Voltech

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PM6000

POWER ANALYZER

USER MANUAL

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Voltech Instruments is committed to a policy of continuous product development. Hence product specification and the information given in this manual are subject to change without notice.

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5	v1.06.01

DANGER OF ELECTRIC SHOCK

Only qualified personnel should install this equipment, after reading and understanding this user manual. If in doubt, consult your supplier.

RISQUE D'ELECTROCUTION

L'installation de cet équipement ne doit être confiée qu'à un personnel qualifié ayant lu et compris le présent manuel d'utilisation. Dans le doute, s'adresser au fournisseur.

GEFAHR VON ELEKTRISCHEM SCHOCK

Nur entsprechend ausgebildetes Personal ist berechtigt, diese Ausrüstung nach dem Lesen und Verständnis dieses Anwendungshandbuches zu installieren. Falls Sie Zweifel haben sollten, wenden Sie sich bitte an Ihren Lieferanten.

RISCHIO DI SCARICHE ELETTRICHE

Solo personale qualificato può installare questo strumento, dopo la lettura e la comprensione di questo manuale. Se esistono dubbi consultate il vostro rivenditore.

IMPORTANT: Please consult the safety information section of this user manual before installation and use.

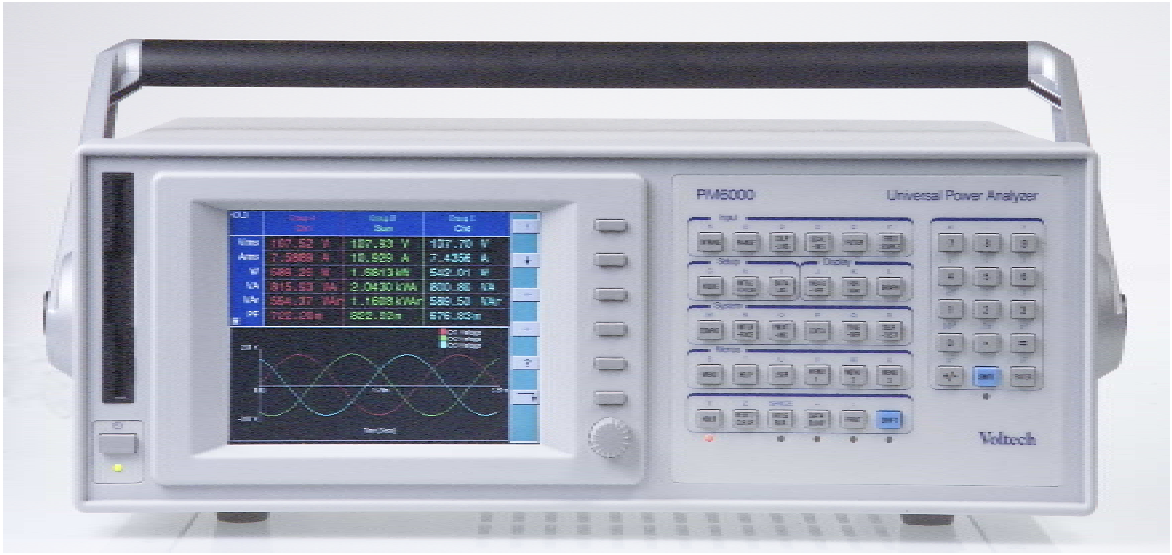
Contents

1. INTRODUCTION

Thank you for choosing to use this Voltech product. If you experience any difficulty during installation or use of the Voltech PM6000, or are unsure of any of its features or abilities, please do not hesitate to contact either your local Voltech supplier or one of our Voltech main service centers.

1.1. FEATURES & ABILITIES

The Voltech PM6000 is a powerful and versatile precision power analyzer. The accuracy and bandwidth of the PM6000 allow definitive measurements of all power quantities to be made on all electrical and electronic products. In applications ranging from a power supply operating in standby mode, through high-frequency power converters, to large power transformers, the PM6000 provides stable, reliable, and accurate measurements every time



Versatile Technology

The PM6000 couples a fast PCI bus architecture with powerful digital signal processing to provide 5 mega-samples per second (MSPS) - processed on all channels - simultaneously and continuously. This ensures that accurate real-time measurements can be made on products such as power supplies, motor drives and lighting ballasts. Up to 40 MSPS are available for burst and transient measurement modes.

There is room for up to 6 wattmeter channels to be installed into a PM6000 with a variety of shunts and current sensors, creating flexible test options

Rugged Performance

Each measurement channel can measure up to 2000Vpk and will accept a range of Voltech plug-in current shunts and other current transducers. The PM6000 automatically recognizes Voltech shunts when the instrument is powered up and reads the shunt's own calibration data to ensure optimum accuracy. In this way, only the standard measurement channel is required for all applications.

An embedded PC running the Linux operating system is used to display, communicate and control all the available measurements

Easy to use

The display soft keys and rotary control are used to select and group measurements, display multi-phase sum quantities, calculate efficiency and to display waveforms. The menu items may also be selected using the front panel short-cut keys or remotely on a PC.

In this way, the PM6000 can be set up to make complex measurements in seconds. Front panel settings may be stored for future use.

For on the spot assistance, a comprehensive help system is built in to the analyzer

Evolving capability

The power of the PM6000 is being further developed by a program of software enhancement. Regularly visit the Voltech website to keep up to date with developments

1.2. PACKAGE CONTENTS

The following items are supplied with your PM6000. Please check that you have every item and report any missing items to your Voltech supplier as soon as possible.

- PM6000 Chassis
- Certificate of Conformance and Calibration Certificates
- CD including the manual and calibration data
- Mains power cable
- Current Connector plug for each measurement card
- Voltech product registration card

Returning your product registration card will ensure that you continue to receive the latest product and application information.

If you have ordered measuring channels and shunts together with a PM6000 chassis, they will be fitted ready for use

1.3. OPTIONS

The following items may also be supplied with the PM6000. For logistical reasons, some items may be supplied in separate packages. All these items are also available post sale.

- PM6000 Measurement Channel (Fitted by a Voltech service center only)
  High performance wattmeter channel. Voltage 2000Vpk, current 2.5Vpk for shunt or current transducer. ±5Vdc isolated supply (at current channel potential) and ±12dc supply (at chassis potential) for external current transducer
- 1A Shunt
  1Arms, 5A pk precision measuring shunt with calibration stored in EPROM
- 30A shunt
  30Arms, 250Apk precision measuring shunt with calibration stored in EPROM
- Lead set
  2 pairs (yellow and black) 1.5m 2000V 32A leads with safety connectors and alligator clips
- Rack mounting kit
  For 19”, 3 ½ U high

2. QUICK START

2.1. GETTING STARTED

1. Check the power analyser is in good condition with the correct number of measurement channels and shunts fitted
2. Connect the power cable. Ensure the supply is Earth grounded.
3. Press the power switch at the rear to ON (I)
4. Press the front panel power switch

   The instrument will start its power up sequence. This takes approximately one minute

   Once completed the display should show columns for the measurement channels
5. The instrument is now ready for use

2.2. NAVIGATING THE MENU SYSTEM

The menu system provides complete access to all settings of the PM6000. The menu system may be accessed as follows:

1. By use of the 6 soft keys found to the right of the display
2. By using the short-cut keys on the front panel. These keys are grouped in a logical left to right sequence for setting up the instrument and provide fast access to the top-level menu items. Additional keys may be used to store your own short cuts to frequently used menu items, [MENU1], [MENU2] and [MENU3].

   Press the [HELP] key at any time to activate the in-built context sensitive help system.

For optimum ease of use the actions that the soft keys will take is adjusted to suit the measurement display or menu point shown on the display. The key action is described by a simple graphic symbol that is shown in alongside each key

In most situations pressing the [Menu] key is the quick way to exit the menu system

	Down Menu	View the details of the selected menu item.
	Up Menu	Go back up the menu system.
✓	**Accept**	Accept the choice or save the setting.
✗	**Cancel**	Cancel setting, exit without saving.
	Up	Move up or through the menu or measurements.
	Down	Move down through the measurements.
	Rotate	Display the next group or trigger.
	Left	Display the measurement column to the left.
	Right	Display the measurement column to the right.
?	**Help**	Switch the help display on or off.
DEL	**Delete**	Delete one character to the left of the cursor.
CLR	**Clear**	Clear the current alpha or numeric entry.
ESC	**Escape**	Escape from the menu without saving changes.
OK	**Save**	Save changes.

Rotary

The rotary knob is used to scroll up and down through measurements or menu items

2.3. MEASUREMENT DISPLAY

The display may be used to show numerical results, graphics, or both. (See the [GRAPH], [FORMAT] menu for details).

Numerical measurements are organized like a spreadsheet with the measurement channels (and groups of channels) in columns and the measured parameters (e.g. watts, volts, amps) in rows.

Channels →

Status	Group A CH1	Group B CH2	Group B CH3	Group B SUM
Vrms				
Arms				
W				
VA				
VAr				

Measurements ↓

To display further measurement columns, use the left and right keys ← →.

To display further measured parameters, use the up and down keys ↑, ↓.

When no further measurements are available, these keys are shown in gray.

To group channels together to display sum quantities see the [WIRING] menu description.

To hide numeric results columns, see the [FORMAT], [DISPLAY COLUMNS] menu

The Status area is used to show important status indicators such as an over-range (OVR) on a measurement input, or if [HOLD] has been pressed.

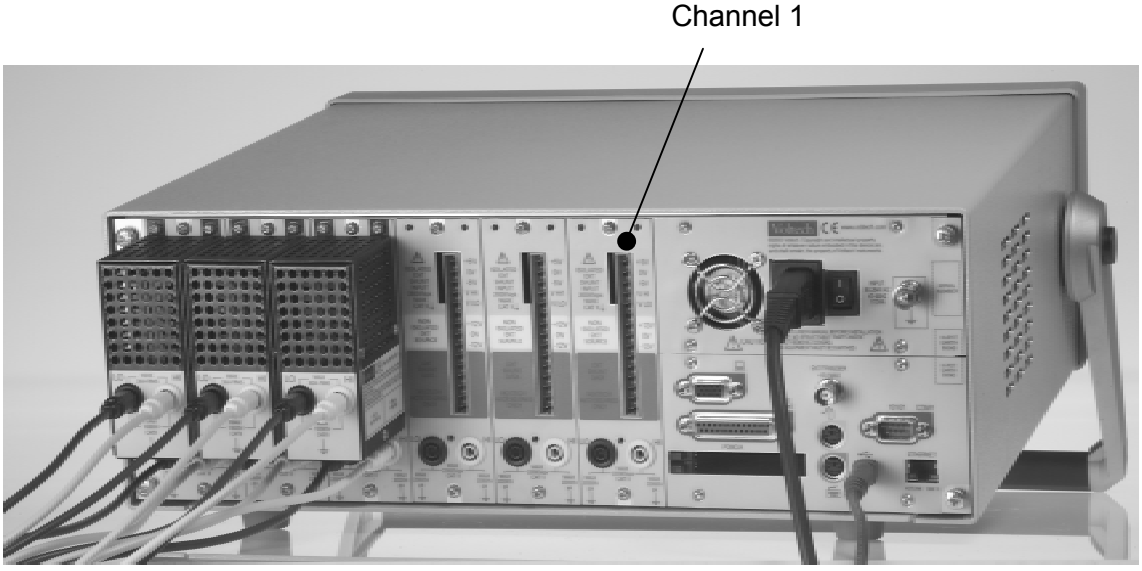
2.4. WIRING AND GROUPS

The analyzer uses the concept of groups of measurement channels for many of its functions. By default each channel is assigned to its own group, so Channel 1 is Group A, Channel 2 is Group B, and so on.

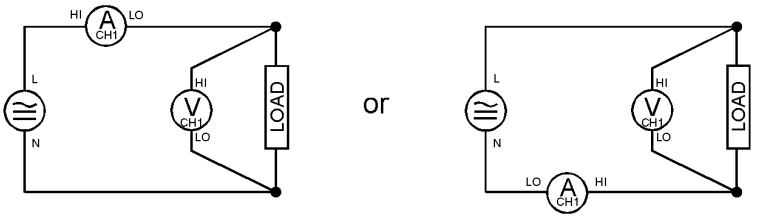
For multiphase measurements, a number of channels can be assigned to a group allowing precise frequency and phase analysis of the multiphase signals. The frequency of the first channel in the group is used as the fundamental frequency for all channels in the group, and all phase measurements are relative to the phase reference (Voltage by default) of the first channel in the group.

Channels are assigned to a group by selecting the required wiring configuration from the [WIRING] menu or by remote commands. The appropriate number of adjacent channels will be included in the group.

