

# High Speed Comprehensive Power Quality Analyzer

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## Ranger Power Master 7000 (PM7000) Power Quality Analyzer Operation Manual



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## Safety Warnings



Please read and feel comfortable with the safety warnings below.

## Warning



The Symbol  is about SAFETY and concerns YOU

**Please read and take careful note of the following safety recommendations before using your PM7000 for the first time.**



This symbol is displayed on the instrument to alert the user to the potential danger of using it. The symbol also appears from time to time in the manual. In some cases  draws attention to the fact that the parts or adjustments to which  refers are not serviceable by the user. In all cases the unit MUST be repaired or serviced by properly qualified personnel.

**Please note that this includes changing internal fuses and batteries.**

**These following safety statements are particularly concerned with connecting your logger to the power source. To ensure your safety and avoid any damage to the PM7000 please take careful note.**



Use extreme caution when connecting the signal input cables to the logger. Any voltage potential at the signal source will exist on the instrument's respective signal input cable. Consequently HAZARDOUS LIVE VOLTAGES may be exposed inside the instrument case and also may exist on the signal input terminals, which are floating with respect to the instrument chassis.



Because you will be attaching the PM7000 to a potentially hazardous live circuit, you must be suitably qualified. Before you make any such connection or disconnection you need to understand the dangers associated with doing this and how to eliminate those dangers and control the risks associated with CAT IV (Category IV) type high fault current electricity supplies.

You may safely connect the PM7000 input terminals to hazardous live circuits in normal operation provided that you take the following sensible precautions:



Never use damaged leads. Always check leads for wear and tear or damage before using them. Once you are satisfied with their soundness make sure that they are securely plugged into the logger before they make contact with any live power source. Connect sensor leads to the logger first to remove the risk of producing any hazardous live lead ends.

 When using current transformers, current probes, or step-down voltage transformers other than the voltage probes and Rogowski coils supplied with the logger, always consult the manufacturer's guide for connection information. Further information is also found in the *Ranger PM3000* manual.

## Voltage Measurement Leads

 Use the GS38 approved test voltage leads supplied. These have fuses in the alligator clip end and safety connectors at the connection end. They are rated at CAT IV for 600 volts (CAT III for 1000 volts). Always use these or equally GS38 compliant leads for your safety.

 Voltage leads must be treated with respect as they do an important job of carrying live voltage in a safe manner. Because they are flexible test leads they are strong and easy to coil and twist and will give good, safe, service when looked after carefully.

 Always connect the voltage leads through the upper 4mm voltage ports, never through the lower BNC current ports.

## Current Measurement Leads

 Any current transformer (CT) used with this logger must be **voltage output** type. This equipment is **NOT** designed for use with current output, current transformers.

 When installing voltage output current transformers, connect them to the adaptors and then the adaptors to the logger before you attach them round the source of power. Be careful not to touch any of the connection points.

 Always make sure that your logger is positioned in a way that ensures it is mechanically stable. There must be no possibility of the test leads becoming disconnected from it while they remain attached to any external power source.

 For your safety and to avoid damage to the logger do not connect your PM7000 to a live voltage source outside the specified range of 0-600 (+ 10%) Vac. For measurements between 600 and 1000 Vac please refer to the manual. These are a special case.

 Under no circumstances should you remove the front panel of the logger while it is connected to a power source.

 In line with safety requirements the PM7000 gives correct over range voltage readings. No danger will arise for an operator relying on any indicated values. However, this does not remove the possibility that a single fault in the unit could give misleading results, leading to a hazard for the operator.

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# High Speed Comprehensive Power Quality Analyzer



## Intended Use and Safety Statements

Welcome to the Ranger family and to our top of the range Power Master Ranger, the PM7000.



