Table of Contents

High performance power analyser

The AC2000 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 AC2000 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.

Compliance-quality harmonics analyser

The AC2000 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 from Laplace).

Capabilities include real-time Class D evaluation and visual display, continuous automatic calculation of harmonic limits to EN61000-3-2, continuous monitoring of the supply voltage, inrush current analysis, and timed test sequences with analysis of fluctuating harmonics.

Compliance-quality flicker meter

The AC2000 has the optional capability to operate as a compliance quality flicker meter in conformance with EN60868 and EN61000-3-3.

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

Flicker severity can be measured in terms of Pst and Plt with analysis periods variable between 5 minutes and 2 hours.

The graphical display can show Cumulative Probability, Voltage Deviation as well as Pst values.

A full range of interfaces

A printer interface is included for record keeping and archiving, together with RS-232 (standard) and IEEE-488 (optional) interfaces for use with PC based software or as part of a GPIB system.

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

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:	45 – 66 Hz.
Shunt Resistance:	3mΩ.
Sampling Rate:	300 points per cycle.
Basic Accuracy:	Better than 0.2%.
Measured Parameters:	Vrms, Vpk, Arms, Apk, Crest factors, THD, W, VA, Power factor, Frequency, Inrush current.
Display Modes:	Tabular display of all parameters including latest and highest inrush current. Waveform Graph display of Voltage and Current with Max hold and Accumulate modes.
Monitor Outputs:	Re-constructed Voltage and Current Signals.

HARMONICS ANALYSER

Measurements:	1st harmonic to 40th harmonic.
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:	45 – 66 Hz.
Shunt Resistance:	3mΩ.
Sampling Rate:	300 points per cycle.
Basic Accuracy:	Better than 5% of limit or 0·2% of selected range whichever is the greater.
Display Modes:	Histogram display of harmonics with limits (calculated from IEC1000-3-2) and Min. hold/Max. hold display options. Tabular display for steady-state harmonics with present values, minimums, maximums, limits, % of limits (present values and maximums) and pass/fail assessment for each harmonic. Option of using filtered measurements. Tabular display for fluctuating harmonics with present values (filtered) maximums, % of steady-state limits (present values and maximums) % of time spent above steady-state limits (last 150s and worst 150s) and pass/fail assessment for each harmonic. Graphical display of a selected harmonic against time, with limits. Graphical display against time of all harmonics exceeding steady-state limits. Display of load supply assessment for voltage, harmonics, crest limits and frequency against requirements defined in IEC1000-3-2. Waveform Graph display of Voltage and Current with automatic Class D envelope fit for Class A/Class D detection. Max hold and Accumulate display modes.
Test Control:	Untimed, manually timed or automatically timed tests; user-defined test time. Declare load classification or automatic Class A/Class D detect. Minimum and maximum power thresholds for Class D limits can be changed by the user. Limits automatically determined from IEC1000-3-2 for appropriate class; facility for insetting test limits. Facility for defining alternative supply voltages (i.e. other than 230V) and deriving appropriate limits.
Report Printing:	Direct printer connection for hard-copy report of either steady-state or fluctuating harmonics showing minimum and maximum values, limits, % of

limits, fluctuation duration and pass/fail assessment for each harmonic. Also provides supply voltage assessment and user-entered narrative.

FLICKER METER (OPTION)

Measurements:	Pst and Plt to EN60686 and EN61000-3-3.
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:	45 – 66 Hz.
Shunt Resistance:	3mΩ
Sampling Rate:	300 points per cycle.

GENERAL

Display:	320 x 240 pixel backlit LCD.
Interfaces:	Parallel Printer, RS-232, Optional IEEE-488 (GPIB)
Instrument Supply:	230V or 115V ± 14%, 48 to 65Hz. Installation Category II. Maximum instrument power 25VA. The instrument can be operated at a different supply voltage and/or frequency from that used to supply the load.
Operating Range:	+5°C to 40°C, 20-80% RH.
Storage Range:	–10°C to +60°C.
Environmental:	Indoor use at altitudes up to 2000m, Pollution Degree 2.
Safety:	Complies with EN61010-1.
EMC:	Complies with EN50081-1 and EN50082-1.
Dimensions:	305 x 148 x 220mm (WxHxD).
Weight:	4·2kg.

Safety

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

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

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

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

WARNING! THIS INSTRUMENT MUST BE EARTHED

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

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

Any adjustment, maintenance and repair of the opened instrument under voltage shall be avoided as far as possible and, if inevitable, shall be carried out only by a skilled person who is aware of the hazard involved. If the instrument is clearly defective, has been subject to mechanical damage, excessive moisture or chemical corrosion the safety protection may be impaired and the apparatus should be withdrawn from use and returned for checking and repair.

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

This instrument uses a Lithium button cell for the real-time clock and non-volatile memory battery back-up; typical life is 3 years. In the event of replacement becoming necessary, replace only with a cell of the correct type, i.e. 3V Li/$Mn0_2$ 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.

. The following symbols are used on the instrument and in this manual:-

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

terminal connected to chassis ground.

alternating current.

This instrument has been designed to meet the requirements of the EMC Directive 89/336/EEC.

Compliance was demonstrated by meeting the test limits of the following standards:

Emissions

EN50081-1 (1992) Generic emission standard for residential commercial and light industry. Test methods and limits used were:

a) EN55022 Conducted, Class B

b) EN55022 Radiated, Class B

Immunity

EN50082-1 (1992) Generic immunity standard for residential, commercial and light industry. Test methods and limits used were:

EN60801-2 (1993) Electrostatic Discharge, 8 kV air discharge.

IEC801-3 (1984) RF Field, 3 V/m.

IEC801-4 (1988) Fast Transient, 1 kV peak (AC line) and 0.5kV peak (Signal lines and RS232/GPIB/Printer Ports).

Cautions

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

a) after opening the case for any reason ensure that all signal and ground connections are remade correctly before replacing the cover. Always ensure all case screws are correctly refitted and tightened.

In the event of part replacement becoming necessary, only use components of an identical type, see the Service Manual.

Note that the conducted emissions measured on the LOAD POWER connection of the AC2000 will be those of the load itself since the AC2000 contains no filtering on this connection. When making measurements on non-compliant loads, therefore, care must be taken to ensure that its emissions do not interfere with other equipment.

Mains Operating Voltage - Instrument Power

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

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

Mains Operating Voltage - Load Power

The fixed LOAD POWER mains lead is an independent connection with 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 45 - 66Hz.

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

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

Fuse - Instrument Power

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

For 230V operation use 250mA (T) 250V time-lag HBC
For 115V operation use 500mA (T) 250V time-lag HBC

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

Fuse - Load Power

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

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

Mains Lead

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

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

WARNING ! - THIS INSTRUMENT MUST BE EARTHED

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

Front Panel Connections

Appliance Connector

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

A wide choice of national appliance connectors is available but the connector is factory fitted and cannot be changed by the user.

The maximum load current that can be supplied is 16Arms or the rating of the connector, whichever is lower.

Voltage and Current Monitor

The Voltage Monitor and Current Monitor BNC sockets output reconstructed scaled versions of the load power voltage and current waveforms referenced to instrument ground, permitting direct connection to other instruments such as an oscilloscope.

The output voltage is approximately 2.5V pk-pk for a full scale output on any current or voltage range; the ranges in use are shown at the top of the Waveform Graph view.

Rear Panel Connections

Instrument Power

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

Load Power

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

RS232

The RS232 interface is intended for connection to a PC with a high speed RS232 port which is running the HA-PC LINK software for data display and archiving.

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. The instrument should be connected to a standard PC port using a fully wired 1-1 male-female cable without any crossover connections.

GPIB (IEEE-488)

The GPIB interface is an option. It is not isolated; the GPIB signal grounds are connected to the instrument ground.

The implemented sub-sets are:

SH1 AH1 T6 TE0 L4 LE0 SR1 RL1 PP1 DC1 DT0 C0 E2

The GPIB address is set from the front panel.

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. Detailed descriptions of each function are given in later sections, starting with Power Meter.

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

Switching On

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

Switch the POWER switch to ON to turn the instrument power on; the display will show the Initialisation screen for a few seconds followed by the Select screen. Press the **Resume Operation** soft-key (F5) at this point to continue normal operation; the instrument will start up in its default configuration 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 measurement 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. If no key is pressed whilst the Select screen is shown normal operation is resumed after a self-timed delay, as shown in the display.

The other soft-key options on the Select screen are **Restore Defaults**, which continues normal operation with all parameters defaulted to their original factory setting, and **Setup**. **Setup** gives access to a further screen where the soft-keys are **Restart** and **Update Software.** **Restart** returns the instrument to the Initialisation screen. **Update Software** selects the mode in which the instrument's software can be updated from a PC via its RS232 port; full details of this operation will be provided with the software update itself.