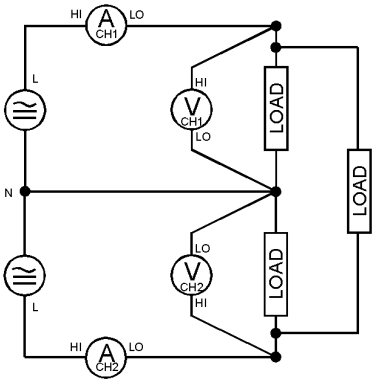
This should be done before connecting the test leads to avoid confusion when wiring up to the PM6000



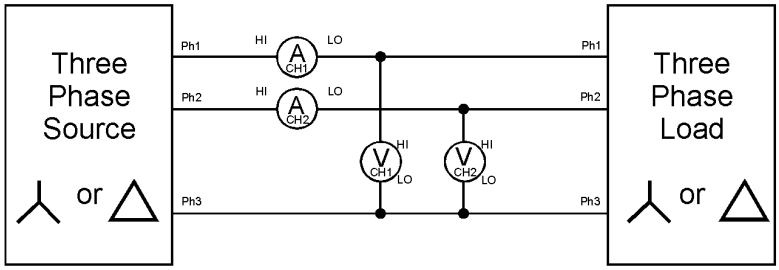
• Figure 1 Rear View of Instrument



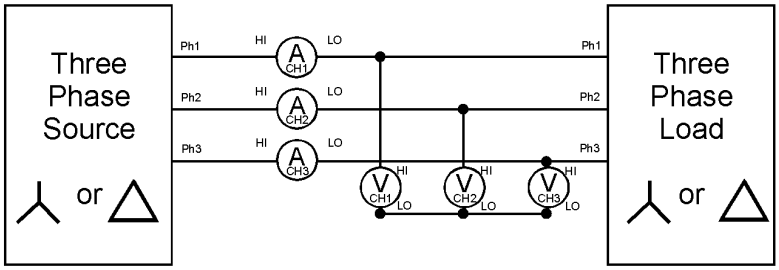
Single-phase, Two wire and DC measurements



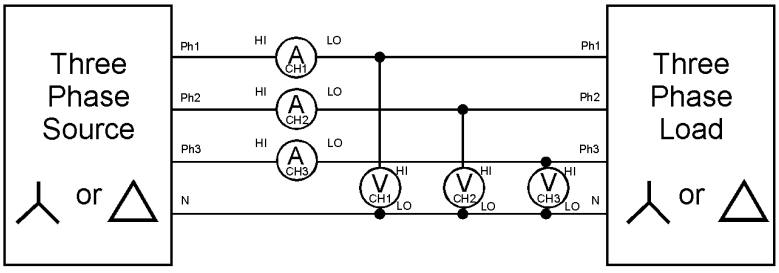
Single-phase, Three wire



Three-phase, Three wire (2 wattmeter method)



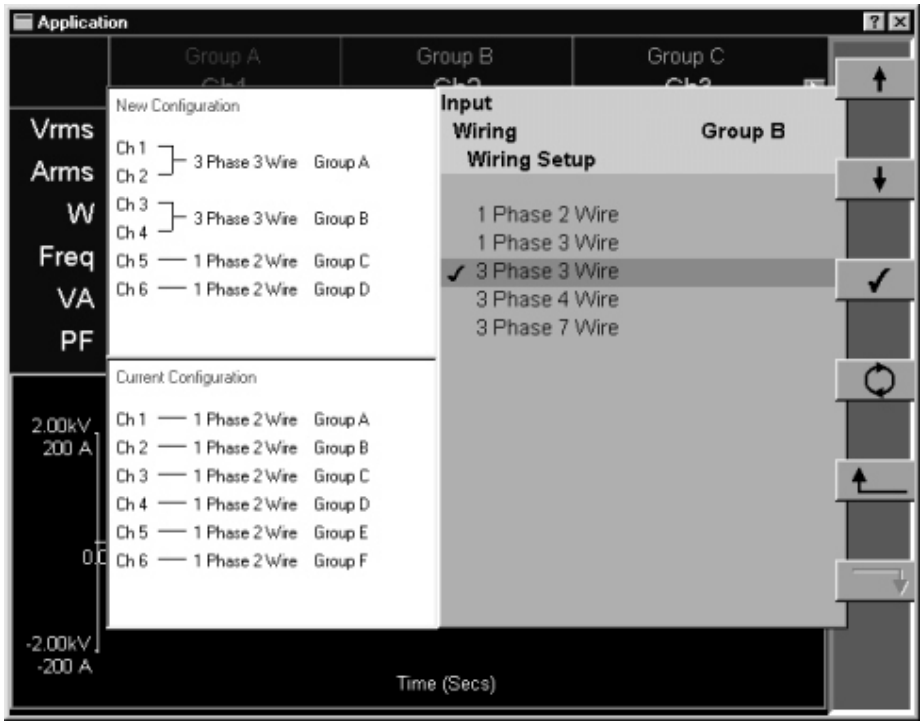
Three-phase, Three wire (3 wattmeter method - Set Analyzer to Three Phase, Four Wire mode)



Three-phase, Four wire (3 wattmeter method)

• Figure 2 Common Wiring Configurations

1. In the [WIRING] menu, choose how you wish to group measurements together, if required



   In this example, CH1 and CH2 have been grouped together to measure a 3-phase input, and CH3 and CH4 have been grouped together to simultaneously measure a 3-phase output

2. Choose and set up current and voltage transducers, as required and described below.
3. Then make the physical connections, taking care to observe health and safety regulations.

Each measurement channel has inputs for both voltage and current. The inputs are fully isolated from each other and from ground. The instrument chassis must be Earth grounded at all times

For a discussion of three-phase measurements, see Voltech application note 104-022 'Three-Phase Measurements'.

The three-phase 7-wire configuration may be used to measure total power on distribution systems with center-tapped three-phase transformers. The connection method is similar to the three-phase 4-wire 3-wattmeter method above, with all VLO terminals of the analyzer common and a VHI terminal taken to each of the 6 line wires

2.4.1 Voltage and Current Input Overview

Voltage

Voltages of up to 2000V peak may be connected directly to the black and yellow 4mm safety sockets at the bottom of the channel

Current

The measurement channel accepts a voltage of up to 2.5Vpk that is proportional to the current being measured. This input allows a very wide range of external current transducers to be connected, from low mA current shunts to MA current transformers. For each type of transducer, the PM6000 may be scaled to read the correct current. See the [SCALING] menu.

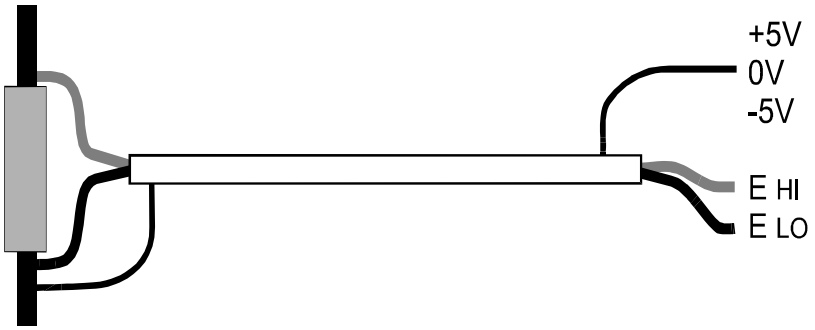
Any combination of Voltech shunts or other transducers can be used simultaneously on different channels of the PM6000

The choice of current transducer will depend on:

- The current being measured, including peaks and transients.
- The accuracy required.
- The bandwidth required: Unless the waveforms are purely sinusoidal, a bandwidth in excess of the fundamental frequency will be required.
- Whether there is DC current present.
- Convenience of connection – E.g. using a clamp-on current transformer, with jaws that open, for quick connection in a fixed wiring loom.
- The effect of the transducer on the circuit.

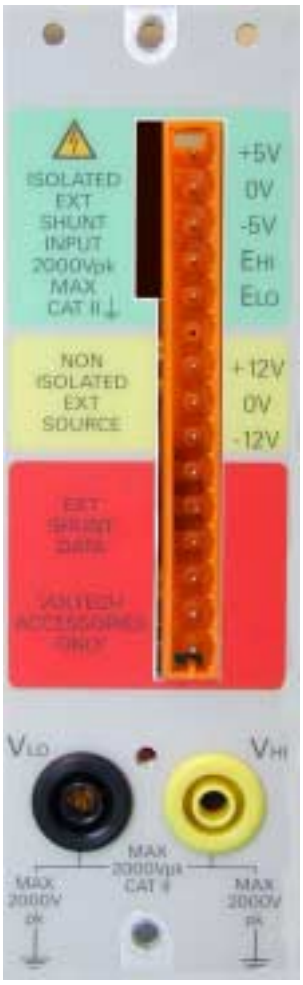
2.4.2 To connect an external resistive shunt:

1. Use the plug supplied to make the connections to the measurements channel connections
2. Use good quality shielded twisted pair cable to minimize pick-up



• Figure 3 External Resistive Shunt with Shielded Twisted Pair

3. For optimum rejection of common mode signals, the 0V guard terminal must be used. Connect this to the shield of the twisted pair cable, if available. If there is no shield, connect this directly to the ELO terminal



0V – Guard terminal
± 5V isolated supply at shunt potential

Voltage input 2.5V pk max.
For current transducers with a voltage output

± 12V @100mA external transducer supply.
NON ISOLATED 0V at Chassis ground

DO NOT USE Incorrect use will damage PM6000

Connections for Voltech accessories only

Voltage Input V_{HI}, V_{LO}

4. Enter the value in mΩ of the external shunt into the PM6000. See the [SCALING], [External Shunt mV/A] menu. E.G. For a 100mΩ shunt, enter the value 100

2.4.3 To connect a transducer with a voltage output

(E.g. Hall-effect current transformer)

1. Follow the manufacturer's instructions for the safe use and installation of the transducer.
2. Connect the voltage output to the EHI and ELO terminals of the PM6000 channel as above.
3. Connect the 0V guard terminal to 0V on the transducer if one is available. If not, connect the 0V guard to ELO along with the transducer. Use the 0V guard terminal as the 0V return for those transducers that require one.

2.4.4 To connect a transducer with a current output only

To use a conventional current transformer like the Voltech CL series, use a Voltech 1A shunt as described later, and use the [SCALING] [AMPS SCALING] function to enter the ratio of the current transformer

2.4.5 Voltech Shunts

For optimum performance, Voltech provides two resistive shunts which mount directly onto the measurement channels. These shunts include a precision resistive element designed with minimum inductance for maximum high frequency performance. The Voltech shunts:

- Connect directly to a measurement channel without any extra wiring.
- Have a very low effect on the circuit.
- Excellent high frequency performance.
- Automatically recognized by the PM6000 during power on and scaled appropriately.
- Calibration constants are stored within the shunt module and read automatically by the PM6000 for optimum traceable accuracy.
- 4mm safety connectors for direct connection to the circuit or current transducers with a current output (e.g. current transformers).
- Two models, 30Arms and 1Arms.

Voltech 30A shunt-

No fuse

Voltech 1A shunt –

Fused with a 2.5A HRC Anti-surge 20x5mm fuse

Use a 1A shunt for current transformers with up to 2.5A secondary current

2.5. SUMMARY

Having an appropriate choice of voltage and current transducers and a careful wiring arrangement, the PM6000 can now be set up via its menu system to make a wide variety of power related measurements. For a description of each of the menu options, see the next section.

3. MENU SYSTEM

3.1. NAVIGATION

The PM6000's menu is a powerful yet easy-to-use system for control of the analyzer. See the 'Quick Start' section of this manual for an overview of how to access and use the menu system. The soft-key actions are repeated here for convenience.

	**Down Menu**	View the details of the selected menu item.
	**Up Menu**	Go back up the menu system.
	**Accept**	Accept the choice or save the setting.
	**Cancel**	Cancel setting, exit without saving.
	**Up**	Move up or through the menu or measurements.
	**Down**	Move down through the measurements.
	**Rotate**	Display the next group or trigger
	Left	Display the measurement column to the left.
	Right	Display the measurement column to the right.
?	**Help**	Switch the help display on or off.
DEL	**Delete**	Delete one character to the left of the cursor.
CLR	**Clear**	Clear the current alpha or numeric entry.
ESC	**Escape**	Escape from the menu without saving changes.
OK	**Save**	Save changes.

For help at any time whilst using the product:

- Press the [?] soft key at the top level menu.
- Press the [HELP] key at any time

In most situations pressing the [Menu] key is the quick way to exit the menu system

3.2. MENU ITEMS

Pressing the [Menu] key on the front panel or the down menu soft key when measurements are displayed activates the menu.

To clear the display of any menu item, press the [Menu] key again or navigate up through the menu system using the menu up soft key.

The top-level menu items are the same as the groups of keys on the front panel. They are organized into groups of similar functions.

Input	**Setup**	**Display**	**System**	**Menus**
Wiring	Mode	Measurement	Config	Menu
Range	Integrator	Format	Interface	Help
Coupling	Datalog	Graph	Printing	User
Scaling			Data	Menu 1
Filter			Trigger	Menu 2
Frequency Source			Self Test	Menu 3

Other functions

HOLD

RESET / CLEAR

INTEG RUN

DATA DUMP

PRINT

This section describes these menu and submenu functions in order of the buttons in each group.

3.2.1 Wiring

This menu is used to configure the analyzer to reflect the way that the measurement channels are connected to the system under test. For example, three measurement channels may be connected to a three-phase system. Grouping the channels together in this menu simplifies the setup of sum calculations and other settings that can then be applied to the group as a whole.

Wiring Setup

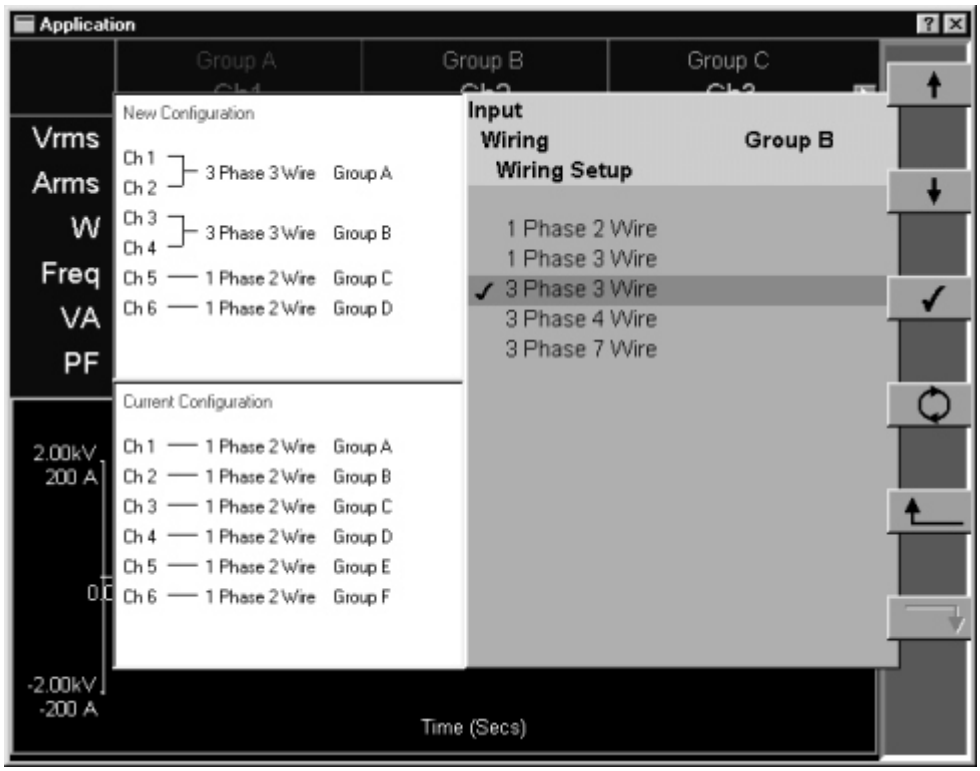
Default: **All 1 Phase 2 Wire**

By configuring the wiring of the analyzer, adjacent measurement channels are grouped together.

