$	Remarks	Result
PSL53g1.csv	150 Hz	0.98	$f_i = 140$ Hz	Pass
PSL53g2.csv	200 Hz	0.96	$f_i = 190$ Hz	Pass
PSL53g3.csv	250 Hz	0.99	$f_i = 240$ Hz	Pass
PSL53g4.csv	300 Hz	1.01	$f_i = 290$ Hz	Pass
PSL53g5.csv	350 Hz	0.99	$f_i = 340$ Hz	Pass
PSL53g6.csv	400 Hz	0.99	$f_i = 390$ Hz	Pass
PSL53g7.csv	450 Hz	0.97	$f_i = 440$ Hz	Pass
PSL53g8.csv	500 Hz	0.96	$f_i = 490$ Hz	Pass

PSL Test 5.3(h) – Verify flicker P_{st} accuracy with phase jumps

Purpose of test: Verifies the measured value of P_{st} with a sequence of phase jumps, according to Table 10 of IEC 61000-4-15. Applied waveforms are sinusoidal, V_{din} nominal, 50/60 Hz. Pass/fail criteria is $\pm 5\%$ of P_{st} or ± 0.05 , whichever is larger.

Table 5.3(h)

Applied Waveform	Phase jump angle	Expected P_{st}	EUT P_{st} reading	Remarks	Result
PSL53j1.csv	+30°	0.913	0.94	Tolerance = ± 0.050	Pass
PSL53j2.csv	-30°	0.913	0.92	Tolerance = ± 0.050	Pass
PSL53j3.csv	+45°	1.060	1.10	Tolerance = ± 0.053	Pass
PSL53i4.csv	-45°	1.060	1.08	Tolerance = ± 0.053	Pass

PSL Test 5.3(i) – Verify flicker P_{st} accuracy with rectangular voltage changes with 20% duty cycle

Purpose of test: Verifies the measured value of P_{st} when the voltage is rectangularly modulated at 28 Hz with a duty cycle of 20%, according to Table 11 of IEC 61000-4-15. Applied waveforms are sinusoidal, V_{din} nominal, 50/60 Hz. Pass/fail criteria is $\pm 5\%$ of $P_{st} = 1.00$.

Table 5.3(i)

Applied waveform	Expected P_{st}	EUT P_{st} reading	Remarks	Result
PSL53i1.csv	1.00	1.02	See Note below	Pass

Note: PSL has determined there is an error in IEC 61000-4-15, Ed. 2.0, section 6.6, based on our simulations and tests. Our simulations and tests indicate that the values published in Table 11 are correct for a 50% duty cycle, instead of a 20% duty cycle. Accordingly, PSL Test 5.3(i) was performed with a 50% duty cycle. This error in IEC 61000-4-15, Ed. 2.0 has been reported to the Convener of the IEC SC77A Working Group, which is responsible for this standard.

5.11 Rapid Voltage Changes

Summary of 5.11 Rapid Voltage Changes Conformance Results

Rapid voltage change measurements conform to Class A requirements	Yes
Rapid voltage change measurements conform to Class S requirements	Yes

Table 5.11 Class A – Summary of Rapid Voltage Changes Results

	61000-4-30 section	Rapid voltage changes requirement	EUT conforms to Class A	Remarks
PSL Test 5.11.3(a)	¶5.11.3	Simple RVC measurement	Yes	Pass
PSL Test 5.11.2	¶5.11.2	RVC event discarded if voltage dip or swell detected	Yes	Pass
PSL Test 5.11.3(b)	¶5.11.3	Verify RVC event start time	Yes	Pass
PSL Test 5.11.4(a)	¶5.11.4	Verify measurement uncertainty – single-phase	Yes	Pass
PSL Test 5.11.4(b)	¶5.11.4	Verify measurement uncertainty – polyphase	Yes	Pass

Table 5.11 Class S – Summary of Rapid Voltage Changes Results

	61000-4-30 section	Rapid voltage changes requirement	EUT conforms to Class S	Remarks
PSL Test 5.11.3(a)	¶5.11.3	Simple RVC measurement	Yes	Pass
PSL Test 5.11.2	¶5.11.2	RVC event discarded if voltage dip or swell detected	Yes	Pass
PSL Test 5.11.3(b)	¶5.11.3	Verify RVC event start time	Yes	Pass
PSL Test 5.11.4(a)	¶5.11.4	Verify measurement uncertainty – single-phase	Yes	Pass
PSL Test 5.11.4(b)	¶5.11.4	Verify measurement uncertainty – polyphase	Yes	Pass

PSL Test 5.11.3(a) – Simple RVC measurement

Purpose of test: Verifies that EUT reports start time, duration, ΔU_{max} , ΔU_{ss} . Test is single-phase, applied to reference channel. Voltage is approximately U_{din} . For all tests in this section, RVC waveform applied is similar to the sample RVC waveform shown in IEC 61000-4-30, Ed. 3, Figure 6. RVC threshold = 5%, hysteresis = 2.5%.

