AIM & THURLBY THANDAR INSTRUMENTS

HA1600A

Power and Harmonics Analyzer with Flickmaster

INSTRUCTION MANUAL

Aim-TTi

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Note: The latest revision of this manual, firmware, device drivers and software tools can be downloaded via: http://aimtti.com/support

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 1^{st} to the 40^{th} 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).

Capabilities include continuous monitoring of the supply voltage, continuous comparison to harmonic limits and timed test sequences with analysis of fluctuating harmonics.

Compliance-quality flicker meter

The HA1600 has the capability to operate as a compliance quality voltage variation and flicker meter in conformance with EN61000-3-3 and EN61000-4-15.

Flicker severity can be measured in terms of P_{st} and P_{lt} while simultaneously performing full analysis of voltage variations, including the calculation of d_c (the largest difference between steady states), d_{max} (the maximum voltage difference during a change interval), and t_{max} (the cumulative duration over a specified value during a voltage change characteristic).

For pre-compliance testing, a current measurement method can be used, rather than voltage measurement, to eliminate the need for a clean power generator and a reference impedance.

A full range of interfaces

A parallel printer interface is included, for record keeping and archiving, and also a high speed RS-232 interface is provided for use with either a printer or remote control software running on a PC. The HA1600A also has a USB port for use with the HA-PC Link Plus software.

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.

HA1600 and HA1600A

The two versions of the instrument are in different cases, with slightly different front panel layouts. The HA1600A has a USB port. In all other respects the operation and performance of the two types is identical. Both use the same firmware, and this manual applies to either type if fitted with firmware version 3.00 or later.

MAINS ANALYSER

Measurement Circuit:	Single Phase with standard mains connector.
Current Rating:	16A rms continuous, or national connector rating if lower.
Voltage Ranges:	115V (± 200V pk) and 230V (± 400V pk).
Current Ranges:	± 24mA pk to ± 400A pk in fifteen 2:1 ranges.
Frequency Range:	43 – 67 Hz.
Shunt Resistance:	3mΩ.
Sampling Rate:	300 points per cycle.
Basic Accuracy:	Better than 0.2% ±1mA, up to 16A.
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:	1st harmonic to 40th harmonic. Measurement processing to EN61000-3-2. and EN61000–4–7 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 (± 200V pk) and 230V (± 400V pk).
Current Ranges:	± 24mA pk to ± 400A pk in fifteen 2:1 ranges.
Frequency Range:	43 – 67 Hz.
Shunt Resistance:	3mΩ (less than 150mV across shunt up to 50 Amp peak).
Transform Windows:	Continuous 4, 10, 12 or 16 cycle Discrete Fourier Transforms.
Basic Accuracy:	Better than 5% of limit or 0.2% of selected range (whichever is the greater) ±1mA.
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 current harmonics with limits (calculated from EN61000-3-2), with Min. hold, Max. hold and percentage of limit display options.
	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.

Test Control:	Untimed, manually timed or automatically timed tests; user-defined test time.
	Declaration of load class. 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.
	Facility for declaring supply voltages other than 230V and deriving appropriate limits. Facility for insetting test limits.
Report Printing:	Direct printer connection for hard-copy report with user-entered narrative, supply voltage assessment and current harmonic analysis and assessment.

VOLTAGE FLUCTUATIONS & FLICKER METER

Measurements:	Voltage fluctuations d_c, t_{max} and d_{max} and flicker P_{st} and P_{lt} to EN61000-3-3 and EN61000-4-15.
Current Rating:	16A rms continuous, or national connector rating if lower.
Voltage Ranges:	115V (± 200V pk) and 230V (± 400V pk).
Fluctuation Range:	25% max (relative to nominal voltage).
Flickermeter Range:	Voltage change up to 20% (sinewave change) or 10% (low repetition rate rectangular change) relative to AGC level. Equivalent to 6400 pu on 8.8 Hz sinewave.
Flickermeter AGC:	Up to ±5%.
Flickermeter Accuracy:	Better than 5% for P_{st} range 0·7 to 10·0.
Frequency Range:	50Hz (operates over 43 – 67 Hz).
Report Printing:	Tabular listing of voltage variations, P_{st} classifier and P_{st} in each P_{lt} 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 (for printer or PC); also USB (for PC) on HA1600A.	
Instrument Supply:	220V–240V or 110V–120V ±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 & EMC:	Complies with EN61010-1 & EN61326-1. For details, request the EU Declaration of Conformity for this instrument via http://www.aimtti.com/support (serial no. needed).	
Dimensions (WxHxD):	HA1600A: 357 x 132 x 235mm;	HA1600: 305 x 148 x 220mm.
Weight:	HA1600A: 4.4kg;	HA1600: 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/$Mn0_2$ 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.

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 220V to 240V. When the 115V marking is upwards, the unit is set for operation over the range 110V to 120V. 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

Connect the instrument to the AC supply using the mains lead provided. Should a mains plug be required for a different mains outlet socket, a suitably rated and approved mains lead set should be used which is fitted with the required wall plug and an IEC60320 C13 connector for the instrument end. To determine the minimum current rating of the lead-set for the intended AC supply, refer to the power rating information on the equipment or in the Specification.

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 the rating of the connector, or 16Arms, 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 signal on any current or voltage range.

Rear Panel Connections

Instrument Power and Load Power

The IEC inlet supplies power for the instrument only; the fixed lead supplies the load power to the front panel appliance connector. Refer to the Installation section.

USB

The USB interface is intended for communication with a PC running the HA-PC Link Plus software. See software installation section for information about device driver requirements.

RS232

The RS232 interface should be connected to a standard PC port using a fully wired 1-1 male-female cable without any crossover connections. It may also be used with a serial printer.

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

Pin	Name	Direction	Description
1	DCD	O	Passively asserted (+10V through 10kΩ)
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 10kΩ)
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.

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. It is important to recognise that compliance quality measurements cannot be taken by relying on the instrument defaults. A full understanding of the various configuration options must be gained by studying the detailed descriptions of each function which follow in the sections of this manual below, 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`**; this 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 firmware can be updated from a PC via its RS232 or USB port; see the section of the Firmware Update chapter of this manual 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 auto-range to show the current waveform at the best resolution achievable. Load power is always 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 outlets; make sure that the means of disconnection are readily accessible. Disconnect from the AC supplies 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 switches the instrument between remote and local (keyboard) control.

Stored Settings and their Factory Defaults

The following parameters have their present 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.

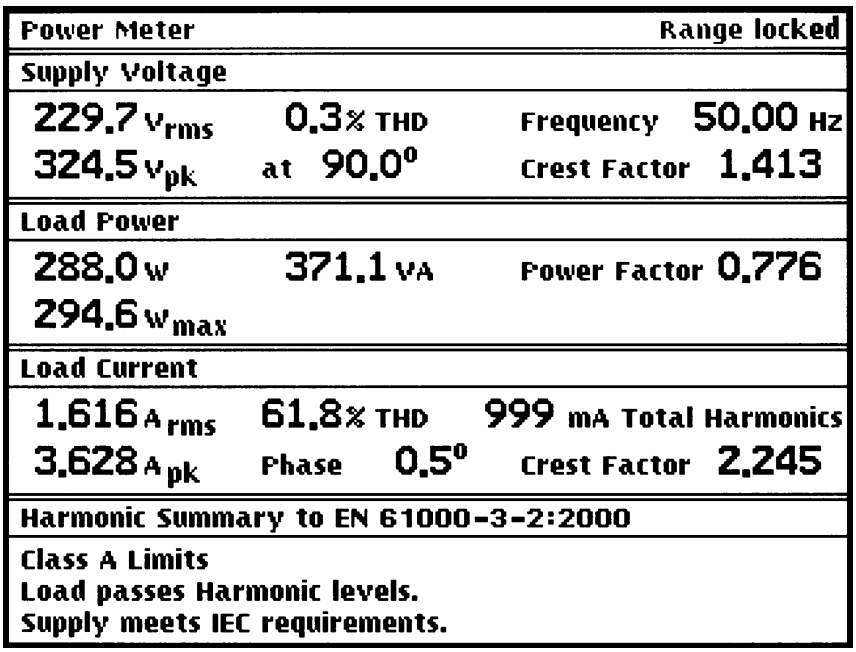
Parameter	**Default Setting**
Nominal Voltage and tolerance	230V ± 2%
Nominal Frequency and tolerance	50Hz ± 0.5%
Test Duration	Standard value for each mode.
Assessment inset	1.00
Operating Mode	EN61000-3-2:2014 Harmonics
Load Classification	Class A
Class C Limit basis, current and PF	Automatic (maximum fundamental current)
Class D Limit basis and power	Automatic (maximum power)
Class A, B or 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 %
t_{max} limit	* < 500 ms above 3.3%
d_c limit	* 3.3 %
Steady State Definition	* > 1000 ms within ±0.2%
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

* These values apply to EN 61000-3-3:2013 and differ from earlier issues.

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.



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 Vrms and frequency of the load power supply, together with its total harmonic distortion (THD), peak voltage (Vpk), the phase of the peak with respect to the zero-crossing point and the calculated crest factor (Vpk/Vrms).

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

Harmonics (max % of fundamental)	0.9% : 3rd 0.4% : 5th 0.3% : 7th 0.2% : 9th 0.1% : even 2nd – 10th 0.1% : all 11th – 40th
Voltage	230 Vrms ± 2%
Frequency	50Hz ± 0.5%
Crest Factor (Vpk/Vrms)	Between 1.40 and 1.42
Phase of Vpk	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 maximum value of the true power is also shown.

The **`Load Current`** group shows the rms and peak load currents, together with the total harmonic distortion (THD), the phase of the current peak, the calculated crest factor (Ipk / Irms) and the total harmonic current (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 testing harmonics for a Class C equipment the total harmonics display is replaced by the value of the fundamental current

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 and any power related exclusions detected by the analyser; refer to the Test Control section. 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 chapters in this manual.

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 auto-ranging; the **Lock Range** key keeps the present measurement range, while the **Up** and **Down** keys change the range in ×2 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 auto-range 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 auto-range 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.

Auto-ranging is only available in Harmonics operating mode (see the Test Control section). Note that auto-ranging is disabled while the LOAD switch is OFF to prevent the instrument auto-ranging to the most sensitive range when there is no load current. At switch-on the default range is 3A peak if the LOAD switch is OFF; at other times, switching the LOAD to OFF locks the range at the setting currently in use.

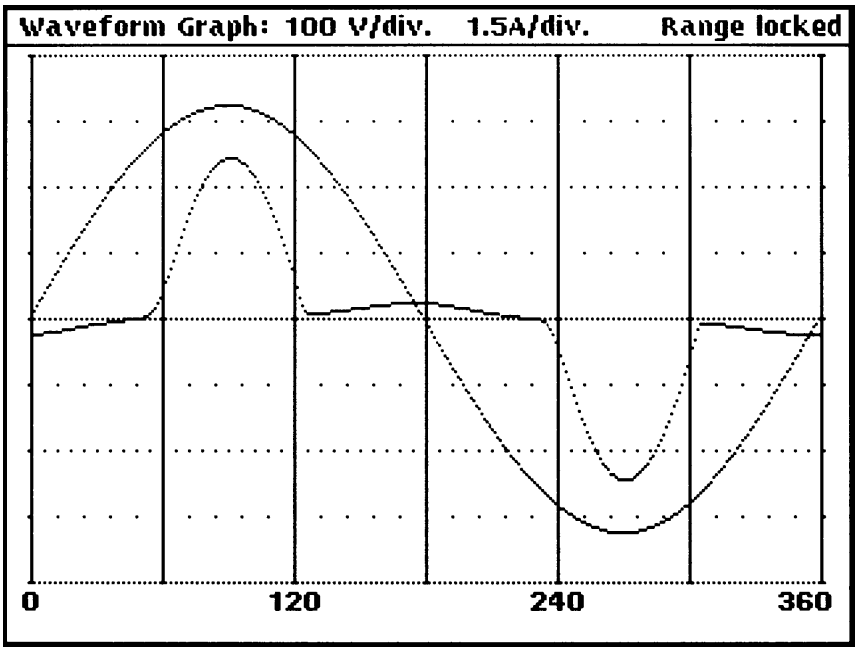
In Flicker mode with voltage sensing, the current range can be manually changed, but should be left at a setting that avoids overload at any time during the test (otherwise the test will be needlessly aborted). When the current sensing method is selected, the range is fixed to suit the requirements of the reference impedance calculations and cannot be changed.

