



HA1600
Power and Harmonics Analyser
with Flicker Meter

Operating Manual



Measurably Better Value

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EC Declaration of Conformity

We Thurlby Thandar Instruments Ltd
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declare that the

HA1600 Power and Harmonics Analyser

meets the intent of the EMC Directive 89/336/EEC and the Low Voltage Directive 73/23/EEC. Compliance was demonstrated by conformance to the following specifications which have been listed in the Official Journal of the European Communities.

EMC

Emissions: a) EN61326 (1998) Radiated, Class B
 b) EN61326 (1998) Conducted, Class B
 c) EN61326 (1998) Harmonics, referring to EN61000-3-2 (2000)

Immunity: EN61326 (1998) Immunity Table 1, Performance B, referring to:
 a) EN61000-4-2 (1995) Electrostatic Discharge
 b) EN61000-4-3 (1997) Electromagnetic Field
 c) EN61000-4-11 (1994) Voltage Interrupt
 d) EN61000-4-4 (1995) Fast Transient
 e) EN61000-4-5 (1995) Surge
 f) EN61000-4-6 (1996) Conducted RF

Safety

EN61010-1 (1993) Installation Category II, Pollution Degree 2.

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CHRIS WILDING
TECHNICAL DIRECTOR
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Table of Contents

Introduction	3
Specification	4
Safety	6
EMC	7
Installation	8
Connections	9
Front Panel Connections	9
Rear Panel Connections	9
Initial Operation	10
Power Meter View	12
Power Meter Set-up	14
Waveform Graph View	15
Waveform Graph Set-up	16
Harmonics View	19
Harmonics Set-up	20
Display Format – Histogram	20
Display Format – Standard Table	23
Display Format – Fluctuation Table	24
Display Format – Fluctuation Map	26
Display Format – Time Chart	27
Test Control View	28
Test Control Set-up (Harmonics)	29
EN61000-3-3 Flicker and Fluctuations	34
Test Control Set-up (Flicker)	36
Taking Flicker and Fluctuation Measurements	37
Meter View (Flicker)	38
Inrush Current Measurement	41
Inrush Current Test Control Set-up	43
Report View	44
Report Formats	45
Report Set-up	47
Compliance Measurements with the HA1600	50
Taking Harmonics Measurements	51
HA-PC LINK Documentation Software	53
Maintenance & Calibration	55
Software Updates	56

High performance power analyser

The HA1600 is a high speed, high accuracy AC power analyser for single phase supplies of up to 16 Amps rms.

The supply to be measured is connected via a dedicated input cable independently of the supply to the instrument. The output to the load is via a front panel mounted 'standard' mains connector. A wide range of power connectors is available including most European national types.

The HA1600 can measure Watts, VA, Volts rms, Volts peak, Amps rms, Amps peak, Crest factors, THD, Power factor, Frequency and Inrush current.

The large display can show multiple parameters simultaneously along with graphical representations of voltage and current waveforms.

Dual 16 bit Analog to Digital converters continuously sample both voltage and current and give a wide dynamic range. A fast Digital Signal Processor gives the performance needed for continuous real-time analysis of the data. Advanced algorithms yield accurate results, using extended precision or floating point arithmetic wherever necessary.

Compliance-quality harmonics analyser

The HA1600 has been designed to make harmonics measurements both quick and simple. It measures harmonics from the 1st to the 40th and updates the display in real time.

It is suitable for pre-compliance measurements using a normal mains supply and is capable of full compliance measurements to EN61000-3-2 in conjunction with a suitable power source (such as the AC1000).

Support is provided for both the 1995 and 2000 editions of EN61000-3-2. Capabilities include continuous monitoring of the supply voltage, continuous automatic calculation of harmonic limits (with real-time Class D evaluation and visual display to 1995 requirements), and timed test sequences with analysis of fluctuating harmonics.

Compliance-quality flicker meter

The HA1600 has the capability to operate as a compliance quality flicker meter in conformance with EN61000-3-3 and EN60868.

A current measurement method can be used rather than voltage measurement thus eliminating the need for a reference impedance and stabilised supply.

Flicker severity can be measured in terms of P_{st} and P_{lt} with analysis periods variable between 5 minutes and 2 hours. Simultaneously full analysis of voltage variations is performed, including the calculation of the maximum value d_{max} , the difference between steady states d_c and the change characteristic $d(t)$.

A full range of interfaces

A printer interface is included for record keeping and archiving, together with a high speed RS-232 interface for use with a PC.

Software is also available that enables results to be displayed, recorded and documented using a PC.

The internal software of the instrument is stored in flash memory and can be updated through the serial port as the requirements of the measurement standards evolve.

Specification

MAINS ANALYSER

Measurement Circuit:	Single Phase with standard mains connector.
Current Rating:	16A rms continuous, or national connector rating if lower.
Voltage Ranges:	115V ($\pm 200V$ pk) and 230V ($\pm 400V$ pk).
Current Ranges:	$\pm 24mA$ pk to $\pm 400A$ pk in fifteen 2:1 ranges.
Frequency Range:	43 – 67 Hz.
Shunt Resistance:	3m Ω .
Sampling Rate:	300 points per cycle.
Basic Accuracy:	Better than 0.2%.
Measured Parameters:	Vrms, Vpk, Arms, Apk, Crest factors, THD, W, VA, Power factor, Frequency, Peak Inrush current.
Display Modes:	Tabular display of all parameters including latest and highest inrush current. Waveform Graph display of Voltage and Current with normal, Max hold, accumulate and multiple cycle display modes.
Monitor Outputs:	Re-constructed Voltage and Current Signals.

HARMONICS ANALYSER

Measurements:	1 st harmonic to 40 th harmonic. Measurement processing for both 1995 and 2000 Editions of EN61000-3-2. Continuous calculation, analysis and assessment of unfiltered, filtered, average, minimum and maximum current harmonic levels and limits. Continuous measurement and assessment of supply waveform and harmonics.
Current Rating:	16A rms continuous, or national connector rating if lower.
Voltage Ranges:	115 ($\pm 200V$ pk) and 230V ($\pm 400V$ pk).
Current Ranges:	$\pm 24mA$ pk to $\pm 400A$ pk in fifteen 2:1 ranges.
Frequency Range:	43 – 67 Hz.
Shunt Resistance:	3m Ω (less than 150mV across shunt up to 50 Amp peak).
Sampling Rate:	300 points per cycle. 4 or 16 cycle Discrete Fourier Transforms.
Basic Accuracy:	Better than 5% of limit or 0.2% of selected range whichever is the greater.
Display Modes:	Display of load supply assessment for voltage, harmonics, crest limits and frequency against requirements defined in EN61000-3-2. Histogram or tabular display of supply voltage harmonics. Histogram display of harmonics with limits (calculated from EN61000-3-2) and Min. hold, Max. hold and percentage of limit display options.
<i>For assessment to EN61000-3-2:2000</i>	Tabular display of current harmonics showing present values, limits, average values, average as percent of limit, maximum values, maximum as percent of limit and pass or fail assessment for each harmonic.
<i>For assessment to EN61000-3-2:1995</i>	Automatic fit of the Class D envelope on the Waveform Graph display for Class A / Class D detection. Tabular display for steady-state harmonics with present values, minimums, maximums, limits, % of limits (present values and maximums) and pass or fail assessment for each harmonic. Option of using filtered measurements.

	<p>Tabular display for fluctuating harmonics with present values (filtered) maximums, % of steady-state limits (present values and maximums) % of time spent above steady-state limits (last 150s and worst 150s) and pass or fail assessment for each harmonic.</p> <p>Graphical display of a selected harmonic against time, with limits.</p> <p>Graphical display against time of all harmonics exceeding steady-state limits.</p>
Test Control:	<p>Untimed, manually timed or automatically timed tests; user-defined test time.</p> <p>Declare load classification or automatic detection of Class A or Class D. Limits automatically determined from EN61000-3-2 for appropriate class; Class C and Class D limits can be automatically calculated from power measurements or from ratings declared by the user. Minimum and maximum power thresholds for limits can be changed by the user.</p> <p>Facility for declaring supply voltages other than 230V and deriving appropriate limits. Facility for inseting test limits.</p>
Report Printing:	<p>Direct printer connection for hard-copy report with user-entered narrative, supply voltage assessment and current harmonic analysis and assessment. One report format for assessment to EN61000-3-2:2000 and two (steady state and fluctuating) for assessment to EN61000-3-2:1995.</p>

FLICKER METER

Measurements:	Voltage fluctuations d_c , $d(t)$ and d_{max} and flicker P_{st} and P_{ft} to EN61000-3-3 and EN60868.
Current Rating:	16A rms continuous, or national connector rating if lower.
Voltage Ranges:	115V ($\pm 200V$ pk) and 230V ($\pm 400V$ pk).
Fluctuation Range:	25% max.
Frequency Range:	Limit values in EN61000-3-3 and Flicker meter parameters in EN60868 are only defined for 50Hz. Operates over 43 – 67 Hz. (filter frequencies scale proportionately)
Report Printing	Tabular listing of voltage variations, P_{st} classifier and P_{st} in each P_{ft} interval.

GENERAL

Display:	320 x 240 pixel backlit LCD.
Clock:	Real-time clock for time and date-stamping of Report data.
Interfaces:	Parallel Printer, RS-232.
Instrument Supply:	220V–240V or 110V–120V $\pm 10\%$, 48 to 65Hz. Installation Category II. Maximum instrument power 25VA. The instrument can be operated at a different supply voltage and/or frequency from that used to supply the load.
Operating Range:	+5°C to 40°C, 20-80% RH.
Storage Range:	–10°C to +60°C.
Environmental:	Indoor use at altitudes up to 2000m, Pollution Degree 2.
Safety:	Complies with EN61010-1.
EMC:	Complies with EN61326.
Dimensions:	305 x 148 x 220mm (WxHxD).
Weight:	4.2kg.

Safety

This instrument is Safety Class I according to IEC classification and has been designed to meet the requirements of EN61010-1 (Safety Requirements for Electrical Equipment for Measurement, Control and Laboratory Use). It is an Installation Category II instrument intended for operation from a normal single phase supply.

This instrument has been tested in accordance with EN61010-1 and has been supplied in a safe condition. This instruction manual contains some information and warnings which have to be followed by the user to ensure safe operation and to retain the instrument in a safe condition.

This instrument has been designed for indoor use in a Pollution Degree 2 environment in the temperature range 5°C to 40°C, 20% - 80% RH (non-condensing). It may occasionally be subjected to temperatures between +5° and -10°C without degradation of its safety. Do not operate while condensation is present.

Use of this instrument in a manner not specified by these instructions may impair the safety protection provided. Do not operate the instrument outside its rated supply voltages or environmental range.

WARNING! THIS INSTRUMENT MUST BE EARTHED

Any interruption of the mains earth conductor inside or outside the instrument will make the instrument dangerous. Intentional interruption is prohibited. The protective action must not be negated by the use of an extension cord without a protective conductor.

When the instrument is connected to either supply, terminals may be live and opening the covers or removal of parts (except those to which access can be gained by hand) is likely to expose live parts. The apparatus shall be disconnected from all voltage sources before it is opened for any adjustment, replacement, maintenance or repair.

Any adjustment, maintenance and repair of the opened instrument under voltage shall be avoided as far as possible and, if inevitable, shall be carried out only by a skilled person who is aware of the hazard involved.

If the instrument is clearly defective, has been subject to mechanical damage, excessive moisture or chemical corrosion the safety protection may be impaired and the apparatus should be withdrawn from use and returned for checking and repair.

Make sure that only fuses with the required rated current and of the specified type are used for replacement. The use of makeshift fuses and the short-circuiting of fuse holders is prohibited.

This instrument uses a Lithium button cell for the real-time clock and non-volatile memory battery back-up; typical life is 3 years. In the event of replacement becoming necessary, replace only with a cell of the correct type, i.e. 3V Li/MnO₂ 20mm button cell type 2032. Exhausted cells must be disposed of carefully in accordance with local regulations; do not cut open, incinerate, expose to temperatures above 60°C or attempt to recharge.

Do not wet the instrument when cleaning it and in particular use only a soft dry cloth to clean the LCD window. The following symbols are used on the instrument and in this manual:-



Caution -refer to the accompanying documentation, incorrect operation may damage the instrument.



Terminal connected to chassis ground.



Alternating current.

This instrument has been designed to meet the requirements of the EMC Directive 89/336/EEC. Compliance was demonstrated by meeting the test limits of the following standards:

Emissions

EN61326 (1998) EMC product standard for Electrical Equipment for Measurement, Control and Laboratory Use. Test limits used were:

- a) Radiated: Class B
- b) Conducted: Class B
- c) Harmonics: EN61000-3-2 (2000) Class A; the instrument is Class A by product category.

Immunity

EN61326 (1998) EMC product standard for Electrical Equipment for Measurement, Control and Laboratory Use.

Test methods, limits and performance achieved were:

- a) EN61000-4-2 (1995) Electrostatic Discharge : 4kV air, 4kV contact, Performance B.
- b) EN61000-4-3 (1997) Electromagnetic Field, 3V/m, 80% AM at 1kHz, Performance A.
- c) EN61000-4-11 (1994) Voltage Interrupt, 1 cycle, 100%, Performance A.
- d) EN61000-4-4 (1995) Fast Transient, 1kV peak (AC line), 0.5kV peak (signal lines and RS232/GPIB ports), Performance A.
- e) EN61000-4-5 (1995) Surge, 0.5kV (line to line), 1kV (line to ground), Performance A.
- f) EN61000-4-6 (1996) Conducted RF, 3V, 80% AM at 1kHz (AC line only; signal connections <3m not tested), Performance A.

According to EN61326 the definitions of performance criteria are:

Performance criterion A: 'During test normal performance within the specification limits.'

Performance criterion B: 'During test, temporary degradation, or loss of function or performance which is self-recovering'.

Performance criterion C: 'During test, temporary degradation, or loss of function or performance which requires operator intervention or system reset occurs.'

Cautions

To ensure continued compliance with the EMC directive the following precautions should be observed:

- a) After opening the case for any reason ensure that all signal and ground connections are remade correctly before replacing the cover. Always ensure all case screws are correctly refitted and tightened.
- b) In the event of part replacement becoming necessary, only use components of an identical type, see the Service Manual.

Note that the conducted emissions measured on the LOAD POWER connection of the HA1600 will be those of the load itself since the HA1600 contains no filtering on this connection. When making measurements on non-compliant loads, therefore, care must be taken to ensure that its emissions do not interfere with other equipment.

Mains Operating Voltage – Instrument Power

Before making connections to the AC line source ensure that the operating voltage of the instrument is correctly set. The operating voltage is indicated by the orientation of the fuseholder. When the 230V marking is upwards, the unit is set for operation over the range 198V to 264V. When the 115V marking is upwards, the unit is set for operation over the range 99V to 132V. To change the operating voltage range, remove the AC line plug, pull out the fuse holder, replace the fuse with one of the appropriate rating (see below) and rotate the fuse holder before pushing it firmly back into place.

Safety Note: To fully disconnect the Instrument Power from the AC supply, unplug the mains cord from the INSTRUMENT POWER inlet or from the AC supply outlet.

Mains Operating Voltage – Load Power

The fixed LOAD POWER mains lead is an independent connection, which provides power to the appliance connector on the front panel; it can be at a different voltage and frequency from the instrument power. The maximum permitted load power voltage is 264Vrms and the frequency range is 43 - 67Hz.

For full compliance measurements to EN61000-3-2 the load power lead should be connected to an AC supply that meets the voltage, frequency and harmonics requirements defined in the standard; the AC1000 low distortion power source can be used for this purpose.

Safety Note: To fully disconnect the Load Power from the AC supply unplug the mains cord from the AC supply outlet.

Fuse – Instrument Power

The correct time-lag fuse must be fitted for the selected operating voltage.

For 230V operation use 250mA (T) 250V time-lag HBC

For 115V operation use 500mA (T) 250V time-lag HBC

Make sure that only fuses with the required rated current and of the specified type are used for replacement. The use of makeshift fuses and the short-circuiting of fuse holders are prohibited.

Fuse – Load Power

A high voltage, high breaking current, fuse is fitted internally in the load power circuit. The correct fuse type is: 20A 500V HBC Type aM or gL.

Make sure that only fuses with the required rated current and of the specified type are used for replacement. The use of makeshift fuses and the short-circuiting of fuse holders are prohibited.

Mains Lead

When a three core mains lead with bare ends is provided this should be connected as follows:

BROWN	-	MAINS LIVE
BLUE	-	MAINS NEUTRAL
GREEN/YELLOW	-	EARTH

WARNING ! - THIS INSTRUMENT MUST BE EARTHED

Any interruption of the protective conductor inside or outside the instrument will make the instrument dangerous. Intentional interruption is prohibited.

Front Panel Connections

Appliance Connector

The load under test should be plugged into the front panel appliance connector. Power to the connector is supplied from the fixed LOAD POWER cable via an internal 20A fuse and a relay which is controlled by the LOAD switch. If the LOAD switch is in the OFF position, or if there is no instrument power (e.g. the POWER switch is OFF) then the load power supply is disconnected from the appliance socket.

A wide choice of national appliance connectors is available but the connector is factory fitted and cannot be changed by the user. The maximum load current that can be supplied is 16Arms or the rating of the connector, whichever is lower.

