NATIONAL PHYSICAL LABORATORY
Teddington Middlesex UK TW11 0LW Switchboard 020 8977 3222

Certificate of Calibration

UKAS CALIBRATION 0478

Universal Power Analyser
Type PM6000 S/No. 100006700004

FOR	Voltech Instruments Limited 148 Harwell Science and Innovation Campus Didcot OX11 0RA
ORDER REFERENCE	28272 dated 9 November 2006
MANUFACTURER	Voltech Instruments Limited
DATE OF CALIBRATION	5 March 2007 to 26 March 2007
MEASUREMENT NUMBER	ED.17/07/004/EtD 335.074

The mains circuit of the Power Analyser was energised from a nominal 230 V mains supply for at least 24 hours before any tests were carried out.

The instrument was tested at a mean ambient temperature of 23.0 ± 1.0 °C.

The reported uncertainties are based on a standard uncertainty multiplied by a coverage factor as specified, providing a level of confidence of approximately 95%. The uncertainties relate only to the measured value and carry no implication regarding the stability of the instrument. The uncertainty evaluation has been carried out in accordance with UKAS requirements.

The Power Analyser was used with a 2.4 GHz Pentium 4 PC with 512 MB of RAM. Drive C contained a 19.5 GB hard disk drive, with approximately 9.7 GB free. The computer was interfaced to the Power Analyser using the customer provided RS232 interface lead. Customer provided software was used which was identified as follows:

IEC61000-3 For PM6000 Release 1.03.02, IEC1000.exe, Last Modified 02/11/06, 942,080 bytes.

Reference: E06100288/1 **Page 1 of 10**

Date of Issue: 17 May 2007 **Signed:** (signature) **(Authorised Signatory)**

Checked by: (initials) **Name: P S Wright** **for Managing Director**

For all tests the following configuration was selected via the Config / View Settings menu:

WIRING:	1 Phase 2 Wire
RANGE:	Voltage 500V; Current 25A
COUPLING:	AC+DC
SCALING:	Ch 1: Volts 1, Current 1
FILTER:	2 MHz
FREQUENCY SOURCE:	Volts
PHASE REFERENCE:	Volts
MODE:	IEC Harmonics
INTEGRATE:	Off

Under View Hardware, the following was recorded.

PM6000:	S/N 100006700004; Firmware v1.11.04 RC1
Channel 1:	S/N 090015500069, Hardware 21, Date Calibrated 4 Jul 2006
Shunt Type 30A:	S/N 091024300051, Hardware 4, Date Calibrated 11 Aug 2006
Channel 2:	S/N 090015500007, Hardware 21, Date Calibrated 5 Jul 2006
Shunt Type 30A:	S/N 091024300051, Hardware 21, Date Calibrated 11 Aug 2006
Channel 3:	S/N 090015500035, Hardware 21, Date Calibrated 6 Jul 2006
Shunt Type 1A:	S/N 091024300031, Hardware 4, Date Calibrated 18 Aug 2005

The current terminals marked 'CH1' were used in all tests. The voltage terminals marked 'CH1' were used in all tests. The current and voltage terminals marked 'LO' were independently connected to earth potential.

EN 61000-4-7: 2002, Section 5.3 states that "the uncertainty terms are related to the permissible limits (5 % of the permissible limits) or the rated current (I_r) of the tested appliance (0.15 % I_r) whichever is greater". Where applicable Target Errors based on 5 % of reading have been given in the following tables.

Current Accuracy and Linearity Tests

Purpose of Tests

These tests assess the accuracy of the Power Analyser on a selection of its ranges, in order to test for any errors that are outside the 5 % limit stated in EN 61000-4-7: 2002.

Measurement Method and Results

During these tests the Power Analyser readings from the Power Analyser display were observed.

The nominal ac currents as shown in Table 1 were applied to the Power Analyser. The frequency of the applied current was 50 Hz. The waveforms were sinusoidal with distortion of less than 0.1 %. The dc component of the applied current was negligible.