To group channels together, start with the first group (GroupA), select the wiring setup required (up / down arrow keys).

Move to the next group using the group rotate key and repeat as required.

The example below shows CH1 and CH2 grouped together for a three-phase, three-wire connection and CH3 and CH4 grouped for a similar connection.



The new configuration is saved upon exiting this menu.

For further information, see our website for technical notes on wiring configurations - 'Three-Phase Measurements' or call your local supplier.

Group Name

Default: **Group A, Group B, etc**

Change the name of the group. The group name may be up to 19 characters long. Permitted characters are those available on the keyboard of the PM6000. The name will be displayed above the grouped channels on the instrument display.

Press OK to save; press ESC to exit without changing the group name.

3.2.2 Range

These settings are applied to groups of measurement channels. Use the group rotate key to set up the next group.

The ranges are identified by the peak signal that can be measured. For example, if the volts range is 200V then signals with a peak of ± 200V can be measured.

Voltech Shunts will be scaled on instrument power up. For other shunts the relevant scaling should be applied using the External Shunt Scaling menu (see 3.2.4)

Range Number	Volts Peak Full Scale	Amps Peak Full Scale		
		No Shunt	Voltech 1A Shunt	Voltech 30A Shunt
1	5	5mV	10mA	500mA
2	10	10mV	20mA	1A
3	20	25mV	50mA	2.5A
4	50	50mV	100mA	5A
5	100	100mV	200mA	10A
6	200	250mV	500mA	25A
7	500	500mV	1A	50A
8	1000	1V	2A	100A
9	2000	2.5V	5A	250A

• Table 1 Volts and Amps Ranges

Volts Range

Amps Range

Default: **Auto**

To adjust the range, select as required from the available displayed ranges and then accept the choice.

Auto allows the instrument to continuously determine the best range to use

Auto Up Only may be used to ensure that the analyzer automatically ranges upwards, but never downwards. This setting may be used in pulsed applications to avoid measurement delays caused by the time taken to auto range upwards during the pulse.

Display Volts Range

The voltage range will be displayed as a measurement item when this is selected.

Display Amps Range

The current range will be displayed as a measurement item when this is selected.

3.2.3 Coupling

Default: **AC+DC**

In **AC+DC** mode, the PM6000 includes DC signals in its analysis.

Select '**AC**' to measure AC signals only. This is useful when attempting to measure the ac characteristics of a signal that are superimposed on a high level of dc. For example, to measure the ac ripple on a dc bus, select '**AC**' only.

In either coupling mode, the analyzer will accept peak voltage or current up to its normal rating. It is therefore safe and accurate to measure small amounts of ac ripple when connected to a 350V dc bus with '**AC**' coupling selected.

3.2.4 Scaling

Scaling is used to adjust the scaled output of transducers such a current transformers such that the true measured current is displayed on the PM6000.

Maximum scale factor: 100 000

Minimum scale factor: 0.000 01

Amps Scaling

Default: 1

Enter the scale factor of the transducer being used. For example, the Voltech CL1000 produces 1 amp for every 1000 amps flowing in the opening of the CL. It is a 1000:1 current transformer. Enter the scale factor 1000 and the PM6000 will display the correct current.

Scale factor = Transducer Input Current / Transducer Output Current

Volts Scaling

Default: 1

Enter the scale factor of the transducer. E.g. a 100:1 voltage transformer is used to measure 15kV. The output of the transformer is 15000 / 100 = 150V. Enter the scale factor 100, and the PM6000 will display 15,000 V

External Shunt Scaling mV/A

Default: **12.5 or value for detected Voltech Shunt**

External shunt scaling is automatic when Voltech current shunts are used. Shunt types are detected during power up of the analyzer.

This scaling is applied to the current measurement channel voltage inputs. This is used for current transducers that have a voltage output. These include Hall-effect transducers as well as simple resistive shunts.

Enter the scaling of the chosen transducer. For example a clamp-on Hall-effect current transducer measures up to 100A. It has a voltage output of 10mV per amp. Enter '10' and the PM6000 will display the correct system current.

3.2.5 Filter

Default: **2MHz**

This is the filter applied to all measurements for the group. It defines the measurement bandwidth. Different filter settings may be applied to different groups.

The default setting of 2MHz is suitable for most general applications. The PM6000 always maintains a sample rate sufficient to avoid aliasing problems at any filter setting.

A range of filters are provided to allow the user to optimize the measurement performance. The nominal filter frequency corresponds to the -3dB frequency so allow sufficient bandwidth to include all harmonics of relevance to the measurements with some margin. As a guideline select a filter of ten times the highest frequency of interest.

Selecting a lower frequency filter will help reduce noise on some measurements or may be useful to eliminate unwanted higher frequency components of low frequency signals.

For settings of 2MHz and below, the signal is analyzed continuously; ensuring no characteristic of the signal is missed.

The 10MHz filter puts the instrument into a 40MSPS burst mode, allowing analysis of signal components up to 10MHz. This mode is only suitable for signals with a fundamental frequency greater than 10 kHz.

Experiment with filter settings to find the most appropriate for each application

3.2.6 Frequency Source

Source

Default: **Volts**

Many measurements (including rms volts, amps and watts), are based on calculations that are dependant on the correct fundamental frequency being determined by the analyzer.

The PM6000 uses proprietary techniques to determine frequency that eliminate the problems created by noise when simple zero-crossing techniques are used.

It is therefore not normally necessary to adjust the settings from the default of voltage.

Volts is the default frequency source and is suitable for most applications.

Amps may be selected if the voltage waveform is heavily distorted, but the current is not. The waveforms at the output of a PWM motor drive are an example of this.

External sets the external input at the back of the PM6000 as the frequency source. Choose this option if the frequency cannot be detected from volts or amps but is available elsewhere. Apply a TTL compatible square wave to the external input at the required frequency.

Fixed Frequency Enter a frequency and this will be used as the fundamental frequency for measurements.

Phase Reference

Default: **Volts**

This is the zero reference for phase angle measurements in each group.

Volts Phase is calculated with respect to the voltage signal on the first channel in the group

Amps Phase is calculated with respect to the current signal on the first channel in the group

Low Frequency

Default: **OFF**

Tick this option if the fundamental frequency is expected to be below 5Hz.

Enter sub menu to specify the frequency

1 - 5Hz - The analyzer will update once per second and a half

< 1Hz - The analyzer will update once every 16 seconds, allowing measurements down to 0.1Hz.

3.2.7 Mode

Default: **Normal**

This menu contains the special application modes of the PM6000. When selected, the analyzer will be automatically set to use the optimum measurement techniques for the waveforms under test

Normal

This is the default operating mode of the analyzer and is ideal for making measurements in most applications.

PWM Output

This mode should be used to analyze the output of electronic motor drives. The output waveform of a PWM drive is a complex mixture of high and low frequency components that can be difficult to accurately assess. In this mode, the data is sampled at high speed but aligned with and over an integral number of cycles of the low frequency motor frequency. The graph display will attempt to display the modulated waveform for both voltage and current when in the 2MHz filter setting. Changing the filter setting may cause unpredictable graphing, but all measurements will continue to operate correctly.

See the Voltech Technical Note 86-165 for a more detailed discussion of the application

Minimum Fundamental Frequency

Default: **5Hz**

Set this to allow for the lowest expected fundamental frequency. The instrument will set the analysis time so that the lowest frequency can be detected. The results update rate will be correspondingly affected.

0.1 Hz

1 Hz

5Hz

HF Ballast (AM)

This mode is ideal for making accurate measurements on AM (amplitude modulated) power signals. The waveforms are found at the output of electronic lighting ballasts, ultrasonic supplies for cleaning and medical imaging and radio frequency cutting equipment.

The PM6000 sets the sample time to be an integral number of cycles of the modulation frequency to ensure accurate results. This frequency can be determined from a number of sources that the user configures as described below

For more information, see Voltech Application Note 101, part number 98-030

Freq source

Default: **50/60Hz**

This setup parameter allows the user to control how the instrument determines the modulation frequency. This is important for AM signals as the PM6000 will adjust the analysis period to an integer number of complete cycles to ensure accurate results

From Channel

The modulation frequency can be taken from the detected frequency of another channel. This channel must be in Normal mode. Available channels are shown in the selection menu. If the selected channel is unable to detect a valid frequency then the Ballast mode results will show invalid results

50/60Hz

When selected the analysis period is set to 300ms ensuring an integer number of cycles for both 50Hz and 60Hz modulation

Fixed Frequency

If known, the modulation frequency can be entered directly

3.2.8 Integrator

Default: **OFF**

The integrator is used to determine the characteristics of an electrical system over time. For example, a washing machine consumes different amounts of power at different times. The energy rating over an operating cycle can be determined using the integrator.

The PM6000 provides a highly flexible integration system that allows multiple integrations to be configured and run independently.

Enabling the integrator will display rows for the integration parameters and show results for each channel in the integrated group

Integration Parameter	**Row Title**
RMS Ampere hours	Ahr
RMS Watt hours	Whr
RMS VA hours	VAhr
RMS Reactive VA hours	VArh
Average RMS power	Wav
Average power factor	PFav
Integration time in hours:min:sec	Tint

• Table 2 Integration Parameters

The integration time is the accumulation of the measurement time and is the time over which the integration and average parameters are calculated

Integration is enabled on a group basis, but is calculated for each channel in the group. Where a group has SUM parameters enabled the integration results will be also be displayed for the summed results

The integration is controlled by either the trigger configuration of keys and system time or by remote commands

Integrate

Default: **OFF**

Select to enable the integrator for the group

Trigger

Default: **Trigger T2**

Each group must be assigned a trigger to determine the start, stop and reset events. Multiple groups can be assigned the same trigger to synchronize events.

For the integrator function the trigger events have the following effect

START Start or resume the integration

STOP Stop the integration

RESET Clear the integration parameters to zero

See also the Trigger menu (3.2.17)

3.2.9 Datalog

No function at present

3.2.10 Measurement

Select the parameters to display.

Use the up / down arrow soft-keys to highlight the choice and enable or disable the measurement using the key.

Note that to remove a parameter row from the display, the parameter must be disabled in all groups

For most parameters simply enable the parameter in the list. However some parameters require further explanation or configuration and these are covered below

Sum

Default: **OFF**

Display sum quantities for the group of channels. This is only available for groups with multiple channels. An additional column is displayed to the right of the group showing the calculated multiphase sum results for relevant parameters

Harmonics

To display the harmonic components of volts, amps or watts use this menu

Watts Harmonics

The magnitude of the Watts harmonics selected are displayed in new rows for the selected group

Min

Default: **1**

The lowest harmonic to display

Max

Default: **7**

The highest harmonic to display

ODD

ODD and EVEN

Default: **ODD and EVEN**

Determines which harmonics are calculated

Volts Harmonics

The magnitude and phase of the Volts harmonics selected are displayed in new rows for the selected group. The second and higher harmonic magnitudes are usually displayed as a percentage of the first harmonic. Phase angles are referenced to the group phase reference

The sub menu is as for **Watts Harmonics**

Amps Harmonics

As **Volts Harmonics**

Phase

Default: **0 to 360**

Choose the convention used to display the phase angle. Phase angles may be displayed as 0 to 360 degrees or -180 to 180 degrees

Volts THD

THD or Total Harmonic Distortion is a measure of the distortion of a waveform.

Several different formulae may be used to calculate THD

$$thd = \frac{\sqrt{\left(rms^2 - H_1^{\,2}\right)}}{H_1} \text{ x } 100\%$$

- Figure 4 THD Difference formula using the fundamental as reference

$$thd = \frac{\sqrt{H_2^{\,2} + H_3^{\,2} + H_4^{\,2} + \ldots H_n^{\,2}}}{H_1} \text{ x } 100\%$$

- Figure 5 THD Series formula using the fundamental as reference

The resultant value is very different between formulae so ensure the configuration matches the required equation

Reference

Default: **Fundamental**

The reference (denominator) may be the RMS value or the fundamental (1st harmonic) value

Formula

Default: **Difference**

The numerator can be calculated in two ways; the difference formula includes the effects of high frequency and noise, the series formula will

produce more accurate results for harmonic noise when the THD is less than 5%.

Note that when selecting the series formula, it is important to set the MAX HARMONICS setting to an appropriate number, to get valid results. The higher the harmonic count the more accurate the calculation

Amps THD

See **Volts THD** above

MAX / MIN Hold

Select MAX Hold and / or MIN Hold as required. The maximum and / or minimum measurement is displayed in a new column adjacent to the relevant results column. Any averaging is applied to the channel results prior to comparing with the MIN/MAX Hold values, so the Averaging Depth should be considered when configuring a measurement. To detect fast or transient values set the averaging depth to 1.

The [RESET / CLEAR] key is pressed to reset the held measurements.

For harmonic results the MIN/MAX result is determined by the magnitude component of the complex harmonic result. The reported MIN/MAX angle is the angle of the complex harmonic result that set the MIN/MAX magnitude, and as such it will not necessarily be the MIN/MAX angle.

For example, to measure the inrush current (the current drawn at switch-on) of a power supply

- Select Apk, MIN HOLD and MAX HOLD from the measurement list
- Then, in the [RANGE] menu, select ‘Auto Up Only’
- Set the averaging to 1. (See the [Format] > [Averaging] menu below).
- Now switch on the supply to the load and the peak inrush current will be displayed
- Repeat the measurement to capture the worst case current, since the peak current will vary with the point in the voltage cycle at which the supply is connected

See also

- Voltech PS1000 Inrush Switch data sheet. (This accessory greatly simplifies inrush testing).

