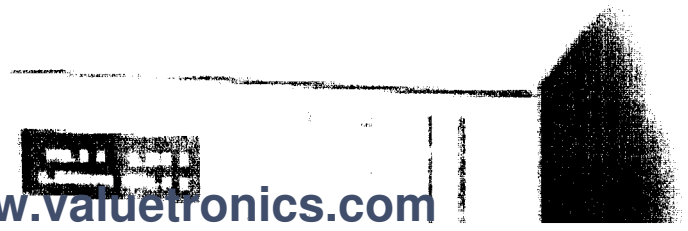
PM3000A
Power Analyser
User Manual



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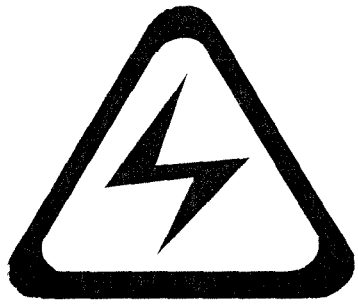
HEALTH AND SAFETY AT WORK

Electrical devices can constitute a safety hazard. It is the responsibility of the user to ensure the compliance of the installation with any local acts or bylaws in force. Only qualified personnel should install this equipment, after reading and understanding this users guide. These operating instructions should be adhered to. If in any doubt, consult your supplier.



DANGER

ELECTRIC SHOCK RISK

Please note:

This equipment is supplied under warranty conditions, in force at the time of purchase from your supplier. Contact your supplier for details. Any attempt to disassemble or modify the unit will render any warranty agreement invalid.

The contents of this guide are believed to be accurate at the time of printing. The manufacturers, however, reserve the right to change the content, product specification, and performance criteria, without notice. No liability is accepted for the inappropriate, negligent, or incorrect set-up of the instrument by the user, either by manual or automated means.

SAFETY PRECAUTIONS

1. The PM3000A is constructed in compliance with the requirements of EN61010-1, Pollution Degree 2, Installation Category II, and as such ensures the safety of the meter and the user when normal precautions are followed.

2. The power source should be inserted in a socket with a protective ground contact.

3. The power source should be inserted before connections are made to measuring or control circuits.

4. Do not attempt to remove outer cover without first disconnecting auxiliary and test power supply.

5. This instrument must only be serviced by qualified personnel who understand the danger of shock hazards.

6. When the instrument is removed from its case hazardous voltages are present.

7. The electronic circuitry of this instrument is fully floating with respect to ground. If the instrument is opened and dangerous voltages (above 50V peak) applied to the input terminals then all the circuitry must be considered 'Live'.

8. The signal leads must be in good condition with no damage.

LIST OF SECTIONS

See also INDEX TO FUNCTION KEYS

SECTION 4 IEEE COMMUNICATION

SECTION 5 CALIBRATION

SECTION 6 EMC COMPLIANCE

ALPHABETICAL INDEX

INDEX TO FUNCTION KEYS

See also ALPHABETICAL INDEX after section 6

SECTION 1

GENERAL DESCRIPTION

1.1 EQUIPMENT CHECK LIST

The following items comprise a complete instrument:

6 off	red test leads
6 off	black test leads
6 off	red crocodile clips
6 off	black crocodile clips
1 off	power lead

1.2 ACCESSORIES

Current Transformer 1000/100:1	(CT1000)
1000:1 Current Clamp Transformer	(CL1000)
100:1 Current Clamp Transformer	(CL100)
Parallel Printer Cable	(VPN 77-001)
Serial Cable 25pin to 9 pin connectors	(77-002)
Test Probe Kit	(VPN 78-024)

1.3 INTRODUCTION: SIGNAL PROCESSING

Referring to block diagram.

The PM3000A has 6 isolated input channels (3 voltage - 3 current) with 12 ranges per channel. Each channel has its own A/D converter which samples the input and sends the digital data back to a microprocessor using a pulse transformer link. This technique allows the PM3000A extremely high common mode rejection, minimising the effects caused by high dv/dt waveforms such as exist in motor drives etc.

The sampling is under the direct control of the processor and the analogue to digital conversion for all channels is simultaneous (no phasing errors). The normal measurement procedure is as follows. (Note that inrush and data log measurements have separate routines).

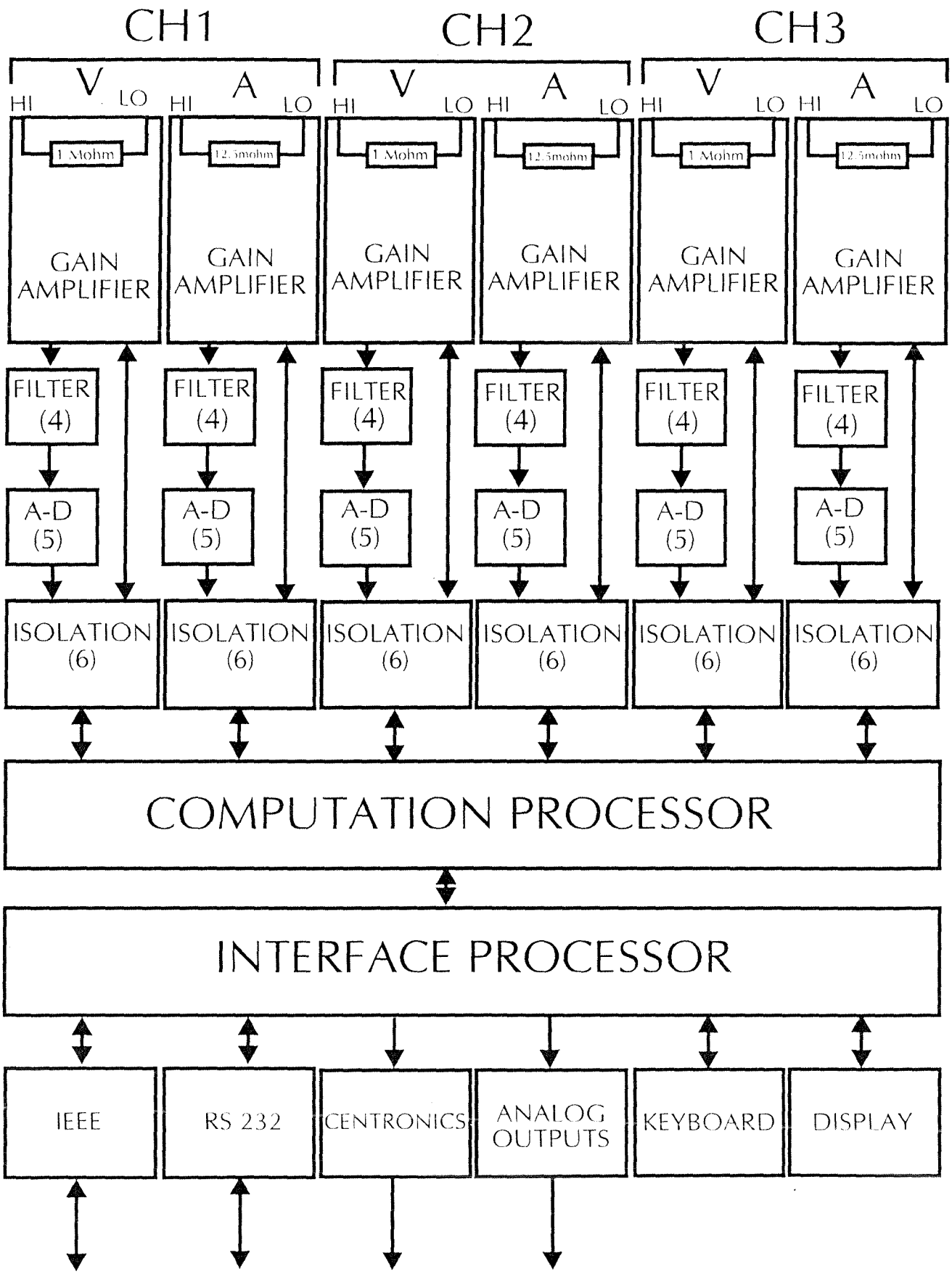
All channels are sampled at a sample rate set by the microprocessor. The data is stored in memory until 400 samples for each channel have been made. The data is then checked for over-range or under range. If the range is correct the frequency of the input is calculated. If the sample rate is not right for the input frequency the sample rate is adjusted and 400 new samples are taken.

The digital signal processor then calculates the volts, amps and watts etc. for each channel and then performs a Fourier analysis of the data to compute the fundamental components of the volts and amps and any other harmonics required.

This data is then transferred to the interface processor and another set of samples are taken.

The interface processor averages and displays the results required for the front panel display. Further to this all the results for every phase are computed and averaged and stored in memory. These background results are available to the printer and the IEEE, and RS232 interfaces.

The user can select over 400 different measurements from this store making the PM3000A an extremely versatile instrument.



PM3000A BLOCK SCHEMATIC

SECTION 2

SPECIFICATION

NOTE: All stated accuracies are based upon a minimum AVERAGING DEPTH setting of 8. The default on power-up is 16.

2.1 VOLTAGE (V)

Range (Auto or Manual)		0.5V to 2000Vpk
(12 ranges 1-2-5 sequence)		(1400V rms)
Scaling Factors		0.001 to 99999
Computation		True rms or rectified mean
Crest Factor		Up to 20
Frequency Range		DC and 0.1Hz to 500KHz
Accuracy 23° ± 5°C	45Hz - 450Hz and DC	±0.05% rdg ±0.05% range ± 20mV
0.2V - 1000Vrms	0.1Hz-500kHz	±0.1% rdg ±0.05% range ±0.02%/kHz ±20mV
Effect of Common Mode Voltage	1000Vrms 60Hz	Less than 20mV
PM3000A and 001	100Vrms 100kHz	Less than 500mV
PM3000A-002	100Vrms 100kHz	Less than 1V
Maximum Input	Continuous	2000Vpk
	1 second	5000Vpk
Input Impedance		1 Mohm in parallel with 100pF on all ranges

2.2 CURRENT (A)

Range (auto or Manual)	INT	0.05A to 200Apk
(12 ranges 1-2-5 sequence)		(30A rms)
	EXT	6.25mV to 2.5Vpk (1.5Vrms)
Scaling Factor	INT	0.00001 to 99999
	EXT	0.8uA/mV to 8000A/mV
Computation		True rms or rectified mean
Crest Factor		Up to 20
Frequency Range		DC and 0.1Hz to 500kHz
Accuracy 23° ± 5°C	45 - 450Hz	±0.05% rdg ±0.05% range ± 1mA
20mA to 30Arms	DC	±0.05% rdg ±0.05% range ± 3mA*
	0.1Hz-500kHz	±0.1% rdg ±0.05% range ±0.04%/kHz ±1mA
PM3000A-002	45 - 450Hz	±0.05% rdg ±0.05% range ± 1mA
80mA to 30Arms	DC	±0.05% rdg ±0.05% range ± 9mA*
	0.1Hz-500kHz	±0.1% rdg ±0.05% range ±0.08%/kHz ±1mA
Effect of Common	1000Vrms 60Hz	Less than 2mA rms
Mode Voltage	100Vrms 100kHz	Less than 20mA rms
Maximum Input	Continuous	30Arms (must be limited by external devices)
	1 second	200Arms
Input Impedance	INT	12.5 mohms on all ranges
	INT (PM3000A-002)	3.5 mohms on all ranges
	EXT	1 Mohm in parallel with 10pF on all ranges
	EXT (PM3000A-002)	20kΩ in parallel with 10pF on all ranges

* Specification using auto-zero. User may also perform a manual zero to cancel offset. Refer to section 3.11.17.

2.3 POWER (W)

Ranges (auto or manual)	25mW to 400kW pk
(144 ranges corresponding to V & A)	(with scaling to 100,000MW)
Accuracy(23±5°C, sinewave)	
45Hz to 450Hz	± Current reading x voltage deviation ± Voltage reading x current deviation ± (0.06/PF)% ± 1mW
0.1Hz to 500kHz	
PM3000A and 001	± Current reading x voltage deviation ± Voltage reading x current deviation ± (0.06/PF)%/kHz ± 1mW
PM3000A-002	± Current reading x voltage deviation ± Voltage reading x current deviation ± (0.1/PF)%/kHz ± 1mW
Polarity	+ = Positive powerflow – = Negative powerflow

2.4 APPARENT POWER (VA)

Ranges (auto or manual)	25mVA to 400kVA pk
(144 ranges corresponding to V & A)	(with scaling to 100,000MVA)
Accuracy(23±5°C, sinewave)	
45Hz to 450Hz	± Current reading x voltage deviation ± Voltage reading x current deviation ± (0.06/PF)% ± 1mVA
0.1Hz to 500kHz	
PM3000A and 001	± Current reading x voltage deviation ± Voltage reading x current deviation ± (0.06/PF)%/kHz ± 1mVA
PM3000A-002	± Current reading x voltage deviation ± Voltage reading x current deviation ± (0.1/PF)%/kHz ± 1mVA

2.5 REACTIVE POWER (VAR)

Ranges (auto or manual)	25mVAr to 400kVArpk
(144 ranges corresponding to V&A)	(with scaling to 100,000MVAr)
Accuracy(23±5°C, sinewave)	
45Hz to 450Hz	± Current reading x voltage deviation ± Voltage reading x current deviation ± $[0.06/(1-PF^2)^{0.5}]$ ± 1mVAr
0.1Hz to 500kHz	
PM3000A and 001	± Current reading x voltage deviation ± Voltage reading x current deviation ± $[0.06/(1-PF^2)^{0.5}]$%/kHz ± 1mVAr
PM3000A-002	± Current reading x voltage deviation ± Voltage reading x current deviation ± $[0.1/(1-PF^2)^{0.5}]$%/kHz ± 1mVAr
Polarity	+ = Inductive load – = Capacitative load

2.6 POWER FACTOR (PF)

Range	±0.000 to ±1.000
Accuracy 23° ± 5°C	±0.002 ±(0.001÷PF)/kHz
Polarity	+ = Leading – = Lagging

2.7 CREST FACTOR (CF)

Range	1.000 to 19.999
Basic Accuracy	
Voltage Crest Factor	± 0.1% reading ± (0.05/range) ± 0.02
Current Crest Factor	± 0.1% reading ± (0.01/range) ± 0.01

2.8 INRUSH CURRENT

Range	0.1A to 200Apk (with scaling to 20 MA)
Accuracy	2% of selected range
Sampling Interval	1Ø2wire 3.6 µS 1Ø3wire/3Ø3wire 6.8 µS 3Ø4wire 10 µS

2.9 IMPEDANCE

Range	0.0001 ohms to 9.999 Mohms
Accuracy 23° ± 5°C	45 - 450Hz ±0.5% rdg 0.1Hz-500kHz ±0.5% ± (0.05÷PF)%/kHz

2.10 FREQUENCY

Range	Int Source 5Hz to 1MHz Ext Source 0.1Hz to 1MHz
Accuracy 23° ± 5°C	±0.1%

2.11 HARMONIC ANALYSIS

Range	DC fundamental to 99th harmonic for voltage and current. Max Harmonic = 1MHz
Accuracy 23° ± 5°C	
Fundamental	±0.1% rdg ± 0.1% range ± 0.02%/kHz ±20mV (voltage)
PM3000A and 001 20mA - 30Arms.	± 0.04%/kHz ±1mA (current)
PM3000A-002 80mA - 30Arms.	± 0.08%/kHz ±1mA (current)
Harmonics	± (0.1 ± 0.05/kHz)% of fundamental
THD	± (0.2 ± 0.01/kHz) %; Harmonic series (dc excluded)

2.12 INTEGRATOR

Range	0.001 Whr to 100,000MWhr
Integration Interval	1 second
Elapsed time display	7 digit, floating decimal point

2.13 BANDWIDTH FILTER

Unfiltered bandwidth DC - 500kHz

A default low bandpass filter is applied at power-up. The filter response is flat to the specified cut-off frequency, and thereafter zero. It is deselected using F[2].

Filtered bandwidth:

PM3000A and PM3000A - 001	DC-25kHz (specified accuracies achieved to 12.5kHz)
PM3000A - 002	DC-5kHz (specified accuracies achieved to 2.5kHz)

2.14 ANALOGUE OUTPUTS

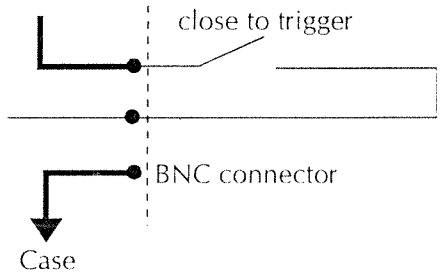
Functions	Volts, Amps and Neutral.
No. of Outputs	8
Output levels	0 to + 5V; 5mA max

2.15 EXTERNAL FREQUENCY SOURCE

Input	4 - 20Vpk to pk 0.1Hz - 1MHz 10 kΩ input impedance Negative inputs see a reverse diode (very high) impedance.

2.16 EXTERNAL INTEGRATOR INPUT (DATALOG TRIG)

Closed switch to pass 5mA.



2.17 OPERATING TEMPERATURE AND HUMIDITY

10 - 80% RH non condensing
5° - 40°C

2.18 DIELECTRIC STRENGTH

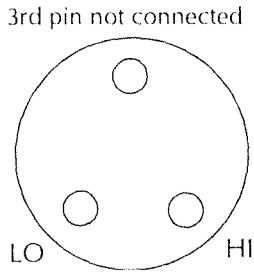
V & I Inputs - case	4kV AC 50/60Hz for 1 minute
V & I Inputs - power supply	4kV AC 50/60Hz for 1 minute
V Input - I input	2kV AC 50/60 Hz for 1 minute
Power supply - case	2.9 kV DC for 1 minute

2.19 POWER SOURCE

AC Input voltage	100 -220V ± 20% (48 -440Hz)
Protection	Fuse 20mm 1AT
Consumption	30W, 50VA max

2.20 EXTERNAL SHUNT INPUT

3 pin DIN connector



2.21 AUXILIARY INPUTS A AND B (TORQUE AND SPEED): PM3000A-001 ONLY*

Pulse		
	External Frequency Input	0.5Hz - 1kHz
	High Frequency	100 Hz - 1MHz
Input		0 - 1V DC 0 - 10V DC (software selectable)
Type		BNC rear panel connector
Accuracy		0.5% reading ± 0.5% range
Input Impedance		20kΩ in the normal operating range.

* This specification is valid only when inputs are used in PWM Motor Drive Mode.

2.21 WARRANTY

This product is warranted against defect in materials and workmanship for a period of one year from date of shipment. During warranty period, Voltech Instruments will, at its option, either repair or replace products which prove to be defective.

For repair services under warranty, the instrument must be returned to a service centre designated by Voltech. Purchaser shall pre-pay shipment charges to service centre and Voltech will pay shipment charges to return instrument to purchaser.

Limitation of Warranty

The foregoing warranty shall not apply to defects resulting from unauthorised modification or misuse, or operation outside specification of instrument. No other warranty is expressed or implied.

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SECTION 3

OPERATION

IMPORTANT NOTE

The PM3000A is a high bandwidth (500kHz) instrument. It is fitted with a low bandpass filter (25kHz) for low frequency applications, normally applied on power-up. Its response is flat to 25kHz and then zero. To select high bandwidth, configure F[2] (see section 3.11.17).

Version PM3000A-002 has a 5kHz filter (in place of 25kHz filter) to meet IEC555 requirements. It provides specified accuracy up to 2.5kHz. Apply the filter for IEC555 mode, and low frequency power measurements with harmonics below 2.5kHz. For higher frequencies, deselect the filter.

3.1 Power On

The instrument is supplied with power lead to suit the local electricity supply. In some cases a power plug will need to be fitted: connect brown wire to phase or live pin; blue wire to neutral pin and green/yellow wire to ground/earth pin. On no account should the instrument be used without the safety ground connection being made.

Depress the power switch and observe the display. It will briefly show the software version number. Then all LED indicators will be briefly illuminated. If the instrument is new, it will not contain any previously defined user programs and the display will show

0.000V 0.000A
WATTS = +0.000W

As will be described later, the display parameters may be altered to suit the users requirements. (see section 3.11.5)

3.2 Control Features

The PM3000A incorporates powerful advanced control features, and its front panel is designed such that functionally related keys are logically grouped together thus simplifying operation. Each of these function will now be described. Function in square brackets refer to a key operation e.g. [STOP] means press stop key.

3.3 Basic Measurement Functions and the HOLD Function

This group of 12 keys allows the user to select the required measurement function. Press any of the select keys to choose a particular function. The one you have chosen will appear in the second line of the display. Its value is shown to 4 or 4½ digits depending on the function selected.

A useful feature of the PM3000A is its DISPLAY HOLD function (see section 3.11.16). By pressing the [ENTER] key, when not entering data, the display freezes with the current values. Then, by pressing other function keys, e.g. VArs, the display will present the simultaneous frozen value of that parameter. By pressing a channel key, simultaneous frozen values for the appropriate channel are displayed. Pressing the [ENTER] key again unfreezes the display.

3.3.1 [W] True Power

Measures accurately the power absorbed by a load or delivered from an AC source, even with distorted waveforms. The instrument is (AC + DC) coupled (see section 3.4.4) and therefore measures the total real power.

Connect the PM3000A as shown in appropriate connection diagram (see section 3.7) and select [W]. The instrument is fully autoranging and the display will show the actual power in watts. The polarity indicates the direction of power flow.

Real power is computed as:

$$\text{Total watts} = \left[\frac{1}{2\pi}\int_0^{2\pi}(v \times i)dt\right]$$

v and i represent instantaneous volts and amps

The polarity of Watts, VArs (fundamental) and PF (fundamental) are given in the table below. The displacement angle is the angle of the current fundamental with reference to the voltage fundamental.

	0°	-90°	-180°	-270°	-360°
W	+	-	-	+	
PF	-	-	+	+	
VArs	+	+	-	-	

For Watts: + indicates positive power flow.
- indicates negative power flow.

3.3.2 [VA] Apparent Power

Determines the apparent power absorbed by a load or delivered from a source. Connect the instrument as for power measurements and select [VA]. The apparent power is computed as VA = Vrms x Arms and displayed in volt-amperes and is calculated.

$$VA = \left[V_{rms} \times A_{rms} \right]$$

3.3.3 [VAR] - Reactive Power (volt-amperes)

The PM3000A computes and displays the reactive power flow due to the phase difference between the current and voltage waveforms and due to wave form distortion.
VAr is computed as:

$$\text{VAr} = \left[\text{VA}^2 - \text{Watts}^2 \right]^{\frac{1}{2}}$$

The polarity of the (fundamental) VArs is shown in the table in section 3.3.1. for various angles between current and voltage.

For VArs: + indicates an inductive load
- indicates a capacitive load

3.3.4 [V] Voltage

Used in conjunction with SETUP keys to display true RMS or MEAN value of the input voltage, even with distorted waveforms. The input is (AC + DC) coupled, (see section 3.4.4) and the instrument will record the RMS or MEAN value of the combined AC and DC components. Only the voltage input leads need be connected for Vrms measurements. Vrms is computed as:

$$V_{rms} = \left[\frac{1}{2} \int_0^2 v^2 dt \right]^{\frac{1}{2}}$$

and Vmean is computed as:

$$V_{mean} = \frac{1}{2} \int_0^2 |v| \, dt$$

3.3.5 [A] Current

Used in conjunction with SETUP keys to display the true or mean values of the load current irrespective of waveform. As for Vrms, the input is (AC + DC) coupled, and displays the total RMS value.
Only the current input need be connected when taking Arms measurements. Arms is computed as:

$$A_{rms} = \left[\frac{1}{2} \int_0^2 i^2 dt \right]^{\frac{1}{2}}$$

$$A_{mean} = \frac{1}{2} \int_0^2 |i| \, dt$$

3.3.6 [PF] Power Factor

Displays the true power factor of an AC load. Power factor is not cos ø except for undistorted waveforms; cos ø is merely the displacement factor of the load, a measure of the phase shift between the voltage and current waveforms. Power factor is computed as:

$$PF = \left[\frac{Watt}{V_{rms} \times A_{rms}} \right]$$

If the current waveform is distorted, the fundamental components of the voltage and current may well be in phase, with cos Ø = 1, but the true power factor will be less than unity. The PM3000A computes the ratio W/VA, which is the true power factor even for distorted waveforms.

The polarity of the (fundamental) power factor is given in the table of section 3.3.1 for various angles between current and voltage.
For PF: + indicates a leading current
- indicates a lagging current
NB. The polarity of the power factor can be reversed if desired. Refer to FP 190 in section 3.11.17.

3.3.7 [Vpk] Peak Voltage

Displays the repetitive peak value of the applied voltage. Useful for determining the working voltage on insulation or voltage available for rectification.

3.3.8 [Apk] Peak Current

Display repetitive peak current. Used for setting current limit levels in UPS and other power electronic applications.

3.3.9 [Vcf] Voltage Crest Factor

Displays the voltage crest factor. The value of Vcf for a pure sine wave is 1.41. A non-linear load will cause distortion of the input voltage wave form, resulting in a reduction in the value of voltage crest factor. A measurement of voltage crest factor thereby provides a useful indication of the effect of a load on the AC supply. Voltage crest factor is computed as:

$$cf = \left[\frac{V_{pk}}{V_{rms}} \right]$$

Where Vpk is the magnitude of the repetitive peak voltage, irrespective of polarity.

3.3.10 [Acf] Current Crest Factor

Displays the current crest factor. If the load takes a sinusoidal current, Acf = 1.41. Many loads, such as a rectifier with capacitor filter produce a distorted current wave form and Acf will be greater than 1.41. This measurement is useful in determining the repetitive peak current requirement of a power source. For example in a UPS installation the crest factor must be determined to ensure that the system can handle the repetitive peak current without being overloaded.

Current crest factor is computed as:

$$Acf = \left[\frac{A_{pk}}{A_{rms}} \right]$$

Where Apk is the magnitude of the repetitive peak current, irrespective of polarity

3.3.11 [Inrush A] Peak Inrush Current

The [INRUSH A] key allows the user to capture and hold the peak current of all three current channels. This feature is typically used to display the peak inrush current at switch on of power supplies and motors etc.

The measurement is made by sampling continuously on all three current channels and holding the highest value. The sample rate varies according to the wiring configuration.

WIRING SELECTION	SAMPLE RATE
Single phase two wire	3.6 µsec
Single phase three wire	6.8 µsec
Three phase three wire	6.8 µsec
Three phase four wire	10.0 µsec

Inrush current can also be measured using the data log function. This has the advantages of allowing the user to view the captured inrush waveforms and of making other measurements on the same data.

To measure inrush current:

Press the [INRUSH A] key. Select an amps range that is able to accommodate the expected peak inrush current. Switch on the load. The display will show the highest current captured. If the load is multi-phase the inrush current on each phase will have been captured and can be viewed with the [CH1], [CH2] and [CH3] [CHANNEL SELECT] keys.
The highest value captured will be held until the [INRUSH] key is pressed again to reset the display. If an overload occurs the display will not clear until the key is pressed even if the overload is no longer present.

3.3.12 [IMPEDANCE]

The impedance of a load can be measured by pressing the [IMPEDANCE] key and is calculated as

$$z = \pm R \pm jX \text{ ohms}$$

If the `FUND' LED is off the total impedance will be displayed in ohms, calculated as:

$$\frac{\text{Total RMS Volts}}{\text{Total RMS Amps}}$$

If the `FUND' LED is on, the complex impedance due to the fundamental volts and amps will be displayed. This will be in the form of resistance and reactance.

Polarity sign indicates direction of power flow.

viz:
+ R indicates power flow into load
- R indicates power flow from load
+ X indicates inductive reactance
- X indicates capacitive reactance

3.4 Set-Up

The `SETUP' keys control the configuration of the analogue circuitry of the PM3000A. This enables the PM3000A to be used in a wide variety of specialised applications.

3.4.1 [FREQ SOURCE] Frequency Source

The measurements made by the PM3000A are synchronised to the ac supply frequency.

[INT] mode synchronises measurement to input voltage or current, over the frequency range 5Hz to 1MHz. The user can choose voltage or current frequency measurement, which is helpful in applications such as motor drives, where one input may be 'chopped'.
[EXT] mode synchronises measurements to a signal applied to a rear panel connector. It is used when both voltage and current are `chopped' or a frequency down to 0.1Hz is required to be measured.

In order to correctly analyze all the functions available on the PM3000A it is necessary to determine the frequency of the ac input. The frequency source for this measurement may be selected by pressing the [FREQ SOURCE] key.