On selecting Peak Inrush mode, the highest current range is initially set, but it can be manually changed as required.

The Voltage range is determined by the Nominal Voltage value which must be declared on the Test Control set-up menu to match the actual supply voltage.

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. 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 ± 400mA peak range has been selected on the set-up screen. Note that although the hardware ranges of the instrument are in a precise 2:1 ratio, the scaling of the graph display is adjusted slightly to give convenient round number values per division. 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 about 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 value of the nominal voltage which must be declared on the Test Control set-up display.

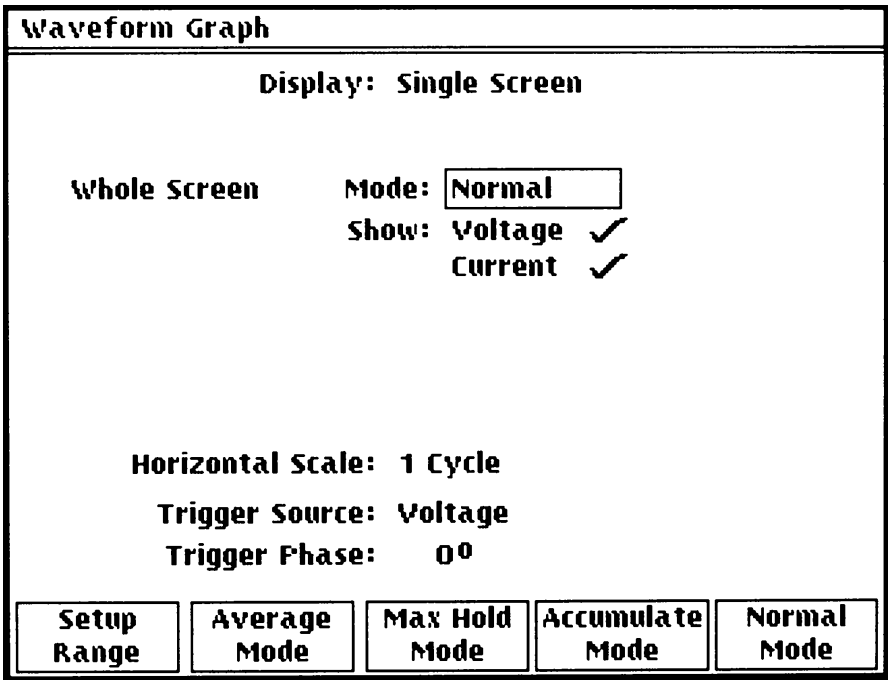
The X-axis of the single cycle display is divided into 6 divisions, each representing 60° of phase. The rising zero-crossing point of the single voltage waveform cycle displayed is positioned at the left edge of the display for the default selection of voltage as the Trigger Source; this will change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

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

When measuring low power lighting equipment <25 Watts to the Class C rules specifying waveform phase angle requirements, the bottom line of this screen reports the phase angles of the start of conduction, the last current peak and the end of conduction. There are also two graphical markers (short vertical lines above and below the centre line) showing the assessed position of the last current peak in each half cycle.

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 auto-ranging; 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 auto-range 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 auto-range 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.

Auto-ranging is only available in Harmonics operating mode (see the Test Control section). Note that auto-ranging is disabled while the LOAD switch is OFF to prevent the instrument auto-ranging to the most sensitive range when there is no load current. At switch-on the default range is 3A peak if the LOAD switch is OFF; at other times, switching the LOAD to OFF locks the range at the setting currently in use.

In Flicker mode with voltage sensing, the current range can be manually changed, but should be left at a setting that avoids overload at any time during the test. When current sensing is selected, the range is fixed to suit the requirements of the calculations and cannot be changed.

On selecting Peak Inrush mode, the highest current range is initially set; it can be manually changed as required.

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 with 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 (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.

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 **Show Traces** field the soft-keys are **Voltage** and **Current**. 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 **Show Traces** edit zone.

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

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 are only available for a 1 cycle display. The 10 cycle display is mainly used in Peak Inrush mode and can only show Current. It is not available in some other modes. No action is required from 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:

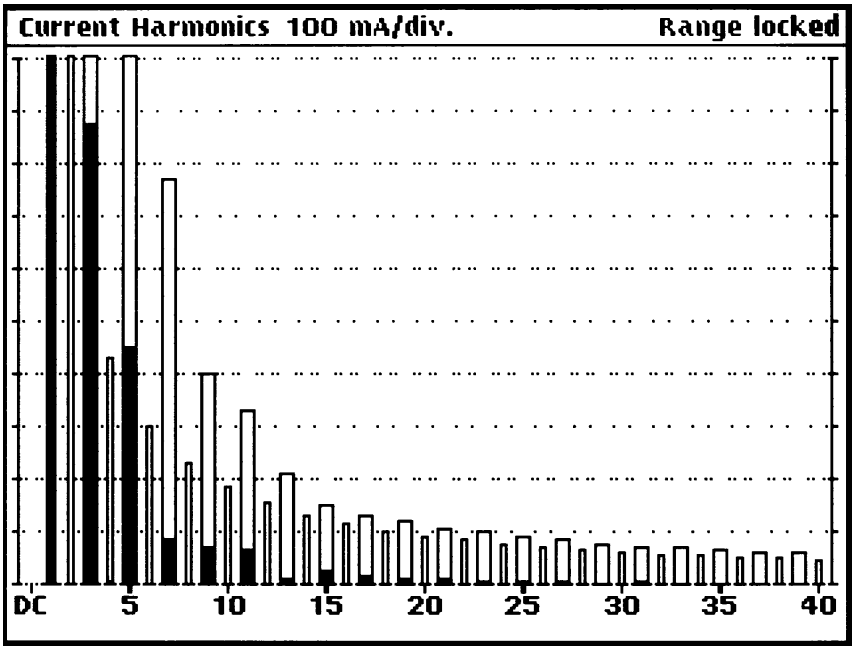
Voltage	The default condition: the rising zero-crossing point of the voltage waveform is set at the left hand edge of the display.
Current	Sets the rising zero-crossing point of the current waveform at the left hand edge of the display.
Internal	Synchronises the display with the internal data buffers; 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.

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



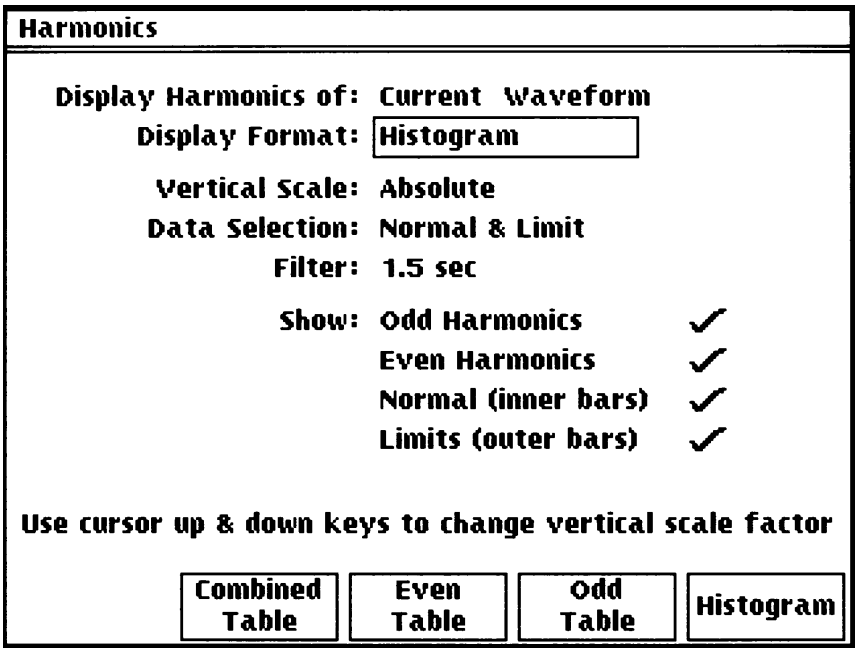
The horizontal scale is marked with the harmonic number. Odd harmonics & limits are shown as wide bars and even harmonics & limits are shown as narrow bars. The fundamental is shown to the left of the second harmonic as a wide bar and the DC component is shown to the left of the fundamental as a narrow bar.

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 EN specification limit for that harmonic. Other combinations may be selected as detailed in the Harmonics View Set-up section following.

The harmonics can also be listed in a table, with limits. The table has two forms: a compact form showing all 40 harmonics and a detailed form, separated into two pages, showing full results on either all the even or all the odd harmonics. Additionally, the harmonics of the supply voltage can also be displayed in histogram and table form.

All the above view options are set from the Harmonics set-up screen; full descriptions of each are given in the Harmonics Set-up Section. The measurement parameters and the classification of the unit under test are made on the Test Set-up screen and are described in that section of this manual.

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



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 normally **Histogram**, **Odd Table, Even Table** and **Combined Table**. When appropriate, an additional selection **C < 25W Table** is also offered.

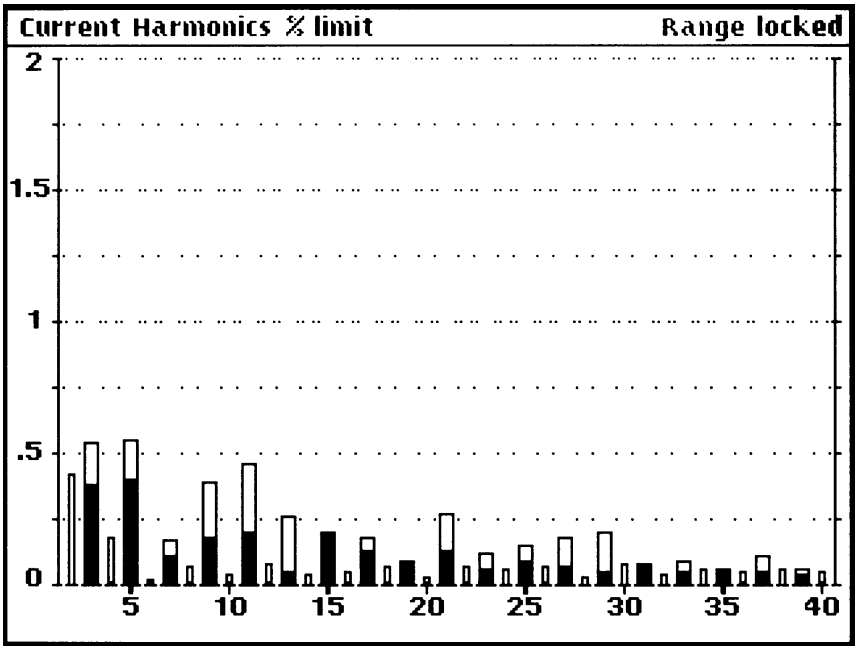
With **Histogram** selected as the Display Format the further editable fields of **Vertical Scale, Data Selection** and **Show** are available; these can be used to optimise the form of the histogram for particular measurement. In the power-up default form shown in the Harmonic View section, for example, 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 this display resolution does **not** affect the hardware measurement range, which, for correct operation of the transform processing, must always be chosen so the waveform peak is in-range; see the 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; in particular the DC and fundamental components are excluded and replaced by the numeric scale on the left.