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

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

Display Contrast

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

Keyboard

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

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

The four cursor keys marked 3 5 4 and 6 are used to move the edit zone (shown as an outline box) around the editable fields of a set-up display. For each position of the edit zone the keys below the display have the functions shown immediately above them in boxes on the

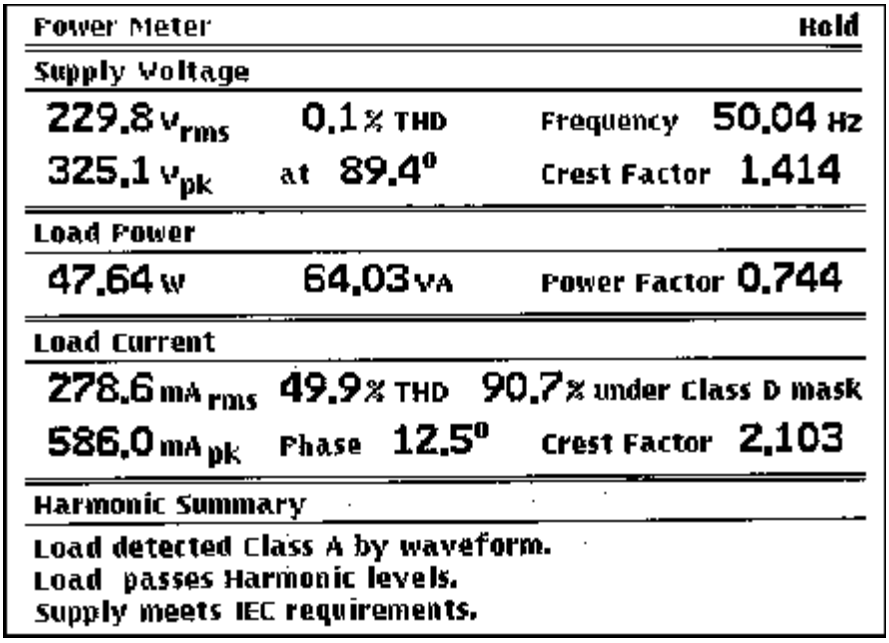
LCD; the functions change as the edit zone is moved which is why they are called 'soft' keys. The cursor keys auto-repeat when held down.

Numeric keys permit direct entry of values in certain set-up displays. ENTER confirms a numeric entry and CANCEL terminates the entry without changing the parameter to the new value.

START TEST and STOP TEST have specific functions determined by the type of test selected on the Test Control set-up display; full details are given in the Test Control section.

The LOCAL key returns the instrument from remote (GPIB) to local (keyboard) control.

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/fail indication is given in the **`Harmonic Summary`** section of the display.

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

The **Load Current** group shows the rms and peak load currents, together with the total harmonic distortion (THD), the phase of the current peak and the calculated crest factor (Ipk/Irms). Most important, the percentage of the waveform under the dynamically calculated Class D envelope defined by EN61000-3-2 is shown; the load is considered Class D if the current waveform falls within the envelope for more than 95% of the waveform period. Since Class D limits are generally more severe than Class A (for ≤ 600W loads) it is extremely useful to know whether a nominally Class A load approaches Class D at some point in its operation, e.g. a power supply with a wide operating range. Load class is discussed further in the Test Control section.

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

Power Meter Set-up

With the Power Meter view displayed, pressing SET-UP shows the Power Meter set-up screen which gives access to the **Setup Range** soft-key.

Setup Range

Pressing the **Setup Range** soft-key changes the display to a graphical view of the current waveform with 3 further soft-keys: **Up**, **Down** and **Lock Range**. The **Up** and **Down** keys change the measurement range in x2 and ÷2 steps respectively; using either key locks the range at the new value (i.e. autoranging is disabled) and the scaling of the waveform display changes accordingly. The range scaling 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. During range set-up the display waveform is always normal, i.e. updated every cycle, even if Max Hold or Accumulate mode has been set for the Waveform Graph view.

Important Note: When the range is locked, the user must be sure that the load current waveform stays within the selected range throughout the measurement, i.e. the range must be chosen to accommodate the highest waveform peak likely to be encountered during the load's operating cycle. If the range is 'overloaded' no damage will result and the graphical waveform display will still be correct; however, the Power Meter display cannot be used (it will show Overload in the status line at the top of the display) and calculation of the harmonics will be incorrect. It is therefore recommended that for a preliminary assessment of the load the instrument is used in autorange mode to determine the peak current that may be drawn during the load's operating cycle. Having determined this peak the instrument should be locked on a suitable range to ensure that harmonics measurements are correct and that Accumulate, Max Hold and Min Hold measurements are meaningful (see Mode section). 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.

Note that autoranging is disabled when the LOAD switch is OFF to prevent the instrument autoranging to the most sensitive range when there is no load current. At switch-on the default range is 3A pk if the LOAD switch is OFF; at other times, switching the LOAD to OFF locks the range at the setting currently in use.

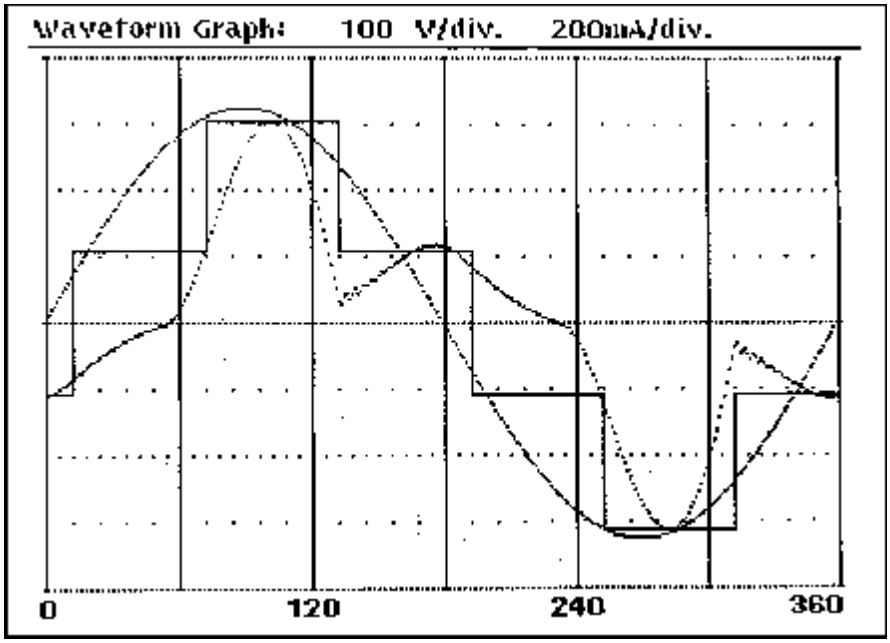
When the **Lock Range** soft-key is pressed it becomes **Auto Range**. Several soft-keys 'toggle' between alternate choices in this way; it is only necessary to remember that at any time the soft-key box shows what will happen when the key is pressed.

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

Waveform Graph View

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

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

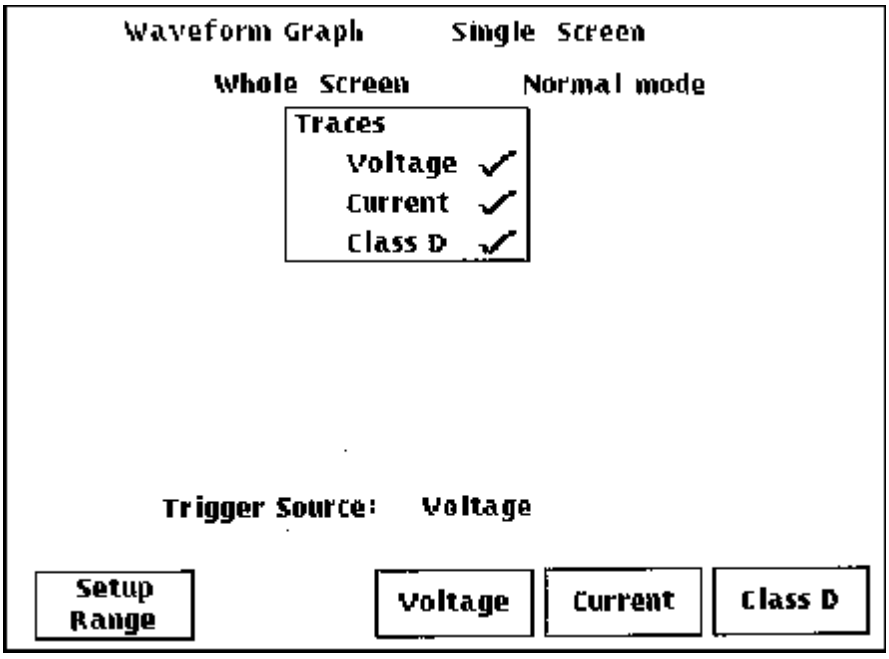


The voltage display has 2 ranges only : 100V/div, for nominal 230V supplies, and 50V/div for nominal 115V supplies; the voltage range is set from the Test Control set-up display.

