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PM3000ACE
User Manual

Version 10

Applies to:

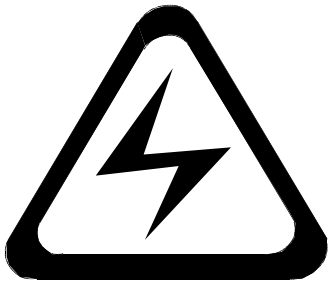
PM3000ACE
(Standard)

PM3000ACE-001
(with torque and speed inputs)

PM3000ACE-002
(for full compliance IEC harmonics)

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.

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CHAPTER 1
GENERAL DESCRIPTION

1.1 EQUIPMENT CHECK LIST

The following items comprise a complete instrument:

1 off	PM3000A Unit
6 off	Yellow Test Leads
6 off	Black Test Leads
6 off	Yellow Crocodile Clips
6 off	Black Crocodile Clips
1 off	AC Power Lead
1 off	User Manual
1 off	RS232 Lead
1 off	VPAS Demonstration Disk
1 off	IEC1000-3 Demonstration Disk

1.2 ACCESSORIES

Current Transformer 1000/100:1	(CT1000)
1000:1 Current Clamp Transformer	(CL1000)
100:1 Current Clamp Transformer	(CL100)
Ballast Current Transformer	(Ballast CT)
Parallel Printer Cable	(VPN 77-001)
VPAS (Visual Power Analysis Software)	(VPAS)
IEC1000-3 Software for Windows	(IEC1000-3)
PS1000 Power Switch for Inrush Current Measurements	(PS1000)

1.2.1 APPLICATION NOTES

Power Measurements in Lighting Applications	(APP Note 101)
IEC1000-3 Application Note	(APP Note 104)
PWM Drives	(APP Note 105)

1.3. SYSTEM OVERVIEW

The user is referred to the block diagram on the next page.

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 an isolation link. This technique allows the PM3000A to have an extremely high common mode rejection, minimizing the effects caused by high dv/dt waveforms such as those existing 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 many of the measurements have separate routines).

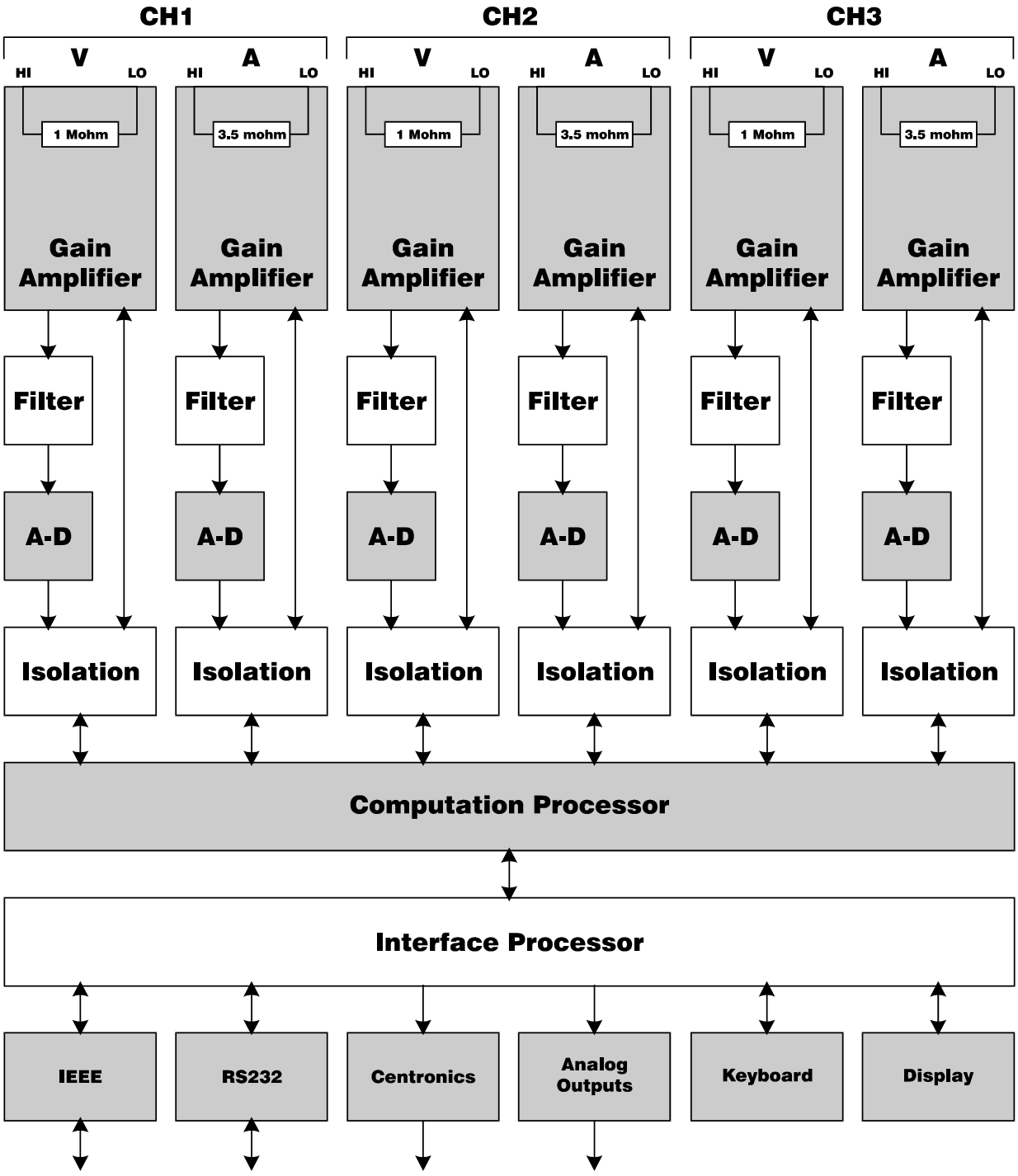
All channels are sampled at a sample rate set by the microprocessor. The data is stored in memory until 400 samples for each channel have been made. The data is then checked for over-range or under range. If the range is correct, the frequency of the input is calculated. If the sample rate is not right 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 is 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, averaged, and stored in memory. These background results are available to the IEEE, RS232 and printer interfaces.

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

PM3000A BLOCK SCHEMATIC



CHAPTER 2

GETTING STARTED

2.1 POWER ON

The instrument is supplied with a 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 or earth pin. **On no account should the instrument be used without the safety ground being made.**

Turn the power on at the front of the instrument.

The display will briefly show 'VOLTECH INSTRUMENTS' and the firmware version number, followed by the default display:

0.000 V	0.000 A
Watts =	+0.000 W

All the LED indicators will be lit for a short time before the default display is shown and it is assumed at this stage that no voltage and current inputs are present.

The factory set default display is for a single-phase 2-wire connection (see section 2.3). Watts, Volts and Amps are displayed for channel 1 (confirmed by the LED indicator below the [CH1] key. In this display mode the keys for phases 2 and 3, [CH2] and [CH3], as well as the calculated sum key [$\sum$] and neutral current key [N] are invalid.

(The power on display may have been changed by a previous user. It is possible to restore the default display by loading the standard program - see section 4.1.1)

Important Note. The PM3000A is a high bandwidth (500kHz) instrument. The standard and 001 versions of the instrument are fitted with a low bandpass (25 kHz) filter that is enabled as default.
Version PM3000A-002 has a 5kHz filter to meet requirements of the EN60555-2 and EN61000-3-2 standards. For high frequency measurements disable the filter as described in section 5.2.

2.2 USING THE CONTROL KEYS

Although a sophisticated instrument, the PM3000A is extremely easy to configure and operate. The control keys are all front panel mounted, and are arranged in a manner to aid intuitive operation of the equipment.

To enable the user to get 'up and running' as quickly as possible several of the basic measuring functions are described below. Greater detail of their operation plus a description of the remainder of the control keys is covered in the following chapters.

2.2.1 WIRING KEYS

Before meaningful measurements can be made the wiring mode must be selected and appropriate connections made to the rear panel. The PM3000A is highly versatile and can be configured to analyze almost any electrical system. This versatility is achieved because all power inputs are ac + dc coupled and isolated from each other and ground. The four main wiring modes are:

[1Ø2W] SINGLE PHASE, TWO WIRE.
Select for single phase loads with two-wire distribution system.

[1Ø3W] SINGLE PHASE, THREE WIRE.
Select for single phase loads with three-wire distribution system.

[3Ø3W] THREE PHASE, THREE WIRE.
Select for single-phase loads without neutral connection (two-wattmeter method).

[3Ø2W] THREE PHASE, FOUR WIRE.
Select for single-phase loads with or without neutral connection (three-wattmeter method).

Refer to section 2.3 for the rear panel connections to be used for each wiring mode.

2.2.2 CHANNEL SELECT KEYS

These keys are used in conjunction with the wiring keys to display the measure values for the selected phase or channel.

The function of each is as follows:

[CH1] Displays the measured values for the phase connected to channel 1

[CH2] Displays the measured values for the phase connected to channel 2

[CH3] Displays the measured values for the phase connected to channel 3

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

[N] Displays neutral currents in multiphase systems. These waveforms are computed by summation of the instantaneous values of the individual phase currents.

Information is only displayed if relevant to the wiring mode selected. For example, if [1Ø2W] has been selected only the [CH1] key will display the measured parameters. Selecting any of the other four keys will result in the message FUNCTION INVALID being displayed.

The user is encouraged to assess the effect of selecting combinations of the Channel Select and Wiring keys.

2.2.3 AUTO KEYS

The PM3000A is a fully auto-ranging instrument, and in most measurement modes the green LED under the [AUTO] keys for volts and amps should be illuminated. Specific ranges for voltage or current may be chosen if desired. Use the up and down arrow keys beneath the appropriate display to select a measurement range. The green LED beneath the [AUTO] key will be extinguished and the range chosen (volts or amps) indicated by the red LED panel. If the voltage or current range is set too low an OVERLOAD message will be displayed.

2.2.4 MEASUREMENT KEYS

The use of the six keys at the top left of the front panel is described below – these are used for the most common measurements of power systems. Further details of these and other measurement keys are covered in the following chapters.

2.2.4.1 [W] TRUE POWER

Measures the power absorbed by a load or delivered from an ac source even with distorted waveforms. The instrument is ac + dc coupled and therefore measures the total real power.

2.2.4.2 [VA] APPARENT POWER

Determines the apparent power absorbed by a load or delivered from a source.

2.2.4.3 [VAR] REACTIVE POWER

Computes and displays the reactive power flow due to the phase difference between the current and voltage waveforms and due to waveform distortion.

2.2.4.4 [V] VOLTAGE

Displays the true RMS or mean values of the input voltage(s) even with distorted waveforms.

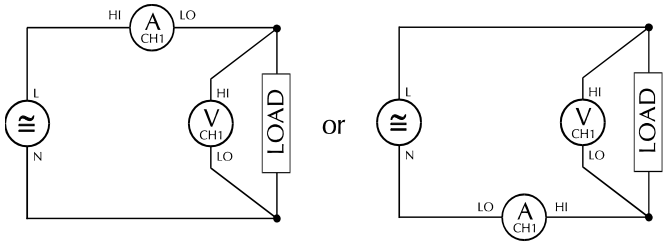
2.2.4.5 [A] CURRENT

Displays the true RMS or mean values of the load current(s) even with distorted waveforms.

2.2.4.6 [PF] POWER FACTOR

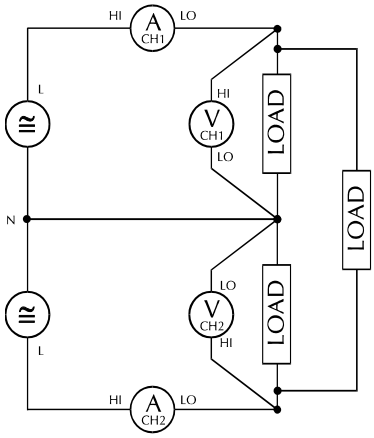
Displays the true power factor of an ac load.

2.3 CONNECTION DIAGRAMS



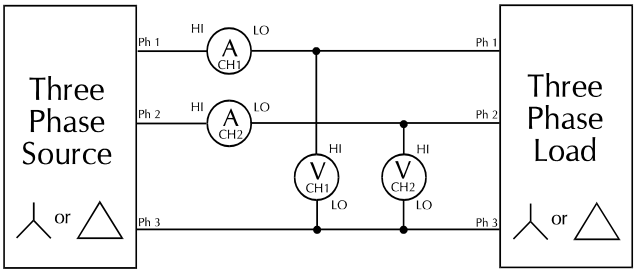
Single-phase, Two-wire and DC measurements.

Select **1Ø 2W**



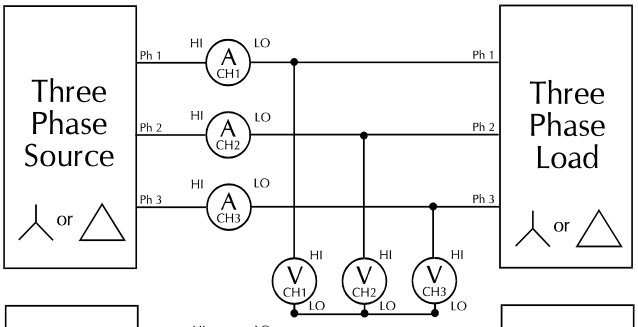
Single-phase, Three-wire.

Select **1Ø 3W**



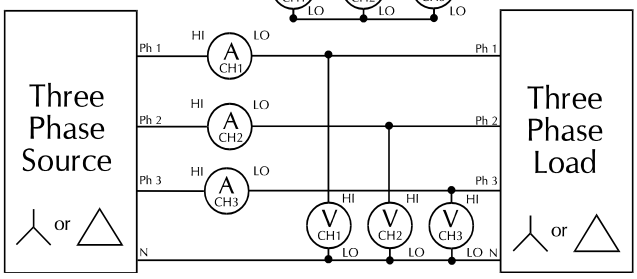
Three-phase, Three-wire (2 wattmeter method)

Select **3Ø 3W**



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

Select **3Ø 4W**



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

Select **3Ø 4W**

CHAPTER 3
BASIC FUNCTIONS

3.1 BASIC MEASUREMENT FUNCTION KEYS

3.1.1 [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 3.2.4), and therefore measures the total real power.

Connect the PM3000A as shown in the appropriate connection diagram (see section 2.3) 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:

$$W = \frac{1}{T}\int_0^T v_i \; i_i \; dt$$

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.

	0º	-90º	-180º	-270º	-360º
W	+	-	-	+	
PF.f	-	-	+	+	
VArs.f	+	+	-	-	

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

3.1.2 [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]

VA is computed as:

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

3.1.3 [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 waveform distortion.

VAr is computed as:

$$VAr = \sqrt{(VA)^2 - W^2}$$

The polarity of the (fundamental) VArs is shown in the table in section 3.1.1. for various angles between current and voltage.

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

3.1.4 [V] VOLTAGE

The input is (AC + DC) coupled, (see section 3.2.4) and the instrument will record the RMS or MEAN (see section 3.2.2) value of the combined AC and DC components. Only the voltage input leads need be connected for Vrms measurements. Vrms is computed as:

$$V_{RMS} = \sqrt{\frac{1}{T}\int_0^T v_i^2 \, dt}$$

and Vmean is computed as:

$$V_{MEAN} = \frac{1}{T}\int_0^T |v| \, dt$$

3.1.5 [A] CURRENT

Only the current input need be connected when taking Arms measurements. Arms is computed as:

$$A_{RMS} = \sqrt{\frac{1}{T}\int_0^T i_i^2 \, dt}$$

and Amean is computed as:

$$A_{MEAN} = \frac{1}{T}\int_0^T |i| \, dt$$

3.1.6 [PF] POWER FACTOR

Displays the true power factor of an AC load. Power factor is *only* cos ø 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 3.1.1 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 (see section 6.1).

3.1.7 [VPK], [APK] PEAK VOLTAGE OR CURRENT

These keys display the repetitive peak current or voltage. The peak voltage measurement is used to determine the working voltage of insulation or the voltage available for rectification.

The peak current measurement can be used to set current limit or trip levels in UPS or similar equipment.

3.1.8 [VCF], [ACF] VOLTAGE OR CURRENT CREST FACTOR

Crest factor is the ratio of the magnitude of the peak value to the RMS value of a waveform.

$$CF = \frac{Peak\,Value}{RMS\,Value}$$

The crest factor of a sinewave is √2 or 1.41.

Many loads, such as rectifiers with capacitor filters, produce a distorted current waveform where the Amps crest factor will be much larger than √2.

3.1.9 [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 as power supplies, motors, etc., are switched-on.

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	3.6μS
Single phase three wire	6.8μS
Three phase three wire	6.8μS
Three phase four wire	10.0μS

Inrush current can also be measured using the data log function (see section 9.1). This has the advantage 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- the display will then be similar to that shown below.

SET MANUAL RANGE

Inrush = 0.000 A

Using the up and down arrow keys beneath the red LED panel select an amps range that is able to accommodate the expected peak inrush current. Switch on the load and 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 or a higher value is measured. If an overload occurs the display will not clear until the [INRUSH] key is pressed even if the overload is no longer present. Press another Function key to return to the previous displays.

3.1.10 [IMPEDANCE]

The impedance of a load can be measured by pressing the [IMPEDANCE] key. The total impedance will be displayed in ohms, calculated as:

$$Z = \frac{Total\ RMS\ Volts}{Total\ RMS\ Amps}$$

If fundamentals have been selected, i.e. the FUND LED is on, the complex impedance due to the fundamental volts, amps and power factor is displayed.

$$Z = R + jX \text{ Ohms}$$

Only the resistive part, R, of the impedance is displayed on the single function and multiple channel displays.

+R Indicates power flow into load
-R Indicates power flow from load
+X Indicates inductive reactance
-X Indicates capacitive reactance

3.1.11 [ENTER] TO HOLD THE DISPLAY

When not in a configuration, programming or data entry mode, the [ENTER] key may be used to hold the value of the parameter in the lower line of the display. The values of other parameters are also held when [ENTER] is pressed and these may be displayed by pressing the appropriate control key.