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 increasing) and that the solid inner bar will 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).

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 actual (100%) limits are shown; it may be permissible for the maximum harmonic level to be up to 150% or 200% of the limit, see the standard.

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 **Unfiltered** and **Filtered**. The standard now requires the transform results to be passed through a 1st order filter with a 1.5s time constant before assessment. When **Filtered** is selected these values are displayed; the raw values from the transforms can be viewed if required by selecting **Unfiltered,** but this usage is now obsolete. This **Filter** option is also available when tables are displayed.

Display Format – Tables

With the edit zone in the **Display Format** field, the soft-key choices are normally **Histogram**, **Odd Table, Even Table** and **Combined Table**. When the Equipment Class is declared as Class C <25W (by conduction angles) then the left hand soft-key selection offers a special table format which includes the conduction phase angles and a limited set of harmonics.

The Table displays have two distinct forms – one option shows limited data for all 40 harmonics on a single page; the others show more columns of data but are separated into multiple pages. This second form is available for current harmonics only. The alternatives are reflected in the **Show** field of the setup display; the soft-key choices available when the edit zone is in that field offer another way to choose the table format.

Selecting **Combined Table** (which sets the **show** field to **All Harmonics**) and returning to the Harmonics view by pressing the VIEW key gives a display of the following form:

Current Harmonics (mA) — Hold

	Filtered	Limit	% limit		Filtered	Limit	% limit
1:	1268.3	-	-	2:	3.4	1080.0	0.3
3:	877.3	2300.0	38.1	4:	5.5	430.0	1.3
5:	451.7	1140.0	39.6	6:	4.4	300.0	1.5
7:	84.5	770.0	11.0	8:	1.2	230.0	0.5
9:	73.7	400.0	18.4	10:	1.9	184.0	1.1
11:	64.9	330.0	19.7	12:	1.7	153.3	1.2
13:	10.0	210.0	4.8	14:	0.7	131.4	0.5
15:	29.8	150.0	19.9	16:	1.0	115.0	0.9
17:	16.9	132.3	12.8	18:	0.3	102.2	0.4
19:	10.4	118.4	8.8	20:	0.7	92.0	0.8
21:	13.8	107.1	12.9	22:	0.7	83.6	0.9
23:	5.5	97.8	5.7	24:	0.1	76.7	0.2
25:	8.0	90.0	9.0	26:	0.5	70.8	0.8
27:	6.1	83.3	7.3	28:	0.0	65.7	0.0
29:	4.3	77.6	5.6	30:	0.3	61.3	0.6
31:	5.0	72.6	6.9	32:	0.1	57.5	0.3
33:	3.0	68.2	4.5	34:	0.1	54.1	0.3
35:	3.5	64.3	5.6	36:	0.1	51.1	0.4
37:	2.6	60.8	4.4	38:	0.0	48.4	0.0
39:	2.3	57.7	4.1	40:	0.3	46.0	0.8

This table 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 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. A '—' is shown in the table when no limit applies, (e.g. for the fundamental, or for loads below the minimum power limit for their class). The assessment of current harmonics against the limits requires the use of the average and maximum values, which are not shown in this combined table.

To display the full information, return to the Harmonics set-up, by pressing SET-UP, and select either **Even Table** or **Odd Table** (alternatively, move the edit zone to the **Show** field and choose **Even Harmonics,** or **Odd Harmonics**). These tables have additional columns of data, but list only the even or only the odd harmonics respectively.

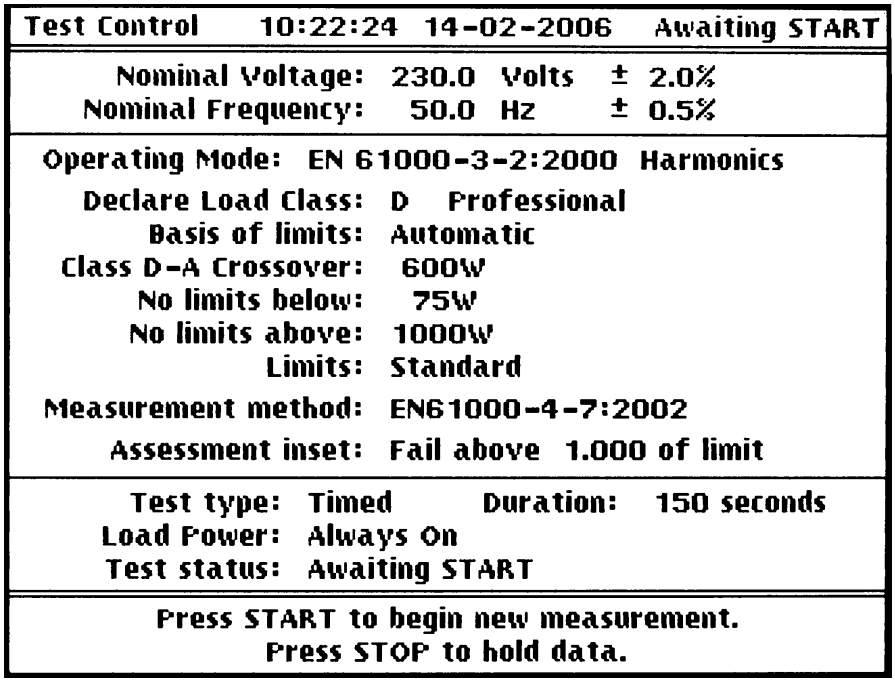
Current Harmonics (mA) Hold

N	Filtered	Limit	Average	%Limit	Max.	%Limit	%Time	
1:	137.7	-	276.5	-	519.5	-		
3:	47.8	170.0	125.7	73.9	258.0	151.8	8.3	✓
5:	24.9	95.0	30.6	32.2	41.3	43.5	-	✓
7:	6.8	50.0	30.6	61.3	70.1	140.3	-	✓
9:	7.7	25.0	20.0	80.1	40.2	161.1	21	X
11:	5.7	17.5	9.1	51.7	15.1	86.3	-	✓
13:	2.8	14.8	9.9	66.9	21.5	145.7	-	✓
15:	3.2	12.8	4.4	34.6	6.6	51.8	-	✓
17:	2.3	11.3	5.3	47.0	10.2	90.5	-	✓
19:	1.7	10.1	2.3	22.5	3.4	33.7	-	✓
21:	1.2	9.2	2.6	28.4	4.6	51.0	-	✓
23:	0.8	8.4	1.0	12.5	1.6	19.3	-	✓
25:	0.8	7.7	1.6	20.9	2.8	37.4	-	✓
27:	0.5	7.1	0.6	8.5	1.0	15.1	-	✓
29:	0.5	6.6	1.2	17.7	2.3	35.2	-	✓
31:	0.5	6.2	0.6	9.8	1.0	17.4	-	✓
33:	0.3	5.8	0.9	15.4	1.7	30.8	-	✓
35:	0.3	5.5	0.5	9.7	1.0	19.6	-	✓
37:	0.3	5.2	0.6	12.3	1.2	24.2	-	✓
39:	0.0	4.9	0.4	7.4	0.8	18.2	-	✓
P:	2.1	21.5	3.8	17.7	6.6	30.9		-

These tables show 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, that maximum as a percentage of the limit and the percentage of the measurement time that the maximum value has exceeded 150% of limit. Finally the right-hand column gives a pass or fail assessment for that harmonic indicated by a ✓ or **X** respectively. This assessment includes the application of the best of either the “Partial Odd Harmonic Current” rule or the “200%/90%” rule. A fuller description of these rules is given in the section on Taking Harmonics Measurements later in this manual; complete details are in the standard. Note that the percentage of limit figures are shown for information only, and may be subject to small calculation errors. The Pass or Fail assessment is made more accurately by a subtractive comparison as required by the standard.

The bottom line of the Odd Harmonic page is marked **P:** and shows the present Partial Odd Harmonic Current (POHC) and its limit. The assessment symbol shows ✓ if the POHC assessment is needed and passes, if **X** it is needed and fails, or **–** if the POHC rule is not used, which may be either because none of the maximum values of the relevant harmonics exceeds 100% of limit, or because the maximum value of one or more harmonics exceeds 150% of limit, in which case the 200%/90% rule is tried (as in the illustration above).

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, Voltage Variations & Flicker, or Peak Inrush Current 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.



The Harmonics mode Test Control view has three sections. The top section shows the nominal voltage and frequency parameters of the test supply. The middle section contains the declaration of the class of the item being tested, and other parameters of the measurement to be performed. The lower section summarises the time element of test control (i.e. whether timed or continuous) and shows the current test status. There are two lines of help text at the bottom of the screen.

The associated selections are made on the Test Control Set-up screen and a full explanation of the options available is given in the Test Control Set-up section below. Tests are controlled by the START and STOP keys as prompted on this view.

The measurement requirements for current harmonics are given in two standards. The first, EN61000-3-2, describes the classification of equipment, the methods of assessment and gives the permitted limits. Users must be familiar with this standard.

There were substantial technical changes between the 1995, 2000 and 2006 editions of EN61000-3-2 which were implemented in revisions to the instrument firmware. Changes subsequently introduced by amendments to the 2006 edition and the 2014 edition have not altered the measurement requirements on the instrument, but have extended Classes C and D and added to the requirements of Annex C, which define the operating conditions of particular types of equipment under test while the test is being conducted. It is up to the user to comply with these requirements.

EN61000-3-2 refers to the second standard EN61000-4-7 for the measurement methods; the instrument firmware implements these requirements. There are significant differences between the 1993 edition (which measured harmonics only) and the 2002 edition (which introduced inter-harmonics and grouping). The present issue of the instrument firmware still supports both (the choice is made on the Test Set-up view) but compliant measurement must be made with the current version.

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 Harmonics**; which issue of this standard is applied depends on the selection of the **Measurement Method** made further down the screen (for simplicity, amendment dates are not always shown). The alternative modes are **Voltage Variations & Flicker** and **Peak Inrush Current**.

The Inrush Current and Flickermeter facilities are described in separate chapters; the editable fields of the Harmonics mode are described below.

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 the correct entry **must** be 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: *The transform length and the filter time constants used in the measurements are determined by this value, so for proper operation the correct value of the actual frequency of the load supply **must** be entered.*

Load Class

EN61000–3–2 defines different harmonic current limits for different classes of equipment; users must refer to the standard to determine the class of the equipment being tested. 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 include **Class A**, **Class B**, **Class C**, and **Class D;** a **Professional Equipment** modifier is also 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** there are three alternative sets of limits. For lighting equipment over 25 Watts the standard class C requirements apply, when 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 discharge lighting equipment below 25 Watts there are two alternatives. The first uses the (power related) harmonic limits of table 3 of EN61000-3-2 (this is the table used by class D). The second alternative imposes limits (proportional to the fundamental current) on the third and fifth harmonics, together with a set of phase angle requirements on the current waveform.

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.

The 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 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.

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 standard class C the maximum fundamental current and the simultaneous power factor are used, while the second (conduction angles) alternative for class C<25 Watts uses only the fundamental current. For both class D and the first (power related) alternative for Class C<25 Watts, the maximum 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 standard Class C load both **Declare Current** (for the fundamental current) and **Declare PF** (for the power factor) must be entered in a similar manner. If the value given for the current is 16 or less then it will be taken as Amps, otherwise it will be taken as mA. The power factor will default to 1.0 if not explicitly entered. For Class C<25 Watts loads the soft-keys offer the appropriate selections for the assessment method chosen.