The x-axis of the 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.

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 5 6 keys; each field is described below. Pressing the VIEW key returns the display to the Waveform Graph view.

Setup Range

Pressing the **Setup Range** soft-key changes the display to a graphical view of the current waveform with 3 further soft-keys: **Up**, **Down** and **Lock Range**. The **Up** and **Down** keys change the measurement range in x2 and ÷2 steps respectively; using either key locks the range at the new value (i.e. autoranging is disabled) and the scaling of the waveform display changes accordingly. The range scaling 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. During range set-up the display waveform is always normal, i.e. updated every cycle, even if Max Hold or Accumulate Mode has been set for the Waveform Graph view.

Important Note: When the range is locked, the user must be sure that the load current waveform stays within the selected range throughout the measurement, i.e. the range must be chosen to accommodate the highest waveform peak likely to be encountered during the load's operating cycle. If the range is 'overloaded' no damage will result and the graphical waveform display will still be correct; however, the Power Meter display cannot be used (it will show Overload in the status line at the top of the display) and calculation of the harmonics will be incorrect. It is therefore recommended that for a preliminary assessment of the load the instrument is used in autorange mode to determine the peak current that may be drawn during the load's operating cycle. Having determined this peak the instrument should be locked on a suitable range to ensure that harmonics measurements are correct and that Accumulate, Max Hold and Min Hold measurements are meaningful (see Mode section). 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.

Note that autoranging is disabled when the LOAD switch is OFF to prevent the instrument autoranging to the most sensitive range when there is no load current. At switch-on the default range is 3A pk if the LOAD switch is OFF; at other times, switching the LOAD to OFF locks the range at the setting currently in use.

When the **Lock Range** soft-key is pressed it becomes **Auto Range**. Several 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 Waveform Graph view can be recalled by pressing the VIEW key.

Screen

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

Mode

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

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

Accumulate: The display is written to every waveform cycle without erasing the previous data. In this mode, short-term aberrations can be captured.

For clarity it is recommended that the Class D envelope is turned off (see Traces section below) and preferably only a Voltage or Current waveform displayed. Since the Accumulate mode is automatically reset at every range change it is also recommended that the current range is locked, see Set-up Range section above. The Accumulate mode can be manually reset at any time by pressing the VIEW key twice. The Accumulate display is lost when the view is changed.

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

For clarity it is recommended that the Class D envelope is turned off (see Traces section below) and preferably only a Voltage or Current waveform displayed. Since the Max Hold data is automatically reset at every range change it is also recommended that the current range is locked, see Set-up Range section above. The Max Hold data can be manually reset at any time by pressing the START key.

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

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

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

Traces

With the edit zone in the **Traces** field the soft-keys are **Voltage**, **Current** and **Class D**. Alternate presses of each key will turn that trace on and off; confirmation is given by a **4** or **X** against the corresponding trace name in the **Traces** edit zone.

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

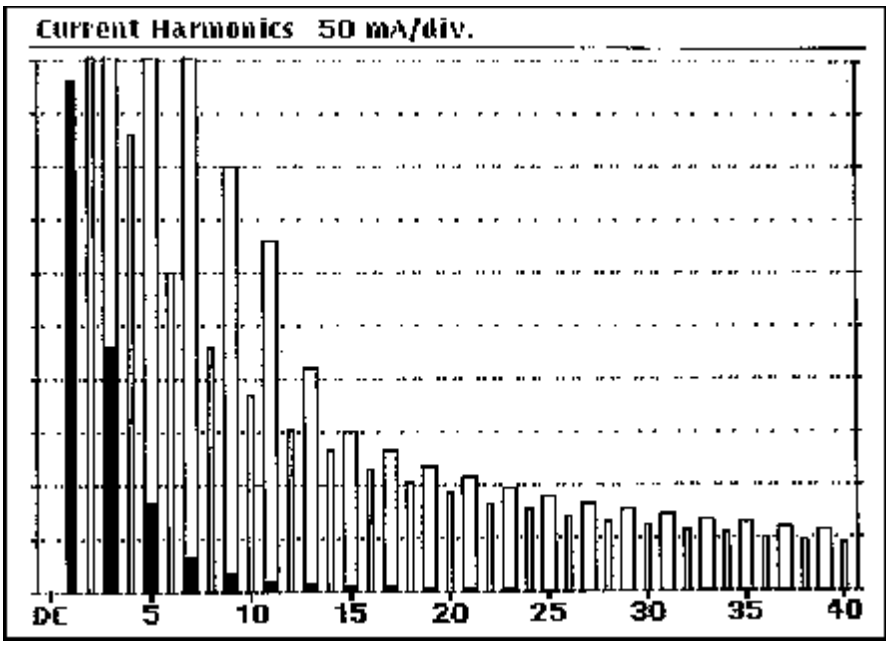
Trigger Source

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; can be useful under some circumstances when a voltage or current waveform causes display jitter. The actual synchronisation point is arbitrary; it is determined at instrument switch-on and can be changed by switching the instrument off and on again.

Harmonics View

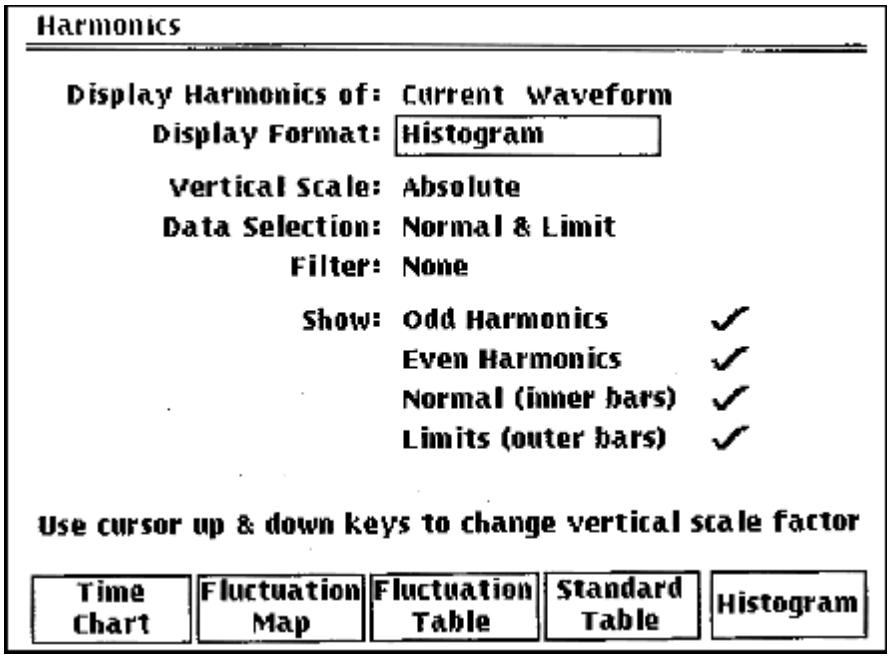
With the green VIEW lamp lit, press the HARMONICS key to display the Harmonics view. The default display is a current harmonics histogram.



The harmonics histogram can be set to show either absolute harmonic levels or levels as a percentage of individual limits; it can also be modified to show, for example, odd harmonics only. The harmonics can also be listed in a table, with limits; there are two sets of tables, one of which is optimised for fluctuating harmonics. There are also two graphical views of the harmonics against time, primarily intended for viewing fluctuating harmonics. The Time Chart provides a 'chart recorder' view of a selected harmonic for the last 150 seconds; the Fluctuation Map shows when any of the relevant harmonics exceed the specified limits during the last 150 seconds. Lastly, the harmonics of the supply voltage can also be displayed in histogram and table form. All the above view options, together with the measurement mode selections, are set from the Harmonics set-up screen; full descriptions of each are given in the Harmonics Set-up Section.

Harmonics Set-up

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



The soft-key functions change as the edit zone is moved through the editable fields of the display using the 5 6 keys; each field is described below. Pressing the VIEW key returns the display to the Harmonics view.

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 apply as explained in the appropriate sections.

Display Format - Histogram

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

With Histogram selected 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.