PM7000 in Australia



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## Introduction: PM7000



### Each kit includes:

- **Ranger PM7000** power quality analyzer
- Four 24" 6000 Amp Flexible Current Clamps (max conductor size 8"), braided
- Four Voltage probes 1000V Cat III (600V Cat IV), braided
- One earth voltage probe (600V Cat IV)
- Three Neutral Common Leads
- Mains lead or charger (US)
- USB lead
- Pronto for Windows Analysis Software
- Customer CD with Ranger User Manuals and Simulators
- Bluetooth Adaptor

## Intended Use of the PM7000

The PM7000 is an advanced, high performance, state of the art data-logging instrument for measuring, displaying and storing AC power parameters for single and multi-phase systems. It measures voltage using voltage leads and current, indirectly as voltage, either with Rogowski coils that plug directly into the logger or voltage output type current transformers. It records the results in memory for transfer to a computer for analysis. The PM7000 measures any low voltage supply, or a high voltage supply, through the use of secondary transformers.

The PM7000 is available with different signal processing options and sampling speeds and those options are 'field programmable'. In addition there is a hardware variant to allow measurements of voltages up to 1000 V A.C R.M.S. The different hardware variants are clearly distinguishable by the information printed on the overlay on the front panel. All variants may be powered and charged from an auxiliary nominal 12 volt supply such as a car battery or a wall charger, and all variants have the same internal battery pack to 'ride through' periods when external power is unavailable.

The regular PM7000 unit is normally powered by an integral internal mains power supply designed to

operate from supplies between 100 and 600 V A.C. R.M.S. On the regular unit the internal mains power supply draws current from the 'Phase A' measurement channel. When the auxiliary 12V input is powered the mains power supply is automatically disconnected from the 'Phase A' measurement channel.

The PM7000 variant used for measurements of working voltages up to 1000 A.C. R.M.S. is prevented by the hardware configuration from drawing power from any measurement channel. These units are not powered by an integral internal mains power supply. Instead it uses the auxiliary 12V input, or in absence of the 12V input it may run from energy stored in the battery pack.

Before you use your logger read this manual. Throughout you will find '**warnings**' because this instrument can be attached to potentially hazardous

live voltages. They are prefaced by this symbol  and are necessary for our compliance with the safety standards. Please note them carefully as the reason for their requirement is your safety and guidance.

---

## PM7000 General Description

The PM7000 measures AC current and voltage waveforms. It processes the results to a wide variety of power parameters and records them, eventually making the results available (via interfaces to associated I.T. equipment) - for display, storage or further processing. The PM7000 is also configured and controlled through the same I.T. interfaces. Such I.T. interfaces include PDAs, mobile phones with Windows Mobile 5 or computer screens.

## PM7000 Technical Specification

**Input Voltage:** Four 0-600 Vac. fully differential input channels.

Sensors: Inline shrouded 4mm banana sockets.  
Fused leads, crocodile or dolphin clip.

**Input Currents:** Four input channels.

Sensors: two ranges on two types. Menu Selectable Rogowski coil with range 0-6000A, 0-400A, or Voltage Type 0-1 Vac. Safety BNC Socket. Phase reversal in software.

**Three Distinct Simultaneous Recording Systems:**

**Waveform capture:** High Speed sampling on all inputs.

**Troubleshooting:** utilizing the patented single cycle Adaptive Store to capture comprehensive detail over long recording periods on up to 32 selected parameters.

**General Parameter Analysis:** including reporting to Standards.

**Configurations:** Space for over 200 files. These may be used for configuration or recording sessions.

**Accuracy:** < 0.25% (excluding sensors), +/- 2LSBs (in target ranges).

**Resolution:** Programmable to 0.1 Vac and 0.1 Aac, 0.01V high resolution mode.

**General Parameter Measurement:** happens automatically. Fixed Functions recorded on (selected) intervals (1sec to 2 hours). Voltage & Current RMS (Max, Min, Avg). THD / Harmonic Value (8 inputs). Flicker (3 Voltage inputs). Power (kW, VAR, AP, PF), Individual Harmonics 2-50 (8\*50 signals). Unbalance.