Voltage and Current Monitor

The Voltage Monitor and Current Monitor BNC sockets output reconstructed scaled versions of the load power voltage and current waveforms referenced to instrument ground, permitting direct connection to other instruments such as an oscilloscope. The output voltage is approximately 2.5V pk-pk for a full scale output on any current or voltage range; the ranges in use are shown at the top of the Waveform Graph view.

Rear Panel Connections

Instrument Power

IEC inlet for the instrument power only; refer to the Installation section.

Load Power

Fixed lead for supplying the load power to the front panel appliance connector.

RS232

The RS232 interface is intended for connection to a PC which is running the HA-PC LINK software for data display and archiving. It should be connected to a standard PC port using a fully wired 1-1 male-female cable without any crossover connections.

The 9-pin female D-connector has the following pin-out:

Pin	Name	Direction	Description
1	DCD	O	Passively asserted (+10V through 10k Ω)
2	TXD	O	Transmitted data to computer
3	RXD	I	Received data from computer
4	DTR	I	Computer can receive
5	GND		Signal ground
6	DSR	O	Passively asserted (+10V through 10k Ω)
7	RTS	(I)	Assumed asserted
8	CTS	O	Computer may send
9	RI		No connection

The signal ground is connected to instrument ground. The Baud rate is fixed at 115,200.

Printer

25-way female D-connector configured as a standard parallel (Centronics) printer port. Connect directly to a suitable printer using a standard shielded cable.

Initial Operation

This section is a general introduction to the organisation of the instrument and is intended to be read before using it for the first time. Detailed descriptions of each function are given in later sections, starting with Power Meter.

In this manual front panel keys and connectors are shown in capitals, e.g. METER, VOLTAGE MONITOR; all soft-key labels, messages and data values displayed on the LCD are shown in a different type font, e.g. **Setup Range, Load Declared Class A.**

Switching On

With both the POWER and LOAD switches in the OFF position connect the INSTRUMENT POWER lead to the standard AC supply and connect the LOAD POWER lead to a suitable low distortion AC source as described in the Installation section.

Switch the POWER switch to ON to turn the instrument power on; the display will show the Initialisation screen for a few seconds followed by the Select screen. A 20 second time-out is started, with a count down shown on the display. If no key is pressed during this time out, or if the **Resume Operation** soft-key (F5) is pressed, the instrument will continue operation using the Test and Report parameters automatically stored at the last power-down; the parameter settings stored are given in the table at the end of this chapter. The instrument will start up with the LCD showing the Waveform Graph display. The display will show the load voltage waveform, which will appear to be unstable for 4 to 5 seconds or more until the sampling clock synchronises exactly with the incoming supply; the display will then show a single cycle of the voltage waveform with the rising zero-crossing point at the left edge.

The second soft-key option on the Select screen is **Restore Defaults**, which continues operation with all parameters defaulted to their original factory setting; the stored parameters and their default settings are listed in the table at the end of this chapter.

The final soft-key option is **Setup**, which gives access to a further screen where the soft-keys are **Restart** and **Update Software**. **Restart** returns the instrument to the Initialisation screen. **Update Software** selects the mode in which the instrument's software can be updated from a PC via its RS232 port; see the section of the Maintenance chapter for details.

If the load is now connected and the LOAD switch also turned to ON the load current waveform will also show in the display; the instrument will autorange to show the current waveform at the best resolution achievable. Load power is disconnected, even if the LOAD switch is ON, when INSTRUMENT POWER is turned off.

Safety Note: Neither the POWER switch nor the LOAD switch fully disconnect their respective AC supplies when switched to the OFF position. To fully disconnect from the AC supply unplug the mains cords from the AC supply outlet; make sure that the means of disconnection is readily accessible. Disconnect from the AC supply when not in use.

Display Contrast

The contrast of the LCD may vary a little with changes of ambient temperature or viewing angle but can be optimised for a particular environment by using the front panel contrast control. Insert a small screwdriver or trimmer tool through the adjustment aperture marked LCD and rotate the control for optimum contrast.

Keyboard

The keys on the front panel can be considered in the following groups:

- The five keys beneath the LCD. When the green VIEW lamp is lit these are used to directly call each of the five main display views (METER for Power Meter, WAVE for Waveform Graph, etc.). In addition, when the set-up screen for each of these views is displayed (by pressing the SET-UP / VIEW key to light the red SET-UP lamp) they become 'soft-keys' which take the functions shown immediately above them in boxes on the LCD.

- The four cursor keys marked ▲ ▼ ◀ and ▶ are used to move the edit zone (shown as an outline box) around the editable fields of a set-up display. For each position of the edit zone the keys below the display have the functions shown immediately above them in boxes on the LCD; the functions change as the edit zone is moved which is why they are called 'soft' keys. The cursor keys auto-repeat when held down.
- Numeric keys permit direct entry of values in certain set-up displays. ENTER confirms a numeric entry and CANCEL terminates the entry without changing the parameter to the new value.
- START TEST and STOP TEST have specific functions determined by the type of test selected on the Test Control set-up display; full details are given in the Test Control section.
- The LOCAL key returns the instrument from remote (GPIB) to local (keyboard) control.

Stored Settings and their Factory Defaults

The following parameters have their current setting stored at power-down; these are recalled at power-up if **Resume Operation** is selected. If **Restore Defaults** is selected instead, the settings are those shown in the **Defaults Setting** column.

Parameter	Default Setting
Nominal Voltage and tolerance	230V ± 2%
Nominal Frequency and tolerance	50Hz ± 0.5%
Test Duration	150 seconds
Assessment inset	1.00
Operating Mode	EN61000-3-2:2000 Harmonics (Edition 2)
Load Classification	Class A (2000); Auto detect A or D (1995)
Class C Limit basis, current and PF	Automatic
Class D Limit basis and power	Automatic
Class D minimum power	75W
Class D – A cross-over power (1995)	600W
Flicker sensing method	Voltage
Simulated Flicker Reference Impedance	0.4 + j 0.25 Ω
d _{max} limit	4 %
d(t) limit	< 200 ms above 3%
d _c limit	3 %
Steady State Definition	> 1000 ms within ±0.15%
Switching sequence On and Off time	1000 cycles
Switching sequence On and Off phase	0 degrees
Left Margin (of Report)	5 characters
Report No.	1

Note that the Report's Header, Title and Footer text is not restored to the original form by the **Restore Defaults** choice; the text can only be changed by entering new characters.

Power Meter View

With the green VIEW lamp lit, press the METER key to display the Power Meter view.

Power Meter			Hold
Supply Voltage			
229.8 V _{rms}	0.1% THD	Frequency	50.04 Hz
325.1 V _{pk}	at 89.4°	Crest Factor	1.414
Load Power			
47.64 W	64.03 VA	Power Factor	0.744
Load Current			
278.6 mA _{rms}	49.9% THD	90.7% under Class D mask	
586.0 mA _{pk}	Phase 12.5°	Crest Factor	2.103
Harmonic Summary			
Load detected Class A by waveform.			
Load passes Harmonic levels.			
Supply meets IEC requirements.			

The Power Meter view gives a continuously updated display of the major parameters of the supply voltage and load current, together with an instantaneous summary of whether the supply and load meet the limits of the harmonics standard.

The **Supply Voltage** group shows the V_{rms} and frequency of the load power supply, together with its total harmonic distortion (THD), peak voltage (V_{pk}), the phase of the peak with respect to the zero-crossing point and the calculated crest factor (V_{pk}/V_{rms}).

For compliance quality measurements, the load power supply must meet the following requirements:

<i>Harmonics</i> (max % of fundamental)	0.9% : 3 rd 0.4% : 5 th 0.3% : 7 th 0.2% : 9 th 0.1% : even 2 nd – 10 th 0.1% : all 11 th – 40 th
<i>Voltage</i>	230 V _{rms} ± 2%
<i>Frequency</i>	50Hz ± 0.5%
<i>Crest Factor</i> (V _{pk} /V _{rms})	Between 1.40 and 1.42
<i>Phase of V_{pk}</i>	Between 87° and 93° after zero crossing

All the above parameters are continuously monitored. All supply parameters are compared against the limits and a pass or fail indication is given in the **Harmonic Summary** section of the display.

The **Load Power** group shows the true power (Watts), apparent power (V.A) and power factor (W/V.A).

The **Load Current** group shows the rms and peak load currents, together with the total harmonic distortion (THD), the phase of the current peak and the calculated crest factor (I_{pk} / I_{rms}). In the default mode (measuring harmonics to EN61000-3-2:2000) the total harmonic current is shown; this is the rms sum of all the harmonics between 2 and 40 and can be used to find a worst case operating condition of the load under test. When measuring harmonics to EN61000-3-2:1995 (see the Test Control view) the percentage of the waveform under the

dynamically calculated Class D envelope defined by this standard is shown; the load is considered Class D if the current waveform falls within the envelope for more than 95% of the waveform period. Since Class D limits are generally more severe than Class A (for $\leq 600\text{W}$ loads) it is extremely useful to know whether a nominally Class A load approaches Class D at some point in its operation, e.g. a power supply with a wide operating range.

Load class is discussed further in the Test Control section. See the chapter on Making Compliance Measurements with the HA1600 for information on the differences between the 1995 and 2000 Editions of EN61000-3-2.

The **Harmonic Summary** group gives a simple overview of the supply and load harmonic status. It states whether the supply passes or fails the specified requirements; compliance quality measurements can obviously only be made with a supply that meets the harmonics, voltage, frequency, crest factor and phase requirements described earlier. It also states the load class as declared by the user or automatically detected by the analyser (if auto-detect was the option selected on the Test Control Set-up); refer to the Test Control section. Typical messages are **Load detected Class D by waveform** or **Load declared Class A**. Lastly the display states whether the load current passes or fails the harmonics limits of the Class shown.

When the instrument is operated in Inrush or Flicker mode the region at the bottom of the screen is used to display a summary of those measurements instead of the Harmonic Summary. In Flicker mode two further display pages are available: one showing Voltage Variations and the second Flicker Results. For full details, see the relevant chapter in this manual.

Power Meter Set-up

With the Power Meter view displayed, pressing SET-UP shows the Power Meter set-up screen, which gives access to the **Setup Range** soft-key. In Flicker mode, it also gives access to the **Flicker** and **Voltage Variations** result pages. See the Flicker Meter chapter for details.

Set-up Range

Pressing the **Setup Range** soft-key (on either the Meter or Waveform Graph views) changes the display to a graphical view of the current waveform with three further soft-keys: **Up**, **Down** and **Lock Range**. Pressing any of these turns off autoranging; the **Lock Range** key keeps the present measurement range, while the **Up** and **Down** keys change the range in $\times 2$ and $\div 2$ steps respectively. The scaling of the waveform display changes to reflect the peak capability of the new range and the maximum current is shown in the bottom left-hand corner of the display; for example, **1500mA peak** means that the top of the display represents +1500mA and the bottom represents -1500mA with respect to the centre zero line.

The range can be set from 24mA peak to 400A peak in 2:1 steps. The waveform display on this set-up screen is always updated every cycle, regardless of the mode set up for the Waveform Graph view.

Important Note: To take compliance quality measurements the range must not change during the test. The user must select a range that will accommodate the highest waveform peak that will be encountered during the load's operating cycle. It is therefore recommended that a preliminary assessment of the load should be made, with the instrument in autorange mode, to determine the highest peak current operating condition. The instrument should then be locked on this range to ensure that harmonics measurements are correct and that the derived values (Average, Max Hold and Min Hold etc.) are meaningful.

If too low a range is chosen, no damage will be done but all the measurement results will be invalid and the message Overload will show in the status line at the top of the Meter View display. It is more important to maintain adequate 'headroom' for the measurement, i.e. to avoid overload, than it is to maximise the vertical resolution on the Waveform Graph view; measurement accuracy is maintained even when the vertical scaling of the display is well below optimum.

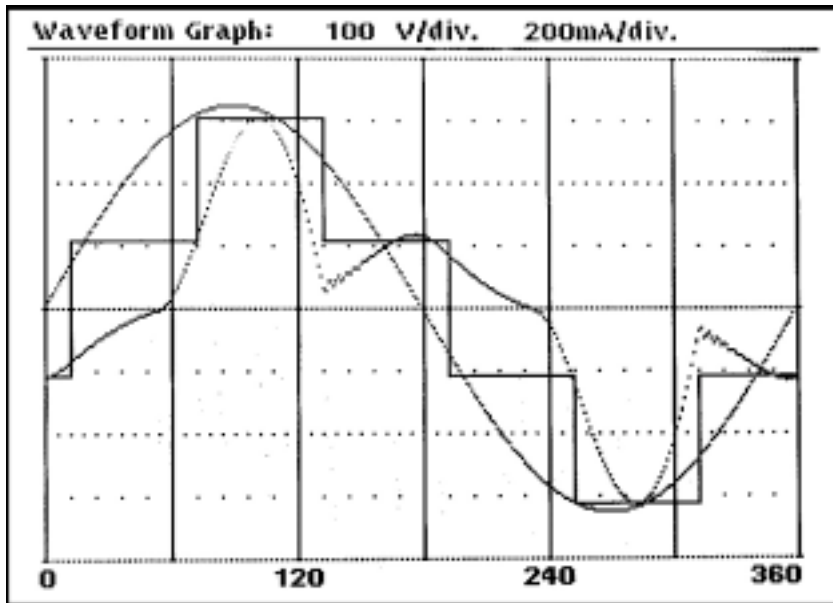
Once the range is locked, the **Lock Range** soft-key label becomes **Auto Range**; pressing this key releases the lock and allows the instrument to autorange on the present waveform. Several other soft-keys 'toggle' between alternate choices in this way; it is only necessary to remember that at any time the soft-key box shows what will happen when the key is pressed.

Having set the range (or selected auto-range), the previous view can be recalled by pressing the VIEW key.

Autoranging is only available in Harmonics operating mode (see the Test Control section). In Inrush mode the range can be manually changed (the highest current range is set by default); in Flicker mode with current sensing the range is fixed. Note that autoranging is disabled while the LOAD switch is OFF to prevent the instrument autoranging to the most sensitive range when there is no load current. At switch-on the default range is 3A pk if the LOAD switch is OFF; at other times, switching the LOAD to OFF locks the range at the setting currently in use.

Waveform Graph View

The Waveform Graph display (which is the default display at instrument switch on) can be selected by pressing the WAVE key whenever the green VIEW lamp is lit. The default format of the display is a full-screen view of both the voltage and current waveforms together with the Class D mask, or envelope, fitted to the current waveform. The format of the display can be changed in various ways as described in the Waveform Graph Set-up section below.



At the top of the display the scaling for both voltage and current are given. There are 8 divisions vertically, thus 100mA/div is the scaling shown if the $\pm 400\text{mA}$ peak range has been selected on the set-up screen. In auto-range mode (the default condition) the most sensitive range that gives an in-range display is automatically selected. To avoid excessive range changes when the measurement is near a range boundary the instrument auto-ranges up at full-scale and auto-ranges down at $0.44 \times$ full-scale.

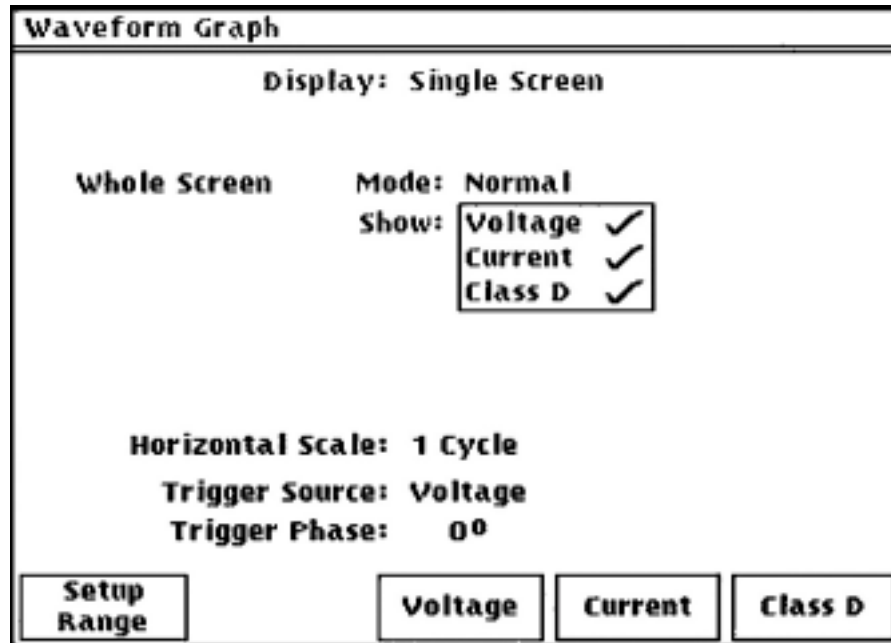
The voltage display has two ranges only: 100V/div , for nominal 230V supplies, and 50V/div for nominal 115V supplies; the voltage range is set from the Test Control set-up display.

The X-axis of the single cycle display is divided into 6 divisions, each representing 60° of phase. The rising zero-crossing point of the single voltage waveform cycle displayed is positioned at the left edge of the display for the default selection of voltage as the Trigger Source; this will change if alternative Trigger Sources are selected, see Trigger Source section.