During these tests voltage CH1 of the Power Analyser was connected to a nominal 230 V RMS, 50 Hz signal with a fixed phase relationship to the applied fundamental current.

The current results in Table 1 were obtained from the reading on the Power Analyser display, after the current had been applied for approximately 5 minutes, on the peak current ranges shown. The uncertainties given in Table 1 are based on a standard uncertainty multiplied by a coverage factor $k = 2.37$, providing a level of confidence of approximately 95 %.

Table 1 - Accuracy and Linearity Tests

Nominal Applied RMS Current (A)	Peak Current Range (A)	Instrument Reading (A)	Instrument Error (mA)	Uncertainty in Instrument Error (mA)	Target Error (mA)
16.000	50.0	16.004	+4	±3	±800
13.500	25.0	13.502	+2	±3	±675
6.500	10.0	6.501 1	+1.1	±0.3	±325.0
3.400	5.0	3.400 7	+0.7	±0.2	±170.0
1.300	2.5	1.300 7	+0.7	±0.2	±65.0
0.650	1.0	0.650 37	+0.37	±0.03	±32.50
0.330	1.0	0.330 16	+0.16	±0.02	±16.50
0.100	0.5	0.100 32	+0.32	±0.01	±5.00
0.065	0.5	0.065 342	+0.342	±0.010	±3.250
0.025	0.5	0.025 823	+0.823	±0.010	±1.250

The RMS voltages shown in Table 2 were applied to voltage CH1 of the Power Analyser, on the peak voltage ranges shown. The frequency of the applied voltage was 50 Hz. The voltage results in Table 2 were obtained from the reading on the Power Analyser display. The uncertainties given in Table 2 are based on a standard uncertainty multiplied by a coverage factor $k = 2$, providing a level of confidence of approximately 95 %.

Table 2 - Voltage Indications

Nominal Applied RMS Voltage (V)	Voltage Range (V)	Instrument Reading (V)	Instrument Error (V)	Uncertainty in Instrument Error (V)	Target Error (V)
230	500	230.32	+0.32	±0.01	±11.50
115	200	115.11	+0.11	±0.01	±5.75

Checked by:

Power Measurements

Purpose of Tests

If the power measured by the Power Analyser during a compliance test differs from the power specified by the manufacturer by more than 10 % then it should be used to determine the Class-D harmonic limits, as stated in Section 6.2.2 of IEC61000-3-2: 2000: Amendment 1:2001-08. It is therefore important that the Power Analyser measures power accurately in order that it calculates the limits correctly when performing compliance tests on Class D equipment.

Measurement Method and Results

During these tests the Power Analyser readings were taken from the Power Analyser display.

For true power measurements, the Power Analyser was tested with sinusoidal alternating voltage and or current applied, the distortions of which were less than 0.1 %. The DC components of AC voltage and AC current were negligible.

The Power Analyser was tested at a nominal voltage of 240 V RMS and at nominal currents and power factors as shown in Table 3. Lag and Lead in Table 3 refer to current lagging and current leading respectively. The uncertainties given in Table 3 are based on a standard uncertainty multiplied by a coverage factor k = 2.13, providing a level of confidence of approximately 95 %.

Table 3, Power Measurements, 50 Hz

Nominal Applied RMS Voltage (V)	Nominal Applied RMS Current (A)	Nominal Power Factor	Nominal Power (W)	Instrument Indication (W)	Instrument Error (W)	Uncertainty in Instrument Error (W)
240	1.25	0.5 Lag	150	150.33	+0.33	±0.03
"	"	0.5 Lead	150	150.18	+0.18	±0.03
"	0.625	Unity	150	150.27	+0.27	±0.03

Steady State Harmonics Tests

Purpose of Tests

These tests assess the ability of the Power Analyser to correctly measure steady state harmonics to an accuracy within the 5 % limit stated in EN 61000-4-7: 2002, Section 5.3, when testing equipment having Class A or Class D characteristics.