There are four options. Use the [SELECT] key to display the required option between the cursors and then press [ENTER]:

i. >voltage< CH1 Volts with a frequency range of dc and (5 Hz -1MHz)

ii. >current< CH1 Amps with a frequency range of dc and (5 Hz -1MHz)

iii. >external< Frequency source applied to EXTERNAL FREQUENCY input, with a range of dc and 5Hz-1MHz.

iv. >slow external< Frequency source applied to EXTERNAL FREQUENCY input, with a range 0.1Hz-100Hz. Selecting this mode will give measurement times in excess of 10 seconds for frequencies under 5Hz

The maximum voltage to be applied to the EXTERNAL input is limited to 20 V pk to pk.

If >voltage< is selected, the phase reference source is automatically set as the Voltage Waveform of CH1.

If >current<, >external< or >slow external< have been selected, the display then shows.

PHASE REFERENCE
>voltage<

The user can select >voltage< or >current< as the phase reference source for harmonic analysis.

>voltage< The voltage waveform of CHI is selected as reference.

>Current< The current waveform of CHI is selected as reference.

3.4.2 [VOLTS AMPS] RMS and MEAN

The PM3000A can display voltage and current in either true RMS or rectified MEAN values.

RMS mode is normally selected, as indicated by corresponding LED being illuminated, whereby the PM3000A displays voltage and current measurement as true rms.

In the MEAN mode voltage and current measurements will be displayed in terms of their rectified mean value. Only the volts, amps and amp hours will be affected. All other parameters remain in RMS value. However, when printing results, all values are printed in terms of the RMS values. Corrected rectified mean value (MEAN * 1.11) can be obtained by pressing the [FUND] key and reading the (FUND) MEAN volts and (FUND) MEAN amps. In this case the value is NOT a fundamental component but MEAN X 1.11.

This feature will be useful for comparing the reading of MEAN reading multimeters which work using this principle.

For example a 110 volt rms sinusoidal input would read:

V rms = 110 volts
V mean = 99 volts
V mean (F) = 110 volts

The corrected mean and rms will only give the same values if the input is a pure sine wave.

A 10 volt rms square wave would read:

V rms = 10 volts
V mean = 10 volts
V mean (F) = 11.1 volts

3.4.3 [AVG] Averaging

The PM3000A will average a number of measurements to display a steady reading despite fluctuations at the inputs. The results to be averaged are placed in an averaging store of user defined length. As a new result is made available the contents of the store are moved down one position. The new result is placed at the top of the store and the oldest result in the store is discarded. There are two averaging stores; display and background. The display averaging stores serve to average all the results that are displayed on the front panel, and can average up to 64 measurements. The background averaging stores serve to average results that are required to be output to external interfaces, and can average up to 64 measurements.

AUTO mode: The instrument will average 16 measurements; any substantial change in the input conditions will automatically reset averaging to give a fast response. The averaging depth in AUTO mode, can be set from 1 - 64 using FP38 (See section 3.11.17) for normal wiring modes. For independent wiring modes, use FP58 and FP78 also.

N mode: This allows the user to set the averaging stores to be any length from 1 - 64.

To make a selection, press [AVG]. Use the [SELECT] key to display >auto reset< for AUTO mode, or >fixed< for N mode. Then press [ENTER]. If >fixed< has been selected, next select the depth of averaging from 1 to 64 using the digit entry keys, and press [ENTER].

Pressing the key for the parameter currently displayed on the lower line of the front panel (or the key for the channel already selected) will reset the display averages, but the background averages will not be affected unless the basic mode of operation is changed.

3.4.4 [COUPLING] Input Coupling

AC + DC coupling is normally selected. The PM3000A will compute results due to all components in the input voltage and current waveforms, including the dc and low frequency components. AC coupling configures the instrument to ac couple the input signals. This is useful for examining ripple voltage on rectifier outputs and for the calibration of other instruments that are coupled.

3.4.5 [SHUNT] Shunt Selection

INT mode: is selected for direct measurements of ac and dc currents up to 30A rms, and uses signals from precision internal shunts in the PM3000A. This mode is also used with AC current transformers.
EXT mode: is used when taking current measurements with external high current shunts. DC current transformers, or other devices provide a voltage signal that is proportional to current.

(see section 3.11.3 for setting appropriate scaling factors.)

3.5 Ranging

Each channel has twelve ranges which may be manually selected or auto-ranged to the same degree of sensitivity. In most cases auto ranging will be preferred. In special cases such as inrush current measurements and data logging the range has to be set manually.

The instrument powers up in the autoranging mode as indicated by both AUTO lamps being lit. To select a manual range press the corresponding [AUTO] key(s) and the corresponding LED will be extinguished.

Press the UP / DOWN arrows under the bar LED's to move to the required range.

Each range is marked with the PEAK value, which should be taken into account when manually setting the range. E.g. a sinusoidal voltage of 15 V RMS has a 21.2 volt peak. As this peak will exceed the 20 volt range it will require the 50 volt range. The display will show 'OVERLOAD' if an input is too high for a certain range.

The normal mode of operation for autoranging is that the PM3000A auto ranges to the maximum input of all three channels. If required, the ranging can be made independent for all three channels using FP28 configuration (see section 3.11.17).

3.6 Channel Selection

The channel select push buttons allow the PM3000A to display the measured value in the selected phase or the total for all phases, or where appropriate for the neutral current. Various configurations are possible:

[CH1] Displays the measurement value for phase connected to channel 1

[CH2] Displays the measurement value for phase connected to channel 2

[CH3] Displays the measurement value for phase connected to channel 3. This channel can also be used independently to channels 1 and 2. (see example opposite).

[Σ] Displays the summation (total) value for the multiphase system.

[N] This provides analysis of neutral currents in multiphase systems. Neutral current waveforms are computed by summation of the instantaneous values of the individual phase currents.

In 3φ3W the current measurements presented on the [N] channel are the computed values for the third (unmeasured) phase of the system.

Arms, Amean, Apk and Acf can be displayed. The distortion factor of the neutral current can be measured and harmonic analysis of this current can be performed.

3.7 Wiring

The PM3000A is highly versatile and can be configured to analyze almost any electrical system. The versatility is achieved because all power inputs are ac + dc coupled, and are isolated from each other and from the ground.

The four main wiring modes are:-

[1Ø2W] SINGLE PHASE, TWO WIRE.
Select for single phase loads, two wire distribution system and rectifier output.

[1Ø3W] SINGLE PHASE, THREE WIRE.
Select for three wire single phase distribution systems.

[3Ø3W] THREE PHASE, THREE WIRE.
Select for three phase loads without neutral connection (two wattmeter method). Note that the [N] channel provides computed values of current (Arms, Afund, Acf, Apk, Aharm and Athd) for the third (unmeasured) phase of the system.

[3Ø4W] THREE PHASE, FOUR WIRE.
Select for three phase loads with or without neutral connection (three wattmeter method).

These four wiring modes setup the PM3000A to measure the conventional wiring systems (see section 3.7.2). The PM3000A will enable the appropriate channel(s) and calculate the summation ([Σ] key) values using these channels according to

the wiring mode. The PM3000A will use channel 1 as the frequency source in these modes.

Additional wiring modes can be selected using F[3] function select key (see section 3.11.17). These are outlined below:

Channel 3 Only
This wiring mode allows the connection made to channel 3 to be measured independently of channel 1. This is suited for applications where two different measurements need to be made. For example to measure the input and output of a single phase frequency converter, the input could be connected to channel 1 and the output to channel 3. 'The measurement' will be made accurately as this mode will use channel 3 as the frequency source rather than channel 1 - where the frequency is different.

Channel 2 Only
This wiring mode can be used as CHANNEL 3 ONLY but for connection made to channel 2.

Independent Channel 3
This wiring mode allows simultaneous measurement of a three phase three wire system on CH1 and CH2 and a single phase system on CH3. An example for this mode is measurement of a PWM motor drive where the input can be measured on channels 1 and 2 and the DC bus of the motor drive can be measured using channel 3. The input is measured using channel 1 as the frequency source and the DC bus can be measured totally independent on channel 3. The [Σ] key will give summation values using measurement from channels 1 and 2. The two different power measurements are available by selecting channel keys [Σ] and [CH3].

Measurement of CH1 or CH2 will have CH1 as the frequency source measurement of CH3 will have CH3 as the frequency source.

Independent Channels
This wiring mode allows each of the three channels to work independently of each other. Three different single phase measurements can be made and are available by selecting the appropriate channel keys. The PM3000A will use whichever channel is selected as the frequency source.

Independent CH3 and Independent Channels wiring modes allow each measurement to be set up independent of the other. For example: For Independent CH3, any change of setup such as averaging will only effect the measurement being currently made. If fixed averaging was selected whilst the instrument was set to channels 1 the averaging will be fixed for both channels 1 and 2 but channel 3 will remain on auto averaging. For Independent Channels wiring mode, only the channel selected at the time will be affected.

3.7.1 Phase to Phase Voltage Reading

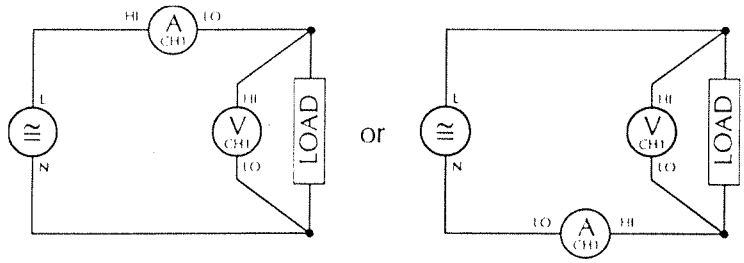
When voltage measurements are made by the PM3000A the value displayed is normally the voltage across the V hi and V lo inputs. In the case of three phase four wire multi-phase measurements (three watt meter) this voltage is normally the phase to neutral volts.

In other cases the voltage of interest is the phase to phase voltage. To select this option:

Using the F[3] function for Wiring Configuration, select 3 phase 4 wire wiring. Note that on selecting 3 phase 4 wire, there is an additional menu which enables the user to select Phase to Phase measurement.

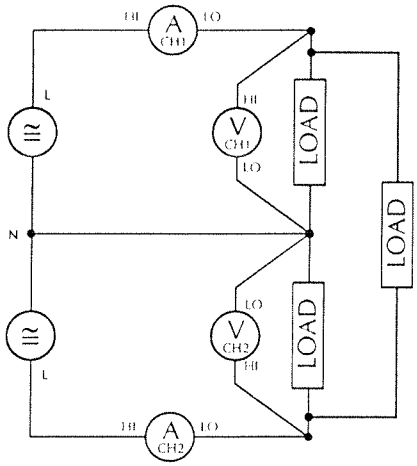
The voltage readings will be from phase to phase, computed vectorially from the phase to neutral data.

3.7.2 CONNECTION DIAGRAMS



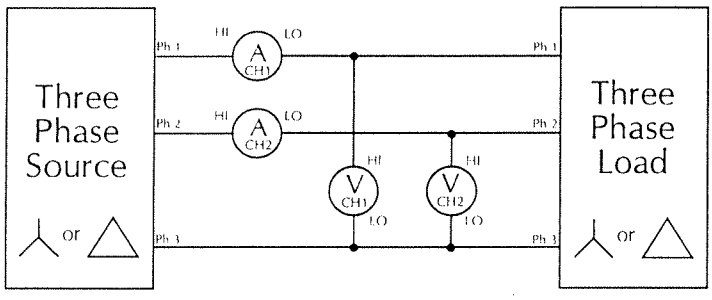
Single-phase, Two-wire and DC measurements.

Select 1Ø 2W



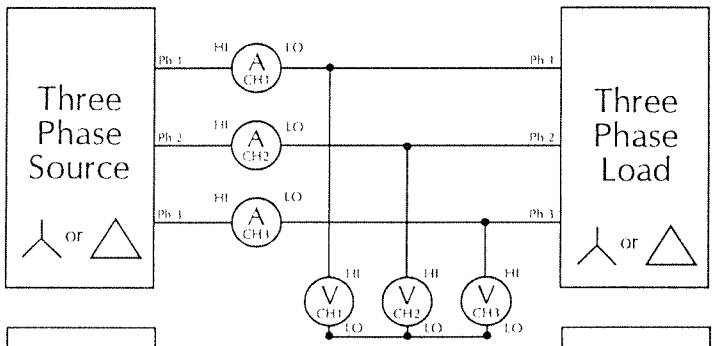
Single-phase, Three-wire.

Select 1Ø 3W



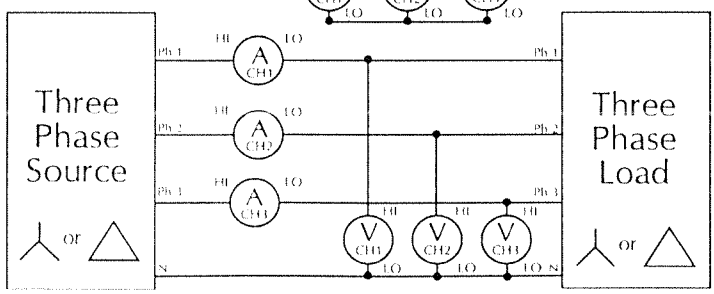
Three-phase, Three-wire (2 wattmeter method)

Select 3Ø 3W



Three-phase, Three-wire. (3 wattmeter method)

Select 3Ø 4W



Three-phase, Four-wire. (3 wattmeter method)

Select 3Ø 4W

3.8 Efficiency Measurement

The PM3000A can be configured to calculate the efficiency using any combination of power and apparent power between any two channels or between a 3 phase 3 wire measurement and CH3.

The units used for numerator and denominator in the efficiency calculation can be:

NUMERATOR / DENOMINATOR
WATTS / WATTS
VA / VA
WATTS / VA
VA / WATTS

The channels used to calculate the efficiency are:-

CH1 / CH2
CH1 / CH3
CH2 / CH3
(CH1 + CH2) / CH3
CH3 / (CH1 + CH2)

Where CH1 + CH2 are the Σ values of WATTS or VA.

The efficiency result can be scaled to suit the application. The efficiency reading is displayed in top right position of the display and is displayed as a percentage. Fundamental values of efficiency are calculated using fundamental values of WATTS and VA when fundamentals are selected. When enabled the wiring is set to independent CH3 what ever the configuration chosen in menu.

If 'independent channels' wiring is preferred, select using F[3] function. Efficiency formula and the scaling factor used in the calculation is automatically printed out when WATTS and VA are selected in a printout. Efficiency is also available over the IEEE interface see : EFF under the IEEE commands : FND, : FNC and : SEL in section 4.6.4.

3.9 Harmonic Analysis

The PM3000A will measure the harmonic content of the voltage and current for all components up to the 99th harmonic. It will also analyze the current flowing in the neutral and will calculate any dc components.

A specially designed mode is incorporated to meet IEC555 requirements for steady state and fluctuating harmonics, and flicker measurements. The IEC555 mode is dedicated function F[6]. See section 3.18 for details

To obtain the harmonic information the PM3000A performs a discrete Fourier analysis at each harmonic frequency. This will give excellent results even when the harmonic component is very small. The magnitude of the fundamental is presented in volts or amps rms, while harmonics 2 - 99 are given as a percentage of the fundamental or as absolute value (see FP18, section 3.11.17). Harmonic 0 (dc) is also calculated and is presented as dc volts or dc amps. These measurements can be carried out at any frequency within the bandwidth of the instrument.

The phase angle of harmonics 1 - 99 is also calculated, and is always referenced back to the volts ch1 fundamental. The phase angle is given in the range 0 to -360 degrees and relates directly to the harmonic in question. The phase is relative to channel 1 fundamental voltage (unless no voltage input is present, in which case the phase is automatically referenced to the fundamental current on channel 1).

3.9.1 [FREQ] Frequency

Press the [FREQ] to display the frequency of the AC supply. This is the fundamental frequency for harmonic analysis and is derived from volts, amps or external source using the [FREQ] source key (see 3.4.1).

3.9.2 [VHARM] Voltage Harmonic

Press this key and enter the required voltage harmonic (max. 99). The display top line shows fundamental value together with its phase angle referenced to channel 1 fundamental voltage. The bottom line displays the magnitude of the selected harmonic as a percentage of fundamental together with its phase angle referenced to channel 1 voltage or current. The default reference is voltage, but may be selected as current via the [FREQ SOURCE] menu (See section 3.4.1.).

The harmonic can also be displayed in volts absolute values (see section 3.11.17 for FP18 setup).

To view another harmonic, press the [VHARM] key again and enter another harmonic number. Alternatively, press the [SELECT] key and the next higher order harmonic will be selected and displayed.

To get a printout of all harmonics up to a preset limit use the printer selection menu. A choice of printing all harmonics or odd only is available.
The harmonics are printed in their absolute values and as a percentage of the fundamental, together with their phase angles. The results are followed by the thd calculated from the percentages of the harmonics chosen. WATTS HARMONICS are also available in the printout if both volts and amps harmonics are selected.

3.9.3 [AHARM] Current Harmonic

Press this key and enter the required current harmonic (max. 99). The display top line shows fundamental value together with its phase angle referenced to channel 1 voltage fundamental. The bottom line, displays the magnitude of the selected harmonic as a percentage of current fundamental together with its phase angle referenced to channel 1 voltage, or current. The default reference is voltage, but may be selected as current via the [FREQ SOURCE] menu (See section 3.4.1.).

The harmonic can also be displayed as an absolute value of amps (see section 3.11.17 for FP18 to set.)

To view another harmonic, press the [AHARM] key again and enter another harmonic number. Alternatively, press the [SELECT] key and the next higher order harmonic will be selected and displayed.

To get a printout of all harmonics up to a preset limit use the printer selection menu. A choice of printing all the harmonics or odd harmonics only is available. The results are followed by the thd calculated from the percentages of the harmonics chosen. WATTS HARMONICS are also available in the printout if volts and amps harmonics are selected.

3.9.4 [Vthd] Voltage Distortion Factor

When selected the instrument displays the distortion factor, as a percentage of the voltage waveform. See section below for a full explanation of this measurement.

3.9.5 [Athd] Current Distortion Factor

When selected the instrument displays the distortion factor, as a percentage of the current waveform. See section below for a full explanation of this measurement.

3.9.6 Harmonic Distortion Measurements

The distortion factor of a waveform can be measured by pressing the [VTHD] or [ATHD] keys. The result is obtained by the calculation

$$df = \frac{\sqrt{RMS^2 - H1^2}}{REF} \times 100\%$$

where REF is normally the fundamental component. It can be set to RMS (see FP17, section 3.11.17).

This measurement takes into account all distortion including noise and dc offsets. This will give very good results with waveforms having greater than 2% distortion. The alternative method which works well with any distortion level, is to measure individual harmonics and calculate the total harmonic distortion with the formula

$$thd = \sqrt{H2^2 + H3^2 + H4^2 + H5^2 + \ldots}$$

where H2 is the 2nd harmonic percentage of reference, H3 is the third harmonic percentage of the chosen REF value.

The default for the front panel display values is the distortion factor (df) value. This can be changed to total harmonic distortion (thd) value by following the setup described for FP16 THD FORMULA in section 3.11.17.

In addition, the default reference value used in the formulae can be changed from fundamental to rms, by selecting FP17 (see section 3.11.17).

3.9.7 [FUND] Fundamental

The PM3000A will normally display results as true RMS values. This takes into account harmonics, noise, offsets etc.

Pressing the fundamental key will return results calculated by using the fundamental components of voltage and current only.

The [FUND] key can be used in conjunction with another function key, e.g. [FUND] + [PF] will calculate the power factor due to the phase shift between the voltage and current fundamentals. Total [PF] on the other hand takes into account phase and distortion and for many non linear loads will give a low power factor when there is little or no phase shift.

3.10 Integrator Measurements

The PM3000A provides comprehensive integration capability for determining energy consumption or maximum demand. The ACCUMULATED VALUES of WHr, VAHr, VAr-Hr, AHr, average power factor and correction VArs are normally displayed and printed out. These can be changed to provide AVERAGED VALUES of W, VA, VAr, A for the elapsed integrator period by using FP115 to 'averaged' (see section 3.11.17). This can be set during, before or after the integration period. The instrument operates independently of other measurement functions allowing the operator to make normal measurements whilst integration is in progress. The following functions are available:

3.10.1 [W-hr] - Watt Hours

This records total energy consumption. When used in conjunction with [FUND] key, the integrator will display energy consumption due to fundamental components only. Averaged values are displayed by setting of FP115.

Elapsed Time 0.00000 W hrs = +0.000

3.10.2 [VA-hr] - VA-Hours

This records the apparent energy consumption or maximum demand. When used in conjunction with [FUND] key, the integrator will display energy consumption due to fundamental components only. Averaged values are displayed by setting FP115.

Elapsed Time 0.00000 VA hrs = 0.000

3.10.3 [VAr-hr] - VAr-Hours

This records the reactive energy consumption. When used in conjunction with [FUND] key, the integrator will display energy consumption due to fundamental components only. Averaged values are displayed by setting FP115.

Elapsed Time 0.00000 VAR hrs = 0.000

3.10.4 [A-hr] - Ampere-Hours

This measures the ampere-hours consumed. Can be programmed to respond to true rms or rectified mean current. When used in conjunction with [FUND] key, the integrator will display energy consumption due to fundamental components only. Averaged values are displayed by setting FP115.

Elapsed Time 0.00000 A hrs = 0.000

3.10.5 [AV-PF] - Average Power Factor

This displays the average power factor during the integration interval. When used in conjunction with [FUND] key, the integrator will display average power factor due to fundamental components only.

Elapsed Time 0.00000 Av PF = 0.000

3.10.6 [CORR-VAr] - Correction VArs

This displays the value of the VArs required to correct the average power factor to a value preset by the user. See section 3.10.12 for further details.

Elapsed time 0.00000
Corr VArs =+0.000

3.10.7 [INTEGRATOR] Integrator menu

The integrator allows total flexibility and is controlled in response to:

1. Manual control i.e. Local Control
2. External/Remote control
3. The internal real time clock
4. IEEE commands

the required integrating mode being selected from the menus integrator key as described below.

Press [INTEGRATOR] key from menu selection. Display will show:

ENABLE INTEGRATOR
>disabled<

Choose (using data entry [SELECT] key) to >enable< the integrator, then [ENTER]. The display will show:

INTEGRATOR CONTROL
>trigger<

Assuming trigger operation is required, choose trigger option using the [ENTER] key. The display will show:

EXTERNAL TRIGGER
>disabled<

Assuming manual operation is required, choose manual option using the [ENTER] key. The display will show:

Integrator Run Time
HH : MM 00:00

Using the data entry keys, enter the time for which the integrator will run after pressing the [START RESET] key. If the integrator is to run continuously until the [STOP] key is pressed, enter a time of 00:00. Press [ENTER] to continue. The LED beneath the integrator key will now be illuminated, waiting for [START RESET] key to be operated and integration to commence.

To start the integrator press the 'INTEGRATION START' key. The LED under the start key will turn on to show that the integrator is running. Pressing any of the integration function keys will give the run time in a 6 digit value of hours and the integrated function.

If RUN TIME was set to "00:00", The integrator can now be reset or stopped. To reset press the [INTEGRATOR START/RESET] key again. The integrator will be reset and restarted. The terminal results are not available on the front panel display but will automatically be sent to the printer if the interface is enabled (see integrator printouts).

To stop the integrator press the [INTEGRATOR STOP] key. The LED under the START key will turn off and the integrator will stop. The terminal results are held and can be viewed from the front panel display, and will automatically be printed if the printer interface is enabled.

The integrator can be reset and restarted at this point by pressing [START] again or can be disabled by pressing the integrator menu key and selecting >disabled<.

3.10.8 Setup External Trigger

Press the integrator menu key and enable the integrator, then select >trigger< control. >Enable< external trigger. The LED under the integrator key will illuminate to show that the integrator is ready to be triggered.

The integrator will start when the external trigger input on the rear panel is grounded. The integrator will run all the time this input is low. To stop the integrator release the input. The terminal results may then be viewed on the front panel display and will automatically be printed out if the printer interface is enabled.

The integrator can be reset and restarted at this point by grounding the external input again or can be disabled by pressing the integrator menu key and selecting >disabled<.

3.10.9 Set up Time Control

Press the integrator menu key and enable it. Then select >timed< control using the [SELECT] and [ENTER] keys. Enter a start date, followed by a stop date. Follow this with a start time and a stop time. After each date/time entry, press [ENTER] to move on to the next display. Dates and times are entered in the order

Day(DD):Month(MM):Year(YY)

Hour(HH):Minutes(MM)

The next display offers selection of CYCLIC INTEGRATION (see next section). Select >disabled<. The display then offers selection of timeband resets within the integration period (see next section). Repeatedly press [ENTER] to skip these. The integrator is then set up to integrate between the set start and stop times automatically.

The terminal results may then be viewed on the front panel display and will automatically be printed out if the printer interface is enabled.

3.10.10 Set up Resets

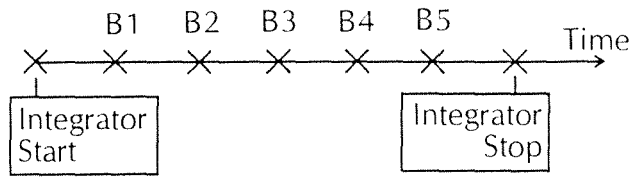
Resets can be CYCLIC or TIMEBAND. The CYCLIC reset will start the integrator at a user defined interval and will need the printer interface enabled to print the terminal results. TIMEBAND will reset and start the integrator at user programmable times, up to five times may be set, and will be useful for monitoring and costing consumption over different tariff bands. The printer interface will also have to be enabled to print the terminal results.

After entering the start and stop dates/times for the integration period, the next display offers CYCLIC INTEGRATION resets. Press [SELECT] to >enable< and press [ENTER]. Then enter the reset period in Hours(HH) and Minutes(MM) and press [ENTER].

The integrator will proceed to integrate for the cycle period, resetting and printing out the results (printer enabled) at the end of each cycle.

3.10.11 Integrator Setting Timebands

If CYCLE INTEGRATION is >disabled<, the display prompts for timeband resets B1, B2, B3, B4 and B5. Enter each band reset time in Hours(HH) and Minutes(MM) and press [ENTER]. If not all resets are needed, skip them by pressing [ENTER] without selecting a time. The integrator will integrate between start and stop times, resetting and printing out results (printer enabled) at each timeband setting. If the integrator is set over several days the timeband resets will continue in a cyclic manner for each day of the period.



3.10.12 Correction VArs and Target Power Factor

An integrator function which displays the value of the VArs required to correct the average power factor to a target power factor preset by the user.

The target power factor is requested after the [Corr VArs] key has been pressed. Enter the value with the data keys and press [ENTER].(To change the sign press the [SELECT] key following data entry).

\+ = leading power factor

\- = lagging power factor

Note that the [FUND] LED illuminates when 'CORR VAr' is selected. The correction will calculate the VArs necessary to provide the phase shift required to reach the target power factor, it does not compute total VArs. e.g., if a poor power factor is due solely to distortion, no amount of phase lead or lag will improve it, and the correction VArs value will be low, as the fundamental power factor is unity.

3.10.13 Integrator Printouts

The integrator results can be printed in two ways :

i. Using [DATA DUMP] and read or print out the results from the display.

ii. Enable the printer before the integrator resets. All the results will be dumped automatically to the printer. This will not affect any other printer operation (such as timed printouts).

Totals can be read from the front panel display at any time during the integration period without affecting the operation of the integrator.

3.11 Menus

The PM3000A provides a host of programmable functions to meet almost every power analysis need. These programs can be stored in non-volatile memory and recalled at will via the menu functions.

3.11.1 [SCALING] Scaling

This menu enables the user to scale the readings of the PM3000A to suit the ratio of external voltage and current transducers. If required inputs may be individually scaled to match calibration transducers.

If a scaling factor of other than unity is given for either volts or amps the LED under the [SCALING] key will be illuminated.

3.11.2 To Change Scaling Factor

Press the [SCALING] key. The display will show

VOLTAGE SCALING
>locked<

Use of the [SELECT] key at this display, allows the user the choice of >locked< or >independent< scaling. Press [ENTER] to move to the next display. Locked scaling applies the same scaling factor to all channels. Independent scaling allows individual scaling values to be applied for each channel. Whichever is selected, the sequence of data entry follows the same order as described below, independent scaling requiring three scaling values at each stage.

Use the data entry keys to first enter the voltage scaling factor(s).Press [ENTER] after each value has been entered to move on to the next display. Scaling values can be entered from 0.001 up to 100,000 using the digit keys and the k, M key. The [SELECT] key reverses the displayed polarity of the scaling factor. A negative scaling factor has the same effect as reversing the appropriate input connection wires.