The X-axis is marked every 180° of the 2 cycle display and every cycle of the 4 and 10 cycle displays.

Waveform Graph Set-up

With the Waveform Graph view displayed, pressing SET-UP shows the Waveform Graph set-up screen.



With the exception of the **Setup Range** key, the functions of the soft-keys change as the edit zone is moved through the editable fields of the display using the **▲ ▼** keys; each field is described below. Pressing the **VIEW** key returns the display to the Waveform Graph view.

Set-up Range

Pressing the **Setup Range** soft-key (on either the Meter or Waveform Graph views) changes the display to a graphical view of the current waveform with three further soft-keys: **Up**, **Down** and **Lock Range**. Pressing any of these turns off autoranging; the **Lock Range** key keeps the present measurement range, while the **Up** and **Down** keys change the range in x2 and ÷2 steps respectively. The scaling of the waveform display changes to reflect the peak capability of the new range and the maximum current is shown in the bottom left-hand corner of the display; for example, **1500mA peak** means that the top of the display represents +1500mA and the bottom represents -1500mA with respect to the centre zero line. The range can be set from 24mA peak to 400A peak in 2:1 steps. The waveform display on this set-up screen is always updated every cycle, regardless of the mode set up for the Waveform Graph view.

Important Note: To take compliance quality measurements the range must not change during the test. The user must select a range that will accommodate the highest waveform peak that will be encountered during the load's operating cycle. It is therefore recommended that a preliminary assessment of the load should be made, with the instrument in autorange mode, to determine the highest peak current operating condition. The instrument should then be locked on this range to ensure that harmonics measurements are correct and that the derived values (Average, Max Hold and Min Hold etc.) are meaningful.

If too low a range is chosen, no damage will be done but all the measurement results will be invalid and the message **Overload** will show in the status line at the top of the Meter View display. It is more important to maintain adequate 'headroom' for the measurement, i.e. to avoid overload, than it is to maximise the vertical resolution on the Waveform Graph view; measurement accuracy is maintained even when the vertical scaling of the display is well below optimum.

Once the range is locked, the **Lock Range** soft-key label becomes **Auto Range**; pressing this key releases the lock and allows the instrument to autorange on the present waveform.

Several other soft-keys 'toggle' between alternate choices in this way; it is only necessary to remember that at any time the soft-key box shows what will happen when the key is pressed.

Autoranging is only available in Harmonics operating mode (see the Test Control section). In Inrush mode the range can be manually changed (the highest current range is set by default); in Flicker mode with current sensing the range is fixed. Note that autoranging is disabled while the LOAD switch is OFF to prevent the instrument autoranging to the most sensitive range when there is no load current. At switch-on, the default range is 3A pk if the LOAD switch is OFF; at other times, switching the LOAD to OFF locks the range at the setting currently in use.

Having set the range (or selected auto-range), the Waveform Graph view can be recalled by pressing the VIEW key.

Screen

With the edit zone in the **screen** field, the soft-key choices are **Single Screen** and **Split Screen**. The default mode is **Single Screen**, which uses the whole display with 8 vertical divisions. **Split Screen** changes the screen into 2 separate displays, each with 4 vertical divisions; this is particularly useful when the current waveform is essentially in phase with the voltage and displaying both together would cause confusion. At the same time the Waveform Graph set-up display changes to add extra editable fields (**mode** and **Traces**) for the second display, see below.

Mode

With the edit zone in the **mode** field the soft-key choices are as follows:

Normal: The display is updated every waveform cycle. This is the default mode.

Accumulate: The display is written to every waveform cycle without erasing the previous data. A history of the waveform is built on the screen, which means that short-term aberrations can be captured.

The Accumulated display is lost when the view is changed, and can be manually cleared at any time by pressing the VIEW key twice. Since it is also automatically cleared at every range change it may be necessary to lock the current range, see Set-up Range section above. For clarity, it is recommended that only one waveform be accumulated, by selecting either Voltage or Current and turning off the Class D envelope (see Traces section below).

Max Hold: The display is updated every waveform cycle with the greater of the new and existing value at every point on the display.

The Max Hold algorithm keeps the largest amplitude (positive or negative) for each pixel. This often results in an apparent small discontinuity in the maximum hold waveform at the zero-crossing point.

The Max Hold data can be manually reset at any time by pressing the START key. It is also automatically reset at every range change, so it may be necessary to lock the current range, see Set-up Range section above. There is no Max Hold facility for the Class D envelope and it is recommended that this trace is turned off (see Traces section below).

Average: The display is updated every waveform cycle with a rolling average of the last 8 cycles. This mode offers a degree of noise reduction.

When split screen is selected, the modes for the upper and lower screens can be set independently. Changing between single screen and split screen will also change the modes to those last used for that screen set-up. The modes are maintained when the view is changed.

Traces

With the edit zone in the **Traces** field the soft-keys are **Voltage**, **Current** and **Class D**. Alternate presses of each key will turn that trace on and off; confirmation is given by a **■** or **X** against the corresponding trace name in the **Traces** edit zone.

The default setting for single screen is all three traces selected. If split screen is selected the default is Voltage only on the upper screen and Current plus Class D envelope on the lower screen. However, any combination of traces can be set on either screen.

The Class D envelope has no significance when testing to EN61000-3-2 Edition2:2000 as this edition classifies equipment only by its type, not by its waveform.

Horizontal Scale

With the edit zone in the **Horizontal Scale** field, the soft-keys allow the choice of 1, 2, 4 or 10 cycles of the waveform across the width of the screen. When split screen is selected, both graphs have the same horizontal scale. There are some restrictions on the facilities available in the multi-cycle displays: the Max Hold and Average modes and the Class D envelope trace are only available for a 1 cycle display. The 10 cycle display can only show Current. No action is required by the user; the soft-keys only offer available options and any conflicting selections are automatically ignored. The set-up display changes to describe the graphs that will actually be shown.

Trigger Source

With the edit zone in the **Trigger Source** field the signal source for the display synchronisation can be selected. Note that this is the trigger source for the display only and does not affect the measurement synchronisation. The soft-key choices are:

Voltage	The default condition: the rising zero-crossing point of the voltage waveform is set at the left hand edge of the display.
Current	Sets the rising zero-crossing point of the current waveform at the left hand edge of the display.
Internal	Synchronises the display with the internal data buffers; this can be useful under some circumstances when asynchronous components in a voltage or current waveform cause display jitter. The actual synchronisation point is arbitrary; it is determined at instrument switch-on and will be different if the instrument is switched off and then on again. The trigger phase setting can be used to move the waveform if desired.
Inrush	Provides a single shot display refreshed whenever there is an Inrush event. The trigger occurs whenever the peak current in a cycle is more than twice the peak current in the previous cycle.

When split screen is selected, both graphs have the same trigger point and are exactly synchronised.

Trigger Phase

This field defines the phase of the waveform (relative to its rising zero crossing) to be set at the left hand edge of the display. The required value may be entered using the number keys followed by ENTER. Values between -999 and 999 are accepted and converted into the range 0 to 359 degrees.

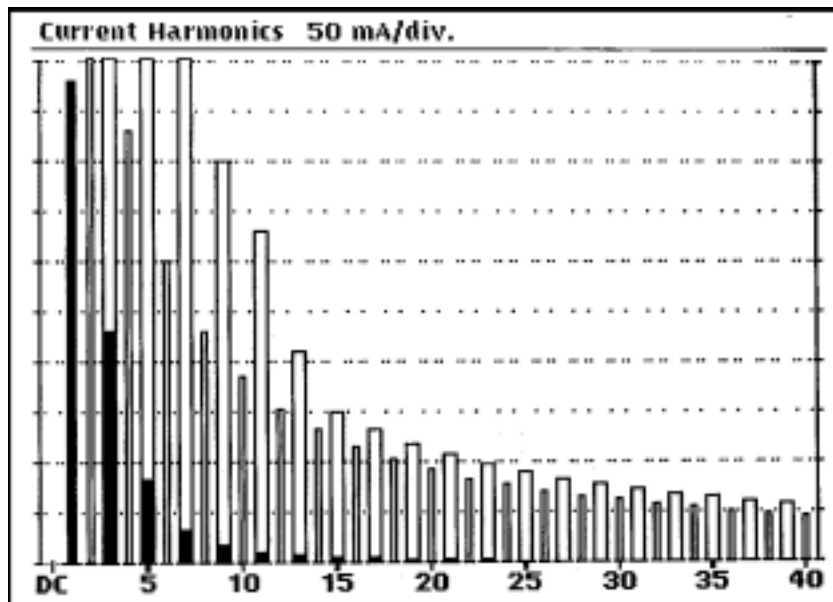
Harmonics View

The measurement requirements for current harmonics are given in EN61000-3-2; there are two editions of this standard. The original edition, which was published in 1995, was later changed by an amendment known as A14. This introduced changes that were so substantial that a revised version was published, known as EN61000-3-2 Edition 2 : 2000.

This instrument supports both sets of requirements, to allow for a changeover period between the two editions and for the fact that these changes apply to the European standard while the corresponding IEC standard remains (for the present) unamended. The changes primarily affect equipment classification, limit calculation and fluctuating harmonic assessment and require two different operating modes of the instrument; the required mode is selected on the Test Control View.

There are differences in the Harmonics View between the two modes, which are referred to in this manual as 1995 mode and 2000 mode.

With the green VIEW lamp lit, press the HARMONICS key to display the Harmonics view. The default display is a current harmonics histogram.



The harmonics histogram can be set to show either absolute harmonic levels or levels as a percentage of individual limits; it can also be modified to show, for example, odd harmonics only. The histogram bar for each harmonic is made up of two parts: an inner section, which is normally used to show the presently measured value, and an outer section which by default shows the IEC specification limit for that harmonic. Other combinations may be selected.

The harmonics can also be listed in a table, with limits. There are two sets of tables; the standard table is altered by the operating mode to suit the 1995 or 2000 rules, the other is used only for examining fluctuating harmonics to the 1995 rules.

There are also two graphical views of the harmonics against time, primarily intended for viewing fluctuating harmonics to the 1995 requirements. The Time Chart provides a 'chart recorder' view of a selected harmonic for the last 150 seconds; the Fluctuation Map shows when any of the relevant harmonics exceed the specified limits during the last 150 seconds.

Lastly, the harmonics of the supply voltage can also be displayed in histogram and table form.

All the above view options, together with the measurement mode selections, are set from the Harmonics set-up screen; full descriptions of each are given in the Harmonics Set-up Section.

Harmonics Set-up

With the Harmonics view displayed, pressing SET-UP shows the Harmonics set-up screen.

Harmonics

Display Harmonics of: Current Waveform

Display Format: Histogram

Vertical Scale: Absolute

Data Selection: Normal & Limit

Filter: None

Show: Odd Harmonics ✓
Even Harmonics ✓
Normal (inner bars) ✓
Limits (outer bars) ✓

Use cursor up & down keys to change vertical scale factor

Time Chart Fluctuation Map Fluctuation Table Standard Table Histogram

The soft-key functions change as the edit zone is moved through the editable fields of the display using the ▲ ▼ keys; each field is described below. Pressing the VIEW key returns the display to the Harmonics view. The selections made for each of the display formats are stored until the instrument is switched off.

Waveform Selection

With the edit zone in the **Display Harmonics of** field, the soft-key choices are **Current Waveform** and **Voltage Waveform**. Current harmonics are the default choice, for which the full range of display and measurement mode options described previously are available. When Voltage harmonics are selected, a restricted choice of display and measurement modes applies as explained in the appropriate sections.

Display Format - Histogram

With the edit zone in the **Display Format** field, the soft-key choices are **Histogram**, **Standard Table**, **Fluctuation Table**, **Fluctuation Map** and **Time Chart**.

With Histogram selected as the Display Format the further editable fields of **Vertical Scale**, **Data Selection** and **Show** are available; these can be used to optimise the form of the histogram for particular measurement. In the power-up default form shown in the Harmonic View section, for example, the histogram shows all harmonics and limits as absolute values.

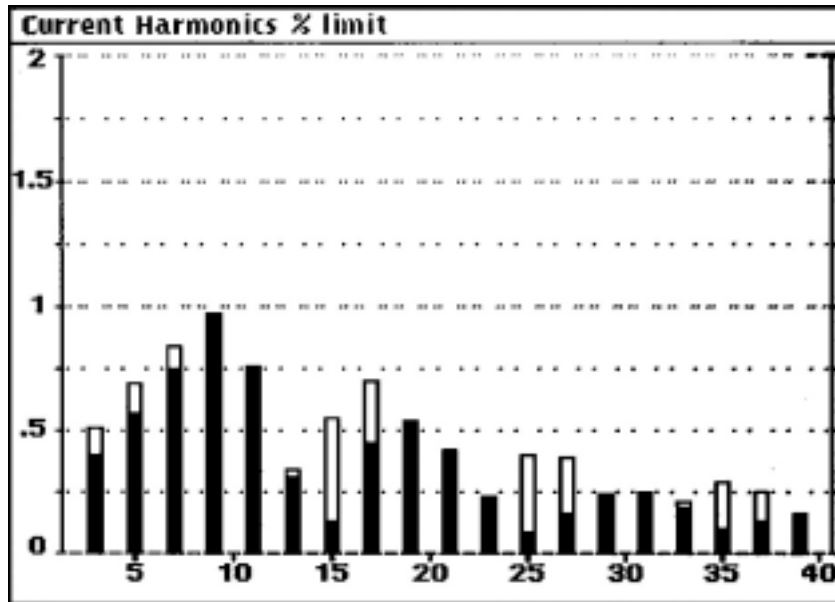
All histograms are of the same general form as the default version. The horizontal scale is marked with the harmonic number, odd harmonics/limits are shown as wide bars and even harmonics/limits are shown as narrow bars. The fundamental is shown to the left of the second harmonic as a wide bar and the DC component is shown to the left of the fundamental as a narrow bar. More information about what combinations of data can be shown in the display is given in the **Data Selection** and **Show** sections below.

Vertical Scale

With the edit zone in the **Vertical scale** field the soft-key choices are **Absolute** or **Percent Limit**. With the default condition of Absolute, the initial scaling is determined by the instrument's measurement range. However, the scaling can be changed easily using the

▲ and ▼ keys; the ▲ key increases the resolution, permitting a 'zoom' view of low level harmonics, and the ▼ key reduces resolution, bringing off-screen harmonics and limits into view. In this way any harmonic can be observed with optimum display resolution. Changing the display resolution does **not** affect the measurement range. The waveform peak must always be in-range for correct operation of the transform processing, see Important Note in the Power Meter Set-up section.

Measuring and reporting absolute harmonic levels is necessary during development and type approval exercises but a quicker pass or fail assessment can be made by viewing harmonics as a percentage of their individual limits; this is more appropriate in a Q.A. situation, for example. With the edit cursor in the **Vertical Scale** field, selecting **Percent Limit** and returning to the Harmonics View gives the following display.



The horizontal scale is marked with the harmonic number as before but now the vertical scale is 0 to 200% of limit. The value of each harmonic is shown as a percentage of its individual limit; where the limit changes with the power level, e.g. Class D products, the harmonic level is shown as a percentage of its instantaneous limit corresponding to that measurement. The Percent Limit display thus gives an instant view of harmonic performance, even as absolute levels change, without having to adjust display scaling.

Note that when Percent Limit is selected as the display mode the **Data Selection** field (see next section) is forced to **Normal & Max Hold**, so the inner (solid) bars represent the instantaneous harmonic values and the tops of the outer bars mark the maximum value reached by each harmonic. The Max Hold can be reset at any time by pressing the START key and is automatically reset when the measurement range is changed or auto-ranges. Only those harmonics that are subject to a limit are shown.

Data Selection

When Absolute is selected for the Vertical Scale, moving the edit zone to **Data Selection**, changes the soft-key choices to **Normal & Limit** (the default), **Max Hold & Limit**, **Normal & Max Hold** and **Min & Max Hold**. These keys determine which parameters the inner (solid) bars and outer (open) bars of the histogram represent. For example, with the default selection of **Normal & Limit** the individual limits are shown by the open outer bars while the normal (instantaneous) values of the harmonics are shown by the solid inner bars, 'thermometer' style. Note that, in this example, the limits might also be changing dynamically (e.g. for a Class D device whose power is varying) and that the solid inner bar may extend beyond the open outer bar if the limit is exceeded.

The full list of display options is described below; only the first of these (Normal & Limit) is available for Voltage Harmonics Histograms.

Normal & Limit: The default selection for Absolute scaling. The solid inner bars represent the normal (instantaneous) harmonic value (the choice of filtered or unfiltered is made below) and the open outer bars show the instantaneous limit for each harmonic.

The histogram is updated with the values from every transform. The limits are also calculated dynamically where appropriate (e.g. Class D) using the instantaneous power level of the interval.

Max Hold & Limit: The open outer bars show the limits for each harmonic, as above, but the solid inner bars now mark the maximum harmonic level; the histogram is updated after every transform with the greater of the new and existing value for every harmonic. The limits are calculated dynamically where appropriate (e.g. Class D) using the instantaneous power level of the latest interval, i.e. they are not necessarily relevant to the maximum harmonic value. There is no problem when fixed limits (e.g. Class A) are used but care must be taken when the limits are changing dynamically.