Table 5.11.3(a)

Applied waveform	Applied duration	Applied ΔU_{max}	Applied ΔU_{ss}	EUT measured duration	EUT measured ΔU_{max}	EUT measured ΔU_{ss}	Result
PSL5113a1.csv	0.150 sec	17.5V	3.59V	0.160 sec	17.3V	3.4V	Pass
PSL5113a2.csv	0.200 sec	20.0V	6.74V	0.200 sec	19.8V	6.6V	Pass

PSL Test 5.11.2 – Verify RVC event discarded upon voltage dip/swell detection

Purpose of test: Verifies “If a voltage dip or voltage swell is detected during an RVC event, including the disabled 100/120 half cycles, then the RVC event is discarded because the event is not an RVC event. It is a voltage dip or voltage swell.” Test is single-phase, applied to reference channel. Voltage is approximately U_{din} .

Table 5.11.2

Applied waveform	Dip/swell magnitude	Dip/swell duration	Remarks	Result
PSL51121.csv	80% U_{din}	3 cycles	Verify that RVC event is discarded when voltage dip is detected	Pass
PSL51122.csv	130% U_{din}	3 cycles	Verify that RVC event is discarded when voltage swell is detected	Pass

PSL Test 5.11.3(b) – Verify start time of RVC event

Purpose of test: Verifies “The start time of an RVC event shall be time stamped with the time that the ‘voltage-is-steady-state’ logic signal became false and initiated the RVC event.” Test is single-phase, applied to reference channel. Voltage is approx U_{din} .

Table 5.11.3(b)

Applied waveform	Expected start time	EUT time stamp	Remarks	Result
PSL51131.csv	Approx. 15:54:32:391 PST	15:54:32:401 PST		Pass

PSL Test 5.11.4(a) – Verify RVC measurement uncertainty – single-phase

Purpose of test: Verifies uncertainty of an RVC event characterization, which “is determined by the uncertainty of U_{rms} measurements as described in 5.4.5.1, and on the correct implementation of the method in 5.11.1 and 5.11.2.” Based on this requirement, acceptable duration uncertainty is one cycle, and ΔU_{max} and ΔU_{ss} uncertainty are 0.2% U_{din} . Voltage is approximately U_{din} .

Table 5.11.4(a)

Applied waveform	Applied duration	EUT measured duration	Applied ΔU_{max}	EUT measured ΔU_{max}	Applied ΔU_{ss}	EUT measured ΔU_{ss}	Remarks/Result
PSL5114a1.csv	0.060 sec	0.060 sec	20.0V	19.9V	8.10V	8.1V	Pass Threshold = 6%, hysteresis = 2%
PSL5114a2.csv	0.130 sec	0.140 sec	15.4V	15.3V	3.99V	3.9V	Pass Threshold = 5%, hysteresis = 2.5%
PSL5114a3.csv	0.040 sec	0.040 sec	11.1V	10.9V	3.96V	3.9V	Pass Threshold = 3.5%, hysteresis = 1%

PSL Test 5.11.4(b) – Verify RVC measurement uncertainty – polyphase

Purpose of test: Verifies uncertainty of an RVC event characterization, which “is determined by the uncertainty of U_{rms} measurements as described in 5.4.5.1, and on the correct implementation of the method in 5.11.1 and 5.11.2.” Based on this requirement, acceptable duration uncertainty is one cycle, and ΔU_{max} and ΔU_{ss} uncertainty are 0.2% U_{din} . Voltage is approx U_{din} . Test is three-phase.