The display next prompts the choice of >locked< or >independent< scaling for the current channels. Use the [SELECT] and [ENTER] keys as appropriate.
Use the data entry keys to enter the current scaling factor(s). Values can be entered up to 100,000, and the [SELECT] key reverses the polarity of the scaling factor. A negative value corresponds to a reversal of the input connection wires. If a scaling value other than unity is selected, the next display will prompt,

CURRENT SCALING
>up<

Use the [SELECT] and [ENTER] keys to choose >up< where the readings will be multiplied by the scaling factor, or >down< where the readings will be divided by the scaling factor.

E.g. if a 1000:1 current transformer is used the amps scaling factor should be set to +1000:1 >up<. i.e. Select >up< to increase scaling factor or >down< to decrease scaling.

3.11.3 Scaling the External Shunt

The external shunt input has a range of 0 - 2.5 Vpk, this corresponds to 12.5mV / amp (2500mV ≡ 200A).

If, for example, a 0.1 ohm external shunt was used this would give 100mV/ amp. The PM3000A amps scaling factor would therefore have to be set to 8:1 >down< to obtain the required 12.5mV / amp ratio.

If mV / amp < 12.5	If mV / amp > 12.5
Scale >up< i.e.	Scale >down< i.e.
$SF = \frac{12.5}{\text{actual mV / A}}$	$SF = \frac{\text{actual mV / A}}{12.5}$

3.11.4 [INTERFACE] Interface

This menu programs the digital and analogue interfaces of the PM3000A. Press the [INTERFACE] key and the display will show

INTERFACE
>printer<

Use the [SELECT] key to step through the selection menus as described below. Press [ENTER] to select required menu function.

>printer< For Centronics printer. Sets up measurement functions for printout, and the printout interval. See section 3.12.

>IEEE-488< Enables and sets up IEEE address for system application, and sets operation as IEEE488.1 or IEEE488.2 mode. See section 4.

>RS232< Sets up baud rate and configures instruments for RS232 data transfer to a printer, or communicate with a PC. See section 3.14.

>chart recorders< 8 recorder outputs are available. These are individually programmed by the user for measurement function, and also for range, to optimize resolution. They can act as programmable alarms (e.g. PF <0.7). See section 3.11.9.

>analogue outputs< The real time input voltage and current waveforms can be output to the analogue outputs in this mode. See section 3.11.8.

3.11.5 [DISPLAY] Display

This menu sets up the display format of the PM3000A. The PM3000A can display, for the selected channel, three or four simultaneous measurements as programmed by the user:- (e.g. VA, VAr, W, Freq).

On multiphase systems, the PM3000A can display the measurement value of each phase, plus the total: (e.g. CH1W, CH2W, CH3W, ΣW).

The display update rate is set to 0.5 seconds by default. This may be changed from 0.1 seconds to 10 seconds by using [F][P]20 (see section 3.11.7).

3.11.6 Display Menu

The Display menu allows the user to :

i. Choose the results to be shown on the display top line (and lower right for four function display) or if multi channel measurements are being made:

ii. Display all channels plus sum simultaneously.

To display all channels:

Select WIRING [3 ø 4 W]
CHANNEL SELECT [Σ]
FUNCTION [W] (for example)

Display will show the sum of the Volts, sum of the Amps and sum of the Watts.

0.000 V 0.000 A
Watts = +0.000 W

Press the [DISPLAY] key. The display will show

DISPLAY FORMAT
>single<

Select >multiple< using the [SELECT] and [ENTER] keys. The LED under the [DISPLAY] button will illuminate. The display will now show

+0.000 +0.000 +0.000
Watts = +0.000 W

The three numbers on the top row correspond to CH1, CH2, CH3 Watts respectively. The bottom row shows the sum of the Watts. Note that some functions are invalid for a multiple display (e.g. frequency). Press [CH1]. The display will now revert to showing CH1 Volts, CH1 Amps and CH1 Watts.

To Change the top line default:

Press the [DISPLAY] key. The display will show

DISPLAY FORMAT
>single<

Select >single< and press [ENTER]. The display shows,

UPPER RIGHT DISPLAY
>Arms<

Press the required function key for this display location, e.g. VArs, and then press [ENTER]. The parameters allowed are Volts, Amps, Watts, VA, Freq, Power factor, Volts peak and Amps peak.

Then repeat for the UPPER LEFT DISPLAY. The display will then show the chosen units. The lower line can be changed as normal with a function key.

To change to four function display:

Press the [DISPLAY] key. Display will show

DISPLAY FORMAT
>single<

Select >four function< and press [ENTER]. The display shows,

UPPER RIGHT DISPLAY
>Arms<

Press the desired function key and press [ENTER]. Then repeat for UPPER LEFT DISPLAY and LOWER RIGHT DISPLAY. Note that some functions are not allowed (FUNCTION INVALID), since some valid bottom line functions do not allow 4 function display. 4 function display returns when a suitable bottom line function is selected.

3.11.7 [DATA LOG] Data Log

The PM3000A can record and analyze short term events, from a few milliseconds, up to several seconds. The waveforms are recorded and parameters already set up on the printer menu, are printed after analysis.

Data logging can be triggered manually, or triggered externally using the 'external trigger' input on the rear panel.

The results from the analysis are not available from the front panel display. Prior to using data log the user has to specify the functions to be printed (printer menu). When the results have been computed they will automatically be sent to the printer.

There are two Data Log modes:

'Cycle by Cycle' - where the analysis is performed on a per-cycle basis.

'Datalog' - where the analysis is performed over a user entered time.

To set up the mode, press the [DATA LOG] key, and at the display:

CYCLE BY CYCLE LOG
>disabled<

press the [SELECT] key to display >disabled< or >enabled<, as required; then press [ENTER].

a) Cycle by Cycle Analysis
(see also IEEE488 command :LOG:TRG (or EXT) :CYC).

After entering the number of cycles to analyze, the PM3000A will produce RMS measurements for each cycle - there is no averaging over cycles, or missing cycles. The data may be printed, or returned to a computer for further analysis over the IEEE488 or RS232 interfaces.

The following parameters may be measured on a cycle by cycle basis:

CH1, CH2, CH3 - Watts, Volts, Amps, VA, Var, Power Factor, Frequency, and Impedance.

Σ - Watts, Volts, Amps, VA, Var, and Power Factor.

Neutral - Amps.

Auxiliary Inputs - Torque, Speed.

The speed input must be the analogue level to input B, since a pulse speed input cannot be analyzed on a cycle by cycle basis.

Setting up Cycle by Cycle Mode:

When setting up Cycle by Cycle Analysis, after pressing [ENTER] at the

CYCLE BY CYCLE LOG
>enabled<

display, there will be the following sequence of displays:

LOG SAMPLES/CYCLES
>1860<

Input the number required and press [ENTER]. The maximum is 1860 (≡ 31 seconds at 60Hz).

EXTERNAL TRIGGER LOG
>disabled<

Analysis can be triggered via the front panel [START] key, the rear trigger input or the IEEE LOG:TRG (or EXT) :CYC(x) command (x=number of cycles).

Select >enabled< to use the rear panel trigger input, or leave it >disabled<, then press [ENTER].

DATALOG
SET MANUAL RANGE

In cycle by cycle mode, the autoranging feature is disabled and the user must set the correct volts and amps range to suit the intended measurement. The ranges should be set higher than the maximum peak input likely to occur. For example, if an inrush of about 20 amps peak is expected, the 50 amp range should be chosen.

Use the V and A cursor arrows to select the range, then press [ENTER].

DATALOG
waiting for trigger

The measurements will then commence after the trigger has been received, and the lower display line will show 'triggered'.

For local operation, the data is output to the selected printer port (parallel or RS232) with each cycle on one line, as shown in the example printout on the next page.

The status indicates OVER if a higher range is required (data invalid), or UNDER if a lower range could be used (data may be outside specification).

Note that once triggered, analysis begins in 10 to 20µsec. The data used for cycle '0' will be incomplete and should be ignored.

b) Datalog

In Datalog, the user has to specify the capture time, the voltage and current ranges (auto ranging is not available in datalog), and the trigger. Once triggered the instrument takes a number of samples on all channels over the chosen capture time. This data is then analyzed.

The captured waveforms are made available on the analogue outputs for visual inspection. (see section 3.11.9).

To Set Up Datalog Functions:

A selection of results to be printed must first be made from the printer menu. (see section 3.12.1).

Check that the correct wiring, coupling, shunt etc. has been chosen. Datalog is not configurable with Integrator or PWM mode F[7].

Press the [DATA LOG] key. The LED will illuminate and the display will show

CYCLE BY CYCLE LOG
>disabled<

Press the [ENTER] key at this display (showing >disabled<), and the next display will be

DATALOG WINDOW
>30ms<

Using the [SELECT] key choose the required time of 30ms, 60ms, 300ms, 1s, 5s or >18ms-65s<. This latter option allows any time value for the datalog period between the limits. Then press [ENTER]. If >18ms-65s< has been selected, enter the time in ms (e.g. 9 sec, enter 9000) and press [ENTER].

The table on the next page shows the capture times available, together with the sample rates and number of samples.

The next display will then show

EXTERNAL TRIGGER LOG
>disabled<

This display allows selection of EXTERNAL or MANUAL triggering. EXTERNAL operation is performed by shorting the EXTERNAL TRIGGER BNC connector input on the rear panel. MANUAL operation is performed using the front panel DATALOG [START] key. Use [SELECT] to choose >disabled< for MANUAL, or >enabled< for EXTERNAL operation, and press [ENTER]. The display will then show,

DATALOG
SET MANUAL RANGE

Cycle By Cycle Example Printout

```
18 Jly 95 13:42
RMS DC COUPLED

Cycle  Status   Frequency  Channel 1
                Hz         W          V          A          PF

0      OVER     2.620      +1.9453    357.7m     5.469      0.994
1      OK       10.064     +15.376    1.0134     12.874     1.000
2      OK       10.072     +15.409    1.0140     12.847     1.000
3      ......
```

Data Log Sample Rates

WIRING	CAPTURE TIME	SAMPLE RATE	MAX. FREQ	SAMPLES / CHANNEL
ALL WIRING SETUPS	30 msec	5 µsec	50 kHz	6000
	60 msec	10 µsec	25 kHz	6000
	300 msec	50 µsec	5 kHz	6000
	1 sec	167 µsec	1.5 kHz	6000
	5 sec	833 µsec	300 Hz	6000
NOTE: The maximum input wave form frequency is limited as indicated in the MAX. FREQ column, if harmonic analysis, fundamental or frequency are to be recorded.				

In data log mode the autoranging feature is disabled and the user must set the correct volts and amps range to suit the intended measurement. The ranges should be set higher than the maximum peak input likely to occur. For example, if an inrush of about 20 amps peak is expected the 50 amp range should be chosen. When the correct ranges have been set press [ENTER]. The display will then show

DATALOG waiting for trigger

Press the [START] key to capture the event. The delay from the trigger to the commencement of sampling is in the order of 10 - 20 µsec. Then the display will show

DATALOG triggered

After the trigger, the LED under the [START] key will illuminate to show that the analysis is under way.

When the analysis is complete the LED will turn off and the results chosen to be output will be printed. At the same time the captured waveforms will be presented on the analogue outputs connector. If there is a neutral wire the calculated neutral wave form will be output. An oscilloscope trigger output is also generated. After the event has been captured the display will show

DATA LOG < stop > or < reset >

To set up a different menu in DATALOG, first exit DATALOG by pressing [STOP] and then re-enter the menu. Press [RESET] to arm the PM3000A for another datalog trigger under the same conditions.

3.11.8 Analogue Output Connector

In analogue output mode, the waveforms on each input are digitized and sent to the analogue outputs. The outputs can therefore be conveniently viewed in real time at a safe potential (0 - 5V). The outputs can be viewed without distortion for waveforms of frequency less than 1kHz. The voltage and current ranges can be changed to obtain the best resolution but all other measurement functions ease while this mode is active. For this reason it is not possible to enter this mode while the integrator is running. Press the [INTERFACE] key.

Use the [SELECT] key to choose the >analogue outputs< menu and press [ENTER]. The display will then show ANALOGUE OUTPUTS MODE and the waveforms seen by the A/D converters will be output to the analogue connector.

This function can be cancelled by pressing the [INTERFACE] key again.

3.11.9 Chart Recorder

The PM3000A has eight chart recorder outputs. Each output can also act as an alarm. e.g. CH2 volts over 255V. All functions (except Inrush, Vpk, Apk, Vharm and Aharm) can be recorded, including their fundamental. These can be either CH1, CH2, CH3, or SUM. Integrator values (except CORR VArs and AVPF) can be charted recorded. These outputs can be ranged to obtain the maximum resolution.

3.11.10 To Setup the Chart Recorder

Press the [INTERFACE] key. Use the [SELECT] key to choose the >chart recorder< menu and press [ENTER].

ANALOGUE OUTPUT CONNECTOR		
WIRING	**PIN**	**WAVE FORM**
SINGLE PHASE / TWO WIRE	1	CH1 AMPS
	3	CH1 VOLTS
	15	SCOPE TRIGGER
	2-16 EVEN	GROUND
SINGLE PHASE / THREE WIRE	1	CH1 AMPS
	3	CH1 VOLTS
	5	CH2 AMPS
	7	CH2 VOLTS
	13	NEUTRAL AMPS
	15	SCOPE TRIGGER
	2-16 EVEN	GROUND
THREE PHASE / THREE WIRE	1	CH1 AMPS
	3	CH1 VOLTS
	5	CH2 AMPS
	7	CH2 VOLTS
	13	NEUTRAL AMPS
	15	SCOPE TRIGGER
	2-16 EVEN	GROUND
THREE PHASE / FOUR WIRE	1	CH1 AMPS
	3	CH1 VOLTS
	5	CH2 AMPS
	7	CH2 VOLTS
	9	CH3 AMPS
	11	CH3 VOLTS
	13	NEUTRAL AMPS
	15	SCOPE TRIGGER
	2-16 EVEN	GROUND
Note: The neutral current will be output on a reduced scale compared to the other phase currents. (See section 3.11.8).		

The display will show,

CHART RECORDER
>disabled<

Press [SELECT] to >enable< and then press [ENTER]. The next display shows,

CHART RECORDER
>R1<

Use the [SELECT] key to choose recorder output channel from R1 to R8 and press [ENTER] to display,

CHART RECORDER Rx
>enabled<

Use the [SELECT] and [ENTER] keys to >enable< channel Rx.

The display shows,

CHART RECORDER Rx
>CH1<

Use the CHANNEL SELECT keys to set the required channel (CH1, CH2, CH3, SUM, or NEU) and press [ENTER]. The next display shows,

CHART RECORDER Rx
>Watts<

Use the function keys to enter the required parameter(such as VArs, PF etc.). Follow this with the [FUND] key if the fundamental value is to be recorded. Then press [ENTER]. The display then shows,

RECORDER MINIMUM Rx
+0.000

Use the digit keys, the k, M key for value entry and the [SELECT] key to reverse the polarity. Then press [ENTER]. The display shows,

RECORDER MAXIMUM Rx
+10.00

Enter then required value as above and press [ENTER]. The display returns to the recorder output channel selection mode,

CHART RECORDER
>Rx<

Set up all further output channels required as above. To exit the menu and save the setup, use the [SELECT] key repeatedly until >quit< appears in the display and then press [ENTER]. The chart recorder output is now active, and available at the ANALOGUE ALARMS output connector on the rear panel. See the next section for the pin-out connections. To disable it, re-enter the menu and select CHART RECORDER >disabled<.

3.11.11 To Set Alarms

To set alarms simply program the low and high limits to the same value. If the measured value is below the limit, the recorder output will be 0V, if the measured value is above the limit, the recorder output will move to +5V.

ANALOGUE CONNECTOR 25 WAY 'D' SOCKET	PIN	RECORDER
	1	R1
	3	R2
	5	R3
	7	R4
	9	R5
	11	R6
	13	R7
	15	R8
	2-16 even	GROUND

3.11.12 [CLOCK SET] Clock Set

This function sets the clock to local time and date. The clock is powered by a lithium cell which should not require replacing for at least 5 years. To display time and date press [CLOCK SET] key. Press [ENTER] key to accept, otherwise to change settings press [SELECT] key then [ENTER] key.

Using the numeric keys 0-9, enter the time using prompt format shown in display. Display will then prompt for the date. Again enter in format shown. New settings will then be displayed, press [ENTER] key if setting is correct, otherwise select >change< and repeat above procedure.

3.11.13 [START/RESET STOP] Start/Reset Stop

These keys are used to start and stop the integrator, or trigger data logging, when in manual control.

3.11.14 [DATA DUMP] Data Dump

When the printer is connected to the PM3000A, the user can output results to the printer at any time by pressing this key. The values on the display will be printed, or else a selection of other measurements as previously set on the interface menu.

3.11.15 [LOCAL] Local

This allows the user to switch from remote (IEEE or RS232) control (see section 4) of the instrument to control from the front panel.

3.11.16 [SELECT] [ENTER] Data Entry and DISPLAY HOLD

The [SELECT] key is used to choose menu options presented on the display it also acts as a clear key to cancel numeric data entered incorrectly in the display. It will also clear a PRINTER HOLD condition, although the printout will be abandoned. The [ENTER] key will load the PM3000A with numeric or other data input to the keyboard. When not entering data this key will act as a HOLD key to `freeze' the display.

This DISPLAY HOLD function stores all parameter values on all channels like an on-board printer. The lower line of the display can be made to show the value of any parameter, frozen at the time of pressing the [ENTER] key. Simply press the appropriate function or channel select key to display the required value. To return to real time display, press the [ENTER] key once again.

3.11.17 [P] [F] Function Program Select

The [P] key is used to store front panel settings, including scaling factors and other menu set ups. Up to 5 settings may be stores and recalled using this key, including the power-up setting.

The [F] key is used to obtain an option selection from the following functions:

F[1]:POWER-ON DEFAULT - Section 3.13.2
Allows the choice of standard default settings, one of the programs P[1] to P[5] or power down (which saves the settings on turn off and restores them on power up) as the power up configuration.

F[2]:HIGH BANDWIDTH OPTION
Allows selection of 1MHz as the instrument bandwidth. The power up default is 25kHz (PM3000A and PM3000A-001). For the version PM3000A-002 it is 5kHz. To select the high bandwidth option:
Press [F], then 2. Press [ENTER].
Press the [SELECT] key to choose >1MHz< on the display and press [ENTER].

F[3]:WIRING CONFIGURATION - Section 3.7
This function provides a wider range of wiring setups than available from the 4 WIRING keys. For this function the menu allows the user to select the appropriate wiring mode using the [SELECT] key, or immediately with the wiring mode number. The list of available wiring modes and their number are as below:

1. 1 phase 2 wire.
2. 1 phase 3 wire.
3. 3 phase 3 wire.
4. 3 phase 4 wire.
5. Channel 3 only.
6. Channel 2 only.
7. Independent CH3.
8. All independent.

If 3 phase 4 wire is selected an additional menu allows the choice of Phase to Phase or Phase to Neutral voltage measurement. For details on Phase to Phase and Phase to Neutral measurement see Phase to Phase voltage Reading - section 3.7.1.

F[4]:EFFICIENCY - Section 3.8
When enabled the PM3000A calculates the WATTS or VA efficiency between any two channels or the efficiency between a 3 phase 3 wire measurement and CH3. The user can fully configure this feature to suit the measurement being made, including the application of scaling factor on the efficiency result.

F[5]:PROGRAM SWITCH - Section 3.11.18
Allows single key program switching between programs P1 and P2.

F[6]:IEC555 MODE - Section 3.18
Provides a special mode to meet IEC555 requirements for fluctuating. harmonics, and flicker measurement.

F[7]:PWM MOTOR DRIVES - Section 3.16
Applies filtering of the waveforms for PWM inverter applications.

F[8]:BALLAST/USONIC MODE - Section 3.17
Provides mains cycle synchronisation for mains modulated waveforms such as lighting ballasts. and ultrasonic applications.

F[9]:TRANSFORMER TEST MODE - Section 3.19
For measuring the 'no-load' losses in large power transformers.

F[10]:CALIBRATION - Section 5.2-5.5
Allows coded entry to the calibration procedure.

The [F] and [P] keys pressed consecutively, provide a greater selection of instrument configuration. Press [F], then [P] and then the number according to the selection list below. Then press [ENTER]. Use [SELECT] to make the chosen selection for a display with cursors (e.g. >harmonic series< for FP16), or a digit key for a display with numeric information (e.g. 5 for FP13). Then press [ENTER]. Note that only the FP selection numbers shown below are useful at the front panel. (For full list refer to CONFIGURATION LISTING at the end of section 4).

0 **MANUAL ZERO.** To reduce the current and voltage offsets, a zeroing calibration can be carried out. Each of the inputs should be shorted together and >MANUAL ZERO< should be selected. The instrument will proceed to self-calibrate for each measurement range.

10 **LANGUAGE MODE.** The default display language is English. this can be changed to >French< or >German< (depending on the version of software) using this option. Use [SELECT] key to choose and press [ENTER]

12 **DISPLAY HOLD**. This is identical to pressing the ENTER key for display hold. See section 3.11.16.

16 **THD FORMULA**. The displayed THD value may be calculated from the difference formula or from series thd (see section 3.9.6). If calculated from series thd, the background averaging is used, and the displayed value is updated each time that the averaging is filled. The top line continues to be updated at the normal rate. The default setting is the difference formula. To select series thd:

* Press F,P,16 and [ENTER]
  Select >harmonic series< and [ENTER]
* Press F,P,19 and [ENTER]
  Select >H0(dc) excluded< or >H0(dc) included< as required. Press [ENTER].
* Press F,P,135 to select odd or odd and even harmonics in the thd series. Press [ENTER].
* Press F,P,136 to select max. harmonic for the thd series. Press [ENTER].

17 **HARMONIC REFERENCE**. The fundamental or RMS value may be chosen as reference for thd calculation, both on the display and the printout. The default is fundamental.

18 **HARMONIC DISPLAY**. The harmonics may be chosen to display as percentage of the reference or as actual values of volts or amps.

19 **HARMONIC ZERO (DC)**. The zero harmonic (dc) can be included or excluded in the thd series formula.

20 **DISPLAY UPDATE RATE**. This is set as 0.5 sec default. It may be changed from 0 to 9.9s in units of 100ms in this option, by selecting 0-99.

21 **SAMPLE RATE (FIXED FREQUENCY ENABLE)**. For accurate operation, the PM3000A needs to obtain the frequency of whatever source it measures. Sometimes this may be impractical. To overcome this, the user can set a fixed frequency value in FP22 and enable it as the instruments source of reference. >Autoranging< is the default

(normal operation). >Manual< is the fixed frequency mode.

22 FIXED FREQUENCY. Through this option, the value of fixed frequency is can be set and it is activated by selecting >manual< in FP21.

26 LOW VALUE BLANKING. If the PM3000A is operated in manual ranging (or if the lowest range is operating in autoranging), the display value will blank to zero if the voltage or current falls below a given value. This preserves the accuracy of the instrument. If , however, you want to observe the (blanked) value, the blanking can be disabled through this option.

28 RANGE LOCKING. The normal mode of operation is that the PM3000A responds to the maximum input on all three channels. This is >locked< operation. The ranging can be made >independent< through this option. Once selected, each channel will range according to the level of inputs experienced by that channel.

36 LOAD FIXED CHANNEL 1 FREQUENCY. When enabled, this option allows you to use existing measured frequency as the frequency reference source, for later measurements. It is used for example in the F[7] PWM MODE when measuring harmonics above the filter cut-off frequency.

38 CH1 AVERAGING DEPTH. This option allows the averaging depth to be set from 1 - 64. It is useful for reconfiguring the depth for AUTO mode (see section 3.4.3) The equivalent FP setting for CH2 is 58 and CH3 is 78.

115 INTEGRATOR DISPLAY. This option allows selection of >accumulated< integrator values (e.g. WHr) or >averaged< values (e.g. W average) for the integrator period.

126 CURSOR HOME. The PM3000A can be connected to a PC via RS232 and configured to send "Print mode" results to the screen using [DATA DUMP] key, for remote monitoring. Using a VT100 or VT320 terminal and this configuration, "Print Mode" results can be displayed with each "Dump" beginning at the top left hand corner of the screen, rather than scrolling from the bottom of screen.

127 DISPLAY MODE. In 'communications control' the display will show 'Communications Control' instead of updating the display measurements. Communications speed is improved.

0 = Normal display mode
1 = Communications control display mode

135 HARMONIC SERIES. This option allows selection of odd-only or odd and even harmonics in the harmonic series for thd or printout.

136 MAXIMUM HARMONIC. This option allows selection of the maximum harmonic in the harmonic series for thd or printout.

190 POWER FACTOR POLARITY. This may be reversed from the normal applied convention by enabling this option.

191 SUM A $=(A_1+A_2+A_3)/3$. The Summation Current is normally calculated using the formula:

$$\frac{\Sigma VA}{\Sigma V}$$

The Summation current can be calculated as the arithmetic mean of the 2ϕ or 3ϕ channel inputs using FP191

$$3 \quad 4W \quad \Sigma A = \frac{(A_1 + A_2 + A_3)}{3}$$

$$1 \quad 3W/3 \quad 3W \quad \Sigma A = \frac{(A_1 + A_2)}{2}$$

192 SUM V $=(V_1+V_2+V_3)/3$. The Summation Voltage for 3ϕ4W wiring is normally calculated using the formula:

$$\Sigma V = \frac{(V_1 + V_2 + V_3)}{\sqrt{3}}$$

The Summation Voltage can be calculated as the arithmetic mean for 3ϕ4W wiring using FP192.

$$\Sigma V = \frac{(V_1 + V_2 + V_3)}{3}$$

276 **DATA RETURN FORMAT**. Data is normally returned in multiple lines, with 8 pieces of data on each line. This requires a data return request to be issued to the analyzer at the end of each line.
In 'single reply string' mode, all of the data is returned in one string with a line feed as a terminator. There is no 'END OF DATA' appended to the data

0 = Normal multiline reply string
1 = Single reply string

277 **V, A, W, F ONLY MODE**. By restricting the parameters computed by the analyzer, communications speed is improved.

0 = Normal functions available
1 = V, A, W, and Frequency are the only measurements available

3.11.18 Program Switch

The program switch facility enables two stored setups to be alternatively loaded with a single key press. This is especially useful in cases where channel 3 is used as a separate input with its own printer and scaling setups etc.

To use, save the first setup into P[1], and then reconfigure the instrument for the second setup and save in P[2]. See SETUP PROGRAMS (section 3.13). Press the [F] button and choose F[5] PROGRAM SWITCH. Press [ENTER], and then use the [SELECT] key to choose >on<. Press [ENTER].

Pressing the [P] button now switches the configuration between setup P[1] and setup P[2]. To restore the [P] button to normal operation use the F[5] function to turn PROGRAM SWITCH off.

NB. The PROGRAM SWITCH does not change integrator, chart recorder or datalog.

3.12 Printer Operation

The printer output can be standard Centronics or RS 232. Centronics is the default but the output will be directed to the RS232 port if the RS232 interface is enabled. When the printer output is enabled the LED under the interface key will illuminate. The printout data can be from one of four sources:

i. The results currently on the front panel display.

ii. A selection of results from one or more than one channel. In this mode over four hundred results can be programmed to be printed from one measurement cycle.

iii. The integrator results. When the integrator is stopped the results will automatically be output to the printer interface if enabled.

iv. The datalog results. Results are selected as in (ii) and are computed and printed following a datalog capture cycle.

3.12.1 Printer Setup Menu (Display Results)

To print out the results given on the front panel display:

Press the [INTERFACE] key and select >printer< using the [SELECT] and [ENTER] keys. Select printer >enabled<, then select >display< for the PRINT MODE and press [ENTER].

The PM3000A can print after a trigger input, or it can be programmed to print at set time intervals.

i. To print with a trigger input (manual or external) proceed as follows ;

a. MANUAL. Select external trigger >disabled<. (Pressing the [DATA DUMP] key will trigger printout).

b. EXTERNAL. Select external trigger >enabled<. (Shorting the Ext Trigger input on the rear panel will give a printout).

The display continues to TIMED TRIGGER setup. Select >disabled< if not required, otherwise proceed as follows;

ii. To print at set intervals:

Select TIMED TRIGGER >enabled< and press [ENTER]. Then enter the print interval in hours(HH) and Minutes(MM). Press [ENTER]. Printouts will then automatically occur at that interval. Additional printouts can be made by pressing [DATA DUMP].

The printout will reflect the front panel display with the additional information of:

i. The time and date.
ii. AC or AC+DC coupling.
iii. RMS or MEAN volts and amps.
iv. Phase-phase or phase-neutral volts.
v. Frequency source.
vi. Special modes (e.g. PWM mode).