3.2.11 Format

This menu is used to set the general display features

Zoom

Zoom may be 1, 2 or 3 columns. Zoom 1 displays one column only. The display fonts are scaled automatically. 1 = largest font.

Averaging

This menu configures how the instrument averages results. Results are returned from the measurement channels typically every 300ms unless in a low frequency mode. For an averaging depth of 16, it will take approximately 5 seconds to report a fully averaged result. Increasing the averaging depth will reduce noise on the result, at the cost of time.

Auto

Default: ON

Auto averaging means that the analyzer will automatically reset the averaging queue if a significant change of signal is detected. This produces the fastest response to changes for measurements of the steady state value

Fixed

Default: OFF

The fixed mode stops the averaging queue from being automatically reset. Use this to average a signal that will significantly change.

Depth

Default: **16**

The averaging depth is the number of readings used to return the displayed result. It may be set to any value from 1 to 64.

Display Columns

This menu may be used to enable and disable the display of columns. This is most useful when for example, it is important to view sum columns side by side. This setting is also used to determine the printed columns (see Print section 3.2.27)

Math

This menu provides access to the powerful formula editor of the PM6000. Any combination of parameters may be used and manipulated to provide a new measurement. An example of this the calculation of efficiency based on different watts measurements. The new math measurements are shown in a new 'math' column on the display

To enter and display a math measurement, choose a function (e.g. Math Fn1) and then "Edit"

Up to 255 characters may be entered. Those characters may be numeric, operators, or measurements that are currently available on the display.

Numeric characters are the numbers 0 to 9 plus the decimal point with up to 6 significant figures

Operators available from the front panel keyboard are:

+ - x / ( ) [ ]

X^2 {shown as ^2 and will square the preceding number}

10^x {shown as x10^ and will multiply the preceding number by 10 to the power of the following number)

X^y {shown as ^ and will take the preceding number to the power of the following number}

E^x {shown as *e^ and will multiply the preceding number by e to the power of the following number)

√ {shown as SQRT() and will take the square root of the number between the brackets}

Operators that may be typed:

SIN(), COS(), TAN() {which take an angle in degrees which is between the brackets and return its sine, cosine or tangent)

ASIN(), ACOS() {which take a number between -1 and 1 which is between the brackets and return an angle in degrees}

ATAN() {which takes a number which is between the brackets and return an angle in degrees}

ATAN2(_) {which takes a pair of coordinates that are between the brackets and separated by the underscore and returns an angle in degrees between -180 and +180}

LN(), LOG10() {which returns the logarithm of the number between the brackets. LN is log to the base e, LOG10 is log to the base 10}

PI() (3.14159)

Parameters must be in the form:

GrpA:CH1:Mmnt {where 'Mmnt' is the measurement mnemonic shown on the left of the display}

The formula will be checked for validity only when OK is selected. If there is an error, this will be shown in red.

If the math result is invalid (e.g. infinity because of a divide by zero) the display will show 4 red dashes.

Blanking

Default: **ON**

When blanking is enabled the analyzer displays '0' when the measurement is less than 5% of range. When disabled results will be displayed down to the displayed resolution, which may be measurement noise

Grid

Default: **ON**

Toggles the display of the grid for measurements

Harmonic Results as Percent

Default: **ON**

When enabled magnitude results for all harmonics other than the fundamental will be displayed as a percentage of the fundamental.

When disabled each harmonic magnitude will be displayed in the normal units of V, A or W

3.2.12 Graph

This menu is used to control the display of waveforms and other graphics.

View

Default: **Split**

The view of the graph may be split screen (half screen), full screen or none

Format

Waveform

Items

Default: **CH1:V and CH1:A**

Choose the items to display as a waveform.

The graph timebase will be determined from the first item displayed

Up to 6 may be shown at one time.

3.2.13 Config

Reset Default

Returns the PM6000 to default settings

View Settings

Displays the current settings of the PM6000

View Hardware

Displays the type, serial numbers and calibration status of the PM6000's hardware

Config Clock

Set the date and time for the PM6000's internal clock that is displayed in the bottom right corner of the screen.

When prompted to enter dates or times, the keypad will be put into character mode to allow entry of letters and numbers.

Note that to avoid confusion of date format, the month should be entered as the first three letters of the month. E.G. AUG for August.

A colon ':' is used between time and date elements, and this is on the [PRINT] key beside the [SHIFT] key.

Date format: dd:mmm:yy

Time format: hh:mm (24h clock)

Config Zero

This menu may be used to cancel the effects of small amounts of DC offset in the measuring circuits

Auto Zero

Default: **ON**

The PM6000 will automatically measure internal zero offsets and cancel them. This process is repeated automatically every minute to ensure the best possible measuring performance. It will however cause a short pause in measurements whilst the zeroing process is performed. If this interruption causes a problem, select OFF for the duration of the measurement.

Config Beeper

The internal beeper of the PM6000 may be used to emphasize important key actions and warnings. If operator safety or damage to the analyzer is possible, the ON / OF setting of the beeper is ignore

On/Off

Default: **ON**

Switch the beeper on or off

Volume

Default: **3**

Adjust the beeper volume. 1= Min. 4 = Max.

3.2.14 Interface

This menu is used to configure the control interfaces of the PM6000

Serial

RS232

The RS232 port is a standard PC type 9 way male D-type located on the rear of the instrument and may be used for remote control of the PM6000

The RS232 port uses 8bit, no parity, one stop bit and hardware flow control

Baud Rate

Default: **9600**

The baud rate must be matched to the host controller baud rate. This setting is NOT affected by an instrument reset. However, the firmware upgrade may return this to the default

Options

Echo

Default: **OFF**

This setting determines if the PM6000 should echo all received characters back to the host

USB

Parameters for the USB port have not yet been defined. See www.voltech.com for the latest information.

Ethernet

The PM6000 may be connected to a network for remote control and data transfer. This option will be available soon. At present, this is for service or upgrade use only

Set IP using DHCP

Default: **ON**

If the PM6000 is connected to a network with a DHCP server, then the PM6000 can determine its settings automatically. It does this during the power up sequence or when this menu item is selected. If no IP address is shown in the View Settings dialog then repeat the selection of Set IP using DHCP to repeat the attempt to get network settings.

Fix IP Address

If unable to configure the network settings by DHCP, then these menus provide a way to enter an IP address, Subnet Mask and Default Gateway address. Contact your network administrator for the appropriate settings

View Settings

Displays the network settings

Parallel

This is a standard Centronics interface dedicated to printing and has no user configuration.

PCMCIA

This interface is for future development

3.2.15 Printing

There are currently no user specified parameters for printing. See the [Print] key

3.2.16 Data

This is for future development

3.2.17 Trigger

Six trigger configurations (T1 to T6) are available which may be set up in separate ways such that different events trigger different actions. Trigger events may be front panel keys, time based or remote controlled.

This menu is used to configure triggers. Use the 'cycle' soft key to select the trigger to configure. To associate a trigger with a particular function, select the trigger in the relevant function menu.

The default trigger configurations will be suitable for most measurements. For example the Trigger T2 is primarily for use with the Integrator function and is defined as follows:-

Trigger T2

Start – [Integ Run]

Stop – [Integ Run]

Pause – [Hold] (Not used by the Integrator function)

Reset – [Reset / Clear]

Trigger T1 to T6

Each trigger action may be allocated to an event, such as a key press or time.

To set up the trigger T1 to T6, first select the action (e.g. start or stop) that you want the trigger to perform, and then allocate the event (e.g. key press) that will cause the trigger to act

Trigger actions are

Start

Stop

Pause

Reset

Timed

Key press events that can be allocated are:

[Data Dump]

[Integ Run]

[Print]

[Enter]

[Reset / Clear]

[Hold]

Trigger T1 to T6 Timed

The triggers can be set up to start and stop at a particular date and time, and to trigger at a particular interval. When prompted to enter dates or times, the keypad will be put into character mode to allow entry of letters and numbers.

Note that to avoid confusion of date format, the month should be entered as the first three letters of the month. E.g. AUG for August.

A colon ':' is used between time and date elements, and this is on the [PRINT] key beside the [SHIFT] key. Interval time can be entered in several formats and will be converted to a decimal number of hours

Date format: dd:mmm:yy

Time format: hh:mm (24h clock)

Interval format: hh:mm:ss or decimal hours

3.2.18 Self Test

It is not normally necessary for the user to perform any self tests on the PM6000. However, you may be asked to perform some of them in response to an applications or service enquiry. Several of the tests require specific external equipment and so tests should not be attempted unless instructed to do so. However none of the self tests will damage or adversely affect the instrument.

Instructions for carrying out each test are displayed whenever that test is selected.

Should any of the tests fail, please ensure that the instructions displayed have been carried out carefully before contacting your supplier for advice.

3.2.19 Menu

If no menu displayed, then the [MENU] key displays the top level menu providing an alternative access to all the menu items in this section.

The [MENU] key also acts as a way to remove the menus from the display

3.2.20 Help

This is the home page of the help system.

To switch the display of help ON or OFF, press the [HELP] key

3.2.21 User

This is for future development

3.2.22 Menu 1, 2, 3

The [Menu 1], [Menu 2] and [Menu 3] keys may be used to store and recall your own menu short cuts.

If there is a particular menu that you wish to return to frequently, navigate to that menu and then press and hold the Menu 1, 2, or 3 key for more than 1 second.

Next time that you press the Menu 1, 2, or 3 key for less than 1 second you will be taken directly to the stored menu short cut.

3.2.23 HOLD

This programmable key may be used to initiate a trigger. (See the trigger overview)

Press this key to freeze the display. This is useful when you wish to examine different measurements that were taken at exactly the same time. When the [HOLD] key is pressed ‘HOLD’ is displayed in the top right corner of the screen, all measurements are frozen and the screen can be scrolled to view all the measurements that were taken at the time the [HOLD] key was pressed.

Press the [HOLD] key again to update the display

3.2.24 RESET / CLEAR

This programmable key may be used to initiate a trigger. (See the trigger overview)

By default, [RESET / CLEAR] will clear stored MAX / MIN values and integrator measurements.

This key will always cause the measurement sample to be restarted. This can be useful when making low frequency (<10Hz) measurements with long sample times.

There can be a short delay of several seconds whilst the instrument functions are restarted

3.2.25 INTEG RUN

This programmable key may be used to initiate a trigger. (See the trigger overview)

By default, the [INTEG RUN] key is used to start and stop the integrator.

3.2.26 DATA DUMP

This programmable key may be used to initiate a trigger. (See the trigger overview)

3.2.27 PRINT

This programmable key may be used to initiate a trigger. (See the trigger overview)

By default, the [PRINT] key is used to start printing. When pressed, the LED will briefly flash as the data is formatted and sent to the printer driver for printing.

The PM6000 supports ASCII/ MSDOS compatible printers connected to the parallel port using a standard PC Parallel printer cable. The printout is formatted for 80-character page width, and so a printer with at least 80 character width will produce best results

Results for all currently enabled parameters and channels will be printed, along with instrument information, time and date. Columns can be disabled or enabled for printing using the Display Columns menu (see Format section 3.2.11)

4. REMOTE OPERATION

4.1. OVERVIEW

Using the remote commands the PM6000 can be used to perform high speed, complex or repetitive measurements. Many of the PM3000 commands are supported although the increased flexibility of the 6-channel PM6000 design brings the new concept of multiple groups of channels.

Many of the functions apply to the currently selected group of channels. By default, each measurement card is grouped individually. Read the section on Wiring for further discussion on groups

4.2. INTERFACING WITH GPIB SYSTEMS

The PM6000 remote commands are compatible with IEEE488.2. However a hardware GPIB interface is not provided. Commercially available GPIB to RS232 converters can be used to provide connection to GPIB control systems. One example is the National Instruments GPIB-232CV-A that has been reliably used with the PM6000 at 38400 baud. Refer to the National Instruments documentation for more details

4.3. REMOTE COMMAND SYNTAX AND CONVENTIONS

The following conventions are used for command syntax

- Square brackets indicate optional parameters or keywords [ ]
- Triangle brackets indicate values to be specified < >
- Vertical bar indicates the choice of parameters |

Commands and responses are sent as ASCII strings terminated with a line feed. The PM6000 is not case sensitive and white space characters are ignored except where required between command and parameter.

Multiple commands can be sent in a single string where a ‘;’ character is used at the end of each command.

The PM6000 will respond to invalid commands by adding an error message to the error queue. It is recommended that the error queue is checked after issuing command sequences by using the SYST:ERROR queries to ensure successful configuration

4.4. STATUS REPORTING

The PM3000 had four status bytes used to determine the overall status of the instrument. These have also been included in the PM6000, although the background status register and display data status register are effectively the same because in the PM6000 there are not separate averaging buffers for both remote commands and the display.

4.4.1 Status Byte Register

This register is read using the "*STB?" command. A value is returned representing a bit pattern. Each bit represents a condition

Bit	Condition	Description
0	DAS	Summary bit for data status
1	BAS	Summary bit for data status. This condition is exactly the same as DAS on the PM6000, but is preserved for backwards compatibility
2		
3		
4	MAV	Always 0 for RS232
5	ESB	Summary bit for data status.
6	MSS	Master summary status, set if any of the other bytes in the register have been set and their corresponding bit in the service request enable register is also set.
7		

4.4.2 Background and Display Status Register

In the PM3000 these were separate status registers. In the PM6000 the same register is used. Both the ":BSR?" and ":DSR?" commands read from this register.

Bit	Condition	Description
0	DVL	Set when data is available
1	NDV	Set when data is available
2	AVF	Set to when the averaging buffer is full to the specified depth
3	OVA	Set when a current over range has occurred
4	OVV	Set when a voltage over range has occurred
5		
6		
7		

4.4.3 Standard Event Status Register

This register is read using the "ESR?" command.