To return to real-time display press [ENTER] again.

3.2 SET-UP KEYS

The SET UP keys control the configuration of the input circuits of the PM3000A. Since each channel is entirely separate and isolated from each other, the set-up can be different for each channel when independent channel wiring modes are selected. In normal 3 phase 3 wire or 3 phase 4 wire connection modes, the set-up parameters are linked together for simplicity.

3.2.1 [FREQ SOURCE]

As part of the operation of the PM3000A the measurement functions are synchronized to the ac supply frequency. The source of this frequency is selected by means of the [FREQ SOURCE] key.

[INT] mode synchronizes measurement to input voltage or current over the frequency range 5Hz to 1MHz. The user can choose between voltage or current frequency measurement. This feature is useful in applications such as motor drives where one input may be ‘chopped’.

[EXT] mode synchronizes measurement to a signal applied to a rear panel connector. It is typically used when both voltage and current are 'chopped', or when frequencies as low as 0.1Hz are required to be measured.

Options

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

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

ii. >**current<:** CH1 Amps with a frequency range of DC and (5Hz -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 10Vrms.

Phase Reference

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<

By pressing [SELECT] the user can switch between voltage and current as the phase reference source for harmonic analysis. Press [ENTER] to confirm the selection. Either the red or green LED beneath the [FREQ SOURCE] key will illuminate to indicate the status.

3.2.2 [VOLTS AMPS] RMS OR MEAN

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

RMS mode is the default and this is indicated by the corresponding LED beneath the key. In the mean mode voltage, current and amp hours only are displayed as rectified mean values. All other parameters are displayed as RMS. However when printing results all values are printed as RMS.

3.2.3 [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. When a new result is added to the store the oldest result in the store is discarded.

In AUTO mode the instrument will average the last 16 results. If a large change occurs at the input the averaging store is reset (all values are made zero) and only new data is averaged. This gives a fast response to large input changes. The number of results averaged (the 'averaging depth') in AUTO mode can be changed by using the configuration keys [F],[P] 38 (see section 6.1). (For independent wiring modes, [F],[P] 58 and [F],[P] 78 set the AUTO averaging depth for CH2 and CH3 respectively.)

In FIXED mode the instrument performs averaging as before, but large changes at the input will not reset the averaging store. This can be useful when measuring an input, which contains large voltage spikes for example.

To make a selection, press the [AVG] key. Choose >fixed< or >auto reset< with the [SELECT] key and press [ENTER]. If fixed averaging has been chosen the green LED next to 'N' beneath the [AVG] key will illuminate. Next enter an averaging depth using the digit keys and press [ENTER].

The averaging store can be reset by pressing the channel key for the measurement currently selected. For example, if Watts is currently selected, pressing the [W] key resets the averaging store. Zeros are temporarily displayed for all measurements before new averaged values are displayed.

3.2.4 [COUPLING] INPUT COUPLING

AC + DC coupling is normally selected. The PM3000A computes results due to all components in the input voltage and current including DC and low frequency components in this mode.

AC coupling the instrument means that DC and low frequency components are ignored. This is useful measuring the ripple voltage on rectifier outputs, and for calibration of instruments that are only AC coupled.

Press the [COUPLING] key to toggle between AC + DC coupling and AC coupling only.

3.2.5 [SHUNT] SHUNT SELECTION

This key switches between internal (INT) and external (EXT) shunt selection.

INT mode is selected for direct measurement 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 providing a voltage signal that is proportional to current.

3.2.6 [SCALING]

Scale factors for the voltage and current input on all three channels can be entered. If 1000:1 current transformers are being used, for example, use a current scale factor of 1000 UP to make the PM3000A display the actual currents, watts, etc.

If a wiring configuration other than 1Ø2W is used scaling can be locked (the same scaling on all channels) or independent. Press the [SCALING] key. Choose >locked< or >independent< voltage scaling using the [SELECT] key and press [ENTER] to confirm the setting. Enter a voltage scale factor (if required) using the numeric keys and press [ENTER] to confirm the setting.

If you have chosen independent scale factors you are then prompted for the CH1, CH2, and CH3 scale factors.

Next choose >locked< or >independent< current scaling, and then enter a scale factor in the same manner if required. If a current scale factor other than 1.0 is entered, the display then shows:

CURRENT SCALING
>up<

Pressing [SELECT] switches between >up< and >down<. Choose >up< to multiply the measured current by the scale factor or >down< to divide the measured current by the scale factor. Press [ENTER] to confirm the setting.

A scale factor of 100 down is equivalent to 0.01 up. If you return to this menu, the scale factor is always displayed as the equivalent >up< scale factor.

3.2.6.1 SCALING THE EXTERNAL SHUNT

The external shunt input has a range of 0 to 2.5V peak. This corresponds to 12.5mV per amp (2500mV = 200A). If for example a 0.1Ω external shunt is used, this will generate 100mV per Amp. The current scale factor must be set to 8.0 'down' to obtain the correct display.

$$\frac{100\ mV\ /\ Amp}{12.5\ mV\ /\ Amp} = 8\ down$$

The formulae for UP and DOWN scaling are as follows:

$$SF = \frac{12.5}{Actual\ mV\ /\ Amp}$$ **UP**

$$SF = \frac{Actual\ mV\ /\ Amp}{12.5}$$ **DOWN**

If you return to this menu, the scale factor is always displayed as the equivalent 'up' scale factor. If 8.0 'down' were entered, the display will show a SF of 0.125 the next time this menu is accessed.

3.2.7. [DISPLAY] DISPLAY FORMAT

Using this key allows the user to specify the measurements to be shown in each part of the display. If multi-channel measurements are being made it is possible to display simultaneously the results for all channels plus the sum. Examples of use are provided below.

3.2.7.1. SINGLE FUNCTION DISPLAY

Press the [DISPLAY] key and use the [SELECT] key to show the following display:

DISPLAY FORMAT
>single<

Press [ENTER] to select this display mode. The display will be similar to the following:

UPPER RIGHT DISPLAY
>Arms<

Press the required function key (at the top left of the front panel) to choose the required parameter for display. The allowed keys are [V], [A], [W], [VA], [FREQ], [PF], [Vpk] and [Apk]. The lower line of the display will change to show the selected parameter. Press [ENTER] to confirm, and then repeat this procedure for the upper left display.

The display will reconfigure to show the selected measured parameters on the upper line. (The lower line may be changed simply by pressing the required function key).

3.2.7.2 MULTIPLE FUNCTION DISPLAY.

To display measure parameters for all channels first select the [3Ø4W] key, the Channel Select key [∑] and the required function key, for example [W]. Press the [DISPLAY] key and use the [SELECT] key until the display is as shown below:

DISPLAY FORMAT
>multiple<

Press [ENTER] to select this option and the display will be similar to:

+0.000 +0.000 +0.000
Watts = +0.000 W

The three numbers on the top row correspond to CH1, CH2 and CH3 respectively and the bottom row shows the sum of the Watts. Other function keys may be pressed to indicate their values but note that not all are valid for a multiple display.

3.2.7.3 FOUR FUNCTION DISPLAY.

Press the [DISPLAY] key and use the [SELECT] key until the display is as shown below:

DISPLAY FORMAT
>four function<

Press [ENTER] to select this option and then choose the parameters to be displayed in a manner similar to that for single function display. Note that not all are valid for the four function display.

3.2.8 [CLOCK SET] DATE AND TIME

The date and time may be changed by the user. To do this, press the [CLOCK SET] key. Use [SELECT] to switch between >accept< and >change< and then press [ENTER]. If changing the current date and time use the digit keys to enter new values in the format shown. Press [ENTER] after each entry and again to >accept< the revised date and time.

3.3 HARMONIC ANALYSIS

The PM3000A will measure the harmonic content of the voltage and current waveforms for all components up to the 99th harmonic. It will also analyze the current flowing in the neutral wire of a 3 phase 4-wire system and calculate any DC components.

A specially designed mode is incorporated for testing to EN60555 and EN61000-3. Flicker and fluctuating harmonics as well as steady state harmonics can be measured in the IEC555 mode. (See section 5.6).

The VPAS Demo software supplied can be used to display and print harmonic barcharts (see section 10.8).

Harmonic measurements can be made at any frequency within the bandwidth of the instrument.

3.3.1 [V HARM] VOLTAGE HARMONIC

Press the [V HARM] key. Enter the required harmonic using the number keys followed by [ENTER]. Use [SELECT] if you make a mistake during number entry. The chosen harmonic amplitude is displayed.

For harmonic 0 (DC component) and harmonic 1 (fundamental) the absolute value of the amplitude is displayed, for other harmonics (up to 99) the harmonic amplitude is displayed as a percentage of the fundamental. To display harmonics 2 to 99 as absolute values use [F],[P]18 (see section 6.1).

To view another harmonic press [V HARM] again and repeat the above procedure, or press [ENTER] for the next highest order harmonic. Harmonic phase information is not displayed in the multiple channel display.

To get a printout of all harmonics up to a pre-set limit, use the printer selection menu (see section 8.1.). Watts harmonics can also be selected for print if both volts and current harmonics are selected.

3.3.2 [A HARM] CURRENT HARMONIC

Press the [A HARM] key. Enter the required harmonic using the number keys followed by [ENTER]. Use [SELECT] if you make a mistake during number entry. The chosen harmonic amplitude is displayed.

For harmonic 0 (DC component) and harmonic 1 (fundamental) the absolute value of the amplitude is displayed, for other harmonics (up to 99) the harmonic amplitude is displayed as a percentage of the fundamental. To display harmonics 2 to 99 as absolute values use [F],[P]18 (see section 6.1).

To view another harmonic press [A HARM] again and repeat the above procedure, or press [ENTER] for the next highest order harmonic. Harmonic phase information is not displayed in the multiple channel display.

To get a printout of all harmonics up to a pre-set limit, use the printer selection menu (see section 8.1). Watts harmonics can also be selected for print if both volts and current harmonics are selected.

3.3.3 [V THD] VOLTAGE HARMONIC DISTORTION MEASUREMENTS

The distortion factor of the voltage waveform can be measured by pressing the [V THD] key. The result is obtained by the calculation:

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

where REF is normally the fundamental component. It can be set to RMS (see [F],[P] 17, section 6.1). This method is known as the 'difference formula'.

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.

An 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 and H3 is the third harmonic percentage of the chosen REF value.

The default for the front panel display values is the difference formula. This can be changed to 'harmonic series' (THD) value by using [F],[P] 16 (see section 6.1).

3.3.4 [A THD] CURRENT HARMONIC DISTORTION MEASUREMENTS

The distortion factor of the current waveform can be measured by pressing the [A THD] key. The calculation method is similar to that described in section 3.3.3 above.

3.3.5 [FREQ] FREQUENCY

Press the [FREQ] key to display the fundamental frequency of the AC input.

This frequency is used as the basis for harmonic analysis. Frequency is derived from the volts, amps or external source - see [FREQ SOURCE] (section 3.2.1). In 1Ø2W, 1Ø3W, 3Ø3W, and 3Ø4W wiring modes, the frequency source is channel 1. In independent CH3 wiring, the frequency source for channels 1 and 2 is CH1, and for channel 3 it is CH3. For all other wiring modes, the frequency source is its respective channel.

3.3.4 [FUND] FUNDAMENTAL VALUES

The PM3000A normally displays measurements as true RMS values. This takes into account all harmonics, noise, offsets, etc. that can be measured within the bandwidth of the instrument.

When the [FUND] key is pressed, results are displayed which are calculated from the fundamental components of voltage and current only. For example, the fundamental power factor displayed cos Ø, is the phase shift between the voltage and current fundamentals.

CHAPTER 4

PROGRAM SET-UP

4.1 PROGRAMMING

Up to five set-ups can be stored in the PM3000A's non-volatile memory. Any of the five programs may be loaded on power up to configure the instrument automatically to a particular set-up. All settings are stored when a set-up is saved.

The [P] button can also switch the instrument from the P[1] set-up to the P[2] set-up if the PROGRAM SWITCH function is enabled. (See section 5.5).

To save a set-up, press the [P] key. Use the [SELECT] key to choose >save program< and press [ENTER]. 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.

4.1.1 TO LOAD A STORED SETUP

Press the [P] key. Use the [SELECT] key to choose >load program< and press [ENTER]. 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. Press the [ENTER] key to confirm the setting.

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 set-up 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.

4.1.2 TO SET THE POWER ON DEFAULT

The contents of any of the five program stores P1 - P5, or the power down setting, can be made the power on default set-up. To do this, press the [F] key. Use the [SELECT] key to display the following:

F[1] P. ON DEFAULT
<select> or <enter>

Press [ENTER] and then use [SELECT] to display >standard<, >program 1-5< or >power down<. Press [ENTER] to confirm the choice. If >program 1-5< is selected, then enter the program number using the digit keys and press [ENTER] again. Until the default is changed back to 'standard', the PM3000A will power up with the set-up stored in the program number selected.

4.1.3 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 use the [SELECT] key to display >print program<. Press [ENTER] and select >yes<. The configuration will then be printed.

```
************************************************************
PM3000 configuration data

operating mode      1
program switch      off
1 phase 2 wire
wiring lock         on
phase lock          on
function selection  00000001 10000001 11110000 11111111   1
target power factor +1.000
pre-averaging time  5
fixed frequency      60.00
channel control     10001000 00110001 00000000            2
voltage range       auto
current range       auto
averaging           16 auto
voltage scale       +1.000
current scale       +1.000
harmonic control    00000100                              3
maximum harmonic    7
printer control     00000000 10100001                     4
integrator control  00000001                              5
datalog control     00000001                              6
datalog window      0
IEEE address        10
RS232 baud rate     9600
****************************************
```

There are 6 items of information marked on the printout that require further explanation.

They are:

1. Function Selection
2. Channel Control
3. Harmonic Control
4. Printer Control
5. Integrator Control
6. Datalog Control

1. Function Selection

xxxxxxxx xxxxxxxx xxxxxxxx xxxxxxxx
bit 31 bit 0

bit 0 Watts selected
bit 1 VA selected
bit 2 VAr selected
bit 3 Vrms selected
bit 4 Arms selected
bit 5 Power factor selected
bit 6 V peak selected
bit 7 A peak selected
bit 8 V crest factor selected
bit 9 A crest factor selected
bit 10 Not used
bit 11 impedance selected
bit 12 W hours selected
bit 13 VA hours selected
bit 14 VAr hours selected
bit 15 A hours selected
bit 16 Average PF selected
bit 17 Correction VArs selected
bit 18 Efficiency selected
bit 19 Voltage harmonics selected
bit 20 Current harmonics selected
bit 21 Voltage THD selected
bit 22 Current THD selected
bit 23 Frequency selected
bit 24 Channel 1 selected
bit 25 Channel 2 selected
bit 26 Channel 3 selected
bit 27 Sum channel selected
bit 28 Neutral channel selected
bit 29 Fundamentals selected
bit 30 Watt harmonics selected
bit 31 Not used

2. Channel Control

xxxxxxxx xxxxxxxx xxxxxxxx
bit 23 bit 0

bit 0&1 Freq source: 0 = voltage
1 = current
10 = external
11 = slow external
bit 2 Slow sampling enabled
bit 3 Fast mode
bit 4 Jitter fixed
bit 5 Frequency fixed
bit 6 Voltage range fixed
bit 7 Current range fixed
bit 8 Filter on
bit 9 Not used
bit 10 Rectified mean enabled
bit 11 Fundamentals enabled
bit 12 Jitter enabled
bit 13 AC coupled
bit 14 External shunt selected
bit 15 Current phase reference
bit 16 Ballast/ultrasonic mode
bit 17 Ballast/ultrasonic mode
bit 18 Fixed sample rate
bit 19 Autozero enabled
bit 20 PWM mode
bit 21 PWM mode
bit 22 Not used
bit 23 Channel enabled

3. Harmonic Control

xxxxxxxx
bit 7 bit 0

bit 0 Harmonic reference = rms
bit 1 Harmonic display = absolute
bit 2 Even harmonics in series
bit 3 not used
bit 4 Series thd formula
bit 5 DC included in thd
bit 6 not used
bit 7 not used

3. Printer Control

xxxxxxxx xxxxxxxx
bit 15 bit 0

bit 0	manual trigger	bit 8	logic output 1
bit 1	external trigger	bit 9	logic output 2
bit 2	timed trigger	bit 10	logic output 3
bit 3	not used	bit 11	logic output 4
bit 4	not used	bit 12	logic output 5
bit 5	printer port = RS232	bit 13	not used
bit 6	print selection	bit 14	not used
bit 7	printer enabled	bit 15	not used

4. Integrator Control

xxxxxxxx
bit 7 bit 0

bit 0	manual trigger	bit 4	averaged integration display
bit 1	external trigger	bit 5	reset accumulators after print
bit 2	timed trigger	bit 6	not used
bit 3	cyclic interval	bit 7	integrator enabled

5. Datalog Control

xxxxxxxx
bit 7 bit 0

bit 0	manual trigger	bit 4	not used
bit 1	external trigger	bit 5	not used
bit 2	timed trigger	bit 6	not used
bit 3	cycle by cycle	bit 7	not used

CHAPTER 5
THE FUNCTION MENUS

5.0 THE FUNCTION MENUS

The Func [F] key can be used to configure the PM3000A into special operating modes for a wide number of application areas including:

PWM motor drives
High-frequency electronic ballasts
Testing to EN60555 parts 2 and 3 and EN61000-3
Transformer testing to IEC76-1

The function system also accesses other PM3000A configuration menus including the calibration menu.
The function structure and operation are described below in the same numerical order in which they appear on the PM3000A.

5.1. F[1] POWER ON DEFAULT

The contents of any of the five program stores P1 - P5, or the power down setting, can be made the power on default set-up. To do this, press the [F] key. Use the [SELECT] key to display the following:

F[1] P. ON DEFAULT
<select> or <enter>

Press [ENTER] and then use [SELECT] to display >standard<, >program 1-5< or >power down<. Press [ENTER] to confirm the choice. If >program 1-5< is selected, then enter the program number using the digit keys and press [ENTER] again. Until the default is changed back to 'standard', the PM3000A will power up with the set-up stored in the program number selected.