Note that if the range changes then the previous Max Hold data is lost. The range should be locked when making measurements of this nature; use the Set-up screen of either the Power Meter or Waveform Graph displays. This must be done with care, see the Important Note in those Set-up sections.

The Max Hold can be manually reset at any time by pressing the START key.

Normal & Max Hold: The solid inner bars represent the instantaneous harmonic values from every transform and the open outer bars mark the maximum value reached by each harmonic since Max Hold was last reset by pressing START or changing range (see notes above).

This is the only Data Selection mode available if Vertical Scale is set to Percent Limit but, since the vertical scale represents the normalised limits (0 to 200%), limits information is always available.

Min & Max Hold: In this display mode, the open outer bars show the Max Hold value as described above but the solid inner bars now represent the Min Hold, i.e. the lesser of the new and existing value after each transform. The display therefore shows the range of individual harmonics over a period of time or as operating conditions are varied.

Note that Min Hold and Max Hold are both automatically reset when the instrument changes range (see above), and can be manually reset at any time by pressing the START key.

The above represent all combinations of data and limits that might be displayed; any of the parameters may also be completely suppressed using the Show facility, see below.

Show

With the edit zone in the Show field there are four soft-keys which permit the parameters of the chosen Data Selection mode to be turned on and off in the display. For example, for the default condition of Normal & Limit, the four soft-keys are **Odd Harmonics**, **Even Harmonics**, **Normal** and **Limits**. For clarity, the list changes to confirm the present usage of the inner and outer bars of the histogram. Alternate presses of each key will turn that item on and off in the display; confirmation is given by a **█** or **X** against the corresponding parameter in the **show** edit zone. Note that when the odd harmonics are turned off the fundamental is also turned off and when the even harmonics are turned off the DC component is also turned off.

Filter

With the edit zone in the **Filter** field, the soft-key choices are **None** and **Filtered**. When **None** is selected, the harmonic values are updated after every transform; when **Filtered** is selected, the transform results are processed by a 1st order filter with a 1.5s time constant before being displayed. To reduce the data rate to a readable speed the display is updated after alternate 4-cycle transforms or every 16-cycle transform.

The filter is also optional when Standard Table is selected as the Display Format but for Fluctuation Table, Fluctuation Map and Time Chart the 1.5s filter is always selected, as required by the standard for fluctuating harmonics measurements.

Filtered values are always used for assessment in 2000 mode, but unfiltered values are still available for viewing if required.

Display Format – Standard Table

With the edit zone in the **Display Format** field, the soft-key choices are **Histogram**, **Standard Table**, **Fluctuating Table**, **Fluctuation Map** and **Time Chart**.

The Standard Table has two distinct forms – one shows limited data for all 40 harmonics on a single page; the other shows more columns of data but is separated into Even and Odd harmonic pages. The format of these is altered depending on the choice of 1995 or 2000 mode on the Test Control View.

Selecting **standard Table** (leaving the **show** field at the default **All Harmonics**) and returning to the Harmonics view by pressing the VIEW key gives a display of the following form:

Current Harmonics							
	mA	Limit	% limit		mA	Limit	% limit
1:	480.0	-	-	2:	1.4	1080.0	0.1
3:	230.8	2300.0	10.0	4:	0.4	430.0	0.1
5:	84.2	1140.0	7.4	6:	0.0	300.0	0.0
7:	32.8	770.0	4.3	8:	0.1	230.0	0.1
9:	19.5	400.0	4.9	10:	0.0	184.0	0.0
11:	12.0	330.0	3.6	12:	0.0	153.3	0.0
13:	8.9	210.0	4.2	14:	0.0	131.4	0.0
15:	7.2	150.0	4.8	16:	0.0	115.0	0.0
17:	5.1	132.3	3.9	18:	0.0	102.2	0.0
19:	4.5	118.4	3.8	20:	0.0	92.0	0.0
21:	3.2	107.1	3.0	22:	0.0	83.6	0.0
23:	3.1	97.8	3.3	24:	0.0	76.7	0.0
25:	2.3	90.0	2.6	26:	0.0	70.8	0.0
27:	2.3	83.3	2.9	28:	0.0	65.7	0.0
29:	1.8	77.6	2.4	30:	0.0	61.3	0.0
31:	1.8	72.6	2.5	32:	0.0	57.5	0.0
33:	1.5	68.2	2.2	34:	0.0	54.1	0.0
35:	1.4	64.3	2.3	36:	0.0	51.1	0.0
37:	1.3	60.8	2.2	38:	0.0	48.4	0.0
39:	1.2	57.7	2.2	40:	0.0	46.0	0.0

This All Harmonics form of the Standard Table (as shown above) lists all odd and even harmonics up to the 40th in two groups on a single page: the left-hand group has the fundamental and all the odd harmonics up to the 39th, the right-hand group lists the even harmonics 2nd to 40th. The format is the same for both groups; for each numbered harmonic, the measured harmonic current value is shown together with the limit for that harmonic and the measured value expressed as a percentage of that limit. The harmonic value can be filtered or unfiltered depending on the selection in the Filter field (as described above); the column heading changes to indicate the selection made. When the limit is variable, e.g. for varying Class C or D loads, the limit is also calculated and changed every transform. When there are no limits (e.g. for the fundamental or for loads below the minimum power limit for their class), a '-' is shown in the table.

The form of the Standard Table can be modified by returning to the Harmonics set-up, by pressing SET-UP, and moving the edit zone to the **show** field where the soft-key choices are

All Harmonics, Even Harmonics, and Odd Harmonics. All Harmonics gives the table described above; selecting Even Harmonics or Odd Harmonics gives a table having additional columns of data but listing only the even or only the odd harmonics respectively. The content of these tables depends on the operating mode.

In 2000 mode, the table shows the present measured value (normally the filtered value should be chosen), the limit, the average of the filtered value since the test started, that average as a percentage of the limit, the maximum filtered value and that maximum as a percentage of the limit. Finally the right-hand column gives a pass or fail assessment for that harmonic indicated by a or **X** respectively. This assessment includes a comparison of the average value against 100% of the limit, the maximum value against 150% of the limit and (where relevant) the Partial Odd Harmonic current against its limit. The bottom line of the Odd Harmonic page is marked **P:** and shows the present Partial Odd Harmonic Current and its limit.

Current Harmonics (mA)							
N	Filtered	Limit	Average	% limit	Max.	% limit	
1:	1005.7	-	1006.3	-	1007.3	-	
3:	173.3	285.0	229.1	80.4	243.8	85.5	<input checked="" type="checkbox"/>
5:	40.2	100.0	40.2	40.2	40.4	40.5	<input checked="" type="checkbox"/>
7:	20.8	70.0	20.4	29.2	20.8	29.8	<input checked="" type="checkbox"/>
9:	61.8	50.0	67.9	135.7	73.3	146.7	<input checked="" type="checkbox"/>
11:	8.0	30.0	8.2	27.3	8.6	28.8	<input checked="" type="checkbox"/>
13:	5.7	30.0	5.9	19.5	6.1	20.4	<input checked="" type="checkbox"/>
15:	44.7	30.0	40.3	134.4	44.7	149.3	<input checked="" type="checkbox"/>
17:	3.5	30.0	3.5	11.7	3.5	12.0	<input checked="" type="checkbox"/>
19:	2.6	30.0	2.7	9.1	2.8	9.6	<input checked="" type="checkbox"/>
21:	33.4	30.0	28.7	95.5	33.4	111.5	<input checked="" type="checkbox"/>
23:	1.9	30.0	1.9	6.3	1.9	6.6	<input checked="" type="checkbox"/>
25:	1.4	30.0	1.5	5.1	1.6	5.4	<input checked="" type="checkbox"/>
27:	24.6	30.0	22.2	74.0	24.8	82.7	<input checked="" type="checkbox"/>
29:	1.0	30.0	1.1	3.7	1.2	4.2	<input checked="" type="checkbox"/>
31:	1.0	30.0	1.0	3.4	1.0	3.6	<input checked="" type="checkbox"/>
33:	18.8	30.0	18.1	60.3	19.7	65.9	<input checked="" type="checkbox"/>
35:	0.7	30.0	0.8	2.7	0.8	3.0	<input checked="" type="checkbox"/>
37:	0.7	30.0	0.7	2.4	0.7	2.4	<input checked="" type="checkbox"/>
39:	16.3	30.0	15.2	50.8	16.7	55.7	<input checked="" type="checkbox"/>
P:	48.7	94.9	43.4	45.7	48.7	51.4	<input checked="" type="checkbox"/>

In 1995 mode, the normal measured value, limit and percentage of limit are shown as before, together with the minimum, maximum and maximum percentage of limit for each harmonic since the Min Hold and Max Hold were last reset (by pressing the Start key or by changing range). The extreme right-hand column also gives a pass or fail indication for each harmonic against the limit with or **X** respectively.

Display Format – Fluctuation Table

With the edit zone in the **Display Format** field, the soft-key choices are **Histogram**, **Standard Table**, **Fluctuation Table**, **Fluctuation Map** and **Time Chart**.

The Fluctuation Table is only significant when the instrument is in IEC61000-3-2:1995 mode. The 2000 edition deletes these fluctuating Harmonic requirements and replaces them with new rules using the average and maximum values displayed in the revised standard table described above.

With **Fluctuation Table** selected the edit zone can be moved to the **show** field permitting three further soft-keys **Fluctuation Set**, **Even Harmonics** and **Odd Harmonics** – to be used to define what is shown in the Fluctuation Table. The columns are the same for all three selections but the harmonics listed vary.

Odd Harmonics and **Even Harmonics** select all the odd or all the even harmonics respectively. The **Fluctuation Set** lists the odd harmonics up to the 27th plus the even harmonics up to the 10th, i.e. it includes all those for which a limit is set by the standard for fluctuating harmonics; this is the default version and is shown below.

Current Harmonics (mA)							
N	Filtered	% limit	% fluct	Max.	% limit	% fluct	
1:	1006.3	-		1006.4	-		
3:	363.2	128.8	12.5	364.3	129.3	12.5	X
5:	40.2	40.0	0.0	40.2	40.1	0.0	✓
7:	20.6	29.3	0.0	20.6	29.4	0.0	✓
9:	77.1	153.4	29.5	77.1	153.4	37.4	X
11:	8.2	27.3	0.0	8.4	27.8	0.0	✓
13:	5.9	19.4	0.0	6.1	20.0	0.0	✓
15:	51.7	171.6	29.7	53.2	176.3	36.3	X
17:	3.4	11.6	0.0	3.5	11.9	0.0	✓
19:	2.6	9.2	0.0	2.8	9.3	0.0	✓
21:	37.2	123.3		37.2	123.3		X
23:	1.9	6.3		1.9	6.3		✓
25:	1.6	5.1		1.6	5.4		✓
27:	27.1	90.0		27.8	92.2		✓
2:	22.1	109.8	100.0	22.2	111.1	100.0	X
4:	0.0	-	-	0.1	-	-	✓
6:	2.5	-	-	2.5	-	-	✓
8:	0.1	-	-	0.1	-	-	✓
10:	0.7	-	-	1.0	-	-	✓

The columns of the Fluctuation Table are as follows:

- 1) **N:** The harmonic number. The 3 versions list either all the odd, all the even or those to which the wider fluctuation limits may be applied, i.e. odd 3 to 19, even 2 to 10.
- 2) **Filtered:** The actual value, processed by the 1st order filter.
- 3) **%Limit:** The value expressed as a percentage of the steady-state harmonic limit; for Class D this is dynamically calculated from the total power.
- 4) **%Fluct:** The percentage of the last 150 seconds that the value has been over the steady-state limit.
- 5) **Max:** The maximum value since START was last pressed (or the instrument auto-ranged).
- 6) **%Limit:** The maximum value, since START was last pressed (or the instrument auto-ranged), as a percentage of the steady-state limit.
- 7) **%Fluct:** The worst percentage of any 150 second period, since START was last pressed, that the value has been over the steady-state limit.
- 8) **☐ (pass) or X (fail):** A fail will be signalled if either:
 - a) The value has exceeded 150% of the steady-state limit at any time
 - b) The value has exceeded 100% of the steady-state limit for more than 10% of any 150 second period.
 - c) The value has exceeded 100% of the limit at any time for those harmonics that don't have a wider fluctuation limit.

This indication must not be taken as valid until the test has been running for at least 150 seconds. A false pass may be shown up to that time.

Note that no **%Limits** are shown (a '-' is displayed) where there are no steady-state limits, e.g. for Class D loads below the minimum power. The **%Fluct** limits are only shown for those harmonics that have a wider fluctuation limit, i.e. odd harmonics 3 to 19 and even harmonics 2 to 10. On the tables that show all the odd or all the even harmonics, the harmonics outside the fluctuation set have the **%Fluct** column blank.

In all cases, the harmonic values used have been filtered by a 1st order filter (with a 1.5s time constant) as required by the standard when assessing fluctuating harmonics. This is indicated in

the Set-up screen where the field **Filter : 1.5 sec** is displayed and cannot be altered as it can for Histogram or Standard Table displays.

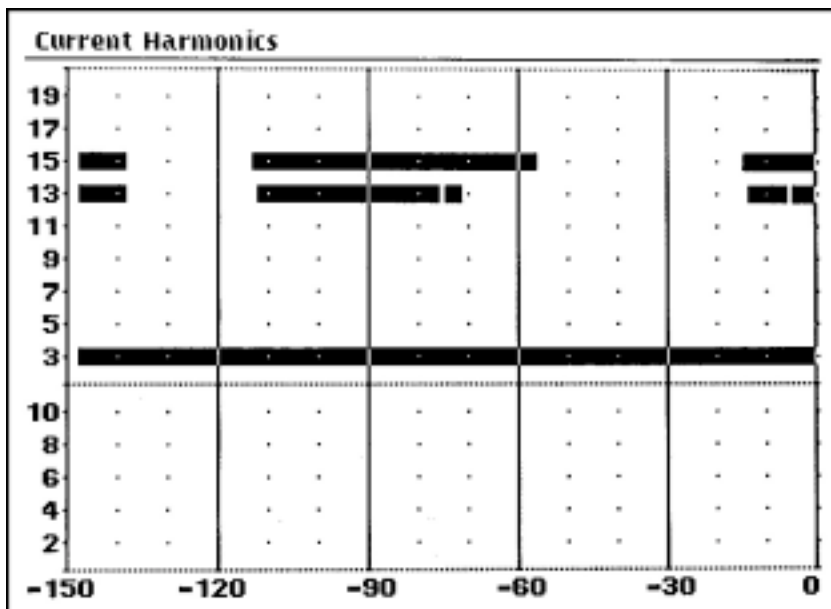
Fluctuating harmonics must be assessed over a test duration of at least 2.5 minutes, or a full operating cycle of the equipment being tested if that is longer, and the pass or fail assessment may be misleading until that time has elapsed. It is recommended that users should set up a proper timed test - see the Test Control chapter.

Pressing START at any time resets the **Max**, **Max %Limit** and **%Fluct** columns; the **Y** and **X** are therefore reset. If the peak current changes sufficiently to cause the instrument to autorange, **Max**, **Max %Limit**, etc., will again be reset. It is therefore necessary to lock the range during the measurement of fluctuating harmonics, having first chosen a range that will not be overloaded during the operating cycle of the device under test. See Important Note in the Power Meter Set-up section.

Display Format – Fluctuation Map

With the edit zone in the **Display Format** field, the soft-key choices are **Histogram**, **Standard Table**, **Fluctuation Table**, **Fluctuation Map** and **Time Chart**.

Selecting **Fluctuation Map** and returning to the Harmonics view by pressing the VIEW key gives the following display:



The Fluctuation Map is also only significant in 1995 mode. It is a simultaneous graphical display of all the harmonics to which the fluctuating specification can be applied (odd 3 to 19, even 2 to 10). The harmonics are arranged one above the other with their number shown on the left-hand vertical axis. The horizontal scale shows the most recent 150 seconds of measurements; the map moves from right to left, i.e. the right-hand edge is the most recent value. A solid bar is shown when the harmonic exceeds the steady-state limit, permitting a visual assessment of the percentage of the last 150 seconds that the harmonic has been above the limit. Each pixel represents 0.5 seconds; the value used is the maximum value of the filtered harmonic (processed by a 1st order filter with a 1.5s time constant) within that 0.5 seconds. Pressing START at any time clears the history and resets the map.