Measurement Method

Harmonics tests were carried out using the program supplied as described on Page 1. The program was configured to 'EN61000:2001', 'Fluctuating Harmonics' mode, with a test time of 2 minutes and 30 seconds. The Power Analyser results were written to a data file on the controlling computer and the reported results were obtained by averaging the results given in the data file.

The Power Analyser was tested with a 50 Hz fundamental current and appropriate levels of associated harmonic currents. The fundamental component of the applied current was phase-locked to the signal that supplied the voltage channel.

Class-A Wave Shape

The nominal amplitude of the harmonics was set at the Class-A limits as defined in Table 1 of IEC61000-3-2: 2000-08, page 33. The fundamental amplitude was set to a nominal 2.3 A RMS. The dc component of the applied current was negligible. Voltage CH1 of the Power Analyser was supplied with a nominal 230 V RMS sinusoidal voltage at 50 Hz. The distortion of the voltage waveform was less than 0.1 % of value.

The Power Analyser program was configured to Class-A mode. The Power Analyser was configured to perform the measurements on the 25 A Peak range.

The phases of the harmonics were set such that harmonics 2, 5, 6... 37, 38 were set to zero phase relative to the fundamental and harmonics 3, 4, 7, 8...39, 40 set to 180 degrees relative to the fundamental. This combination of harmonic amplitudes and phases gives a wave shape with well defined positive and negative going peaks.

Class A Steady State Harmonics Results

The resulting harmonic amplitudes as measured by the Power Analyser are given in Table 4. The uncertainties given in Table 4 are based on a standard uncertainty multiplied by a coverage factor $k = 2$, providing a level of confidence of approximately 95 %.

Table 4, Class A Tests					
Harmonic Number	Nominal Harmonic Amplitude (A)	Instrument Reading (A)	Instrument Error (mA)	Uncertainty in Instrument Error (mA)	Target Error (mA)
2	1.080 0	1.076 5	−3.5	±0.8	±54.0
3	2.300 0	2.297 5	−2.5	±1.6	±115.0
4	0.430 0	0.430 5	+0.5	±0.3	±21.5
5	1.140 0	1.140 8	+0.8	±0.8	±57.0
6	0.300 0	0.301 8	+1.8	±0.2	±15.0
7	0.770 0	0.769 0	−1.0	±0.6	±38.5
8	0.230 0	0.230 2	+0.2	±0.2	±11.5
9	0.400 0	0.402 0	+2.0	±0.3	±20.0
10	0.184 0	0.184 8	+0.8	±0.2	±9.2
11	0.330 0	0.330 0	−0.0	±0.3	±16.5
12	0.153 3	0.153 6	+0.3	±0.2	±7.7
13	0.210 0	0.210 8	+0.8	±0.2	±10.5
14	0.131 4	0.131 4	+0.0	±0.1	±6.6
15	0.150 0	0.150 1	+0.1	±0.1	±7.5
16	0.115 0	0.115 4	+0.4	±0.1	±5.8
17	0.132 4	0.132 0	−0.3	±0.1	±6.6
18	0.102 2	0.102 3	+0.1	±0.1	±5.1
19	0.118 4	0.118 2	−0.3	±0.1	±5.9
20	0.092 0	0.092 5	+0.5	±0.1	±4.6
21	0.107 1	0.107 8	+0.7	±0.1	±5.4
22	0.083 6	0.084 0	+0.4	±0.1	±4.2
23	0.097 8	0.097 9	+0.1	±0.1	±4.9
24	0.076 7	0.076 5	−0.2	±0.1	±3.8
25	0.090 0	0.091 0	+1.0	±0.1	±4.5
26	0.070 8	0.070 9	+0.1	±0.1	±3.5
27	0.083 3	0.083 4	+0.1	±0.1	±4.2
28	0.065 7	0.065 5	−0.2	±0.1	±3.3
29	0.077 6	0.077 8	+0.3	±0.1	±3.9
30	0.061 3	0.061 3	+0.0	±0.1	±3.1
31	0.072 6	0.072 6	−0.0	±0.1	±3.6
32	0.057 5	0.057 8	+0.3	±0.1	±2.9
33	0.068 2	0.068 4	+0.2	±0.1	±3.4
34	0.054 1	0.054 0	−0.2	±0.1	±2.7
35	0.064 3	0.064 5	+0.2	±0.1	±3.2
36	0.051 1	0.051 4	+0.3	±0.1	±2.6
37	0.060 8	0.061 3	+0.5	±0.1	±3.0
38	0.048 4	0.048 7	+0.3	±0.1	±2.4
39	0.057 7	0.057 8	+0.1	±0.1	±2.9
40	0.046 0	0.045 7	−0.3	±0.1	±2.3