Bit	Condition	Description
0	OPC	Set after a *OPC command has been received, once all messages sent have been processed.
1		
2	QRE	Unterminated query error.
3		
4	EXE	Execution error. A command parameter was invalid or out of range
5	CME	Command error. The command was not recognized.
6		
7		

4.5. IEEE488.2 COMMON COMMANDS

4.5.1 *CLS Clear event status

Format: *CLS

Return format: None

Description: Clears the standard event status register to 0

4.5.2 *ESE Set standard event status enable register

Format: *ESE <*flags*>

flags = value for enable register as a decimal 0 – 255

Return format: None

Description: Sets the bits that are enabled in the standard event status register. The status enable register uses the same bit definitions as the standard event status register

4.5.3 *ESE? Read standard event status enable register

Format: *ESE?

Return format: 0 - 255

Description: Returns the value in the standard event status enable register

4.5.4 *ESR? Read event status register

Format: *ESR?

Return format: 0 - 255

Description: Returns the value in the standard event status register, ANDed with the value in the standard event status enable register. The event status register is cleared once it has been read

4.5.5 *IDN? Unit Identity

Format: `*IDN?`

Return format: VOLTECH, PM6000, *Serial Number*, *Firmware Version*

Description: The serial number returned is the chassis unit serial number

4.5.6 *OPC Initialize Operation Complete Function

Format: `*OPC`

Return format: None

Description: Enables OPC bit to be reported in the standard event status register

4.5.7 *OPC? Flag when Operation Complete

Format: `*OPC?`

Return format: 1

Description: Returns once the OPC bit is set in the standard event status register, indicating that the PM6000 has finished processing commands

4.5.8 *RST Reset Device

Format: `*RST`

Return format: None

Description: Resets the unit configuration to default values (performs the same action as Reset Defaults menu option on the front panel)

4.5.9 *SRE Set Service Request Enable Register

Format: `*SRE <flags>`

`flags = value for enable register as a decimal 0 – 255.`

Return format: None

Description: Sets the bits that are enabled in the status byte register. The service request enable register uses the same bit definitions as the status byte register with the exception of the MSS bit.

4.5.10 *SRE? Read Service Request Enable Register

Format: `*SRE?`

Return format: 0 – 255

Description: Returns the value in the service request enable register.

4.5.11 *STB? Read Status Byte

Format: `*STB?`

Return format: 0 - 255

Description: Returns the value in the status byte, masked by the service request enable register. Once read, the status byte is cleared to 0.

4.5.12 *TRG Trigger

Format: `*TRG`

Return format: None

Description: Used to trigger a measurement when in single measurement mode.

4.5.13 *TST? Report Self Test

Format: `*TST?`

Return format: None

Description: Always returns 0 for the PM6000.

4.5.14 *WAI Wait for Operation

Format: `*WAI`

Return format: None

Description: Waits for the operation complete bit in the standard event status register to be set.

4.6. FORMAT COMMANDS

4.6.1 :AVG Set Averaging

Format: `:AVG:FIX <depth>`

`:AVG:AUT <depth>`

`:FIX – set fixed averaging`

`:AVG – set auto averaging`

`depth – averaging buffer depth (integer between 1 – 64)`

Return format: None

Description: Sets up the averaging buffer for the measurements made by the PM6000. The sample period is approximately a third of a second so for an averaging buffer depth of 16, the buffer will fill in around five seconds. When in 'auto' mode, the buffer will be cleared if a significant change in value is detected. This has the effect of minimizing the drift between values. It will however affect the use of the Average Buffer Full status bit, as this will only be set when the buffer has valid values to its full depth. If this status bit is being polled, it is recommended to use fixed averaging mode.

The averaging buffer can be cleared using the RAV command

When the averaging buffer is full, bit 2 of the display status register becomes true

4.6.2 :BAL AM/Ballast Mode

Format: `:BAL:ENB`
`:BAL:DIS`

Return format: None

Description: Enable AM/Ballast mode for the currently selected group. When this mode is enabled, the filter is automatically set to 2MHz, and set for 50/60Hz modulation

Format: `:BAL:50H`
`:BAL:60H`

Return format: None

Description: Configure the mode for 50/60Hz modulation

Format: `:BAL:FIX <freq>`
`Where <freq> is 5.0 to 10000 Hz`

Return format: None

Description: Set to a fixed modulation frequency. The frequency is a decimal frequency

Format: `:BAL:SRC <ch>`
`Where <ch> is 1 to 6`

Return format: None

Description: Set to use the detected frequency from the specified channel. The specified channel must be in normal mode

Format: `:BAL:?`

Return format: 5060Hz or FIX,<freq> or SRC,<ch>

Description: Returns the Ballast frequency source of the currently selected group. Only responds if Ballast mode enabled

4.6.3 :BRD? Read Background Data

Format: `:BRD?`

`:BRD:CH<ch>?`

`:BRD:SUM?`

Return format: A number of floating point values depending upon selection. Up to 8 values on each line.

Description: The BRD command actually reads from the same results buffer as the FRD command. It differs from FRD in that BRD returns all the enabled harmonic results, whereas FRD returns results only for the currently selected harmonic (see :HRM command)

If no secondary command is sent, results for all channels are returned.

The results to be returned are selected using the :SEL command.

Once results are available, they are returned in floating point format with up to 8 values on each line. Results are returned in the following order. If the result has not been selected, it will just be skipped.

Watts, VA, VAr, Vrms, Arms, PF, Vpeak, Apeak, Vcf, Acf, Imp, Vthd, Athd, Freq, Vmean, Amean, VAV(always 0), k-Factor(always 0), P-corr(always 0), Fund Watts, Fund VA, Fund VAr, Fund V, Fund A, Fund PF, R, X, Fund Vmean, Fund Amean, Voltage harmonics (magnitude & phase), Current harmonics (magnitude & phase), Watts harmonics (magnitude only).

When returning harmonics, the DC value (harm 0) is first returned if AC+DC coupling is set. If odd and even harmonics have been selected, all the harmonics up to the maximum will be sent. If only odd is selected, all the odd harmonics up to the maximum will be sent.

The sum results returned are those for the group currently selected.

4.6.4 :BRF? Read Background Data Selected Fields

Format: :BRF?

:BRF:CH<ch>?

:BRF:SUM?

Return format: A number of parameter names depending upon selection. Up to 8 values on each line.

Description: The BRF command returns the field names that would be returned by the BRD command. This can be used to confirm the selected parameters.

4.6.5 :BSE Set Background Status Enable Register

Format: :BSE <*flags*>

flags = value for enable register 0 - 255

Return format: None

Description: Sets the bits that are enabled in the background and display status register. In the PM6000 there is only one set of results, but the background results commands are included for backwards compatibility. Command has exactly the same functionality as :DSE

4.6.6 :BSE? Read background Data Status Enable Register

Format: :BSE?

Return format: 0 – 255

Description: Returns the value in the data status enable register. Command has exactly the same functionality as :DSE?

4.6.7 :BSR? Read background Data Status Register

Format: :BSR?

Return format: 0 – 255

Description: Returns the value in the data status register, ANDed with the value in the data status enable register. The data status register is cleared once it has been read. Command has exactly the same functionality as :DSR?

4.6.8 :CFG Configure

Format: :CFG <*prog*>, <*data*>

Return format: None

Description: See the Configuration Commands section below for valid *prog* and *data* settings.

4.6.9 :CFG? Read Configuration

Format: :CFG? <*prog*>

Return format: Integer or floating point as appropriate.

Description: Returns the configuration of the PM6000. See the Configuration Commands section below for valid *prog* settings.

4.6.10 :CPL Set AC/DC Coupling

Format: :CPL:+DC
:CPL:-DC
:+DC – sets AC+DC coupling
:-DC – sets AC only coupling

Return format: None

Description: Sets the coupling for the group currently selected.

4.6.11 :DSE Set Data Status Enable Register

Format: :DSE *<flags>*

Return format: None

Description: As for :BSE above.

4.6.12 :DSE? Read Data Status Enable Register

Format: :DSE?

Return format: 0 – 255

Description: As for :BSE? Above

4.6.13 :DSR? Read Data Status Register

Format: :DSR?

Return format: 0 – 255

Description: As for :BSR? Above.

4.6.14 :DVC Device Clear

Format: :DVC

Return format: None

Description: Performs a soft reboot.

4.6.15 :FNC? Read Result

Format: :FNC:CH<ch>:<*func*>[:MIN|MAX]?

ch – 1 to 6

:FNC:SUM:<*func*>[:MIN|MAX]?

Func can be one of

WAT – Watts

VAS – VA

VAR – VAr

VLT – Vrms

AMP – Arms

PWF – Power factor

FRQ – Frequency

VPK – Volts peak

APK – Amps peak

VCF – Volts crest factor

ACF – Amps crest factor

IMP – Impedance

WHR – Watt-Hrs (Integrator result)

VAH – VA Hours (Integrator result)

VRH – VAr Hours (Integrator result)

AHR – Amp Hours (Integrator result)

APF – Average power factor (Integrator result)

TIM – Integrator time elapsed in hours (Integrator result)

VDF – Volts distortion (THD)

ADF – Current distortion (THD)

VDC – Volts DC

ADC – Amps DC

VMN – Voltage rectified mean

AMN – Current rectified mean

Return format: Requested result (floating point)

Description: Returns the requested result for the requested channel.

The SUM results returned are those for the group currently selected (see :INST:NSEL) and can only be read if SUM

has been configured for the group (:SEL:SUM)

Min/max hold must be enabled prior to reading min/max results by using the :MIN and :MAX commands

4.6.16 :FND? Read Fundamental Result

Format:

```
:FND:CH<ch>:<func>[:MIN|MAX]?
     ch – 1 to 6
:FND:SUM:<func>[:MIN|MAX]?
     Func can be one of
     WAT – Watts fundamental
     VAS – VA fundamental
     VAR – VAr fundamental
     VLT – V fundamental
     AMP – A fundamental
     PWF – Fundamental Power factor
     IMP – Fundamental Impedance
     VHM – Voltage Harmonic
     AHM – Current harmonic
     WHM – Power harmonic
     VHA – Voltage harm angle
     AHA – Current harm angle
```

Return format: Requested result (floating point)

Description: Returns the requested result for the requested channel.

The SUM results returned are those for the group currently selected (see :INST:NSEL) and can only be read if SUM has been configured for the group (:SEL:SUM).

Min/max hold must be enabled prior to reading min/max results by using the :MIN and :MAX commands

Fundamental measurements must be enabled prior to requesting fundamental results. This can be done with :SEL:FUN or by specifying the number of harmonics to analyze with the HRM or HMX commands

4.6.17 :FRD? Read Foreground Data

Format: `:FRD?`

`:FRD:CH<ch>?`

`:FRD:SUM?`

Return format: A number of floating point values depending upon selection. Up to 8 values on each line.

Description: If no secondary command is sent, results for all channels are returned.

The results to be returned are selected using the :SEL command.

Once results are available, they are returned in floating point format with up to 8 values on each line.

Results are returned in the following order. If the result has not been selected, it will just be skipped.

Watts, VA, VAr, Vrms, Arms, PF, Vpeak, Apeak, Vcf, Acf, Imp, Vthd, Athd, Freq, Vmean, Amean, VAV(always 0), k-Factor(always 0), P-corr(always 0), Fund Watts, Fund VA, Fund VAr, Fund V, Fund A, Fund PF, R, X, Fund Vmean, Fund Amean, Voltage harmonics (magnitude & phase), Current harmonics (magnitude & phase), Watts harmonics (magnitude only).

When returning harmonics, only the harmonic selected with :HRM command is returned. If the harmonic is H0 (DC), only the magnitude is returned. For other harmonics, both the magnitude and phase in degrees are returned.

The sum results returned are those for the group currently selected (see :INST:NSEL) and can only be read if SUM has been configured for the group (:SEL:SUM).

4.6.18 :FRF? Read Foreground Data Selected Fields

Format: :FRF?
:FRF:CH<ch>?
:FRF:SUM?

Return format: A number of parameter names depending upon selection. Up to 8 values on each line.

Description: The FRF command returns the field names that would be returned by the FRD command. This can be used to confirm the selected parameters.

4.6.19 :FSR Set Frequency Source

Format: :FSR:VLT|AMP|EXT|SLW

VLT – Set voltage frequency source
AMP – Set current frequency source
EXT – Set external frequency source
SLW – Same as EXT on PM6000

Return format: None

Description: Sets the frequency source for the group currently selected. See also CFG 21 and 22

4.6.20 :HRM Set Single Harmonic

Format: `:HRM <harm>`

`harm - integer harmonic number 0 – 99`

Return format: None

Description: Sets the harmonic to be returned by the FNC, FND and FRD commands. Use CFG 18 to set the return format of harmonic results. Harmonic magnitudes may be returned in percentage of the fundamental or absolute value form.

4.6.21 :HMX Set Maximum Harmonic for Series

Format: `:HMX:ODD <harm>`

`:HMX:ALL <harm>`

`:ODD – Only odd harmonics`

`:ALL – All harmonics`

`harm – integer maximum harmonic 0 – 99`

Return format: None

Description: Sets the maximum harmonic for the group currently selected. Also sets whether odd or all harmonics in the group are returned.

4.6.22 :INT Set up Integrator

Format: `:INT:ENB`

`:INT:DIS`

Return format: None

Description: Enables or disables the integrator for the currently selected group (see :INST:NSEL)

If an integrator is enabled with a trigger that is already running, then the integrator on this group will start immediately

Format: `:INT:TRG <trigger>`

Where `<trigger>` is a number 1 to 6

Return format: None

Description: Specifies the trigger associated with the integrator on the currently selected group (see :INST:NSEL)

This allows the user to configure a number of groups to use the same RUN/STOP/RESET events or to run independently

Format: `:INT:TRG?`

Return format: Number 1 to 6

Description: Returns the trigger associated with the integrator on the currently selected group (see :INST:NSEL)

Format: `:INT:RUN [<hours>]`

hours – Run time in hours

Return format: None

Description: Starts the integrator on the currently selected group and any other groups using the same trigger

:INT:RUN *hours* will start an integration over the specified number of hours. If *hours* is omitted :INT:RUN will start/ resume the integration

Integration results can be read using the :FNC command

Format: `:INT:STOP`

Return format: None

Description: Stops the integrator on the currently selected group and any other groups using the same trigger

Integration results can be read using the :FNC command

Format: `:INT:RESET`

Return format: None

Description: Resets the integrator on the currently selected group and any other groups using the same trigger

The :INT:RESET commands clears the integration results and Tint, but the does not stop the integration. So results will be set to zero but integration will continue

Integration results can be read using the :FNC command

4.6.23 :MAX Enable Max store

Format: `:MAX ON|1|OFF|0`

Return format: None

Description: The MAX store holds the maximum result for each parameter until the store is reset either by the ':RES' command or by the front panel [Reset/Clear] key.