**Troubleshooting Maths Functions:**

**AC Single Phase Installation:** RMS (line-neutral, line-line where appropriate), Stray Voltage RMS Hi Res < 35V. Real power W, Reactive Power VARS, Apparent Power VA, Power Factor PF, Displacement Power Factor, Phase Angle, Frequency, Instantaneous Flicker Sensation, Short Term & Long Term Perceptibility, Flicker Flag, Distortion Power.

**AC 2 (split) Phase Installation:** Real Power, Reactive Power VARS, Apparent Power, Power Factor

**AC 3 Phase Installation (Delta, Wye and variants):** Real Power, Reactive Power VARS, Apparent Power, Power Factor, Voltage Unbalance, (Conventional & Sequential Components), Current Unbalance. Distortion Power, Positive Sequence Fundamental Real & Reactive Power (IEEE1459).

**Harmonics:** Odds, Evens, Triplens, Individual Harmonics value and % and Harmonic Direction to the

50th, K Factor, % Total Harmonic Distortion, Total Harmonic Value. Individual Harmonics to the 127<sup>th</sup> included in the Interharmonics option.

**Other Maths Options:** Channel X \* Constant, Channel X / Channel Y, Filtered Channel X, Internal Temperature, On Charge, Battery Volts.

**Waveform Capture:** Sample rate - up to 1.2288 Ms/s in the PM7000T (~ 24,576 samples/cycle at 50 Hz) on 8 channels. Events examined, Ranked & stored in real time.

**Selectable Waveform Parameters:**

**Wave Retention Basis:** Greatest disturbances (automatic ranking and low rank discard) and first past a threshold.

**Capture wave bracket:** Wave Sets: from 20ms up to 60secs.

**Signals to be captured:** offending wave / complementary current or voltage, All Voltages, All Currents.

**Triggers to be used:** Transient, Ring, Notch, Sag, Surge, THD Volts, THD Current.

**Wave Allocation:** waves allocated across trigger functions.

**Sampling:**

PM7000S (Standard)	19.2kSamples per sec
PM7000H (High speed)	153.6kSamples per sec
PM7000T (Turbo)	1,228.8kSamples per sec

**Memory:** 128MB Flash memory for all files. 32MB RAM for high speed waveform capture data, 64MB working RAM. Expansion with USB Memory Device. Firmware (program memory)  
- Flash upgradeable 2MB  
User Preferences  
- Stored in non-volatile Flash Memory

**Portable Device Requirements for PMScreen:**

Pocket PC, mobile phone or PDA with Windows Mobile 5 or later.

**Data Retention:** During recording sequential data is saved to Flash memory. Waveform capture data is held in RAM and transferred to Flash memory when recording ends. Configurations etc. stored in Flash memory.

**User Interface via Remote Screen:** PC via Bluetooth or USB running PMScreen, or PDA/ Mobile phone with Windows Mobile 5 via Bluetooth running PMScreen. Setup/Configuration and Data Review via remote screen. Data analysis using Pronto for Windows. Automatic download to USB stick.

**Displays On PMScreen:** Power & Energy, Waveforms, Harmonics, Phasors, Harmonic Phasors, Trends, Statistics, List of Channels. Comparison to Standards. Interharmonics (optional).

**Communications:**

**Bluetooth:** Wireless interface (isolated)  
**USB:** Memory module interface (non-isolated).  
**USB:** Serial interface to PC (isolated > 2.5kV) download to PC & control through Pronto for Windows.  
**Protocol:** MODBUS ASCII

**Power:** Requires 90-660 VRMS, 15 W Max from Phase A voltage measurement (40 - 64Hz Rated power consumption 11Watts) or separate power supply @12Vdc, 6 W.

**Burden 600 Volt model :** Normally <10 VA when powered from Phase A. If a charger is used the Power Supply is automatically disconnected from Phase A (input impedance per phase 32MOhms).