Class A Limit Pass/Fail Indication Tests

These tests were performed in order to test the performance of the Power Analyser's reported Pass/Fail indication for each harmonic.

A Class-A waveform was applied to the Power Analyser and results were obtained as described in the 'Steady State Harmonic Tests' 'Class-A Wave Shape' section above.

In order to test the Power Analyser's 'Fail' indication, the amplitudes of the harmonics were adjusted so that the average amplitudes reported by the Power Analyser were marginally above the Class-A limits. The Power Analyser was found to correctly report 'Fail' for each harmonic and an overall test 'FAIL'.

In order to test the Power Analyser's 'Pass' indication, the amplitudes of the harmonics were then adjusted so that the average amplitudes reported by the Power Analyser were marginally below the Class-A limits. The Power Analyser was found to correctly report 'Pass' for each harmonic and an overall test 'PASS'.

Partial Odd Harmonic Current Limit Assessment

IEC61000-3-2: 2000: Amendment 1:2001-08 specifies limits for odd harmonics at the 21st and above (high harmonics). It states that these harmonics may go up to 150 % of the specified limits, provided the partial odd harmonic current (POHC) is less than the POHC of the limit values. This allows for a small number of the high harmonics to be excessive, provided the overall high harmonic current is not.

The following tests were used to assess the Power Analyser's ability to correctly report a 'Pass' or 'Fail' based on the harmonic values reported by the Power Analyser, relative to the reported POHC.

Test 1 – POHC Pass: The POHC is below the limit POHC. Harmonic 21 (H21) and harmonic 39 (H39) are set to nominally 140 % of the limits. All other harmonics are at nominally 75 % of the limits. Therefore the DUT should indicate a pass.
The Power Analyser correctly indicates 'Pass' at both H21 and H39 and indicates an overall test 'PASS'. The Power Analyser also correctly reports that the reason for the overall 'PASS' indication is that the POHC is not exceeded, even though there are odd harmonics with an average current above the limit value.

Test 2 – POHC Fail Due to Harmonic: The POHC is below the limit POHC. H21 and H39 are set to nominally 155 % of the limits. All other harmonics are at nominally 75 % of the limits. Therefore the DUT should indicate a fail.
The Power Analyser correctly indicates 'Fail' at both H21 and H39 and indicates an overall test 'FAIL', as well as the reason for the failure being a harmonic current above 150 % of the harmonic limit.

Test 3 – POHC Fail Due to POHC Limit: The POHC is ABOVE the limit POHC. H21 and H39 are set to nominally 140 % of the limits. All other harmonics are at nominally 90 % of the limits. Therefore the DUT should indicate a fail.
The Power Analyser correctly indicates 'Fail' at both H21 and H39 and indicates an overall test 'FAIL' and that the reason for the failure is that the POHC is above the POHC limit.

Test 4 – POHC Fail Due to Even High: POHC does not include exceptions for even harmonics so all even harmonics above H21, which are above the harmonic limits, should give a failure. The POHC is set below the limit POHC. Harmonic 22 is set to nominally 105 % of the limit. All other harmonics are at nominally 75 % of the limits. Therefore the DUT should indicate a fail.
The Power Analyser correctly indicates 'Fail' at harmonic 22 and indicates an overall test 'FAIL'.

Measurement of POHC and POHC Limits

The values of 'Maximum POHC' and 'POHC Limit' from the Power Analyser report were compared to the values calculated from the harmonic results and limits using the equation in Section 3.18 of IEC61000-3-2: 2000: Amendment 1:2001-08. These values are given in Table 5.