Table 5.11.4(b)

Applied waveform	Applied duration	EUT measured duration	Applied ΔU_{max}	EUT measured ΔU_{max}	Applied ΔU_{ss}	EUT measured ΔU_{ss}	Remarks/Result
PSL5114b1.csv	0.180 sec	0.180 sec	19.5V	19.7V	3.66V	3.5V	Pass Threshold = 5%, hysteresis = 2.5%
PSL5114b2.csv	0.250 sec	0.240 sec	19.8V	19.7V	4.54V	4.3V	Pass Threshold = 5%, hysteresis = 2.5%
PSL5114b3.csv	0.270 sec	0.280 sec	19.8V	19.7V	4.54V	4.3V	Pass Threshold = 5%, hysteresis = 2.5%
PSL5114b4.csv	0.150 sec	0.160 sec	17.3V	17.6V	3.69V	3.6V	Pass Threshold = 3.5%, hysteresis = 1%
PSL5114b5.csv	0.130 sec	0.130 sec	10.9V	10.7V	3.69V	3.5V	Pass Threshold = 3.5%, hysteresis = 1%

5.13 Current

Summary of 5.13 Current Measurement Results

Current measurements conform to Class A requirements	Yes
Current measurements conform to Class S requirements	Yes

Table 5.13 Class A, Ed. 3 – Summary of Current Measurement Results

	61000-4-30 section	Current measurement requirement	EUT conforms to Class A	Remarks
Magnitude of current				
Engineering review	Table 1, and ¶5.13.1.1, Paragraph 1	Manufacturer specifies full-scale rms current, with measuring range 10% to 150% FS and min. crest factor of 3.0	Yes	Pass EUT full-scale rms input (excluding external sensors) is 0.333V. EUT measuring range exceeds 10% to 150% and CF > 3.0.
PSL Test 5.13.1	None	Simple current magnitude measurement	Yes	Pass
PSL Test 5.13.1.1(a)	¶5.13.1.1, Paragraph 2	True RMS	Yes	Pass
PSL Test 5.13.1.1(b)	¶5.13.1	Contiguous non-overlapping intervals	Yes	Pass
Engineering review	¶5.13.1.1, Paragraph 4	±1% of reading uncertainty according to published specifications	Yes	Pass
PSL Test 5.13.1.1(c)	¶5.13.1.1, Paragraph 4	±1% of reading uncertainty over required range	Yes	Pass
PSL Test 5.13.1.2(a)	¶5.13.1.2	10/12-cycle RMS interval	Yes	Pass
PSL Test 5.13.1.2(b)	¶5.13.1.2	Aggregation conforming to ¶4.4 and ¶4.5 shall be used	Yes	Pass
Current recording				
Engineering review	¶5.13.2	Current recording	Yes	Pass
Harmonic currents				
Engineering review	IEC 61000-4-7, ¶1, Note 3	EUT specifications meet required range for harmonic order	Yes	Pass
Engineering review	IEC 61000-2-4	EUT specifications meet required amplitude range for current harmonics	Yes	Pass
Engineering review	IEC 61000-4-7, Table 1, Line 2 of Class 1	EUT specifications meet required accuracy for current harmonics	Yes	Pass

Table 5.13 Class A – Summary of Current Measurement Results (continued)

	61000-4-30 section	Current measurement requirement	EUT conforms to Class A	Remarks
Harmonic currents (continued)				
Engineering review	IEC 61000-4-7, ¶8	Operating conditions and errors caused by temperature, humidity, EUT supply voltage, common mode, static discharges, radiated EMF	Yes	Pass
PSL Test 5.13.3(a)	IEC 61000-4-7, ¶5.3 paragraph 2	Verify suitable anti-alias filter	Yes	Pass
PSL Test 5.13.3(b)	IEC 61000-4-7, ¶4.4.1	Verify 10/12 cycle window	Yes	Pass
PSL Test 5.13.3(c)	IEC 61000-4-30, ¶5.8	Verify gapless measurements and G_{sqn} implementation	Yes	Pass
PSL Test 5.13.3(e)	IEC 61000-4-7, ¶5.3, Table 1, Line 2	Verify single harmonic accuracy at $\geq 3\%$	Yes	Pass
PSL Test 5.13.3(f)	IEC 61000-4-7, ¶5.3, Table 1, Line 2	Verify single harmonic accuracy at $< 3\%$	Yes	Pass
PSL Test 5.13.3(g)	IEC 61000-4-30, ¶5.13.3	Verify harmonics aggregation	Yes	Pass
Interharmonic currents				
Engineering review	IEC 61000-2-4	EUT specifications meet required range for current interharmonics	Yes	Pass
Engineering review	IEC 61000-4-30, ¶5.13.4	Verify interharmonics aggregation	Yes	Pass
PSL Test 5.13.4(a)	IEC 61000-4-30, ¶5.13.4	Verify $C_{isq,n}$ implementation	Yes	Pass
PSL Test 5.13.4(b)	IEC 61000-4-7, ¶5.3, Table 1, Line 2	Verify single interharmonic accuracy	Yes	Pass
Current unbalance				
Engineering review	¶5.13.5	Verify negative-sequence-unbalance u_2 and zero-sequence-unbalance u_0 are available.	Yes	Pass
Engineering review	Table 1 Line 5	EUT specifications meet required range for current unbalance	Yes	Pass
PSL Test 5.13.5(a)	¶5.13.5	Verify unbalance measurement method – symmetrical components	Yes	Pass
PSL Test 5.13.5(a)	¶5.13.5	Verify unbalance measurement uncertainty	Yes	Pass
PSL Test 5.13.5(a)	¶5.13.5	Verify unbalance measurement aggregation	Yes	Pass