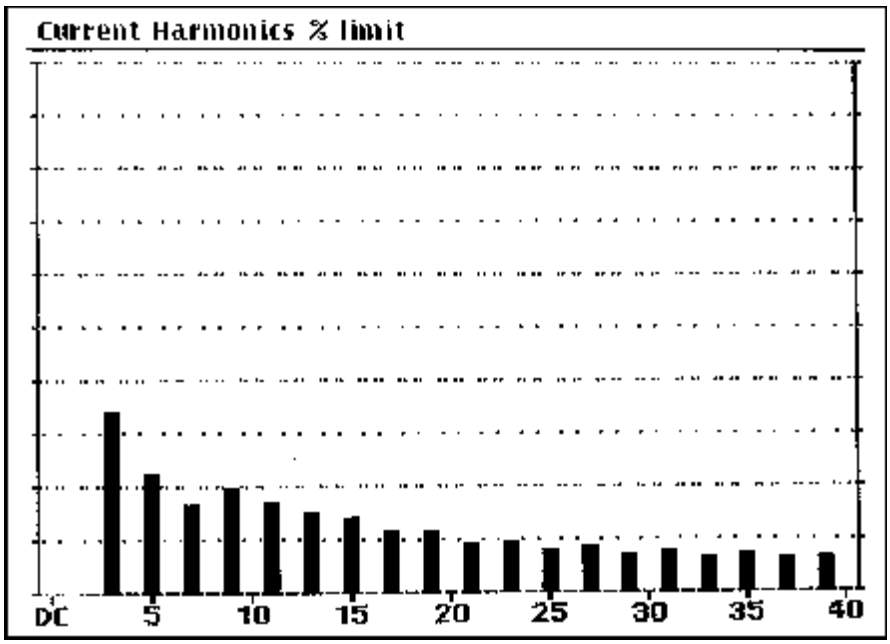
All histograms are of the same general form as the default version. The horizontal scale is marked with the harmonic number, odd harmonics/limits are shown as wide bars and even harmonics/limits are shown as narrow bars. The fundamental is shown to the left of the second harmonic as a wide inner bar only and the DC component is shown to the left of the fundamental as a narrow inner bar only. 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 instruments measurement range. However, the scaling can be changed easily using the 5 and 6 keys; the 5 key increases the resolution, permitting a 'zoom' view of low level harmonics, and the 6 key reduces resolution, bringing off-screen harmonics and limits into view. In this way any harmonic can be observed with optimum display resolution. Changing the display resolution does **not** affect the measurement range. The waveform peak must always be in-range for correct operation of the transform processing, see Important Note in the Power Meter Set-up section.

Measuring and reporting absolute harmonic levels is necessary during development and type approval exercises but a quicker pass/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 the selected display mode the **Data Selection** field (see next section) is forced to **Normal & Max. Hold**, i.e. 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.

Data Selection

Moving the edit zone to **Data Selection**, having selected Absolute for Vertical Scale, 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 and the normal (instantaneous) values of the harmonics are shown by the solid inner bars, 'thermometer' style. Note that, in this example, the limits might also be changing dynamically (e.g. for a Class D device whose power is varying) and that the solid inner bar may extend beyond the open outer bar if the limit is exceeded.

The full list of display options is described below; only the first of these (Normal & Limit) is available for Voltage Harmonics Histograms and this is also the default for Current Harmonics Histograms (Absolute scaling).

Normal & Limit: The default selection for Absolute scaling. The solid inner bars represent the normal (instantaneous) harmonic value and the open outer bars show the instantaneous limit for each harmonic.

The histogram is updated with the values from every 4-cycle transform. The limits are also calculated dynamically where appropriate (e.g. Class D) using the instantaneous power level of the same 4 cycles.

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 4-cycle transform with the greater of the new and existing value for every harmonic. The limits are calculated dynamically where appropriate (e.g. Class D) using the instantaneous power level of the latest 4 cycles, i.e. they are not necessarily relevant to the maximum harmonic value. There is no problem when fixed limits (e.g. Class A) are used but care must be taken when the limits are changing dynamically.
Note that the Max Hold is automatically reset at every range change. It is therefore recommended that the range is locked (using the Set-up screen of the Power Meter or Waveform Graph displays) before Max Hold is used; 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 4-cycle 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 4-cycle 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. The selected

Data Selection mode is maintained until changed as described above or until the instrument is turned off; the mode defaults to **Normal & Limit** when the instrument is turned on again.

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.** Alternate presses of each key will turn that item on and off in the display; confirmation is given by a **4** or **X** against the corresponding parameter in the **Show** edit zone. Note that when the odd harmonics are turned off the fundamental is also turned off and when the even harmonics are turned off the DC component is also turned off.

Filter

With the edit zone in the **Filter** field the soft-key choices are **None** (the default) and **Filtered**. When **None** is selected the harmonic values are updated after every 4-cycle transform; when **Filtered** is selected the values are processed by a 1st order filter with a 1.5s time constant before being displayed.

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

Display Format - Standard Table

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

Selecting **Standard Table** and returning to the Harmonics view by pressing the VIEW key gives a display of the following form:

Current Harmonics

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

The default form of the Standard Table (shown above) lists all odd and even harmonics up to the 40th in two groups; 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 actual value is shown (updated after every other 4-cycle transform) together with the limit for that harmonic and the measured value expressed as a percentage of that limit. When the limit is variable, e.g. for varying Class D loads, the limit is also calculated and changed every transform. When there are no limits (e.g. for the fundamental or for Class D loads below the minimum power limit) a '¾' is shown in the table.

The form of the Standard Table can be modified by returning to the Harmonics set-up, by pressing SET-UP, and moving the edit zone to the **Show** field; the soft-key choices are **All Harmonics, Even Harmonics,** and **Odd Harmonics**. All Harmonics, the default, gives the

table described previously; selecting Even Harmonics or Odd Harmonics gives a table listing only the even or only the odd harmonics respectively but with additional columns as follows.

The normal value, limit and percentage of limit are shown as before, together with the minimum, maximum and maximum percentage of limit for each harmonic since the Min Hold and Max Hold were last reset (by pressing the Start key or by changing range). The extreme right-hand column also gives a pass/fail indication for each harmonic against the limit with a **4** or **X** respectively.

With the edit zone moved to the **Filter** field the soft-key choices are **None** and **Filtered.** With **None** selected (the default) the values are updated after alternate 4-cycle transforms; when **Filtered** is selected all values are processed by a 1st order filter with a 1.5s time constant before being displayed.

Display Format - Fluctuation Table

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

With **Fluctuation Table** selected the edit zone can be moved to the **Show** field permitting three further soft-keys – **Fluctuation Set, Even Harmonics** and **Odd Harmonics** – to be used to define what is shown in the Fluctuation Table.

The columns are the same for all three selections but the harmonics listed vary. The **Fluctuation Set** lists the odd harmonics up to the 27th plus the even harmonics up to the 10th, i.e. it includes all those for which a limit is set by the standard for fluctuating harmonics; this is the default version and is shown below.

Odd Harmonics and **Even Harmonics** select all the odd or all the even harmonics respectively. Note that in all cases the values used have been filtered by a 1st order filter (with a 1.5s time constant) as required by the standard when assessing fluctuating harmonics. This is indicated in the Set-up screen – **Filter : 1.5 sec** is displayed but is not an editable field as it is for Histogram or Standard Table displays.

Current Harmonics mA

N	Filtered	% limit	% Fluct		Max	% limit	% Fluct	
1:	199.54	-			201.24	-		
3:	91.91	107.0	14.1	X	92.76	107.3	14.1	X
5:	29.15	60.7	0.0	✓	29.28	61.5	0.0	✓
7:	15.53	61.5	0.0	✓	15.64	62.8	0.0	✓
9:	2.31	18.3	0.0	✓	2.71	21.9	0.0	✓
11:	4.74	53.7	0.0	✓	5.05	57.0	0.0	✓
13:	8.15	109.2	14.1	X	8.33	111.1	14.1	X
15:	7.08	109.2	14.1	X	7.17	110.9	14.1	X
17:	4.13	72.3	0.0	✓	4.29	76.1	0.0	✓
19:	2.40	47.2	0.0	✓	2.49	49.4	0.0	✓
21:	2.47	53.4		✓	2.54	54.9		✓
23:	2.28	54.3		✓	2.29	54.4		✓
25:	1.64	42.4		✓	1.66	43.2		✓
27:	0.74	20.3		✓	0.83	23.4		✓
2:	1.93	-	-	✓	2.36	-	-	✓
4:	2.06	-	-	✓	2.47	-	-	✓
6:	0.49	-	-	✓	0.69	-	-	✓
8:	1.05	-	-	✓	1.10	-	-	✓
10:	1.43	-	-	✓	1.48	-	-	✓

The columns of the Full Table are as follows:

1) **N:** The harmonic number. The 3 versions list either all the odd, all the even or those to which the wider fluctuation limits may be applied, i.e. odd 3 to 19, even 2 to 10.
2) **Filtered:** The actual value, processed by the 1st order filter.
3) **%Limit:** The value expressed as a percentage of the steady-state harmonic limit; for Class D this is dynamically calculated from the total power.
4) **%Fluct:** The percentage of the last 150 seconds that the value has been over the steady-state limit.