In general, the present edition of the standard requires the manufacturer's declared rating to be entered as the basis of the limits, rather than using the automatic detection.

Class D – A Crossover Power

The use of this edit field is now unlikely, but it makes it possible to change the crossover power setting slightly and take one set of measurements in class D and a second set in class A. The reason for this is that 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. If this is the case, the standard now suggests that the declared power (rather than the crossover point) should be changed slightly to clearly define whether the equipment is in class A or class D.

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.

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

Minimum Power (No limits below)

The standard specifies that no harmonic current limits apply to equipments (other than class C) below a power consumption of 75 watts. This figure might change in a future edition of the standard. The default value is restored whenever the Class declaration is changed.

With the edit zone in the **`No Limits below`** field, the minimum power limit can be changed from the default by using the **`Set Power`** soft-key and entering the value in the usual way.

When the load power is below this power, no limits are applied. The value 0 can be used to force limits to be shown at all times.

Maximum Power (No limits above)

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 for Supply Voltage

The **`Limits`** field provides the user with the opportunity to scale the current limits defined in the standard (which strictly only apply to 230V ±2% operation) to a different operating voltage, e.g. 100V, to give the same harmonic power. 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 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.

Measurement Method

With the edit zone in the **Measurement Method** field, the soft-keys offer the choice of **EN61000–4–7:1993, EN61000–4–7:2002** or **4 Cycle transforms** as measurement methods. This selection affects both the length of the data window for each Discrete Fourier Transform and the post-transform data processing.

EN61000–4–7:2002 (the present method) requires transform windows nominally 200ms long: 10 cycles at 50Hz, or 12 cycles at 60Hz. This instrument makes the choice depending on whether the nominal frequency declared is above or below 55Hz. The amplitudes of any signal components that fall between two harmonic frequencies (called inter-harmonics) are rms summed into the nearest harmonic value before subsequent processing. This procedure is known as grouping.

EN61000–4–7:1993 uses 16 cycle transforms, with only the results at harmonic frequencies used; there is no grouping of inter-harmonic values. At present, it is still permissible to use this method, provided that this fact is recorded in the report, but the only reason to do this is to repeat historical measurements. Any equipment currently in production should use the methods of the latest edition of the standard. This facility may be deleted in future issues of the instrument firmware.

This instrument also offers the option of 4 cycle transforms. These give a faster response on screen and may be useful for development purposes, but they should not be used for compliance measurements.

All three methods use transforms with contiguous rectangular windows; the data processing is continuous with no gap or overlap between successive transforms.

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 allows the value to be set in the usual way.

Test Timing, Measurement Hold 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.

Important note: *When making compliance measurements it is essential to set up and execute a proper timed test after locking the current range. 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.*

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: This state is entered at power-up, to allow initial investigation of the equipment under test. 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 using 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 the test status changes to **completed** and the TEST lamp flashes; the report can then be printed. If an overload occurs, or the STOP key is pressed before the end of the timed test, the test status changes to **aborted** and the TEST lamp flashes. Once the TEST lamp is flashing, pressing STOP again 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, if the load power has been selected to be on only **During Test** then 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.

When the timed test is complete there is a short beep and the STOP light flashes; the report should then be printed. If an overload occurs, there is a long beep, and the test is aborted.

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 purpose of these requirements is to limit the impact of a varying load on neighbouring consumers connected to the same supply network. The magnitude of the voltage 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.

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

Voltage sensing mode is the reference method of the standard. A physical implementation of the reference impedance must be connected between a zero impedance low distortion test supply and the test circuit input terminals of the instrument. The instrument then measures the voltage across the input to the equipment under test on the load side of the reference impedance. Some laboratory grade AC power sources can simulate the necessary reference impedance using a feedback mechanism, but it is important to allow for the impedance of the connecting cable between the source and the instrument. Any error in the value of the actual source impedance directly affects the results of the measurement.

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. This calculation uses both the magnitude and rate of change of current at 300 sampling points in the cycle. 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 waveform is fed to the subsequent processing exactly as if it had been obtained by voltage sensing.

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 EN61000-4-15 (which has replaced EN60868). These characteristics (in time, amplitude and frequency) are designed to simulate the response of the lamp, eye and human brain combination.

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 (e.g. ten minutes); P_{st} = 1 is the conventional threshold of irritability.
Long-term flicker indicator, P_{lt}:	The flicker severity evaluated over a long period (usually two hours) using successive P_{st} values.

The flicker meter produces an indication of the 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 signal processing and statistical analysis processes are given in EN61000-4-15.

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

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

Version 3.0 (and later) of the firmware supports both 120V and 230V lamp characteristics, and both 50Hz and 60Hz filter responses. It also implements the correction factors for other supply voltages defined in clause B.2 of EN61000-4-7:2011. These selections follow the declarations on the Test Setup screen for the nominal supply voltage and frequency.

Voltage Fluctuation Analysis

EN61000-3-3:2013 and EN61000-4-7:2011 include substantial clarifications and revisions to the algorithms used in the analysis of Voltage Variations and Fluctuations, and the presentation of the results. These changes are incorporated in version 3.0 of the instrument firmware. There is no facility to revert to the previous algorithms.

The input to the voltage fluctuation analysis is a sampled representation of the voltage waveform 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 difference from the nominal voltage. This is a signed value, now defined as positive when below nominal and negative when above (this is the reverse of the convention used in previous versions). This will normally be positive as 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” (an interval when the current consumption of the equipment under test does not vary significantly) or in a “change interval”. This is done by comparing each successive half-cycle against the limits of a tolerance band of ±0.2% around a rolling 1 second average value. (Previously values of ±0.15% and ±0.32% have been used for this band.) A steady state starts when all the half-cycle voltage values remain within the tolerance band for 1 second. It ends the first time a half-cycle falls outside the band. During a steady state the centre value of the tolerance band follows the rolling 1 second average. During a change interval the tolerance band centre value is only moved when a half-cycle crosses the limits of the band. The details of the algorithm are quite complex, and are defined in the standards.

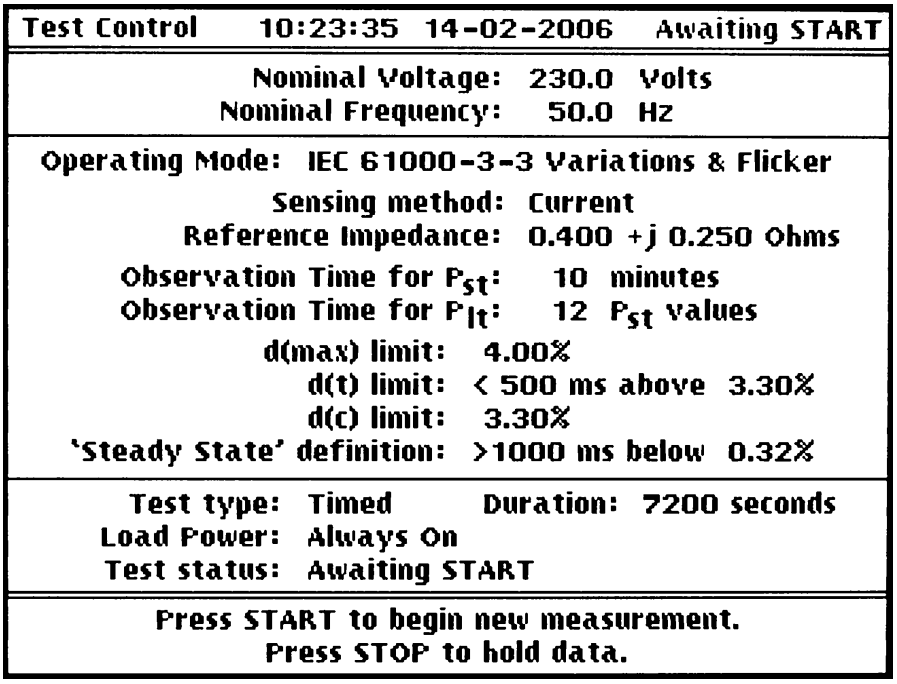
The standard is concerned with the value d_c, which is the largest difference (down or up) during the test between the level at the end on one steady state and the level at the entry to the next steady state following the voltage change characteristic that separates them.

While in a voltage change interval there is a limit on the total length of time the voltage change d(t) may exceed 3·3% from the level at the end of the preceding steady state. This is a cumulative time, not necessarily a single contiguous interval. This time is now called t_{max} and is compared to the limit of 500ms.

Also during every voltage change characteristic the instrument compares each half-cycle value with the level at the end of the preceding steady state and keeps a record of the largest downward and upward values. At the end of the test the greatest of these is the value called d_{max}. This is compared against a limit which must be set by the user, as required by the standard, depending on the switching characteristics of the equipment under test.

As with all compliance measurements it is essential that the standard is read and understood before testing is undertaken. In particular, note that the voltage variation limits of the standard include the effects of inrush currents at manual switching events, but the flicker limits do not. If these events cause a failure against the flicker limit then two separate tests should to be made, starting the flicker measurement after the equipment is initially switched on. Note also the requirement for a repeated manual switching test as defined in EN61000-3-3 Annex B.

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



Nominal Voltage and Frequency

Move the edit zone up to **`nominal voltage`** and **`nominal frequency`** and enter the correct values to describe the test supply. It is **important** to note that all the voltage variation and flicker results will only be valid if the correct values are declared here.

The Voltage declaration is used to set the hardware voltage input range, and also to select the correct lamp characteristics filter and correction factor. (see EN61000-4-15:2011 Table 3 and Clause B.2). Also, all the Voltage Variation results are expressed as a percentage of this declared nominal value.

The Frequency declaration is used to select the correct filter response characteristics in the flickermeter. For correct results the supply applied must actually be the right frequency.

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. When using **`Voltage`** sensing the range is also set to 96A, but this can be changed (from the Meter or Waveform views) as required, provided there is no overload during the test (as that would cause the test to be aborted).

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. This might be needed for measurements at 60Hz, as some authorities require the reactance value to be changed to 0.3Ω to implement unchanged inductance. The firmware 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 not needed for some types of equipment: if required its duration is twelve P_{st} intervals, 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(t) and d_c 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, and were different in earlier issues.

d_{max}

The pass or fail limit for the maximum relative voltage change d_{max} has different values depending on the nature of switching operations in the equipment under test. Users must read the standard and enter the relevant value here. If in doubt, use the lowest value: 4%. The d_{max} value is now the largest magnitude of upward and downward voltage difference during a change interval, not simply the difference between the highest and lowest values.

d(t)

The time value set here is the pass or fail limit for the parameter called t_{max} in the latest edition of the standards. This is the total cumulative time in a change interval that the voltage variation exceeds the threshold set here. A very old edition of the standard had different values, but there is now no expectation that they will need to be changed.

The present edition of the standard clarifies that this is a cumulative time over the threshold, not just each interval taken separately. Previous versions of the firmware displayed the highest value which persisted for a single interval of 500ms; this is no longer significant and has been removed.

d_c

This is the pass or fail limit for the difference between two steady states. The value is now 3.3% (it was once 3.0%) and is not expected to change.

Steady State Definition

Early editions of the standards lacked a numeric definition of “steady”, and did not give clear algorithms for determining when a voltage change characteristic should be considered to enter or leave a steady state. Various values for both the width of the tolerance band and the duration of the assessment have been used at different times in the industry.

The present editions clearly state that the duration of the waveform history used for the assessment is 1 second, and the width of the tolerance band is ±0.2% around the moving average value.