3.12.2 Printer Setup Menu (Selection)

To print out a selection of results;

Press the [INTERFACE] key and select >printer< using the [SELECT] and [ENTER] keys. Select printer >enabled<, then select >selection< for the PRINT MODE and press [ENTER].

Using the five [CHANNEL SELECT] keys along the bottom of the display choose the channels for which selected results will be printed. Pressing a channel key which is already displayed (selected) will cancel it. Press [ENTER] when the displayed choice is correct. Now use the function keys to enter the functions that require printing. For example if power factors are needed to be printed press the [PF] key. Pressing [PF] again will deselect it. Do not press [ENTER] until the selection is complete.

Note that as soon as a function key is pressed, it clears any previous selections (however, pressing [ENTER] without selecting functions will retain the previous selection).

If the fundamental components of V, A, W, PF, VA, VArs etc. need to be printed this can now be selected. Choose PRINT FUNDAMENTALS >enabled< and press [ENTER].

As all the basic functions are stored automatically, additional results to be printed will not slow the instrument down. However, choosing more than the fundamental harmonic of either volts or amps will impose an additional burden on the processor and will lengthen the measurement cycle.

If harmonics have been selected, the next display prompts selection of the MAXIMUM HARMONIC. Use the digit entry keys to select this value from 1 to 99. The next display then prompts the type of HARMONIC SERIES. Select >odd only< or >odd and even< and press[ENTER]. If both voltage harmonics and current harmonics have been selected in the menu setup, then the user is prompted for Watts harmonics. If selected, these will be printed out in addition to the current and voltage harmonics.

Finally, the choice of trigger (external, manual or timed) is selected as described in section 3.12.1.

When the trigger is executed, e.g. [DATADUMP], the background averaging store commences to be filled with the measurement results and the display will indicate the status of the averaging. For example;

240.0V 67.91mA average 8 of 16

This indicates that selected measurements have been stored for 8 of the 16 data acquisition periods required by the AVERAGING setting. When the display shows that the averaging is complete the printer will output the results, and the display returns to normal mode.

3.13 Programming

Up to five setups can be stored in the PM3000A's non-volatile memory. Any of the five programs may be automatically loaded on power up to configure the instrument to a user's setup.

All settings are stored when a setup is saved.

The [P] button can also switch the instrument from the P[1] setup to the P[2] setup if the PROGRAM SWITCH function is enabled (see section 3.11.18).

To save a setup press the [P] key. Use the [SELECT] and [ENTER] keys to choose to >save program<. The next display shows >Program 1-5<. Press [ENTER] to continue (or [SELECT] to >quit<). Then select the required program number with the digit keys, and press [ENTER]. The current configuration will be stored as the program selected in non-volatile memory. This is powered by a lithium battery with a life of at least five years.

3.13.1 To Load a Stored Setup

Press the [P] key. Use the [SELECT] and [ENTER] keys to choose to >load program<. The next display offers the choice of >standard<, >program 1 to 5< or >quit< using the [SELECT] key. Choose STANDARD for power-up configuration, or PROGRAM 1 TO 5 for a programmed configuration.

If >program 1 to 5< is selected, the next display allows choice of the program number. Enter the number using the digit keys and press [ENTER]. The setup will be loaded. If no program has ever been loaded into that store or the data has been corrupted, the load will be cancelled and the program will exit the menu.

3.13.2 To Program P(1) as the Power On Default

The contents of any of the five program stores P1 - P5 can be made the power on default setup. To do this press the [F] key. Select F[1] 'POWER ON DEFAULT'. Use the [SELECT] key to choose >program 1-5<. Press [ENTER]. Then select the program number 1 - 5 and press [ENTER].

Until the default is changed back to 'STANDARD' the PM3000A will power up with the setup stored in program P(1).

3.13.3 To Print a Program Set-up

The program configuration currently in use can be printed at any time. To print any other program set-up it must first be loaded.

To print, press [P], then [SELECT] to display >print program<. Press [ENTER] and select >yes<. The configuration will be printed.

3.14 RS232 Operation

The RS232 port can be set up as:

i) Printer port or
ii) Computer control mode

These are described in the two sections that follow.

3.14.1 Printer Port Mode

Set up the printer menu to output the required results. These are by default directed to the Centronics interface.

Press the [INTERFACE] key and use the [SELECT] key to choose the RS232 menu.
Press [ENTER]. Then Select >enabled< and press [ENTER]. Use the [SELECT] key to choose the required baud rate. Press [ENTER]. Then [SELECT] RS232 MODE as >printer< and press [ENTER].

The printer output will now be directed to the RS232 port. The data is output with 1 start bit, 8 data bits, 2 stop bits, no parity. Simple CTS/RTS handshaking is used to control data flow. connection is as shown in the table of section 3.14.2.

3.14.2 Computer Control mode

The PM3000A can be controlled from a PC over the RS232 serial interface. To select this mode, proceed as described in section 3.14.1 until RS232 mode selection. Then select >Computer Control< and press [ENTER].

The PM3000A is now set for PC communication. The PM3000A obeys all of the commands described in the IEEE section of this manual (Section 4), including 488.1 and 488.2 formatted commands. The data is transmitted with 1 start bit, 8 data bits, 2 stop bits, no parity.

Simple CTS/RTS handshaking is used to control data flow.

The PM3000A operates will a simple ASCII protocol where any received characters are echoed back to the sender. On receipt of a carriage return, the command is processed and any reply is returned terminated with an idle prompt, ">". Note that this means that all commands return some characters (only the idle prompt if no other data). If the PM3000A is unable to receive characters due to internal operations it will de-assert the RTS handshaking line.

Due to delays in responding to the RTS line, the preferred method of communicating with the PM3000A is to wait for the echoed data before sending the next character.

The completed protocol then becomes

DO send character
wait for echo
UNTIL all strings sent
send carriage return ('\r' or OD, hex or 13, decimal)
DO receive data
UNTIL '>' received

The REMOTE L.E.D. illuminates when the first command has been sent. A screen prompt (>) is provided to denote that the RS232 line is idle. Connection details are shown in the table below.

25 way PC Connector

PM3000A			Computer
screen	1	1	screen
Rx	2	2	Tx
Tx	3	3	Rx
CTS	4	4	RTS
RTS	5	5	CTS
	20	20	DTR
	6	6	DSR
ground	7	7	ground

NOTE: On some PC's it may be necessary to link pins 20 and 6 at the PC connector.

9 Way PC Connector

PM3000A			Computer
Rx	2	3	Tx
Tx	3	2	Rx
CTS	4	7	RTS
RTS	5	8	CTS
		1	DCD
		4	DTR
		6	DSR
ground	7	5	ground

Note: On some PC's it may be necessary to link pins 1, 4 and 6 at the PC connector

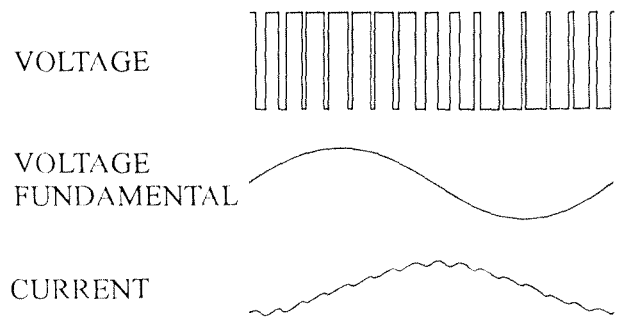
3.15 PWM Motor Drive Measurement Mode F[7]

The difficulties associated with making measurements on the complex waveforms of PWM drives are overcome with this special operating mode. It is described fully in Voltech Application Note 105.

High frequency sampling and digital filtering reject the carrier frequency, and extract the motor frequency and harmonic components. True power and other rms parameters are computed from the PREFILTERED data.

There is a choice of 3 filters, selected according to the frequency range of the motor:

5Hz to 1kHz (400mS display update)
0.5Hz to 50Hz (4sec update time)
0.1Hz to 40Hz (16sec update time)



Notes:

1. The low bandpass filter (25kHz) is normally applied to prevent anti-aliasing. Version PM3000-002 has a lower bandpass filter (5kHz). This will affect the PWM prefiltered data values. PWM filtered values will be unaffected.

2. Output mode Harmonics are blanked to give zero values above the maximum frequency of the filter selected. For example,
   Filter = 5Hz to 1kHz
   Motor frequency = 30 Hz
   Max. harmonic computed = 33rd (990Hz)

3. Input mode harmonics are blanked at frequencies above the limit (400/Input Window) Hz.

4. For low loaded motors, it is advisable to remove the display blanking as the fundamental can be very small compared to the total rms value. In such a case, the display value may be forced to zero. Select [F][P]26 (Low value blanking).

5. It is important to check that the correct frequency has been obtained when the mode is selected. If not, then select [FREQ] to >current<.

6. The wiring configurations for PWM mode are either 3ϕ3W or 3ϕ4W. The [N] channel provides computed values of current (Arms, Afund, Acf, Apk, Aharm and Athd) for the third (unmeasured) phase of the system.

To use this operating mode, first select F[7] and press [ENTER]. Then 3 measurement options are available:

>output< Measurements of the output power of a drive.
>input< Measurements of the input power of a drive.
>real timeoutput< Real time values of Vrms, Arms, Watts and power factor are each scaled and output to a chart recorder.

All wiring configurations for the PWM mode that are 3Ø3w will enable the third channel (CH3) as independent. This allows the DC link of the drive to be measured simultaneously. Using the DC link, efficiency (E) measurements for the drive can be derived :

$$E = \frac{DC\ Link\ power\ (CH3)}{Input\ power\ (3\phi 3w)} \times \frac{Useful\ Output\ power\ (3\phi 3w)}{DC\ Link\ power\ (CH3)}$$

Note: If the DC bus measurement on CH3 varies, set fixed frequency of line supply (50/60Hz) to stabilise the value. (see FP21/22).

The 3 modes of operation are described below.

3.15.1 >output< Mode

1. Connect the output of the drive to the PM3000A and motor in either 3Ø3W or 3Ø4W mode (see diagram page 3.9).
2. Select F[7] PWM DRIVES and press [ENTER].
3. Select >output< using [SELECT] key, and press [ENTER].
4. Select the chosen frequency band depending on the motor operating speed range, e.g. >5Hz to 1kHz< using the [SELECT] and [ENTER] keys.
5. Select >3Ø3W< or >3Ø4W< as required.

Check that the frequency is being monitored correctly. Measurement of the RMS values, fundamentals and harmonics (up to the limit frequency of the filter) can now be analyzed.

It is normal for there to be a large difference between the Vrms and Vfund values, but only small differences between Arms and Afund/Wrms and Wfund, as the inductive motor filters the current.

Harmonic losses = total power - fundamental power

Note that if a printer output is selected, then Watts Harmonics can be selected for printout (if Aharm and Vharm have previously been selected in the menu). For measurement of harmonics above the upper filter limit, see the section below on Harmonics. (3.15.4)

3.15.2 >input< Mode

The input waveforms are modulated by the output motor frequency. Accurate measurements are obtained by synchronising the sampling of data to the line frequency, and sampling over an interval

(τ) between 1 and 10 seconds as follows:

Output frequency f	τ input time window
10 < f	1
1 < f < 10	10/f
f < 1	1/f

For example, if f = 7.2Hz, then set τ to 10/7.2 = 1.39 (or a multiple of this value).

1. Connect the input of the drive to the PM3000A in either 3Ø3w or 3Ø4w mode (see diagram page 3.9).
2. Select F[7] PWM DRIVES and press [ENTER].
3. Select >input< using [SELECT] key, and press [ENTER].
4. The display will show PWM INPUT WINDOW. Using the data entry keys, set the calculated value for τ (e.g. 1.39) and press [ENTER].
5. Select > 3Ø3w < or >3Ø4w < as required.

The PM3000A will now measure input power over an integral number of input cycles within the selected time window of measurement, 1.39 seconds.

3.15.3 >real time output< Mode

Real time output of the FILTERED values of Vrms, Arms, Wrms and PF can be output as analogue outputs for chart recorders.

1. Connect the output of the drive to the PM3000A and motor in either 3Ø3w or 3Ø4w mode (see diagram page 3.9).
2. Select F[7] PWM DRIVES and press [ENTER].
3. Select >real time output< using [SELECT] key, and press [ENTER].
4. Select the chosen frequency band depending on the motor operating speed range, e.g. >5Hz to 500Hz< using the [SELECT] and [ENTER] keys.
5. Select the maximum PWM OUTPUT VOLTS for recorder scaling, e.g. 250. Press [ENTER].
6. Select the maximum PWM OUTPUT AMPS for recorder scaling, e.g. 20. Press [ENTER].
7. Select the maximum PWM OUTPUT WATTS for recorder scaling, e.g. 5000. Press [ENTER].

The computed results appear on outputs 1 to 4 of the Analogue output connector.

For the example:

Output 1	total Vrms	0 to 5V	= 0 to 250 V
Output 2	total Arms	0 to 5V	= 0 to 20 A
Output 3	total Watts	0 to 5V	= -5000W to +5000W
Output 4	total PF	0 to 5V	= 0 to 1

3.15.4 Harmonics

To extend measurements of harmonics greater than the filter cut-off frequency, and provided the frequency is not fluctuating, the following procedure can be followed.

First measure and store the frequency with the PWM filter on, and then switch to a configuration with the filter disabled and which uses the stored frequency. Harmonics to the 99th may be analyzed. By using the PROGRAM SWITCH, these two configurations can be toggled to update the stored frequency.

1. Select F[7] >output< and the appropriate filter as described in the earlier sections.
2. Select [F][P]36 LOAD FIXED FREQUENCY and set >enable<. Press [ENTER]. This stores the frequency.
3. Save as Program 1 (see section 3.13). Note that this overwrites any previous program stored in P1.
4. Set F[7] to >disabled< and press [ENTER].
5. Select [F][P]21 FIXED FREQUENCY and set >enabled<.
6. Save as Program 2.
7. Load Program 1 (See Section 3.13.1)
8. Enable the PROGRAM SWITCH F[5]. (See section 3.11.18)
9. Select [P]. This now toggles the configuration between program 1 and program 2 each time it is pressed. Full harmonics can be measured when program 2 is set.

3.16 F[8]: 50/60 Hz only mode for lighting ballasts

In situations where voltage and current waveforms at high frequencies are heavily modulated by mains borne frequencies, it is difficult to make accurate measurements as the sampling is not synchronised to the 50/60 Hz modulation. This occurs frequently with lighting ballast power measurements.

The F[8] synchronisation function solves this problem. Voltech Application Note 101 covers its use in detail.

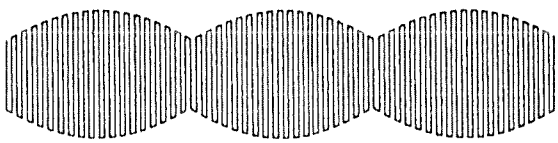
To use the function;

1. Select F[8]. The display shows 50/60 HZ MODE >off<. Select >on< using the [SELECT] and [ENTER] keys.

2. Select >50Hz< or >60Hz< as the frequency of modulation and press [ENTER].

3. The PM3000A will now capture and analyse the relevant number of samples to correspond to one complete cycle of 50Hz or 60Hz at the fastest sampling rate. Once captured, the subsequent processing is carried out as normal, including autoranging. The display automatically sets to a four function display. The frequency displayed is the carrier frequency.

4. If three phase three wire mode has previously been selected as the wiring configuration, then after selecting 50/60Hz (step 2), you can select INDEPENDENT CH3. This allows you to measure ballast power output using CH1, CH2 and Σ, while measuring ballast power input on CH3 for efficiency measurements (see section 3.11.17 for FP13 Wiring Configuration 7 to understand this mode in more detail).



20 kHz wave form
50/60 Hz modulation

3.17 F[6] IEC 555 Harmonic Measurement Mode.

The IEC 555 standard provides limits for the size of harmonics that can be generated by equipment connected to the public low voltage system. It defines these limits for steady state harmonics and fluctuating harmonics. Voltage fluctuations which cause flicker in lighting equipment are also limited by the Standard. It further defines the requirements of the measuring instrument and the method by which the measurements are made.

For steady state (fixed) harmonics, the PM3000A harmonic measurement mode normally meets these criteria. For fluctuating harmonics and voltage fluctuation measurement, special operating modes are included to meet these requirements. See Voltech Application Note 104 for more details.

To select this mode, press [F], then 6, then [ENTER].

The options available are:

>Fixed Harmonics<

>Fluctuating Harmonics<

>Changing Voltage<

>Flickermeter<

Use the [SELECT] and [ENTER] keys to choose the desired measurement mode.

3.17.1 >Fixed Harmonics<

There are 4 classes of IEC Limits, A,B,C, & D, each of these limits applicable to certain types of equipment, such as, balanced 3 phase, portable tools, lighting, motor driven or other.

The IEC555 Test Software Disk can help select the correct class limit to test the equipment under test, including a waveform capture to check for Class D limits.

The equipment under test has met the IEC555 specification of fixed harmonics, if the appropriate limits are not exceeded.

Refer also to our IEC555 Test Software Disk (See section 3.17.5), which provides bar graphs with IEC limits, and captured waveform display.

3.17.2 >Fluctuating Harmonics<

Fluctuating harmonics mode continuously measures the current harmonics of the equipment under test over a set period of time.

The harmonic levels are tested against the appropriate class limits and against a second set of limits which are 1.5 × class limits for the set period of time.

If any harmonic exceeds the second set of limits at any time during the test period the unit under test has failed the test. If any harmonics exceed the first set of limits for more than 15 seconds (10%) over any 2.5 minute interval, it has failed the test and does not meet the IEC specifications for fluctuating harmonics.

To choose this mode of analysis, press [SELECT] to display >fluctuating harmonics< and then press [ENTER]. The display then shows:

IEC 555 MODE Freq = xx.xx

Select the appropriate display harmonic by pressing [A HARM], the digit keys and [ENTER]. The harmonics can be stepped through using [SELECT].

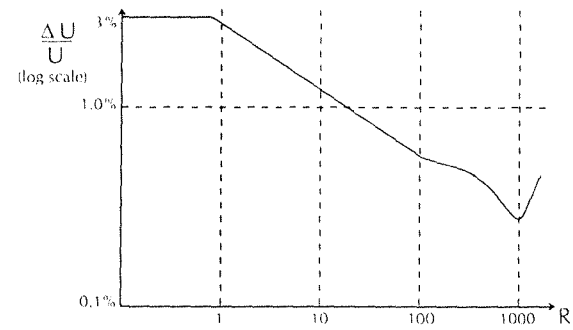
To printout or read the display value for other channels, press the appropriate channel selection key and wait five seconds (3 × 1.5sec time constant) before taking a reading, to allow the filtering time constant to establish itself. Refer also to our IEC555 Test Software Disk (see section 3.17.5) which provides a real time bar graph output of fluctuating harmonics, with IEC limits, and also graphs of single harmonic levels over time.

3.17.3 >Changing Voltage<

Flicker is defined as the fluctuating luminance of lighting equipment caused by voltage fluctuations on the supply system to which it is connected.

Changing Voltage is a method of measuring "flicker" to IEC Standard 555-3 and is suited to measuring flicker where the load is changing regularly.

The IEC Standard 555-3 stipulates limits for the voltage disturbances in the supply system that can be caused by household (and similar) electrical equipment. The limits are defined in the graph below . This shows the magnitude of the maximum permissible percentage voltage changes (ΔU/U) with respect to the allowed number of voltage changes per minute (R).



In addition, the total "accumulated memory time" should not exceed the duration of the observation period. Memory time is a concept defined by the Standard.

The "power measurement" technique is used, in which the in-phase and quadrature components of current are measured to define the size of the voltage disturbance.

Connect and power up the load under test to the CH1 inputs. Selecting this option, causes the display to report the MEMORY TIME. This will accumulate in value over the observation period, for the voltage fluctuations detected.

For more guidance, refer to our Application Note 104. Refer also to our IEC555 Test Software Disk (see section 3.17.5) which provides a PC based analysis mode for fluctuating voltage measurement.

3.17.4 >Flickermeter<

Flickermeter is the preferred method of measuring flicker to IEC Standard 555-3 and is suited to measuring flicker where the load is either changing regularly or irregularly varying loads.

The IEC 868 Flickermeter simulates the Lamp-Eye-Brain chain which is the basis upon which an acceptable level of disturbance to the supply caused by a piece of equipment was decided.

The Flicker Meter produces flicker values of Pst or Pst and Plt where:-

Pst is the short term flicker severity evaluated over a short period (in minutes) and:

Plt is the long term flicker severity evaluated over a long period, (a few hours), using successive Pst values.

IEC set limits for Pst=1 and Plt=0.65 where a Pst > 1, or Plt > 0.65 indicates the equipment under test causes flicker that exceeds the acceptable level.

The PM3000A can measure flicker by the Voltage Method which provides full compliance testing and by the Current Method which is not part of the IEC 868 Flickermeter Standard but provides very effective pre compliance testing.

FULL COMPLIANCE TESTING

EQUIPMENT REQUIRED:

AC Power Source.
Source Impedance.
PM3000A
PC.
Printer.

Connect as in figure 1.

NOTE 1: AC power source must meet stability and distortion requirements of the IEC555 standard.

NOTE 2: Source Impedance of R=0.4Ω, X=0.25 Ω must meet specification of the IEC555 standard.

OPERATION: The PM3000A monitors the voltage fluctuations and performs a series of filter functions (digitally), to produce an instantaneous flicker level. This flicker level is classified into 1024 logorithmically scaled "Bins" to provide a 1024 level classifier.

At the end of the observation period the PC reads the values in the "Bins" and from the results creates a "Cumulative Probability Function" representing the probability of exceeding a particular flicker level for a given percentage of the observation time.

From this the PC calculates values of Pst and Plt from equations defined in this standard.

PRE COMPLIANCE TESTING:

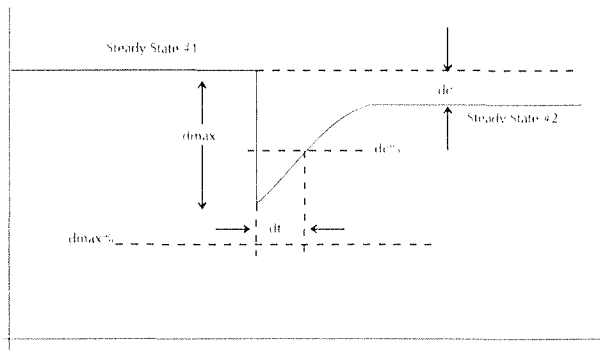
Pre Compliance testing does not require a Source Impedance as the measurement is made by the fluctuating current taken by the load. Connect as in figure 2.

Operation is the same except that the PM3000A determines the fluctuating voltage by calculating the instantaneous voltage drop across a Standard Source Impedance (as set in flickermeter menu) and subtracting this calculated voltage drop from the voltage as seen by the voltage inputs of PM3000A.

VOLTAGE DEVIATIONS TESTS:

The Flickermeter technique provides an excellent assessment of continuous voltage changes but a load that causes a single or very occasional large voltage change will have only a small effect on the Pst/Plt measurement, yet this large voltage change will have a disturbing effect on lamps.

Because of this, measurement of voltage deviations are made throughout the observation period by the PM3000A and the percentage value displayed is the largest change in voltage seen during observation.



If the Steady State Voltage should undergo a voltage change, dmax, which exceeds the prescribed limit dc% for a time dt seconds but within the limit dmax% and returns to a second steady state voltage level dc, which is less than dc%, and dt is less than 200ms the dc, dmax and dt voltage deviations test will pass.

Figure 1 - Connection Diagram for Full Compliance Testing

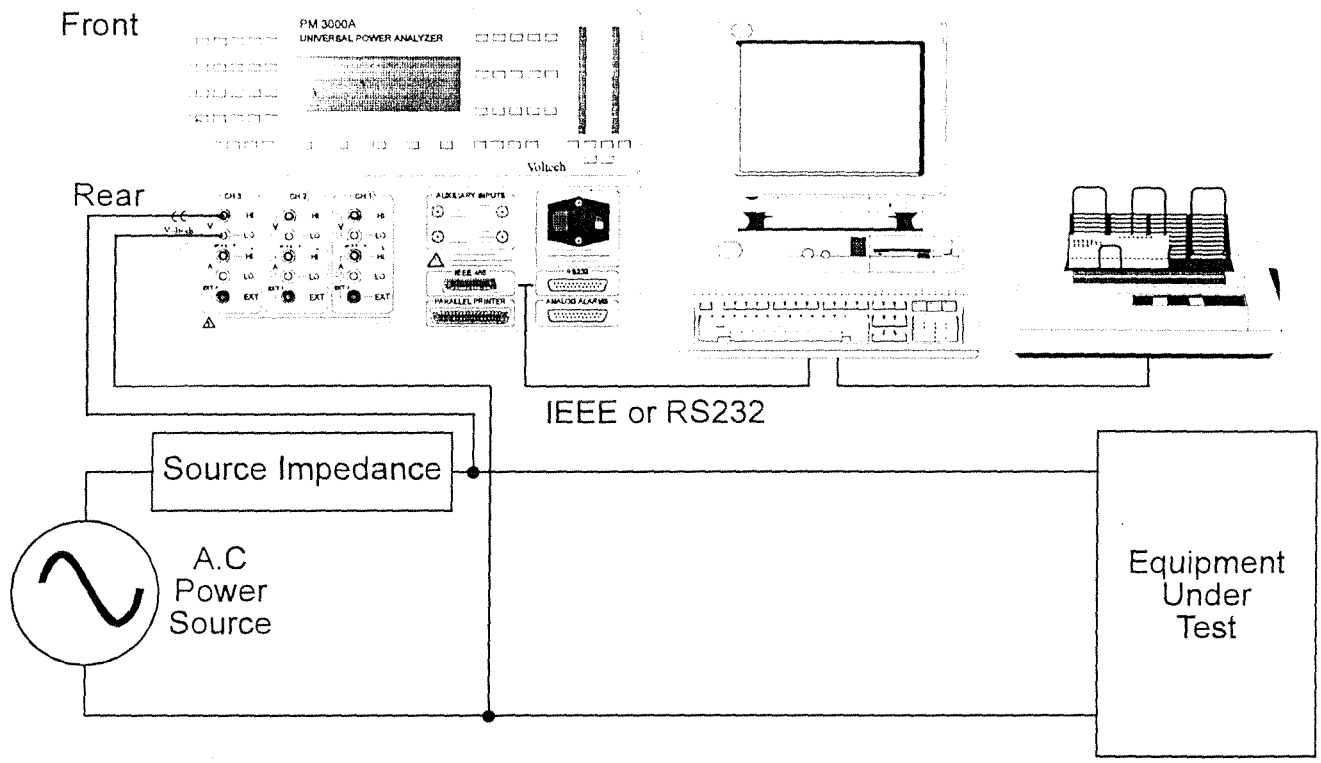
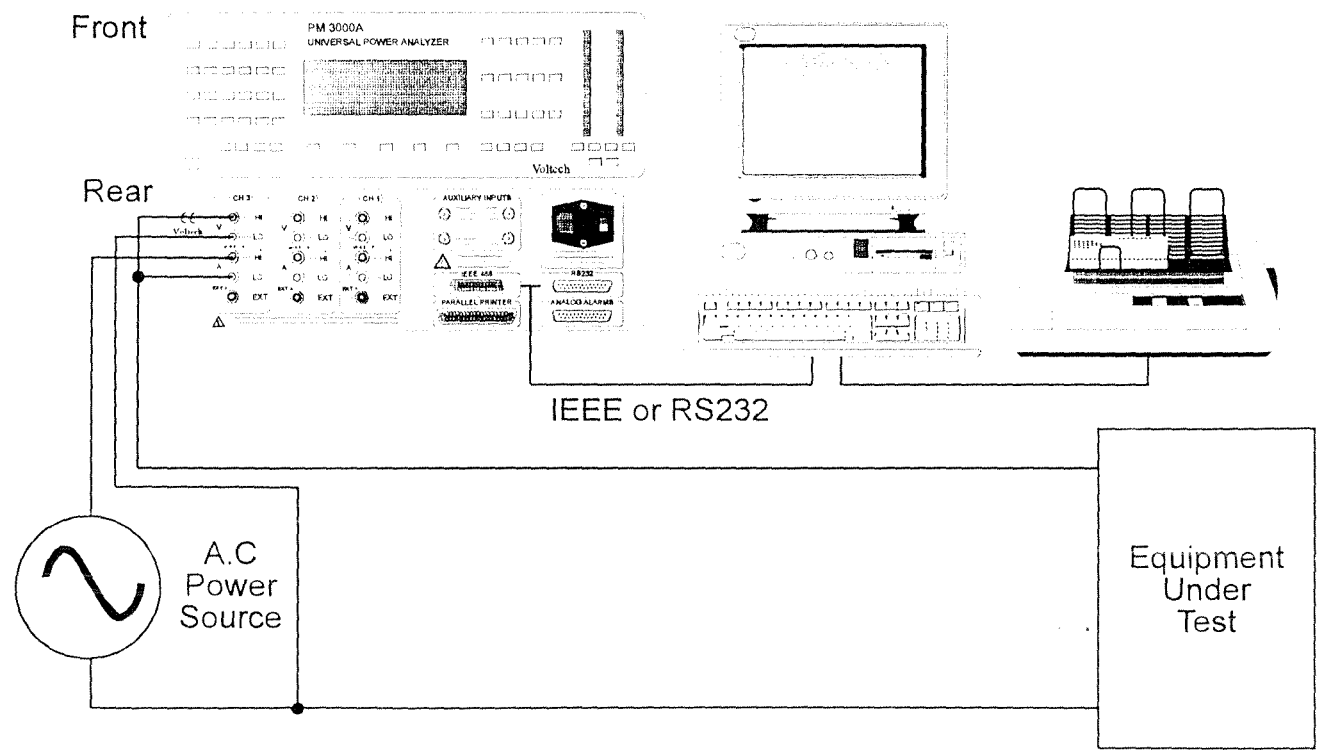


Figure 2 - Connection Diagram for Pre Compliance Testing



3.17.5 >IEC555 Test Software<

The software disk, supplied with your PM3000A, contains full IEC555 PC analysis software which can be operated over RS232 (up to 19200 Baud rate) or IEEE bus. It supports steady state and fluctuating harmonic measurement, and changing voltage and flickermeter measurement.