**Burden 1000 Volt model :** Negligible, power supply is out of use (input impedance per phase 32MOhms).

**Battery Capacity:** 2100mAh (5 HI-Temp NiMH batteries).  
 Battery Ride Through: ten minutes at a time.

**Charge Method:** From V1 input or from 12V Wall Charger (auto switching)

**A/D Converters, 2 sets:**

(i) 24 bit at 19.2 kSamples, top 16 bits used normally for harmonics, power & energy, Flicker.  
 (ii) 12 bits used for High Speed and Turbo only.

**Measurement & Reporting Standards:**

IEC 61000-4-15, IEC 61000-4-7, IEC 61000-4-30, IEEE1453 (Flicker), IEEE1459, IEEE100, Report to EN50160

**Safety Standards:** IEC 61010, (600v Cat. IV, pollution level 2, 1000V CAT III if PSU fuses removed), CE Fused voltage leads (lead fuses 500mA, 700V, 50kA rupture current), IEC 61326 (EMC).

**Internal fusing:** PSU (x2), Charger input, Battery stack, Internal Thermal Switch (x2)

**Computer Requirements for Pronto Software:**

Windows 9x, ME, NT4, XP, 2000, Pentium class processor or higher.

**Case:** Pelican 1150 Guard Box:  
 Dimensions 22.9 x 19.1 x 11.0cm

**Weight:** 3.5 kg without leads and clamps

**Operating Temp:** -20°C (-4°F) to 60°C (140°F)

**Environmental: Main unit water resistant.** Leads and their connections are not watertight and for safety reasons we strongly recommend that the operator does not connect and disconnect the unit in wet environments.

**Applicable Patents:** 6424277, 0230712, 4910692

## Measurement Categories

Assessment of the hazards depends on where the connections are made in the installation, the working voltages involved and the configuration of the instrument. A brief description of the four measurement categories in the Standard can be found in Appendix A. Category IV is the most stringent.

suitably qualified. Before you make any such connection or disconnection you need to understand the dangers associated with doing this and how to eliminate those dangers and control the risks associated with CAT IV (Category IV) type high fault current electricity supplies

**PM7000 regular hardware versions**



Your PM7000 has undergone rigorous safety tests and is certified to Category IV requirements of the European IEC 61010 Standard for a measuring instrument operating at a working voltage of up to < 600V A.C. R.M.S.



Because you will be attaching the PM7000 to a potentially hazardous live circuit, you must be

**PM7000 hardware versions suitable for measurements to 1000 V A.C.RMS**



Your variant PM7000 is certified for measurements in Category III installations up to 1000 V A.C. R.M.S. Note that the hardware is different from the regular PM7000. There are internal hardware locks to prevent power being drawn from any measurement channel input. It is prudent to ensure that the internal batteries are fully charged before starting a recording.

## Power Requirements

### Regular units

When the logger is powered up on phase A above 100 Volts the batteries will automatically be charged. PM7000 normally draws about 5 Watts at voltages ranging from 100 to 600 V A.C. RMS +/-10% and 40-64 Hertz (cycles per second) derived from the Phase 'A' input. For a Phase 'A' powered PM7000, the maximum current is drawn when operating close to the low end of the voltage range, all peripherals are driven and the batteries are charging at the maximum rate (Maximum rated power is 11 Watts ).

### All units

Alternatively any PM7000 may be powered via the

2.1 mm standard jack socket (close to I1) from a separate supply at 12Vdc, 6 W. In this case on regular units the internal mains power supply is automatically disconnected from 'Phase A' (input impedance per phase 32MOhms). The alternative power input may be used, for example, when monitoring current only, when no mains supply or voltage is available, when the impedance of the 'mains' is so high that the burden of the internal logger power supply on the Phase 'A' measurement circuit is sufficient to affect the results, and on PM7000 hardware variants that do not use an internal mains power supply.



This 12VDC PSU charger socket is only suitable for connection to products certified to IEC60950.