This issue of the instrument firmware retains the ability to alter these two values, but there is now no longer any need to do so. Note that changing these values does not restore the previous algorithm, which used a constant value (from the start point of the steady state) rather than the moving average.

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_{lt} 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.

The Meter View is used for displaying the Flicker and Voltage variation results. When the operating mode has been set to **`Variations & 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 difference between two steady states d_c and the largest variation within a change interval 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%	1.65			
0.7%	1.63		1:	0.79
1.0%	1.63		2:	0.00
1.5%	1.62		3:	0.00
2.2%	1.59		4:	0.00
3%	1.55		5:	0.00
4%	1.53		6:	0.00
6%	1.45		7:	0.00
8%	1.37		8:	0.00
10%	1.28		9:	0.00
13%	1.19		10:	0.00
17%	1.04		11:	0.00
30%	0.70		12:	0.00
50%	0.36			
80%	0.14			
P_{st}=	0.79		P_{lt}=	0.34
Peak pu=	1.70	(hold)	AGC:	1.010
Instantaneous pu=	0.44			

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. An addition in version 3 of the firmware shows the largest Pst value of all the Plt slots in the right hand column.

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.

A peak reading display of the instantaneous flicker sensation in p.u. is shown. The peak value is held on the display for half a second to allow it to be read, and then decayed towards zero; a text annotation indicates the state. This value is not used in the assessment of any equipment under test, but the calibration of the early stages of the flickermeter is specified in EN61000-4-15 in terms of this peak p.u. reading. The instrument will handle a peak p.u. up to about 6400 before overload – this is far above the level of any equipment that will pass the requirements of the standard.

The AGC (Automatic Gain Control) correction factor of the flickermeter is also shown. The AGC circuit adjusts the input gain of the flickermeter until the average value of the voltage waveform is equal to a reference value. A very long time constant is used in this AGC circuit, so for best accuracy, the user should wait until the value shown has stabilised before starting a timed test. The value displayed here is the square of the voltage ratio and would normally be expected to be between 0·90 and 1·10.

Voltage Variation Page

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 the nominal voltage as declared on the Test Control set-up.

This view changed considerably from firmware version 3.00 onwards to better reflect the measurements required by EN61000-3-3:2013 and EN61000-7-15:2011. Note in particular that voltage reductions are shown as positive and voltage increases as negative. This is the opposite of the convention used in previous versions of the firmware.

Present Behaviour

All the values shown in the top section are absolute values as percentages of the declared nominal voltage, relative to that declared voltage. If there is a difference between that declaration and the actual supply voltage then that bias will be reflected in these values. The subsequent processing to produce the relative change values that are subject to the limits of the standard removes that bias.

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 gives an indication of the stability of the operation of the load at the present time.

Below that are shown the greatest positive and negative excursions throughout the test; these are not directly subject to a pass or fail assessment. In general (if the nominal voltage is declared correctly), both extremes will be positive, as a load that consumes power will always cause a voltage drop. The variation will only be negative if a load (such as a motor with regenerative braking) returns energy to the supply.

The next line shows the present value of the tolerance band centre. The behaviour of this is quite complex, but during a steady state it is the value of the 1 second rolling average. During a change interval the band centre is only moved each time a half cycle value lies outside the tolerance band around the previous centre value.

Below this is shown the categorisation of the present load behaviour as either a steady state or a voltage change interval, and the length of time (in multiples of half a cycle) since that state began. A change is described as an extended change if it persists for more than the 1 second minimum duration required for assessing whether it is no longer a change interval but has become a steady state.

Voltage Change Intervals and d_{max} and t_{max} assessments

The next group starts with a count (for information only) of the number of change intervals since the start of the test. Below this is the analysis of d_{max}, the largest instantaneous voltage differences that have occurred in a change interval (each change interval is considered separately). Separate values are retained for downward and upward changes; the larger of these two magnitudes is the final value of d_{max}, which is checked against the limit entered on the Test Setup configuration and marked with a ✓ (pass) or **X** (fail).

Below this is shown (for information) the cumulative length of time in the present change interval that the change characteristic has exceeded the 3.3% threshold. For ease of reading, this value is held on the display during the subsequent steady state.

The largest value of this time in any of the change intervals throughout the test is the assessment value t_{max}, which is compared against the 500ms limit and marked with a ✓ (pass) or **X** (fail). (The value of this limit can be changed on the Test Setup screen, but there is no expectation that it will be amended again.)

Steady State Intervals and d(c) assessment

The bottom group of lines displays the analysis of steady states including (again for information only) the number of steady states since the start of the test.

The first pair of values show the levels (relative to nominal voltage) of (first) the point where the voltage characteristic passed through the boundary of the tolerance band at the end of the last steady state, and (second) the point where it satisfied the requirement to be within the tolerance band for 1 second that marked the start of the latest steady state. The next value is the d(c) relative change between those two levels.

The next line shows the largest d(c) changes down and up that have occurred during the test.

Then finally is the d(c) assessment is shown, where the largest magnitude of the down and up changes is compared against the limit (set on the Test Setup screen) and marked with a ✓ (pass) or **X** (fail).

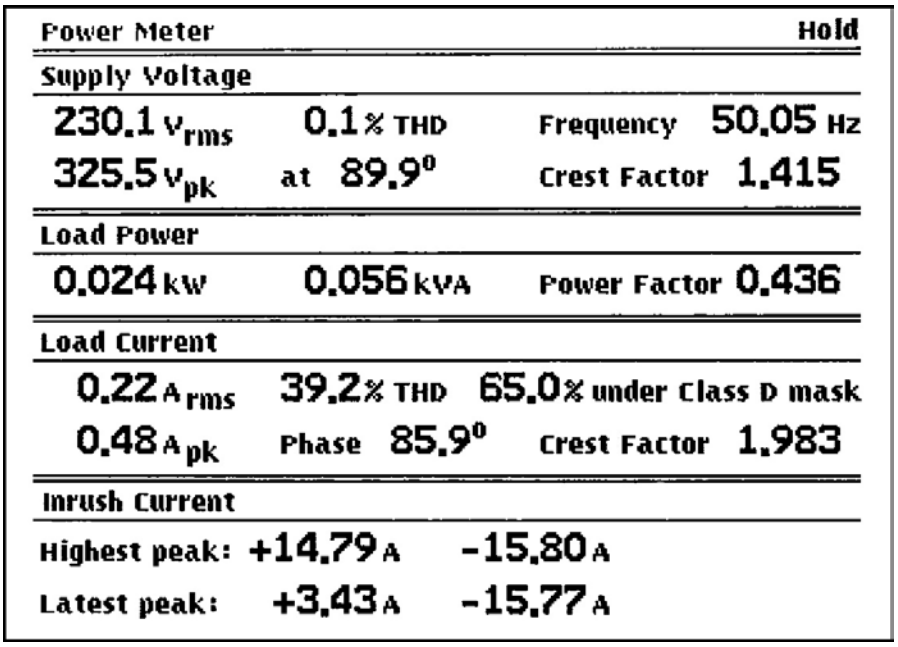
Note that these d(c) values can be subject to an uncertainty of up to the ±0.2% width of the tolerance band, depending on the nature of the voltage change characteristic.

Peak Inrush Current Measurement

This Peak Inrush Current mode is intended to measure the instantaneous peak inrush current characteristics of an equipment under test.

***Important Note**: There are no standards requiring compliance tests on this value. Limits on inrush current effects are specified indirectly, in EN61000-3-3, by a requirement on the voltage variation result d_{max} during manual switching events (which makes it, in effect, a half-cycle rms measurement). Such measurements should be conducted with the instrument in the Voltage Variations and Flicker mode described above. See also the section on taking Flicker and Voltage Variation Measurements later in this manual. This peak inrush mode is intended primarily for assessing the suitability of items such as switches and fuses.*

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:



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 (although different switch characteristics may affect the results).

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 auto-ranging 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.

Important Note: *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. The measured value can vary significantly depending on the characteristics of the switch.*

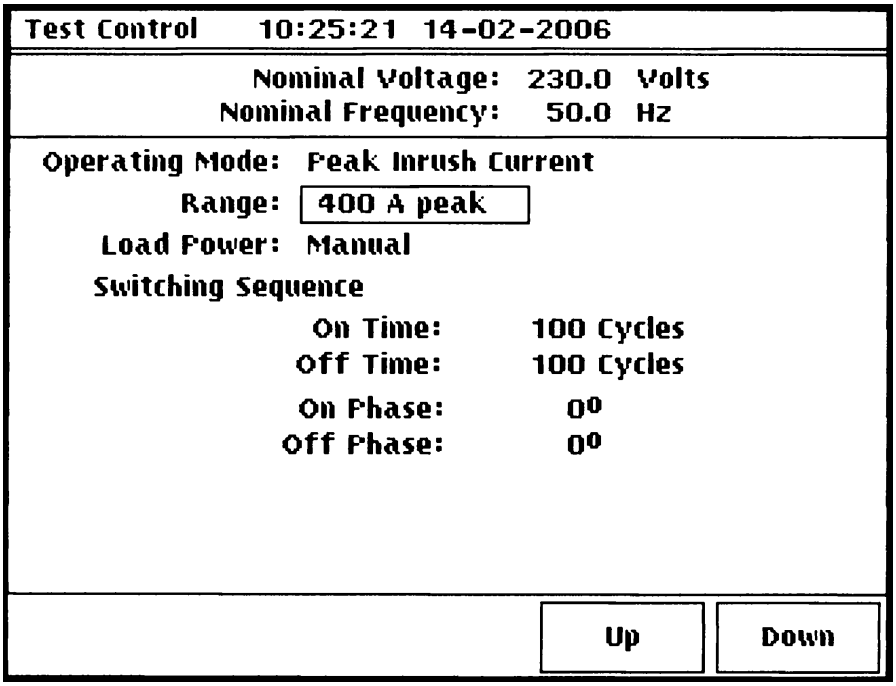
There are however occasions when an automatic measurement is useful so this instrument provides a sequencer using its internal relay to switch the load. There is provision for setting the on and off durations and for adjusting the phase of the switching points.

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.

Important Note: *This facility is only intended for use with relatively low power loads. To avoid damage to the relay the sequencer should not be used with highly reactive loads likely to cause arcing at the contacts, or with loads taking peak inrush currents in excess of 30 Amps.*

Test Control Set-up (Peak Inrush Current)

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



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. Auto-ranging 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.

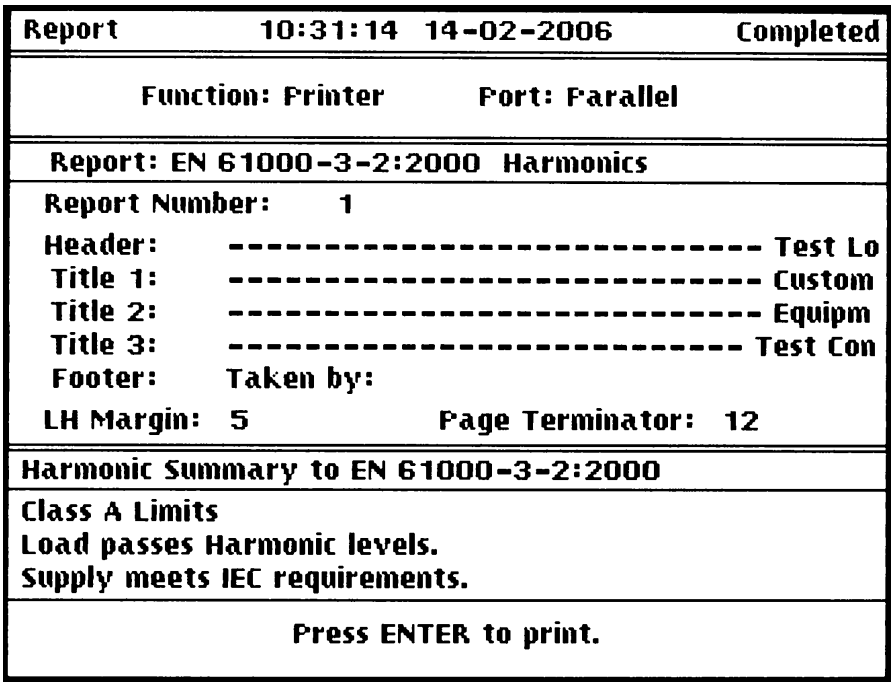
Switching Sequence on and off times.