INSTALLATION: To install to your hard disk from the floppy disk drive, type 'INSTALL C:'. To operate, select directory 'IEC555', type 'RUN' and press [ENTER]. Note that the PC requires VGA graphics to display the graphs and waveforms, and requires DOS 5 (or higher) for printing graphics. You must preload 'graphics.com' from the DOS 5 library, before running the software if you want to print graphic display screens. It should be configured for your printer type.

The main menu provides the following options which are described in detail below.

IEC555 Files
Run Tests.
PlayBack Tests
Set Defaults
Help

Screen prompts are provided at the bottom of each screen display and Help messages appear as required. Use of the yellow letter Hotkeys provide quick selection of options. Generally you will configure the test system with the SET DEFAULTS menu first. Then configure IEC555 files, and run tests.

IEC555 FILES: This menu allows you to create new files and perform associated file management such as editing. File names can be up to 8 characters long, and do not need an extension. After selecting CREATE NEW FILE and providing a filename, the type of analysis can be selected;

Steady state harmonics
Fluctuating harmonics
Changing voltage
Flickermeter

Select using the arrowed keys and [ENTER]. The appropriate settings for the chosen analysis are then displayed. IEC555 Test Class A, B, C or D is selectable for steady state and fluctuating harmonics. Measurement period is selectable for fluctuating harmonics and fluctuating voltage. In addition, the CAPTURE WAVEFORM can be selected for Steady State Harmonic measurements option. This provides the voltage and current waveforms derived from the raw sampled data of the PM3000A. Graphs, waveforms and results can be selected for printout to a PC printer.

RUN TESTS: This menu allows the user to run configured files and checks the waveform for Class D status. The choices are

Run (same data file)
Run (New data file)
Auto Class D determination

(Same data file). This will store data in a file with the same name as the configured RUN file.

(New data file). This allows you to select a different name for a configured data file each time the file is run.

Auto Class D determination. This will automatically return voltage and current waveforms and check that the current waveform conforms to the shape for class D status (or otherwise). This is useful before setting up IEC555 files.

On selecting one of these, the display shows the analysis type to be selected:

Steady state Harmonics
Fluctuating Harmonics
Changing Voltage
Flickermeter

A window list of files is presented. Use the arrowed keys to select, or press the first (and second) letters of the required file name. Then press [ENTER]. Note that if you have many files, they will not all appear within the window.

The PM3000A will be configured, and commence measurement. On completion of the measurement, the results are displayed at the PC together with the selected limit values.

For fluctuating harmonics, two sets of limits (L_1 and L_2) are shown in the bar graph and table of results. L_1 is the standard limit defined in the IEC555-2 specification. L_2 is equal to $L_1 \times 1{\cdot}5$. Harmonics up to the 19th are allowed to reside in

the range between L_1 and L_2 for a maximum of 10% of the observation period, and still pass the test criteria.

PLAYBACK TESTS: This option allows you to playback results saved from a previous test. Select the data file by first choosing the type of analysis (e.g. fluctuating harmonics), and press [ENTER]. Then select the data file as above and press [ENTER].

SET DEFAULTS: The menu provides the following set-ups for the software:

PM3000A Settings
RS232 or IEEE
Printer port
Class D minimum
Help for menus

These options allow you to set up the PM3000A shunt, scaling and select which channel; use IEEE or RS232 for PC communication; at which address or which COM Port to use; select which PC Port to use for the printer; and whether or not to display Help windows on the screen.

Nb. Baud rate for RS232 communication must be set to 9600.

IEEE INTERFACE CARD SETUP

The PM3000A can be operated with IOTECH488B, NATIONAL PII/IIA or many other GPIB interface cards. For help in setting up such cards, refer to section 4.4.10.

3.18 Auxiliary inputs (Torque and Speed) : PM3000A - 001 option only

TO ENSURE ACCURATE RESULTS, THESE INPUTS SHOULD BE USED IN PWM MOTOR MEASUREMENT MODE (SEE SECTION 3.15).

Instruments fitted with this option have two BNC input connectors on the real panel marked AUXILIARY INPUTS A and B. Each input can accept a slowly fluctuating DC level of 0-1V or 0-10V (selected in the menu) from a signal conditioner connected to a motor tacho generator or torque transducer. In addition, the EXTERNAL FREQ BNC connector can be used to input a pulse signal from a transducer which is proportional to motor speed (20V peak to peak maximum).

These features allow the user to monitor motor torque, speed and mechanical power, together with efficiency based upon these inputs and the electrical power delivered to the motor (monitored on the main channel inputs).

Connect the motor electrical inputs to CH1/CH2/CH3 in 3Ø3W or 3Ø4W mode. Connect the torque and speed inputs to the marked BNC inputs (Channel A = Torque input, Channel B or EXTERNAL FREQ = Speed input). Select [INTERFACE] and press [SELECT] to choose >Auxiliary Inputs< and press [ENTER]. The display the shows:

AUXILIARY INPUTS
>disabled<

Use the [SELECT] and [ENTER] keys to >enable< this mode. The display then shows:

TORQUE INPUT
> 10V full scale<

Use the [SELECT] and [ENTER] keys to choose the appropriate DC voltage range for the input to the Torque Channel. (10V or 1V).
The display shows:

TORQUE INPUT
>torque in Nm<

Use the [SELECT] and [ENTER] keys to choose Newton-metres or foot-pounds (ftlb) as the units of torque for the display. The display shows:

TORQUE INPUT
1.000 per Volt

Use the digit keys to enter the scaling for the torque input in the selected units, and press [ENTER]. The display shows:

RPM INPUT
>pulse<

Use the [SELECT] and [ENTER] keys to choose the appropriate input for motor speed (rpm). Choose >pulse< if a pulse transducer output has

been connected to EXTERNAL FREQ. Choose >voltage< if a voltage transducer output has been connected to AUXILIARY B input.

If >voltage< has been selected, the display then shows:

RPM INPUT
>10.0V full scale<

Use the [SELECT] and [ENTER] keys to choose the appropriate DC voltage range for the input to the speed channel. The display shows:

RPM INPUT
1.000 per Volt

Use the digit keys to enter the scaling for the speed input, and press [ENTER]

If >pulse< has been selected for the RPM INPUT the display shows:

HIGH FREQUENCY
>disabled<

Use the [SELECT] and [ENTER] keys to enable high frequency mode if required. The screen now shows:

RPM INPUT
1.000 pulses/rev

Use the digit keys to enter the scaling for the speed input, in pulses per revolution of the motor and press [ENTER].

With 3Ø3W or 3Ø4W wiring selected and [W] selected for display, press the [Σ] channel key. The display will automatically show (Metric units as example)

xxxx Nm	xxxx rpm
xxxx W	xxxx %

The top line shows Torque and Speed. The bottom line shows Mechanical Power in Watts or Horse power (Torque × Speed) and Motor Efficiency in percent.

Pressing the [DISPLAY] key when [ΣW] is selected, will toggle the display between the mechanical data presentation (auxiliary inputs), and the electrical data presentation (CH1, CH2, CH3 inputs). In this way, the electrical power value can be inspected. If any other channel or parameter e.g. [PF] is selected during the electrical data display, press [W] and [Σ] before pressing [DISPLAY] to return to the mechanical data display.

Efficiency is calculated from the formula

$$100 \times \frac{Power\ Out}{Power\ In}\ \%$$

Where Power Out is the Mechanical Power displayed on channel Σ, and Power In is the simultaneous electrical power input to the motor on the Σ channel.

If a background selection printout is requested, while this mode is selected, it will automatically printout the auxiliary data (there is no means of requesting it in the printer menu). An example printout is shown below.

```
14 June 93                17:12
RMS DC COUPLED
VOLTAGE FREQUENCY SOURCE
************* CHANNEL 1 *************
Watts        +154.67 W
Vrms           3.936  V
Arms          39.30   A
************* CHANNEL 2 *************
Watts        +0.000  W
Vrms           0.000  V
Arms           0.000  A
************* CHANNEL 3 *************
Watts        +154.88 W
Vrms           3.940  V
Arms          39.31   A
************* SUM 1+2+3 *************
Watts        +309.6  W
Vrms           4.547  V
Arms          39.31   A
************* AUXILIARY *************
Torque        45.73   Nm
Speed         45.68   rpm
Power        218.8    W
Efficiency    70.67   %
*****************************************
```

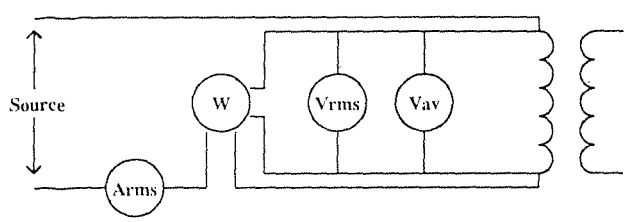
The mode can be selected from a PC using the :AUX command. Data can be returned using :BRD:AUX? and :FRD:AUX?

3.19 Transformer Test Mode

The Transformer Test Mode has an application in the measurement of 'no-load' losses when testing large (eg 10 to 20 kVa) power transformers. The 'no-load' losses include core loss, dielectric loss, conductor loss in the winding due to excitation current, and conductor loss due to circulating current in parallel windings. The core loss is usually the most important; it is a function of the magnitude, frequency and waveform of the input voltage, and it also varies significantly with temperature.

The method of testing is specified in the Standards: IEC76 - 1 and IEEE C57.

An example single phase test circuit as specified in IEEE C57 is as follows:



where:

Arms = Ammeter (rms)
W = Wattmeter
Vrms = Voltmeter (rms)
Vav = Voltmeter (mean-sensing - rms scaled for sinewave).

Other test circuits are shown in the Standards, involving both current and voltage (instrumentation) transformers, and three phases.

IEEE C57 also quotes the formula:

$$P_c(T_m) = \frac{P_m}{P_1 + kP_2} \qquad k = \left(\frac{E_r}{E_a}\right)^2$$

where:

T_m = temperature
$P_c(T_m)$ = the no load losses corrected for waveform at temperature T_m
P_m = the measured no load losses at temperature T_m
P_1 = the ratio of hysteresis loss to total iron losses
P_2 = the ratio of eddy-current loss to total iron losses
E_r = the test voltage measured by the rms voltmeter (≡ Vrms)
E_a = the test voltage measured by the mean-sensing voltmeter (≡ Vav)

In the Transformer Test Mode, the PM3000A will measure the Vav, and will calculate the factor 'k' and the corrected power P_c (using a value of 0.5 for both P1 and P2). Any one of these may be displayed.

Setting Up Transformer Test Mode

To set up Transformer Test Mode using the keyboard, press the keys:

[F], [9], [ENTER]

to display

F[9] TRANSFORMER MD <select> or <enter>

Press [ENTER] to display

TRANSFORMER MD >off<

Press [SELECT] to display in turn

TRANSFORMER MD >Vav<

TRANSFORMER MD >k-fctr<

TRANSFORMER MD >P-corr<

and [ENTER] the choice.

The measured results are displayed as

0.000 V	0.000 A
+0.000 W	0.000 V*

if 'Vav' is selected, or

0.000 V	0.000 A
+0.000 W	0.000

if 'k' is selected, or

0.000 V	0.000 A
+0.000 W	0.000 W*

if 'P_c' is selected,

where the lower right-hand number is the selected parameter 'Vav', 'k' or 'P_c'

SECTION 4

IEEE488 OPERATION

4.1 Introduction

The PM3000A is configurable to IEEE488.1 and IEEE 488.2 protocol standards . Refer to section 4.5 for IEEE488.1 and section 4.6 for IEEE488.2 respectively

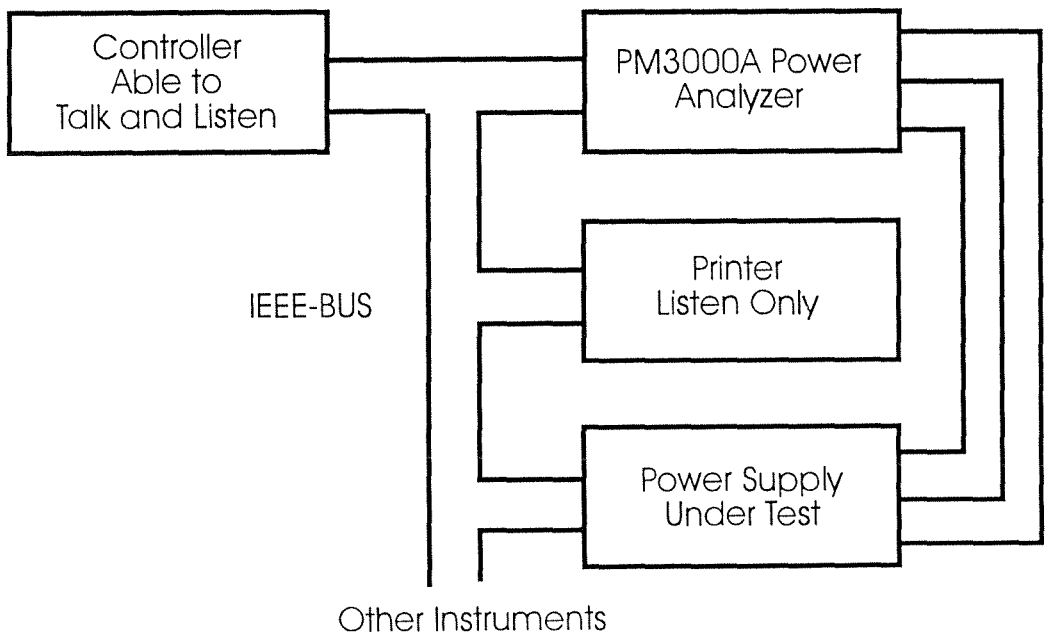
To enable IEEE 488.2 mode, it is necessary to enter the IEEE488 option on the [INTERFACE] menu, >enable< IEEE488 and select IEEE488.2 operation.

To enable IEEE488.1 mode, it is only necessary to >enable< IEEE488.

The IEEE Interface allows the PM3000A to form part of a system, providing measurement data to other parts of that system. In addition, the instrument can be instructed via the interface so that the instrument's configuration can be selected remotely. A typical installation is shown below.

The IEEE-488 bus consists of a controller (e.g. a computer with an IEEE card) and one or more instruments. These may be talkers (able to send results) or listeners (able to receive commands) or talker-listeners (able to receive commands and send results).

The PM3000A IEEE-488 interface is a full talker-listener as defined by the IEEE Standard 488-1978. A menu driven software demonstration package (PM3PC) allows the PM3000A to be exercised over the IEEE interface. Various facilities may be selected through a series of user prompts, then saved on disc. Any of the configuration files created in this way may be run on the PM3000A and the results stored on disc.



The following subset is implemented:

SH1	Source Handshake complete capability
AH1	Acceptor Handshake complete capability
T6	Basic Talker, with serial poll and unaddress with MLA
TE0	No extended Talker
L4	Basic Listener, unaddress with MTA
LE0	No extended Listener
SR1	Service request complete capability
RL1	Remote-Local complete capability
PP0	No parallel poll capability
DC1	Device Clear complete capability
DT1	Device Trigger complete capability
C0	No controller capability

4.2 Addressing

Each instrument has an address by which it is recognised on the bus. The PM3000A has a default address of 9 which may be altered via the interface menu as follows:

Press [INTERFACE] key, using [SELECT] key step through various options until display shows:

INTERFACE >IEEE-488<

Then press [ENTER]. Select >enabled< and press [ENTER]. Enter a new address when prompted by the display. Press [ENTER] to store this value. This remains the default value, even when the PM3000A is powered off. When the PM3000A is addressed as a talker results may be read by the controller, as a listener it will respond to commands sent by the controller.

After the PM3000A has been addressed the REMOTE LED will illuminate and the keyboard will be locked out. It is possible to return to front panel control by pressing the [LOCAL] key. The controller can send a LOCAL LOCKOUT command which will disable the [LOCAL] key if required.

4.3 Data Sources

The PM3000A may send information from four different sources: display, background, integrator and datalog.

i) Display buffer

The contents of the foreground results buffer will be sent. This is the default setting.

ii) Background results buffer

When the PM3000A takes a measurement it computes not only the three or four results to be viewed on the front panel display, but also results for all the functions on every active channel. These are stored and averaged in the background results buffer and are available over the IEEE bus.

iii) Integrator results buffer

When the integrator is stopped the results for all active channels are automatically stored in the integrator results buffer.

These results only become available at the end of a measurement cycle. The duration of each cycle normally varies from 0.5 - 1 second. This time will increase if more than one harmonic is to be analysed or the input frequency is very low. e.g. A 0.1Hz input will take at least 10 seconds to update results.

iv) Datalog

Data captured during datalog can be transferred to the PC as computed values, as 8 bit sample data or as 16 bit filtered data

4.4 PM3PC IEEE Software with IEC555-2 Current Limit Checking

The software disk supplied with your PM3000A is designed to run with an IBM compatible PC fitted with an IEEE interface card such as IOTECH 488B or NATIONAL PCII/IIA.

It allows you to configure and run the PM3000A for harmonic analysis from your PC, storing the measured results in files which can be viewed from the main menu.

The harmonic data can be easily viewed as bar graphs and reconstructed into current and voltage waveforms.

A special feature of this software is its IEC555-2 current harmonic limit checking. The setup menu allows you to select class A, B, C or D as IEC555 standard against which the results are compared:

* The PC displays a banner message to advise pass/fail status compared to the chosen standard when the results are returned to the PC.

* The filed harmonic results are listed against the IEC limits, and individual harmonics are verified as passed or failed.

* The bar graphs display the harmonics and the chosen IEC555 limits for an overview of the harmonic performance of the load under test

An additional useful feature is the ability to play back acquired measurement data at any time, with or without a different IEC555 class limit, to review data and graphs.

In addition, external data files obtained from the PM3000A (such as from a data tracker) can be easily imported into the software to allow limit checking and waveform synthesis.

4.4.1 Installing, Startup and the Main Menu

We recommend that the software is run from the hard disk drive for speed and performance. To install, insert the disk into drive a: and type install after the a: drive prompt . Screen prompts will guide you to execute the procedure. To start the program, type "run". This presents you with the main menu page supplying the following options:

Select options
Run options
View results file
Display harmonics
Print results file
Play back data file
Exit to DOS

Options are selected using the cursor controlled by the arrow keys, or by using the highlighted hot keys. A description of each option is given below.

4.4.2 Demonstration example

An example set of results is stored on the disk to demonstrate its use. You will find this data in the file PM3PC.DAT, derived from running the setup file PM3PC.IEE.

The load under test was a switched mode power supply.

From the main menu, you can view the results, display the graphs and use the playback function to re-analyse the data under different IEC555 class limits by following the guidance given below.

4.4.3 Select Options

This option allows you to set up configuration of the PM3000A. Press ENTER (or S) to select. A window appears with previous setup programs and a "New File". Use the cursor to select an existing file that you want to edit, or select New File to create one.

If New File is selected, the display will prompt for a filename . Eight character names with a .IEE extension are allowed. You need not type the extension.

The display then presents the PM3000A setup menu. The menu is conveniently set up for standard IEC555 current harmonic measurements to class A. Note the controls at the bottom of the screen, which are accessed by the cursor or hotkeys. Select EDIT to change PM3000A configuration or IEC555 class.

The cursor moves into the setup field. To adjust any parameter, use the space bar to change it, and the number keys for data entry. Pressing ENTER when the cursor is over "Channel select" or "functions" will reveal windows for channel selection and function measurement selection respectively.

Note that some setup options are only selectable when valid. For example, 'Fastmode' is only available when harmonics are not selected.

To exit the setup menu, press the escape key and select SAVE.

4.4.4 Run Options

On selecting this option, a window is revealed with program files available to be run (the list may be longer than the available window - to access the hidden files run the cursor down the list). Choose the file to be run with the cursor and press ENTER.

The program first offers you the choice of changing the data file to which the results will be sent. This allows you to rerun the same setup file and retain the data for each run in separately named files. The filename can be up to eight characters, terminated with a .DAT extension. You do not need to type the extension.

Thereafter, the program continues automatically, advising status on the PC screen. On completion, the program returns to the main menu page.

4.4.5 View Results File

You can view the last set of readings obtained from the PM3000A by entering this option. Alternatively, you can view previous data by the Playback option (see later).

The file presents the following information;

* The returned data from the PM3000A.

* A table comparing the measured harmonic data with the selected IEC555 class limits.

To exit this option press the ESC key.

4.4.6 Display Harmonics

The harmonic results stored in the Viewdata file can be examined graphically, and reconstructed into current and voltage waveforms in this option. The graphs can be printed by using the PRINT SCREEN key if you are operating your PC on DOS 5.0 or higher.

The software will normally recognise the type of graphics adapter you are using on your PC. If you experience difficulty in obtaining graphics displays it is because it has failed to recognise the adapter. In this case, you will need to set up the CONFIG.VPM file on the disk to correct this situation. See section 4.4.9 for guidance.

The harmonic bar graphs display the harmonics and the IEC limits if selected. If the current bar graph values are very small compared to the displayed IEC limits, you can obtain better resolution by rerunning the data through the playback option with no limits set.

To view successive graphs, press the ENTER key. If you do not want to review all graphs, press CTRL+C to exit back to the main menu.

4.4.7 Print Results File

The results currently stored in the Viewdata file can be printed using this option.

4.4.8 Play Back Data File

This option allows you to rerun data obtained from either the PM3000A directly or imported from a datatracker, with an option to reselect the IEC555 limits applied.

Press ENTER to select the option and a window appears containing all data files with .DAT extensions. In addition, the Newfile option allows you to select a data file for review which does not have this extension (eg from a datatracker). Choose the file to run with the cursor, and then you are given the option to change the limits applied. The program will reprocess the chosen data into the Viewdata file and graphic displays, and then returns to the main menu. You can then use the View Results file and Display Options to inspect the data.

Note that to review a data file under class C and D limits, the file must contain power factor data and power data respectively.

4.4.9 The CONFIG.VPM File

As described in Display Harmonics, you can use this file to set up for graphic display in cases of difficulty.

Exit to DOS from the main menu and type,

ed config.vpm

and press ENTER.

Now type into the file the # command for the screen type. For example, for an EGA screen adapter;

#screen = ega

Now press ALT X, enter, followed by Y to save the change

Return to the main menu and use Playback to rerun the data into the Viewdata file. You should now be able to view the graphs in the Display option. Once this has been set up for your PC, there will be no further need to adjust the software.

4.4.10 Set-up of IEEE Interface Cards

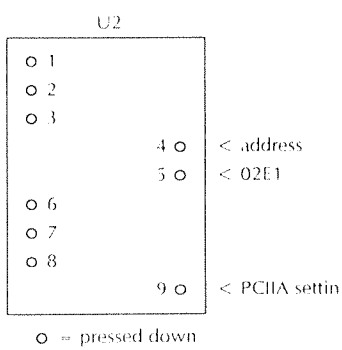
This software will operate with a wide range of interface cards, provided that they have been set up correctly. The RUN.BAT file sets up the IEEE card as a system controller (SC) on bus address 21 (B21) with DMA transfers set for channel 1. Its I/O port address is set at A&H02E1.

It is generally only necessary to change the I/O address to obtain successful communication. Details of settings are outlined below for two popular cards, IOTECH 488B and NATIONAL PCII/IIA.

IOTECH 488B: There is no need to make any adjustments to the standard factory default settings on this card.

NATIONAL PCII/IIA: This card needs to be set for address 02E1 and PCIIA operation as below. The jumper settings are:

IRQ7..... interrupt level 7
DRQ1 and DRCK1..... DMA channel 1



4.5 IEEE 488.1 Operation

It is first necessary to enable IEEE operation by selecting the [INTERFACE] menu , and pressing [SELECT] until >IEEE488< is displayed. Press [ENTER], and use the [SELECT] key to obtain >enabled< on the display. Press [ENTER]. Then select the address and press [ENTER]. The next display is for selection of IEEE488.2. Select >disable< and press [ENTER].

The following commands are available to control the operation of the PM3000A. Additionally, ALL OF THE IEEE488.2 COMMANDS are able to be used alongside these commands in IEEE488.1 mode. (See section 4.6.2) Terminate command strings with a line feed or assert EOI (End or Identify) with the last byte.

Upper and lower case are ignored with commands, eg p4 or P4 are acceptable. White space is ignored, eg "output; p1" and "output;p1" are equivalent.

COMMAND SUMMARY

A	Averaging
B	Data output source (display / buffer / integrator / data log)
C	Channel select
D	Display setup
E	Phase-phase/phase-neutral switch (3phase 4wire)
F	Parameter function select
G	Fast mode. switch
H	Single harmonic select
I	Integrator switch
J	Amps scaling factor
K	Voltage scaling factor
L	Multiple harmonics select
M	Service request switch
N	AC/DC coupling select

O Mean or RMS volts/amps select

P Wiring select

Q Frequency source select

R Range select (RA:amps RV:volts)

S Internal/external shunt select

T Trigger

U Parallel port control

W Analogue outputs only select

X Data log setup

Y Fundamental display select

4.5.1 Averaging:

FORMAT A [00-64]

This command selects the display and background averaging. It resets the display and background averaging.

A00 - Selects auto averaging. (16)

A01-A64 - Selects the number of display and background averages.

4.5.2 Data Output Source: Display

FORMAT B [0]

B0 will return the contents of the 40 character display buffer (ensure IEEE488.2 is disabled for this command). The results seen on the display will be returned in a 40 character string followed by a line feed. The buffer may only be read once each measurement cycle and will return a single line feed on each subsequent read until new data is available.

4.5.3 Data Output Source: Buffer

B [1] _xx_x_xxxxxxxxxxxxxxxxxxxxxxxx

B1 - This allows the full versatility of the instrument to be utilised on the IEEE bus. Over 400 different measurements may be initialised with this one command.

There are 27 arguments in three fields consisting of:

i. Channel Select (2 digits)

This field comprises the decimal addition of the following:

01	Ch 1 results
02	Ch 2 results
04	Ch 3 results
08	SUM results
16	Neutral results

e.g. To select results from Channels 1 and 2 only the string to send would be:

B1 03 x xxxxxxxxxxxxxxxxxxxxxxxx

To select results from Channels 1 and 2 and Neutral:

B1 19 x xxxxxxxxxxxxxxxxxxxxxxxx

To select results from Channel 3 only send:

B1 04 x xxxxxxxxxxxxxxxxxxxxxxxx

ii. Select fundamental components (1 digit)

B1 xx 1 xxxxxxxxxxxxxxxxxxxxxxxx will store the fundamental components of those functions where the PM3000A computes the fundamental.

B1 xx 0 xxxxxxxxxxxxxxxxxxxxxxxx will not store fundamental components.

iii. Select function (24 digits)

Digit 1 selects Watts, digit 2 selects VA etc To select the function write 1. Write 0 if not required.