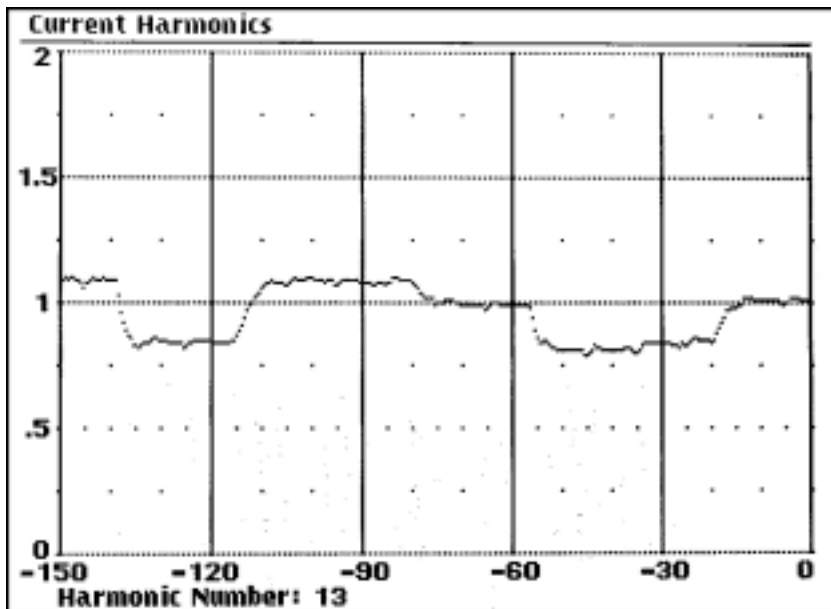
Display Format – Time Chart

The Time Chart is also primarily designed for 1995 mode but the information it gives may be found useful in diagnostic investigations.

With the edit zone in the **Display Format** field, the soft-key choices are **Histogram**, **Standard Table**, **Fluctuation Table**, **Fluctuation Map** and **Time Chart**.

With **Time Chart** selected, a further editable field called **Harmonic Number** is displayed. The number of the harmonic to be displayed on the Time Chart can now be entered directly from the keyboard and confirmed with ENTER. Alternatively the edit zone can be moved to the **Harmonic Number** field which causes the **Set Harmonic** soft-key to be shown; pressing this key prompts the user to enter the harmonic number from the keyboard, as before. Only those harmonics in the Fluctuation Set can be chosen. This selection switches the display only; the history of all the relevant harmonics is continuously stored.

Pressing CANCEL instead of ENTER returns the harmonic to the previous value. When the harmonic number is confirmed with ENTER, the display changes to the Time Chart shown below:



The vertical scale of the chart is expressed in terms of the limit for that harmonic; the centre-line is the limit (1) with the other graticules being 0.5, 1.5 (the fluctuating limit) and 2.0. The horizontal scale shows the most recent 150 seconds of measurements.

The Time Chart provides a 'chart recorder' view of a selected harmonic for the last 150 seconds; the right hand edge is the most recent value. Each pixel represents 0.5 seconds; the value shown is the maximum value of the filtered harmonic (processed by a 1st order filter with a 1.5s time constant) within that 0.5 seconds.

The Time Chart is always 'running' (i.e. it is not reset by the START key) and acquiring data for all relevant harmonics; changing the selected harmonic simply changes the harmonic currently viewed.

Test Control View

With the green VIEW lamp lit, press the TEST key to display the Test Control view. This display sets the operating mode of the instrument to Harmonics, Inrush Current or Flicker and allows the details of all the measurements to be configured.

The contents of the Test Control view change depending on which mode is selected; the following paragraphs describe the Test Control facilities available in the Harmonics mode. The other modes are described in their own chapters.

Test Control	
Operating Mode: EN 61000-3-2:2000 Harmonics	
Declare Load Class: D Professional	
Basis of limits: 150W Rating	
Class D-A Crossover: 600W	
No limits below: 75W	
No limits above: 1000W	
Limits: Standard	
Nominal Voltage: 230.0 Volts ± 2.0%	
Nominal Frequency: 50.0 Hz ± 0.5%	
Transform length: 4 cycles	
Assessment inset: Fail above 1.000 of limit	
Test type: Timed	Duration: 150 seconds
Load Power: Always On	
Test status: Completed	Elapsed time: 00:02:30
Press START to begin new measurement.	
Press STOP to release hold.	

The Harmonics mode Test Control view has two sections. The upper section summarises the key parameters of the test set-up. In practice, most of these parameters, once set on the Test Control Set-up screen for a particular user's requirement, will be changed infrequently.

The lower section summarises the time element of test control (i.e. whether timed or continuous) and shows the current test status. The associated selections are made on the Test Control Set-up screen but control is by use of the START and STOP keys as prompted from the Test Control view.

A full explanation of the options available is given in the Test Control Set-up section below.

Test Control Set-up (Harmonics)

With Test Control view displayed, pressing SET-UP shows the Test Control set-up screen. This is essentially the same as the view screen but with soft-keys at the bottom of the display that change as the edit zone is moved through the editable fields of the display with the ▲ ▼ keys.

Operating Mode

With the edit zone in the **Operating Mode** field, the soft-keys are used to select the operating mode.

The default is **EN61000-3-2:2000 Harmonics**; the alternatives are **IEC61000-3-2:1995 Harmonics**, **Inrush Current** and **IEC Flicker**. The Inrush Current and Flickermeter facilities are described in separate chapters; the editable fields of the Harmonics modes are described below. The two editions of the Harmonics standard differ in limit calculation, assessment processing (particularly of fluctuating harmonics) and in equipment classification.

Load Class

EN61000-3-2 defines different harmonic current limits for different classes of equipment; users must refer to the relevant edition of the standard to determine which class covers the equipment being tested (the definition of class D in particular is completely different in the two editions of the standard). The class must be declared to the analyser so that the correct limits are used for the pass or fail assessments.

With the edit zone in the **Declare Load Class** field, the soft-key options for either mode include **Class A**, **Class B**, **Class C**, and **Class D**; in 1995 mode only the additional option **Automatic Class A or D** is also available while, in 2000 mode a **Professional Equipment** modifier is offered.

For **Class A** the limits are absolute values for all harmonics, as given in Table 1 of EN61000-3-2.

For **Class B** the limits are absolute values for all harmonics and are the class A limits multiplied by a factor of 1.5.

For **Class C** the limits depend on the fundamental current and power factor of the load and are calculated according to the percentage factors in Table 2 of EN61000-3-2. Limits apply to all odd harmonics and to the second harmonic; there are no limits for the other even harmonics.

For **Class D** the limits depend on the power consumption of the load and are calculated according to the milliamps per Watt factors in Table 3 of EN61000-3-2, subject to the maximum values also listed in that table (which are equal to the class A limits). There are limits for the odd harmonics only.

If **Automatic Class A or D** is selected (only available in 1995 mode) the waveform shape is first checked every transform to see whether 95% or more fits within the Class D envelope, i.e. it is checked to see whether it has the 'special wave shape' defined by IEC61000-3-2:1995. If it does, and if the instantaneous load power is below the Class D-A crossover power and above the minimum power applicable to class D, then that instantaneous load power is used as the basis for calculating the Class D limits (according to Table 3 of IEC61000-3-2) for assessing the results of that transform. If the waveshape is class D but the power is below the minimum threshold no limits apply. In all other cases, the fixed limits of Class A are applied. These calculations are repeated every transform.

In 2000 mode an additional soft-key option determines whether the equipment under test is considered to be Professional Equipment or not. No limits are applied to Professional Equipment with a rated power consumption over 1000 Watts. This soft-key acts as a toggle, displaying either **Professional Equipment** or **Standard Equipment** to reverse the setting currently active.

The **Harmonic Summary** section of the Power Meter view shows the load Class declared or, in the case of automatic Class A or D detection, which Class is detected and any power limits that apply.

A number of subsidiary configuration lines appear on the Test Control screen depending on the class declared.

Basis of limits

If either Class C or D is selected then the limits depend on the behaviour of the unit being tested and an additional line becomes available to control the way the limits are calculated. With the edit zone in the **Basis of Limits** field, the soft-key choices are **Automatic**, **Declare Value** and **Store Present**.

When **Automatic** is selected, the limits are continuously calculated from the measured consumption of the equipment under test. For class C the fundamental current and power factor are used; for class D the power consumption in Watts is used.

When **Store Present** is pressed, the actual power consumption (or, for class C, the fundamental current and power factor) of the load at the moment the key is pressed is stored and used thereafter as the basis for calculating the limits. The values measured are displayed on the Basis of Limits line, followed by the word **Condition**. The limits then remain fixed until the basis of limits is changed.

This method is used, for example, when testing Discharge lamp luminaires with built-in dimming devices when the standard requires the limits to be calculated from the fundamental current and power factor measured at the maximum load condition. After setting up the maximum condition press **Store Present** to set the basis of limits. As the dimmer setting is varied, the harmonic currents are assessed against the limits derived from the stored setting.

When **Declare Value** is pressed the user is prompted to enter the rated consumption of the equipment being tested using the keyboard.

For a Class D load, pressing the **Declare Value** soft-key brings up a message at the bottom of the display (in place of the soft-keys) with a flashing cursor.

Rated Power: _Watts

The rated value is entered from the keyboard and confirmed with the ENTER key; the entered value is shown in the Basis of Limits field following by the term **Rating** to indicate that it is a declared rating. Pressing CANCEL instead of ENTER returns the Basis of Limits to the previous state.

For a Class C load both **Declare Current** (for the fundamental current) and **Declare PF** (for the power factor) must be entered in a similar manner (the power factor will default to 1.0 if not explicitly entered).

In general when making tests to the 1995 edition of the standard the Automatic basis of class C or D limits will be used, while the 2000 edition requires the manufacturer's declared rating to be entered as the basis of the limits.

Class D-A Crossover Power

Class D is only defined for equipments with power consumption up to 600 Watts; above that power class A limits apply. If the consumption of a particular equipment varies around the crossover value, the applicable limits change rapidly, resulting in measurements that are hard to interpret. In this case the crossover power setting can be changed slightly to take one set of measurements in class D and a second set in class A.

Note that each individual harmonic limit in class D (when calculated by the appropriate mA/W formula) is also subject to a maximum value equal to the class A limit for that harmonic. The power level at which this occurs is around 600 watts, but varies slightly between harmonics (because of the coefficients of the various equations). Changing the crossover power setting does not alter these calculations.

The 2000 revision to the standard suggests that if the consumption of the equipment falls near the crossover point, then the declared power (rather than the crossover point) should be changed slightly to clearly define the equipment as class A or D.

With the edit zone in the **Class A-D Crossover** field, the default class crossover point can be changed using the **Set Power** soft-key exactly as described above.

Minimum Power (No limits below)

In some circumstances, the standard specifies that no harmonic current limits apply to equipments below a certain minimum power consumption. In the 1995 edition, this requirement only applies to class D; in the 2000 edition, it applies to all except class C. The normal minimum power is 75 watts.

With the edit zone in the **No Limits below** field, the default minimum power limit can be changed using the **Set Power** soft-key. Pressing this key brings up a message at the bottom of the display (in place of the soft-keys) with a flashing cursor:

Minimum power _ Watts.

The new value is entered from the keyboard and confirmed with the ENTER key; pressing CANCEL instead of ENTER returns the limit to its previous value. When the load power is below this power, no limits are applied.

Class C lighting equipment with an active input power $\leq 25\text{W}$ must meet the power-related harmonics limits of Class D (i.e. Table 3 of EN61000-3-2). The analyser can be set up to do this by declaring Class D and setting the Minimum Power to zero, so that limits are calculated and displayed for all load power levels. Note that the user must monitor the actual power level (using the Meter view); if the load exceeds 25W then conventional Class C limits apply.

Maximum Power (No limits above)

In 2000 mode, if the equipment under test is defined as Professional Equipment then no limits apply above 1000 Watts. This power threshold can be changed if required (perhaps to allow testing with some margin beyond the exemption level).

With the edit zone in the **No limits above** field, the default Professional exemption power can be changed using the **Set Power** soft-key exactly as described above.

This line only appears if the equipment has been declared Professional in the Declare Load Class field.

Adjust Limits

The **Limits** field provides the user with the opportunity to scale the limits defined in the standard (which strictly only apply to 230V $\pm 2\%$ operation) to a different operating voltage, e.g. 100V. This facility is available in both 1995 and 2000 modes; users should check carefully the details of the national adaptation of the standard to determine the requirements.

With the edit zone in the **Limits** field the soft-key choice is **Standard** or **Voltage Ratio**. With **standard** selected (the default), the limits defined in the EN (or IEC) standard apply; if **Voltage Ratio** is selected, the limits are scaled by the ratio between 230V and the nominal voltage set in the **Nominal Voltage** field. In Voltage Ratio mode the set-up display reads:

Limits: Adjust by 230V/Nominal

This adjustment is reflected both in the limit current values shown in the results and in the assessments.

Nominal Voltage

With the edit zone in the **Nominal Voltage** field the nominal supply voltage and its voltage tolerance, against which the load supply will be monitored, can be set using the **Set Voltage** and **Set tolerance** soft-keys. When either key is pressed, an appropriate message is displayed at the bottom of the display (in place of the soft-keys) with a flashing cursor, e.g.

Nominal Voltage: _ Volts.

The new value is entered from the keyboard and confirmed with the ENTER key; pressing CANCEL instead of ENTER returns the voltage (or tolerance) to the previous value.

Important note: The hardware voltage measurement range is automatically set according to the value entered here, so for optimum accuracy it is important that the correct entry is made.

Nominal Frequency

With the edit zone in the **Nominal Frequency** field the nominal supply frequency and its frequency tolerance, against which the load supply will be monitored, can be set using the **Set Frequency** and **Set tolerance** soft-keys. The numeric entry procedure is the same as described for Nominal Voltage above.

Important note: Certain internal time constants are calculated from this value, so for proper operation it is important that the correct value of the actual frequency of the load supply is entered.

Transform Length

With the edit zone in the **Transform length** field, the soft-keys offer the choice of **4 Cycles** or **16 Cycles** for the length of the data window for each Discrete Fourier Transform. All transforms use contiguous rectangular windows; the data processing is continuous with no gap or overlap between successive transforms.

It is most unlikely that changing the window length will result in any noticeable difference in the results. The instrument uses 4-cycle transforms by default as they give a faster display update rate, however the standard defines the 16-cycle window as the reference method. Therefore if differences do arise then the 16 cycle results should be used for assessment.

Assessment Inset

With the edit zone in the **Assessment inset** field, the **Set Level** soft-key allows the actual limit to be set as a decimal fraction or multiple of the limits automatically defined by the choice of Operating mode and load Class. Setting the inset to 0.95, for example, gives a 5% 'safety margin' between the measurement limits used and the limits defined by the standards. Note that this inset only affects the Pass or Fail assessment on the Harmonics View and in the printed reports; the numerical data and limit values shown in the tables are not affected.

Pressing the **Set Level** soft-key the message:

Assessment inset: _ of limit

is shown at the bottom of the display (in place of the soft-keys) with a flashing cursor. The new value is entered from the keyboard and confirmed with the ENTER key; pressing CANCEL before ENTER returns the multiplier to the previous value.

Test Timing and Load Power Control

The lower section of the Test Control set-up has two further editable fields, **Test type** and **Load Power**, for which the soft-key choices are inter-dependent. In addition, the **Test status** field (non-editable) immediately above the soft-keys provides the same information about a timed test as the Test Control view display.

With the edit zone in the **Test type** field, the soft-key choices are as follows; the corresponding **Load Power** options are detailed with each test type choice.

-
- Untimed:** The default option. Measurement is continuous; consequently load power is **Always On**. The test status is **Normal** (i.e. continuous measurement) unless STOP is pressed. When STOP is pressed, the measurement is interrupted and the displayed values are held; test status changes to **Hold**. The TEST lamp flashes to show that the measurement is held; pressing STOP again restarts the measurement and turns the TEST lamp off. STOP can be used with the instrument set to any view. Thus, it can be used to “freeze” the values in the Power Meter view or the histogram or tabular displays of the Harmonics view; however, STOP does not hold the Waveform Graph view.
- Manual:** The test is manually controlled by the START and STOP keys. With the edit zone moved into the **Load Power** field there is now the option to have the load power **Always On** or just on **During Test**. With **Always On** selected, when the test is started with the START key the **Test status** field changes to show **Running** and **Elapsed time**, the time is taken from the internal real-time clock and is given in hours, minutes and seconds. The TEST lamp lights while the test is running. When it is stopped, by pressing the STOP key, the test status changes to **Completed** and the TEST lamp flashes. The total time of the test is shown in the **Elapsed time** field; pressing STOP again erases the elapsed time and arms the timer for the next test; test status reverts to **Normal**. With **During Test** selected, the operation is essentially as for **Always Running** but the Test status shows **Load Power OFF** before and after the test period itself.
- Timed:** When **Timed** is selected a further soft-key, **Set Duration**, is shown; pressing this permits the numeric entry of the test duration, in seconds, exactly as described for Nominal Voltage entry, for example; the default duration is 150 seconds. Alternatively, with the **Set Duration** soft-key showing, direct numeric entries can be made from the keyboard. The maximum duration that can be entered is 65535 seconds. With the edit zone moved into the **Load Power** field there is again the option to have the load power **Always On** or just on **During Test**, as described for **Manual** above. When **Timed** is selected the **Test status** field changes to show **Awaiting START**. Pressing the START key starts the test; the TEST lamp lights and the test status changes to show **Running** and **Elapsed time** in hours, minutes and seconds. At the end of the timed period (or before if the STOP key is pressed) the test status changes to **completed** and the TEST lamp flashes. Pressing STOP at this point erases the elapsed time and arms the timer for the next test; the test status returns to **Awaiting START**.

In any mode, whenever the TEST lamp is flashing the measurement is suspended and all displayed values are held. Pressing the START key at any time in any mode resets the Min Hold and Max Hold values.