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. Sufficient time should be allowed between power cycles for the load under test to fully return to its quiescent state; in many cases this can take several minutes.

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.

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



Printed reports of tests can be produced either by using the HA-PC Link Plus software (described later) with the instrument under remote control, or by attaching a printer directly to the instrument. Any printer capable of accepting 7-bit ASCII can be used; it will print in whatever font and page layout it has been set to.

The reports produced directly 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 (this can be changed). 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.

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.

Report Formats

The type of report printed (Harmonics or Voltage Variations and Flicker) is determined automatically by the operating mode of the instrument. A sample of each report type is given below. At the top of the report are the date and time the test was taken, the report number and the user entered title lines. These are followed, on a Harmonics report, by 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.

If discharge lighting equipment <25 Watts is being tested against the special requirements including waveform phase angles then the results for these angles are summarised next, followed by a shortened table of harmonic values (only the third and fifth harmonics matter).

Then follows the data table showing the measurement results for the fundamental and all the harmonics. For EN61000-3-2:2006 onwards, 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.
Time >150%:	The percentage of the test time limit that the Filtered Value has exceeded 150% of limit (for the application of the 200%/90% rule). If that time totals more than 10 minutes, then the time is shown to make the cause of the failure obvious.
Assessment:	A Pass or Fail assessment based on either the rule: 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. or the alternative rule: Max Value < 200 % of limit and Average value < 90 % of limit and Time over 150 % of limit is both < 10 % of limit and < 10 minutes total.

Sample Harmonics Report

Note that this report has a false power declaration, in order to illustrate the features of the report.

```
--------------------------------  TTi  ---------------------------------
Tested on: 25-06-2010 at 12:38:09 for 00:02:30  v2.75 Report Number:   1
-----------------------  HA1600 Development  -------------------------
----------------------  Reports for User Manual  ----------------------
----------------------  Fluctuating Harmonics  ------------------------

Supply Voltage: 229.7 to 229.8 Vrms     324.9 Vpk    Frequency: 50.00 Hz
                THD:  0.4%     Crest Factor:  1.414   peak at:  90.2 deg
                Supply meets IEC requirements.

Load Power:        21.3 to  124.8 W      151.1 VA   Power Factor:  0.825

Load Current:   0.155 to 0.641 Arms     1.275 Apk   Crest Factor:  1.873

Limits:         EN 61000-3-2:2014 Class D limits for   55W Rating
```

Harmonic Number	Limit current mA	Average current mA	% Limit	Maximum current mA	% Limit	Time >150%	Assessment
Fundamental:		264.1		513.7			
2:	-	8.3	-	21.0	-	-	-
3:	187.0	121.9	65.2	270.0	144.4	-	Pass
4:	-	5.5	-	13.6	-	-	-
5:	104.5	43.7	41.8	73.0	69.9	-	Pass
6:	-	3.7	-	7.3	-	-	-
7:	55.0	20.5	37.4	53.7	97.8	-	Pass
8:	-	3.0	-	5.2	-	-	-
9:	27.5	19.2	69.7	44.4	161.5	7.33 %	Pass
10:	-	2.3	-	3.5	-	-	-
11:	19.3	8.2	42.6	10.6	55.1	-	Pass
12:	-	2.1	-	3.2	-	-	-
13:	16.3	7.9	48.3	18.5	113.7	-	Pass
14:	-	1.6	-	2.6	-	-	-
15:	14.1	3.6	25.8	6.2	44.6	-	Pass
16:	-	1.4	-	2.3	-	-	-
17:	12.5	4.6	36.6	9.5	76.5	-	Pass
18:	-	1.0	-	1.6	-	-	-
19:	11.1	2.3	20.8	3.9	35.5	-	Pass
20:	-	0.7	-	1.4	-	-	-
21:	10.1	2.2	22.0	4.4	44.6	-	Pass
22:	-	0.5	-	0.8	-	-	-
23:	9.2	1.2	13.1	2.8	31.3	-	Pass
24:	-	0.4	-	1.0	-	-	-
25:	8.5	1.1	13.4	2.5	29.7	-	Pass
26:	-	0.3	-	0.7	-	-	-
27:	7.8	1.2	15.1	2.3	29.8	-	Pass
28:	-	0.3	-	0.7	-	-	-
29:	7.3	0.9	11.9	2.1	29.6	-	Pass
30:	-	0.3	-	0.7	-	-	-
31:	6.8	0.9	12.5	1.7	26.3	-	Pass
32:	-	0.3	-	0.7	-	-	-
33:	6.4	0.8	11.9	1.4	22.4	-	Pass
34:	-	0.3	-	0.7	-	-	-
35:	6.0	0.7	12.0	1.6	26.8	-	Pass
36:	-	0.2	-	0.5	-	-	-
37:	5.7	0.4	6.6	0.8	15.7	-	Pass
38:	-	0.2	-	0.5	-	-	-
39:	5.4	0.5	8.7	1.2	23.2	-	Pass
40:	-	0.2	-	0.5	-	-	-

```
   Evaluated using 200% Max and 90% Average rule.

  Taken by: MGR                                        HA1600 # 112443
```

Voltage Variations and Flicker Report

On a Voltage Variations and Flicker report, the usual user configurable title lines are followed first by a summary of the voltage, load power and load current measurements; note that these show filtered values as for a harmonics report. This section is 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. This information is the same as that shown on the two meter view pages.

Sample Flicker Report

```
--------------------------------  TTi  ---------------------------------
Tested on: 24-11-2015 at 15:13:54              v3.02 Report Number:   3
-----------------------  HA1600 Development  --------------------------
---------------------  Reports for User Manual  ----------------------
-------------------- 120 changes per minute Flicker --------------------
Supply Voltage: 229.1 to 229.5 Vrms     324.6 Vpk    Frequency: 50.00 Hz
                THD:  0.1%     Crest Factor:  1.414   peak at:  89.9 deg
Load Power:       104.6 to  331.5 W      336.3 VA   Power Factor:  0.986
Load Current:    506 to 1468 mArms      2114 mApk   Crest Factor:  1.432

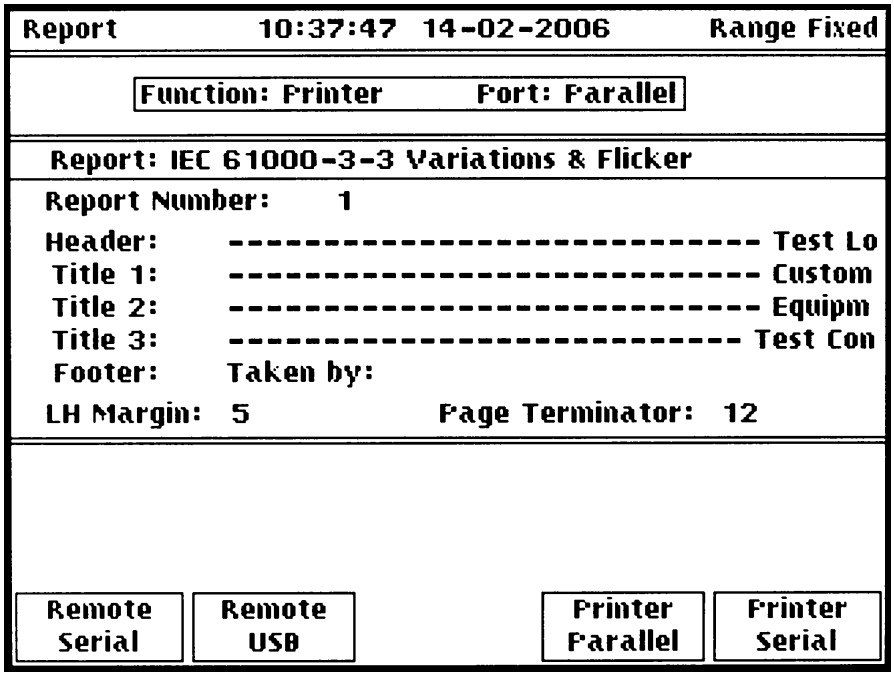
              EN 61000-3-3:2013 - Voltage reduction is positive.
Voltage Variations
            Nominal Voltage: 230.0 Vrms
   Highest Half-cycle level: +0.25%
    Lowest Half-cycle level: +2.04%
 Number of Change Intervals:     9
                    d(max): +1.72%            Limit:  4.00%   Pass
                    t(max):   0.000 seconds   Limit:  0.500s  Pass
  `Steady State' definition:  >1000 ms within  0.20%
   Largest d(c) change down:  1.73%
     Largest d(c) change up: -1.19%
        Largest d(c) change:  1.73%           Limit:  3.30%   Pass

Flicker (correction factor for voltage: 1.00)
  Short-term Flicker indicator Pst:   0.41     Limit:  1.00    Pass
   Long-term Flicker indicator Plt:   0.17     Limit:  0.65    Pass
                       Plt Interval     Pst
                            1:          0.41
                            2:          0.00
                            3:          0.00
                            4:          0.00
                            5:          0.00
                            6:          0.00
                            7:          0.00
                            8:          0.00
                            9:          0.00
                           10:          0.00
                           11:          0.00
                           12:          0.00

    Pst classifier:    Duration      Flicker
                         0.1%          0.40
                         0.7%          0.39
                         1.0%          0.39
                         1.5%          0.39
                         2.2%          0.38
                           3%          0.38
                           4%          0.38
                           6%          0.37
                           8%          0.36
                          10%          0.35
                          13%          0.34
                          17%          0.32
                          30%          0.27
                          50%          0.19
                          80%          0.13

Taken by: MGR                                          HA1600 # 112443
```

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.

Function

With the edit zone in this area, both the function and port can be chosen. If the **`Function`** is **`Printer`** there is a choice of **`Parallel`** (Centronics) or **`Serial`** (RS232) port. If the **`Function`** is **`Remote`**, the port may be **`Serial`** (RS232) or **`USB`** (if fitted).

Once a Remote Control function is selected, press the LOCAL key to enter remote operation. The LOCAL key can be used again to return to local control. The remote control facilities are intended for use only with the HA-PC Link Plus software supplied by the manufacturer, see that section in this manual.

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.

Reset Spooler

With the edit zone moved to the top (clock) line of the display a further soft-key **`Reset Spooler`** 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.

Report Type

The report type is automatically determined by the operating mode of the instrument.

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. The number is automatically incremented after each report is printed.

Header, Title 1 to 3 and Footer

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 text can be changed using the edit facility. Any or all of the lines can also be omitted completely.

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

To delete the header, title or footer 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** on the display. 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.

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 configured, 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 individual reports through the serial port to a communications capture 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).

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.

Overview of Harmonics Measurements

The standard defining the limits for harmonic current emissions, for equipment with input current ≤ 16A per phase, is EN61000–3–2. This standard is an essential document that should be read before any compliance quality measurements are attempted. There have been multiple versions of it, each with a succession of Amendments. This standard (which defines the required characteristics of the equipment being tested) refers to EN61000–4–7 for measurement methods. The present version of the instrument firmware supports both the current issue, EN61000–3–2:2014 (using the test methods from EN61000–4–7:2002 as amended, which include inter-harmonics and grouping – see below) and also the earlier version EN61000–3–2:2000 (using the test methods of EN61000–4–7:1993, which did not include inter-harmonics and grouping); the latest methods are preferred. All these documents should be available for purchase from National Standards Organisations worldwide (BSI in the UK).