Position Table:

1. Watts
2. VA
3. Vars
4. Volts
5. Amps
6. Power Factor
7. Volts Peak
8. Amps Peak

9. Volts Crest Factor
10. Amps Crest Factor
11. Not Used
12. Impedance
13. Not Used
14. Not Used
15. Not Used
16. Not Used
17. Not Used
18. Not Used
19. Not Used
20. Voltage Harmonics
21. Amps Harmonics
22. Volts Distortion Factor
23. Amps Distortion Factor
24. Frequency

E.g. To store Ch 1
Watts,Volts,Amps and Freq (no fundamentals):

B1 01 0 10011000000000000000001

Ch 1,2,3
Volts, Amps, V Peak, A Peak, V THD, A THD
(with fundamental Volts and Amps):
B1 07 1 00011011000000000000110

Ch 1,2,3,SUM,Neutral
Volts, Amps, Freq, Amps, Harmonics 0-20
(no fundamentals)
B1 31 0 00011000000000000001001 then send
'L20 0' to set the maximum harmonic at 20

Once the B1 command has been set the PM3000A will measure and average all the functions selected.

However nothing will be entered into the results store until a trigger command 'T1' is sent. At the end of the next measurement cycle the averaged results will be stored and may be read sequentially over the bus.

A further trigger 'T1' will enable the store to receive a new set of results at the end of the next measurement cycle.

The B1 command should not be used in a multi line command.

4.5.4 Data Output Source: Integrator

FORMAT B [2]

B2 - Allows access to the integrator result store.

The integrator store is filled by the integrator stop 'I0' command, and can be read sequentially following 'B2'.

The integrator results (inc fundamentals) for all phases are stored automatically by 'I0' (integrator stop).

4.5.5 Data Output Source: Data Log

FORMAT B [3]

B3 Only use after Data Log to access the individual samples.
See DATA LOG (section 4.5.27).

4.5.6 Channel Select

FORMAT C [1-5]

Selects the displayed Channel

C1	Channel 1
C2	Channel 2
C3	Channel 3
C4	SUM
C5	NEUTRAL

This function will have no effect if the selection is invalid. (eg if WIRING is configured for single phase two wire and 'C4' (SUM) is sent).

This command will reset the display averaging.

4.5.7 Display Setup

These commands will reset the display averaging.

FORMAT DL [0-7]

This command will configure the display.
DL will set the top left hand display window
Top Left Hand Window

DL0	Volts	DL5	Power factor
DL1	Amps	DL6	Peak Volts
DL2	Watts	DL7	Peak Amps
DL3	VA		
DL4	Frequency		

FORMAT DR [0-4]

DR will set the top right hand window
Top Right Hand Window

DR0	Volts	DL5	Power factor
DR1	Amps	DL6	Peak Volts
DR2	Watts	DL7	Peak Amps
DR3	VA		
DR4	Frequency		

FORMAT DM [0-1]

DM will set the SUM display mode. (See 3.11.6)
DM0 Allows all three channels plus sum to be displayed
DM1 Sets the SUM Display mode to single

The options are:

4.5.8 Three Phase Four Wire Volts Measurement

Phase to Phase or Phase to Neutral

FORMAT E [0-1]

Selects the voltage measurement system for 3 phase 4 wire measurements only.

E0 Selects phase to neutral voltage measurements
E1 Selects phase to phase voltage measurements

If 3 phase 4 wire measurements are being made E0 or E1 should be sent at the start of the program to ensure the correct voltage measurements are taken.

These commands have no relevance for any other wiring configuration.

4.5.9 Select Function

FORMAT F [00-23]

The main measurement function (bottom row of the display) may be selected with this command. The leading zero is necessary.

The functions are:

F00	Watts
F01	VA
F02	Var
F03	Volts
F04	Amps
F05	Power Factor
F06	Volts Peak
F07	Amps Peak
F08	Volts Crest Factor
F09	Amps Crest Factor
F10	Inrush Current
F11	Impedance
F12	Watt Hours
F13	VA Hours
F14	Var Hours
F15	Ampare Hours
F16	Average Power Factor
F17	Correction Vars
F18	Toggle Fundamental
F19	Voltage Harmonics
F20	Current Harmonics
F21	Voltage Distortion Factor
F22	Current Distortion factor
F23	Frequency

4.5.10 Fast Mode

FORMAT G[0-1]

Sets the PM3000A to the fast mode of operation (no harmonic analysis), where measurement times are reduced by a factor of 10%. Results needing harmonic data will not be valid in this mode.

G0 Fast mode off (default)
G1 Fast mode on

4.5.11 Single Harmonics

FORMAT H [00-99]

Use in conjunction with F19 and F20 To read individual Harmonics. Send Hxx and then F19 for V Harm xx or F20 for A Harm xx.

For example, the following sequence programs the instrument to display the voltage harmonic 5

H05F19

This command resets the display averaging.

H00 Harmonic 0 (dc)
H01 Fundamental component only
H02-99 Harmonics 2 - 99

See DATA OUTPUT SOURCE for multiple harmonics. (4.5.3)

4.5.12 Integrator Control

This command allows control of the integrator function

I1 Starts integration

I0 Stops integration and stores all integrator values in the integrator result store. The contents of the store may then be accessed with the B2 command (see Data output control).

The integrator results may be read from the display at any time by the F12-F17 commands.

4.5.13 Amps Scaling Factor

FORMAT J [D-U][1-99999]

Sets amps scaling factors for all three channels. Scaling up (JU) will multiply the result by the scaling factor. Scaling down (JD) will divide the result by the scaling factor.

JU1000 Scale Amps up by 1000:1
JD10.5 Scale Amps down by 10.5:1
JU1 Set Scaling Factor 1:1

Scaling factor may not be less than one and may be no more than 5 digits plus decimal point.

The **SCALING LED** will illuminate if a scaling factor of other than 1:1 is set for volts or amps.

This command must not be used in a multi command line. Any commands following this will not be recognised.

4.5.14 Voltage Scaling Factor

FORMAT KU[1-99999]

Sets voltage scaling factors for all three channels

KU1000 Scale Volts up by 1000:1
KU10.5 Scale Volts up by 10.5:1
KU1 Set Scaling Factor 1:1

Scaling factor may not be less than one and may be no more than 5 digits plus decimal point.

There is no command to scale the volts down.

This command must not be used in a multi command line. Any commands following this will not be recognised.

4.5.15 Multiple Harmonics

FORMAT L [00-99] [0-1]

Use after the B1 command where V Harmonics and/or A Harmonics have been selected. All the harmonics up to and including the limit[00-99] will be analysed and averaged.
The second field selects odd harmonics only to be returned.

L01 0 Will return fundamental component only

L02 0 Will return dc, fundamental and all
| harmonics up to the limit.
L99 0

L02 1 Will return odd harmonics only up to the
| limit.
L99 1

e.g. 'L17 1' will analyze harmonics 1,3,5,7,9,11,13,15 and 17

'L08 0' will analyze harmonics 0,1,2,3,4,5,6,7 and 8

4.5.16 Service Request Enable

FORMAT M [0-1]

Enables or disables the service request.

M0 disables service request
M1 enables service request on data ready

After the 'M1' command the service request line will be asserted when data is ready to be read.

The PM3000A will return a status byte after a serial poll. This byte has the following significance.

bit 0 data ready
bit 1 background averaging has reached maximum
bit 2 display averaging has reached maximum
bit 3 not used
bit 4 not used
bit 5 not calibrated or calibration corrupted
bit 6 set if service requested
bit 7 not used

e.g.

01 means new data is ready
65 means data is ready and the srq line has been asserted
00 no data is ready

4.5.17 AC/DC Coupling Selection

FORMAT N [0-1]

This command selects ac or dc coupling.

N0 AC+DC coupling selected.
N1 AC coupling only.

There is a 1 Sec delay after this instruction is executed. This command resets the display and background averaging.

4.5.18 Mean/RMS Volts and Amps Selection

FORMAT O [0-1]

Set the Volts and Amps results to read in either RMS or MEAN terms.

O0 Set to RMS
O1 Set to MEAN

This command will be inoperative if the integrator is running.

The display averaging will be reset by this command.

4.5.19 Wiring Select

FORMAT P [1-5]

Selects the wiring configuration. This command resets the display and the background averaging.

P1 Sets single phase two wire
P2 Sets single phase three wire
P3 Sets three phase three wire
P4 Sets three phase four wire
P5 Sets the channel 3 only mode

After sending P4 (3 phase 4 wire) it is recommended that either the E0 (phase - neutral volts) or E1 (phase - phase volts) command is sent.

4.5.20 Frequency Source

FORMAT Q [0-3]

This command selects either the CH1 Volts or CH1 Amps or External as the frequency source.

Q0 Selects the Ch1 Volts
Q1 Selects the Ch1 Amps
Q2 Selects the External frequency input (0.1 Hz minimum)
Q3 Selects the External frequency input (5Hz minimum)
Q4 Selects the 50Hz only mode (see 3.17)
Q5 Selects the 60Hz only mode (see 3.17)

This command resets the display and background averaging.

The Q2 command will take approx. 10 seconds to make a reading if a low frequency (<5 Hz) is to be measured.

4.5.21 Select Voltage Range

FORMAT RV [00-12]

Selects the voltage range.

RV00 Selects auto ranging
RV01 Selects 0.5 Volt Peak range (manual)
RV02 Selects 1.0 Volt Peak range (manual)
RV03 Selects 2.0 Volt Peak range (manual)
RV04 Selects 5.0 Volt Peak range (manual)
RV05 Selects 10 Volt Peak range (manual)

RV06 Selects 20 Volt Peak range (manual)
RV07 Selects 50 Volt Peak range (manual)
RV08 Selects 100 Volt Peak range (manual)
RV09 Selects 200 Volt Peak range (manual)
RV10 Selects 500 Volt Peak range (manual)
RV11 Selects 1000 Volt Peak range (manual)
RV12 Selects 2000 Volt Peak range (manual)

The commands RV01 - RV12 reset the display and background averaging. The auto ranging command RV00 has no effect on averaging.

4.5.22 Selects Amps Range

FORMAT RA [00-12]

Selects the amps range of all three channels

RA00 Selects auto ranging
RA01 Selects 0.05 Amp Peak range (manual)
RA02 Selects 0.1 Amp Peak range (manual)
RA03 Selects 0.2 Amp Peak range (manual)
RA04 Selects 0.5 Amp Peak range (manual)
RA05 Selects 1.0 Amp Peak range (manual)
RA06 Selects 2.0 Amp Peak range (manual)
RA07 Selects 5.0 Amp Peak range (manual)
RA08 Selects 10 Amp Peak range (manual)
RA09 Selects 20 Amp Peak range (manual)
RA10 Selects 50 Amp Peak range (manual)
RA11 Selects 100 Amp Peak range (manual)
RA12 Selects 200 Amp Peak range (manual)

The commands RA01 - RA12 reset the display and background averaging. The auto ranging command RA00 has no effect on averaging.

4.5.23 Internal/External Shunt Selection

FORMAT S [0-1]

This command selects the internal shunt or external voltage input for the current channel.

S0 The AMPS input is taken from the 30 Amp shunt.
S1 The AMPS input is taken from the external input.

This command resets the display and background averaging.

4.5.24 Trigger

FORMAT T [1]

Triggers the instrument to take a reading after the B1 command has been sent. (Selected results mode).

T1 The selected results will be prepared for output after the next measurement cycle.

4.5.25 Parallel Port Control

FORMAT U [00-63]

Controls the lowest six bits on the parallel port.

U00 Resets bits 0-5
U03 Sets bits 0,1 Resets bits 2,3,4,5

The parallel port may be utilised with this command to switch external logic.

4.5.26 Analogue Outputs Only Selection

FORMAT W [0-1]

Converts the signal on each input channel to a 0-5 Volt analog output.

W0 Turns off the analog outputs
W1 Turns the analog outputs on

All other functions are suspended while the analog outputs are enabled. This command will be ignored if the integrator is running. Analog connector (25 way 'D' socket):

Pin 1 - Amps Channel 1
Pin 3 - Volts Channel 1
Pin 5 - Amps Channel 2
Pin 7 - Volts Channel 2
Pin 9 - Amps Channel 3
Pin 11 - Volts Channel 3
Pins 2,4,6,8,10,12 - Ground

Channels 2 and 3 will only be operative if the wiring is selected for multi - phase (P2 - P4).The wiring and range commands (P and RV,RA) are still available with the analog outputs enabled.

4.5.27 Data Log

FORMAT X [0]
X [1] _x_x_x

This command allows entry to the data logging routines. A 'B1' command should be sent first to specify which results are to be calculated and stored. If the integrator is running this command will be ignored.

X0 Exits the data log mode and should be used before returning to normal operation.

X1 Enters data log mode. There are three fields

i. Capture Time 0-4

X1 0 x x 30 milli Seconds
X1 1 x x 60 milli Seconds
X1 2 x x 300 milli Seconds
X1 3 x x 1 Second
X1 4 x x 5 Seconds

ii. Internal or External Trigger

X1 x 0 x The PM3000A will start data logging without waiting for any further trigger.

X1 x 1 x The PM3000A will wait for either:

a) The external trigger input to be brought low.

b) An IEEE bus GET (Group Execute Trigger)

iii. Data Dump

This will allow the user to transfer the data captured during data log to the computer for further analysis. After the data log is complete a 'B3' command must be sent to read the samples. The 8 bit data (000-255) will be returned for each channel (plus neutral if applicable) in the following formats:

SINGLE PHASE TWO WIRE
V1 A1 (6000 S/Ch)

SINGLE PHASE THREE WIRE
V1 A1 V2 A2 N (6000 S/Ch)

THREE PHASE THREE WIRE
V1 A1 V2 A2 (6000 S/Ch)

THREE PHASE FOUR WIRE
V1 A1 V2 A2
V3 A3 N (6000 S/Ch)

X1 x x 0 Data Dump off (for normal format data)
X1 x x 1 Data Dump on (for 8 bit data)

To use the data log mode with the data dump facility:

a. Set the list of results required with the B1 command.

b. Send the X1 x x 1 command.

c. Wait until data log is complete.

d. Read the computed data.

e. Send 'B3'.

f. Read the data (6000 sets of samples).

g. Send 'X0' data log off.

4.5.28 Fundamental Display Selection

FORMAT Y [0-1]

Turns the fundamental lamp on or off to select the fundamental component of the displayed results.

Y0 Display reads total values (Fund LED off)
Y1 Display reads fundamental values (Fund led on)

This command will not work where the fundamental button would not have valid effect (e.g. fundamental amps peak is not valid).

4.5.29 Example 1

To read single phase VA ,WATTS and POWER FACTOR on PM3000A at address 9.

* Send MLA 9 address the PM3000A to listen.

* The following sequence sets to single phase with W,VA,PF on the display, turn

fundamental LED off. Read from the display buffer.

'P1DL2DR3F05Y0B0'

* Wait 0.5 secs

* Send MTA 9 address the PM3000A to talk and read 40 character string.

* The PM3000A will return

+121.52 W 196.76 VA PF = 0.617

4.5.30 Example 2

To read VOLTS,AMPS,WATTS,FREQ and AMPS HARMONICS (1-15 odds only) for a 3 phase 3 wire configuration, CH1, CH2 and SUM.

* Send MLA 9 address the PM3000A to listen

* Send 'P3' Set WIRING to 3 phase 3 wire

* Send 'B1 11 0 10011000000000000001001'

This requests results to be returned from the background averaging store. Return ch1,ch2 and Sum results (1+2+8=11) with no fundamental components.

Selection of parameters is, WATTS, VOLTS, AMPS, AMPS HARMONICS, FREQUENCY

* Send 'L15 1' for harmonics 1,3,5,7,9,11,13,15

The display will now read HARMONIC ANALYSIS RUNNING and the PM3000A will now analyse all the parameters requested.

* Send 'T1' Trigger

* Wait x seconds appropriate to the time needed to do the harmonic analysis for the averaging depth used. For averaging of 4, this may be 1 second approximately.

* The results requested may now be read from the PM3000A. An empty string will be returned if the results are not ready.

If the serial poll is sent to the PM3000A, bit 1 of the status byte will show if data is ready to be read. Bit 1 shows when the results have been averaged to a preset limit. This can be used to ensure that the results are stable and full accuracy is maintained.

A detailed program in Quick Basic is given on the following page. The results returned are shown below

Program results:

```
**************CHANNEL 1 **************
        +0.1263W
        2.511   V
        0.050   A
        50.60   Hz
        AH1 =  0.050A          000.0 deg
**************CHANNEL 2 **************
        +0.000W
        2.514   V
        0.000   A
        50.06   Hz
        AH1 =  0.000A          000.0deg
**************  SUM 1 + 2  **************
        +0.1263W
        2.513   V
        0.029   A
**************HARMONICS**************
        AH00 =  +0.003A
        AH00 =  +0.000A
        AH03 =  0.108          -014.1  deg
        AH03 =  1.000%         0.000   deg
        AH05 =  0.066%         -019.7  deg
        AH05 =  1.000%         0.000   deg
        AH07 =  0.039%         -319.6  deg
        AH07 =  1.000%         0.000   deg
        AH09 =  0.073%         -117.8  deg
        AH09 =  1.000%         0.000   deg
        AH11 =  0.108%         -147.4  deg
        AH11 =  1.000%         0.000   deg
        AH13 =  0.060%         -029.2  deg
        AH13 =  1.000%         0.000   deg
        AH15 =  0.053%         -223.0  deg
        AH15 =  1.000%         0.000   deg
        0.203 =  %Athd
        0.000 =  %Athd
        END OF DATA!
```

```
start:
        CLS
        OPEN "\dev\ieeeout" FOR OUTPUT AS #1
        IOCTL #1, "BREAK"
        PRINT #1, "RESET"
        OPEN "\dev\ieeein" FOR INPUT AS #2
'-------------------------------------------------------------------------------
'       program setup, send code to set up B1 command etc
'
         PRINT #1, "CLEAR 10"
         GOSUB delay.5
         PRINT #1, "REMOTE 10"
         GOSUB delay.5
         PRINT #1, "OUTPUT 10;A04"
         PRINT #1, "OUTPUT 10;P3"
         PRINT #1, "OUTPUT 10;B1 11 0 10011000000000000000001001"
         GOSUB delay.5
         PRINT #1, "OUTPUT 10;L15 1"
         GOSUB delay.5
         PRINT #1, "OUTPUT 10;T1"
         GOSUB delay.5
         GOSUB spoll
         WHILE a$ <> "END OF DATA!"
         PRINT #1, "ENTER 10;"; "LF"
         INPUT #2, a$
         LPRINT ; a$
         WEND
         END
'-------------------------------------------------------------------------------
spoll:
        spoll = 0
        WHILE spoll <> 3
        PRINT #1, "SPOLL 10"
        INPUT #2, spoll
        spoll = spoll AND 3
        WEND
        RETURN
'-------------------------------------------------------------------------------
delay.5:
        t1 = TIMER
1       t2 = TIMER
        IF t2 - t1 < .5 THEN GOTO 1
        RETURN
```

4.6 IEEE 488.2 Operation

4.6.1 Selection

It is first necessary to enable IEEE operation by selecting the [INTERFACE] menu, and pressing [SELECT] until >IEEE488< is displayed. Press [ENTER], and use the [SELECT] key to obtain >enabled< on the display. Press [ENTER]. Then select the address and press [ENTER]. The next display is for selection of IEEE488.2. Select >enable< and press [ENTER].

4.6.2 Command structure

Commands and replies are passed as a sequence of ASCII letters and numbers terminated by either a line feed or an EOI (hardware signal for 'end of instruction').

Upper and lower case letters are treated equally and all white-space characters are ignored. Thus to set manual voltage range 6:

```
output 09; :RNG:VLT:FIX 6
output 09; :rng:vlt:fix6
output 09; :Rng :Vlt :Fix     6
```

all have exactly the same effect (although it takes longer to transmit strings with more characters).

Commands may be of one of two types - common or device. Common commands (and common queries) apply universally to all instruments and are preceded by an '*' character e.g.

```
output 09; *TRG
```

Device commands are defined by the manufacturer of each instrument, and Voltech instruments' device commands are preceded by a ':' character e.g.

```
output 09; :RNG:VLT:FIX 6
```

This allows the instrument to continue to support the previous IEEE command set alongside the new IEEE488.2 command set and automatically distinguish between the commands. Where there is a direct incompatibility (such as in the status reporting) the instrument must be configured for IEEE488.2 operation (select 2 on program 12).

The instrument will obey both sets of commands no matter whether IEEE488.2 operation has been selected or not with the following exceptions:

Serial Poll. - The serial poll byte is defined differently according to IEEE488.2 or the IEEE488.1 protocol.

Unterminated query error. - The IEEE488.1 protocol gives repeated BO command replies without a specific request. This is not valid in IEEE488.2 mode and the instrument will time-out and set the query error bit in the standard event time register if there is an attempt to read data without first sending a query

Commands may be cascaded if separated by ';'. If a reply is waiting to be read, further commands are received and buffered but will not be executed until the reply buffer has been read, e.g.:

```
output 09; :CAL:CH1:VLT? 5;
:CAL:CH2:VLT? 5; :CAL:CH3:VLT? 5
enter 09;
1.1111E-01
enter 09;
2.222E-02
enter 09;
3.333E-03
```

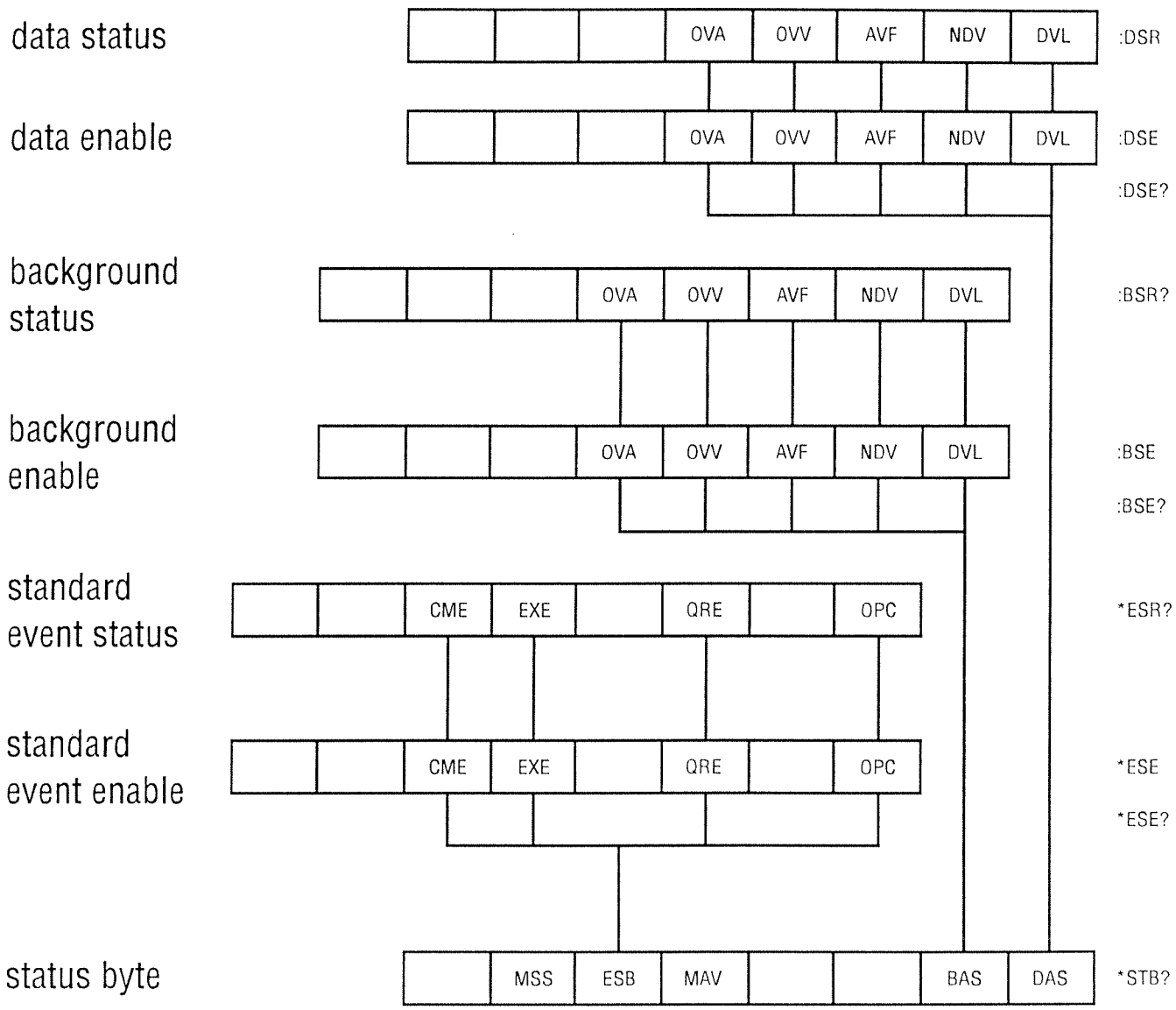
Data replies may only be sent in response to a query message which ends with a question mark. The data is returned either as an integer (NR1 numeric response type) or in scientific format with 4½ digit signed mantissa and 2 digit signed exponent (NR3 numeric response type). Data may be entered as integer, integer with decimals, or scientific e.g. to set target power factor, the following commands have the same effect:

```
output 09; :cfg 2, 1
output 09; :cfg 2, 1.00
output 09; :cfg 2, 1.0000E+00
```

Two detailed examples of operation are given under the BRD? and FRD? commands listed later.

4.6.3 Status reporting

The IEEE488.2 status byte contains the mandatory MSS, ESB and MAV bits with two instrument specific summary bits, BAS and DAS. The enable registers are set by the user, and act as a mask to reflect chosen elements of the appropriate status registers to the Status Byte Register. Transparency is set by setting the appropriate bit of the enable register to 1. If any of the status registers are read, the register is reset to zero.



4.6.3.1 Status byte register

Read by *STB? or serial poll

	MSS	ESB	MAV			BAS	DAS

DAS — summary bit to show display data available

BAS — summary bit to show background data available

MAV — set whenever there is a message available in the output buffer

ESB — summary bit to show standard event status

MSS — master summary status set as a result of the logical bitwise AND of the status byte register with the service request enable

Note that the serial poll register is the same as the status byte register except that bit 6 (MSS in stb, RQS in serial poll) is controlled in order to generate the service request.

4.6.3.2 Background status

Read by :BSR? or in summary by *STB? BAS bit

			OVA	OVV	AVF	NDV	DVL

DVL — set to indicate the availability of data

NDV — set to indicate that new data has become available since the last :BSR? command

AVF — set to indicate that the averaging is full to the specified depth

OVA — set to indicate current range overload has occurred

OVV — set to indicate voltage range overload has occurred

4.6.3.3 Display Data status

Read by :DSR? or in summary by *STB? DAS bit

			OVA	OVV	AVF	NDV	DVL

DVL — set to indicate the availability of data

NDV — set to indicate that new data has become available since the last :DSR? command

AVF — set to indicate that the averaging is full to the specified depth

OVA — set to indicate current range overload has occurred

OVV — set to indicate voltage range overload has occurred

4.6.3.4 Standard event status

Read by *ESR? on in summary by *STB? ESB bit

		CME	EXE		QRE		OPC

OPC — operation complete (data available)

QRE — unterminated query error

EXE — execution error

CME — command error

4.6.4 Available commands

:AUX	Auxiliary input control (PM3000A-001 only)
Class	device command
Return type	none
Format	:AUX:DIS ENB SIU range, scale USU range, scale PLS pulse VLT range, scale
Options	:DIS disable :ENB enable :SIU SI units (Nm and W) :USU US units (ftlb and HP) :PLS pulse speed input :VLT voltage speed input range 0 = 10V, 1 = 1V scale 10^{-9} to 10^{9} pulse pulses per revolution.
Example	CMD> output 10; :AUX:SIU 0, 10
Notes	Measured values can be read using :BRD and :FRD commands (see later sections and corresponding notes).