5.2. F[2] BANDWIDTH

The power-up default is >low< i.e. filter enabled:

25 kHz for 001 and standard models
5 kHz for 002 models

This option allows the user to select the full 1MHz bandwidth by selected >high<.

5.3. F[3] WIRING

Various wiring modes are available to suit the various input connections that can be made by the user (see Connection Diagrams - Section 2.3). All the voltage and current inputs are isolated from each other and from ground.

Connection to the PM3000A voltage channel inputs is via 4mm sockets on the rear panel of the instrument. Currents up to 30A RMS may be connected directly to similar rear panel sockets. For higher current measurement, use either a current transformer to reduce the current presented to the PM3000A, or an external shunt to derive a voltage input suitable for the external shunt input. Four wiring keys are provided on the front panel to allow convenient access to these modes of operation. These and other modes may also be accessed via the menu system as follows:

Press the [F] key and then use [SELECT] until the display is as shown below:

F[3] WIRING
<select> or <enter>

Press [ENTER] to display the Wiring Configuration options. Use the [SELECT] key to cycle through the options and press [ENTER] to confirm the required setting. The options are covered in more detail below.

5.3.1. 1 PHASE 2 WIRE

Select for single-phase loads on a 2-wire distribution system. Also use to measure the output of a rectifier stage. Connect to channel 1.

5.3.2. 1 PHASE 3 WIRE

Select for three-wire, single-phase distribution systems. Connect to channels 1 and 2.

5.3.3. 3 PHASE 3 WIRE

Select for three phase measurements where there is no neutral connection (two wattmeter method). The current in the [N] channel is computed by summation of the instantaneous phase currents. In this way Arms, Amean, Apk, Acf and Amps harmonics can be displayed for the 3rd wire. They are displayed as neutral current measurements. Total watts, volts, etc. for CH1 and CH2 are displayed as $\sum$ values. Connect to channels 1 and 2.

5.3.4. 3 PHASE 4 WIRE

Select for three phase measurements with or without a neutral connection (three wattmeter method). The current in the neutral wire is computed by summation of the instantaneous phase currents. In this way Arms, Amean, Apk, Acf and Amps harmonics can be displayed for the neutral wire. Total watts, volts, etc. are displayed as $\sum$ values.

5.3.5. CHANNEL 3 ONLY

Select for single-phase measurements on channel 3.

5.3.6. CHANNEL 2 ONLY

Select for single-phase measurements on channel 2.

5.3.7. INDEPENDENT CH3

Channel 3 will operate completely independently of the other channels. For example, use in conjunction with 3-phase, 3-wire mode for taking simultaneous input and output measurements on 3-phase rectifier assemblies.

5.3.8. ALL INDEPENDENT

All three channels operate completely independently of each other. Each channel operates as a completely independent power analyzer, sourcing its own frequency, and selecting ranges and set-up functions.

5.3.9. PHASE TO PHASE VOLTAGE

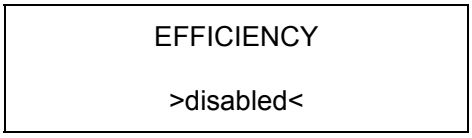
When voltage measurements are made by the PM3000A, the value displayed is normally the voltage across the Vhi and Vlo inputs. In the case of three-phase, four-wire, multi-phase measurements (three watt meter), this voltage is normally the phase to neutral volts. In other cases, the required voltage is the phase-to-phase voltage.

When wiring is set to 3∅ 4W mode, an additional menu allows the PM3000A voltage display to be configured to display phase to phase measurement. Select 3∅4W in the wiring menu to achieve this.

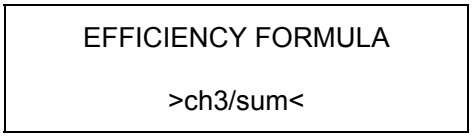
The voltage readings will be from phase to phase, computed vectorially from the phase to neutral data.

5.4 F[4] EFFICIENCY

The PM3000A can be configured to calculate efficiency, using a combination of power or apparent power between any two channels, or between a 3-phase 3-wire measurement and CH3. Press the [F] key and use [SELECT] and [ENTER] to choose F[4] ‘EFFICIENCY’ mode. The display is as follows:



Select >enabled< to give the following display:



Use [SELECT] and [ENTER] to choose the channels to calculate the efficiency from:

>ch3/sum<
>sum/ch3<
>ch1/ch3<
>ch2/ch3<
>ch1/ch2<

Then use [SELECT] and [ENTER] to choose the units for calculation from:

>Watts/Watts<
>VA/VA<
>Watts/VA<
>VA/Watts<

If required, the efficiency can then be scaled to suit the application using the digit keys followed by [ENTER]. When the [FUND] key is pressed, the efficiency is calculated from the fundamental values of WATTS and/or VA.

When efficiency is enabled, independent CH3 is set-up, irrespective of the previously selected wiring mode. The efficiency units, formula, and scaling are printed when Watts and VA are selected for printout.

5.5 F[5] PROGRAM SWITCH

The program switch facility enables two stored set-ups to be alternatively loaded with a single key press. To use, save the first set-up in P[1] and reconfigure the instrument for the second set-up; save this in P[2]. Press the [F] key and use [SELECT] and [ENTER] to choose F[5] 'PROGRAM SWITCH' mode. Use [SELECT] and [ENTER] to switch the option >on<.

Pressing the [P] key now switches the configuration between set-up P[1] and set-up P[2]. To restore the [P] function to normal operation, repeat the above procedure, selecting PROGRAM SWITCH >off<.

N.B. The Program Switch does not change integrator, chart recorder or datalog functions.

5.6. F[6] IEC555 TESTING MODE

The EN60555 and EN61000-3 standards provide limits for the magnitude 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 that 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.

To simplify measurements to EN60555 and EN61000-3, Voltech recommends the use of the 'Windows' based PC software that is available for the PM3000A power analyzer as listed in the accessories section of this manual (page 1-2). This software is available from your supplier, and comes complete with its own user manual.

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

To select this mode, press the [F] key and use [SELECT] and [ENTER] to choose F[6] 'IEC555 TESTING'.

The options available are:

>Disable<
>Fixed Harmonics<
>Fluctuating Harmonics<
>Changing Voltage<
>Flickermeter<

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

5.6.1 FIXED HARMONICS

There are various classes of EN60555 and EN61000-3-2 Limits. Each of these limits is applicable to certain types of equipment, such as, balanced 3 phase, portable tools, lighting, motor driven or other.

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

Selecting this mode automatically sets up the printer output for 40 current harmonics (AH1-AH40), Watts and Power Factor. Press [DATADUMP] to print the selection to the printer. Refer also to our EN60555/61000-3 Test Software Disk, which provides bargraphs with IEC limits, and captured waveform display.

5.6.2 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, select >fluctuating harmonics< and then press [ENTER]. The display then shows:

IEC555 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].

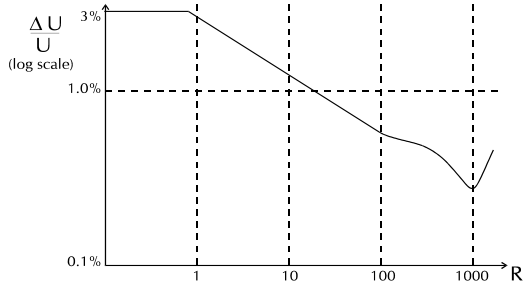
Refer also to our EN60555/61000-3 Test Software Disk which provides a real time bargraph of fluctuating harmonics with IEC limits, and graphs of single harmonic levels over time.

5.6.3 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 EN60555-3 and is suited to measurements where the load is changing regularly.

The EN60555 Standard 555-3 stipulates limits for 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. At the end of the test period, pressing the [DATADUMP] key will automatically cause a print-out of the total memory time, elapsed time, and the number of occurrences for each size of voltage fluctuation (ΔU/U), from 0.1% to >3% (40 bins in all). These can then be checked according to the graph for IEC555-3 to assess compliance. For more guidance, refer to our Application Note 104.

5.6.4 FLICKERMETER

Flickermeter is the preferred method of measuring flicker to EN60555/61000-3-3, and is suited to measuring flicker where the load is either changing regularly or varying irregularly.

The IEC 868 Flickermeter simulates the Lamp-Eye-Brain Chain; 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 that 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.

5.6.5 FULL-COMPLIANCE TESTING

Equipment Required:
AC Power Source.
Source Impedance.
PM3000A
PC
Printer.

Note 1: The AC power source must meet stability and distortion requirements of the EN60555/61000-3-3 standards.

Note 2: Source Impedance of R=0.4Ω, X=0.25Ω must meet specification of the standards.

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 logarithmically scaled 'Bins' to provide a 1024 level classifier.

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

The PC will then calculate values of Pst and Plt from equations defined in this standard.

5.6.6 PRE-COMPLIANCE TESTING

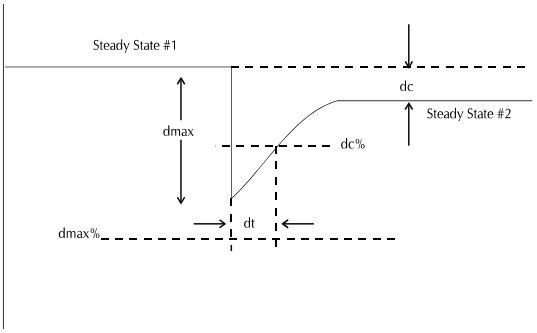
Pre Compliance testing does not require a Source Impedance as the measurement is made by the fluctuating current taken by the load.

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 seen by the PM3000A.

5.6.7 VOLTAGE DEVIATION TESTS

The Flickermeter technique provides an excellent assessment of continuous voltage changes. However, 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, measurements 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.



A steady state voltage that undergoes a voltage change (dmax), exceeding the limit dc% for a time dt seconds (but staying within the limit dmax%), before returning to a second steady state dc voltage level (which is less than dc%, with dt being less than 200ms), will pass the dc, dmax, and dt voltage deviations test.

5.6.8 IEC1000-3 SOFTWARE FOR WINDOWS

This versatile software package greatly simplifies the task of making the measurements that qualify a product under test to the specification EN61000.

The software runs on a PC and works with your Voltech PM3000A Power Analyzer and the programmable ac source of your choice. The test equipment may be connected to the PC using either an RS232 or IEEE488 interface.

The software allows you to quickly set up the tests to be done, and controls the ac source and Power Analyzer to make the measurements. It then reads back the measurement data, and presents the results in easy-to-read tables and graphs, including comparisons with the specification limits and highlighting the Passes and Fails.

When the test is finished, all results can be archived to disk, printed or passed on to another application, for example to be included in a document produced by a word processor.

5.6.8.1 INSTALLATION

To enable this software to install and run correctly, please ensure that your PC and relevant hardware conforms to the specifications outlined as follows.

5.6.8.2 PC REQUIREMENTS

PC: 486 DX. or higher
RAM: At least 4Mb
Disk: 1Mb of hard disk space for program installation, plus at least 1Mb for recording test data
(The requirements for each type of test are as follows:
Waveform capture: 1.5kb per waveform
Steady State Harmonics: 1kb per measurement
Fluctuating Harmonics: 7Mb per hour
Flicker: 5kb per 10 minutes)
Windows: Version 3.1 or higher

5.6.8.3 IEEE 488 INTERFACE CARDS SUPPORTED

All current National Instruments cards supporting 488.2 protocols

5.6.8.4 INSTALLING THE SOFTWARE TO YOUR PC

1) Insert the 3½ inch disk into drive A on your PC.
2) From the Windows Program Manager, using the mouse
   - Pull down the File menu
   - Click on Run
3) In the Run dialogue box, on the Command Line type a:\setup, and click on the OK button.
4) Follow the on-screen prompts.

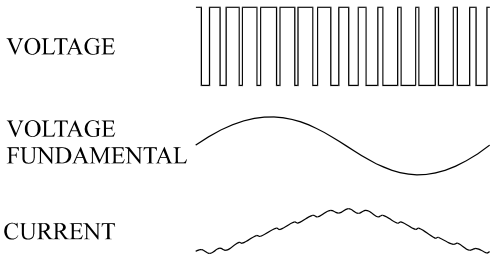
The default directory for the IEC1000 for Windows software is C:\IEC1000. You may choose an alternative drive / directory, when prompted, during the installation process. (For more information on installation, please refer to the IEC1000-3 User Manual.)

5.6.8.5 SETTING UP YOUR IEEE488 INTERFACE CARD.

Initially, refer to the user manual supplied with your IEEE488 interface card for the recommended procedures for installation and set-up of the card in your PC. If there is any difficulty, please refer to the IEC1000 software on-line help.

5.7 F[7] PWM DRIVE MODE

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 is normally applied to prevent anti-aliasing. This will affect the PWM pre-filtered 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 SOURCE] to >current<.

6. The wiring for PWM mode is either 3Ø3W or 3Ø4W. The [N] channel provides computed values of neutral current (Arms, AFund, Acf, Apk, Aharm and Athd).

To use this operating mode, select F[7] PWM DRIVES by pressing the [F] key and then using [SELECT and [ENTER]. Four options are then available:

>disable<
>input<
>output<
>real time output<

All wiring configurations for the PWM mode that are 3Ø 3W 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:

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

5.7.1 OUTPUT MODE

1. Connect the output of the drive to the PM3000A and motor in either 3Ø3W or 3Ø4W mode (see diagram in section 2.3).

2. Select PWM DRIVES >output< mode.

3. Select the chosen frequency band depending on the motor operating speed range, e.g. >5Hz to 1kHz< using the [SELECT] and [ENTER] keys.

4. Select >3Ø3W< or >3Ø4W< as required.

5. Select High Bandwidth mode (see section 5.2)

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 & Vfund values, but only small differences between Arms & Afund and Wrms & Wfund, as the inductive motor filters the current.

$$Harmonic\ Losses = \quad Total\ Power - Fundamental\ Power$$

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 later section on harmonics.

5.7.2 INPUT MODE

If the output of the drive is unbalanced, the input waveforms are modulated by the output motor frequency. Accurate measurements are obtained by synchronizing 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 3Ø3W or 3Ø4W mode (see diagram in section 2.3).

2. Select PWM DRIVES >input< mode and the display will be as follows:

PWM INPUT WINDOW
>1.000<

3. Use the digit keys to set the calculated value for τ (e.g. 1.39) and press [ENTER]. If you make a mistake, press [SELECT] to re-enter the value and then press [ENTER].

4. 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.

5.7.3 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 in 3Ø3W or 3Ø4W mode (see diagram in section 2.3).

2. Select PWM DRIVES >real time output< mode and the display shows as follows:

PWM OUTPUT RANGE
>5 Hz to 1kHz<

3. Use the [SELECT] and [ENTER] keys to choose the frequency band depending on the motor operating speed range, e.g. ‘5Hz to 1kHz’.

4. Use the digit keys to enter the maximum PWM OUTPUT VOLTS for recorder scaling, e.g. 250. Press [ENTER].

5. Use the digit keys to enter the maximum PWM OUTPUT AMPS for recorder scaling, e.g. 20. Press [ENTER].

6. Use the digit keys to enter 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 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

5.7.4 HARMONICS

To extend the measurement of harmonics that exceed the filter cut-off frequency (provided the frequency is not fluctuating), the following procedure can be followed.

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

1. Select PWM >output< mode and the appropriate filter, as described in the earlier sections.

2. Select [F],[P] 36 LOAD FIXED FREQUENCY and set >enable<. Press [ENTER]. This will store the frequency.

3. Save as Program 1 (see section 4.1). Note that this overwrites any program previously stored in P1.

4. Set PWM mode F[7] to >disabled<.

5. Select [F],[P] 21 FIXED FREQUENCY and set >enabled<.

6. Save as in Program 2.

7. Load Program 1 (see section 4.1.1).

8. Enable the PROGRAM SWITCH (see section 5.5).

9. The [P] key 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.

5.8. F[8] BALLAST/ULTRASONIC MODE

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

The ballast/ultrasonic mode F[8] solves this problem. Voltech Application Note 101 covers its use in detail. To use the function:

1. Press the [F] key and use [SELECT] and [ENTER] to choose F[8] 'BALLAST' mode.

2. Select 'off' or '50Hz' or '60Hz' and press [ENTER].

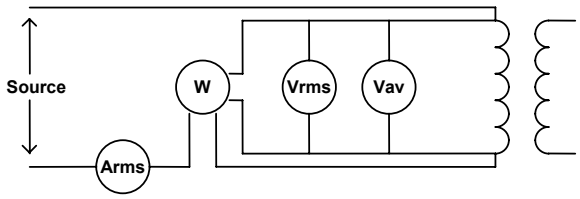
2. The PM3000A will now capture and analyze the relevant number of samples that correspond to one complete cycle of 50Hz or 60Hz at the fastest sampling rate. Once captured, the subsequent processing is carried out as normal, including autoranging. The display automatically sets to a four-function display.
   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 $\sum$, whilst measuring input power on CH3.

5.9 F[9] TRANSFORMER MODE

The Transformer Test Mode has an application in the measurement of 'no-load' losses when testing large (e.g. 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).

5.9.1 SETTING UP TRANSFORMER TEST MODE

Press the [F] key and use [SELECT] and [ENTER] to choose F[9] 'TRANSFORMER' mode. The display is as follows:

TRANSFORMER MODE
>off<

Use [SELECT] and [ENTER] to choose from the following options:

Vav
k-fctr
P-corr.

The measured results are typically displayed as:

0.000 V	0.000%
+0.000 W	0.000 V*

for Vav,

0.000 V	0.000 A
+0.000 W	0.000

for k-fctr,

0.000 V	100.00%
+0.000 W	0.000 W*

for P-corr,

although use of the function keys and other display changes will alter the parameters displayed.

5.10 F[10] CALIBRATION

5.10.1 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 verified at power-on, and the message 'UNCALIBRATED' is displayed if the contents are invalid.

5.10.2 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 and use [SELECT] and [ENTER] to choose F[10] 'CALIBRATION' mode. Press [ENTER] to proceed. The display is as follows:

CAL CODE ? 0-9999
>0<

Enter the current 4-digit passcode – if this is incorrect you will be returned to the default display. The display then shows:

ENTER NEW CAL CODE ?
>yes<

Press [ENTER] to change the passcode and then enter the new code. (If the instrument does not require calibration it may be switched off at this point.) To skip entering a new passcode press [SELECT] to display >no< and then [ENTER]. The system will now enter the main calibration menu. Refer to section 5.10.8 for the equipment needed.