Note: IEC 61000-4-7:2002 is referenced in the table above, due to IEC 61000-4-30 ¶ 5.8.

Table 5.13 Class S, Ed. 3 – Summary of Current Measurement Results

	61000-4-30 section	Current measurement requirement	EUT conforms to Class S	Remarks
Magnitude of current				
Engineering review	¶5.13.1.1, Paragraph 1	Manufacturer specifies full-scale RMS current, with a minimum crest factor of 3.0	Yes	Pass
Engineering review	¶5.13.1.1, Paragraph 2	Manufacturer shall specify the RMS measurement method and period	Yes	Pass
PSL Test 5.13.1	none	Simple current magnitude measurement	Yes	Pass
Engineering review	¶5.13.1.1, Paragraph 4	±2% of reading uncertainty according to published specifications	Yes	Pass
PSL Test 5.13.1.1(b)	¶5.13.1.1, Paragraph 4	±2% of reading uncertainty over required range	Yes	Pass
Engineering review	¶5.13.1.2	Manufacturer or user shall specify measurement intervals	Yes	Pass
Current recording				
Engineering review	¶5.13.2	Manufacturer or user shall specify when current will be recorded	Yes	Pass
Harmonic currents				
Engineering review	¶5.13.3	Manufacturer shall specify measurement and aggregation methods	Yes	Pass
PSL Test 5.13.3(f)	IEC 61000-4-7, ¶5.3, Table 1, Line 2	Verify single harmonic accuracy	Yes	Pass
Interharmonic currents				
Engineering review	¶5.13.4	Manufacturer shall specify measurement and aggregation methods	Yes	Pass
Engineering review	¶5.13.4	Manufacturer shall specify measurement uncertainty. Measuring range shall be 10% to 100% of IEC 61000-2-4, Class 3	Yes	Pass
Current unbalance				
Engineering review	¶5.13.5	Manufacturer shall specify measurement and aggregation methods	Yes	Pass
Engineering review	¶5.13.5	Verify negative-sequence-unbalance u_2 and zero-sequence-unbalance u_0 (optional) are available.	Yes	Pass
Engineering review	Table 1 Line 5	EUT specifications meet required range for voltage unbalance	Yes	Pass
PSL Test 5.13.5(a)	¶5.13.5	Verify unbalance measurement uncertainty	Yes	Pass

PSL Test Suite 5.13: Current

Note: The EUT's current channels have voltage inputs, rated at 0.333V nominal. For all tests in this suite, a low-voltage signal simulating the voltage output of an external current sensor was applied to the EUT current channel under test, since external current sensors were not used in these tests. For the purposes of these tests, the resulting EUT current reading was translated into an equivalent voltage input.

PSL Test 5.13.1 – Simple current magnitude measurement

Purpose of test: Verifies general steady-state RMS magnitude accuracy. Verifies that we know how to make magnitude measurements with the EUT. Test is single-phase, applied to EUT current channel. Current is sinusoidal, 50 Hz. Voltage is applied to EUT reference channel for all tests in this suite.

Table 5.13.1

Applied frequency Hz	Applied V_{rms}	Ambient temperature °C	EUT current reading V_{rms}	Error V_{rms}	Remarks
50.000	0.333V	24°C	0.333V	0.000V	Pass
50.000	0.033V	24°C	0.033V	0.000V	Pass

PSL Test 5.13.1.1(a) – Verify current true RMS measurements

Purpose of test: Verifies "...the measurement shall be the $I_{rms(1/2)}$ value...." Test is single-phase, applied to EUT current channel. Current is series of non-sinusoidal waveforms (fundamental plus 20% 3rd harmonic and 30% 5th harmonic), approx. full-scale, 50/60 Hz. Ambient temperature approx. 23°C.