:AVG	Set averaging
Class	device command
Return type	none
Format	:AVG :FIX depth AUT
Options	:FIX set fixed averaging :AUT set auto averaging depth 1-64
Example	CMD> output 10; :AVG:FIX 16

:BAL	Set ballast/ultrasonic mode
Class	device command
Return type	none
Format	:BAL:50H 60H
Options	:50H set ballast mode for lock to 50Hz :60H set ballast mode for lock to 60Hz
Example	CMD> output 10; :BAL:50H

:BRD?	Read background data (Background buffer)
Class	device query
Return type	arbitrary ASCII response data
Format	:BRD :CH1? CH2 CH3 CHN SUM AUX
Options	:CH1 Channel 1 only :CH2 Channel 2 only :CH3 Channel 3 only :CHN Neutral Channel :SUM Summation values :AUX Auxiliary inputs (PM3000A - 001 only)
Return format	sequence of data strings terminated by 'END'
Example	First select the functions you wish to acquire. OUTPUT 10; :SEL:CLR OUTPUT 10; :SEL:CH1 OUTPUT 10; :SEL:VLT OUTPUT 10; :SEL:AMP OUTPUT 10; :SEL:FRQ OUTPUT 10; :SEL:PWF OUTPUT 10; :SEL:FUN Enable the AVF(Averaging full) bit of the Background Data Status Register. OUTPUT 10; :BSE 4 Trigger background analysis. OUTPUT 10; *TRG Ensure that IEEE488.2 has been set for following protocol. Spoll until bit 1(Background Available) goes high. (i.e. spoll AND 2 = 2) SPOLL 10 . . . SPOLL 10 Send BRD command with selected channel. OUTPUT 10; :BRD:CH1? Receive data until 'END'. ENTER 10 1.0734E2,8.714E-2,7.044E-1,6.102E1,1.0734E2,6.137E-2, -9.999E-1

ENTER 10

'END'

The values above correspond to the following results:-

Vrms	1.0734E2
Arms	8.714E-2
PF	7.044E-1
Freq	6.102E1
Fund Vrms	1,0734E2
Fund Arms	6.137E-2
Cos phi	-9.999E-1

Notes

BRD (Background ReaD) can be used to collect background analysis data over the IEEE interface. It facilitates the passing of large amounts of data from the PM3000A to the host computer.

BRD uses the printer function selection bytes to establish which functions should be returned. Once background data is available, the BRD command is sent and the data will then be returned.

BRD sends data over the IEEE in the floating point format and up to 8 values are sent on each line. This will continue until all lines have been sent. BRD will then send a final line containing 'END'.

It is important to note the order in which functions are returned. There follows a list of the function order and this is constant for all channels. Even if certain functions are not selected in the background analysis, the same basic order will be maintained except those functions will be missing.

1. Watts	2. VA	3. VAr	4. Vrms
5. Arms	6. PF	7. Vpeak	8. Apeak
9. Vcf	10.Acf	11.Imp	12.Vthd
13.Athd	14.Frq	15.Fund watts	16.Fund VA
17.Fund VAr	18.Fund Vrms	19.Fund Arms	20.Cos phi
21.Resistance	22.Reactance		

23.Voltage harmonics (Magnitude & Phase angle)
24.Current harmonics (Magnitude & Phase angle)
25.Power harmonics (Magnitude only)

Harmonics and BRD

When retrieving harmonics with BRD, the following should be noted:-

1. If coupling is set to AC+DC, Harm 0 (Magnitude only) will be the first harmonic sent. Harm 0 will not be sent if coupling is set to AC.
2. If Odd & Even harmonics are selected then both odd and even harmonics will be sent, otherwise only odd harmonics will be sent.
3. Only harmonics up to and including that specified in Maximum harmonic will be sent.

:BSE	Set background data status enable register
Class	device command
Return type	none
Format	:BSE data
Options	none
Data format	0-255

			OVA	OVV	AVF	NDV	DVL

DVL - data available enable
AVF - averaging full enable
NDV - new data available enable
OVV - Voltage overload enable
OVA - Current overload enable

Example: CMD> output 10; :BSE 4

Notes: The BAS bit in the serial poll status byte is set according to the logical bitwise AND of the background data status register and the background data status enable register.

:BSE?	Read background data status enable register
Class	device query
Return type	NR1 numerical response data
Format	:BSE?
Options	none
Return format	0-255

			OVA	OVV	AVF	NDV	DVL

DVL - data available enable
AVF - averaging full enable
NDV - new data available enable
OVV - Voltage overload enable
OVA - Current overload enable

Example:
CMD> output 10; :BSE?
CMD> enter 10
4

Notes: The BAS bit in the serial poll status byte is set according to the logical bitwise AND of the background data status register and the background data status enable register.

:BSR?	Read background data status register
Class	device query
Return type	NR1 numerical response data
Format	:BSR?
Options	none
Return format	0-255

			OVA	OVV	AVF	NDV	DVL

DVL - data available
AVF - averaging full
NDV - new data available
OVV - Voltage overload
OVA - Current overload

Example:
CMD> output 10; :BSR?
CMD> enter 10
7

Notes: This command clears the background data status register. The BAS bit in the serial poll status byte is set according to the logical bitwise AND of the background data status register and the background data status enable register.

:CAL	Calibrate	
Class	device command	
Return type	none	
Format	:CAL:PWD pass :CAL:CH1:VLT range, value CH2 AMP CH3 EXT ALL :CAL:END pass	
Options	:PWD	enter password to start calibration
	:CH1	calibrate channel 1 only
	:CH2	calibrate channel 2 only
	:CH3	calibrate channel 3 only
	:ALL	calibrate all channels
	:VLT	calibrate voltage
	:AMP	calibrate current
	:EXT	calibrate external shunt
	:END	end calibration and save values in EEPROM
	pass	calibration password 0-9999
	range	range to be calibrated 1-12
	value	measured value
Return format	none	
Example	CMD> output 10; :CAL:PWD 1234 CMD> output 10; :CAL:CH1:VLT 3, 1.2345 CMD> output 10; :CAL:END 1234	
Notes	For the external shunt calibration, only ranges 7-12 are directly calibrated due to the very low signal levels. Having calibrated ranges 7-12, ranges 1-6 may then be calibrated with a derived value by a single :CAL command e.g. CMD> output 10; :CAL:PWD 1234 calibrate voltage, current and external 7-12 CMD> output 10; :CAL:CH1:EXT 6 CMD> output 10; :CAL:END 1234 In this example, the top 6 ranges, 7-12, are explicitly calibrated then the lower 6 ranges are calibrated with the single command for range 6 - any range less than 7 may be passed as the argument. Note that the current ranges must be calibrated before the lower external ranges.	

:CAL?	Read calibration values
Class	device query
Return type	NR3 numerical response data or string response data
Format	:CAL:CH1:VLT? range CH2 AMP CH3 EXT
Options	:CH1 read calibration value for channel 1 :CH2 read calibration value for channel 2 :CH3 read calibration value for channel 3 :VLT read voltage calibration :AMP read current calibration :EXT read external shunt calibration range range calibrated 1-12
Return format	4½ digit signed mantissa with 2 digit exponent '** UNCAL **'
Example	CMD> output 10; :CAL:CH2:VLT? 3 CMD> enter 10 +6.73E-02
Notes	This represents the calibration correction for the given channel. The calibrated value of an input is given by: actual value = measured value x (1 + calibration)

:CFG	Configure
Class	device command
Return type	none
Format	:CFG prog, data
Options	prog integer program location 0-255 data appropriate integer of floating point data
Return format	none
Example	CMD> output 10; :CFG 21, 1
Notes	The prog number is the program selected from the configurable list (e.g. 21 will select FP21 - Fixed frequency enabled). See end of commands listings for configuration list.

:CFG?	Read configuration
Class	device query
Return type	NR1 numerical response data or NR3 numerical response data
Format	:CFG? prog
Options	prog integer program location 0-255
Return format	integer or floating point data as appropriate
Example	CMD> output 10; :CFG? 21 CMD> enter 10 1

*CLS	Clear standard event status register
Class	common command
Return type	none
Format	*CLS
Options	none
Return format	none
Example	CMD> output 10; *CLS
Notes	'Clearing' this register leaves OPC set to 1.

:CPL	Set ac/dc coupling
Class	device command
Return type	none
Format	:CPL:+DC -DC
Options	:+DC set AC+DC coupling :-DC set AC only coupling
Return format	none
Example	CMD> output 10; :CPL:+DC

:DSE	Set data status enable register
Class	device command
Return type	none
Format	:DSE data
Options	none
Data format	0-255

			OVA	OVV	AVF	NDV	DVL

DVL - data available enable
AVF - averaging full enable
NDV - new data available enable
OVV - Voltage overload enable
OVA - Current overload enable

Example: CMD> output 10; :DSE 2

Notes: The DAS bit in the serial poll status byte is set according to the logical bitwise AND of the data status register and the data status enable register.

:DSE?	Read data status enable register
Class	device query
Return type	NR1 numerical response data
Format	:DSE?
Options	none
Return format	0-255

			OVA	OVV	AVF	NDV	DVL

DVL - data available enable OVV - Voltage overload enable
AVF - averaging full enable OVA - Current overload enable
NDV - new data available enable

Example

```
CMD> output 10; :DSE?
CMD> enter 10
2
```

Notes: The DAS bit in the serial poll status byte is set according to the logical bitwise AND of the data status register and the data status enable register.

:DSP?	Read display
Class	device query
Return type	string response data
Format	:DSP?
Options	none
Return type	40 ASCII characters in quotes

Example

```
CMD> output 10; :DSP?
CMD> enter 10
' 239.5V   67.89mA   Watts  =  +12.345 W'
```

:DSR?	Read data status register
Class	device query
Return type	NR1 numerical response data
Format	:DSR?
Options	none
Return format	0-255

			OVA	OVV	AVF	NDV	DVL

DVL - data available OVV - Voltage overload
AVF - averaging full OVA - Current overload
NDV - new data available

Example

```
CMD> output 10; :DSR?
CMD> enter 10
7
```

Notes: This command clears the data status register. The DAS bit in the serial poll status byte is set according to the logical bitwise AND of the data status register and the data status enable register.

:DVC	Device clear
Class	device command
Return type	none
Format	:DVC
Options	none
Return format	none
Example	CMD> output 10; :DVC
Notes	Same function as DEVICE CLEAR. It is a useful function for RS232 applications.

*ESE	Set standard event status enable register
Class	common command
Return type	none
Format	*ESE flags
Data format	0-255 [ ][ ][CME][EXE][ ][QRE][ ][OPC] OPC - operation complete QRE - unterminated query error EXE - execution error CME - command error
Example	CMD> output 10; *ESE 32
Notes	The ESB bit in the serial poll status byte is set according to the logical bitwise AND of the standard event status register and the standard event status enable register.

*ESE?	Read standard event status enable register
Class	common query
Return type	NR1 numeric response data
Format	*ESE?
Options	none
Return format	0-255 [ ][ ][CME][EXE][ ][QRE][ ][OPC] OPC - operation complete QRE - unterminated query error EXE - execution error CME - command error
Example	CMD> output 10; *ESE? CMD> enter 10 32
Notes	The ESB bit in the serial poll status byte is set according to the logical bitwise AND of the standard event status register and the standard event status enable register.

*ESR?	Read standard event status register
Class	common query
Return type	NR1 numeric response data
Format	*ESR?
Options	none
Return format	0-255

		CME	EXE		QRE		OPC

OPC - operation complete
QRE - unterminated query error
EXE - execution error
CME - command error

Example

```
CMD> output 10; *ESR?
CMD> enter 10
1
```

Notes: The ESB bit in the serial poll status byte is set according to the logical bitwise AND of the standard event status register and the standard event status enable register. The register is then cleared.

:FNC?	Read function data
Class	device query
Return type	NR3 numerical response data
Format	:FNC? CH1? function CH2 CH3 CHN SUM

Options

CH1:	WAT?	Watts
CH2	VAS	VA
CH3	VAR	VArs
CHN	VLT	Volts
SUM	AMP	Amps
	PWF	Power factor
	VPK	Volts peak
	APK	Amps peak
	VCF	Volts Crest factor
	ACF	Amps Crest factor
	IMP	Impedance
	EFF	Efficiency
	WHR	Watt-Hrs
	VAH	VA Hours
	VRH	VAr Hours
	AHR	Amp Hours
	APF	Average Power Factor
	VHM	Voltage Harmonic
	AHM	Current Harmonic
	VDF	Volts Distortion
	ADF	Current distortion
	FRQ	Frequency
	TIM	Integrator time elapsed
	VDC	Volts DC
	ADC	Amps DC
	VHA	Voltage Harm Angle

	AHA Current Harm Angle
Return format	4½ digit mantissa with 2 digit exponent ±x.xxxE±xx ±1.xxxxE±xx
Example	CMD> output 10; :FNC:CH1:VLT? CMD> enter 10 +2.395E+02
Notes	Data read can be synchronised to new data values by using the NDV bit in the data status register (see :DSR?), or via the SPOLL register if the appropriate enable register is set (see :DSE) For Harmonics VHM, AHM The HRM command must be used to set up the Harmonic to be read, eg; output 10; :HRM 3 output 10; :FNC:CH1:VHM? enter 10 (dummy read to clear buffer) output 10; :HRM 3 output 10; :FNC:CH1:VHM? enter 10 (reads harmonic 3) Harmonics can be returned as %'s or absolute value. See CFG 18. INRUSH Current The FNC? command can also be used in the special case of reading inrush current, as in the following example: output 10; :FNC:CH1? 10 (setup inrush mode) output 10; :CFG 41, x (x=range) output 10; :FNC:CH1? 10 (read inrush current) enter 10

:FND?	**Read fundamental data**
Class	device query
Return type	NR3 numerical response data
Format	:FND:CH1? function CH2 CH3 CHN SUM
Options	:FND:CH1:WAT? Watts CH2 VAS VA CH3 VAR VArs CHN VLT Volts SUM AMP Amps PWF Power factor IMP Impedance EFF Efficiency WHR Watt-Hrs VAH VA Hours VRH VAr Hours AHR Amp Hours

	APF Average Power Factor CVR Correction VArs VHM Voltage Harmonic AHM Current Harmonic VHA Voltage Harm Angle AHA Current Harm Angle
Return format	4½ digit mantissa with 2 digit exponent ±x.xxxE±xx ±1.xxxxE±xx
Example	CMD> output 10; :FND:CH1:VLT? CMD> enter 10 +2.395E+02
Notes	Data can be synchronised to new data values by using the NDV bit in the data register (see :DSR?), or via the SPOLL register if the appropriate enable register is set (see :DSE)

:FRD?	**Read foreground data (Display buffer)**
Class	device query
Return type	multiple NR3 numerical response data separated by commas, terminated by string response data, 'END'
Format	:FRD:CH1? CH2 CH3 CHN SUM AUX
Options	:CH1 Channel 1 only :CH2 Channel 2 only :CH3 Channel 3 only :CHN Neutral channel :SUM Summation values :AUX Auxiliary inputs (PM3000A-001 only)
Return format	NR3,NR3,NR3..... (maximum 8 on one line)
Example	First select the functions you wish to acquire. OUTPUT 10; :SEL:CLR OUTPUT 10; :SEL:CH1 OUTPUT 10; :SEL:VLT OUTPUT 10; :SEL:AMP OUTPUT 10; :SEL:FRQ OUTPUT 10; :SEL:PWF OUTPUT 10; :SEL:FUN Send FRD command with selected channel. OUTPUT 10; :FRD:CH1? Receive data until 'END'. ENTER 10 1.0734E2,8.714E-2,7.044E-1,6.102E1,1.0734E2,6.137E-2, -9.999E-1

ENTER 10
'END'

The values above correspond to the following results:-

Vrms	1.0734E2
Arms	8.714E-2
PF	7.044E-1
Freq	6.102E1
Fund Vrms	1,0734E2
Fund Arms	6.137E-2
Cos phi	-9.999E-1

Notes

It is important to note the order in which functions are returned. There follows a list of the function order and this is constant for all channels. Even if certain functions are not selected in the background analysis, the same basic order will be maintained except those functions will be missing.

1. Watts	2. VA	3. VAr	4. Vrms
5. Arms	6. PF	7. Vpeak	8. Apeak
9. Vcf	10.Acf	11.Imp	12.Vthd
13.Athd	14.Frq	15.Fund watts	16.Fund VA
17.Fund VAr	18.Fund Vrms	19.Fund Arms	20.Cos phi
21.Resistance	22.Reactance		

23.Voltage harmonics (Magnitude & Phase angle)
24.Current harmonics (Magnitude & Phase angle)

Voltage and current harmonics are further broken down as follows:-

H0	Magnitude only
H1	Magnitude & phase only
H2-H99	This depends on the setting of FP17(Harmonic Reference Mode).
	If FP17 is set to '% of ref' then, % of reference & phase
	If FP17 is set to 'absolute value' then, Magnitude & phase.

When requesting harmonics in :FRD?, if a harmonic is selected which falls between H2 and H99 then it will only be returned if it is currently being displayed. This is true for voltage and current harmonics. H0 and H1 are returned regardless of whether they are displayed or not as long as one or the other has been selected.

Only one harmonic can be selected at a time.

PM3000A-001 Auxiliary Inputs and FRD

If auxiliary inputs are selected, then data is returned in the following order: Torque, speed, power, efficiency, 'END'.

:FSR	Set frequency source
Class	device command
Return type	none
Format	:FSR:VLT AMP EXT SLW
Options	:VLT set voltage frequency source :AMP set current frequency source :EXT set external frequency source :SLW set external slow frequency source
Return format	none
Example	CMD> output 10; :FSR:VLT

:HGH	Set high bandwidth mode
Class	device command
Return type	none
Format	:HGH:ENB DIS
Options	:ENB enable 1MHz bandwidth :DIS disable 1MHz bandwidth
Return format	none
Example	CMD> output 10; :HGH:ENB

:HRM	Set single harmonic
Class	device command
Return type	none
Format	:HRM harm
Options	harm integer harmonic number 0-99
Return format	none
Example	CMD> output 10; :HRM 3

:HMX	Set maximum harmonic for series
Class	device command
Return type	none
Format	:HMX:ODD harm ALL
Options	:ODD only odd harmonics :ALL use both odd and even harmonics harm integer maximum harmonic 0-99
Return format	none
Example	CMD> output 10; :HMX:ODD 39

*IDN?	Identify
Class	common query
Return type	arbitrary ASCII response data
Format	*IDN?
Options	none
Return format	VOLTECH,PM3000,0,version
Example	CMD> output 10; *IDN? CMD> enter 10 VOLTECH,PM3000,0,v1.20

:IEC	Set up IEC555 harmonics
Class	device command
Return type	none
Format	:IEC:DIS :IEC:FIX:CH1 FLU:CH2 FLI:CH3 FLM
Options	:DIS disable IEC555 mode :FLM flicker meter :FIX fixed harmonic mode :FLU fluctuating harmonic mode :FLI changing voltage
Return format	none
Examples	Setting up Fluctuating Harmonic Mode CMD> output 10; :IEC:FLU:CH1 Returning Data to Fixed Harmonic Mode eg; output 10; :IEC:FIX:CH1 - Set up Fixed Harmonics. output 10; :BSE 4 - Enable AVF Bit in Background Status Enable Register. output 10; :*TRG - Trigger background analysis. Spoll until Bit 2 goes high Spoll 10 ... Spoll 10 ... Output 10; :BRD:CH1? Receive data until 'END'. Data Return Format - 46 NR3's - WATT, AMP, PF, ATHD (series formula) Aharm0... Aharm40

:IEC?	Fetch IEC555 harmonic data
Class	device command
Return type	multiple NR3 or NR1 numeric response data separated by commas, terminated by string response data, 'END'
Format	:IEC:FLU? FLI FLM
Options	:FLU - Fluctuating harmonic mode :FLI - Changing voltage :FLM - Flickermeter
Return format	:FLU 86 NR3's: Frequency, Run time, Status, Watts, Voltech reserved value, Voltech reserved value, Ahrm 1, ...Ahrm40, Vhrm1, ...Vhrm40 :FLI 40 NR1's bin1, bin2, ...bin40 :FLM 1028 NR3's Frequency, DC, DMAX, DT, bin1...bin1024 In the default mode, 8 returned results appear on one line. The 'ENTER 10' command must be repeated to continue reading the sequence. The whole data sequence is terminated with the word 'END'. In single reply string mode (set-up by :CFG 276,1) the whole data sequence appears as one string, with values separated by commas. A single 'ENTER 10' command can be used to read the whole string. The characters 'END' do not form part of the string.
Example	Fluctuating Harmonics CMD> output 10; :IEC:FLU:CH1 CMD> output 10; :IEC:FLU? CMD> enter 10 to receive all the data as a single string or CMD> enter 10 read 8 values ... CMD> enter 10 'END' Flickermeter CMD> output 10; :IEC:FLM:VLT or CMD> output 10; :IEC:FLM:AMP real,imag Where 'real' is the real part and 'imag' is the imaginary part of the test impedance. Both values are in Ohms. CMD> output 10; :IEC:FLM:CH1 runtime,DC% Where 'runtime' is the measurement time in minutes, and 'DC%' is the `relative steady state voltage change` in % as defined in EN 61000-3-3. Check for the NDV bit set in the Data Status Register CMD> output 10; :IEC:FLM? CMD> enter 10 to receive all the data as a single string or CMD> enter 10 read 8 values ... CMD> enter 10 'END'
Notes	The modes must be first set up with one of the :IEC commands (see example).

:INT	Set up integrator
Class	device command
Return type	none
Format	:INT:ENB DIS RUN time
Options	:ENB enable integrator :DIS disable integrator :RUN time set in minutes
Return format	none
Example	CMD> output 10; :INT:ENB

:LOG	set up and datalog
Class	device command
Return type	none
Format	:LOG:EXT window TRG :LOG:EXT:DMP window TRG :LOG:EXT:CYC number TRG :LOG:DIS
Options	:EXT wait for external trigger :TRG trigger immediately :DMP return also data dump :CYC enable cycle by cycle mode :DIS disable datalog window capture window in ms number the number of cycles in cycle by cycle mode
Return format	none
Example	Datalog Using :BRD? To Read The Results CMD> output 10; :SEL:CLR CMD> output 10; :SEL:CH1 CMD> output 10; :SEL:CH2 CMD> output 10; :SEL:VLT CMD> output 10; :SEL:AMP CMD> output 10; :SEL:WAT CMD> output 10; :BSE 2 CMD> output 10; :LOG:TRG 50 wait for datalog (BAS spoll bit) CMD> output 10; :BRD:CH1? CMD> enter 10 NR3,NR3,NR3 CMD> enter 10 'END' CMD> output 10; :BRD:CH2? CMD> enter 10 NR3,NR3,NR3 CMD> enter 10 'END'

Notes	The command ':LOG:EXT (or :TRG) window' takes 6000 samples and analyses for the functions previously selected (see :SEL). The data may be read using :BRD. Additionally, the sample data may be requested using the command ':LOG:EXT (or :TRG):DMP window' and read using :LOG:DMP? The command ':LOG:EXT (or :TRG):CYC number' sets up cycle by cycle analysis over the specified 'number' of cycles. The data should be read using the :LOG:CYC? command.

:LOG?	**read datalog samples**
Class	device query
Return type	multiple NR1, or NR1 and NR3 in combination
Format	:LOG:DMP? N_A :LOG:CYC?
Options	:DMP read data dump :CYC read Cycle by Cycle results N_A number of accumulated raw samples per output sample
Return format	:DMP sequence of NR1's (terminated by 'END' if not in single reply string mode) :CYC two NR1's plus a sequence of NR3's (terminated by 'END' if not in single reply string mode)
Example 1	Data Dump CMD> output 10; :LOG:TRG:DMP wait for datalog (NDV bit in BSR) CMD> output 10; :LOG:DMP? 8 CMD> enter 10 8000 ,12345 CMD> enter 10 8002 ,12340 CMD> enter 10 8004 ,12335 repeat for 6000/8 lines CMD> enter 10 'END' The command :LOG:DMP? reads raw sample data in multiple lines depending on the wiring selected: 1 phase 2 wire V1,A1, Torque, Speed 1 phase 3 wire V1,A1,V2,A2,N, Torque, Speed 3 phase 3 wire V1,A1,V2,A2,N, Torque, Speed 3 phase 4 wire V1,A1,V2,A2,V3,A3,N, Torque, Speed Data for Torque and Speed will only be available if the AUX inputs are enabled. (See :AUX). Each sample returned is the sum of 'N_A' raw samples. This allows the user both to select a smaller number of samples than 6000 if this is required, or to use this summation to filter out high frequency noise. The number N_A should be chosen to divide into 6000 exactly, as the number of data replies returned is equal to 6000 ÷ N_A.
Example 2	Cycle by Cycle CMD> output 10; :WRG:3P4 CMD> output 10; :AUX:ENB CMD> output 10; :AUX:SIU 0,10 CMD> output 10; :AUX:VLT 0,10 CMD> output 10; :BSE 2 (enable NDV bit) CMD> output 10; :SEL:CLR

	CMD> output 10; :SEL:CH1; :SEL:CH2; :SEL:CH3; :SEL:SUM CMD> output 10; :SEL:VLT; :SEL:AMP; :SEL:WAT CMD> output 10; :LOG:TRG:CYC 10 CMD> output 10; *STB? CMD> enter 10 2 CMD> output 10; :LOG:CYC? CMD> enter 10 0,62528,1.5934E2,.....,3.576E1 (results for cycle 0) CMD> enter 10 1,0,1.5968E2,.....,3.574E1 (results for cycle 1) CMD> ... The results read by the command :LOG:CYC? have data in the following order: Cycle, Status (integer), (both NR1) Frequency, (NR3) WATT, VA, Var, V, A, PF, IMP, (for CH1 - all NR3) WATT, VA, Var, V, A, PF, IMP, (for CH2 - all NR3) WATT, VA, Var, V, A, PF, IMP, (for CH3 - all NR3) WATT, VA, Var, V, A, PF, IMP, (for Σ - all NR3) Torque, Speed (both NR3) If more than 24 NR3's are required per cycle, single reply string mode should be used.
***OPC**	**Initialise operation complete function**
Class	common command
Return type	none
Format	*OPC
Options	none
Return format	none
Example	CMD> output 10; *OPC
***OPC?**	**Flag when operation complete**
Class	common query
Return type	NR1 numeric response data
Format	*OPC?
Options	none
Return format	1
Example	CMD> output 10; *OPC CMD> output 10; *OPC? CMD> enter 10 1
:PRG	**Program Drive Setup**
Class	device command
Return type	none
Format	:PRG:LOD 1-5 - Load Program :SAV 1-5 - Save Program
Example	CMD> Output 10 ;:PRG:LOD 3

:PWM	PWM drive mode
Class	device command
Return type	none
Format	:PWM:DIS INP window OUT filter REC
Options	:DIS disable PWM mode :INP set PWM drive input mode :OUT set PWM output mode :REC set real time chart recorder mode window input window in seconds from 1 to 10 filter output filter - 1 = 5 to 500Hz 2 = 0.5 to 25Hz 3 = 0.1 to 25Hz
Return format	none
Example	CMD> output 10; :PWM:OUT 1

:RAV	Reset averaging
Class	device command
Return type	none
Format	:RAV
Options	none
Return format	none
Example	CMD> output 10; :RAV
Notes	This command can be used to speed up the response of fixed averaging

:RMS	Set rms or rectified mean measurement
Class	device command
Return type	none
Format	:RMS:TRU MEA
Options	:TRU true rms measurement :MEA rectified mean
Return format	none
Example	CMD> output 10; :RSM:TRU

:RNG	Set ranging
Class	device command
Return type	none
Format	:RNG:VLT:FIX range AMP :RNG:VLT:AUT AMP
Options	:VLT set voltage ranging :AMP set current ranging :FIX fixed ranging :AUT autoranging range integer range 1-12
Return format	none
Example	CMD> output 10; :RNG:AMP:FIX 5

*RST	Reset device
Class	common command
Return type	none
Format	*RST
Options	none
Return format	none
Example	CMD> output 10; *RST
Notes	This command resets the standard configuration

:RTR	Set retrigger mode
Class	device command
Return type	none
Format	:RTR:ENB DIS
Options	:ENB retrigger after completion of next trigger :DIS do not retrigger
Return format	none
Example	CMD> output 10; :RTR:ENB
Notes	After sending :RTR:ENB to initialise the re-trigger function, followed by *TRG, the PM3000A will start measuring and accumulating averages. When it reaches the maximum number of measurements for the average, it will reset and start averaging again. This process will continue indefinitely until either, the PM3000A is reset or :RTR:DIS is sent. At any time during the process, :BRD? can be sent, and the latest complete average will be read back. If retrigger is not selected, when the average is complete, the results will be stored and there will be no further measurement. The results may then be read when required.