5.10.3 MANUAL CALIBRATION

Switch on the PM3000A into its standard power-up mode, and allow at least 30 minutes for the analyzer to reach a stable temperature. Follow the instructions in the previous section until the following display appears:

CHANGE CONFIGURATION
>yes<

If >yes< is selected the instrument can be re-configured as a single phase, two phase or three phase instrument. Press the [SELECT] key to display >no< and then press [ENTER] to continue to the next display:

SELECT CHANNELS
CH1 CH2 CH3

You can deselect (and reselect) each of the channels to be simultaneously calibrated by pressing the CHANNEL SELECT keys. If all three channels are to be calibrated together, press [ENTER].

The next display shows:

CALIBRATE VOLTS ?
>yes<

Press [ENTER] for the voltage calibration routines. Press [SELECT] to display >no< followed by [ENTER] if the voltage channels do not need calibration.

5.10.4 VOLTAGE RANGE CALIBRATION

The display shows:

VR1 input 200mV rms
Value in V >0.000<

If you wish to by-pass the calibration of this range, press [ENTER] and the program will move on to the next range.

To calibrate the range, set the voltage generator output to approximately the value requested on the display (±10%), and allow it 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 will then show 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. If a PASS occurs, 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:

INPUT 10Vrms 20kHz enter to continue

This allows the calibration of the low bandwidth filter (20kHz on standard and 001 models, 4kHz on 002 models).

This step can be bypassed by pressing the [F] key, which will cause the previously stored filter calibration to be retained.

Input 10Vrms sinewave at the specified frequency, then press the [ENTER] key. The PM3000A will calibrate and after a few seconds, will display:

CHANNEL 1+2+3 PASS

or indicate the failed channels. Press [ENTER] to continue.

The display will then show:

CALIBRATE AMPS ? >yes<

If only the Voltage channels require calibration, press [SELECT] to display >no< followed by [ENTER] and move to the 'SAVE NEW CAL DATA?' prompt). The Current channels may now be calibrated by choosing >yes<.

5.10.5 AMP RANGE CALIBRATION

The display shows:

AR1 input 20mA rms Value in A >0.000<

If you wish to by-pass the calibration of this range, press [ENTER] and the program will move on to the next range.

To calibrate the range, set the current generator output to approximately the value requested on the display (±10%), and allow it to settle. Key-in the measured value from the digital multimeter. Enter the data in amps (e.g. 0.020A).

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 section 5.10.4. Repeat for all twelve ranges (AR1-AR12).

The display will then show:

INPUT 250mArms 20kHz enter to continue

This allows the calibration of the low bandwidth filter (20kHz on standard and 001 models, 4kHz on 002 models).

This step can be bypassed by pressing the [F] key, which will cause the previously stored filter calibration to be retained.

Input 250mArms sinewave at the specified frequency, then press the [ENTER] key.The PM3000A will calibrate and after a few seconds, will display:

CHANNEL 1+2+3 PASS

or indicate the failed channels. Press [ENTER] to continue.

The display will then show:

CALIBRATE EXTERNAL ? >yes<

If the external inputs do not require calibration, press [SELECT] to display >no< followed by [ENTER] and move to the 'SAVE NEW CAL DATA?' prompt. Choose >yes< to proceed with the calibration.

5.10.6 EXTERNAL INPUT CALIBRATION

Note: To calibrate EXTERNAL, the AMP RANGE must already be calibrated. The display shows:

XR7 input 31mV rms Value in V >0.000<

To proceed, set the voltage generator output to approximately the value requested on the display (±10%), and connect to all external inputs. Key-in the measured value from the digital multimeter. Enter the data in volts (e.g. 0.031V).

Press [ENTER] and the calibration constants will be calculated.

The display will then advise PASS or FAIL (as for the voltage range). Proceed as described in section 5.10.4. Repeat for all six ranges (XR7-XR12). If the instrument has the –001 option the display will then show:

CALIBRATE AUX ?
>yes<

If the auxiliary inputs do not require calibration, press [SELECT] to display >no< followed by [ENTER] and move to the 'SAVE NEW CAL DATA?' prompt (see section 4.6.8.7). Choose >yes< to proceed with the calibration.

5.10.7 AUXILIARY INPUT CALIBRATION

The display shows:

10V AUX input 1V dc
Value in V >0.000<

To proceed, set the voltage generator output to approximately the value requested on the display (±10%), and connect to both auxiliary inputs (A & B). Key-in the measured value from the digital multimeter. Enter the data in volts (e.g. 0.031V). The display then shows:

10V AUX input 9V dc
Value in V >0.000<

Repeat the above but with a 9V dc input. Press [ENTER] and the calibration constants will be calculated.

The display will then advise PASS or FAIL for the two inputs (similar to the voltage range). Proceed as described in section 5.10.4 pressing [ENTER] to continue and/or repeat the calibration as required.

Press [ENTER] to continue and repeat the above procedure for the 1V AUXILIARY RANGE. The display will then show:

SAVE NEW CAL DATA?
>yes<

To save any new calibration data press [ENTER] to select >yes<. Press [SELECT] and then [ENTER] to return without altering the EEPROM contents.

The next display will show:

PRINT CALIBRATION?
>yes<

Connect a printer to the Centronics port, and press [ENTER] to select >yes< if a printout is required. Otherwise, select >no< and press [ENTER] to end the calibration routine.

5.10.8 RECOMMENDED EQUIPMENT

The following equipment is required to calibrate the PM3000A:

1. Datron 1271 or equivalent (high accuracy, true RMS digital voltmeter).

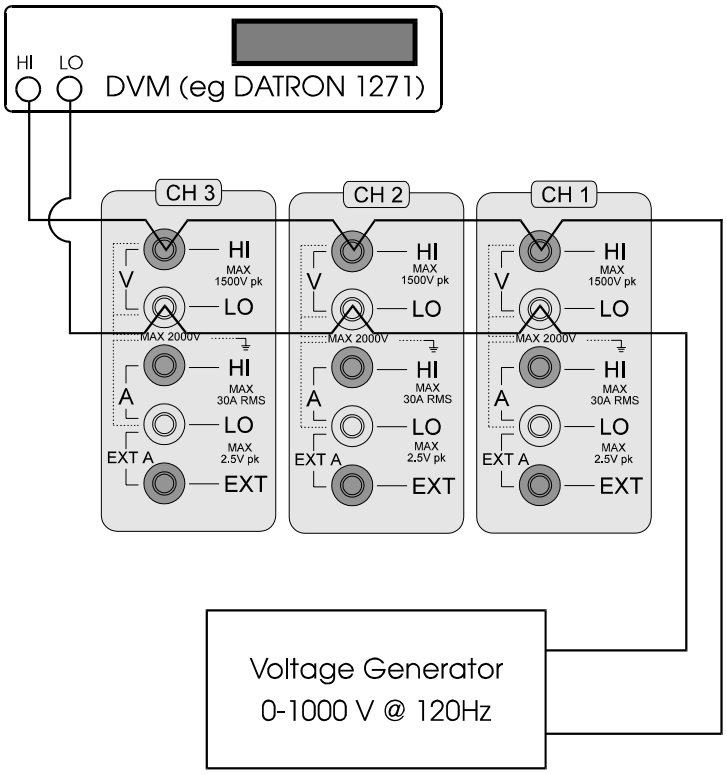
2. Current generator:
   Current 0 - 30 Amps
   Frequency 120 Hz

3. Voltage Generator:
   Voltage 0 - 1000 Volts
   Frequency 120 Hz

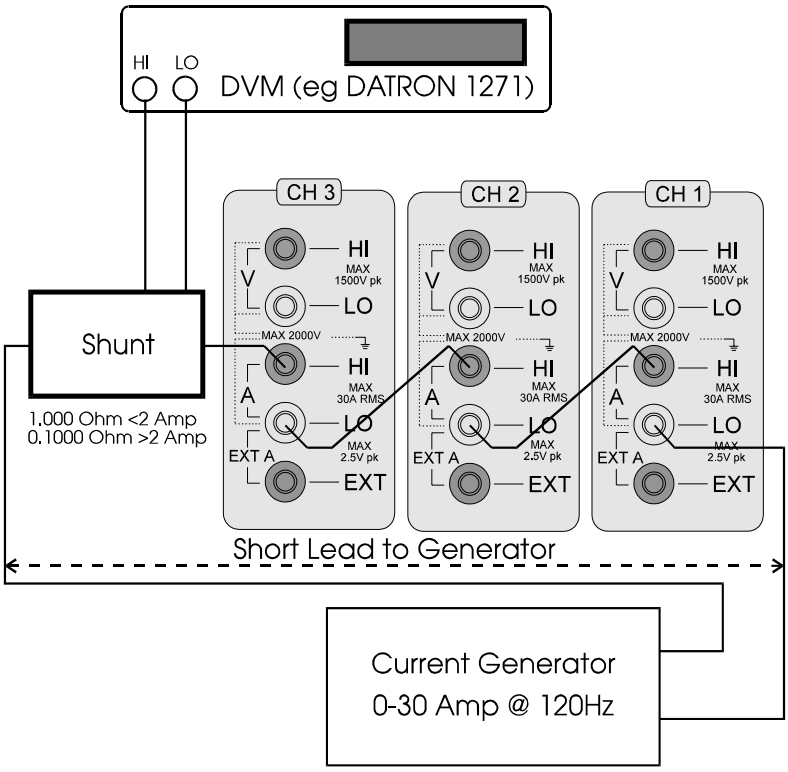
4. Shunts:
   (a) Resistance - 1.0000 Ohms, Current - 2.0 Amp
   (b) Resistance - 0.10000 Ohm, Current - 40 Amp

5. Printer.

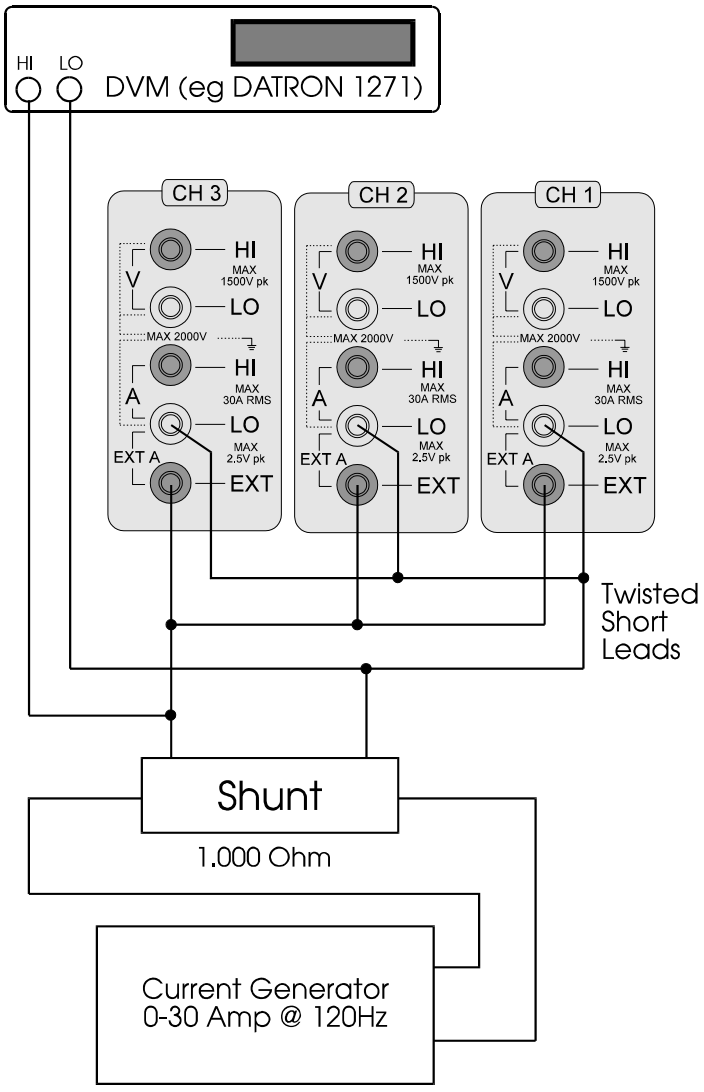
5.10.9 VOLTAGE CALIBRATION CONNECTION



5.10.10 CURRENT CALIBRATION CONNECTION



5.10.11 EXTERNAL CURRENT CALIBRATION



CHAPTER 6

ADVANCED CONFIGURATION

6.1 [F][P] CONFIGURATION

The [F] and [P] keys pressed consecutively provide a greater selection of instrument configuration. Press [F], then [P], followed by the required number from the selection list below, and then [ENTER]. Use the [SELECT] key to highlight the required configuration setting (e.g. 'harmonic series' for [F],[P] 16), or a digit key for a display with numeric information (e.g. 5 for [F],[P] 13). Then press [ENTER].

Note that only the most common [F],[P] selection numbers are shown below, for full list refer to CONFIGURATION LISTING under section 10.6.4.

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. Using this option, it can be changed to the desired language.

16 **THD FORMULA**. The displayed THD value may be calculated from the difference formula or from series THD (see section 3.3.3). If calculated from series THD, the background averaging is used, and the displayed value is updated each time 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 **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 [F],[P] 22 and enable it as the instrument's source of reference. >disabled< is the default (normal operation).

22 **FIXED FREQUENCY**. Through this option, the value of fixed frequency can be set. It is activated by selecting 'enabled' in [F],[P] 21.

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. 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 or to a pre-set fixed range.

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 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 to 64. It is useful for reconfiguring the depth for AUTO mode (see section 3.2.3). The equivalent [F],[P] setting for CH2 is 58 and CH3 is 78.

46 **RMS/MEAN MEASUREMENT MODES.** The voltage and current can be displayed in either true RMS or rectified MEAN values. This option allows you to select between the two modes.

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 the [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:

$$\frac{\Sigma VA}{\Sigma V} / \sqrt{3}$$

The Summation current can be calculated as the arithmetic mean of the 2Ø or 3Ø channel inputs using [F],[P] 191.

$$3Ø4W \quad \Sigma A = \frac{(A_1 + A_2 + A_3)}{3}$$

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

192 SUM V=(V_1+V_2+V_3)/3. The Summation Voltage for 3Ø4W 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 3Ø4W wiring using [F],[P] 192.

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

275 RS232 VERBOSE MODE. The PM3000A defaults to Verbose mode with echoed data when communicating via the RS232 link. This echo function can be disabled via this configuration setting.

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 multi-line 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

279 DATA RETURN FORMAT. Data is normally returned in 4.5-digit ASCII. This configuration can set the returned data to 5-digit ASCII.

282 PAGE FEED. Appends a printed document with a page feed.

283 THD TIF

TIF stands for telephone influence factor and is a measure of the influence of voltage or current distortion in electrical power circuits upon telephone circuits that may be in parallel. It is also a useful comparative measurement of voltage distortion on the output of generators.
It is essentially a series THD measurement with each harmonic having a different weighting.

Formula

$$V_{tif} = \frac{1}{V_{ref}} \sqrt{\sum_{n=1}^{max} (k_n \times Vh_n)^2} \quad A_{tif} = \frac{1}{A_{ref}} \sqrt{\sum_{n=1}^{max} (k_n \times Ah_n)^2}$$

Weighting Factors

Harm	k_n	Harm	k_n	Harm	k_n
1	0.5	21	6050	41	10340
3	30	23	6370	43	10600
5	225	24	6650	47	10210
6	400	25	6680	49	9820
7	650	27	6970	50	9670
9	1320	29	7320	53	8740
11	2260	30	7570	55	8090
12	2760	31	7820	59	6730
13	3360	33	8830	61	6130
15	4350	35	8830	65	4400
17	5100	36	9080	67	3700
18	5400	37	9330	71	2750
19	5630	39	9840	73	2190

The weighting factor for harmonic 0 or harmonics over 73 is zero.

When THD TIF is enabled, the following defaults are automatically set by the PM3000A
CFG, 16 THD FORMULA is 1 = harmonic series
CFG, 17 THD REFERENCE is 1 = RMS
CFG, 19 THD FORMULA is 0 = harmonic 0 (dc) is excluded
CFG, 135 HARMONIC SERIES is 0 = odd and even
CFG, 136 MAXIMUM HARMONIC is 73

After THD TIF is enabled:

If CFG, 16 THD FORMULA is changed then THD TIF will be automatically disabled.

If CFG 17, 19, 135 or 136 are changed, the TIF calculation will remain but adjusted according to the odd / even or maximum harmonic selections.

CHAPTER 7

INTEGRATOR

7.1 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, and A, for the elapsed integrator period by using [F],[P] 115 to 'averaged' (see section 6.1). 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:

7.1.1 [W-HR] WATT HOURS

This records total energy consumption. When used in conjunction with the [FUND] key, the integrator will display energy consumption due to fundamental components only. When the key is pressed the display changes to:

Elapsed time 0.00000
W hrs = +0.000

7.1.2 [VA-HR] VA HOURS

This records the apparent energy consumption or maximum demand. When used in conjunction with the [FUND] key, the integrator will display energy consumption due to fundamental components only. The display format is similar to that shown above.

7.1.3 [VAR-HR] VAR HOURS

This records the reactive energy consumption. When used in conjunction with the [FUND] key, the integrator will display energy consumption due to fundamental components only.

7.1.4 [A-HR] AMPERE HOURS

This measures the ampere-hours consumed. This function can be programmed to respond to true rms or rectified mean current. When used in conjunction with the [FUND] key, the integrator will display energy consumption due to fundamental components only.