Table 5.13.1.1(a)

Applied waveform	Applied V_{rms} , frequency	EUT current reading V_{rms}	Remarks	Result
PSL51311a1.csv	0.354V, 50 Hz	0.354V	Verifies that EUT is using <u>true</u> RMS measurement method.	Pass

PSL Test 5.13.1.1(b) – Verify contiguous non-overlapping RMS intervals – current measurements

Purpose of test: Verifies “Every 10/12-cycle interval shall be contiguous with, and not overlap, adjacent 10/12 cycle intervals.” Test is single-phase, applied to EUT reference channel. Current waveforms are sinusoidal, ramping from 90% to 110% of nominal amplitude over the course of 10 or 20 cycles at 50 Hz, or 12 or 24 cycles at 60 Hz. Current amplitude ranges around full scale. Ambient temperature approx. 23°C.

NOTE: This test is performed only if EUT conforms to Class A requirements in PSL Test 5.2.1(c).

Table 5.13.1.1(b)

Applied waveform	Applied A_{rms} , frequency	Remarks	Result
PSL51311b1.csv	Varying, 50 Hz	Verifies that EUT is measuring RMS voltage over contiguous 12-cycle intervals	Pass
PSL51311b2.csv	Varying, 50 Hz	Verifies that EUT is measuring RMS voltage over non-overlapping 12-cycle intervals	Pass

PSL Test 5.13.1.1(c) – Verify current measurement uncertainty

Purpose of test: Verifies “The measurement uncertainty shall not exceed $\pm 1\%$ of reading in the range of 10% to 100% of the specified full-scale rms current.” Test is single-phase, applied to EUT current channel. Current is sinusoidal. This uncertainty requirement does not take into account uncertainties introduced by current sensors.

Table 5.13.1.1(c)

Applied waveform	Applied V_{rms} (% full scale), frequency	Reference meter reading	EUT 10-cycle reading RMS current	Error (%)	Result
PSL51311c1.csv	10%, 50 Hz	0.03332 V_{rms}	0.03329 V_{rms}	0.1%	Pass
PSL51311c2.csv	32.5%, 50 Hz	0.1082 V_{rms}	0.1082 V_{rms}	0.0%	Pass
PSL51311c3.csv	55%, 50 Hz	0.1830 V_{rms}	0.1831 V_{rms}	0.1%	Pass
PSL51311c4.csv	77.5%, 50 Hz	0.2495 V_{rms}	0.2497 V_{rms}	0.1%	Pass
PSL51311c5.csv	100%, 50 Hz	0.3327 V_{rms}	0.3329 V_{rms}	0.1%	Pass

PSL Test 5.13.1.2(a) – Verify 10/12 cycle RMS interval – current measurements

Purpose of test: Verifies “The basic measurement time interval for parameter magnitudes...shall be a 10-cycle time interval for 50 Hz power system or 12-cycle time interval for 60 Hz power system.” Test is single-phase, applied to EUT current channel. Current waveforms are sinusoidal, with amplitude alternating between 90% and 110% of nominal every 5 or 10 cycles for a 50 Hz system or 6 or 12 cycles for a 60 Hz system. Amplitude ranges around full-scale current. Ambient temperature approx. 23°C.

NOTE: This test is performed only if EUT conforms to Class A requirements in PSL Test 5.13.1.1.

Table 5.13.1.2(a)

Applied waveform	Applied A_{rms} frequency	Remarks	Result
PSL51312a1	Varying, 50 Hz	Verifies that EUT is measuring RMS current over an integer multiple of 10 cycles	Pass
PSL51312a2	Varying, 50 Hz	Verifies that EUT is measuring RMS current over fewer than 20 cycles	Pass

PSL Test 5.13.1.2(b) – Verify aggregation method – current measurements

Purpose of test: Verifies “Aggregation intervals as described in Clause 4.4 and Clause 4.5 shall be used.” For this test, we examine the published specifications to determine if they meet this requirement.

Table 5.13.1.2(b)

Aggregation interval	Verification	Remarks	Result
150/180 cycle interval	Engineering review		Pass
10 minute interval, absolute 10-min boundary	Engineering review		Pass
2-hour interval	Engineering review		Pass

PSL Test 5.13.3(a) – Verify suitable anti-alias filter – current measurements

Purpose of test: Verifies the requirement in 61000-4-7, 5.3: “An anti-aliasing low-pass filter, with a negative -3 dB frequency above the measuring range, shall be provided. The attenuation in the stop-band shall exceed 50 dB.” Single-phase test. Current is approx. full scale, 50 Hz nominal, with harmonics above the measured range. If the EUT sampling rate is greater than 256 samples per cycle, engineering review is sufficient to verify anti-alias filter.