Note that for **Manual** or **Timed** measurements where the load power has been selected to be on only **During Test** the analyser will capture (as Min Hold and Max Hold values) any exceptional harmonics that occur when power is first applied. Since EN61000-3-2 allows such transitory harmonics occurring in the first 10 seconds to be disregarded the user may use the START key at any time during this period to reset the Min Hold and Max Hold values after the transients have finished. If the START key is used in this way the **Elapsed time:** is reset to zero, i.e. the timed period is restarted.

It is important when making compliance measurements to set up and execute a proper timed test. This is especially the case if the harmonic levels vary during the operating cycle of the equipment being tested. Requirements for test duration are given in the standard for some types of equipment and some general guidance has been added to the 2000 edition. If the equipment being tested has an obvious operating cycle over a period of some minutes then a test should be taken over a full cycle. If the cycle is quicker, the test should cover multiple cycles. In any event, the test should last at least 150 seconds.

When the timed test is complete the STOP light flashes; the report should then be printed.

EN61000-3-3 Flicker and Fluctuations

Introduction

EN61000-3-3 defines limits for the low frequency fluctuations in the voltage delivered by a supply network of non-zero impedance caused by changes in the current consumption of the equipment under test. The magnitude of these fluctuations depends on both the load current variations and the impedance of the supply network. The standard specifies a particular source impedance, called the reference impedance, which is to be used for the measurements. It contains both resistance and inductive reactance. The purpose of the requirements is to limit the impact of a varying load on neighbouring consumers connected to the same supply network.

This instrument offers two modes for flicker and fluctuation analysis: voltage sensing or current sensing.

In voltage sensing mode, the unit measures the voltage across the input to the equipment under test on the load side of the reference impedance. A physical implementation of the reference impedance must be connected between a zero impedance test supply and the test circuit input terminals of the instrument.

If a physical reference impedance and a high quality supply are not available, an alternative measurement can be made using current sensing mode. The instrument measures the current into the load and calculates the voltage drop that would occur across the reference impedance. By subtracting this voltage drop from a simulated nominal-voltage sinewave the instrument can synthesise the waveform that would be present at the load terminals of the reference impedance. This calculation uses both the magnitude and rate of change of current at 300 sampling points in the cycle.

The voltage variations are subject to two separate analyses, Flicker and Voltage Fluctuations. Each has separate limits.

Flicker Analysis

Flicker is the subjective effect of the variations in the light output of a 230V 60W coiled-coil filament lamp as a result of fluctuations in its supply voltage. It is measured using an instrument called a Flickermeter with characteristics defined in EN60868 (which is to be replaced by EN61000-4-15). These characteristics (in time, amplitude and frequency) are designed to simulate the response of the lamp, eye and human brain combination. The standard also allows flicker to be assessed by graphical analysis if the load variation waveform is simple and regular, but the use of a Flickermeter is the reference method and is always preferred.

The first output of the flicker meter is an indication of instantaneous flicker sensation, measured in p.u. (perception units), where 1 p.u. is the threshold of perception for 50% of the population. This signal (which can vary widely during the test) is then subject to statistical analysis (based on a "time at level classification") to derive the Short and Long term flicker severity indicators, which are the parameters subject to limits. Full details of the statistical process are given in IEC60860-0.

This instrument is a digital implementation of the Flickermeter and the statistical analyser.

The standard gives the following definitions of flicker and the flicker indicators P_{st} and P_{lt} measured by the HA1600:

Flicker:	Impression of unsteadiness of visual sensation induced by a light stimulus whose luminance or spectral distribution fluctuates with time.
Short-term flicker indicator, P_{st}:	The flicker severity evaluated over a short period (in minutes); $P_{st} = 1$ is the conventional threshold of irritability.
Long-term flicker indicator, P_{lt}:	The flicker severity evaluated over a long period (a few hours) using successive P_{st} values.

In the standard the time specified for P_{st} evaluation is 10 minutes and for P_{lt} is $12 \times P_{st}$, i.e. 2 hours. The limit values specified are $P_{st} \leq 1.0$ and $P_{lt} \leq 0.65$.

Voltage Fluctuation Analysis

The input to the voltage fluctuation analysis is a sampled representation of the voltage waveform; in this instrument, there are 150 data points per half-cycle. This data is rms integrated over each half-cycle interval to obtain the rms value of the voltage in that half-cycle. These are then expressed as a percentage of the nominal voltage. This is a signed value - positive when above nominal and negative when below. It may be helpful to recognise that it will normally be negative - any current drawn by the load must cause a voltage drop across the reference impedance.

The standard defines a number of measurements to be made by analysing the sequence of these half-cycle rms values throughout the duration of the measurement. The instrument must first decide whether the load is in a "steady state". This is an interval when the current consumption of the equipment under test does not vary, so the terminal voltage remains constant for a period of at least 1 second. The alternative is called a voltage change characteristic.

The standard does not give a numerical definition of how small a variation should be considered constant when assessing whether an interval constitutes a steady state. The figure chosen for this instrument is $\pm 0.15\%$ which gives reasonable results on most loads, but the user can change the value if required. After each new half-cycle the instrument computes the average value over the preceding second and compares all the individual half-cycle values against this average \pm the tolerance band specified. The load is considered to be in a steady state if all the values are within this band. The level assigned to the steady state is the average value during the first second. The steady state persists at that level until a half-cycle value lies outside the tolerance band. A voltage change characteristic is then presumed to start.

The standard is concerned with the value d_c which is the difference between the levels of two adjacent steady states separated by at least one voltage change characteristic. There is a point of interpretation here; some may consider that "adjacent" steady states are separated by exactly one change characteristic. The instrument displays the value for both interpretations of d_c .

While in a voltage change characteristic there is a limit on the length of time the voltage change $d(t)$ may exceed 3%. The instrument records and reports this from both perspectives: the longest duration over the 3% threshold and the highest variation over a 200ms interval.

The instrument also keeps a record of the highest and lowest half cycle values - the difference between these is d_{max} (the largest overall change in relative voltage).

As with harmonics measurements it is essential that the standard is read and understood before testing is undertaken. In particular, note that the standard includes the effects of inrush currents at the moment of switch on.

Test Control Set-up (Flicker)

Select Test Control view, enter set-up and, with the edit zone in the **Operating Mode** field, select **IEC flicker** as the operating mode.

Test Control	
Operating Mode: IEC 61000-3-3 Flicker	
Sensing method: Current	
Reference Impedance: 0.400 +j 0.250 Ohms	
Observation Time for P _{St} : 10 minutes	
Observation Time for P _{Lt} : 12 P _{St} values	
d(max) limit: 4.00%	
d(t) limit: < 200 ms above 3.00%	
d(c) limit: 3.00%	
'Steady State' definition: >1000 ms below 0.15%	
Nominal Voltage: 230.0 Volts	
Nominal Frequency: 50.0 Hz	
Test type: Timed	Duration: 7200 seconds
Load Power: During Test	
Test status: Running	Elapsed time: 00:00:26
Press STOP to end measurement.	

Sensing Method

With the edit zone moved to the **Sensing method** field, choose **voltage** sensing if a clean supply and external reference impedance are available (Fig. 1 of EN61000-3-3); otherwise use the **Current** sensing capability of the instrument. When using **Current** sensing the measurement range is locked at 96A full-scale; the internal arithmetic requires this and the results are only calibrated on this range.

Reference Impedance

If **Current** sensing is in use then an additional line allows entry of non-standard values for the **resistive** and **reactive** components of the simulated reference impedance (there is no requirement in IEC 60000-3-3 for this). The software will not accept values outside the working range of the algorithm.

Flicker Observation Times

The next two lines of the screen show the observation times for P_{St} and P_{Lt}. P_{St} is fixed at 10 minutes. The long-term test P_{Lt} is optional: the duration defaults to the twelve P_{St} intervals required by the standard but it can be excluded by pressing the **omit** soft-key.

Voltage Variation Limits

The next three lines set the assessment limits for the voltage variation results d_{max}, d_c and d(t) during a change interval. These are used as the basis for the pass or fail assessments displayed on the Voltage Variations screen and included in the printed report. The limits are defined in the standard; the default settings apply to most equipment, but if the variations are caused by manual switching, or occur only at a very low rate, then relaxed limits apply and can be entered here.

Steady State Definition

Two fields define both the time interval and the tolerance band used to distinguish a steady state interval from a voltage change. The standard specifies a **minimum duration** of 1 second, but does not fix the **tolerance band**. The default ± 0.15% will suit most loads, but can be increased if a particular load causes a large number of short duration steady states with little change in voltage level between them. There is no guidance in the standard about this.

Nominal Voltage and Frequency

Enter the correct **nominal voltage** and **nominal frequency** to match the test supply.

Test Control

The test control and timing fields at the bottom of the screen are the same as in Harmonics mode; see Test Timing and Load Power Control section of the Test Control Set-up Chapter. A **timed** test should be selected for Flicker measurements. The **Duration** field cannot be edited; the test duration is automatically set to 10 minutes (600 seconds) if the P_{it} test is omitted, or to 2 hours (7200 seconds) if it is included. Tests of any other length can of course be made in the Untimed or Manual modes.

Taking Flicker and Fluctuation Measurements

After setting the required options on the Test Control screen, press START to clear the measurement history and then cycle the equipment under test through its normal operating sequence. Note that the moment of initial switch-on is included in these tests, unlike Harmonic testing when the first 10 seconds of operation are excluded. Detailed requirements for some types of equipment are given in Annex A of the standard.

The progress of the test can be seen by selecting Meter view, entering set-up and choosing either the **Flicker Meter** or the **Voltage Variations** display page.

When the timed test has completed, print a report of the results of flicker and voltage fluctuation analysis by selecting report view and pressing ENTER. The report format automatically follows the selected operating mode. After the usual user configurable title lines, the report shows supply voltage, load power and load current measurements followed by the voltage variation results and the flicker analysis. The contents of the flicker classifier from which the P_{st} value is calculated are printed for information. If the long-term flicker test was enabled, the P_{st} results from the 12 intervals are also listed.

Meter View (Flicker)

The Meter View is used for displaying the Flicker and Voltage variation results. When the operating mode has been set to **IEC Flicker** on the Test Control set-up screen, a Flicker and Voltage Variations summary is shown at the bottom of the Power Meter view.

Two additional full pages of results also become available. To view these press SET-UP on the Meter View, the soft key options are **Voltage Variations**, **Flicker Meter** and **Power Meter**. Selecting any of these switches back to view mode showing the requested page - there is no need to press VIEW.

Power Meter View summary

The first line shows the Instantaneous Flicker Sensation in **p.u.** (perception units - see above) and the presently assessed values of the short and long term flicker indicators P_{st} and P_{lt} .

The second line shows the voltage variation over the last second, the highest variation in any 200 millisecond interval and the maximum voltage variation d_{max} .

These values can be observed in more detail on the dedicated full page Flicker Meter and Voltage Variations views. With the Power Meter view displayed, press SET-UP and select the required page on the soft-keys.

Flicker Meter Page

Flicker Meter		Range locked	
P_{st} classifier		P_{lt} calculation	
Duration	Flicker	Interval	P_{st}
0.1%	43		
0.7%	39	>	1: 1.60
1.0%	38		2: 0.00
1.5%	37		3: 0.00
2.2%	35		4: 0.00
3%	33		5: 0.00
4%	30		6: 0.00
6%	25		7: 0.00
8%	21		8: 0.00
10%	17		9: 0.00
13%	12		10: 0.00
17%	8		11: 0.00
30%	2		12: 0.00
50%	0		
80%	0		
$P_{st} =$	1.60	$P_{lt} =$	0.70

The left-hand side of the Flicker Meter view shows the 15 'percentiles' of the cumulative probability function, which are used by the last stage of the Flickermeter (the classifier) in the calculation of P_{st} . In effect, this shows how the P_{st} is being cumulatively calculated from the p.u. values; as the 10 minute period progresses the P_{st} gets closer to its true final value. At the end of the 10 minute period, the P_{st} value is transferred to the appropriate interval field of the P_{lt} calculation on the right-hand side of the display; the P_{lt} value at the bottom of the column is also an 'in progress' value that gets closer to its true final value as the 12 intervals are progressively completed.

Only at the end of the complete, timed, test are the P_{st} and P_{lt} values true; the intermediate values are presented as information to allow a judgement of how the test is proceeding.

Voltage Variation View

Voltage Variations		Range locked
Variation over last 1000ms:	-1.06%	+0.12% -0.11%
Present state:	Steady at -1.07%	
Duration:	4.800 seconds	
Extreme levels:	-0.92% -3.15%	
d(max):	2.23%	✓
Number of Change Intervals:	37	
Highest d(t) for 200ms:	2.93%	✓
Duration of d(t) over 3.00%:	0.00 seconds	
Longest d(t) over 3.00%:	0.08 seconds	
Number of Steady States:	37	
Steady State levels:	-1.05% -2.98%	
d(c) between last two:	1.92%	
max d(c) between adjacent:	1.93%	✓
max d(c) between any:	1.93%	

This view reports the variations in half-cycle rms voltage at the terminals of the load - if Voltage Sensing is selected the actual voltage is measured, if Current Sensing is selected then the voltage is calculated. All values are in percent of nominal voltage as declared on the Test Control set-up. Note that there is no AGC function (unlike the flicker meter) - if the actual supply voltage is not equal to the nominal, this bias will show in the variation figures.

Present Behaviour

The top line shows the behaviour of the load terminal voltage over the last second (or specified d_c interval if a non-standard requirement has been set on the Test Control screen). The three figures show the average value and the peak positive and negative excursions above and below that average. This allows an assessment to be made of the stability of the operation of the load at the present time.

Below this is shown the categorisation of the present load behaviour as either a steady state or a continuing voltage change interval, and the length of time since that state began.

Extreme levels and d_{max}

The next lines show the extreme voltage levels (highest and lowest) that have occurred since the start of the test. In general (if the nominal voltage is declared correctly), both extremes will be negative, as a load that consumes power will always cause a voltage drop. The variation will only be positive if a load (such as a motor with regenerative braking) returns energy to the supply.

The difference between these extremes is d_{max} . This is an important test result and is compared to the permitted limit (as set on the Test Control Screen) and the assessment displayed as a (pass) or **X** (fail).

Voltage Change Intervals

The next group of four lines presents the analysis of voltage changes. The standard includes a requirement that "the value of $d(t)$ during a voltage change shall not exceed 3% for more than 200 ms". The instrument displays the voltage change information from both the time and voltage perspectives: the maximum voltage change that has persisted for more than 200ms, with a (pass) or **X** (fail) assessment, the length of time the present voltage change has been above 3% (zero if it is not) and the longest duration of any voltage change above 3%.

Note that the limits for both time and level can be changed on the Test Control screen if required, for example if the changes are caused by manual switching larger changes are allowed.

Steady State Intervals

The bottom group of lines displays the analysis of steady states. The first pair of values are the levels (relative to nominal voltage) of the highest and lowest steady state intervals that have occurred since the test started. Next is shown the difference d_c between the last two steady states, then the largest difference between any two adjacent steady states and finally the difference between the highest and lowest steady states whether they were adjacent or not. A **▣** (pass) or **X** (fail) assessment is made against the limit set on the Test Control screen. Users must decide their interpretation of the word “adjacent” in the definition of d_c : “the difference between two adjacent steady state voltages separated by at least one voltage change characteristic”.

Inrush Current Measurement

When **Inrush Current** mode is selected in the **Operating Mode** field of the Test Control Set-up screen, the Power Meter view is changed to show Inrush Current results instead of the Harmonics Summary at the bottom of the screen:

Power Meter			Hold
Supply Voltage			
230.1 V_{rms}	0.1% THD	Frequency	50.05 Hz
325.5 V_{pk}	at 89.9°	Crest Factor	1.415
Load Power			
0.024 kW	0.056 kVA	Power Factor	0.436
Load Current			
0.22 A_{rms}	39.2% THD	65.0% under Class D mask	
0.48 A_{pk}	Phase 85.9°	Crest Factor	1.983
Inrush Current			
Highest peak:	+14.79 A	-15.80 A	
Latest peak:	+3.43 A	-15.77 A	

Inrush current measurements are made by repeatedly switching the load on and off and measuring the peak values (both positive and negative) of the resulting current transient. The switching may be done manually, using either the load's own switch or the front panel LOAD switch, or automatically using the power sequencer facility of the instrument.

Two sets of values are kept: Latest Peak and Highest Peak. In each set, the largest positive and negative peaks are recorded separately. Every sample of the current waveform is compared to the stored peak values, which are updated if the new value is larger. The values recorded are instantaneous peak currents, not half-cycle rms values.

An automatic re-trigger mechanism is used to detect when the load has been switched off and then on again to cause a new inrush transient. Whenever the peak current in a half cycle is more than twice the peak current in the cycle before, it is assumed to be the start of a new switching event. The new peak value is then stored in Latest Peak, even if it is smaller than the previous Latest Peak. The Highest Peak value is not reset so it records the highest value of Latest Peak in a sequence of switching events.

Both sets of Peak hold accumulators can be reset by pressing the START key.

The Waveform Graph view can also be used to inspect inrush current transients. A single shot facility is available: if the **Trigger Source** is set to **Inrush** then a new trace will be drawn for each transient (as detected using the mechanism described above). The **horizontal scale** may be set to more than one cycle to show the behaviour of the transient after the initial cycle. The **accumulate** mode can be used to overlay multiple transients. For further details of all these facilities, see the section on Waveform Graph Set-up.