Table 5, POHC Measurements

	Calculated (A)	IEC 61000-3 Software Report (A)
Maximum POHC	0.190	0.190
POHC Limit	0.251	0.251

Class D limit Assessment.

Class D limits are calculated using the power. The power is obtained either from the user's entered value or the measured power. If these two values differ by more than 10 % then the measured power is to be used (see Section 6.2.2 of IEC61000-3-2: 2000: Amendment 1:2001-08).

The IEC61000-3 software was tested at a nominal voltage of 240 V, a nominal current of 2.5 A RMS and a nominal power factor of 0.5, i.e. with a nominal power of 300 W. Class D tests were selected and 300 W was entered for the specified power. The device reported that the measured power was 299.6255 W.

The IEC61000-3 software correctly calculated the Class D limit using the 300 W specified power.

The test was repeated with 269 W entered as the specified power. The IEC61000-3 software reported that the measured power was 299.4197 W, which differs from the specified power by greater than 10 %. **The IEC61000-3 software reported that this was the case but still used the specified power to calculate the Class D limits. For any test where the software reports that the specified power differs from the measured power by greater than 10 %, the 'Result: Change Test Details:' menu option should be used to recalculate the limits with the specified power changed to be exactly equal to the measured power, otherwise it is possible that the IEC61000-3 software could erroneously fail a unit under test.**

Flicker Severity Measurements

Purpose of Tests

These tests assess the ability of the Power Analyser to perform flicker measurements on 50 Hz systems to the accuracy required by IEC 61000-4-15: 1997 Amendment 1:2003-01. According to IEC 61000-4-15: 1997 Amendment 1:2003-01, for the conditions given in Table 5, page 27 for 50 Hz systems, the Power Analyser should measure a flicker severity value of 1.00 ± 0.05. These limits are given as the target values for Pst in Table 6.

Measurement Method

For these tests, a 50 Hz sinewave of nominal amplitude of 230 V RMS was amplitude modulated (A.M.) by a square wave at frequencies as shown in Table 6. The modulation caused the amplitude of the sinewave to have two distinct root mean square (RMS) levels, the higher of the two is defined as V_{RMS1} and the lower is defined as V_{RMS2}. The amplitude of the modulating square wave was adjusted to give the required $\left(\frac{DV}{V}\right)\%$ values, where $\left(\frac{DV}{V}\right)\%$ is defined as follows:

$$\left(\frac{DV}{V}\right)\% = 200\frac{(V_{RMS1} - V_{RMS2})}{(V_{RMS1} + V_{RMS2})}$$

The frequency of modulation determines the number of voltage level changes per minute as shown in Table 6.

Prior to modulation, the distortion of the carrier voltage was less than 0.05 %. The dc component of the applied voltage was negligible.

Each signal of the required $\left(\frac{DV}{V}\right)\%$ and frequency of modulation was applied to the device. The Power Analyser program was configured to 'Flicker' mode. The Power Analyser performed these tests in 'Flicker' mode. A 10 minute test time was used for all tests.

Flicker Measurement Results

The results in Table 6 were obtained from the readings given by the Power Analyser program. The uncertainties given in Table 6 are based on a standard uncertainty multiplied by a coverage factor $k = 2.13$, providing a level of confidence of approximately 95%.

Table 6, Classifier 1 Pst Measurements, 50 Hz Sinewave Carrier					
Modulation Frequency (mHz)	Voltage Changes per Minute	Nominal Applied DV/V (%)	Instrument Pst Reading	Uncertainty in Pst (Pst Units)	Target Pst Reading
8.333	1	2.724	0.980	±0.028	0.95 to 1.05
58.333	7	1.459	0.987	±0.028	0.95 to 1.05
916.667	110	0.725	0.984	±0.028	0.95 to 1.05
13 500	1 620	0.402	0.992	±0.028	0.95 to 1.05
33 333	4 000	2.4	0.978	±0.028	0.95 to 1.05

END OF MEASUREMENTS