Table 5.13.3(a)

Applied waveform	Remarks	Result
PSL5133a1	Checks for alias signal reflected into passband near upper end of passband	Pass per engineering review, since sampling rate is greater than 256 samples per cycle
PSL5133a2	Checks for alias signal reflected into passband well above upper end of passband	Pass per engineering review, since sampling rate is greater than 256 samples per cycle

PSL Test 5.13.3(b) – Verify 10/12 cycle window – current measurements

Purpose of test: Verifies the requirement in 61000-4-7, 4.4.1, “The time window shall be synchronized with each group of 10 or 12 cycles.” Single-phase test. Current is approx. full scale, 50 Hz nominal.

Table 5.13.3(b)

Applied waveform	Remarks	Result
Engineering review	Verifies 10 cycle windows at 50 Hz	Pass

PSL Test 5.13.3(c) – Verify gapless window and G_{sgn} implementation – current measurements

Purpose of test: Verifies requirement for “...gapless harmonic subgroup measurement...” Single-phase test. Current waveform for gapless windows verification consists of three or four repeating harmonic levels varying every 10 or 12 cycles. Current is approximately full scale, 50 Hz nominal.

Table 5.13.3(c)

Applied waveform	Remarks	Result
PSL5133c1	Verifies gapless windows at 50 Hz – part 1	Pass
PSL5133c2	Verifies gapless windows at 50 Hz – part 2 – must pass both parts to confirm gapless harmonics measurements	Pass
PSL5133c3	Verifies G_{sgn} implementation – 10% at 355 Hz plus 50-Hz fundamental	Pass 7 th harmonic: 10.0% of fundamental
PSL5133c4	Verifies G_{sgn} implementation – 10% at 145 Hz plus 50-Hz fundamental	Pass 3 rd harmonic: 10.0% of fundamental

PSL Test 5.13.3(e) (Class A) – Verify single current harmonic uncertainty – $I_m \geq 3\%$

Purpose of test: Verifies the uncertainty requirements of 61000-4-7 Table 1, line 2. RMS current is I_{nom} (nominal current range of EUT). Single-phase test. Harmonic orders and amplitudes based on twice the values in IEC 61000-2-4 class 3 (per line 5 of Table 1 in IEC 61000-4-30). All percentages are percent of I_{nom} . Fundamental current approx. full scale, 60 Hz nominal. Requirement is $\pm 5\%$ of I_m .

Table 5.13.3(e)

Applied waveform	Applied harmonic	EUT measured harmonic	Remarks	Result
PSL5133e1	16.0% 5 th	16.0%		Pass
PSL5133e2	10.0% 11 th	10.0%		Pass
PSL5133e3	7.0% 25 th	7.0%		Pass
PSL5133e4	4.7% 50 th	4.7%		Pass
PSL5133e5	12.0% 3 rd	12.0%		Pass
PSL5133e6	3.5% 21 st	3.5%		Pass
PSL5133e7	6.0% 2 nd	6.0%		Pass
PSL5133e8	4.0% 4 th	4.0%		Pass

PSL Test 5.13.3(f) (Class A) – Verify single current harmonic uncertainty – $I_m < 3\%$
Purpose of test: Verifies the uncertainty requirements of 61000-4-7 Table 1, line 2. RMS current is I_{nom} . Single-phase test. All percentages are percent of I_{nom} . Fundamental current approximately full scale, 60 Hz nominal. Requirement is $\pm 0.15\%$ of I_{nom} .

Table 5.13.3(f)

Applied waveform	Applied harmonic	EUT measured harmonic	Remarks	Result
PSL5133f1	2.9% 5 th	2.9%		Pass
PSL5133f2	1.5% 5 th	1.5%		Pass
PSL5133f3	2.0% 25 th	2.0%		Pass
PSL5133f4	2.0% 50 th	2.0%		Pass

PSL Test 5.13.3(f) (Class S) – Verify single current harmonic uncertainty
Purpose of test: Verifies the uncertainty requirements of 61000-4-7 Table 1, line 2. RMS current is I_{nom} (nominal current range of EUT). Single-phase test. Harmonic orders and amplitudes based on 100% of the values in IEC 61000-2-4 class 3 (per line 5 of Table 1 in IEC 61000-4-30). All percentages are percent of I_{nom} . Fundamental current approximately full scale, 60 Hz nominal. Requirement is 200% of IEC 61000-4-7, Class II (equal to $\pm 1.0\%$ of I_{nom}).