Format: `:MAX?`

Return format: 0 or 1

Description: Returns a zero if MAX store off, and 1 if MAX store enabled

4.6.24 :MEA Set Measurement Mode

Format: `:MEA:CNT – Set continuous measurement mode`
`:MEA:SNG – Set single measurement mode.`

Return format: None

Description: Sets the measurement mode in the PM6000. In continuous mode, results are continually updated. In single mode, measurements are stopped until a *TRG is received. Measurements are made until the averaging buffer has been filled. Once the averaging buffer has been filled measurements are stopped until the next *TRG is received.

4.6.25 :MIN Enable Min store

Format: `:MIN ON|1|OFF|0`

Return format: None

Description: The MIN store holds the maximum result for each parameter until the store is reset either by the ':RES' command or by the front panel [Reset/Clear] key.

Format: `:MIN?`

Return format: 0 or 1

Description: Returns a zero if MIN store off, and 1 if MIN store enabled

4.6.26 :PWM PWM Mode

Format: `:PWM:OUT <lfmode>`
`Where lfmode is 1, 2 or 3`

Return format: None

Description: Enable PWM Output mode for the currently selected group. The minimum expected modulation (or motor) frequency is determined by the *lfmode* parameter as follows

1	5Hz
2	1Hz
3	0.1Hz

The measurement update rate will be correspondingly slower with *lfmode* of 2 or 3

Format: `:PWM:DIS`

Return format: None

Description: Exits PWM mode and returns to Normal mode

4.6.27 :RAV Reset Averaging

Format: :RAV

Return format: None

Description: Reset averaging on all groups.

4.6.28 :RES Reset Min/Max Store

Format: :RES:CH<ch> MIN|MAX|ALL

:RES:SUM MIN|MAX|ALL

:RES:ALL MIN|MAX|ALL

CH<ch> – Reset stores for channel ch

SUM – Reset sum store for current group

ALL – Reset store for all groups

store – MAX Reset MAX store

- MIN Reset MIN store

- ALL Reset MIN and MAX stores

Return format: None

Description: Reset the specified MIN/MAX stores.

Example: To reset all MIN and MAX results

:RES:ALL ALL

To reset the MAX store of channel 2

:RES:CH2 MAX

4.6.29 :RNG Set Ranging

Format: `:RNG:VLT|AMP:FIX <range>`

`:RNG:VLT|AMP:AUTO`

`:RNG:VLT|AMP:AUTUP`

`VLT – Set voltage ranging`

`AMP – Set current ranging`

`FIX – Fixed ranging`

`AUTO – Auto ranging`

`AUTUP – Auto up ranging`

`range – integer range 1 – 9`

Return format: None

Description: Sets the ranging for the group currently selected. Range 1 is the lowest range (i.e. 5V for voltage range).

Format: `:RNG:VLT|AMP?`

Return format: One of 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, AUT, AUTUP

Description: Returns the range configuration for the group currently selected.

4.6.30 :SCL Set Scaling

Format: `:SCL:VLT|AMP <scale>`

`VLT – Set voltage scaling`

`AMP – Set current scaling`

`scale – floating point scale 0.00001 – 100000`

Return format: None

Description: Sets the scaling for the group currently selected.

4.6.31 :SEL Select Function List

Format:

```
:SEL:CLR – Clear previous selection
:SEL:CH1 – Select Channel 1
:SEL:CH2 – Select channel 2
:SEL:CH3 – Select channel 3
:SEL:CH4 – Select channel 4
:SEL:CH5 – Select channel 5
:SEL:CH6 – Select channel 6
:SEL:SUM – Enable sum results
:SEL:FUN – Enable fundamental parameters
:SEL:WAT – Select Watts
:SEL:VAS – Select VA
:SEL:VAR – Select VAr
:SEL:VLT – Select Vrms
:SEL:AMP – Select Arms
:SEL:PWF – Select power factor
:SEL:VPK – Select volts peak
:SEL:APK – Select current peak
:SEL:VCF – Select volts crest factor
:SEL:ACF – Select current crest factor
:SEL:IMP – Select impedance
:SEL:WHR – Select Watt-Hrs
:SEL:VAH – Select VA Hours
:SEL:VRH – Select VAr Hours
:SEL:AHR – Select Amp Hours
:SEL:APF – Select average power factor
:SEL:CVR – Select correction Vars
:SEL:VHM – Select voltage harmonic
:SEL:AHM – Select current harmonic
:SEL:WHM – Select Watts harmonic
:SEL:VDF – Select volts distortion
:SEL:ADF – Select current distortion
:SEL:FRQ – Select frequency
:SEL:TIM – Select integrator time
:SEL:VDC – Select volts DC
:SEL:ADC – Select current DC
:SEL:VHA – Select voltage harm angle
```

```
:SEL:AHA – Select current harm angle
:SEL:VMN – Select voltage rectified mean
:SEL:AMN – Select current rectified mean
```

Return format: None

Description: Selects which results are to be returned for the BRD and FRD commands. The selected parameter field names can be read back using the FRF? and BRF? query commands

:SEL:FUN and :SEL:SUM setup the group for these measurements and other related parameters. Use :INST:NSEL to select the group to be configured.

Use :HMX to ensure required harmonics are configured prior to requesting results

4.6.32 :WRG Set Wiring Configuration

Format:

```
:WRG:1P2 – Set 1 phase 2 wire
:WRG:1P3 – Set 1 phase 3 wire
:WRG:3P3 – Set 3 phase 3 wire
:WRG:3P4 – Set 3 phase 4 wire
:WRG:ALL – Set 1 phase 2 wire in all groups
```

Return format: None

Description: Sets up the wiring configuration for the group currently selected, with the exception of :ALL which sets 1 phase 2 wire in all groups.

4.7. CONFIGURATION COMMANDS (:CFG COMMAND)

The ':CFG *Prog,Value*' command takes as its parameter a numeric value. This indicates the setting that is to be set or read. The table below lists the valid commands. It also indicates the valid settings for each command

Prog Num	Function	Value	Notes
2	Target power factor	Floating point number	For group currently selected
11	Disable acquisition	0 = run 1 = hold	Enables/disables acquisition for remote only
12	Hold display	0 = run 1 = hold	
13	Wiring configuration	0 = 1 phase 2 wire 1 = 1 phase 3 wire 2 = 3 phase 3 wire 3 = 3 phase 4 wire 7 = all groups 1ph 2w	0 – 3 are for group currently selected.
16	THD Formula	0 = difference formula 1 = harmonic series	For group currently selected
17	Harmonic reference	0 = fundamental 1 = RMS	For group currently selected
18	Harmonic display	0 = percentage (Default) 1 = actual value V/A	Affects all groups
19	THD formula	0 = H0 (dc) excluded 1 = H0 (dc) included	For group currently selected
21	Fixed frequency	0 = disable 1 = enable	For group currently selected
22	Fixed frequency val	Floating point freq	For group currently selected

26	Low level blanking	0 = disable 1 = enable	Affects all groups
30	Disable channel (ch1)	0 = disable 1 = enable	Disables group containing ch1
32	AC/DC coupling (ch1)	0 = AC coupled 1 = AC+DC coupled	Affects group containing ch1
33	HF Ballast(AM) (ch1)	0 = off 1 = 50Hz 2 = 60Hz	Affects group containing ch1.
34	Phase reference (ch1)	0 = voltage 1 = current	Affects group containing ch1
39	Freq Source (ch1)	0 = voltage 1 = current 2 = external 3 = slow external	Affects group containing ch1. Setting 3 is exactly the same as 2 on the PM6000.
40	Voltage range (ch1)	0 = 5V 1 = 10V 2 = 20V 3 = 50V 4 = 100V 5 = 200V 6 = 500V 7 = 1kV 8 = 2kV	Affects group containing ch1.
41	Current range (ch1)	0 = 5mV 1 = 10mV 2 = 25mV 3 = 50mV 4 = 100mV 5 = 250mV 6 = 500mV	Affects group containing ch1.

		7 = 1V 8 = 2.5V	
42	Voltage ranging (ch1)	0 = auto ranging 1 = manual	Affects group containing ch1.
43	Current ranging (ch1)	0 = auto ranging 1 = manual	Affects group containing ch1.
44	Voltage scaling (ch1)	Floating point scaling	Affects group containing ch1.
45	Current scaling (ch1)	Floating point scaling	Affects group containing ch1
49	PWM motor drive (ch1)	0 = disabled 1 = input 2 = output	Affects group containing ch1.
50–69	As 30–49 above for ch2		
70–89	As 30–49 above for ch3		
115	Integrator functions	0 = accumulated (default) 1 = averaged	Affects results returned by remote for all groups
119	PWM input window	Floating point num of seconds	Affects group currently selected
120	PWM output range	1 = 5Hz 2 = 0.1Hz 3 = 0.1Hz 4 = 5Hz	Affects group currently selected. On the PM6000, determines the minimum fundamental frequency.
127	Remote display	0 = disabled (Default) 1 = enabled	Determines if display is visible when in remote
135	Harmonic series	0 = odd and even 1 = odd only	Affects group currently selected
136	Maximum harmonic	Integer 0 - 99	Affects group currently selected

179	Integrator reset	0 = disabled 1 = enabled	Affects integrator for the group currently selected
184	Selected harmonic	Integer 0 - 99	Affects the harmonic returned for FND and FNC commands
190	Reversed PF sign	0 = disabled 1 = enabled	Just affects results sent by remote
191	SUM A = (A1+A2+A3)/3	0 = disabled 1 = enabled	Affects group currently selected
192	SUM V = (V1+V2+V3)/3	0 = disabled 1 = enabled	Affects group currently selected
251	Auto zero	0 = disabled 1 = enabled	Affects all groups
275	RS232 verbose Echo mode	0 = disabled 1 = enabled	
276	Single reply string	0 = disabled (Default) 1 = enabled	Also affects FRD response format. If 0 then 8 values per line, if 1 then continuous comma separated values
279	Data return format	0 = 4.5 digit ASCII 1 = 5 digit ASCII 2 = 7 digit ASCII	

4.8. SCPI FORMAT COMMANDS

4.8.1 :CAL Commands

In the following command descriptions the parameters sent or received as part of a command sequence are defined in 1.

• Table 1: SCPI Command Parameter Definitions

Parameter	Meaning	Values
<ch>	Channel / slot number.	Integer 1 to 6.
<phase>	Phase value.	Floating point number.
<voltage range>	Voltage range.	Integer 1 to 9. 1 is the lowest range (i.e.5V)
<current range>	Current range.	Integer 1 to 9. 1 is the lowest range (i.e. 5mV)
<magnitude>	Magnitude value.	Floating point number.
<temperature phase>	Phase offset related to temperature.	Floating point number.
<temperature magnitude>	Magnitude value related to temperature.	Floating point number.
<frequency point>	Frequency point.	Integer 1 to 27.

Retrieving and assigning calibration related configuration and constants use the SCPI standard :CAL:DATA command group.

4.8.2 :CAL:DATA

The formats for assigning calibration related information are described below.

Format: :CAL:DATA <ch>, A, F, <n=number of frequency points>, <frequency$_1$>, …, <frequency$_n$>
:CAL:DATA <ch>, S, F, <n=number of frequency points>, <frequency$_1$>, …, <frequency$_n$>

Return format: None

Description: Sets the calibration frequency points for the analogue card or shunt in the requested channel.

Format: `:CAL:DATA <ch>, A, V, <voltage range>, <frequency point number>, <magnitude>, <phase>, <temperature magnitude>, <temperature phase>`

Return format: None

Description: Sets the calibration constants for a voltage range at a specific frequency point for the analogue card on the channel requested.

Format: `:CAL:DATA <ch>, A, I, <current range>, <frequency point number>, <magnitude>, <phase>, <temperature magnitude>, <temperature phase>`

Return format: None

Description: Sets the calibration constants for a current range at a specific frequency point for the analogue card on the channel requested.

Format: `:CAL:DATA <ch>, S, I, 9, <frequency point number>, <magnitude>, <phase>, <temperature magnitude>, <temperature phase>`

Return format: None

Description: Sets the calibration constants for the shunt on the requested channel at the requested frequency point.

4.8.3 :CAL:DATA?

The formats for retrieving calibration related information are described below.

Format: `:CAL:DATA? <ch>, A, F`
`:CAL:DATA? <ch>, S, F`

Return format: `<n=number of frequency points>, <frequency$_1$>, …, <frequency$_n$>`

Description: Returns the number and the values of the configured frequency points for the analogue card or shunt module.

Format: `:CAL:DATA? <ch>, A, V, <voltage range>, <frequency point number>`

Return format: `<magnitude>, <phase>, <temperature magnitude>, <temperature phase>`

Description: Returns the calibration constants for a voltage range at a specific frequency point for the analogue card on the channel requested.

Format: `:CAL:DATA? <ch>, A, I, <current range>, <frequency point number>`

Return format: `<magnitude>, <phase>, <temperature magnitude>, <temperature phase>`

Description: Returns the calibration constants for a current range at a specific frequency point for the analogue card on the channel requested.

Format: `:CAL:DATA? <ch>, S, I, 9, <frequency point number>`

Return format: `<magnitude>, <phase>, <temperature magnitude>, <temperature phase>`

Description: The shunt module supports only a single set of current calibration constants and no voltage related constants. The current range used to access the constants is range 9. This command returns the calibration constants for the shunt on the requested channel at the requested frequency point.