5) **4** (pass) or **X** (fail): A fail will be signalled if either:

the filtered value exceeds 150% of the steady-state limit.

the filtered value has exceeded 100% of the steady state limit for more than second period.

the filtered value exceeds 100% of the limit for those harmonics which don't

6) **Max:** The maximum value since START was last pressed (or the instrument autoranged).

7) **%Limit:** The maximum value, since START was last pressed (or the instrument autoranged), as a percentage of the steady-state limit.

8) **%Fluct:** The worst percentage of any 150 second period, since START was last pressed, that the value has been over the steady-state limit.

9) **4 or X:** **4** (pass) or **X** (fail). A fail will be signalled if either:

the value has exceeded 150% of the steady-state limit at any time

the value has exceeded 100% of the steady-state limit for more that 0% of any 150 second period.

c) the value has exceeded 100% of the limit at any time for those harmonics which don't have a wider fluctuation limit.

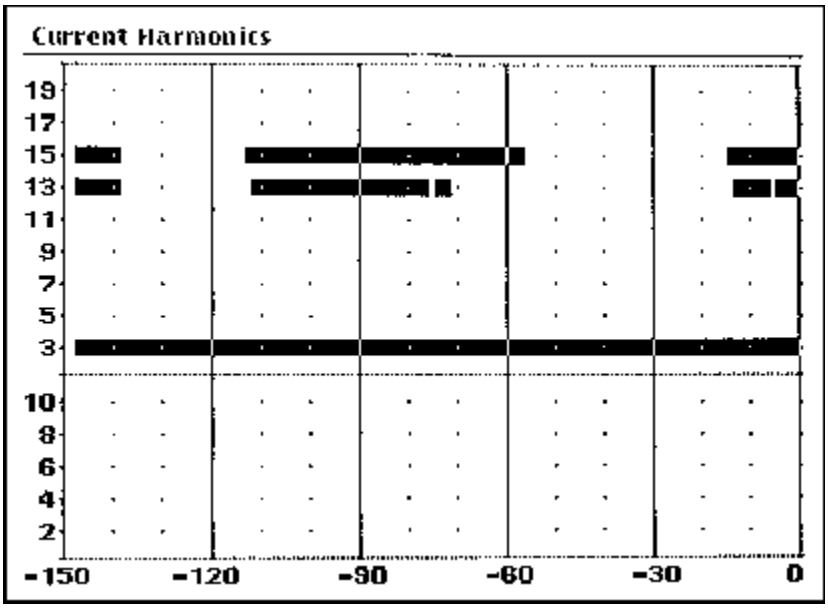
Note that no **%Limits** are shown (a '–' is displayed) where there are no steady-state limits, e.g. for Class D loads below the minimum power. The **%Fluct** limits are only shown for those harmonics which have a wider fluctuation limit, i.e. odd harmonics 3 to 19 and even harmonics 2 to 10. On the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

Pressing START at any time resets the **Max,** Max **%Limit** and **%Fluct** columns; the **4** and **X** are therefore reset. If the peak current changes sufficiently to cause the instrument to autorange, **Max,** Max **%Limit,** etc., will again be reset. It is therefore necessary to lock the range during the measurement of fluctuating harmonics, having first chosen a range which will not be overloaded during the operating cycle of the device under test. See Important Note in the Power Meter Set-up section.

Display Format - Fluctuation Map

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

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

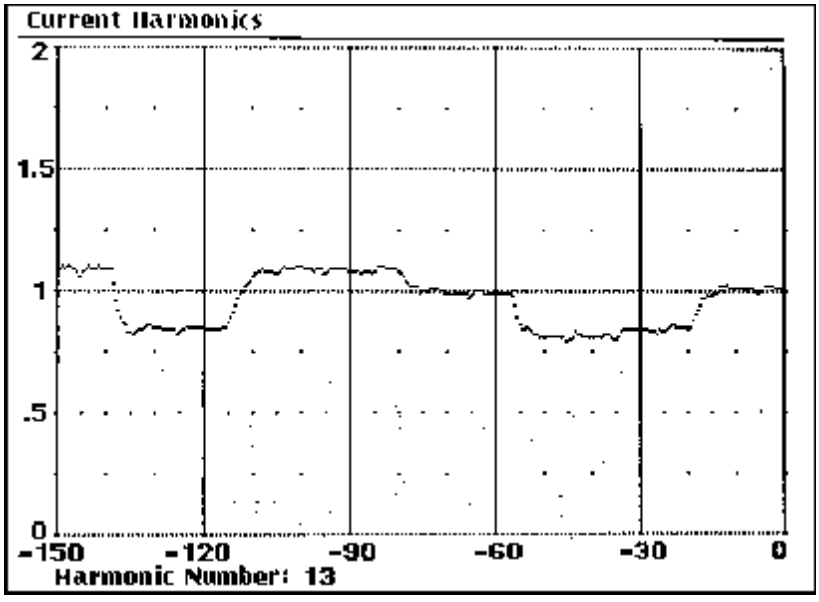


The Fluctuation Map is a simultaneous graphical display of all the harmonics to which the fluctuating specification can be applied (odd 3 to 19, even 2 to 10). The harmonics are arranged one above the other with their number shown on the left-hand vertical axis. The horizontal scale shows the most recent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

Display Format - Time Chart

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

With **Time Chart** selected a further editable field called **Harmonic Number** is displayed. The number of the harmonic to be displayed on the Time Chart can now be entered directly from the keyboard and confirmed with ENTER. Alternatively the edit zone can be moved to the **Harmonic Number** field which causes the **Set Harmonic** soft-key to be shown; pressing this key prompts the user to enter the harmonic number from the keyboard, as before. Pressing CANCEL instead of ENTER returns the harmonic to the previous value.



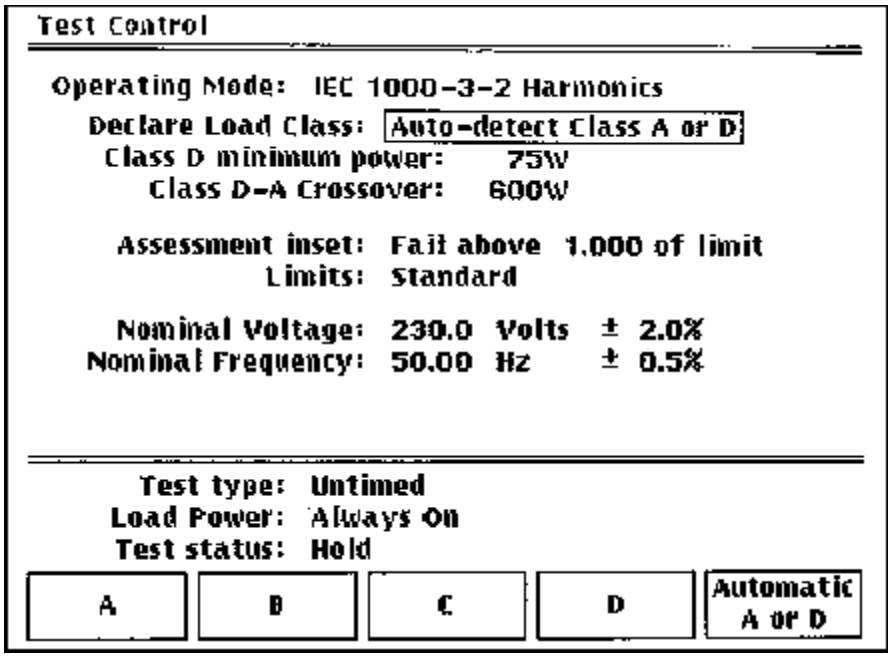
When the harmonic number is confirmed with ENTER the display changes to the Time Chart

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

The Time Chart provides a 'chart recorder' view of a selected harmonic for the last 150 seconds; the right hand edge is the most recent value. Each pixel represents 0.5 seconds; the value shown is the maximum value of the filtered harmonic (processed by a 1st order filter with a 1.5s time constant) within that 0.5 seconds.
The Time Chart is always ‘running’ (i.e. it is not reset by the START key) and acquiring data for all harmonics; changing the selected harmonic simply changes the harmonic currently viewed.