:SCL	Set scaling
Class	device command
Return type	none
Format	:SCL:VLT scale AMP
Options	:VLT set voltage scaling :AMP set current scaling
Return format	none
Example	CMD> output 10; :SCL:AMP 99.34 Scaling values can be sent in any of the below example: 12 12.0 or 1.2E+1

:SEL	Select function list
Class	device command
Return type	none
Format	:SEL:CLR Clear CH1 Channel 1 CH2 Channel 2 CH3 Channel 3 CHN Neutral Channel SUM Sum Channel WAT Watts VAS VA VAR VAr VLT Volts AMP Current PWF Power factor VPK Volts peak APK Current peak VCF Voltage crest factor ACF Current crest factor IMP Impedance EFF Efficiency WHR Watt-Hrs VAH VA Hours VRH VAr Hours AHR Amp Hours APF Average Power Factor CVR Correction VArs VHM Voltage harmonic AHM Current harmonic VDF Volts distortion ADF Current distortion FRQ Frequency TIM Integrator time VDC Volts DC ADC Amps DC VHA Voltage Harm Angle AHA Current Harm Angle EFF Efficiency

Options	:CLR clears entire selection others set selection for that function
Return format	none
Example	CMD> output 10; :SEL:CLR CMD> output 10, :SEL:CH1 CMD> output 10; :SEL:VLT; :SEL:WAT; :SEL:AMP

:SHU	**Set internal/external shunt**
Class	device command
Return type	none
Format	:SHU:INT EXT
Options	:INT use internal shunt :EXT use external shunt
Return format	none
Example	CMD> output 10; :SHU:EXT

***SRE**	**Set service request enable register**
Class	common command
Return type	none
Format	*SRE flags
Data format	0-255 [ ][ ][ESB][MAV][ ][ ][BAS][DAS] DAS - data available summary (see :DSR?) BAS - background data available summary (see :BSR?) MAV - message available ESB - standard event status summary (see *ESR?)
Example	CMD> output 10; *SRE 1
Notes	The RQS bit in the serial poll status byte is set according to the a change in the logical bitwise AND of the status byte register and the service request enable register.

***SRE?**	**Read service request enable register**
Class	common query
Return type	NR1 numeric response data
Format	*SRE?
Options	none
Return format	0-255 [ ][ ][ESB][MAV][ ][ ][BAS][DAS] DAS - data available summary (see :DSR?) BAS - background data available summary (see :BSR?) MAV - message available ESB - standard event status summary (see *ESR?)
Example	CMD> output 10; *SRE? CMD> enter 10 1
Notes	The RQS bit in the serial poll status byte is set according to the a change in the logical bitwise AND of the status byte register and the service request enable register.

*STB?	Read status byte
Class	common query
Return type	NR1 numeric response data
Format	*STB?
Options	none
Return format	0-255

	MSS	ESB	MAV			BAS	DAS

DAS - data available summary (see :DSR?)
BAS - background data available summary (see :BSR?)
MAV - message available
ESB - standard event status summary (see *ESR?)
MSS - master summary status

Example
CMD> output 10; *STB?
CMD> enter 10
65

Notes: Reading the status byte, clears the register.

*TRG	Trigger
Class	common command
Return type	none
Format	*TRG
Options	none
Return format	none
Example	CMD> output 10; *TRG
Notes	*TRG has the same effect as a Group Execute Trigger. It initiates the measurement cycles for BRD? command

*TST?	Report self test
Class	common query
Return type	NR1 numeric response data
Format	*TST?
Options	none
Return format	0-255

	EEP	NVR	SHR	BNK	RAM	ROM	CPU

CPU CPU error
ROM ROM checksum error
RAM RAM read-write error
BNK ROM/RAM error from extended memory
SHR RAM read-write error on DSP
NVR non-volatile RAM checksum error
EEP EEPROM error

Example
CMD> output 10; *TST?
CMD> enter 10
0

:TTM	Set up Transformer Test Mode
Class	device command
Return type	none
Format	:TTM:DIS to disable Transformer Test Mode :TTM:VAV to enable Transformer Test Mode (with 'Vav' in the PM3000 display) :TTM:KAY to enable Transformer Test Mode (with 'k' in the PM3000 display) :TTM:PWC to enable Transformer Test Mode (with 'P_c' in the PM3000 display)
Return format	none

:TTM?	Read Back the Transformer Test Mode results
Class	device query
Return type	multiple NR3 numeric response data separated by commas
Format	:TTM:CH1? :TTM:CH2? :TTM:CH3? :TTM:SUM?
Return format	NR3, NR3, NR3, NR3, NR3, NR3 six results: Watts, Vrms, Arms, Vav, k and P_c for the selected channel

*WAI	Wait for operation
Class	common command
Return type	none
Format	*WAI
Options	none
Return format	none
Example	CMD> output 10; *WAI
Notes	The operation complete flag is set when data is available. *WAI will then effect a delay until data is available.
Return format	none
Example	CMD> output 10; :RST CMD> output 10; *WAI CMD> output 10; :FNC :WAT?

:WRG	Set wiring configuration
Class	device command
Return type	none
Format	:WRG:1P2 1P3 3P3 3P4 CH3 CH2 MIX ALL PHP

Options	:1P2	set 1 phase 2 wire
	:1P3	set 1 phase 3 wire
	:3P3	set 3 phase 3 wire
	:3P4	set 3 phase 4 wire
	:CH3	set channel 3 only
	:CH2	set channel 2 only
	:MIX	set 3 phase 3 wire plus independent channel 3
	:ALL	set independent channels
	:PHP	set phase to phase voltage (3 phase 4 wire only)
Return format	none	
Example	CMD> output 10; :WRG:3P4 CMD> output 10; :WRG:PHP	

4.6.5 CONFIGURATION NUMBER LISTING (:CFG COMMAND)

Number	Function	Data	Settings
1	Power up program	NR1	0-5
2	Target power factor	NR3	
3	Phase to phase	NR1	0 = off, 1 = on
4	Channel 3 only	NR1	0 = off, 1 = on
5	Program switch	NR1	0 = off, 1 = on
10	Language	NR1	0= English, 1= German
11	Stop acquisition	NR1	0 = off, 1 = stop
12	Hold display	NR1	0 = off, 1 = hold
13	Wiring lock	NR1	0-7
14	Phase lock	NR1	0 = off, 1 = on
15	Printer port	NR1	0 = printer, 1 = RS232
16	THD formula	NR1	0 = difference, 1 = series
17	Harmonic reference	NR1	0 = h1, 1 = rms
18	Harmonic display	NR1	0 = percentage, 1 = absolute
19	DC Component in THD	NR1	0 = off, 1 = on
20	Display averaging	NR1	0-255 in units of 100ms
21	Fixed freq enable	NR1	0 = off, 1 = on
22	Fixed frequency	NR3	
25	Jitter enable	NR1	0 = off, 1 = on
26	Low value blanking	NR1	0 = off, 1 = on
27	Waveform enable	NR1	0 = off, 1 = on
28	Independent ranging	NR1	0 = off, 1 = on
30	CH1 disable	NR1	0 = off, 1 = on
31	CH1 current shunt	NR1	0 = int, 1 = ext
32	CH1 AC/DC coupling	NR1	0 = ac, 1 = dc
33	CH1 ballast mode	NR1	0-2
34	CH1 phase reference	NR1	0 = voltage, 1 = current
35	CH1 filter	NR1	0 = off, 1 = on
37	CH1 auto averaging	NR1	0 = off, 1 = on
38	CH1 averaging depth	NR1	1-64
39	CH1 frequency source	NR1	0-5
40	CH1 voltage range	NR1	0-11
41	CH1 current range	NR1	0-11
42	CH1 voltage autorange	NR1	0 = on, 1 = off
43	CH1 current autorange	NR1	0 = on, 1 = off
44	CH1 voltage scaling	NR3	
45	CH1 current scaling	NR3	
46	CH1 RMS format	NR1	0 = rms, 1 = mean
47	CH1 fundamentals	NR1	0 = off, 1 = on
48	CH1 jitter generator	NR1	0 = off, 1 = on
49	CH1 PWM mode	NR1	0-3
50-69	as 30-49 above		
70-89	as 30-49 above		
90	Datalog manual trigger	NR1	0 = off, 1 = on
91	Datalog external	NR1	0 = off, 1 = on
92	Datalog timer trigger	NR1	0 = off, 1 = on
96	Datalog sample set	NR1	200 - 6000
97	Datalog window	NR1	0-65535 in units of 1ms
100	Integrator manual	NR1	0 = off, 1 = on
101	Integrator external	NR1	0 = off, 1 = on
102	Integrator timer	NR1	0 = off, 1 = on

103	Integrator cycle mode	NR1	0 = off, 1 = on
104	Integrator interval	NR1	0-65535 in minutes
105	Integrator start date	NR1	0-65535 yyyyymmmmddddddd
106	Integrator stop date	NR1	0-65535 yyyyymmmmddddddd
107	Integrator start time	NR1	0-65535 in minutes
108	Integrator stop time	NR1	0-65535 in minutes
109	Integrator reset time 1	NR1	0-65535 in minutes
110	Integrator reset time 2	NR1	0-65535 in minutes
111	Integrator reset time 3	NR1	0-65535 in minutes
112	Integrator reset time 4	NR1	0-65535 in minutes
113	Integrator reset time 5	NR1	0-65535 in minutes
114	Integrator run time	NR1	0-65535 in minutes
115	PWM input window	NR3	
116	Real time volts scale	NR3	
117	Real time amps scale	NR3	
118	Real time watts scale	NR3	
119	PWM input window	NR3	units of seconds
120	PWM output filter	NR1	0 - 4
122	IEEE address	NR1	1 - 30
123	IEEE488.2 enable	NR1	0 = off, 1 = on
124	RS232 enable	NR1	0 = off, 1 = on
125	RS232 baud rate	NR1	0-7
126	Cursor Home	NR1	0 = off, 1 = on
127	Display Mode	NR1	0 = Normal, 1 = Communications Control
129	IEC 555 Mode	NR1	0 - 4
130	Enable printer	NR1	0 = off, 1 = on
131	Printer manual trigger	NR1	0 = off, 1 = on
132	Printer external	NR1	0 = off, 1 = on
133	Printer timer trigger	NR1	0 = off, 1 = on
134	Printer mode	NR1	0 = display, 1 = selection
135	Odd or even harmonics	NR1	0 = even, 1 = odd
136	Maximum harmonic	NR1	0-99
137	Print fundamentals	NR1	0 = off, 1 = on
138	Print channel 1 results	NR1	0 = off, 1 = on
139	Print channel 2 results	NR1	0 = off, 1 = on
140	Print channel 3 results	NR1	0 = off, 1 = on
141	Print sum results	NR1	0 = off, 1 = on
142	Print neutral results	NR1	0 = off, 1 = on
143	Printout interval	NR1	0 = off, 1 = on (0-11999 mins)
152	Printout Watts	NR1	0 = off, 1 = on
153	Printout VA	NR1	0 = off, 1 = on
154	Printout VAr	NR1	0 = off, 1 = on
155	Printout Vrms	NR1	0 = off, 1 = on
156	Printout Arms	NR1	0 = off, 1 = on
157	Printout PF	NR1	0 = off, 1 = on
158	Printout Vpk	NR1	0 = off, 1 = on
159	Printout Apk	NR1	0 = off, 1 = on
160	Printout Vcf	NR1	0 = off, 1 = on
161	Printout Acf	NR1	0 = off, 1 = on
162	Printout Ain	NR1	0 = off, 1 = on
163	Printout Z	NR1	0 = off, 1 = on
164	Printout Watt hours	NR1	0 = off, 1 = on
165	Printout VA hours	NR1	0 = off, 1 = on
166	Printout VAr hours	NR1	0 = off, 1 = on
167	Printout A hours	NR1	0 = off, 1 = on

168	Printout average PF	NR1	0 = off, 1 = on
169	Printout correction VAr	NR1	0 = off, 1 = on
170	Print fundamentals	NR1	0 = off, 1 = on
171	Printout V harmonics	NR1	0 = off, 1 = on
172	Printout A harmonics	NR1	0 = off, 1 = on
173	Printout V thd	NR1	0 = off, 1 = on
174	Printout A thd	NR1	0 = off, 1 = on
175	Printout frequency	NR1	0 = off, 1 = on
176	Print W harmonics	NRI	0 = off, 1 = on
177	Logic output	NRI	0 - 63
180	Channel to display	NR1	0-4
181	Function to display	NR1	0-31
182	Upper right display	NR1	0-7
183	Upper left display	NR1	0-7
184	Selected harmonic	NR1	0-99
185	Multiple display	NR1	0 = single, 1 = multiple, 2 = 4 Function
186	Lower right display	NR1	0-7
190	Power factor sign	NR1	0 = off, 1 = on
191	Sum A = $(A_1+A_2+A_3)/3$	NR1	0 = off, 1 = on
192	Sum V = $(V_1+V_2+V_3)/3$	NR1	0 = off, 1 = on
193	Enable auxiliary inputs	NR1	0 = off, 1 = on
194	Torque range (aux. inputs)	NR1	0 = 10V, 1 = 1V
195	Torque scale (aux inputs)	NR3	10^{-9} to 10^{9}
196	Torque units (aux inputs)	NR1	0 = Metric, 1 = USA
197	Speed range (aux inputs)	NR1	0 = 10V, 1 = 1V
198	Speed scale (aux inputs)	NR3	10^{-9} to 10^{9}
199	Speed pulse/voltage (aux inputs)	NR1	0 = pulse, 1= voltage
200	Enable recorder 1	NR1	0 = off, 1 = on
201	Function for rec 1	NR1	0-31
202	Channel for rec 1	NR1	0-4
203	Minimum level rec 1	NR3	
204	Maximum level rec 1	NR3	
206-210	rec 2 as 200-204 above		
212-216	rec 3 as 200-204 above		
218-222	rec 4 as 200-204 above		
224-228	rec 5 as 200-204 above		
230-234	rec 6 as 200-204 above		
236-240	rec 7 as 200-204 above		
242-246	rec 8 as 200-204 above		
260	IEC555: line resistance	NR3	
261	IEC555: line reactance	NR3	
262	IEC555: measurement time	NR1	units of 0.1 minutes
263	IEC555: threshold dc	NRI	units of 0.05%
264	IEC555: measurement method	NR1	0 = Voltage, 1 = Current
270	Efficiency enable	NR1	0 = disable, 1 = enable
271	Efficiency formula	NR1	0 - 4
272	Efficiency units	NR1	0 - 3
273	Efficiency scaling	NR3	
276	Single Reply String	NR1	0 = off, 1 = on
277	V, A, W, F Only Mode	NR1	0 = off, 1 = on
279	Data Return Format	NR1	0 = 4.5 digit ASCII, 1 = 5 digit ASCII

SECTION 5

CALIBRATION

5.1 Calibration Overview

All calibration constants are stored in EEPROM, allowing the PM3000A to be calibrated without having to remove the cover. The calibration sequence is passcode protected. All three voltage or current inputs are calibrated simultaneously for maximum efficiency, although it is possible to calibrate each channel separately if required. The integrity of the EEPROM contents is checked at power on and an 'UNCALIBRATED' message is displayed if the contents are invalid.

The EEPROM is not affected by the state of the battery and will retain its data for at least 10 years.

5.2 Passcode

The passcode is a 4 digit number that allows entry to the calibration routines. It comes factory set at 3000, but may be changed by the user for extra security.

If the new code is lost or forgotten then a master code is held at Voltech to allow access. Contact Voltech or your dealer if this is needed.

To change the Passcode, press the [F] key, then the [SELECT] key until F[10] CALIBRATION is displayed. Press [Enter] to select the calibration program. Press [Enter] again to select >yes<.

The display then shows,

CAL CODE? 0-9999 0

Enter the old 4 digit passcode. If this is incorrect you will be returned to the main program.

The display then shows,

ENTER NEW CAL CODE? >yes<

Press [Enter] to select a new password code, otherwise select >no<. Now input the new code and press [Enter].

The new code is now saved in EEPROM. If the PM3000A does not require re-calibration the instrument may be switched off at this point.

5.3 Manual Calibration

Switch on the PM3000A into its standard power up mode, and allow sufficient time for the unit to reach a stable temperature (minimum 15 minutes).

Press the [F] key, then the [SELECT] key repeatedly until the display shows

F[10] CALIBRATION <select> or <enter>

Press [Enter] to select the calibration program. The next display shows,

CALIBRATION >yes<

Press [Enter] to confirm your intention to calibrate.

A valid passcode (4 digits) is required to proceed further. The code is factory set to 3000 but may be changed by the user (see previous section). Key in the code and press [Enter]. If the code is incorrect the calibration will be terminated.

The display now shows

CHANGE CONFIGURATION >yes<

Normally, the answer to this question is no. Press [SELECT]to display >no< and press [ENTER], to continue to the next display. If >yes< is selected , the instrument is permanently reconfigured as single, two or three phase instrument to complement the number of analogue channels it contains.

If the PM3000A is a 002 option, select >yes< for change configuration and select >yes< at the display,

IEC 555 VERSION >yes<

If the PM3000A is a 001 option the auxiliary inputs can be enabled and disabled in the "Change Configuration" menu. To do this, select >yes< for change configuration and select >yes< at the display,

AUXILIARY INPUTS
>ENABLED<

Use the [SELECT] and [ENTER] keys to enable or disable the inputs as required.

The display now shows

SELECT CHANNELS
CH1 CH2 CH3

You can deselect (and re-select) each of the channels to be simultaneously calibrated by pressing the CHANNEL SELECT keys. If all three channels are to calibrated together, simply press [Enter].

The next display shows,

CALIBRATE VOLTS?
>yes<

Press [Enter] for the Voltage calibration routines. Press [Select] and then [Enter] if the Voltage channels do not need calibration.

5.4 Voltage Range Calibration

The display shows,

VR1 INPUT 200 mV rms
VALUE IN V 0.000

If you wish to skip the calibration of this range press [Enter] and the program will move on to the next range.

To calibrate the range set the generator output to approximately the value requested on the display (+/-10%) and allow to settle. Key in the measured value from the digital multimeter. Enter the data in volts (e.g. 0.200v).

Press [Enter]. The voltage will be measured on all three inputs and the calibration constants for each analogue channel will be calculated.

The display then shows,

either.....

PASS

or, for example.....

FAIL
Channel 2

If a calibration fail occurs, the display advises which channel(s) have failed. In either case, press [Enter] to continue. For a PASS the next range is set. For a FAIL the display returns to the range on which the fail occurred (press [ENTER] to move on through the menu , or retry the range calibration again).

Repeat for all twelve ranges (VR1-VR12).
The display will then show -

CALIBRATE AMPS?
>yes<

If only the Voltage channels require calibration select >no< using the [Select] and [Enter] keys and move to the 'SAVE NEW CAL DATA?' prompt.

The Current channels may now be calibrated by selecting >yes<.

5.5 Amp Range Calibration

The display shows,

AR1 INPUT 20 mA rms
VALUE IN A 0.000

If you wish to skip the calibration of this range press [Enter] and the program will move on to the next range.

To calibrate the range set the generator output to approx. the value requested on the display. Allow to settle and key in the measured value from the digital multimeter. Enter data in Amps (e.g. 0.020). Press [Enter]. The Current will be measured on all three inputs and the calibration constants for each analogue channel will be calculated.

The display will then advise PASS or FAIL as for the voltage range. Proceed as described in voltage section.

Repeat for all twelve ranges (AR1-AR12).

The display will then show -

CALIBRATE EXTERNAL?
>yes<

The external inputs may now be calibrated by selecting >yes<.
If you do not need to calibrate the external input select >no< and move to the 'SAVE CAL DATA?' prompt.

5.6 External Input Calibration

Note: To calibrate EXTERNAL, the AMP RANGE must already be calibrated

The display shows,

XR7 INPUT 31mVrms
VALUE IN V 0.000

Input approximately the displayed voltage to all external inputs and key in the value measured by the digital multimeter. Enter the value in Volts (e.g. 0.031). Press [Enter]. The calibration constants will be calculated.

PASS or FAIL status for each range calibration is displayed. Proceed as described in the voltage section.

Repeat for all 6 ranges (XR7-XR12).

If your instrument has the -001 option the display will the show

CALIBRATE AUX?
>yes<

The auxiliary input may now be calibrated by selecting >yes<.

If you do not need to calibrate the auxiliary inputs select >no< and move on to the SAVE CAL DATA? prompt.

5.7 Auxiliary Inputs Calibration

PM3000A-001 OPTION ONLY

The display shows

10V AUX input 1V dc
Value in V 0.000

Input approximately 1V dc into both auxiliary inputs A &B and key in the value measured by the digital multimeter. All values must be entered in volts.

The display then shows,

10V AUX Input 9V dc
Value in V 0.000

Repeat above but with a 9V dc input as prompted. Once the calibration constants have been calculated the display will indicate,

CHANNEL 1 + 2
PASS

CHANNEL X
FAIL

where X is 1 or 2

Press [ENTER] to continue and repeat the above for the 1V AUXILIARY RANGE.

The display next shows,

SAVE NEW CAL DATA?
>yes<

To save any new calibration data select >yes<. Selecting >no< will return without altering the EEPROM contents.

The next display shows,

PRINT CALIBRATION
>yes<

Connect a printer to the Centronics port, and select >yes< if a printout is required. Otherwise, select >no< and press [Enter] to finish the calibration routine.

5.8 Recommended Equipment

The following equipment is required to calibrate the PM3000A.

1. Datron 1271 or equivalent (High accuracy true RMS digital volt meter.

2. Current Generator:

Current	0 - 30 Amps
Frequency	120 Hz

3. Voltage Generator:

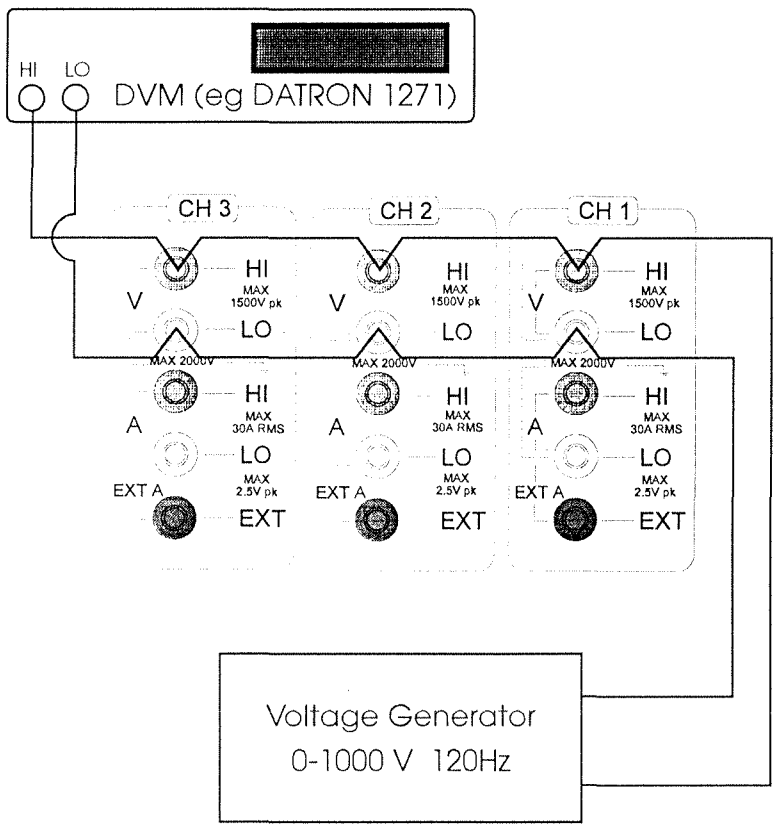
Voltage	0 - 1000 Volts
Frequency	120 Hz

4. Shunts:

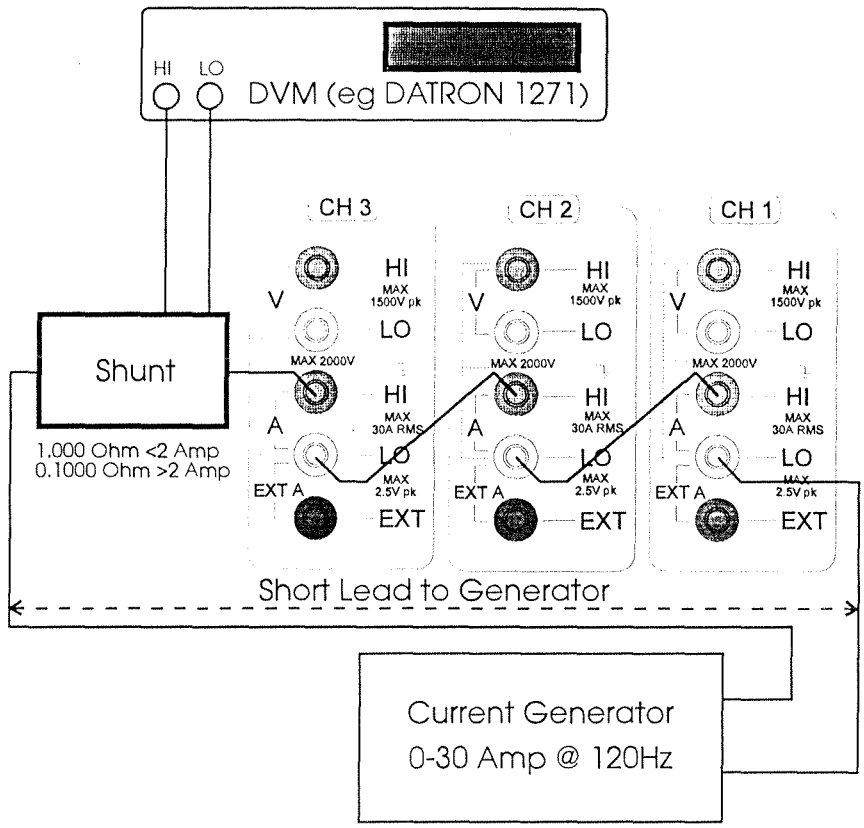
(a)	Resistance	1.0000 Ohms
	Current	2.0 Amp
(b)	Resistance	0.10000 Ohm
	Current	40 Amp

5. Printer

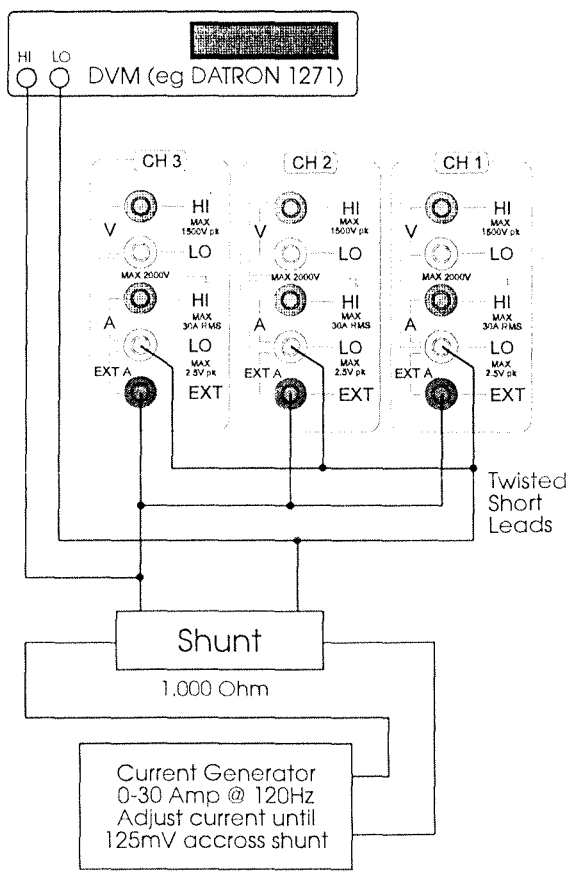
5.9 Voltage Calibration



5.10 Current Calibration



5.11 External Current Calibration



SECTION 6

EMC COMPLIANCE

6.1 Declaration Of Conformity

DECLARATION OF CONFORMITY

Manufacturer's Name	Voltech Instruments Ltd
Manufacturer's Address	65 Milton Park Abingdon, Oxon United Kingdom

declares, that the product

Product Name:	Power Analyzer
Model Number:	PM3000A

conforms to the following Product Specifications

Safety:	BS EN 61010 (1993)
EMC:	BS EN 55022 (1995): Class A BS EN 50082-2 (1992)

Supplementary Information: The product herewith complies with the requirements of the EMC Directives 89/336/EEC and 92/31/EEC and the Low Voltage Directive 73/23/EEC

Signed for on behalf of Voltech Instruments Ltd

Martin Whitley, Quality Manager

Abingdon, United Kingdom January 29, 1996

6.2 EMC Precautions

Conducted and Radiated Emissions

The PM3000A complies with the limits of BS EN 55022 Class A.

To ensure continued compliance, the RS232 lead supplied for PC communications must be fitted with the ferrite at the PM3000A end.

Any other RS232 or Parallel Printer leads used should have a ferrite fitted at the end of the lead closest to the PM3000A.

Immunity

The PM3000A may be susceptible to Fast Electrical Transients on the power line and Electrostatic Discharges, which can disrupt the operation of the unit.

In the event of such an occurrence, to return the PM3000A to normal operation;

1) Switch off the power
2) Wait 5 seconds
3) Switch on again

ALPHABETICAL INDEX