7.1.5 [AV PF] AVERAGE POWER FACTOR

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

7.1.6 [CORR VAR] CORRECTION VARS

This displays the value of the VArs required to correct the average power factor to a target power factor, pre-set by the user. [F],[P] 2 can be used to change the default value from 1.000. The correction will calculate the necessary VArs to provide the phase shift to reach the target power factor; it *does not* compute the total VArs (e.g. if a poor power factor is completely due to distortion, no amount of phase lead or lag will improve it. This implies that the correction VArs value will be very low, due to the fundamental power factor being unity)

7.2 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 is selected by pressing the [INTEGRATOR] key in the Menu section of the front panel. The display will show:

ENABLE INTEGRATOR
>disabled<

Use the [SELECT] and [ENTER] keys to enable the integrator. The display will then show:

INTEGRATOR CONTROL
>trigger<

Use the [SELECT] and [ENTER] keys to choose between ‘trigger’ and ‘timed’ operation. Assuming trigger operation has been selected the display will now show:

EXTERNAL TRIGGER INT
>disabled<

If manual operation is required, press the [ENTER] key to disable the external trigger. The display will show:

INTEGRATOR RUN TIME
HH:MM >00:00<

Use the digit keys to enter the time for which the integrator will run after manual triggering (pressing the [START RESET] key). If the integrator is to run continuously until the [STOP] key is pressed, enter a time of 00:00.

Use the [SELECT] and [ENTER] keys to enable or disable printed output. The LED beneath the integrator key will be illuminated and the system waits for the manual trigger.

To start the integrator, press the [START RESET] key. The LED under the start key will turn on to indicate that the integrator is running. Pressing any of the integration function keys will display the run time in hours and value of the integrated parameter.
If RUN TIME was set to '00:00', the integrator can now be reset or stopped. To reset, press the [START/RESET] key again. The integrator will be reset and restarted. Each time the integrator is reset, the selected integrator functions for that point-in-time will be printed-out, provided the interface has been configured.

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

The integrator can be restarted at this point by pressing [START] again, or can be disabled by entering the integrator menu and selecting disabled.

7.2.1 SETUP EXTERNAL TRIGGER

Enter the integrator menu, use [SELECT] and [ENTER] to >enable< the integrator, then select >trigger< control. Use [SELECT] and [ENTER] to >enable< the 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 whilst 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 (providing 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<.

7.2.2 SET UP TIME CONTROL

With the integrator enabled, use [SELECT] and [ENTER] to choose >timed< control. 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 following format:

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 5 timeband resets within the integration period (see section 7.2.4). Repeatedly press [ENTER] to skip these.

For timed integration there is the option to reset (clear) the integrator result with each timeband or cyclic interval. If the INTEGRATOR RESET option is disabled, the integrator results will be printed at each cyclic interval or timeband, giving an accumulation between the start and stop times without resetting. 'Enabled' will clear the results at each cyclic interval or timeband. When CYCLIC INTEGRATION or TIMEBAND INTEGRATION is not selected, the setting of this option has no effect, press [ENTER].

There is then the option to configure the printer (as described earlier), and the integrator is then set, and will integrate between the 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.

7.2.3 CYCLIC INTEGRATION

If the CYCLIC INTEGRATION option is >enabled< after inputting the start and stop dates/times for the integration period (see above) the next display is as follows:

CYCLIC INTERVAL	
HH:MM	>00:00<

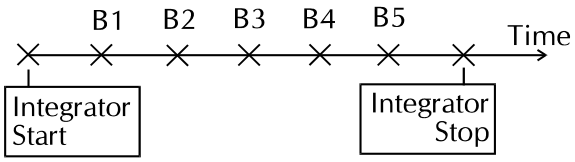
Use the digit keys to enter the cycle interval. Use [SELECT] if you make a mistake whilst entering the time. Press [ENTER] when the interval is correct. Next enter the reset period in hours (HH) and minutes (MM), and press [ENTER].

There is then the option to configure the printer (as described earlier), and the integrator will then run between the start and stop times, and printout at each cyclic interval.

7.2.4 TIMEBAND INTEGRATION

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.

There is then the option to configure the printer (as described earlier). The integrator will then 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.



This option is useful for monitoring and costing consumption over different tariff bands.

CHAPTER 8

INTERFACE SET-UP

8.0 INTERFACE MENU

This key allows the user to program the digital and analogue interfaces of the PM3000A. When pressed the display will show the following:

INTERFACE
>printer<

The [SELECT] key is used to display the options available and the [ENTER] key used to access a specific option:

>printer<
>IEEE488<
>RS232<
>chart recorder<
>analogue outputs<
>auxiliary inputs< (PM3000A – 001 option only)

Each of these is described in more detail in the following sections

8.1 PRINTER INTERFACE

The printer used may be either:

a) A text printer with an RS232 (serial) interface.
b) A text printer with a parallel (Centronics) interface.

Centronics is the default but the output will be directed to the RS232 port if this interface is enabled (see section 8.3.1). The printout can be from one of four sources:

a) The results on the front panel display.
b) The results from one or more channels.
c) The integrator results.
d) The datalog results.

8.1.1 PRINTING FRONT PANEL DISPLAY RESULTS

Press the [INTERFACE] key and use [SELECT] and [ENTER] to >enable< the printer. Then use [SELECT] and [ENTER] again to choose >display<. The front panel display shows:

EXTERNAL TRIGGER PRN
>disabled<

To print use a manual trigger press [ENTER] to choose the >disabled< option. Pressing the [DATA DUMP] key will trigger the printout.

To print use an external trigger use the [SELECT] and [ENTER] keys to choose the >enabled< option. Shorting the Ext Trigger input will trigger the printout.

The timed trigger setup is then entered. The display shows:

TIMED TRIGGER PRN
>disabled<

The PM3000A will automatically print at a user specified time interval if this mode is enabled. Use the [SELECT] and [ENTER] keys to >enable< or >disable< this option as required. If enabled the display will show:

PRINTOUT INTERVAL	
HH:MM	>00:00<

Use the digit keys to enter the time interval between printed output. Use [SELECT] if you make a mistake whilst entering the time. Press [ENTER] when the interval is correct.

Printouts will then occur automatically at the time interval selected. Additional printouts may be initiated by pressing the [DATA DUMP] key.

8.1.2 PRINTING CHANNEL SELECTION RESULTS

Press the [INTERFACE] key and use [SELECT] and [ENTER] to >enable< the printer. Then use [SELECT] and [ENTER] again to choose >selection<. The front panel display shows:

SELECT CHANNELS
CH1

Use the Channel Select keys to choose the channels for which results will be printed. If a channel is already displayed, pressing its key again will cancel it. Press [ENTER] when the choice is correct.

Now use the function keys ([W], [VA], [VAr] etc) to enter the functions to be printed. If a parameter is already displayed, pressing its key again will cancel it. Press [ENTER] when the choice is correct.

If the fundamental components need to be printed use [SELECT] and [ENTER] to >enable< this option. If both volts and amps harmonics have been selected, watts harmonics can also be selected for print.

If harmonic measurements have been selected, the next display allows the user to enter the maximum harmonic to be printed (1 to 99), and whether to print all harmonics (odd and even) or odd only. (Note that 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).

The magnitude of the harmonics is printed in volts or amps, and as a percentage of the fundamental value.

Finally the choice of triggering method is set as described in section 8.1.1.

8.1.3 PRINTING INTEGRATOR RESULTS

Printouts will be generated automatically if the appropriate settings are made in the integrator setup menu (see section 7.2)

8.1.4 PRINTING DATALOG RESULTS

Printouts will be generated automatically if the appropriate settings are made in the datalog setup menu (see section 9.1)

8.2 IEEE488 INTERFACE

The PM3000A is configurable to IEEE488.1 and IEEE488.2 protocol standards. See section 10 for a full description of the commands available in both modes.

To enable the IEEE488 interface, first use [ENTER] to choose the IEEE488 option from the Interface menu, and then use [SELECT] and [ENTER] as necessary to choose >enabled<. Next you are prompted for the IEEE bus address to be used by the instrument. Enter the required address between 1 and 30 and press [ENTER]. Then use [SELECT] and [ENTER] as necessary to choose >enabled< or >disabled< for the IEEE488.2 protocol.

8.3 RS232 INTERFACE

The RS232 interface operates with 1 start bit, 8 data bits, 2 stop bits and no parity. The baud rate is user selectable. Simple CTS/RTS handshaking is used to control data flow.

To enable the RS232 interface, first use [ENTER] to choose the RS232 option from the Interface menu, and then use [SELECT] and [ENTER] as necessary to choose >enabled<. The display will be similar to that shown below:

RS232 BAUD RATE
>19200<

Use the [SELECT] key to choose the required baud rate and press [ENTER] to confirm the selection. The user must now choose between >printer< and >computer control< using the [SELECT] and [ENTER] keys.

8.3.1 USING THE RS232 INTERFACE WITH AN EXTERNAL PRINTER

Choose the >printer< mode as described above. The printer output will now be directed to the RS232 port on the rear of the PM3000A and a printer with a suitable serial interface may be connected.

8.3.2 USING THE RS232 INTERFACE FOR COMPUTER CONTROL

Choose the >computer control< mode as described above to allow the interface to be used for computer control. Note that all of the commands described in section 10 of this manual are obeyed (IEEE488.1 and IEEE488.2).

The PM3000A operates with 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 echo function can be disabled by [F][P] 275 Verbose Mode (see Section 6.1).

The 'REMOTE' LED 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 following tables:

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:

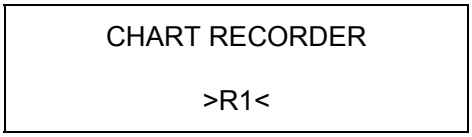
PM3000A			Computer
Rx	2	3	Tx
Tx	3	2	Rx
CTS	4	7	RTS
RTS	5	8	CTS
		1	DCD
		4	DTR
		6	DSR
ground	7	5	ground

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

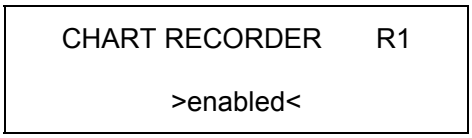
8.4 CHART RECORDER INTERFACE

In Chart Recorder mode, the 'Analog – Alarms' interface provides eight 0 to 5V DC outputs. The signal provided from these outputs is proportional to the level of the function being monitored. The Chart Recorder menu can be configured to record any eight functions, including fundamentals and integrated values (except inrush current, Vpk, Apk, Vharm, Aharm, CORR Vars, and AV PF) from channels 1, 2, 3, and SUM.

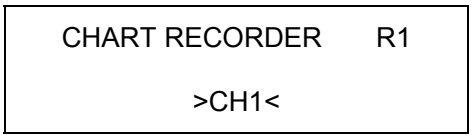
To enable the Chart Recorder interface first use [ENTER] to choose the chart recorder option from the Interface menu, and then use [SELECT] and [ENTER] as necessary to choose >enabled<. The display will be similar to that shown below:



Use the [SELECT] key to choose the required recorder output channel from R1 to R8 and press [ENTER]. The display will then be similar to that shown below:



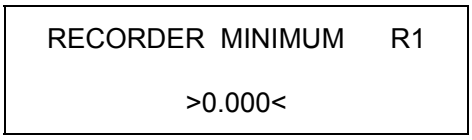
Use the [SELECT] and [ENTER] keys as necessary to enable the recorder output channel. The display will be similar to that shown below:



Now use the Channel Select keys to set the required channel (CH1, CH2, CH3, ∑ or N) and press [ENTER].

The function keys may be used to set the required parameter (e.g. Watts, VA, PF etc.), followed by the [FUND] key if the fundamental is to be recorded. Then press [ENTER].

The display will be similar to that shown below:



Use the digit keys (along with the [k, M] key) to set the minimum value. The [SELECT] key will allow the sign to be changed. Press [ENTER] and use a similar procedure to set the maximum value. Press [ENTER] again, and the display returns to the recorder channel selection mode.

When level of reading for a selected function is less than or equal to the lower limit, the Chart Recorder output will be zero. When the level of the reading for the selected function is greater than or equal to the upper limit, the Chart Recorder output will be +5V.
Repeat the above process to set all required recorder channels and then use [SELECT] to display >Quit<. Press [ENTER] to save the settings and return to the default display.

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 choose 'disabled'.

With the Chart Recorder enabled, the Chart Recorder level will change between 0 and 5V, in proportion to the function being recorded between the upper and lower limits.

8.5 ANALOGUE OUTPUTS INTERFACE

The PM3000A has an Analogue Alarms interface at the rear panel, which can be configured to work as a Chart Recorder (described above), Analogue Alarm, or as an Analogue Output.

8.5.1 ANALOGUE ALARMS

To set alarms simply program the low and high limits in the Chart Recorder option 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

8.5.2 ANALOGUE OUTPUTS

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

To enable the Analogue Outputs interface first use [ENTER] to choose the analogue outputs option from the Interface menu. The display shows:

ANALOGUE OUTPUT MODE
time date

The waveforms will now be output to the analogue connector. Cancel this mode by pressing the [INTERFACE] key. See the table below for pinout details.

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
ANALOGUE OUTPUT CONNECTOR: Note that the neutral current will be output on a reduced scale compared to the other phase current.		

8.6 AUXILIARY INPUTS

If fitted with this option the PM3000A has 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 (menu-selected) 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.

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).

To enable the Auxiliary Inputs interface first use [ENTER] to choose the auxiliary inputs option from the Interface menu, and then use [SELECT] and [ENTER] as necessary to choose >enabled<. The display will be similar to that shown below:

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 will then show:

TORQUE INPUT
>torque in Nm<

Use the [SELECT] and [ENTER] keys to choose Newton-meters (Nm) or foot-pounds (ftlb) as the units of torque for the display. The display will then show:

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 will then show:

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 the AUXILIARY input B.

If 'voltage' has been selected, the display will show:

RPM INPUT
>10V full scale<

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

RPM INPUT
>1.000 per Volt<

Use the digit keys to enter the scaling for the RPM input and press [ENTER]. The display will then show:

If 'pulse' has been selected for the RPM INPUT, the display will show:

HIGH FREQUENCY
>disabled<

Use the [SELECT] and [ENTER] keys to enable the high frequency mode if required. The display will then show:

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 selected, and [W] selected for display, press the [∑] channel key. The display will now show:

xxxx Nm xxxx rpm
xxxx W xxxx %

The top line shows torque and speed. The bottom line shows mechanical power and motor efficiency (horsepower and ft.lb would be used if originally selected).
Pressing the [DISPLAY] key when [∑W] is selected will toggle the display between the mechanical data presentation (auxiliary inputs) and the electrical data presentation (CH1, CH2, CH3 inputs).

Efficiency is calculated from the formula:

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

Where Power Out is the Mechanical Power displayed in the auxiliary window, and Power In is the simultaneous electrical power input to the motor on the ∑ 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), as seen in the following example.

```
04 July 98              15:54
RMS DC COUPLED
VOLTAGE FREQUENCY SOURCE

**********  CHANNEL 1  **********
Watts           +  12.367 W
Vrms               96.96  V
Arms               127.72 mA
**********  CHANNEL 2  **********
Watts           +  13.830 W
Vrms               97.21  V
Arms               142.37 mA
**********  CHANNEL 3  **********
Watts           +  13.297 W
Vrms               98.01  V
Arms               136.12 mA
**********  SUM 1+2+3  **********
Watts           +  39.49  W
Vrms               168.69 V
Arms               135.38 mA
**********  AUXILIARY  **********
Torque             50.63  Nm
Speed              7.002  rpm
Power              37.13  W
Efficiency         94.01  %
****************************************
```

CHAPTER 9
DATA LOG

9.1 DATA LOG OVERVIEW

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 waveforms themselves are available on the analogue outputs.
The results from the analysis are not available at 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 next display is as follows:

CYCLE BY CYCLE LOG
>disabled<

Use the [SELECT] and [ENTER] keys to choose >disabled< or >enabled< as required.

9.2 CYCLE BY CYCLE ANALYSIS

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.

9.2.1 SETTING UP CYCLE BY CYCLE MODE

Choose >enabled< for CYCLE BY CYCLE LOG and the next display will be:

LOG SAMPLES/CYCLES
>1860<

Use the digit keys to input the number required and then press [ENTER]. The maximum is 1860 (31 seconds at 60Hz). The display will then show:

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).

Use the [SELECT] and [ENTER] keys to choose >disabled< or >enabled< for the rear panel trigger input as required. The display will then show:

DATALOG
SET MANUAL RANGE

In cycle-by-cycle mode, the auto-ranging 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 up and down arrow keys beneath the appropriate LED array to select a measurement range for voltage and current, and then press [ENTER]. The display now changes to:

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.