The firmware of the HA1600 is stored in FLASH memory and can be updated from a PC. This capability enables the manufacturer to implement all the changes to the standards as software updates, which can be installed by users without the need to open the instrument or return it to the factory. **See the Firmware Updates section for details of the upgrade process.**

Aspects of the measurements

The following points are a quick guide to some aspects of the measurement requirements, particularly where confusion might arise from the changes made to the standards. As always, users should read the full standards for exact details.

Interharmonics

EN61000–4–7 uses the term interharmonics for spectral components of the current waveform that fall between two harmonic frequencies. The 2002 version introduced a process known as grouping which requires the amplitude of interharmonics to be rms summed into the magnitude of the nearest harmonic before comparing that value with the limit. The 1993 requirements exclude interharmonics.

Equipment classification

All classification is now by equipment type; class D does not depend on a special waveform test.

Basis of limits

For classes A and B the limits are absolute; for classes C and D the limits are now based on a rated consumption declared by the manufacturer. This figure must be within ±10% of the value obtained during the test. It is also possible to base the limits on the maximum consumption that occurs during the test. Dynamic limits that vary continuously during the test, as the consumption of the load changes, are no longer used.

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 “POHC rule” and the “200%/90%” rule

The assessment of fluctuating harmonics has completely changed. A “10% of 2½ minutes” rule, which was applied for a limited set of harmonics in the first issue of the standard, is no longer used. There are now two sets of rules:

The first, commonly known as “the POHC rule”, allows any harmonic 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.

The second rule, commonly known as “the 200%/90% rule” allows any harmonic to fluctuate up to 200% of its limit, provided that its average value is below 90% of the limit and the time for which it is over 150% of the limit does not exceed 10% of the test time or 10 minutes (whichever is shorter).

The standard specifies that these two rules are mutually exclusive, it is not permitted to apply one rule to a particular harmonic and the alternative to other harmonics. If the measured value of any harmonic exceeds 150% of limit at any time during the test (which means that the equipment has failed against the first rule, regardless of the POHC provision), then the instrument automatically applies the 200% /90% rule. There is no need for the user to make any selection. The report states if the second rule was applied, otherwise it reports the POHC values.

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 defining control methods that are not permitted 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 that 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.

- Read and understand the current issue of EN61000-3-2. This document is the prime source of information on how to test a particular piece of equipment and what limits apply. For most types of equipment the requirements are clearly stated in the standard and their implementation in the HA1600 straightforward. However, if there are doubts as to how the equipment under test should be treated, or how the standard should be interpreted, it may be advisable to consult a specialist EMC testing laboratory, or other Competent Body.
- 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.
- Always use an AC source that meets the supply quality requirements (especially for Crest Factor), even for pre-compliance measurements. Without such a source, results can be seriously misleading and will generally substantially underestimate the level of harmonics which will be produced when using a true sinewave source.
- Enter the correct **`nominal voltage`** and **`nominal frequency`** for the test supply.
- Follow the flow chart in the EN61000–3–2 to determine the equipment classification and therefore which limits apply, or follow the advice of a specialist EMC test house. Select the equipment **`load class.`** Specify **`Professional Equipment`** if applicable.
- Set the correct **`basis of limits`** for class C or D equipment. Although the instrument also offers an Automatic basis of limits (which sets the limits according to the maximum consumption during the test), for repeatable compliance measurements the user should explicitly enter the rated value. If class D, enter the rated power. For class C, if over 25 Watts, choose the standard sub-class and enter the nominal fundamental current and power factor. For discharge lighting equipment below 25 Watts, select one of the two permitted methods: either the power related harmonic limits of table 3, or the special set of requirements including conduction angle limitations on the shape of the current waveform. For the table 3 option (which will suit inductive ballasts or electronic controls with full Power Factor correction) enter the rated power as the basis of the limits.

For the other option (which is tailored for simple electronic ballasts) enter the rated fundamental current as the basis of limits. The instrument does not attempt to automatically select the best sub-class, but as it is most unlikely that any given waveform will pass both sets of requirements the correct choice will be obvious.

- Check whether Annex C of the standard gives specific operating conditions for the equipment being tested, as is the case for many common types of domestic appliance.
- 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.
- 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.
- 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. For equipment not covered by Annex C, identify the operating conditions that give a representative maximum set of harmonic levels, using reasonable professional engineering judgement. The value of total harmonic current shown on the Meter view may be helpful.
- 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 main guidance given is that the measurement time must be "sufficient to meet the requirements for repeatability". How long this needs to be is not always 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 standard defines how much of the measurement time may be spent with the unit under test in a standby condition. 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 results and assessment. Keep an archive copy of this and 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.

Taking Flicker and Fluctuation Measurements

- For compliance measurements use a laboratory grade AC power source. If the source provides the reference impedance by feedback, connect its external sense terminals at the point of connection to the load at the front panel of the instrument. If using a physical reference impedance, allowance must be made for the resistance of the connecting leads between the source, the impedance and the instrument. Any error in source impedance translates directly into an error in the result.
- For pre-compliance measurements it is possible to use any reasonable AC supply in conjunction with the Current Sensing option of the instrument. In practice, this is usually sufficiently accurate for compliance measurements, unless the different source impedance significantly affects the behaviour of the load. It is only necessary to use the reference method if the results obtained with current sensing are sufficiently close to the limits to give real cause for doubt.
- Read and understand the current issue of EN61000-3-3. Establish the test conditions and limits (especially for d_{max}) which apply to the particular equipment under test. Refer to the Test Control (Flicker) section of this manual and configure the instrument as required.
- After setting the required options on the Test Control screen switch on the AC source, with the load switched off. Allow at least 30 seconds for the filters in the instrument to settle, then press START to clear the measurement history. Now cycle the equipment under test through its normal operating sequence. Note that the moment of initial switch-on is included in the voltage variation tests, but not in the flicker tests. If the results from a test including manual switching events fails the flicker limits, then a second test can be made pressing START to reset the measurement values a few seconds after the manual switching. 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. Refer to the earlier section of this manual for a detailed explanation of the information presented.
- 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.
- Annex B to the standard details the procedure for measuring voltage changes caused by manual switching events. These requirements amount to a limit on half-cycle rms inrush current, and apply to **all equipment** with manually operated power switches. The tests must be performed manually, using the switch on the equipment under test, and each d_{max} result recorded. The highest and lowest results are discarded before taking the average. The HA-PC Link Plus software provides support for this sequence of measurements and the required calculation: there is no provision in the instrument for the firmware to perform this calculation, but the tests can be made and the results manually recorded.

This software is intended to assist users in taking routine compliance measurements and archiving the results. It can communicate with the instrument through either an RS232 or (on the HA1600A) a USB connection.

The PC is used for configuration, display and data archiving only; all real time data handling and measurement processing continues to be performed by the Digital Signal Processor in the instrument. The performance of the PC does not affect the accuracy of the measurement results, and so there is no need for the either the PC or its software to be covered by a calibration certificate.

Software Installation

The software will run under Windows 2000 or any later version. If an RS232 connection is used (but not a USB connection) it should also run under Windows 98 or ME, but technical support for this is not available. If an earlier version of HA-PC Link is already installed, it is recommended that it should be removed using the Uninstall Program facilities of Control Panel before attempting to install the new version; this ensures that the proper directories are created.

Insert the supplied CD into a drive; navigate to the directory HA1600A\HA-PC Link+. Review any Read Me file that may be present, then double click the .msi file. The Windows Installer will run and suggest a directory for the program files, which can be changed if required. There are no other installation options.

The program can be used to save both report files and configuration files; the default location offered is a directory in the Documents tree of the current user.. Depending on how many different types of equipment are to be tested, users may wish to set up a directory structure for storing these files.

RS232 connection

The instrument must be connected to the PC using a **fully wired** 9-way cable (without any cross-over connections). A suitable cable is provided with the instrument. Full hardware handshaking is used in both directions, so the use of a proper cable is essential. 3-wire connections will **not** work.

After the program is launched and configured for the correct COM port, the program will configure all the necessary communications options.

USB connection

The USB port in the instrument is a full speed (12 Mbits/s) USB 1.1 port. It will function with any modern host port (USB 1.1 or USB 2). Read the section below on USB driver installation before connecting the instrument for the first time.

Operation of the HA-PC Link Plus Software

Place the instrument into Remote mode.

After connecting the instrument to the PC (with either USB or a fully wired 9-way RS232 cable), switch the instrument on, and start it in the usual way.

Select the Report View and press SETUP. If necessary, move the selection box to the "Function" area and select "Remote Serial" or “Remote USB” as required. Press the LOCAL key: the Remote lamp should light. The instrument will be returned to local control when the PC software is closed; alternatively press LOCAL again.

Start the PC software

After placing the instrument in Remote mode, start the HA-PC Link Plus software from the desktop shortcut.

The first time the software is used, a message will appear reporting that there is no initialisation file; the software will then create a default one. If communication is not established, a dialog box will appear allowing selection of the correct COM port. Enter the number of the RS232 port (normally 1 or 2), or of the COM port established by the USB drivers. On a few systems COM ports 3 and 4 can conflict with legacy ports – use Device Manager to assign a different port number (above 4 and if possible below 15).

Once this is done, the software will set the required communication parameters (which over-ride the Windows default properties) and the screen should start to show live data reported from the instrument.

The operating screen follows a workflow sequence, with setting-up on the left and results on the right. It is recommended that users work in the sequence outlined below.

Identify the test

1. Three free-entry text boxes are provided for the user to identify the equipment being tested, its serial number and the person conducting the test. The date is automatically provided.
2. Set the nominal voltage and frequency.
3. Select the measurement required (Harmonics or Flicker & Voltage Variations).

Harmonics Measurements

1. Choose the measurement method. Use the EN61000-4-7:2002 method unless there is specific reason to use the old one (this is still permitted, provided that the fact is documented in the report).
2. Declare the equipment class, and any basis of measurements required. Refer to the standard to make these decisions. See also the guidance given earlier in this manual.
3. Choose and lock the current range required to handle the highest peak current consumed by the equipment under test during its operating cycle. If in doubt range up one more range, as it is essential to avoid overload at any point during the test.
4. Preview the results: waveform, histogram or table displays may be selected by using the radio buttons below the display area on the right hand side.
5. Choose a Test Duration; the standard gives some guidance on this.
6. In the Test Status area at the bottom of the left hand side are four buttons:

   Reset Meter resets the Max. hold and average calculations.

   Hold is a toggle which alternately freezes and releases the measurement.

   Free Run can be used at the end of a timed test.

   Start Timed Test initiates the test:

   Abort test can be used if required, particularly if an overload occurs.
7. Set up the equipment under test as required by Annex C of the current issue of EN61000-3-2.
8. Run the test by pressing **Start Timed Test**. When the set duration expires, the results will be held. While the test is running the software will also monitor the Power Source quality against the requirements of the standard
9. Review the results. The current harmonics report can be previewed on screen. If necessary use the settings menu to choose a fixed pitch font that is available on the computer.
10. Print or save the results:
    - The current harmonics report can be printed (with a simple format) directly to a printer.
    - The Power Supply Quality (PSQ) report can also be printed as a separate menu option.