4.8.4 :CAL:RESET

Format: `:CAL:RESEt <ch>, A`
`:CAL:RESEt <ch>, S`

Return format: None

Description: Resets the calibration constants for the requested card or shunt module to default values. This card does not store the default values in the card so they will be lost at power down unless a :CAL:SAVE command is sent.

4.8.5 :CAL:SAVE

Format: `:CAL:SAVE <ch>, A, <passcode>`
`:CAL:SAVE <ch>, S, <passcode>`

Return format: None

Description: This command saves the calibration constants already sent into EEPROM so that they are retained at power down.

4.9. :INP COMMANDS

4.9.1 :INP:FILT:LPAS

Format:
```
:INP:FILT:LPAS 10000000
:INP:FILT:LPAS 2000000
:INP:FILT:LPAS 500000
:INP:FILT:LPAS 200000
:INP:FILT:LPAS 100000
:INP:FILT:LPAS 50000
:INP:FILT:LPAS 20000
:INP:FILT:LPAS 10000
:INP:FILT:LPAS 5000
:INP:FILT:LPAS 2000
```

Return format: None

Description: Sets the low pass filter to be used in the group currently selected. The frequency value corresponds to the 3dB point of the filter.

Format:
```
:INP:FILT:LPAS?
```

Return format: Floating point 3dB point of the filter selected.

Description: Returns the low pass filter setting for the group currently selected.

4.10. :INST COMMANDS

The PM6000 combines one or more physical channels into groups. These groups may then be configured causing all the channels within the group to be configured with the same values.

To retrieve a list of all the groups configured in a PM6000 the following SCPI command is used

```
:INST:CAT:FULL?
```

To select a group on which to perform an operation the following SCPI commands are used

```
:INST:SEL <group name>
```

or

```
:INST:NSEL <group number>
```

To retrieve which group is currently selected the following SCPI commands are used

```
:INST:SEL?
```

or

```
:INST:NSEL?
```

4.10.1 :INST:CAT

Format: `:INST:CAT:FULL?`

Return format: `<group name`$_n$`> [, ...]`

The format of the returned information is a comma separated list of between none and 6 group identifier names.

Description: Returns the group names for all the groups in the PM6000. The group names are returned in order, i.e. the first group name returned is that for group 1.

4.10.2 :INST:CHAN?

To identify which channels are configured in the currently selected group the standard SCPI `:INST:` command is extended

Format: `:INST:CHAN?`

Return format: `<number of channels>[,<first channel number> [,<second channel number> [,<third channel number>]]]`

Description: Returns the number of channels in the group, and then a list of the channels that are in the group.

e.g. The following may be returned

"2, 4, 5"

In the currently selected group there are 2 channels: ch4 and ch5.

4.10.3 :INST:NSEL

Format: `:INST:NSEL <group number>`

`group number – integer between 1 and 6, depending on the number of groups available in the PM6000`

Return format: None

Description: Selects the group specified

4.10.4 :INST:NSEL?

Format: `:INST:NSEL?`

Return format: <group number>

Description: Returns the number of the group selected (between 1 and 6 depending on wiring configuration)

4.10.5 :INST:SEL

Format: `:INST:SEL <group name>`

Return format: None

Description: Selects the group with the name specified

4.10.6 :INST:SEL?

Format: `:INST:SEL?`

Return format: <group name>

Description: Returns the name of the group currently selected.

4.10.7 :INST:STAT

Format: `:INST:STAT ON|OFF`

Return format: None

Description: Enables current group. By default all are ON. When disabled, no measurements are updated

4.10.8 :INST:STAT?

Format: `:INST:STAT?`

Return format: ON|OFF

Description: Returns enable status of current group

4.11. :SENS COMMANDS

4.11.1 :SENS:ZERO

Format: `:SENS:ZERO IMM`

Return format: None

Description: Performs a one off offset zero immediately

4.11.2 :SENS:ZERO:AUTO

Format: `:SENS:ZERO:AUTO ON|OFF`

Return format: None

Description: Enables automatic offset zero (Default ON)

4.12. :SYST COMMANDS

4.12.1 :SYST:CTYPE

To allow any analogue cards or shunt modules installed to be identified, the standard SCPI 1997 :SYST:CTYPE command group has been extended

Format:	`:SYST:CTYPe? <ch>, A`
Return format:	VOLTECH, ANALOGUE CARD, <serial number>, <card revision>
Description:	Returns the serial number and hardware revision of the analogue card in the requested channel.

Format:	`:SYST:CTYPe? <ch>, S`
Return format:	VOLTECH, SHUNT MODULE, <serial number>, <shunt revision>
Description:	Returns the serial number and hardware revision of the external shunt in the requested channel.

4.12.2 :SYST:TIME

Format:	`:SYST:TIME <hour>,<minute>,<second>`
Return format:	None
Description:	Sets the system time where <hour> is 0 to 23 <minute> is 0 to 59 <second> is 0 to 59

Format:	`:SYST:TIME?`
Return format:	Hour, minute, second
Description:	Returns the system time

4.12.3 :SYST:DATE

Format: `:SYST:DATE <year>,<month>,<day>`

Return format: None

Description: Sets the system date where

<year> is four digit year

<month> is 1 to 12

<day> is 1 to 31

Format: `:SYST:DATE?`

Return format: Year, month, day

Description: Returns the system date

4.12.4 :SYST:ERROR

When remote programming the instrument, it is important to ensure that commands are acting in the expected way. One important part of this is to regularly check to if errors have been raised by the instrument.

The error queue consists on a first-in, first-out buffer that can hold the most recent 20 error messages. When full, an additional message will be supplied indicating a queue overflow

Format:	`:SYST:ERRor[:NEXT]?`
Return format:	Error number, “error description”
Description:	Returns the first error message in the error list. Each message consists of an error number identifying the type of error, and a description that describes the error type and sometimes additional information about the specific error. Once the command has been read it will be removed from the error queue, bringing the next error to the top If no error has occurred since the last error query, then 0, “No error” will be returned

Format:	`:SYSTem:ERRor:ALL?`
Return format:	Error number, “error description”, error number, “error description”, ..., error number, “error description”
Description:	Returns the complete error message list, and so clears the queue If no error has occurred since the last error query, then 0, “No error” will be returned

Format: `:SYSTem:ERRor:CODE:NEXT?`

Return format: Error number

Description: Returns the next error number from the error list, and removed that error from the list

If no error has occurred since the last error query, then

0

will be returned

Format: `:SYSTem:ERRor:CODE:ALL?`

Return format: Error number, error number, ..., error number

Description: Returns the complete error number list, and so clears the queue

If no error has occurred since the last error query, then

0

will be returned

Format: `:SYSTem:ERRor:COUNt?`

Return format: Number

Description: Returns the number of errors in the error list

If no error has occurred since the last error query, then

0

will be returned

5. FITTING OPTIONS

5.1. VOLTECH SHUNTS

The Shunt Assemblies can be fitted into any channel, it is not necessary to fit the Shunts in order and any combination is possible.

5.1.1 Equipment Required

#1 Pozi-Drive Screwdriver

0.1 to 1.2Nm Adjustable Torque Driver

5.1.2 Installation Procedure

Switch off the PM6000 and disconnect all power and measuring leads before starting this procedure.

1. Place the Shunt into the desired channel ensuring that the connector is fully mated. Push the shunt firmly until it rests against the face of the Analogue PCB.
2. Fit the 3 off M3x8mm (VPN 68-197) pan head Pozi (with external lock washer) through the shunt and into the analogue rear panel. Tighten the screws to 0.8Nm.
3. Switch on the PM6000 and the new shunt will be automatically recognized by the PM6000. This can be confirmed in the [CONFIG] menu. If the shunt is not available, or any warnings are displayed during switch on, please contact you Voltech service center.

6. SPECIFICATION

6.1. MEASURING CHANNEL

6.1.1 Voltage connections

- Measurements to 2000Vpk, DC to 10MHz
- Differential input impedance: 1Mohm in parallel with 26pF
- High and low input impedance to ground: 22pF

6.1.2 Current connections

- Measurements to 2.5Vpk, DC to 10MHz
- Differential input impedance: 2Mohm in parallel with 12pF
- High and low input impedance to ground: 22pF

6.1.3 Analogue Card power supply outputs

Non-isolated 12V supply

- ±12V, 100mA max (protected), +5%, -7.6%.

Isolated 5V supply

- ±5V, 50mA max (protected), ±5%.

6.2. MECHANICAL AND ENVIRONMENT

6.2.1 Dimensions (Approx)

- Height: 17cm
- Width: 42cm
- Depth: 36cm

6.2.2 Weight (Approx)

- 12Kg for 6-phase instrument with no shunts

6.2.3 Line Input

- 90VAC to 264VAC, 47-63Hz. 170VA

6.2.4 Dielectric Strength

- Mains supply inlet (Live + Neutral to earth): 2.9KV DC

- Voltage measurement inputs: 2KVpk
- Current measurement inputs: 2KVpk
- Isolated supplies: 2KVpk

6.2.5 Storage Temperature

- -20ºC to +70ºC

6.2.6 Operating Temperature

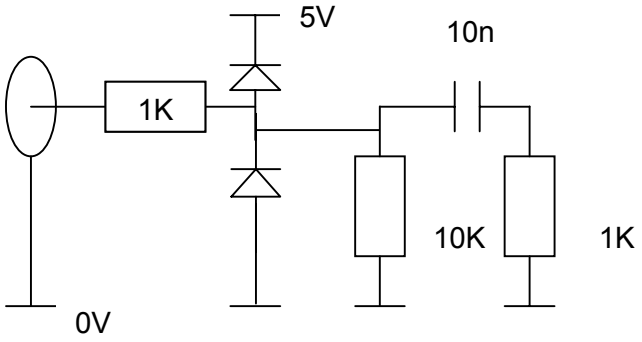
- 0ºC to 40ºC

6.2.7 Humidity

- 10 to 90% relative humidity non-condensing

6.3. EXTERNAL INPUT

Input Impedance:



- Edge triggered system - Minimum dv/dt on each edge is 0.5V/uS
- 5V TTL compatible
- Diode clamp protected to ±20V

6.4. PERIPHERAL PORTS

6.4.1 Serial Port

- 9 pin male D-type connector
- RS232 Interface for connection to a PC for remote control with a null modem cable
- Available baud rates 9600 (Default), 19200, 38400
- 8bit, No parity, 1 stop bit, hardware flow control

Pin		Signal name	Pin		Signal name
1		No connection	6		No connection
2	i/p	RXD	7	o/p	RTS
3	o/p	TXD	8	i/p	CTS
4		No connection	9		No connection
5		0V			

6.4.2 Parallel Port

- 25 pin female D-type connector
- Standard parallel printer interface

Pin		Signal name	Pin		Signal name
1	o/p	!STROBE	11	i/p	BUSY
2	o/p	D0	12	i/p	PE
3	o/p	D1	13		No connection
4	o/p	D2	14	o/p	!AUTOFD
5	o/p	D3	15	i/p	!ERROR
6	o/p	D4	16	o/p	!INIT
7	o/p	D5	17	o/p	!SLCTIN
8	o/p	D6	18		0V
9	o/p	D7	...		
10	i/p	!ACKNLG	25		0V

6.4.3 External Monitor

- Output compatible with IBM® VGA
- Connector:HD-15 Socket

Connector pin-out:

Pin		Signal name	Pin		Signal name
1	o/p	Red Signal	9		
2	o/p	Green Signal	10		
3	o/p	Blue Signal	11		
4		No Connection	12		+5V
5		0V	13	o/p	H Sync
6		0V	14	o/p	V Sync
7		0V	15		+5V
8		0V			

6.4.4 External Keyboard and Mouse

- Compatible with IBM® PS/2
- Connector: 6-pin Mini-DIN socket
- For service use only

6.4.5 USB Slave Port

- Full Speed (12Mbps) USB Device (Slave)
- Connector: USB type B receptacle

Pin		Signal Name
1	Power	+5V
2	Bi	D-
3	Bi	D+
4	Power	0V

6.4.6 Ethernet Port

- IEEE 802.3 10Base-T and 100Base-Tx (Half or Full Duplex)
- Connector: RJ-45 with Link and Activity indicators

Pin	Signal Name
1	Tx+
2	Tx-
3	Rx+
4	Common
5	Common
6	Rx-
7	Common
8	Common

Status indicators:

Green Link/Activity indicator

Yellow Speed 100Mbps indicator

6.5. MEASURED PARAMETERS

Abbreviation	Description	Units	Formula
V_{RMS}	RMS Voltage	Volt (V)	$V_{RMS}=\sqrt{\frac{1}{T}\int_0^T v_i^2\,dt}$
V_{RMN}	Rectified Mean Voltage	Volt (V)	$V_{MEAN} = \frac{1}{T}\int_0^T \lvert v \rvert\, dt$
A_{RMS}	RMS Current	Amp (A)	$A_{RMS}=\sqrt{\frac{1}{T}\int_0^T i_i^2\,dt}$
A_{RMN}	Rectified Mean Current	Amp (A)	$A_{MEAN}=\frac{1}{T}\int_0^T \lvert i \rvert dt$
F	Frequency	Hertz (Hz)	
W	True Power	Watt (W)	$W = \frac{1}{T}\int_0^T v_i\, i_i\, dt$
PF	Power factor		$PF = \left[\frac{Watt}{V_{rms}\times A_{rms}}\right]$
VA	Apparent Power	Volt-Amps (VA)	$\mathrm{VA} = [\mathrm{V_{rms}}\times \mathrm{A_{rms}}]$
VAr	Reactive Power	Volt-Amps (VA)	$VAr=\sqrt{(VA)^2-W^2}$
V_{CF}	Voltage Crest Factor		$CF = \frac{Peak\,Value}{RMS\,Value}$
A_{CF}	Current Crest Factor		$CF = \frac{Peak\,Value}{RMS\,Value}$
$V_{THD\ (DIFF)}$	Voltage THD	%	$df = \frac{\sqrt{(RMS^2 - H1^2)}}{REF}\times 100\%$
$V_{THD\ (SERIES)}$		%	$thd=\frac{\sqrt{H2^2+H3^2+H4^2+H5^2+....}}{REF}$
$A_{THD\ (DIFF)}$	Current THD	%	$df = \frac{\sqrt{(RMS^2 - H1^2)}}{REF}\times 100\%$