Test Control View

With the green VIEW lamp lit, press the TEST key to display the Test Control view.



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

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

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

Test Control Set-up

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 which change as the edit zone is moved through the editable fields of the display with the 56keys.

Operating Mode

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

The default is **`IEC1000-3-2 Harmonics`**; the alternative option is **`Inrush Current`**. For IEC1000-3-2 the display shows the further editable fields described below; for Inrush current there are no further Test Control set-up options.

Load Class

With the edit zone in the **Declare Load Class** field the soft-key options for IEC1000-3-2 are **Class A, Class B, Class C, Class D** and **Automatic Class A or D.** Declaring the class sets the limits for the Harmonics view defined by IEC1000-3-2 for that class, see below.

If **Class A** is selected the absolute values given in Table 1 of IEC1000-3-2 are used as limits.

If **Class B** is selected the absolute values given in Table 1 of IEC1000-3-2 are multiplied by a factor of 1.5 and used as limits.

If **Class D** is selected the further editable fields of **Class D minimum power** and **Basis of Limits** are shown. Class D power limits are explained in the next section; the **Basis of Limits** field gives the user options for defining the power level which will be used to calculate the maximum harmonic values according to Table 3 of IEC1000-3-2.

With the edit zone in the **Basis of Limits** field the soft-key choices are **Automatic, Declare Value** and **Store Present**. When **Automatic** (the default choice) is selected the instantaneous load power (calculated every 4-cycle transform) is used as the basis for calculating the Class D limits according to Table 3 of IEC1000-3-2; this is the normal interpretation of the requirements stated in the standard. Alternatively, selecting **Declare Value** permits the user to set a fixed power level from which the limits are calculated according to Table 3; this is a more literal interpretation of Clause 7.4 of IEC1000-3-2 which defines limits for the 'rated load condition'. 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.

The third option is to use the present actual power consumption as the basis for calculating the limits according to Table 3; this is an alternative literal interpretation of the 'rated load condition' in Clause 7.4 of IEC1000-3-2. Pressing **Store Present** sets the Basis of Limits field to the actual power level measured at the moment of pressing the soft-key; the value is shown in the Basic of Limits field followed by the term **Condition** to indicate that it is a measured rating.

If **Automatic Class A or D** is selected the waveform shape is first checked every transform to see whether 95% or more fits within the Class D envelope, i.e. is checked to see whether it has the 'special wave shape' defined by IEC 1000-3-2. If it does, and if the instantaneous load power is within the limits defined for Class D, that load power is used as the basis for calculating the Class D limits according to Table 3 of IEC1000-3-2; this is exactly the same as selecting **Automatic** for a declared Class D. If not, the fixed limits of Class A are applied.

If **Class C** is selected the further editable field of **Basis of Limits** is shown; with the edit zone in this field the soft-key choices are **Automatic** and **Store Present**. When **Automatic** (the default choice) is selected the instantaneous fundamental current and power factor (measured every 4-cycle transform) are taken as the basis for calculating the Class C limits according to Table 2 of IEC1000-3-2. This is the requirement defined in clause 7.3.1(a) of the standard for lighting equipment with an active input of >25W; for lighting with a power consumption ≤ 25W modified Class D limits apply – see Class D power Limits section.

Discharge lamp luminaires with built-in dimming devices are a special case of Class C where the basis of limits is the fundamental and power factor measured at the maximum load condition. These can be set on the instrument by pressing **Store Present** with the luminaire running in its maximum load condition; the measured values are shown in the Basis of Limits field in the form:

Basis of Limits: 234.5mA at 0.678PF

The fundamental current of 234.5mA and power factor of 0.678 are then used as the basis for calculating the limits according to Table 2 of IEC1000-3-2.

The **Harmonic Summary** section of the Power Meter view shows the load Class declared or, in the case of automatic Class A/Class D detection, which Class is detected; if Class D is detected it will also state when the load power is outside the Class D power limits. In addition, below the Class statement is an overall summary of whether the load passes or fails the specified limits, e.g. **Load passes Harmonics levels**.

Class D Power Limits

With the edit zone in the **Class D minimum power** field the default minimum power limit can be changed using the **Set Power** soft-key. Pressing this key brings up a message at the bottom of the display (in place of the soft-keys) with a flashing cursor:

Class D minimum power _ Watts.

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

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

The facility for changing the limits permits the instrument to accommodate present variations and future changes to the standard. Class C lighting equipment with an active input power ≤ 25W must meet the power–related harmonics limits of Class D (i.e. Table 3 of IEC1000-3-2). The analyser can be set up to do this by declaring Class D and setting the Class D minimum power to zero so that limits are calculated and displayed for all load power levels. Note that the user must monitor the actual power level (using the Meter view); if the load exceeds 25W then conventional Class C limits apply, see Load Class section.

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.

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

Assessment inset: _ of limit

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

Note that setting an inset only affects the Pass/Fail assessment; the data and limit values are unchanged.

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. The correct voltage range is automatically set according to the value entered.

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 exactly the same as described for Nominal Voltage above.

Limits

The **Limits** field provides the user with the opportunity to scale the limits defined in IEC1000-3-2 (which strictly and only apply to 230V ±2% operation) to a different operating voltage, e.g. 100V.

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 IEC standard apply; if **Voltage Ratio** is selected the limits are scaled by the ratio between 230V and the nominal voltage set in the **Nominal Voltage** field. In Voltage Ratio mode the set-up display reads:

Limits: Adjust by 230V/Nominal

Test Timing and Load Power Control

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

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

Untimed: The default option. Measurement is continuous, consequently load power is **Always On.** The test status is **Normal** (i.e. continuous measurement) unless STOP is pressed. When STOP is pressed the measurement is interrupted and the displayed values are held; test status changes to **Hold**. The TEST lamp flashes to show that the measurement is held; pressing STOP again restarts the measurement and turns the TEST lamp off. STOP can be used with the instrument set to any view. Thus it can be used to “freeze” the values in the Power Meter view or the histogram or tabular displays of the Harmonics view; STOP does not, however, hold the Waveform Graph view.

Manual: The test is manually controlled by the START and STOP keys. With the edit zone moved into the **Load Power** field there is now the option to have the load power **Always On** or just on **During Test.** With **Always On** selected, when the test is started with the START key the **Test status** field changes to show **Running** and **Elapsed time**; the time is taken from the internal real-time clock and is given in hours, minutes and seconds. The TEST lamp lights when 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 32767 seconds. With the edit zone moved into the **Load Power** field there is again the option to have the load power **Always On** or just on **During Test**, as described for **Manual** above. When **Timed** is selected the **Test status** field changes to show **Awaiting START**. Pressing the START key starts the test; the

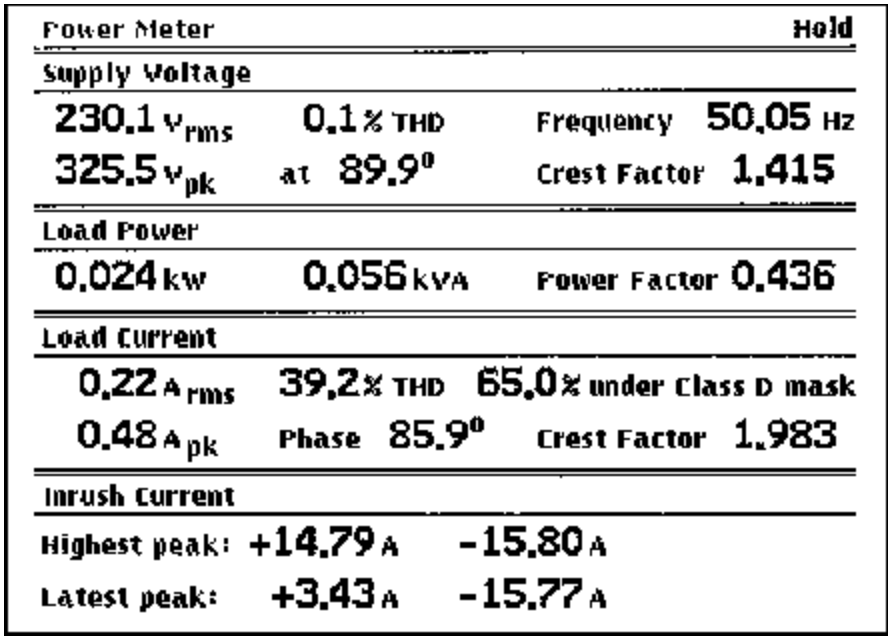
TEST lamp lights and the test status changes to show **Running** and **Elapsed time** in hours, minutes and seconds. At the end of the timed period (or before if the STOP key is pressed) the test status changes to **completed** and the TEST lamp flashes. Pressing STOP at this point erases the elapsed time, arming the timer for the next test; test status to **Awaiting START** again.