- That version can be saved as a text file. A standard dialog box prompts for directory and filename. The PSQ report and a configuration file (with a .HAC extension) are simultaneously saved.
- The results can also be saved as a pair of .CSV (comma separated variable) files. These files can then be imported into a word processor or spreadsheet, formatted as required and incorporated into larger reports. See below for guidance on importing the files into a word processor.

Flicker and Voltage Variation Measurements

In general, it is necessary to conduct two sets of tests:

1. Voltage Variations and Flicker during continuous operation of the equipment.
2. A set of 24 manual switching tests according to annex B of EN61000–3–3.

Continuous Test

1. Apply the test supply, select the Flicker and Voltage Variation mode, set the proper nominal supply voltage and frequency, and wait for the flickermeter filters in the instrument to settle.
2. Refer to the standard to identify the test requirements for the particular type of equipment being tested.
3. Set the appropriate d_{max} limit for the voltage fluctuation test as required by the standard. Check the settings for the d(c) and d(t) limits are 3.3% and 500ms (the facility to change these values is now obsolete).
4. If a flicker test is required, tick the checkbox. If a full 2 hour long term flicker test is required, tick the second checkbox.
5. The test duration is automatically set to 10 minutes (600 sec) or 2 hours (7200 sec). If flicker tests are being conducted, these should NOT be changed; if only voltage fluctuation tests are required, the duration can be adjusted as needed.
6. Run the test and review, print or save the report (as for harmonics above).

Note that the standard requires the Voltage Variations test to include the effect of manual switching events, such as initially switching on the unit under test. The Start Test button should be activated before this switching event. However manual switching events are excluded from the flicker limit. In many cases this does not cause a problem, but if it is found that the initial transient causes the test to fail the flicker limit, then a second test must be run for the flicker limit only, pressing the Start Test button a few seconds after the manual switching event. The two reports need to be properly annotated or manually combined.

Manual Switching Test (refer to Annex B of EN61000-3-3).

1. Set the required d_{max} limit and the number of tests (24, in the current version).
2. Set the duration of each test (the default is 60 seconds). This must be sufficient for the equipment under test to complete any initialisation sequences and stabilise into its normal operating condition.
3. With the equipment under test switched OFF, press **Start Test 1**.
4. Then (within a few seconds) switch the equipment on **using its own switch. T**his is an essential requirement of the standard as the use of any external switch may give different results. It is also the intention that the switching events should occur at random phases of the supply waveform. A green message panel appears on screen as a reminder.
5. A few seconds before the end of the 60 seconds, switch the equipment off (a red message panel appears as a reminder).

6. Allow sufficient time for the equipment to cool fully (particularly if it contains inrush limiting circuits) and for any energy storage components to fully discharge. This may, in some cases, take several minutes.
7. Press **Start Step 2** and repeat the procedure of steps 4 to 6, taking care to perform the operations in the required order. Continue in this way until a message appears stating that the test is complete.
8. After 24 tests, the software discards the highest and the lowest result and computes the average of the rest. This is the required result.
9. The **New Test** button allows the whole procedure to be started again.
10. Save the report.

Exporting and Formatting Reports with a Word Processor

In addition to printing the report in the plain text format of the software, it is possible to save the results as a Comma Separated Variable (.CSV) file. The plain text reports were designed for traditional printers and can be printed directly, but assume the use of a fixed pitch font such as Courier or Consolas. It is not easy to import these files into a word processor and apply any other formatting, because they use spaces to position text. The .CSV files are the best format for transferring reports into formatted word processor documents.

However, the standard association of CSV files is with a spreadsheet program; also using drag and drop facilities to import the file into a word processor will generally create an embedded spreadsheet object. In either case the spreadsheet program will attempt to apply a single layout to the entire file, which will not produce the desired results.

The best way to incorporate the reports into a formatted word processor document is to use the CSV file in conjunction with the “convert text to table” feature of the word processor software. This allows the two parts of the report (the introductory information in the header and the full data table below) to be formatted separately.

The following procedure is generalised to cover different word processor programs, and recognise that the position of the various menus options needed changes between versions of each program. Nevertheless, the terminology is common enough to allow the necessary selections to be identified.

1. At the desired point in the word processor document, choose “insert file”, or “insert text” then “text from file”. The “Open File” dialog should appear.
2. In the “File Type” option of the “Open File” dialog, select .CSV files, or “spreadsheet files” or, if necessary, “all files”. Select the required file saved from HA-PC Link and open it.
3. If offered conversion options, choose “convert from plain text”.
4. Select (highlight) the top (header) part of the data, down to the blank line above the tabulated data at the bottom.
5. Choose “insert table”, then “convert text to table”.
6. In the dialog box, most importantly first specify the character to be used to separate the text: choose “Commas”. The dialog box should now show that two columns will be created. Choose Auto Column Width and click OK.
7. The header items will now be arranged into a two column table. While the whole area is selected, adjust the vertical divider as required. Apply a table style, or format the text as desired.
8. Now repeat the procedure on the tabular harmonics results data: select (highlight) the bottom part of the report, and repeat steps 5 and 6. A seven column table should be created.
9. Apply any detailed formatting required to the data table: many users will start by selecting “centred text”.

The procedure is quite straightforward, once the location of the required menu options has been discovered for the particular version of word processor program being used. The same technique is used with the Voltage Source Qualification report. The Flicker and Voltage variations reports are a little different (it is probably best to separate them into three sections if flicker results are included) but the method is similar.

Users who perform the procedure frequently may wish to define Table Styles to suit their preference, or even to write macros to automate the process.

Installation of USB drivers

The USB port is implemented using a USB-to-serial converter integrated circuit and requires special COM port drivers (provided by the device manufacturer, FTDI) to be installed on the PC. The drivers are provided on the CD in the “USB Drivers” subdirectory, and are installed using the Windows “Found new Hardware” wizard. As there may be a later version than is described here, look for a Read-Me file in that directory for current instructions.

So far as is known, the version provided functions satisfactorily, but users might wish to check the instrument manufacturer’s web site for updated versions of the driver. Any revision to the installation procedure should be documented with the drivers. Note that installation requires the correct INF file, to relate the Vendor ID and Product ID of the HA1600A to the general drivers, so users cannot simply download the version on the device manufacturer’s web site.

1. The instrument does not enable its USB port until it is put into remote USB mode. First connect the instrument to the PC with a USB cable, then switch the instrument on, and select Restore Defaults on the start-up screen.
2. Select the Report View and press SETUP. With the selection box in the "Function" area select “Remote USB”. Press the LOCAL key: the Remote lamp should light. The USB port will then enumerate to the PC.
3. The “New Hardware Found” wizard should open. Click “Next” to continue.
4. Select “Search for a suitable driver for my device (recommended)” and click “Next”.
5. Check the checkbox “Specify a location” and uncheck all the others; click “Next”.
6. Specify the location containing the drivers: “D:\USB drivers” (where D: is the CD drive). Alternatively use “browse” to find the location. Click “Next”.
7. Windows should select “FTDIBUS.INF”; click “Next”. Then click “Finish” to install this driver.
8. Once Windows has installed this driver, the “New Hardware Found” Wizard will appear a second time to install the COM port control driver. The procedure is the same, except the file required is FTDIPORT.INF.

If these drivers have been installed before on a PC (perhaps to support another device using the same integrated circuit), it is common for a warning message to appear asking for permission to overwrite a file with an older version; in general it is best to keep a consistent set of files, so it is recommended that users should not overwrite but should keep their functioning version.

After the drivers are installed, Windows will allocate a COM port number to the particular HA1600A. Whenever this particular instrument is connected to the same PC, it will always be given this same port number. HA-PC Link Plus needs to be configured to use this COM port number; unfortunately the New Hardware wizard does not tell the user which number has been allocated.

9. To discover the COM port number, the instrument must be connected and in Remote USB mode (see 1 & 2 above).
10. Select “Start… Settings… Control Panel. Open the “System” object, select the “Hardware” tab and click “Device Manager…”. Select “Devices by type” from the “View” menu and expand the Ports (COM and LPT) category. There should be an entry for a HA1600 Harmonics Analyser (COM n). Note the port number n.
11. Start HA-PC Link Plus and configure it to this port number.

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

From time to time firmware 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 10 x 38mm 20A 500V HBC Type aM or gL.

To gain access to the fuse, disconnect the instrument from all voltage sources and remove the 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.

Battery Replacement

The instrument uses a battery to support both a real-time clock and the settings memory. If the date reverts to 01-01-2000 then the battery needs to be replaced.

In the HA1600A the battery is user replaceable; proceed as follows:

1. Disconnect (by unplugging) both the Instrument Power and the Test Power connections from all mains supplies.
2. Remove the four screws holding the top cover and lift the cover off the unit.
3. Remove the battery from its holder and replace with a 3V Li/$Mn0_2$ 20mm button cell type 2032. Do not short circuit the battery while removing or replacing it – in particular do not use metal pliers to hold it.
4. 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.
5. Replace the top cover, ensuring that all four screws seat securely.

In older HA1600 units, the battery is soldered in. In this case, return the unit to a service centre to have it replaced by a holder and a user replaceable battery.

Firmware Updates

The HA1600 firmware is held in Flash memory and can be upgraded in the field via either its RS232 or USB interfaces. From time to time firmware updates will be available on the TTi website (tti–test.com). To upgrade your instrument with the latest firmware, and to check what revision of the standards are currently supported by that firmware, visit the Downloads page for the HA1600A & HA1600 at http://aimtti.com/support

The download is a ZIP archive containing the latest firmware, an installer for the latest version of HA-PC Link, a PDF file of the current instruction manual and possibly some notes in Read-me files. The firmware file is named 1600Fvvv.S, where vvv is the version number; it is a text file in S-record format. Unpack the required parts of the archive into a convenient directory. The update procedure requires a computer running a modern operating system with full support for hardware handshaking on the serial port.

If using RS232, connect the HA1600's serial port to COM1 or COM2 on the PC using a fully wired nine core 1-to-1 cable (with **no** cross-over connections) such as the one provided with instrument. Note that many ordinary serial cables have less than 9 cores; these cables will not work. The PC must have a serial port capable of operation at 115 kBaud.

Alternatively for an HA1600A connect the USB port and install the drivers as described earlier. This creates a COM port on the computer, corresponding to a UART inside the instrument. This serial port requires proper configuration of its parameters (baud rate, hardware handshaking etc.) just like any other. Take a note of the COM port number allocated by Windows during the driver installation.

The RS232 port of either model can be connected to a computer through a serial port to USB converter, provided that the converter properly implements full hardware handshaking and a 9 core cable is used. Unfortunately there are some USB to serial converters that do not properly implement the hardware handshaking required and will not work properly. Units based on FTDI silicon have been used successfully.

Use the system configuration utility to set the chosen port to 115200 baud, 8 bits, no parity, with hardware output handshaking using CTS. Under Windows Vista (or later) open the start menu, type cmd into the search box and press Enter. Under Windows 2000 or XP use the Run... command (Start... Run... cmd… OK....). In either case a command prompt window should open.

Change to the directory where the 1600Fvvv.S file was unpacked, and enter the following configuration command (note that the parameters are separated by spaces, not commas) substituting the relevant COM port number:

```
mode com1: baud=115200 data=8 parity=n octs=on dtr=hs
```

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 for RS232 or USB as required. The unit will then to go to the **Software Update** screen which should display the message **Ready for data from PC.**

Now copy the S-record file to the serial port (substituting the correct COM port number and firmware file version):

```
copy 1600Fxxx.S com1:
```

Progress can be seen on the screen of the instrument.

When the transfer is complete, press the **Restart** soft-key, or 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.

Important Note: *Always select* **Restore Defaults** *on the initialisation screen the first time the instrument is switched on after an upgrade has been installed.*



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