Table 5.13.3(e)

Applied waveform	Applied harmonic	EUT measured harmonic	Remarks	Result
PSL5133e1	8.0% 5 th	8.0%		Pass
PSL5133e2	5.0% 11 th	5.0%		Pass
PSL5133e3	3.5% 25 th	3.5%		Pass
PSL5133e4	2.3% 50 th	2.3%		Pass
PSL5133e5	6.0% 3 rd	6.0%		Pass
PSL5133e6	1.75% 21 st	1.74%		Pass
PSL5133e7	3.0% 2 nd	3.0%		Pass
PSL5133e8	1.5% 4 th	1.5%		Pass

PSL Test 5.13.3(g) – Verify current harmonics aggregation

Purpose of test: Verifies “Aggregation will be performed according to 4.5.” RMS current is approx. full scale. Single-phase test.

Table 5.13.3(g)

Applied waveform	Applied harmonic	EUT measured harmonic	Remarks	Result
Engineering review	Varies	Varies	150/180-cycle, 10-minute, and 2-hour aggregations are correct	Pass

PSL Test 5.13.4(a) – Verify $C_{isg,n}$ implementation – current measurements

Purpose of test: Verifies the implementation requirements for $C_{isg,n}$ found in IEC 61000-4-7, equations A3 and A4, and in Figure 6, and in Section 5.6. RMS current is approx. full scale. Single-phase test.

Table 5.13.4(a)

Applied waveform	Applied interharmonic	EUT measured interharmonic	Remarks	Result
PSL5134a1	10% at 175 Hz (3 rd interharmonic group)	10.0% 3 rd interharmonic	Basic check to see if interharmonics are measured	Pass
PSL5134a2	15% at 160 Hz + 10% at 190 Hz (= 18% 3 rd interharmonic group)	18.0% 3 rd interharmonic	Verification that $C_{isg,n}$ is implemented correctly	Pass

PSL Test 5.13.4(b) – Verify single current interharmonic uncertainty

Purpose of test: Verifies the uncertainty requirements of 61000-4-7 Table 1, line 2. RMS current is approx. full scale. Single-phase test. Interharmonic amplitudes based on twice the values in IEC 61000-2-4 Table 6 Class 3, per line 6 of Table 1 in IEC 61000-4-30. Interharmonic frequency is selected based on test. All percentages are percent I_{nom} .

Table 5.13.4(b)

Applied waveform	Applied interharmonic	EUT measured interharmonic	Remarks	Result
PSL5134b1	5.0% 3.5 th	5.0%		Pass
PSL5134b2	4.5% 11.5 th	4.5%		Pass
PSL5134b3	4.0% 13.5 th	4.0%		Pass
PSL5134b4	3.0% 23.5 th	3.0%		Pass
PSL5134b4	2.0% 49.5 th	2.0%		Pass

PSL Test 5.13.5(a) – Verify current unbalance measurement method

Purpose of test: Verifies “The basic measurement method for current unbalance shall be identical to the measurement method for supply voltage unbalance in Clause 5.7” and other requirements in 5.7.1. Test current is approximately full scale.

Table 5.13.5(a)

Applied waveform	Applied negative sequence unbalance U_2	Applied zero sequence unbalance U_0	EUT measured U_2	EUT measured U_0	Remarks	Result
PSL5135a1	9.82%	9.82%	9.81%	9.83%	Simple unbalance, sinusoidal waveforms	Pass
PSL5135a2	0.00%	0.00%	0.01%	0.01%	Differing non-sinusoidal waveforms with balanced fundamental, to verify that the EUT is using only the fundamental (i.e. symmetrical component evaluation)	Pass
PSL5135a3	9.61%	10.64%	9.62%	10.63%	Sinusoidal waveforms with equal fundamental but angles not equal to 120°, to verify that the EUT is using symmetrical component evaluation	Pass
PSL5135a4	Varies	Varies	Varies	Varies	Verifies that the measurement of unbalance is over a 10/12 cycle interval	Pass

PSL Test 5.13.5(b) – Verify current unbalance measurement uncertainty

Purpose of test: Verifies the uncertainty requirements in 5.7.2. Current is approximately full scale. The uncertainty shall be less than $\pm 0.15\%$ for both negative-sequence and zero-sequence unbalance ratio.