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

Note that for **Manual** or **Timed** measurements where the load power has been selected to be on only **During Test** the analyser will capture (as Min Hold and Max Hold values) any exceptional harmonics that occur when power is first applied. Since IEC1000-3-2 allows such transitory harmonics occurring in the first 10 seconds to be disregarded (section 6.2.2a) 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.

Inrush Current Measurement

With the edit zone in the **Operating Mode** field of the Test Control Set-up screen, the alternative to harmonics measurement is **Inrush Current**. Selecting **Inrush Current** blanks the rest of the Test Control Set-up screen (there are no further selection options); the only other change is to the Power Meter view which now shows Inrush Current instead of Harmonics Summary at the bottom of the screen.



Inrush current measurements are made by switching the load on and off with either the load's own switch or the front panel LOAD switch. With the LOAD switch OFF, **Latest Peak:** is reset to zero; with the LOAD switch ON, the peak inrush current is measured and displayed in the **Latest peak:** field. The **Highest Peak:** field shows the maximum inrush current measured since the maximum hold accumulator was last reset with the START key; whenever a new measurement exceeds the previously stored maximum it will appear in the **Highest Peak:** as well as the **Latest Peak:** field. Together the fields therefore show the peak current from the latest switch-on (using the LOAD switch) and the highest peak from all switch-ons since the maximum hold accumulator was last reset with the START key.

The Waveform Graph view can be used to view the inrush current if it is set to Max Hold mode on the Set-up screen, see the Mode section of Waveform Graph Set-up. The waveform displayed in

Max Hold mode will correspond to the Highest Peak of the inrush current shown on the Power Meter view; The Max Hold waveform is also reset when the START key is pressed.

When Inrush Current mode is selected the instrument defaults to the 400A peak measurement range to ensure that the peak current is always within measurement range. The measurement sensitivity can be increased by selecting **Setup Range** on the Waveform Graph Set-up screen and using the **Up** and **Down** soft-keys; see Setup Range section of Waveform Graph Set-up. At each range setting the inrush current waveform should be viewed in Max Hold mode on the Waveform Graph view; the load should be switched on and off several times to ensure that the current waveform remains within range. Since the measurement ranges change in 2:1 steps, the optimum display resolution is achieved with the waveform amplitudes at or above half full-scale.

The current waveform can also be viewed in the Accumulate mode, see Mode section of Waveform Graph Set-up The Accumulate mode can be reset at any time by pressing the VIEW key twice. Optimum display resolution is set as described above.

Note that 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 is well below optimum.

Report View

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

Two types of report – steady-state Harmonics and Fluctuating Harmonics – can be selected on the Report Set-up screen; the Report view is a partial preview of the user-entered text that appears with the tables of results on both these reports.

The top line of the Report view shows the time and date (from the internal clock) as it will appear on the report.

The next 4 lines are nominally titled Header, Title 1, Title 2 and Title 3 and will be printed out at the top of the report. Each allows up to 80 characters of free text to be entered as described in the Report Set-up section. Below this is a further line of text, the footer, which will be printed at the bottom of the report; again, up to 80 characters of free text can be entered.

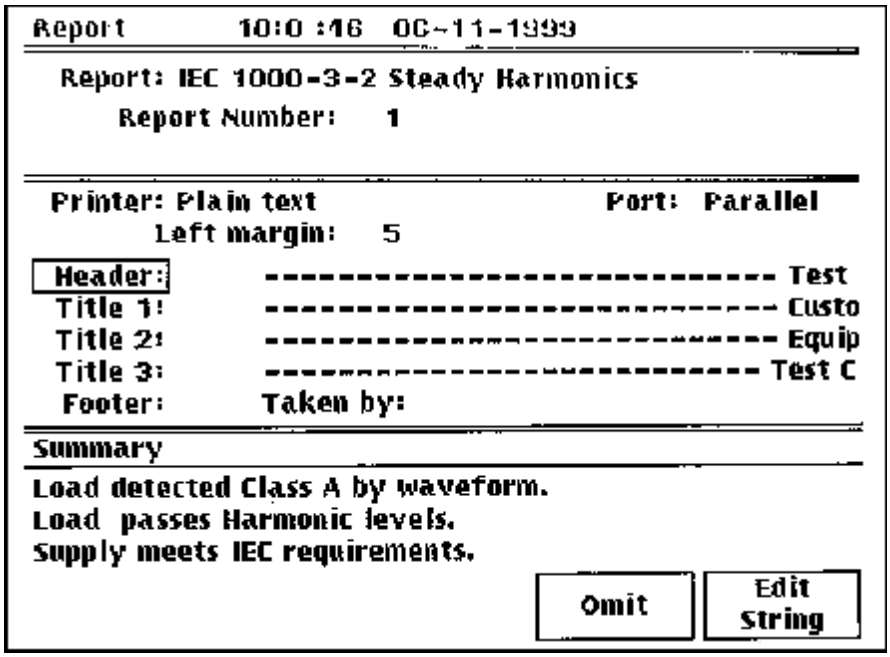
Next is the report type, as selected on the Report Set-up display; the options are Steady-state Harmonics and Fluctuating harmonics. The Report Number increments automatically every time a report is printed or can be set by the user from the set-up screen.

Lastly there is a Harmonic Summary exactly as it appears in the Power Meter view.

A report can be printed by pressing ENTER. If a printer is connected and switched on the status line will show **Spooling** while the data is sent to the printer; after a few seconds printing will start and control will return to the keyboard.

Report Set-up

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



The functions of the soft-keys change as the edit zone is moved through the editable fields of the display using the 5 6 keys; each field is described below. Pressing the VIEW key returns the display to the Report view.

Report Type

With the edit zone in the **`Report`** field the soft-key choices are **`Steady Harmonics`** and **`Fluctuating Harmonics.`** As the names suggest, one is optimised for steady-state harmonics and the other for fluctuating harmonics.

Selecting **`Steady Harmonics`** gives a report with the following columns.

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

Selecting **Fluctuating Harmonics** gives a report with the following columns. Note that all values used have been processed by a 1st order filter with a 1.5s time constant.

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

Report 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.

If no number is entered the number is automatically incremented after each report is printed, starting from the last number entered or 1 if the number has been reset by switching the instrument off then on again.

Printer Selection

With the edit zone in the **Printer** field the printer type can be selected; currently only plain text is supported. All printers capable of accepting 7-bit ASCII can be used; the printer will print in whatever font it has been set to.

With the edit zone in the **Printer** field the **Reset Spooler** soft-key is shown. If printing has been attempted before the printer has been switched on there is the possibility of a 'lock-up' between the instrument and the printer; pressing **Reset Spooler** resets the communication.

Port Selection

The report data can be output to either the **Parallel** (Centronics) port or the **Serial** port by selecting the appropriate interface when the edit zone is in the **Port** field; the default is **Parallel.**

Left Margin

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

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

Header and Title 1 to 3

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

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

To delete the header or a title altogether move the edit zone to that field and press the **Omit** soft-key; the title will be deleted from the display and a **X** will be shown against the parameter. To reinstate the title press the **Include** soft-key which has now replaced **Omit** in the display; the soft-key toggles between **Omit** and **Include** with alternate presses. The overall report is shortened by a line for each header/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.

Exit Set-up mode by pressing VIEW.

Footer

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

Compliance Measurements with the AC2000

This chapter briefly summarises the EMC legislation applying to mains harmonics, the measuring equipment requirements specified by the international standards and the implementation of these requirements in the AC2000 power and harmonics analyser.

General Considerations

Since its publication in 1995, IEC1000-3-2 (Limits for harmonic current emissions (equipment input current ≤_16A per phase)) has been a contentious standard with apparent ambiguities concerning measurement requirements and uncertainties over date of implementation. Nevertheless it is an essential document which should be read, together with IEC1000-4-7 (1993) (General guide on harmonics and interharmonics measurements and instrumentation), before any compliance quality measurements are attempted. In particular, IEC1000-3-2 should be used to determine the Class (for harmonic current purposes) of the equipment under test; this in turn determines the way in which AC2000 should be set up.