9.2.2 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       ......
```

9.3 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.

9.3.1 TO SET UP DATALOG FUNCTIONS

A selection of results to be printed must first be made from the printer menu (see section 8.1.2).

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

Press the [DATA LOG] key and next display is as follows:

CYCLE BY CYCLE LOG
>disabled<

Use the [SELECT] and [ENTER] keys to choose >disabled< and the next display will be:

DATALOG WINDOW
>30 ms<

Using the [SELECT] and [ENTER] keys choose the required time from >30 ms<, >60 ms<, >300 ms<, >1 s<, >5 s<, or >18 ms – 65 s<. If the latter option is chosen use the digit keys to enter the required time in ms (e.g. for 9 sec, enter 9000), then press [ENTER].

The next display will then show:

EXTERNAL TRIGGER LOG
>disabled<

Analysis can be triggered via the front panel [START] key or the rear trigger input.

Use the [SELECT] and [ENTER] keys to choose >disabled< or >enabled< for the rear panel trigger input as required. The display will then show:

DATALOG
SET MANUAL RANGE

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.

Use the up and down arrow keys beneath the appropriate LED panel display to select a measurement range for voltage and current, and then press [ENTER]. The display now changes to:

DATALOG
waiting for trigger

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

DATALOG
triggered

After the trigger, the LED under the [START RESET] 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 waveform will be output. An oscilloscope trigger output is also generated.

After the event has been captured the display will show:

DATALOG
>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.

9.3.2 DATA LOG SAMPLE RATES

WIRING	CAPTURE TIME	SAMPLE RATE	MAX. FREQ	SAMPLES / CHANNEL
ALL WIRING SETUPS	30 mSec	5 uS	50kHz	6000
	60 mSec	10 uS	25kHz	6000
	300 mSec	50 uS	5kHz	6000
	1 Sec	167 uS	1.5kHz	6000
	5 Sec	833 uS	300Hz	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.				

CHAPTER 10
IEEE COMMUNICATION

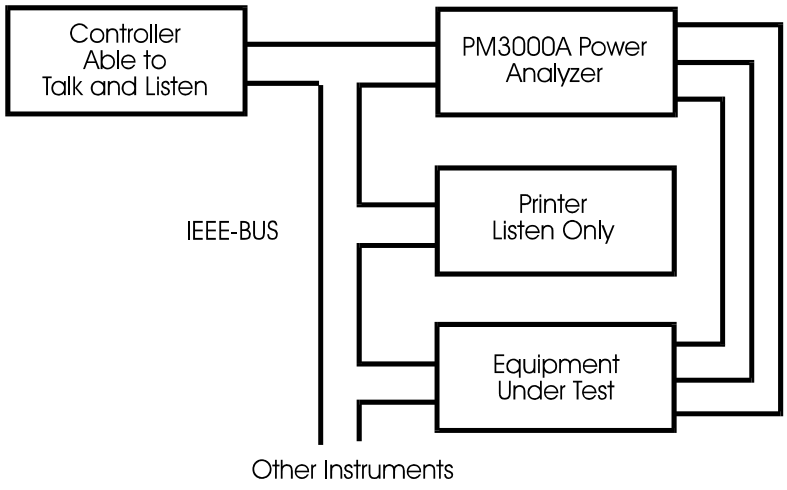
10.1 IEEE488 OVERVIEW

The PM3000A is configurable to IEEE488.1 and IEEE 488.2 protocol standards. Refer to section 10.4 for IEEE488.1 and section 10.6 for IEEE488.2 respectively.

To enable IEEE 488 mode, press the [INTERFACE] key and then use the [SELECT] key to scroll through the options until >IEEE488< is displayed. Press the [ENTER] key and use [SELECT] and [ENTER] to >enable< IEEE488. It will then be necessary to confirm the IEEE address number by pressing [ENTER] (to modify, see section 10.2 below).

If IEEE488.2 operation is required this must also be >enabled< using the [SELECT] and [ENTER] keys.

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), 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.

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

10.2 ADDRESSING

Each instrument has an address by which it is recognized on the bus. The PM3000A address may be altered as follows:

Press the [INTERFACE] key and then use the [SELECT] and [ENTER] keys to >enable< the IEEE488 interface as described above. The display will then show:

IEEE ADDRESS
select 1-30: >10<

Using the data entry keys, enter the value (e.g. 10) and press [ENTER] to store this value. If you make a mistake before pressing [ENTER], press the [SELECT] key and re-enter the value. This now 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.

10.3 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 analyzed 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.

10.4 IEEE 488.1 OPERATION

It is first necessary to enable IEEE operation as described in sections 10.1 and 10.2. Use the front panel keys to enable IEEE488.1 and disable IEEE488.2.

The following commands are available to control the operation of the PM3000A. Additionally, ALL OF THE IEEE488.2 COMMANDS can be used alongside these commands in IEEE488.1 mode. 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, e.g. p4 or P4 are acceptable. White space is ignored, e.g. "output; p1" and "output;p1" are equivalent.

COMMAND SUMMARY

A	Averaging	L	Multiple harmonics select
B	Data output source (display / buffer/ integrator / data log)	M	Service request switch
		N	AC/DC coupling select
C	Channel select	O	Mean or RMS volts/amps select
D	Display set-up	P	Wiring select
E	Phase-phase/phase-neutral switch (3phase 4wire)	Q	Frequency source select
		R	Range select (RA:amps RV:volts)
F	Parameter function select	S	Internal/external shunt select
G	Fast mode switch	T	Trigger
H	Single harmonic select	U	Parallel port control
I	Integrator switch	W	Analogue outputs only select
J	Amps scaling factor	X	Data log set-up
K	Voltage scaling factor	Y	Fundamental display select

10.4.1 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.

10.4.2 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.

10.4.3 DATA OUTPUT SOURCE: BUFFER

FORMAT B [1] _xx_x_xxxxxxxxxxxxxxxxxxxxxxxx

B1 - This allows the full versatility of the instrument to be utilized on the IEEE bus. Over 400 different measurements may be initialized 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 xxxxxxxxxxxxxxxxxxxxxxx

To select results from Channels 1 and 2 and Neutral:

B1 19 x xxxxxxxxxxxxxxxxxxxxxxx

To select results from Channel 3 only send:

B1 04 x xxxxxxxxxxxxxxxxxxxxxxx

ii. Select fundamental components (1 digit)

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

B1 xx 0 xxxxxxxxxxxxxxxxxxxxxxx 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. Watt Hours
14. VA Hours
15. VAr Hours
16. Amp Hours
17. Average Power Factor
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.

10.4.4 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).

10.4.5 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).

10.4.6 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. (e.g. if WIRING is configured for single phase two wire and 'C4' (SUM) is sent).

This command will reset the display averaging.

10.4.7 DISPLAY SETUP

This set of commands configures the display format.

FORMAT DL [0-7]

The DL command will configure the top left hand display.

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

FORMAT DR [0-7]

The DR command will configure the top right hand display.

DR0 Volts
DR1 Amps
DR2 Watts
DR3 VA
DR4 Frequency
DR5 Power Factor
DR6 Peak Volts
DR7 Peak Amps

FORMAT DM [0-1]

The DM command will configure the SUM display.

DM0 Standard three parameter Sum display
DM1 Three channel parameters and Sum display

10.4.8 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.

10.4.9 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 Ampere 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

10.4.10 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

10.4.11 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

10.4.12 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.

10.4.13 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 recognized.

10.4.14 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 recognized.

10.4.15 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 analyzed 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

10.4.16 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

10.4.17 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.

10.4.18 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 and the display averaging will be reset by this command.

10.4.19 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.

10.4.20 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 (5Hz minimum)
Q3 Selects the Slow external frequency input (0.1Hz minimum)

This command resets the display and background averaging.

The Q3 command will take approx. 10 seconds to make a reading if a low frequency (<5 Hz) is to be measured.

10.4.21 SELECT VOLTAGE RANGE

FORMAT RV [00-12]

Selects the voltage range.

RV00 Selects auto ranging (manual)
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.

10.4.22 SELECTS AMPS RANGE

FORMAT RA [00-12]

Selects the amps range of all three channels.

RA00 Selects auto ranging (manual)
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)
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)

RA05 Selects 1.0 Amp Peak range (manual) RA12 Selects 200 Amp Peak range (manual)
RA06 Selects 2.0 Amp Peak range (manual)

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

10.4.23 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.

10.4.24 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.

10.4.25 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 utilized with this command to switch external logic. The Centronics printer must be enabled for this function to operate.

10.4.26 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.

10.4.27 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 a 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.

10.4.28 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).

10.5 EXAMPLE IEEE488.1 PROGRAM

To read VOLTS,AMPS,WATTS,FREQ and AMPS HARMONICS (1-15 odds only) for a 1 phase 2 wire configuration.

* Send MLA 9 address the PM3000A to listen

* Send 'P1' - Set WIRING to 1 phase 2 wire

* Send 'B1 01 0 10011000000000000000001001' - This requests results to be returned from the background averaging store. Return data from CH1 only and no fundamentals. Selection of parameters is, WATTS, VOLTS, AMPS, AMPS HARMONICS, FREQUENCY

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

* 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 as follows:

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

```
'-------------------------------------------------------------------------------------
'       program set-up, 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;P1"
         PRINT #1, "OUTPUT 10;B1 01 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
```

10.6IEEE 488.2 OPERATION

It is first necessary to enable IEEE operation as described in sections 10.1 and 10.2. Use the front panel keys to enable IEEE488.1 and IEEE488.2.

10.6.1 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 the '*' character e.g.

```
output 09; *TRG
```

The manufacturer of each instrument defines device commands, and Voltech instruments' device commands are preceded by the ':' 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.

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. (Note - Single reply string ([F] [P] 276) mode used)

```
output 09; :CAL:CH1:VLT? 5; :CAL:CH2:VLT? 5; :CAL:CH3:VLT? 5
enter 09;
1.1111E-01,2.222E-02,3.333E-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 4 ½digit 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.

10.6.2 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.

10.6.2.1 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 register.

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.

10.6.2.2 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

10.6.2.3 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

10.6.2.4 STANDARD EVENT STATUS

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

		CME	**EXE**		**QRE**		**OPC**

OPC operation complete (data available)

QRE un-terminated query error

EXE execution error

CME command error

ASSISTANCE AND EXAMPLE PROGRAMS

Please do not hesitate to contact your local distributor (see www.voltech.com) or email sales@voltech.com for applications assistance and example programs.

To read basic measurements in the normal measuring mode, we recommend you investigate the :sel and :frd? commands.

10.6.3 AVAILABLE COMMANDS

:AUX	AUXILIARY INPUT CONTROL
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 DIS disable ballast mode
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? :BRD: CH1? CH2? CH3? CHN? SUM? AUX?
Options	:BRD All Channels :BRD:CH1 Channel 1 only :BRD:CH2 Channel 2 only :BRD:CH3 Channel 3 only :BRD:CHN Neutral Channel :BRD:SUM Summation values :BRD: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 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.Vmean	16.Amean
17.VAV	18.k-Factor	19.P-corr	20.Fund Watts
21.Fund VA	22.Fund Var	23.Fund Vrms	24.Fund Arms
25.Cos phi	26.Resistance	27.Reactance	28.Fund Vmean

29.Fund Amean
30.Voltage harmonics (Magnitude & Phase angle)
31.Current harmonics (Magnitude & Phase angle)
32.Power harmonics (Magnitude only)

Resistance and Reactance are returned if the :SEL:FUN (fundamentals) option is used when the :SEL:IMP command is issued.

<u>Harmonics and BRD</u>
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.

<u>PM3000A-001 Auxiliary Inputs and BRD</u>

If auxiliary inputs are selected, then data is returned in the following order: Torque, speed, power, efficiency, 'END'.

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

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 VFI AFI :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 :VFI voltage filter calibration :AFI current filter calibration :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. For filter calibration, VFI and AFI, the 'range' parameter is required, but the 'value' parameter is ignored.
Example	CMD> output 10; :CAL:CH1:VFI 6 In the case of the filter calibration commands, the range parameter is set to a value that is the correct range for the magnitude of the filter calibration input signal:- For Voltage 10 Vrms use range 6 For Current 250mArms use range 4

: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 VFI AFI
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 :VFI voltage filter calibration :AFI current filter calibration range range calibrated 1-12
Return format	4 ½digit 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) VFI and AFI do not require a 'range' parameter

:CFG	CONFIGURE
Class	device command
Return type	none
Format	:CFG prog, data
Options	prog integer program location 0-282 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 [F][P]21 - 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 0-282
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 OVV - Voltage overload enable
AVF - averaging full enable OVA - Current overload enable
NDV - new data available 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 format	40 ASCII characters in quotes
Example	CMD>:DSP? Return > "239.5V 67.89mA Watts = +12.345W"

: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 VMN Voltage rectified mean AMN Current rectified mean AIN Inrush Current
	4 ½ 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 synchronized 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, e.g.; 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. To read SUM data using FNC, first read back CH1 data using FNC to ensure that the SUM measurements are correctly updated.

: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 VMN Voltage rectified mean AMN Current rectified mean
Return format	4 ½digit 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 synchronized 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
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	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
PF	-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.Vmean	16.Amean
17.VAV	18.k-Factor	19.P-corr	20.Fund Watts
21.Fund VA	22.Fund Var	23.Fund Vrms	24.Fund Arms
25.Cos phi	26.Resistance	27.Reactance	28.Fund Vmean

29.Fund Amean
30.Voltage harmonics (Magnitude & Phase angle)
31.Current harmonics (Magnitude & Phase angle)

Resistance and Reactance are returned if the :SEL:FUN (fundamentals) option is used when the :SEL:IMP command is issued.

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.

<u>PM3000A-001 Auxiliary Inputs and FRD</u>

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,PM3000A,1234,v2.15

: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 e.g.; 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 IFS
Options	:FLU - Fluctuating harmonic mode :FLI - Changing voltage :FLM - Flickermeter :IFS - Instantaneous flicker sensation
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. :IFS 2 NR3's Instantaneous flicker sensation, peak instantaneous flicker.
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,imaginary 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 either 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 $6000 \div N_A$.
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 $\sum$ - all NR3) Torque, Speed (both NR3) If more than 24 NR3's are required per cycle, single reply string mode should be used.
***OPC**	**INITIALIZE 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 SET UP**
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 = 5Hz to 1kHz 2 = 0.5Hz to 50Hz 3 = 0.1Hz to 40Hz
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; :RMS: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 DEVICES
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 initialize 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 FUN Fundamentals 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 VMN Voltage Rectified Mean AMN Current Rectified Mean TTM Transformer Test parameters
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 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 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 :TTM:KAY :TTM:PWC
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

10.6.4 CONFIGURATION NUMBER LISTING (:CFG COMMAND)

To change options via the front panel, press [F] and [P] and then [ENTER] the relevant number.

Number	Function	Data	Settings
0	MANUAL ZERO		yes / no
1	POWER ON PROGRAM	NR1	0 = standard 1 – 5 = user program
2	TARGET POWER FACTOR	NR3	
3	N/A		
4	CHANNEL 3 ONLY MODE	NR1	0 = off, 1 = on
5	PROGRAM SWITCH	NR1	0 = off, 1 = on
6	N/A		
7	N/A		
8	N/A		
9	N/A		
10	LANGUAGE	NR1	0= English, 1= German
11	DISABLE ACQUISITION	NR1	0 = run, 1 = hold
12	HOLD DISPLAY	NR1	0 = run, 1 = hold
13	WIRING CONFIGURATION	NR1	0 = 1 phase 2 wire 1 = 1 phase 3 wire 2 = 3 phase 3 wire 3 = 3 phase 4 wire 4 = channel 3 only 5 = channel 2 only 6 = independent ch3 7 = all independent
14	PHASE LOCKING	NR1	0 = locked, 1 = independent
15	RS232 MODE	NR1	0 = computer control 1 = printer
16	THD FORMULA	NR1	0 = difference formula 1 = harmonic series
17	HARMONIC REFERENCE	NR1	0 = fundamental 1 = RMS
18	HARMONIC DISPLAY	NR1	0 = percentage 1 = actual value V/A
19	THD FORMULA	NR1	0 = H0 (dc) excluded 1 = H0 (dc) included
20	DISPLAY UPDATE TIME	NR1	0 -255 in units of 100ms
21	FIXED FREQUENCY	NR1	0 = disable, 1 = enable
22	FIXED FREQUENCY	NR3	
23	FAST MODE	NR1	0 = disable, 1 = enable
24	N/A		
25	JITTER SELECTION	NR1	0 = auto selection 1 = manual
26	LOW LEVEL BLANKING	NR1	0 = disable, 1 = enable
27	WAVEFORM SNAPSHOT	NR1	0 = disable, 1 = enable
28	RANGE LOCKING	NR1	0 = locked, 1 = independent
29	N/A		
30	DISABLE CHANNEL (CH1)	NR1	0 = disable, 1 = enable
31	CURRENT SHUNT (CH1)	NR1	0 = Internal 30A shunt 1 = External 2.5V input
32	AC/DC COUPLING (CH1)	NR1	0 = AC coupled 1 = AC+DC coupled
33	BALLAST/U'SONIC (CH1)	NR1	0 = off 1 = 50Hz 2 = 60Hz
34	PHASE REFERENCE (CH1)	NR1	0 = voltage 1 = current

35	HIGH BANDWIDTH (CH1)	NR1	0 = high 1 = low
36	LOAD FIXED FREQ (CH1)	NR1	0 = disabled 1 = enabled
37	AVERAGING (CH1)	NR1	0 = fixed 1 = auto reset
38	AVERAGING DEPTH (CH1)	NR1	1-64
39	FREQUENCY SOURCE (CH1)	NR1	0 = voltage 1 = current 2 = external 3 = slow external
40	VOLTAGE RANGE (CH1)	NR1	0 = 0.5 1 = 1 2 = 2 3 = 5 4 = 10 5 = 20 6 = 50 7 = 100 8 = 200 9 = 500 10 = 1000 11 = 2000
41	CURRENT RANGE (CH1)	NR1	0 = 0.05 1 = 0.1 2 = 0.2 3 = 0.5 4 = 1.0 5 = 2.0 6 = 5.0 7 = 10 8 = 20 9 = 50 10 = 100 11 = 200
42	VOLTAGE RANGING (CH1)	NR1	0 = auto ranging 1 = manual
43	CURRENT RANGING (CH1)	NR1	0 = auto ranging 1 = manual
44	VOLTAGE SCALING (CH1)	NR3	
45	CURRENT SCALING (CH1)	NR3	
46	RMS DISPLAY (CH1)	NR1	0 = true rms 1 = mean rectified DC
47	FUNDAMENTALS (CH1)	NR1	0 = disabled, 1 = enabled
48	JITTER GENERATOR (CH1)	NR1	0 = disabled, 1 = enabled
49	PWM MOTOR DRIVES (CH1)	NR1	0 = disabled 1 = input 2 = output 3 = real time output
50-69	as 30-49 above for (CH2)		
70-89	as 30-49 above (CH3)		
90	MANUAL TRIGGER LOG	NR1	0 = disabled, 1 = enabled
91	EXTERNAL TRIGGER LOG	NR1	0 = disabled, 1 = enabled
92	TIMED TRIGGER LOG	NR1	0 = disabled, 1 = enabled
93	N/A		
94	N/A		
95	N/A		
96	LOG SAMPLES/CYCLES	NR1	200 – 6000
97	DATA LOG WINDOW	NR1	0-65535 in units of 1ms
98	N/A		
99	N/A		