Table 5.13.5(b)

Applied waveform	Applied negative sequence	Applied zero sequence	EUT negative sequence	EUT zero sequence	Remarks	Result
PSL5135b1	0.30%	2.34%	0.29%	2.35%		Pass
PSL5135b2	0.54%	4.67%	0.54%	4.69%		Pass
PSL5135b3	2.38%	0.39%	2.37%	0.37%		Pass
PSL5135b4	4.69%	0.75%	4.68%	0.76%		Pass
PSL5135b5	51.13%	49.47%	51.13%	49.48%		Pass
PSL5135b6	53.29%	37.80%	53.30%	37.81%		Pass

PSL Test 5.13.5(c) – Verify current unbalance measurement aggregation

Purpose of test: Verifies the unbalance measurement aggregation. Current is approximately full scale.

Table 5.13.5(c)

Applied waveform	Applied negative sequence	Applied zero sequence	Remarks	Result
Engineering review	varies	varies	150/180-cycle, 10-min and 2-hour aggregations are correct.	Pass

Annex C (Informative) – Conducted Emissions in the 2 kHz – 150 kHz range

Summary of Annex C – Conducted Emissions Conformance Results

Conducted emissions measurements conform to Class A requirements	Pass¹
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Table C: Class A – Summary of Conducted Emissions Results

	61000-4-30 section	Conducted emissions requirement	EUT conforms to class A	Remarks
Engineering review	Annex C	Measurement methods of IEC 61000-4-7, Annex B, for 2 kHz to 9 kHz	Pass	
Engineering review	Annex C	Measurement method of CISPR 16-1-2 or IEC 61000-4-7, Annex B, or note in IEC 61000-4-30, Annex C, §C.3, for 9 kHz to 150 kHz	Pass	
Engineering review	Annex C	Measurement range should be at least 200% of largest applicable immunity level in IEC 61000-4-19, Table 1	Pass	EUT measurement range > 40 Vrms
PSL Test C.1	Annex C	Verify measurement uncertainty	Pass	
Engineering review	Annex C	Verify aggregation method	Pass	

¹ The 2 kHz – 150 kHz measurement method is informative in Edition 3. In this section, “Pass” means that the informative recommendations have been met, as noted.

PSL Test C.1 – Verify measurement uncertainty

Purpose of test: Verifies measurement uncertainty of conducted emissions readings (under consideration). Single-phase on reference channel.

For conducted emissions in the range 2 kHz to 9 kHz, suggested requirement is $\pm 5\% U_m$, for $U_m \geq 1\% U_{nom}$, and $\pm 0.05\% U_{nom}$, for $U_m < 1\% U_{nom}$.

For conducted emissions in the range 9 kHz to 150 kHz, suggested requirement is 10% of smallest applicable immunity level specified in IEC 61000-4-19, Table 1. EUT is tested at Class 3 test voltage levels, corresponding to a maximum uncertainty of 0.24 V_{rms} .

Table C.1

Applied waveform	Applied frequency	Applied amplitude	EUT measured amplitude	Remarks
PSLc1_1.csv	2.0 kHz	0.49 V_{rms}	0.49 V_{rms}	Pass
PSLc1_2.csv	2.0 kHz	4.95 V_{rms}	4.92 V_{rms}	Pass
PSLc1_3.csv	2.0 kHz	39.6 V_{rms}	39.4 V_{rms}	Pass
PSLc1_4.csv	6.0 kHz	0.50 V_{rms}	0.49 V_{rms}	Pass
PSLc1_5.csv	6.0 kHz	5.00 V_{rms}	4.95 V_{rms}	Pass
PSLc1_6.csv	9.0 kHz	0.51 V_{rms}	0.50 V_{rms}	Pass
PSLc1_7.csv	9.0 kHz	5.00 V_{rms}	4.97 V_{rms}	Pass
PSLc1_8.csv	10 kHz	2.40 V_{rms}	2.39 V_{rms}	Pass
PSLc1_9.csv	10 kHz	12.0 V_{rms}	12.0 V_{rms}	Pass
PSLc1_10.csv	10 kHz	24.0 V_{rms}	24.0 V_{rms}	Pass
PSLc1_11.csv	50 kHz	2.40 V_{rms}	2.34 V_{rms}	Pass
PSLc1_12.csv	50 kHz	7.01 V_{rms}	6.99 V_{rms}	Pass
PSLc1_13.csv	94 kHz	7.00 V_{rms}	6.85 V_{rms}	Pass
PSLc1_14.csv	100 kHz	1.00 V_{rms}	0.99 V_{rms}	Pass
PSLc1_15.csv	100 kHz	4.80 V_{rms}	4.72 V_{rms}	Pass
PSLc1_16.csv	150 kHz	1.00 V_{rms}	0.99 V_{rms}	Pass
PSLc1_17.csv	150 kHz	4.80 V_{rms}	4.76 V_{rms}	Pass