The requirements of the standard will become mandatory from 1 January 2001 (but can be applied now) yet there are still disagreements over the 'correct' or 'best' method for some measurements, particularly for fluctuating harmonics. This was demonstrated by the wide variation in results recorded by members of the EMC Test Labs Association who measured the same device with fluctuating harmonics in the Autumn of 1999. However, the best advise is still to consult such a test house (or other Competent Body) should there be doubts as to how the equipment under test should be treated. In many cases, this will not be necessary because the requirements for testing a particular class of equipment are clearly stated in the standard and their implementation in the AC2000 clearly defined. However, where there are ambiguities because different interpretations of the standard are possible, or where further changes are made to the standard, it may be appropriate to refer to a test house and/or to the following section which summarises the key requirements of the standard and how the AC2000 implements them.

The firmware of the AC2000 is stored in FLASH memory and can be updated via the RS232 port. Future changes to the standard may require firmware changes to the instrument beyond the measurement choices currently offered and it is the intention to make such upgrades available from the Laplace website. To access these upgrades you need to join the Laplace Users group, entry is via the www.laplaceinstruments.com website.

Implementation of the Key Requirements of IEC1000-3-2

Annexes A and B of IEC1000-3-2 define the 'Measurement Circuit and Supply Source' and 'Requirements for Measurement Equipment' respectively. The requirements of these sections are summarised briefly below, together with their implementation in the AC2000; for completeness this section is best read with those Annexes.

The AC2000 is one of the most powerful power and harmonics analysers on the market. It's dual 16-bit A to D converter samples both voltage and current waveforms at a rate of 300 points per mains cycle; all harmonics are computed every 4 mains cycle using an efficient Discrete Fourier Transform (DFT) and the instrument's displays are updated as described in the relevant sections of this manual. Because the AC2000 has such ample processing power it implements some of the standards implied requirements in the most straightforward way; for example, the supply source is simultaneously and continuously monitored. However, wherever this might be contentious the user has the option to use the instrument in a way determined by alternative interpretations of the standard, e.g. a predetermined 'rated' power can be set for Class D instead of the default instantaneous power which the AC2000 is capable of measuring.

Annex A : Measurement and Circuit Supply Source

The requirements of this annex are not a requirement of the analyser itself but must be met if compliance quality measurements are to be made. The AC supply from a normal wall socket will invariably be 'flat-topped' and have harmonic distortion significantly outside the limits of the annex; it is easy to demonstrate that a device which is a Class A pass with a 'flat-topped' supply can become a clear Class D failure with a compliant source. It is essential, therefore, to use a compliant source; for equipments rated up to 1kW the Laplace AC1000 Low Distortion Source is a cost effective solution.

The usual interpretation of this annex is that the supply source should be compliant throughout the test. There is no stated requirement that the supply source **should** be continuously monitored but that is the most straightforward implementation and that is what the AC2000 does. Further details can be found in the Power Meter View and Test Control Set-up sections.

Annex B : Requirements for Measurement Equipment

Sections B.1, B.2 and B.4 are applicable to the DFT implementation used in the AC2000. The key requirements are as follows:

Measurement Error (B.2a): The total measurement error for steady-state harmonics shall not exceed 0.2% of the rated current or 5% of the permissible limit; the AC2000 meets this requirement, see Specification section. Note that section 6.2 of the standard requires that harmonics less than 0.6% of the input current, or less than 5mA (whichever is the greater) be disregarded.

Input Impedance (B.2b): The voltage drop due to the input current of the test equipment should not exceed 0.15V peak. In the AC2000 the current shunt resistance is <3mΩ, i.e. the 0.15V peak limit is not exceeded for input currents up to 50A peak.

Measurement Filter (B.2c): Measurements of fluctuating harmonics should be made with a 1st order low-pass filter having a 1.5s time constant. The AC2000 implements this filter and provides the capability for both filtered and unfiltered measurements, see Harmonics Set-up section.

Measurement Window (B.4): The AC2000 uses a 4-cycle Rectangular window with no gap and no overlapping between successive windows which meets the requirements of both B.4.1 (steady-state harmonics) and B.4.2 (fluctuation harmonics). The sampling rate is synchronised to the fundamental (f1) frequency (of the voltage waveform) to an accuracy of better than 0.03% of f1 by as required by B.4.1.b.

Other Stated or Interpreted Requirements

The following is a summary of some of the other measurement requirements and the interpretations used in the AC2000; in some cases there are measurement options to cater for alternative interpretations of the standard. Further details are given in the appropriate sections elsewhere in this manual.

Special Waveshape for Class D: The special waveshape to classify equipment as Class D (section 5 of IEC1000-3-2), referred to elsewhere in this manual as the 'Class D envelope', is determined as follows in the AC2000. The amplitudes of the envelopes for the two ½-cycle's are determined independently. The centre-point in time of each ½-cycle's envelope is the **average** of the times of the two peaks; the envelopes for each ½-cycle therefore touch but do not overlap.

Class D Limits: The limits for Class D are defined in terms of mA per Watt at the 'rated load condition' (section 7.4 and Table 3 of IEC1000-3-2). The AC2000 calculates the 'instantaneous' power every 4-cycle transform and the default condition is to use this value to calculate the Class D limits in real-time. However, to cater for other interpretations of 'rated load condition', the AC2000 allows the user to use a previously measured value, or to declare a value, as the basis for calculating Class D limits, see Test Control Set-up section.

Automatic Class A / Class D Assessment: The default class assessment is auto-detect Class A or D; in this mode the 'instantaneous' measured power is used on the basis of limits and a minimum power (default 75W) and Class D to A crossover power (default 600W) can be specified to cater

for both present and future Class limits, see Test Control Set-up section. Note that in marginal cases it is always wise to investigate the equipment to both Class A and Class D limits by setting these in turn on the analyser.

Class D Minimum Power: For Class D loads (whether declared or auto-detected) no limits are applied when the load power is below the Class D minimum power (default 75W) set on the Test Control Set-up screen.

Fluctuating Harmonics: Section 6.2.2. defines the limits for 'transitory harmonic currents'. 6.2.2.a. requires that transients in the first 10 seconds after switch-on be disregarded; this is left for the user to time. 6.2.2.b. sets limits of 1.5x the steady-state limits for certain specified harmonics; these are the limits used in the Fluctuation Table, Fluctuation Map and Time Chart, see Harmonics Set-up section. Note that for Class B equipment, whose limits are 1.5x the Class A limits, the fluctuation limits are 1.5 x 1.5 x Class A limits. Note also that each harmonic is assessed **individually** as to whether it has been within the 1x and 1.5x limit for up to 10% of any 150ms period; this is what the Fluctuation map shows graphically.

The 1st order filter with a 1.5s time constant is always employed when assessing fluctuating harmonics, in accordance with Annex B.2.c.

Making Compliance Measurements

The AC2000 has a set of default conditions which permit the untrained user to quickly make useful measurements. However, compliance quality measurements require considerably more planning and care if they are to be fully valid for self-certification. The following is a summary list of do's and don'ts.

Read and understand IEC1000-3-2. This document is the prime source of information on how to test a particular piece of equipment and what limits apply.

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.

Consult an EMC test house if there is doubt over the equipment classification, etc.

Always use an AC source that meets the supply quality requirements, even for pre-compliance measurements. Without such a source results can be seriously misleading.

Use the 'real-time' capability of the AC2000 to observe dynamically the performance of the equipment under test as operating conditions are varied or as the operating cycle proceeds. Initially use the instrument in the default auto-range mode, perhaps using the histogram view to give the best overall assessment of performance against the limits as conditions are varied. Choose the conditions that generate the worse-case harmonic levels (for **each** harmonic if the conditions vary widely) as required by Annex C of IEC1000-3-2 and lock the range. Decide whether to test to steady-state or fluctuating harmonics limits.

For equipment which may be Class A or may be Class D investigate initially in auto-detect Class A or Class D and determine the classification; set Class A and/or Class D and re-test in marginal cases.

Make final tests with the instrument range **locked** to the highest one that it auto-ranged to during pre-test. Specify the equipment class and set other options and limits as appropriate.

Keep an archive copy of the results and assessment using either the Report facility (for a direct printout) or the optional PC software.

Use common sense. Inset the limits a little to give confidence that specifications will continue to be met from equipment to equipment and under all operating conditions. The Test Control Set-up can be used to universally set an inset on all limits.

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.

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

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

Calibration

Calibration is guaranteed as in the specification. The manufacturer provides a re-calibration service. 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 manufacturer or their agents overseas.

Fuse - Instrument Power

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

Fuse - Load Power

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

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

Software Updates

The AC2000 software is held in Flash memory and can be upgraded in the field via its RS232 interface.

From time to time software updates will be available on the Laplace website (www.laplaceinstruments.com) via the user group. Application to join the user group must be made to Laplace Instruments via e-mail. The download will include the utility which is run on the PC to update the AC2000 software via its RS232 port.

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.