100	MANUAL TRIGGER INT	NR1	0 = disabled, 1 = enabled
101	EXTERNAL TRIGGER INT	NR1	0 = disabled, 1 = enabled
102	TIMED TRIGGER INT	NR1	0 = disabled, 1 = enabled
103	CYCLIC INTEGRATION	NR1	0 = disabled, 1 = enabled
104	CYCLIC INTERVAL	NR1	0-65535 in minutes
105	INTEGRATE START DATE	NR1	0-65535 yyyyymmmmdddddd
106	INTEGRATE STOP DATE	NR1	0-65535 yyyyymmmmdddddd
107	INTEGRATE START TIME	NR1	0-65535 in minutes
108	INTEGRATE STOP TIME	NR1	0-65535 in minutes
109	INTEGRATOR BAND B1	NR1	0-65535 in minutes
110	INTEGRATOR BAND B2	NR1	0-65535 in minutes
111	INTEGRATOR BAND B3	NR1	0-65535 in minutes
112	INTEGRATOR BAND B4	NR1	0-65535 in minutes
113	INTEGRATOR BAND B5	NR1	0-65535 in minutes
114	INTEGRATOR RUN TIME	NR1	0-65535 in minutes
115	INTEGRATOR FUNCTIONS	NR1	0 = accumulated 1 = averaged
116	PWM OUTPUT VOLTS	NR3	
117	PWM OUTPUT AMPS	NR3	
118	PWM OUTPUT WATTS	NR3	
119	PWM INPUT WINDOW	NR3	units of seconds
120	PWM OUTPUT RANGE	NR1	1 = 5 Hz to 1kHz 2 = 0.5Hz to 50Hz 3 = 0.1Hz to 40Hz 4 = 5Hz to 1 kHz
121	ENABLE IEEE488	NR1	0 = disabled, 1 = enabled
122	IEEE ADDRESS	NR1	1 - 30
123	IEEE Std 488.2	NR1	0 = disabled, 1 = enabled
124	ENABLE RS232	NR1	0 = disabled, 1 = enabled
125	RS232 BAUD RATE	NR1	0 = 38400 1 = 19200 2 = 9600 3 = 4800 4 = 2400 5 = 1200
126	RS232 CURSOR HOME	NR1	0 = disabled, 1 = enabled
127	REMOTE DISPLAY	NR1	0 = disabled, 1 = enabled
128	N/A		
129	IEC555 MODE	NR1	0 = disable 1 = fixed harmonics 2 = fluctuating harms 3 = changing voltage 4 = flicker meter
130	ENABLE PRINTER	NR1	0 = disabled, 1 = enabled
131	MANUAL TRIGGER PRN	NR1	0 = disabled, 1 = enabled
132	EXTERNAL TRIGGER PRN	NR1	0 = disabled, 1 = enabled
133	TIMED TRIGGER PRN	NR1	0 = disabled, 1 = enabled
134	PRINT MODE	NR1	0 = display, 1 = selection
135	HARMONIC SERIES	NR1	0 = odd and even 1 = odd only
136	MAXIMUM HARMONIC	NR1	0-99
137	PRINT FUNDAMENTALS	NR1	0 = disabled, 1 = enabled
138	PRINTOUT RESULTS CH1	NR1	0 = disabled, 1 = enabled
139	PRINTOUT RESULTS CH2	NR1	0 = disabled, 1 = enabled
140	PRINTOUT RESULTS CH2	NR1	0 = disabled, 1 = enabled
141	PRINTOUT RESULTS SUM	NR1	0 = disabled, 1 = enabled
142	PRINTOUT RESULTS NEU	NR1	0 = disabled, 1 = enabled
143	PRINTOUT INTERVAL	NR1	0-11999 in minutes
144	N/A		
145	N/A		

146	N/A		
147	N/A		
148	N/A		
149	N/A		
150	N/A		
151	N/A		
152	printout Watts	NR1	0 = disabled, 1 = enabled
153	printout VA	NR1	0 = disabled, 1 = enabled
154	printout VAr	NR1	0 = disabled, 1 = enabled
155	printout Vrms	NR1	0 = disabled, 1 = enabled
156	printout Arms	NR1	0 = disabled, 1 = enabled
157	printout PF	NR1	0 = disabled, 1 = enabled
158	printout V peak	NR1	0 = disabled, 1 = enabled
159	printout A peak	NR1	0 = disabled, 1 = enabled
160	printout V cf	NR1	0 = disabled, 1 = enabled
161	printout A cf	NR1	0 = disabled, 1 = enabled
162	printout A inrush	NR1	0 = disabled, 1 = enabled
163	printout Impedance	NR1	0 = disabled, 1 = enabled
164	printout W hours	NR1	0 = disabled, 1 = enabled
165	printout VA hours	NR1	0 = disabled, 1 = enabled
166	printout VAr hours	NR1	0 = disabled, 1 = enabled
167	printout A hours	NR1	0 = disabled, 1 = enabled
168	printout Average pf	NR1	0 = disabled, 1 = enabled
169	printout C VAr	NR1	0 = disabled, 1 = enabled
170	printout Reactance	NR1	0 = disabled, 1 = enabled
171	printout V harmonics	NR1	0 = disabled, 1 = enabled
172	printout A harmonics	NR1	0 = disabled, 1 = enabled
173	printout V thd	NR1	0 = disabled, 1 = enabled
174	printout A thd	NR1	0 = disabled, 1 = enabled
175	printout Frequency	NR1	0 = disabled, 1 = enabled
176	WATT HARMONICS	NR1	0 = disabled, 1 = enabled
177	LOGIC OUTPUTS	NR1	0 = disabled, 1 = enabled
178	N/A		
179	INTEGRATOR RESET	NR1	0 = disabled, 1 = enabled
180	DISPLAY CHANNEL	NR1	0 = CH1 1 = CH2 2 = CH3 3 = SUM 4 = NEU
181	DISPLAY FUNCTION	NR1	0-31
182	UPPER RIGHT DISPLAY	NR1	0-7
183	UPPER LEFT DISPLAY	NR1	0-7
184	SELECTED HARMONIC	NR1	0-99
185	DISPLAY FORMAT	NR1	0 = single 1 = multiple 2 = 4 Function
186	LOWER RIGHT DISPLAY	NR1	0-7
187	LOWER LEFT DISPLAY	NR1	0-7
188	N/A		
189	N/A		
190	REVERSED PF SIGN	NR1	0 = disabled, 1 = enabled
191	SUM A = $(A_1+A_2+A_3)/3$	NR1	0 = disabled, 1 = enabled
192	SUM V = $(V_1+V_2+V_3)/3$	NR1	0 = disabled, 1 = enabled
193	AUXILIARY INPUTS	NR1	0 = disabled, 1 = enabled
194	TORQUE INPUT	NR1	0 = 10V full scale 1 = 1V full scale
195	TORQUE INPUT	NR3	10^{-9} to 10^{9} (per volt)
196	TORQUE INPUT	NR1	0 = torque in Nm 1 = torque in ftlb

197	HIGH FREQUENCY	NR1	0 = disabled, 1 = enabled
198	RPM INPUT	NR3	10^{-9} to 10^{9} (pulse/rev)
199	RPM INPUT	NR1	0 = pulse 1= voltage
200	CHART RECORDER R1	NR1	0 = disabled, 1 = enabled
201	CHART RECORDER R1	NR1	(function) 0-31
202	CHART RECORDER R1	NR1	0 = CH1 1 = CH2 2 = CH3 3 = SUM 4 = NEU
203	RECORDER MINIMUM R1	NR3	
204	RECORDER MAXIMUM R1	NR3	
205	ALARM TYPE R1	NR1	0 = no alarm 1 = alarm if low 2 = alarm if high 3 = alarm if high or low
206-211	rec 2 as 200-204 above		
212-217	rec 3 as 200-204 above		
218-223	rec 4 as 200-204 above		
224-229	rec 5 as 200-204 above		
230-235	rec 6 as 200-204 above		
236-241	rec 7 as 200-204 above		
242-247	rec 8 as 200-204 above		
248	N/A		
249	N/A		
250	FREQUENCY COMPENSATE	NR1	0 = disable, 1 = enable
251	autozero	NR1	0 = disable, 1 = enable
252	FLICKER SIMULATION	NR1	0 – 99
256	N/A		
257	N/A		
258	N/A		
259	N/A		
260	LINE RESISTANCE Ohms	NR3	
261	LINE INDUCTANCE mH	NR3	
262	RUN TIME minutes	NR1	units of 0.1 minutes
263	PERMITTED DROP %	NRI	units of 0.05%
264	VOLTAGE OR CURRENT	NR1	0 = voltage, 1 = current
265	N/A		
266	N/A		
267	N/A		
268	N/A		
269	N/A		
270	EFFICIENCY	NR1	0 = disable, 1 = enable
271	EFFICIENCY FORMULA	NR1	0 = ch3/sum 1 = sum/ch3 2 = ch1/ch3 3 = ch2/ch3 4 = ch1/ch2
272	EFFICIENCY UNITS	NR1	0 = Watts/Watts 1 = VA/VA 2 = Watts/VA 3 = VA/Watts
273	EFFICIENCY SCALING	NR3	
274	TRANSFORMER MODE	NR1	0 = off 1 = Vav 2 = k-fctr 3 = P-corr
275	RS232 VERBOSE MODE	NR1	0 = disable, 1 = enable
276	SINGLE REPLY STRING	NR1	0 = disable, 1 = enable

277	Vrms, Arms, W ONLY	NR1	0 = disable, 1 = enable
278	CHANNEL 3 DC BUS	NR1	0 = disable, 1 = enable
279	Data Return Format	NR1	0 = 4.5 digit ASCII, 1 = 5 digit ASCII
280	CYCLE BY CYCLE LOG	NR1	0 = disable, 1 = enable
281	HARMONIC WINDOWING	NR1	0 = disable, 1 = enable
282	PAGE FEED	NR1	0 = disable, 1 = enable

10.6.4.1 SETTING DATES USING THE CFG COMMAND

Each date is stored as a 16-bit number (between 0 – 65535). The way the address is translated to this number is shown below:



	Valid Number Ranges
Year	0 - 127 The number given is added to 1900 to give a valid year range of 1900 - 2027
Month	1 - 12
Day	1 - 31

Note: Should an invalid date be entered, then the date will revert to 00-00-00

10.6.4.2 EXAMPLE

For an example date of 20th July 1969, the conversion to a 16-bit number would go as follows

Show the date as 3 appropriate numbers. Then convert each digit to binary.

20th July 1969
= 20-07-69

10100 0111 1000101

Then convert the 16 bit binary number to decimal.

1000101011110100
Year Day Month
= **35572**

Depending upon whether it is for an integrator start or stop, the example date would be entered as:

(Integrator start date) **:CFG 105,35572**
(Integrator stop date) **:CFG 106,35572**

10.7 PROGRAM TIMING

When writing programs to control the PM3000A Analyzer via the IEEE488.2 interface, it may be necessary to insert delays to allow for the relative speeds of the controller and instrument.

The following example (which is part of a program) shows delays being used to stop any commands being written to the instrument after issuing a :DVC command and to break up a long string of commands (150 characters), which could overflow the input buffer. A delay of 5 seconds must be issued after writing a :DVC command to the instrument.

```
PRINT #1, “OUTPUT 10;:DVC”
GOSUB delay_for_5_seconds
PRINT #1, “OUTPUT 10;:SEL:CLR”
PRINT #1, “OUTPUT 10;:SEL:CH1”
PRINT #1, “OUTPUT 10;:SEL:VLT;:SEL:AMP;:SEL:WAT”
PRINT #1, “OUTPUT 10;:SEL:VPK;:SEL:APK;:SEL:VCF;:SEL:ACF”
PRINT #1, “OUTPUT 10;:SEL:VAS;:SEL:VAR;:SEL:PWF”
PRINT #1, “OUTPUT 10;:SEL:FRQ;:SEL:IMP;:SEL:VDF;:SEL:ADF”
PRINT #1, “OUTPUT 10;*TRG”

Wait for averaging to fill and read back results
```

If the program is using serial polling, and, and for example, the DSE has been set to 4 (averaging full), after issuing a *TRG it will be necessary to poll for the averaging to be reset then to poll for the averaging to be set. This restriction is due to the execution speed of the *TRG command; when the *TRG command has been issued the DSR will not have been updated by the time when the first serial poll has been issued and therefore the DSR is still set to averaging full.

10.8 VPAS FOR WINDOWS ä DEMO

This demo software disk supplied with your PM3000A is designed to run with an IBM compatible PC fitted with an IEEE interface (see section 8.2).

VPAS enables the user to set up the PM3000A via a PC, command the measurement and read back the results. All results obtained can be displayed graphically or as text, and can be printed out or exported as ASCII or CSV formats, for word-processing and spreadsheets.

The package also supports HF ballast mode, PWM (motor drive) mode and torque / speed inputs.

10.8.1 HARDWARE REQUIREMENTS

Compatible PC Processor:

DX CPU or installed math co-processor
(SX CPU will not run VPAS)

Memory:

4Mbytes minimum
(Although VPAS will typically run with 4M, Voltech will not guarantee its reliability.)
8Mbytes recommended

Hard Disk Drive:

4Mbytes free minimum

Video:

VGA 640x480 DPI resolution minimum. Higher resolutions will allow the user to view more data simultaneously without having to move windows around. 1024x768 DPI allows the user to view virtually all data simultaneously.

Operating Systems Supported:

Windows™ 3.1
Windows™ 3.11 for Workgroups
Windows™ 95

Power Analyzer:

PM3000A - Firmware version 1.67 or above

Power Analyzer to Computer interface:

RS232:

Comm. ports 1-4

IEEE-488:

All current National Instruments cards supporting 488.2 protocols

10.8.2 INSTALLING VPAS

1) Turn on your computer and run ‘Windows’.

2) Insert the VPAS set-up disk into the computer floppy disk drive.

3) Select ‘RUN’ and choose ‘SETUP’ on the VPAS disk to start the installation process.

The VPAS installation program will prompt you to specify 2 directories, one for the CVI Run-Time executable and one for VPAS. If you have other programs that were written in LabWindow/CVI, you should choose the same Run-Time directory.

When installation is complete, a new program group called 'Voltech Software' will appear on your computer desktop.

To run VPAS, simply double click on the VPAS icon found in the 'Voltech Software' Program Group.

Please Note: Due to the complexity of VPAS it is not recommended to run any other applications while VPAS is running. It is also not recommended to run VPAS while logged on to a network.

If you encounter any problems or difficulties while using this demo, please contact your Voltech supplier.

CHAPTER 11

SPECIFICATION

11.1 VOLTAGE (V)

Range (Auto or Manual)		0.5V to 2000Vpk (1400V rms)
(12 ranges 1-2-5 sequence)		
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	DC:	±0.1% reading ±0.1% range ± 1mV*
(23° ± 5°C)	45 to 450Hz:	±0.05% reading ±0.05% range ± 0.5 mV
(0.2V - 1000Vrms)	0.1Hz to 500kHz:	±0.1% reading ±0.05% range ± 0.5 mV
(All models)		±0.02%/kHz ± 0.5 mV
Effect of Common	1000Vrms 60Hz:	Less than 20mV
Mode Voltage	100Vrms 100kHz:	Less than 500mV (1V - 002 model)
Maximum Input	Continuous:	1500Vpk
	1 second:	5000Vpk
Input Impedance		1 MΩ in parallel with 10pF (all ranges)

11.2 CURRENT (A)

Range (Auto or Manual)		INT:	0.05A to 200Apk (30A rms)
(12 ranges 1-2-5 sequences)		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	DC:		±0.1% reading ±0.1% range ± 200μA*
(23° ± 5°C)	45 to 450Hz:		±0.05% reading ±0.05% range ± 100μA
(20mA to 30Arms)	0.1Hz to 250kHz:		±0.1% reading ±0.05% range
(Std & 001models)			±(kHz x 0.04)% reading ±100μA
	250 to 500kHz:		±0.1% reading ±0.05% range
			±(kHz + 250) x 0.02% reading ±100μA
(002 model)	DC:		±0.1% reading ±0.1% range ± 800μA*
(80mA to 30Arms)	45 to 450Hz:		±0.05% reading ±0.05% range ± 100μA
	0.1Hz to 250kHz:		±0.1% reading ±0.05% range
			±(kHz x 0.08)% reading ±100μA
	250 to 500kHz:		±0.1% reading ±0.05% range
			±(kHz + 250) x 0.04% reading ±100μA

Effect of Common Mode Voltage	1000Vrms 60Hz: 100Vrms 100kHz:	Less than 2mA rms Less than 20mA rms (50mA - 002 model)
Maximum Input	Continuous: 1 second:	30A rms (must be limited by ext. fuses or CT's) 200A rms
Input Impedance (Std & 001 models)	INT: EXT:	12.5mΩ on all ranges 1MΩ in parallel with 100pF (all ranges)
(002 model)	INT: EXT:	3.5mΩ on all ranges 20KΩ in parallel with 33pF (all ranges)

(N.B.: The DC accuracy stated is only valid for a unit using the auto-zero facility.)