When Inrush Current mode is selected, the instrument switches to the 400A peak range and disables autoranging to ensure that the peak current is always within the measurement range. If, after a number of tests, it is apparent that the peak currents are much smaller than this, then the measurement sensitivity can be increased by selecting **Setup Range** on any of the Power Meter, Waveform Graph or Test Control Set-up screens and using the **Up** and **Down** soft-keys. It is important to avoid overload; the Waveform Graph view can be used in Accumulate mode to ensure that valid results have been obtained.

Inrush current measurements should ideally be made by manually switching the unit under test with its own power switch as this gives the most accurate representation of real use. There are however occasions when an automatic measurement is useful so this instrument provides a sequencer using its internal relay to switch the load. There is provision for setting the on and off durations and for adjusting the phase of the switching points.

Because of the stringent requirements of EN61000-3-2 governing voltage drop across the measuring device, this instrument uses a relay to switch the load power, not an electronic device, so the actual switching point is subject to the timing uncertainties of the relay. By viewing the result on the Waveform Graph display, the phase setting can be adjusted until the required result is obtained.

To avoid damage to the relay the sequencer should not be used with highly reactive loads likely to cause arcing at the contacts.

Inrush Current Test Control Set-up

When the Test Control view is displayed with the **Operating Mode** field set to **Inrush Current**, pressing SET-UP introduces the edit field box and allows the settings to be changed:

The screenshot shows a window titled "Test Control" with the following settings:

- Operating Mode:** Inrush Current
- Range:** 400 A peak (highlighted in a box)
- Load Power:** Manual
- Switching Sequence:**
 - On Time:** 100 Cycles
 - Off Time:** 200 Cycles
 - On Phase:** 90°
 - Off Phase:** 270°

At the bottom right of the window are two buttons labeled "Up" and "Down".

Current Range

With the edit zone in the **Range** field the **up** and **down** soft-keys can be used to change the range as required. The highest available current range (400 Amps peak) is automatically set when inrush mode is initially selected. Autoranging is disabled in Inrush mode.

Load Power

Selecting **manual** allows the user to control the load power using either the LOAD switch on the front panel or the switch on the unit being tested. Selecting **sequencer** uses the relay in the instrument to repeatedly switch the load on and off for defined times, with the switching points being approximately synchronised to the load supply waveform.

Switching Sequence on and off times.

These two edit fields specify the duration of the Power On and Power Off parts of the sequence in terms of the number of cycles of the load supply. The use of the **set Time** soft-key is optional: pressing any of the number keys will set the number entry mode directly. Values between 4 and 65535 cycles can be specified. Pressing ENTER completes the number; CANCEL restores the previous value. Short durations should not be set simultaneously for both on and off times, as this will reduce the life expectancy of the relay.

Switching Sequence on and off phase.

These two edit fields specify the switching points of the Power On and Power Off parts of the sequence in terms of the phase angle relative to the rising zero crossing of the load supply. Values between -999 and 999 degrees can be specified. Pressing ENTER completes the number, which is then reduced to the range 0 to 359 degrees; CANCEL restores the previous value. The value specified is only an indication of the approximate switching point; use the Waveform Graph view to check the results obtained and adjust the angle specified as required.

Report View

With the green VIEW lamp lit, press the REPORT key to display the Report view.

Report	16:02:51 25-02-2002
Report Number: 26	
Printer: Plain text	
Port: Parallel	Page Terminator: 12
Report: EN 61000-3-2:2000 Harmonics	
Header:	----- Malcolm's HA1600
Title 1: Equipment:	
Title 2: Conditions:	
Title 3: Notes:	
Footer: Taken by: MGR	
LH Margin: 5	
Harmonic Summary to EN 61000-3-2:2000	
Class A Limits	
Load passes Harmonic levels.	
Supply meets IEC requirements.	
Press ENTER to print.	

The reports produced by the instrument are designed for printers using A4 paper and a fixed pitch font (such as Courier) providing 80 characters across the paper. Only 72 character spaces are actually used, with an adjustable blank left margin allowing space for filing holes. The full reports are 64 lines long. A single Form Feed is sent at the end of the report. Most printers will produce the desired results using their default settings, but in some cases adjustments may be needed to font selection, margin settings or number of lines per page. Automatic line-feed and automatic form-feed should be turned off.

There is provision for user-entered text to be added to a report: four lines at the top of the report and one at the bottom. Each allows up to 80 characters of free text to be entered as described in the Report Set-up section. A partial preview of these lines is shown on screen in the Report View. Reports include the time and date from the internal clock and a Report Number, which increments automatically every time a report is printed, or can be set by the user from the set-up screen.

The download of data to a PC using the optional HA-PC LINK software is also controlled from the Report View.

To produce a valid compliance report first set the required Report and Test Control options, select and lock the current range and then run a full timed test. At the end of the test, the STOP lamp will be flashing; press REPORT to display the Report View, check the Harmonics Summary (which reflects the results of the whole test) and press ENTER to initiate the print. The instrument takes a complete instantaneous snapshot of the test data and creates a print image in its internal memory. This image is then spooled to the printer at whatever speed it can handle while the instrument can continue to take measurement data. All the information in a print is mutually consistent regardless of the physical speed of a particular printer.

The status line will show **spooling** while the data is sent to the printer; after a few seconds, printing will start. If a communication problem occurs, the status line will show **stalled**; there are other diagnostic messages such as **Paper Empty**. If the status signals on the interface indicate that there is no printer connected (or it is not switched on) the instrument will ignore the print command.

The types of report available follow the operating mode of the instrument set up on the Test Control View. The EN61000-3-2:2000 mode and the EN61000-3-3 Flicker and Fluctuations mode each have only one choice of report. The EN61000-3-2:1995 Harmonics mode offers two types of report – steady-state Harmonics and Fluctuating Harmonics – which can be selected on the Report Set-up screen.

Report Formats

At the top of the report are the date and time the test was taken, the report number and the user entered title lines. Below these, on a Harmonics report, are three sections that summarise the test conditions and the behaviour of the load.

The Supply Voltage section shows the range of supply voltages that occurred during the test (only one is shown if the variation is negligible), the peak voltage, frequency and other measured parameters, followed by a text assessment of the supply characteristics against the requirements of the standard.

The Load Power line shows the lowest and highest powers that occurred during the test, the highest VA and the Power Factor associated with the highest fundamental current (this is needed for class C equipment).

The Load Current line shows the lowest and highest rms current that occurred during the test, the highest peak current and the highest Crest Factor that was measured. Note that this Crest Factor is not necessarily associated with the highest current.

This is followed by a statement of the limits that were applied and (if relevant) the basis on which they were derived.

Then follows the data table showing the measurement results for the fundamental and all the harmonics. For EN61000-3-2:2000, this table has the following columns:

Harmonic Number:	The harmonic number in numerical order from 2 to 40. The last line gives the Partial Odd Harmonic Current (POHC) and the Partial Odd Harmonic Limit (POHL). These are the rms sum of the odd harmonics 21 to 39.
Limit Current:	The limit value of the harmonic current, in Amps or milliamps (as indicated in the heading), for the declared Class and rated power.
Average (filtered):	The arithmetic average of all the filtered values measured during the test, from the time the START key was pressed until either a timed test completed or the STOP key was pressed. For valid results always set up and run a timed test before printing a report.
%Limit:	The percentage of the limit that the average value represents.
Max Value (filtered):	The largest individual reading of all the filtered values measured during the test.
%Limit:	The percentage of the limit that the Max Filtered Value represents.
Assessment:	A Pass or Fail assessment for each harmonic based on the rules: Max Value < 150% of limit and either Average value < 100 % of limit or (for odd harmonics 21 - 39) Partial Odd Harmonic Current < Partial Odd Harmonic Limit

For IEC61000-3-2:1995, the top section of the report is similar to that described above. There is a choice of two types of data table for the harmonic results.

The **steady Harmonics** report has the following columns:

Harmonic Number:	The fundamental and harmonic number in numerical order from 2 to 40
Limit Current:	The steady-state limit, in Amps, of the harmonic for the declared or detected Class
Min Value Unfiltered:	The minimum value measured since Min Hold was last reset with the START key. Always press START before a test run.
Max Value Unfiltered:	The maximum value measured since Max Hold was last reset with the START key. Always press START before a test run.
Max Value Filtered:	The maximum value of the measurement after processing by the 1 st order filter with a 1.5 second time constant, since Max Hold was last reset with the START key. Always press START before a test run.
%Limit:	The percentage of the steady-state limit that the Max Unfiltered Value represents.
Assessment:	A Pass or Fail assessment for an individual harmonic based on whether the %Limit was <100% or ≥100% respectively.

For IEC61000-3-2:1995 the **Fluctuating Harmonics** report has the following columns. Note that all values used have been processed by a 1st order filter with a 1.5s time constant. A timed test of at least 2.5 minutes must have been run for the assessments in this report to be valid.

Harmonic Number:	The harmonic number in numerical order from 2 to 40.
Limit Current:	The steady-state limit, in Amps or milliamps (as indicated in the heading), of the harmonic for the declared or detected Class.
Measured Min:	The minimum (filtered) value measured during the whole test.
Measured Max:	The maximum (filtered) value measured during the whole test.
%Limit	The percentage of the steady-state limit that the Measured Max represents.
Fluctuation Duration %:	The percentage of time spent over 100% of the limit during the worst 150 seconds of the test. Only shown for even harmonics 2 to 10 and odd harmonics 3 to 19 for which fluctuating limits apply.
Assessment:	A Pass or Fail assessment of the harmonic over the whole test period. The Fail categories are: Fail Max: The harmonic has exceeded 150% of the steady-state limit if it is one of the fluctuation set harmonics or 100% of the steady-state limit if it is not. Fail Fluct: The harmonic has exceeded 100% of the steady-state limit for more than 10% of the time in a 150 second period.

Report Set-up

With the Report view displayed, pressing SET-UP shows the report set-up screen.

The functions of the soft-keys change as the edit zone is moved through the editable fields of the display using the ▲ ▼ keys; each field is described below. Pressing the VIEW key returns the display to the Report view and allows reports to be printed.

Time and Date Set-up

With the edit zone moved to the top line of the display the **Set Clock** soft-key is shown. Pressing the key changes the display to show the **Present setting** with an editable **New setting** below it.

The ◀ and ▶ cursor keys are used to select each field in turn (hours, minutes, day, month, year) and the ▲ ▼ keys are used to change the setting. When the correct time and date have been set the **save Setting** soft-key (or the ENTER key) can be used to apply the new values.

Pressing the **Leave Unchanged** soft-key exits the edit mode without change.

Report Number

With the edit zone in the **Report Number** field a report number can be entered directly from the keyboard and confirmed by pressing ENTER. Otherwise the number is automatically incremented after each report is printed, starting from the last number entered, or 1 if the number has been reset by restoring defaults at switch-on.

Pressing the **HA-PC Link** soft-key when the edit zone is in the **Report Number** field initiates continuous transmission through the serial port of the measurement data in report format at a rate of typically two complete reports per second; further details are given in the HA-PC LINK chapter.

While HA-PC link mode is running the soft-key changes to **Individual Print**; pressing this returns the instrument to the standard mode of one report every time ENTER is pressed.

Printer

With the edit zone in the **Printer** field a **Reset Spooler** soft-key is shown. If a problem has occurred communicating with the printer (perhaps by attempting to print while the printer was not switched on), there is the possibility of a 'lock-up' between the instrument and the printer; pressing **Reset Spooler** resets the communication.

The Printer Type is described as Plain Text and cannot be changed. All printers capable of accepting 7-bit ASCII can be used; the printer will print in whatever font and page layout it has been set to.

If the printer cannot accept the full 64 line report without throwing a page, omit one or more of the header lines (see below).

Port Selection

The report data can be output to either the **Parallel** (Centronics) port or the **Serial** port by selecting the appropriate interface when the edit zone is in the **Port** field; the default is **Parallel**. The serial port is automatically used in HA-PC link mode, regardless of the setting in this field.

Page Terminator

This field determines the character sent at the end of each report. The default is form feed, but any other control character can be sent by pressing **Set Terminator** and entering the decimal character value (31 or less) on the keypad.

If a printer is emitting extra pages, it may help to set the terminator to 0.

This facility may also be used when sending reports through the serial port to a communications program running on a PC. The page terminator can be set to the End of File character used by the operating system, usually either ^D (decimal 4) or ^Z (decimal 26).

Report Type

Generally the report type is automatically determined by the operating mode of the instrument set on the Test Control View, but in EN61000-3-2:1995 mode there is a choice of two formats shown on the soft-keys as **Steady Harmonics** and **Fluctuating Harmonics**. As the names suggest, one is optimised for steady-state harmonics and the other for fluctuating harmonics.

Left Margin

The report text generated by the analyser uses only 72 of the 80 characters per line of the report format, i.e. there are 8 'spaces' that can be used to position the report text within the paper. The text position is set by defining the number of spaces in the left margin. To enter, move the edit zone to the **Left Margin** field, press the **Set Margin** soft-key and enter a number from the keyboard followed by ENTER. Pressing CANCEL before ENTER returns the margin to the previous value; the value is stored in non-volatile memory.

The margin positioning capability is primarily for formatting the hard-copy report appropriately for filing but is also useful in compensating for the special requirements of some printers and/or paper sizes which might otherwise lose a character at the end of a line, for example.

Header and Title 1 to 3

The four lines of the text that appear at the top of the report are pre-entered with the parameters '**Test Location**', '**Customer Name**', '**Equipment Name**' and '**Test Conditions**' respectively; the report can be printed with these titles by default or the titles can be changed using the edit facility. Any or all of the titles can also be omitted completely.

To edit the titles press the **Edit String** soft-key to show the Edit display. The top half of the display shows all the characters (upper and lower case) and symbols that can be selected by moving the edit zone around with the cursor keys. Below this block is the selected line of the text (**Header**, **Title 1** etc.) with a flashing underline, which can be moved with the **Next Position** and **Previous Position** soft-keys. As the underline is moved the edit zone in the character field moves to the corresponding character; moving the edit zone with the cursor keys to a new character then changes the underlined character to the new one. Two further soft-keys, **Insert Character** and **Delete Character**, aid the editing process. Numbers can be entered directly from the keyboard. Up to 80 characters can be entered on each line. The new title is confirmed by pressing ENTER; exiting the edit mode (by pressing VIEW) or pressing CANCEL instead of ENTER will return the title to its original form.

To delete the header or a title altogether move the edit zone to that field and press the **Omit** soft-key; the title will be deleted from the display and a **X** will be shown against the parameter. To reinstate the title press the **Include** soft-key that has now replaced **Omit** in the display; the soft-key toggles between **Omit** and **Include** with alternate presses. The overall report is shortened by a line for each header or title removed; this can be useful in cases where a particular printer cannot print the 64 lines of a full report on a single sheet. The titles are held in non-volatile memory; once created for a particular company and product only small changes will be needed from test to test.

Footer

The footer that appears at the bottom of the report can be edited in the same way as the header, etc. described previously.

Sample Report

Tested on: 28-02-2002 at 15:17:18
Equipment: Old PSU
Conditions: Worst Case
Notes:

Report Number: 28

Supply Voltage: 225.7 to 226.8 Vrms 320.9 Vpk Frequency: 50.02 Hz
THD: 0.1% Crest Factor: 1.415 peak at: 90.1 deg
Supply meets IEC requirements.

Load Power: 71.8 to 80.3 W 179.8 VA Power Factor: 0.447

Load Current: 0.71 to 0.80 Arms 3.82 Apk Crest Factor: 4.780

Limits: EN 61000-3-2:2000 Class A limits

Harmonic Number	Limit Current mA	Average (filtered) mA	% Limit	max. value (filtered) mA	% Limit	Assessment
Fundamental:		341.7		355.6		
2:	1080.0	8.9	0.8	13.6	1.3	Pass
3:	2300.0	303.9	13.2	317.5	13.8	Pass
4:	430.0	8.2	1.9	11.8	2.8	Pass
5:	1140.0	277.6	24.3	290.5	25.5	Pass
6:	300.0	7.5	2.5	11.5	3.8	Pass
7:	770.0	247.9	32.2	260.0	33.8	Pass
8:	230.0	6.9	3.0	10.7	4.7	Pass
9:	400.0	227.3	56.8	238.4	59.6	Pass
10:	184.0	6.5	3.5	10.0	5.5	Pass
11:	330.0	211.1	64.0	220.8	66.9	Pass
12:	153.3	5.8	3.8	8.9	5.9	Pass
13:	210.0	193.1	91.9	201.0	95.7	Pass
14:	131.4	5.0	3.8	7.5	5.7	Pass
15:	150.0	171.9	114.6	178.7	119.2	Fail
16:	115.0	4.2	3.6	6.4	5.6	Pass
17:	132.3	148.5	112.2	153.5	116.0	Fail
18:	102.2	3.5	3.4	5.3	5.3	Pass
19:	118.4	125.8	106.2	129.8	109.6	Fail
20:	92.0	2.9	3.1	4.3	4.7	Pass
21:	107.1	103.9	97.0	106.4	99.4	Pass
22:	83.6	2.4	2.9	3.5	4.3	Pass
23:	97.8	82.7	84.6	84.1	86.0	Pass
24:	76.7	2.1	2.8	3.2	4.2	Pass
25:	90.0	62.6	69.5	63.6	70.7	Pass
26:	70.8	2.0	2.8	2.8	4.1	Pass
27:	83.3	44.4	53.3	46.7	56.1	Pass
28:	65.7	1.9	2.9	2.8	4.4	Pass
29:	77.6	29.0	37.4	31.6	40.8	Pass
30:	61.3	1.9	3.0	2.8	4.7	Pass
31:	72.6	16.6	22.9	19.4	26.8	Pass
32:	57.5	1.8	3.1	2.5	4.4	Pass
33:	68.2	8.3	12.2	9.3	13.7	Pass
34:	54.1	1.8	3.3	2.5	4.7	Pass
35:	64.3	8.5	13.2	11.1	17.3	Pass
36:	51.1	1.6	3.2	2.5	4.9	Pass
37:	60.8	13.0	21.4	15.8	26.0	Pass
38:	48.4	1.5	3.1	2.1	4.5	Pass
39:	57.7	16.4	28.4	18.7	32.4	Pass
40:	46.0	1.3	2.7	1.7	3.9	Pass
21 - 39:	251.4	158.9	63.2	161.8	64.4	Pass

Compliance Measurements with the HA1600

Since its publication in 1995, IEC61000-3-2 (Limits for harmonic current emissions (equipment input current $\leq 16\text{A}$ per phase)) has been a contentious standard with apparent ambiguities concerning measurement requirements and uncertainties over the date of implementation.