$A_{THD\ (SERIES)}$		%	$thd=\frac{\sqrt{H2^2+H3^2+H4^2+H5^2+....}}{REF}$
Z	Impedance	Ohm (θ)	$Z=\frac{V_{rms}}{I_{rms}}$
V_{DC}	DC Voltage	Volt (V)	$V_{DC}=\frac{1}{T}\int_0^T vdt$
A_{DC}	DC Current	Amp (A)	$A_{DC}=\frac{1}{T}\int_0^T idt$
Vf	Fundamental Voltage	Volt (V)	$Vf=\sqrt{(V1.r^2+V1.q^2)}$
Af	Fundamental Current	Amp (A)	$Af=\sqrt{(A1.r^2+A1.q^2)}$
Wf	Fundamental Power	Watt (W)	$Wf=(V1.r\times A1.r)+(V1.q\times A1.q)$
VAf	Fundamental Apparent Power	Volt-Amps (VA)	$VAf=[Vf\times Af]$
VArf	Fundamental Reactive Power	Volt-Amps (VA)	$VAr=(V1.q\times A1.r)+(V1.r\times A1.q)$
PFf	Fundamental Power Factor		$PFf=\cos\theta$ Where θ = phase angle
R	Resistance	Ohms (Ω)	$R=\frac{Vf}{Af}\times\cos\theta$ (θ = phase angle)
X	Reactance	Ohms (Ω)	$X=\frac{Vf}{Af}\times\sin\theta$ (θ = phase angle)
Vh_n	Voltage harmonic n	Volt (V)	$Mag=\sqrt{(Vh_n.r^2+Vh_n.q^2)}$ $Phase=\tan^{-1}\left(\frac{Vh_n.q}{Vh_n.r}\right)$
Ah_n	Current harmonic n	Amp (A)	$Mag=\sqrt{(Ah_n.r^2+Ah_n.q^2)}$ $Phase=\tan^{-1}\left(\frac{Ah_n.q}{Ah_n.r}\right)$

V_{PK}	Peak Voltage	Volt (V)	$V_{PK} = \max\{v\} or \min\{v\}$ (Whichever magnitude is greater)
A_{PK}	Peak Current	Amp (A)	$A_{PK} = \max\{i\} or \min\{i\}$ (Whichever magnitude is greater)

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

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

There are also two ways to display the phase angle. The first is as the table above where the phase is displayed as 0 to 360°. The second is to display between ±180°. In this case the phases in the table above would read 0, 90, 180, -0 to -180°

6.6. MEASUREMENT ACCURACY

The table below lists the formulae for calculating the accuracy specification for each measurement.

In the equations below

- It is assumed the waveform measured is a sine wave.
- F is the frequency measured in kHz
- V is the voltage measured in V
- I is the current measured in A
- FSv is the full-scale value of the voltage range used for the measurement
- FSi is the full-scale value of the current range used for the measurement (including shunt impedance)
- Z_{EXT} is the external shunt impedance (0.5Ω for 1A shunt, 10mΩ for 30A shunt)
- Θ is the phase angle in degrees (i.e. phase of the current with reference to the voltage).

All specifications are valid 23°C ±5°C

Temperature coefficient ±0.02% of reading / °C, 0 to 18°C, 28 to 40°C.

Meas	
V_{RMS} V_{DC} V_f Vh_n	$Magnitude(V) = 0.02\%rdg + 0.05\%rng + (0.001\% \times F)rdg + 20mV$ $Phase(^\circ) = 0.005 + \left(0.0003 \times \frac{FSv}{V}\right) + \frac{0.05}{V} + (0.001 \times F)$ Phase reported for V_f and Vh_n only. Phase error will be sum of phase error for measured signal and phase error of phase reference signal Specification valid from 500mV and higher Effects of common mode voltage better than: Freq. CMRR 60Hz -100dB 100Hz -95dB 1kHz -90dB 10kHz -80dB

	100kHz-70dB 1MHz -60dB 5MHz -30dB 10MHz-25dB
A_{RMS} A_{DC} A_f Ah_n	$Magnitude(A) = 0.02\%rdg + 0.05\%rng + (0.001\% \times F)rdg + \frac{20uV}{Z_{EXT}}$ $Phase(^\circ) = 0.0025 + \left(0.0005 \times \frac{FSi}{I}\right) + \frac{0.00004}{I \times Z_{EXT}} + (0.0006 \times F)$ Phase reported for A_f and Ah_n only. Phase error will be sum of phase error for measured signal and phase error of phase reference signal Specification valid from 500uV and higher (i.e. 1mA on 1A shunt, 50mA on 30A shunt) Effects of common mode voltage better than: Freq. CMRR 60Hz -140dB 100Hz -140B 1kHz -138dB 10kHz -135dB 100kHz-120dB 1MHz -95dB 5MHz -60dB 10MHz-50dB
V_{PK}	$Error(V) = 0.08\%rdg + 0.05\%rng + (0.001\% \times F)rdg + 600mV$
A_{PK}	$Error(A) = 0.08\%rdg + 0.05\%rng + (0.001\% \times F)rdg + \frac{500uV}{Z_{EXT}}$
F	$Error(Hz) = 0.02\%rdg$ (provided noise on signal < 12.5% range and peak of signal > 12.5% range)
W	$Error\ (Watts) = \left[\frac{V_{RMS}\ error}{V_{RMS}} + \frac{A_{RMS}\ error}{A_{RMS}} + \left(\tan\theta \times (Vh1_{Ph}\ error\ + Ah1_{Ph}\ error\ ) \times \frac{\pi}{180}\right)\right] \times W$
PF	$Error = \tan\theta \times (Vh1_{Ph} error + Ah1_{Ph} error) \times \frac{\pi}{180} \times PF$

VA	$Error(VA) = \left[\frac{V_{RMS}error}{V_{RMS}} + \frac{A_{RMS}error}{A_{RMS}} \right] \times VA$
VAr	$Error(VAr) = \left[\frac{V_{RMS}error}{V_{RMS}} + \frac{A_{RMS}error}{A_{RMS}} + \left(\frac{Vh1_{Ph}error + Ah1_{Ph}error}{\tan\theta} \times \frac{\pi}{180} \right) \right] \times VAr$
V_{CF}	$Error = \left[\frac{V_{PK}error}{V_{PK}} + \frac{V_{RMS}error}{V_{RMS}} \right] \times V_{CF}$
A_{CF}	$Error = \left[\frac{A_{PK}error}{A_{PK}} + \frac{A_{RMS}error}{A_{RMS}} \right] \times A_{CF}$
V_{THD} (DIFF)	
V_{THD} (SUM)	$Error(V_{THD}) = \left[\frac{Vh2_{Mag}error}{Vh2_{Mag}} + \frac{Vh3_{Mag}error}{Vh3_{Mag}} + \frac{Vh4_{Mag}error}{Vh4_{Mag}} + ...etc \right] \times V_{THD}$
A_{THD} (DIFF)	
A_{THD} (SUM)	$Error(A_{THD}) = \left[\frac{Ah2_{Mag}error}{Ah2_{Mag}} + \frac{Ah3_{Mag}error}{Ah3_{Mag}} + \frac{Ah4_{Mag}error}{Ah4_{Mag}} + ...etc \right] \times A_{THD}$
Z	$Error(Ohms) = \left[\frac{V_{RMS}error}{V_{RMS}} + \frac{A_{RMS}error}{A_{RMS}} \right] \times Z$
Wf	$Error(Watts) = \left[\frac{Vh1_{Mag}error}{Vh1_{Mag}} + \frac{Ah1_{Mag}error}{Ah1_{Mag}} + \left(\tan\theta \times (Vh1_{Ph}error + Ah1_{Ph}error) \times \frac{\pi}{180} \right) \right] \times Wf$
VAf	$Error(VAf) = \left[\frac{Vh1_{MAG}error}{Vh1_{MAG}} + \frac{Ah1_{MAG}error}{Ah1_{MAG}} \right] \times VAf$
VArf	$Error\ (VArf\ ) = \left[\frac{Vh1_{MAG}\ error}{Vh1_{MAG}} + \frac{Ah1_{MAG}\ error}{Ah1_{MAG}} + \left(\frac{Vh1_{Ph}\ error\ + Ah1_{Ph}\ error}{\tan\ \theta} \times \frac{\pi}{180} \right) \right] \times VArf$
PFf	$Error = \tan\theta \times (Vh1_{Ph}error + Ah1_{Ph}error) \times \frac{\pi}{180} \times PFf$
R	$Error(Ohms) = \left[\frac{Vh1_{Mag}error}{Vh1_{Mag}} + \frac{Ah1_{Mag}error}{Ah1_{Mag}} + \left(\tan\theta \times (Vh1_{Ph}error + Ah1_{Ph}error) \times \frac{\pi}{180} \right) \right] \times R$
X	$Error(Ohms) = \left[\frac{Vh1_{MAG}error}{Vh1_{MAG}} + \frac{Ah1_{MAG}error}{Ah1_{MAG}} + \left(\frac{Vh1_{Ph}error + Ah1_{Ph}error}{\tan\theta} \times \frac{\pi}{180} \right) \right] \times X$

6.7. REGULATORY COMPLIANCE

6.7.1 Safety

EN61010:2001

6.7.2 EMC

Emissions and immunity

EN61326:1997, A1:1998

6.8. SHUNTS – 30A AND 1A

6.8.1 Mechanical Characteristics

Dimensions (Approx)

- Width: 40mm
- Height: 100mm
- Depth: 60mm

Weight (Approx)

- 250g

6.8.2 Environmental operating conditions

Dielectric Strength

- 2KVpk current inputs to case

Storage Temperature

- -20ºC to +70ºC

Operating Temperature

- 0ºC to 40ºC

Humidity

- 10 to 90% relative humidity non-condensing

6.8.3 Measurement Accuracy (30A Shunt)

Magnitude:

- 0.02% rdg + (0.005% * f) rdg + 0.0001 Amps

Phase:

- 0.005 * f + 0.005 º

where f is frequency in kHz, up to 1MHz

Temperature Coefficient:

- < ± 10ppm/K (20ºC to 40ºC)

Stability (at 125ºC foil temperature):

- Deviation <0.1% after 2000h

Maximum continuous rated current:

- 30A RMS, 250A peak.

6.8.4 Measurement Accuracy (1A Shunt)

Magnitude:

- 0.02% rdg + (0.003% * f) rdg + 0.000003 Amps

Phase:

- 0.003 * f + 0.003 º

where f is frequency in kHz, up to 10MHz

Temperature Coefficient:

- < ± 10ppm/K (20ºC to 40ºC)

Stability (at 125ºC foil temperature):

- Deviation <0.1% after 2000h

Maximum continuous rated current:

- 2.5A, 5A peak.

Module is fused at 2.5A to protect against accidental connection to 15A fused 240V mains supply.

Fuse type 2.5A HRC Anti-surge 20x5mm

Replace only with the same type and rating of fuse

7. WARRANTY & SERVICE

7.1. WARRANTY

The Voltech PM6000 Power Analyzer, PM6000 Measuring Channels and PM6000 Shunts are warranted against defects in materials and workmanship for a period of twelve (12) months from the date of shipment.

In the event of failure of a customer unit during this period, Voltech will:

- At Voltech's discretion, repair or replace the faulty unit free-of-charge for a unit returned to an authorized service center. Shipment from the customer address will be the responsibility of the customer.

  Voltech reserves the right to waive this benefit in any event where it is clear upon inspection that the cause of the failure is due to customer misuse.

  Voltech will be the sole arbiter in this circumstance.
- Pay all return shipment charges from the Voltech service center to the customer.
- Repair/verify the customer unit before dispatch. A certificate of verification will be issued as a matter of course.

The PM6000 is a complex product and may not be completely free of errors. You are advised to verify your work. In no event will Voltech be liable for direct, indirect, special, incidental or consequential damages arising out of the use of or inability to use the PM6000 or its accessories, even if advised of the possibility of such damage. In particular, Voltech is not responsible for any lost profits or revenue, loss of use of software, loss of data, cost of substitute products, claims by third parties, or for other similar costs.

7.2. SERVICE

To confirm the accuracy of your PM6000 and its component measuring channels and shunts, a verification check should be carried out every 12 months.

Verification is carried out using purpose-built equipment. The verification can be performed by an authorized Voltech service center.

For details of verification facilities and any other service requests, contact your supplier. Voltech strongly recommends that you discuss your service requirements with your supplier before service is needed.

7.3. OBTAINING SERVICE AND APPLICATIONS SUPPORT

Voltech personnel will be happy to help you with any query that you may have. Please e-mail your local supplier or your regional Voltech service center, as listed at the front of this manual.

To ensure we provide the fastest possible support, we may ask you for the serial number and firmware revisions of the PM6000, PM6000 Measuring channel or PM6000 shunt.

This information may be found in the [Config], [View Hardware] menu.

8. SAFETY INFORMATION

8.1. SAFETY FEATURES

The PM6000 has been designed with safety features, such as shrouded safety connectors, that provide the operator with a high level of protection against the risk of electric shock. As with any dangerous equipment, however, it is important that an assessment of the overall risk to safety is made during installation. It is the user's responsibility to ensure compliance with any local regulations that may be applicable to the health and safety of operators

8.2. SAFETY INSTRUCTIONS

- The PM6000 and its accessories have been constructed in compliance with the requirements of EN61010-1, Pollution Degree 2, Installation Category II, FOR INDOOR USE ONLY. This ensures the safety of the analyzer and the user when normal precautions are followed
- WARNING: The analyzer MUST be earthed. The power source should be inserted in a socket with a protective ground contact
- The power source should be inserted before connections are made to measuring or control circuits
- Do not attempt to remove outer cover without first disconnecting auxiliary and test power supply
- This instrument must only be serviced by qualified personnel who understand the danger of shock hazards
- When the instrument is removed from its case hazardous voltages are present
- 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'
- The signal leads must be in good condition with no damage.
- Replace fuses only with the same type and rating as specified in this manual