11.3 POWER (W)

Ranges (Auto or Manual) **(144 ranges corresponding to V & A)**		25mW to 400kWpk (with scaling to 100,000MW)
Accuracy **(23±5°C, sinewave)** **(Std & 001 models)**	DC:	±(A reading x V error) ±(V reading x A error) ±0.04% reading ±200µW
	45 to 450Hz:	±((A reading x V error) x PF) ±((V reading x A error) x PF) ±(0.04/PF)% reading ±100µW
	0.1Hz to 250kHz:	±((A reading x V error) x PF) ±((V reading x A error) x PF) ±(kHz x 0.04/PF)% reading ±100µW
	250 to 500kHz:	±((A reading x V error) x PF) ±((V reading x A error) x PF) ±((kHz + 750) x 0.01/PF)% reading ±100µW
(002 model)	DC:	±(A reading x V error) ±(V reading x A error) ±0.04% reading ±200µW
	45 to 450Hz:	±((A reading x V error) x PF) ±((V reading x A error) x PF) ±(0.04/PF)% reading ±100µW
	0.1Hz to 250kHz:	±((A reading x V error) x PF) ±((V reading x A error) x PF) ±(kHz x 0.06/PF)% reading ±100µW
	250 to 500kHz:	±((A reading x V error) x PF) ±((V reading x A error) x PF) ±((kHz + 1250) x 0.01/PF)% reading ±100µW
Polarity		+ indicates positive power flow - indicates negative power flow

11.4 APPARENT POWER (VA)

Ranges (Auto or Manual) **(144 ranges corresponding to V & A)**		25mVA to 400kVApk (with scaling to 100,000MVA)
Accuracy **(23±5°C, sinewave)** **(All models)**	0.1Hz to 500kHz:	±((A reading x V error) x PF) ±((V reading x A error) x PF)

11.5 REACTIVE POWER (VAR)

Ranges (Auto or Manual) **(144 ranges corresponding to V & A)**		25mVAr to 400kVArpk (with scaling to 100,000MVAr)
Accuracy **(23±5°C, sinewave)** **(Std & 001 models)**	45 to 450Hz:	±((A reading x V error) x $(1- PF^2)^{0.5}$ ±((V reading x A error) x $(1- PF^2)^{0.5}$ ±((0.04/$(1- PF^2)^{0.5}$)% reading
	0.1Hz to 250kHz:	±((A reading x V error) x $(1- PF^2)^{0.5}$ ±((V reading x A error) x $(1- PF^2)^{0.5}$ ±((0.04/$(1- PF^2)^{0.5}$)% reading
	250 to 500kHz:	±((A reading x V error) x $(1- PF^2)^{0.5}$ ±((V reading x A error) x $(1- PF^2)^{0.5}$ ±((kHz + 750) x ((0.01/ $(1- PF^2)^{0.5}$) % reading
(002 model)	45 to 450Hz:	±((A reading x V error) x $(1- PF^2)^{0.5}$ ±((V reading x A error) x $(1- PF^2)^{0.5}$ ±((0.04/$(1- PF^2)^{0.5}$)% reading
	0.1Hz to 250kHz:	±((A reading x V error) x $(1- PF^2)^{0.5}$ ±((V reading x A error) x $(1- PF^2)^{0.5}$ ±((0.06/$(1- PF^2)^{0.5}$)% reading
	250 to 500kHz:	±((A reading x V error) x $(1- PF^2)^{0.5}$ ±((V reading x A error) x $(1- PF^2)^{0.5}$ ±((kHz + 1250) x ((0.01/ $(1- PF^2)^{0.5}$) % reading
Polarity		+ indicates positive power flow - indicates negative power flow

11.6 POWER FACTOR (PF)

Range		0.000 to ±1.000
Accuracy (23 ± 5°C)		±0.002 ±(kHz x 0.001/PF)
(All models)		
Polarity		+ indicates leading PF
		- indicates lagging PF

11.7 CREST FACTOR (CF)

Range		1.000 to 19.999
Basic Accuracy	Voltage Crest Factor:	± 0.1% reading ± (0.05/range) ± 0.02
(23 ± 5°C)	Current Crest Factor:	± 0.1% reading ± (0.01/range) ± 0.01
(All models)		

11.8 INRUSH CURRENT

Range		0.1A to 200Apk (with scaling to 20MA)
Accuracy (23 ± 5°C)		2% of selected range
Sampling Interval	1Ø 2 wire:	3.6 µS
(All models)	1Ø 3 wire/3Ø 3 wire:	6.8 µS
	3Ø 4 wire:	10 µS

11.9 IMPEDANCE

Range		0.0001Ω to 9.999 MΩ
Accuracy (23 ± 5°C)	45 to 450Hz:	±0.5% reading
(All models)	0.1 to 500kHz:	±0.5% reading ± (kHz x 0.05/PF)% reading

11.10 FREQUENCY

Range	Internal Source:	5Hz to 1MHz
	External Source:	0.1Hz to 1MHz
Accuracy (23 ± 5°C)		±0.1%
(All models)		

11.11 HARMONIC ANALYSIS

Range		DC and fundamental to 99th harmonic for voltage and current. Max Harmonic = 1MHz
Accuracy (23 ± 5°C)		
(All models)	Voltage Fundamental:	±0.1% reading ±0.1% range ±(kHz^F x 0.02)% reading
(Std & 001 models)	Current Fundamental:	±0.1% reading ±0.1% range ±(kHz^F x 0.04)% reading ± 100 μA
(002 model)	Current Fundamental:	±0.1% reading ±0.1% range ±(kHz^F x 0.08) % reading ± 100 μA
(All Models)	Harmonic:	±((kHz^H x 0.05) +0.1) % fundamental
	THD^1:	±((kHz^F x 0.01) +0.2) % fundamental

(N.B.: kHz^F - Frequency of Fundamental component in kHz.)
(N.B.: kHz^H - Frequency of Harmonic component in kHz.)
(N.B.: ^{1} - Specification using Harmonic series formula with dc excluded.)

11.12 INTEGRATOR

Range	0.001 Whr to 100,000MWhr
Integration Interval	1 Second
Elapsed Time Display	7 Digit, Floating Decimal Point

11.13 BANDWIDTH

A low bandpass filter is applied at power-up. It can be deselected using the BANDWIDTH key.

Unfiltered Bandwidth	DC to 500kHz:	
Filtered Bandwidth:		
(Std & 001 models)	DC to 25kHz:	(Specified Accuracies Achieved to 12.5kHz)
(002 model)	DC to 5kHz:	(Specified Accuracies Achieved to 2.5kHz)

11.14 CHART RECORDER OUTPUTS

Functions	All except Peaks, Harmonics and Inrush Current
Number of Outputs	8
Output Levels	0 to +5V; 5mA max
Update Rate	0.5 seconds

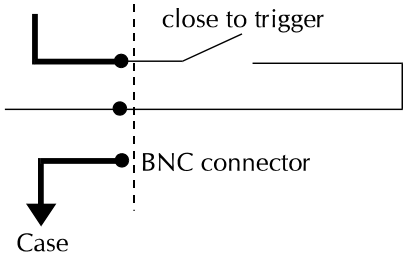
11.15 EXTERNAL FREQUENCY SOURCE

Input	1 to 10Vrms 0.1Hz - 1MHz 10kΩ input impedance

(N.B.: Negative inputs see a reverse diode - very high impedance.)

11.16 EXTERNAL TRIGGER INPUT

Closed switch to pass 5mA max.



11.17 OPERATING TEMPERATURE AND HUMIDITY

Temperature	5° to 40°C
Humidity	10% to 80% RH non condensing

11.18 DIELECTRIC STRENGTH

Input to Case	4kV AC 50/60Hz for 1 minute
Inputs to Power Supply	4kV AC 50/60Hz for 1 minute
Input to Input	2kV AC 50/60Hz for 1 minute
Power Supply to Case	2.9kV DC for 1 minute

11.19 POWER SOURCE

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

11.20 DIMENSIONS AND WEIGHT

Dimensions	420mm (W) 129mm (H) 406mm (D)
Weight	9kg

11.21 AUXILIARY INPUTS A AND B (TORQUE AND SPEED)

Pulse	Ext. Frequency Input:	0.5Hz - 1kHz
	High Frequency:	100 Hz - 1MHz
Bipolar Input		0 - 1V DC (software selectable) 0 - 10V DC (software selectable)
Type		BNC rear panel connector
Accuracy		1V range: 0.5% reading ± 0.5% range ± 10mV 10V range: 0.1% reading ± 0.1% range ± 10mV
Input Impedance		20kΩ over the normal operating range.

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

11.22 WARRANTY

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

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

Limitation of Warranty

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

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CHAPTER 12
COMPLIANCE WITH EC DIRECTIVES

12.1 DECLARATION OF CONFORMITY

DECLARATION OF CONFORMITY

Manufacturer's Name	Voltech Instruments Ltd.
Manufacturer's Address	148 Sixth Street, Harwell International Business Centre Harwell, Didcot, Oxon OX11 0RA 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, July 22, 1996

12.2 EMC PRECAUTIONS

12.2.1 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 end of the lead) closest to the PM3000A.

Any other RS232 or Parallel Printer leads used should have a ferrite fitted at the end of the lead closest to the PM3000A.

12.2.2 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, the PM3000A may be returned to normal operation as follows:

1) Switch off the power
2) Wait 5 seconds
3) Switch on again

APPENDIX 1
INDEX TO FUNCTION KEYS

INDEX TO FUNCTION KEYS

See also Appendix 2 - Alphabetical Index

BASIC MEASUREMENT KEYS

KEY	FUNCTION	PAGE NO.
W	Watts	3-1
VA	Volts-Amps	3-1
Var	Reactive Volts-Amps	3-1
V	Volts	3-2
A	Amps	3-2
PF	Power Factor	3-2
V_{PK}	Peak Voltage	3-3
A_{PK}	Peak Current	3-3
V_{CF}	Voltage Crest Factor	3-3
A_{CF}	Current Crest Factor	3-3
INRUSH A	Peak Inrush Current	3-3
IMPEDANCE	Impedance	3-4

INTEGRATOR KEYS

KEY	FUNCTION	PAGE NO.
W hr	Watt Hours	7-1
VA hr	VA Hours	7-1
Var hr	VAr Hours	7-1
A hr	Ampere Hours	7-1
AV PF	Average Power Factor	7-1
CORR VAr	Correction VArs	7-2

HARMONIC ANALYSIS KEYS

KEY	FUNCTION	PAGE NO.
FUND	Fundamental	3-10
V-HARM	Voltage Harmonic	3-9
A-HARM	Current Harmonic	3-9
V-THD	Voltage Harmonic Distortion	3-10
A-THD	Current Harmonic Distortion	3-10
FREQ	Frequency	3-10

SETUP KEYS

KEY	FUNCTION	PAGE NO.
FREQSOURCE	Frequency Source Selection	3-4
VOLTS AMPS	RMS/Mean Selection	3-5
AVG	Averaging Selection	3-5
COUPLING	AC + DC/AC Coupling Selection	3-6
SHUNT	Shunt Selection	3-6

MENU KEYS

KEY	FUNCTION	PAGE NO.
SCALING	Scale Factor Options	3-6
INTEGRATOR	Integrator Options	7-2
INTERFACE	Interface Options	8-1
DISPLAY	Display Options	3-7
DATA LOG	Event Analysis Options	9-1

WIRING KEYS

KEY	FUNCTION	PAGE NO.
1Ø2W	Single Phase, Two Wire	2-2
1Ø3W	Single Phase, Three Wire	2-2
3Ø3W	Three Phase, Three Wire	2-2
3Ø4W	Three Phase, Four Wire	2-2

CHANNEL SELECT KEYS

KEY	FUNCTION	PAGE NO.
CH1	Channel 1	2-2
CH2	Channel 2	2-2
CH3	Channel 3	2-2
Σ	Summation	2-2
N	Neutral	2-2

ADDITIONAL KEYS

KEY	FUNCTION	PAGE NO.
F	Function Key	5-1
P	Program Key	4-1
SELECT	Option Select Key	3-5
ENTER	Option Confirm Key	3-5
CLOCK SET	Time and Date Adjustment	3-8
STOP	Datalog/Integrator Stop key	9-4
START RESET	Datalog/Integrator Reset key	9-4
DATA DUMP	Printer Data dump Key	4.5
LOCAL	IEEE Local Mode Key	10-2
AUTO	Volts and Amps Auto Ranging	2-3

APPENDIX 2
ALPHABETICAL INDEX

ALPHABETICAL INDEX

A	PAGE NUMBER
A KEY	2-3
AC/DC COUPLING SELECTION	3-6
ACCESSORIES	1-2
ACCURACY SPECIFICATION	11-1
ADDRESSING	10-2
ADVANCED CONFIGURATION	6-1
ANALOG ALARMS OUTPUTS	8-6
ANTI-ALIASING FILTER	2-1,5-1
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APPENDIX 3
FORMULAE

CHANNEL FORMULAE (CH1,2,3 AND NEUTRAL)

RMS FORMULAE

$$W = \frac{1}{T}\int_0^T v_i \; i_i \; dt$$

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

$$VAr = \sqrt{(VA)^2 - W^2}$$

$$V_{RMS} = \sqrt{\frac{1}{T}\int_0^T v_i^2 dt}$$

$$A_{RMS} = \sqrt{\frac{1}{T}\int_0^T i_i^2 \; dt}$$

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

$$Z = \frac{Total\ RMS\ Volts}{Total\ RMS\ Amps}$$

$$CF = \frac{Peak\,Value}{RMS\,Value}$$

FUNDAMENTAL FORMULAE

$$W.fund = V1.r \times A1.r + V1.q \times A1.q$$

$$VAr.fund = (V1.q \times A1.r) - (V1.r \times A1.q) \qquad (if\ W > 0)$$

$$VAr.fund = (V1.r \times A1.q) - (V1.q \times A1.r) \qquad (if\ W < 0)$$

$$V.fund = \sqrt{(V1.r^2 + V1.q^2)}$$

$$A.fund = \sqrt{(A1.r^2 + A1.q^2)}$$

$$VA.fund = \sqrt{W.fund^2 + VAr.fund^2}$$

$$PF.fund = \cos q \qquad (where q = phase\ angle)$$

where

$$\cos q = \frac{W.fund}{VA.fund}$$

r = real part of fundamental V or I fundamental

q = imaginary or quadrature part of V or I

V and I fundamental are complex numbers in the form r+jq

$$Z.fund = R.fund + jX.fund\ Ohms$$

where

$$R.fund = \frac{V.fund}{A.fund} \times \cos q \qquad (where q = phase\ angle)$$

$$X.fund = \frac{V.fund}{A.fund} \times \sin q \qquad (where q = phase\ angle)$$

HARMONIC ANALYSIS FORMULAE

$$Vharm = \sqrt{(Vh.r^2 + Vh.q^2)}$$

$$Vharm\ \deg = \tan^{-1}\left(\frac{Vh.q}{Vh.r}\right)$$

$$Aharm = \sqrt{(Ah.r^2 + Ah.q^2)}$$

$$Aharm\ \deg = \tan^{-1}\left(\frac{Ah.q}{Ah.r}\right)$$

$$Vdf = \frac{\sqrt{\left(VRMS^2 - Vh1^2\right)}}{VREF}$$

$$Vthd = \frac{\sqrt{Vh2^2 + Vh3^2 + Vh4^2 + Vh5^2 + ...}}{VREF}$$

$$Adf = \frac{\sqrt{\left(ARMS^2 - Ah1^2\right)}}{AREF}$$

$$Athd = \frac{\sqrt{Ah2^2 + Ah3^2 + Ah4^2 + Ah5^2 + ...}}{AREF}$$

MEAN FORMULAE

$$V_{MEAN} = \frac{1}{T}\int_0^T |v|\,dt$$

$$A_{MEAN} = \frac{1}{T}\int_0^T |i|\,dt$$

SUM FORMULAE

1 PHASE 3 WIRE SUM FORMULAE

$$\sum V = ch1V + ch2V$$

$$\sum V.fund = ch1V.fund + ch2V.fund$$

$$\sum W = ch1W + ch2W$$

$$\sum W.fund = ch1W.fund + ch2W.fund$$

$$*\sum VAr = \sqrt{\sum VAr.fund^2 + \left(ch1VAr.h + ch2VAr.h\right)^2}$$

$$\sum VAr.fund = ch1VAr.fund + ch2VAr.fund$$

$$\sum VA = \sqrt{\sum W^2 + \sum VAr^2}$$

$$\sum VA.fund = \sqrt{\sum W.fund^2 + \sum VAr.fund^2}$$

$$\sum A = \frac{\sum VA}{\sum V} \quad or \quad \sum A = \frac{ch1A + ch2A}{2}$$ (See Page 6-3)

$$\sum A.fund = \frac{\sum VA.fund}{\sum V.fund}$$

$$\sum PF = \frac{\sum W}{\sum VA}$$

$$\sum PF.fund = \frac{\sum W.fund}{\sum VA.fund}$$

3-PHASE 3-WIRE SUM FORMULAE

$$\sum V = \frac{ch1V + ch2V}{2}$$

$$\sum V.fund = \frac{ch1V.fund + ch2V.fund}{2}$$

$$\sum W = ch1W + ch2W$$

$$\sum W.fund = ch1W.fund + ch2W.fund$$

$$*\sum VAr = \sqrt{\sum VAr.fund^2 + \left(\sqrt{\frac{3}{2}} \times \left(ch1VAr.h + ch2VAr.h\right)^2\right)}$$

$$\sum VAr.fund = ch1VAr.fund + ch2VAr.fund$$

$$\sum VA = \sqrt{\sum W^2 + \sum VAr^2}$$

$$\sum VA.fund = \sqrt{\sum W.fund^2 + \sum VAr.fund^2}$$

$$\sum A = \frac{\sum VA}{\sum V} \Big/ \sqrt{3} \quad or \quad \sum A = \frac{ch1A + ch2A}{2}$$ (See Page 6-3)

$$\sum A.fund = \frac{\sum VA.fund}{\sum V.fund} \Big/ \sqrt{3}$$

$$\sum PF = \frac{\sum W}{\sum VA}$$

$$\sum PF.fund = \frac{\sum W.fund}{\sum VA.fund}$$

3-PHASE 4-WIRE SUM FORMULAE

$$\sum V = \frac{ch1V + ch2V + ch3V}{\sqrt{3}} \quad or \quad \sum V = \frac{ch1V + ch2V + ch3V}{3}$$ (See Page 6-3)

$$\sum V.fund = \frac{ch1V.fund + ch2V.fund + ch3V.fund}{\sqrt{3}}$$

$$\sum W = ch1W + ch2W + ch3W$$

$$\sum W.fund = ch1W.fund + ch2W.fund + ch3W.fund$$

$$*\sum VAr = \sqrt{\sum VAr.fund^2 + \left(ch1VAr.h + ch2VAr.h + ch3VAr.h\right)^2}$$

$$\sum VAr.fund = ch1VAr.fund + ch2VAr.fund + ch3VAr.fund$$

$$\sum VA = \sqrt{\sum W^2 + \sum VAr^2}$$

$$\sum VA.fund = \sqrt{\sum W.fund^2 + \sum VAr.fund^2}$$

$$\sum A = \frac{\sum VA}{\sum V} \Big/ \sqrt{3} \quad or \quad \sum A = \frac{ch1A + ch2A + ch3A}{3}$$ (See Page 6-3)

$$\sum A.fund = \frac{\sum VA.fund}{\sum V.fund} \Big/ \sqrt{3}$$

$$\sum PF = \frac{\sum W}{\sum VA}$$

$$\sum PF.fund = \frac{\sum W.fund}{\sum VA.fund}$$

$$*VAr.h = \sqrt{VAr^2} + VAr.fund^2$$

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