A new edition has now been published, known as EN61000-3-2 (Edition 2):2000 which incorporates changes initially published as Amendment 14 to IEC 61000-3-2:1995. These changes are CENELEC Common Modifications to the IEC standard, with the result that the European Standard is now different to the International IEC standard.

The standard is an essential document that should be read, together with IEC61000-4-7 (1993) (General guide on harmonics and interharmonics measurements and instrumentation), before any compliance quality measurements are attempted. In particular, IEC61000-3-2 should be used to determine the Class (for harmonic current purposes) of the equipment under test; this in turn determines the way in which HA1600 should be set up. All these documents should be available for purchase from National Standards Organisations (BSI in the UK).

In some cases, it may be advisable to consult a specialist EMC testing laboratory (or other Competent Body) should there be doubts as to how the equipment under test should be treated or how the standard should be interpreted. In many cases, this will not be necessary because the requirements for testing a particular class of equipment are clearly stated in the standard and their implementation in the HA1600 clearly defined.

The firmware of the HA1600 is stored in FLASH memory and can be updated via the RS232 port. This capability enables the manufacturer to implement changes to the standards as software updates which can be installed by users without need to open the instrument or return it to the factory. It is the intention to make such upgrades freely available; see the Maintenance and Calibration section for details of the upgrade process.

Changes to the measurements

The following points are a quick guide to the major changes introduced by the new edition of EN61000-3-2. As always, users should read the standard itself for full details.

Equipment classification

All classification is now by equipment type. The special waveform test to establish Class D has been deleted. The facility of this instrument to automatically determine class A or D by analysing the waveform in real-time is no longer needed.

Basis of limits

The amendment moves away from the dynamic determination of limits as the consumption of the load varies during the test. The intention now is to use fixed limits determined in advance. For classes A and B the limits are absolute, for classes C and D the limits are based on a rated consumption declared by the manufacturer. This figure must be within $\pm 10\%$ of the value obtained during the test.

Basis of measurement

The comparisons of measured harmonic currents against the limits are now made using the arithmetic average of all the results of the 1.5 second filtered results of every transform in the measurement interval.

Fluctuating harmonics

The assessment of fluctuating harmonics is completely changed. The "10% of 2½ minutes" rule, which was applied for a limited set of harmonics, has been deleted. Any harmonic is now allowed to fluctuate up to a maximum of 150% of its limit, provided that its average value is below 100% of the limit. In addition, some trade-off between harmonics is allowed for odd harmonics of order 21 to 39 based on a value called the Partial Odd Harmonic Current; this is the rms sum of all the odd harmonics between 21 and 39. This rms sum is compared to the Partial Odd Harmonic Limit, which is the rms sum of the limits for the same set of harmonics. If the actual POHC sum is less than the POHL sum, then the average value of any individual harmonic in this group may exceed

100% of its limit, again provided that no individual measurement exceeds 150% of limit throughout the test. Obviously one or more of the other harmonics must be correspondingly less than 100% of its limit, otherwise the POHC will not be less than 100% of the POHL.

Equipment without limits

No limits are now applied to equipment with power below 75 watts in classes A, B and D (this used to be just class D).

No limits are applied to Professional Equipment above 1 kW.

Note that the clauses limiting permitted control methods apply to all equipments within the scope of the standard even if no harmonic current limits apply.

Taking Harmonics Measurements

The HA1600 has a set of default conditions which permit the untrained user to quickly make useful measurements. However, compliance quality measurements require considerably more planning and care if they are to be fully valid for self-certification. The following is a summary list of do's and don'ts.

- Always use an AC source that meets the supply quality requirements, even for pre-compliance measurements. Without such a source, results can be seriously misleading.
- Fully read this manual before use to understand what measurement options are available and which modes are appropriate to the tests to be carried out.
- Read and understand EN61000-3-2. This document is the prime source of information on how to test a particular piece of equipment and what limits apply.
- Decide which edition of the standard to apply. On the Test Control view enter set-up and select the corresponding **Operating Mode**.
For new equipment destined for the European market, use EN61000-3-2:2000.
For non-European markets, determine the relationship between National standards and the EN or IEC standards. The European Standard specifies limits only for equipment with a rated supply voltage of 220V or more. Select **standard limits** where this applies. Some National Authorities in regions with 100 or 110V supply systems have specified that the standard limits should be multiplied by the ratio of 230V to the nominal supply voltage; the **adjust limits for voltage** selection performs this calculation.
- Follow the flow chart in the standard to determine equipment classification and therefore which limits apply. Consult an EMC test house if there is doubt over the equipment classification, etc. Select the equipment **load class**. Specify **Professional Equipment** if applicable. Set the other measurement options on the Test Control screen.
- Set the correct **basis of limits** for class C or D equipment; if class C, enter the nominal fundamental current and power factor; if class D, enter the rated power. When testing lighting equipment below 25 Watts, select class D and set the Minimum Power to 0.
- Enter the correct **nominal voltage** and **nominal frequency** for the test supply.
- Check whether the standard gives specific operating conditions for the equipment being tested (this is the case for many common types of domestic appliance).
- Use the 'real-time' capability of the HA1600 to observe dynamically the performance of the equipment under test as operating conditions are varied or as the operating cycle proceeds. Identify the operating conditions that give a reasonably representative set of worst-case harmonic levels.
- Find the maximum peak current condition of the equipment under test and (on Waveform View set-up) lock that range. If in doubt select a higher range - it is essential that there is no overload; the resolution of the instrument is sufficient to get accurate results even if a higher than optimum range is selected.

-
- On the Test View, set up a **timed** measurement. Set the **test duration** to cover at least one full cycle of operation of the equipment being tested - for many types detailed instructions are given in Annex C of the standard. However if there is no specific clause the only guidance given is that the measurement time must be “sufficient to meet the requirements for repeatability”. How long this needs to be is not clear but in any event a minimum of 2½ minutes is required.
 - Switch on the equipment under test and, after the first 10 seconds, press the START key on the instrument to clear the averaging accumulators and the max hold values etc. and start the test timer. Now that measurements are based on the average of all the readings over the test interval, it is important not to have the instrument accumulating data while the unit under test is switched off as this will result in a reading below the proper one.
 - The progress of the measurements can be monitored on the Harmonics view. At the end of the test select the Report view and print the report.
 - Keep an archive copy of the results and assessment using either the printed report or the optional PC software. Record the details of the measurement conditions; a photograph is often useful. It should be possible to exactly repeat the measurement at a later date.

The above is necessarily a simplification of the overall procedure. The most important point is that although the instrument is very easy to use ‘automatically’ for instant results, for compliance quality measurements the user must take responsibility for specifying the proper test conditions and setting up the instrument options correctly. If in doubt, seek help from a test house with suitable experience.

HA-PC LINK Documentation Software

HA-PC LINK is a PC software option which collects measurement data from the HA1600 via a serial (RS232) port connection. Data can either be in the form of a single report or continuous, permitting real-time viewing on the PC. HA-PC LINK requires Windows 95 or later.

Software Installation

Insert the disk into the A drive and run Setup.exe; the software will automatically install. The default installation directory is HA1600 though the user has the option to change this during installation. HA-PC LINK uses ActiveX controls (© National Instruments Corporation), which are automatically installed in the Windows System directory.

Data files saved when using HA-PC LINK are automatically stored in the HA-PC LINK folder (which is in the HA1600 directory).

The 'HA-PC LINK' icon in the program folder HA-PC LINK can be dragged to the desktop to create a short-cut in the usual way.

HA1600 Set-up for HA-PC LINK

The HA-PC LINK software accepts data either as a single report or continuously. In both cases, the appropriate mode must be selected on both the PC and the HA1600.

The HA1600 data transmission mode is set on the Report Set-up screen. The default mode is **Individual Print**, i.e. a single report is sent every time the ENTER key is pressed. Continuous data mode is selected by pressing the **HA-PC Link** soft-key when the edit zone is in the **Report Number** field, see the Report Number section of Report Set-up.

Select the required Report Type (**Steady** or **Fluctuating Harmonics**). If individual print mode is being used, the port selection must be set to **serial**; in HA-PC link mode, this is automatic.

For the data transfer to work correctly it is essential that the margin is set to the default value of 5 and that no header or title lines have been deleted; refer to Left Margin and Header sections of the Report Set-up chapter. If in doubt, restore the factory defaults by pressing the **Restore Defaults** soft-key on the Initialisation screen at switch-on.

If a non-standard report format is used, HA-PC LINK cannot parse the data and display the results; however, it is still possible to save the file to disk if individual print mode is used.

HA-PC LINK Operation

Open HA-PC LINK by double-clicking on the desk-top short-cut or on the HA-PC icon in the HA-PC LINK program folder. Opening HA-PC LINK launches four separate windows; these are the HA1600 Status window, Report, Harmonics Histogram and Acquisition Config.

HA1600 Status

This window shows the current status of the data transfer and has a toolbar with the following facilities:

<i>File:</i>	Print permits printing of either the Report or Harmonics Histogram. Print Setup gives access to the standard printer set-up window. Save Report permits a report to be saved and given a name. Load Report permits a report to be reloaded into the Report window.
<i>Configuration:</i>	Opens the Acquisition Config window.
<i>Display:</i>	Report opens the Report window. Histogram opens the Harmonics Histogram window.

In addition, 'radio' buttons permit the selection of either COM1 (the default) or COM2; select the port connected to the HA1600.

Report

The Report window displays the harmonics etc., in tabular form exactly as they appear in the hard-copy report described in the Report View/Report Set-up chapters. Steady harmonics or Fluctuating harmonics are listed, as selected on the HA1600.

The Report Number and the text in the Header, Footer and 4 Title fields are transferred exactly as they appear on the Report Set-up screen but can be edited on the PC providing the acquisition is not currently running.

When a Report is saved, using the Save Report facility available from the HA1600 Status window toolbar, it is saved as a text file, which can be viewed with any text editor (e.g. NotePad) or imported into other documents.

Harmonics Histogram

The Harmonics Histogram window displays the Report data in histogram form. This gives a graphical view of the harmonics levels against their limits and is most useful when the instrument is being run in HA-PC LINK mode (see section titled HA1600 Set-up for HA-PC LINK) when the data is updated about twice per second.

Note that the harmonic values used by the Histogram window are the maximum values measured since the front panel START key was last pressed or since the Max Hold was reset by a range change. The full definition of Max Hold is given in the Data Selection section of the Harmonics Set-up chapter.

Harmonics are displayed using normalised limits for each harmonic with a vertical scale of 0 to 200%, giving an instant graphical overview of performance against limits since the start of the test. Note that when Class D limits are used the harmonics levels are correctly shown as a percentage of the instantaneous limits corresponding to each measurement.

The histogram displays both odd and even limits. However, since in most cases the levels of even harmonic will be low compared to the limit (and in some cases there is no limit at all) the percent limit value will be very small or zero, giving the impression of displaying odd values only.

If Steady Harmonics has been selected on the Report Set-up, the Harmonics window will use the unfiltered Max Hold values; if Fluctuating Harmonics has been selected on Report Set-up, the Harmonics window will use the filtered Max Hold values.

The START key can be pressed at any time to reset the Max Hold values and should always be used before a test run is started.

Acquisition Config

Data transfer into the PC is controlled by the RUN and STOP buttons in the Acquisition Config window. Clicking on the RUN button clears the PC's input buffer and arms the program ready to receive data from the HA1600. Control of data sent by the HA1600 is from HA1600 itself. If the default mode of **Individual Print** has been selected a set of data is sent every time the front panel ENTER key is pressed and the displays on the PC are updated once. If **HA-PC Link** mode has been set, data is sent continuously and the displays on the PC are updated at about twice per second.

In either mode, the transfer of data into the PC can be halted by clicking on the STOP key; this allows data to be viewed and/or files to be saved. Data transfer can be resumed by clicking on the RUN button again; this clears the PC's input buffer so that the next data displayed is the first available after RUN has been selected.

Maintenance & Calibration

Routine hardware maintenance is limited to re-calibration and cleaning. The only repair maintenance that can be carried out by the user is fuse replacement.

From time to time software enhancements may be available which can be uploaded from a PC to the instrument's Flash memory.

Calibration

Calibration is guaranteed as in the specification. The manufacturers provide a re-calibration service, as do most of their agents overseas. Where owners wish to carry out re-calibration themselves, this should only be done by skilled personnel with access to precision equipment working in conjunction with the service manual, which may be purchased directly from the manufacturers or their agents overseas.

Fuse – Instrument Power

The instrument power fuse is located in the fuse holder which forms part of the inlet socket on the rear panel. Refer to the Installation section for the fuse-rating appropriate to the operating supply voltage.

Fuse – Load Power

A high voltage, high breaking current, fuse is fitted internally in the load power circuit; the correct fuse type is 20A 500V HBC Type aM or gL.

To gain access to the fuse, disconnect the instrument from all voltage sources and remove the six screws retaining the top cover. Lift off the cover; the fuse is on the load power printed circuit board mounted on the side of the chassis behind the front panel appliance connector. Make sure that only fuses of the specified type are used for replacement.

Cleaning

If the instrument requires cleaning, use a cloth that is only lightly dampened with water or a mild detergent. Polish the display gently with a soft dry cloth only.

WARNING! TO AVOID ELECTRIC SHOCK, OR DAMAGE TO THE INSTRUMENT, NEVER ALLOW WATER TO GET INSIDE THE CASE. TO AVOID DAMAGE TO THE CASE OR DISPLAY NEVER CLEAN WITH SOLVENTS.

Software Updates

The HA1600 software is held in Flash memory and can be upgraded in the field via its RS232 interface. From time to time software updates will be available on the TTI website (tti-test.com). The file is named 1600Svvv.S, where vvv is the version number; it is a text file in S-record format. A software utility called HA1600Updater, to run on a PC under Windows 95 or later, is also available for download.

The Flickermeter Option is installed the same way; in this case, both the updater and the S-record file are provided on disk. Note that once an instrument has been fitted with the flicker option, any future update must also include that option. Contact technical support at the factory and the necessary S record file (named 1600Fvvv.S) will be sent as an e-mail attachment.

First install the HA1600Updater utility: Insert the disk into the A drive (or switch to the directory containing the downloaded files), run Setup.exe and the software will automatically install HA1600Updater into a directory called HA1600; HA1600Updater uses ActiveX controls (© National Instruments Corporation), which are automatically installed in the Windows System directory.

For computers running other operating systems, use the system configuration utility to set the serial port to 115200 baud, 8 bits, no parity, with hardware output handshaking using CTS.

Connect the HA1600's serial port to COM1 on the PC using a fully wired nine core 1-to-1 cable (with **no** cross-over connections) such as the one provided with the HA-PC Link software. The PC must have a serial port capable of operation at 115 kBaud.

Now switch on the HA1600 and, whilst the Initialisation screen is being displayed, press the **Setup** soft-key. Then, on the **Setup Options** screen, press the **Update Software** soft-key to go to the **Software Update** screen which should display the message **Ready for data from PC**.

Now run the PC software update utility by double-clicking on HA1600Updater.exe in the HA1600 folder; the HA1600Updater window will open. Click on File, then Open; the other file(s) on the disk are shown in the Open window. Double-click on the required S-record file to select it for uploading, and then click on Upload in the HA1600Updater toolbar, followed by Start. The progress bar will indicate the status of the upload; after a few seconds, the message 'File uploaded' should show in the HA1600Updater window.

Under other operating systems, simply copy the S-record file to the serial port. Progress can be seen on the screen of the instrument.

When the upload is complete, turn the instrument off then on again. Check for the new installed version number on the Initialisation screen. Then press the **Restore Defaults** soft-key to resume operation of the instrument.

It is emphasised that it is important to always select **Restore Defaults** on the initialisation screen the first time the instrument is switched on after an upgrade has been installed.