## Safe Working Practices

### HAZARDOUS LIVE VOLTAGES

**YOU, the operator** may safely connect the PM7000 input terminals to hazardous live circuits in normal operation provided that you take sensible precautions including the following:



Ensure that the instrument operates within the limits dictated by both the 'Measurement Category' and the maximum specified working voltage, for failure to fulfill those conditions may permanently compromise the normal electrical protection provided by the instrument and could result in you being exposed to lethal HAZARDOUS LIVE voltages.



Under NO CIRCUMSTANCES make connections at locations in an installation where the electrical stresses might exceed those of the 'Measurement Category' for which the instrument is designed. Appendix 1 gives definitions of the 'Measurement Category' for different connection points in the installation. See also the section about 'Special considerations when working at high voltages' on the following page.

**YOU, the operator:**



are responsible for identifying the hazards involved when connecting the PM7000 to make

measurements.



must adopt safe working practices and take steps to manage the associated risks as well as being responsible for ensuring that the connection to the circuit being measured is electrically safe.



must ensure that the safe working voltage for the appropriate measurement category is NOT exceeded under any circumstances



are advised to use the certified Cat IV 600V test voltage leads supplied. These leads are marked Cat IV 600V or Cat III 1000V and have fuses in the alligator/dolphin clip end and safety connectors at the connection end. For your safety always use leads appropriate to the installation category and look for the necessary marking on the leads.



must treat the voltage leads with respect as they do an important job of carrying live voltage in a safe manner. Because they are flexible test leads they are strong and easy to coil and twist and will give good, safe, service when looked after carefully.



must never use damaged leads. Always check leads for wear and tear or damage before using

them. Once you are satisfied with their soundness make sure that they are securely plugged into the logger. before they make contact with any live power source.



must always connect the voltage leads through the upper 4mm voltage ports, never through the lower BNC current ports.



must always use a voltage output current transducer with this logger. This equipment is NOT designed for use with current output, current transformers.



must, when you are installing voltage output current transformers, connect them to the adaptors and then the adaptors to the logger before you attach them round the source of power. Be careful not to touch any of the connection points.



must always position your logger in a way that ensures it is mechanically stable. There must be no possibility of the test leads becoming disconnected from it while they remain attached to any external power source.



must never position the equipment so that it is difficult to disconnect from the supply.



should under no circumstances remove the front panel of the logger while it is connected to a power source.



In line with safety requirements the PM7000 gives correct over range voltage readings. No danger will arise for an operator relying on any indicated values. However, this does not remove the possibility that a single fault in the unit could give misleading results, leading to a hazard for the operator.



Peripheral devices connected to the I.T. interfaces of the PM7000 must conform to the requirements of IEC 60950. Failure to comply could result in loss of data or damage to the I.T. interfaces and delicate electronics inside the unit. The USB Serial interface is opto-isolated to protect the PM7000 from faults in IEC 60950 compliant I.T. equipment that may be connected. The USB memory stick interface is NOT isolated from the electronics inside the PM7000.

## Care of IT equipment

If you are using a computer to download data from your PM7000, you are using equipment more delicate than the PM7000. (It could be some other instrument.)

**You must take care to protect the more delicate equipment from the environment – in accordance with the directions from the manufacturer of the delicate equipment. Most computing devices conform to the requirements IEC 60950, whereas the PM7000 is designed to conform to IEC 61010-1, which requires more stringent testing for resistance to moisture and liquids.**  
**HAZARDOUS LIVE VOLTAGES**

## Special Considerations When Working at High Voltages

### Measurements at voltages less than 600V A.C.

#### R.M.S



NEVER connect a regular PM7000 to a live voltage source outside the specified range of 90-600 (+/- 10%) V A.C. R.M.S. when using the 'PHASE A' voltage input to power the PM7000

### Measurements at voltages greater than 600V A.C.

#### R.M.S



Under no circumstances may a regular PM7000 be used for measurements using the 'PHASE A' voltage input at working voltages greater than 600V A.C. R.M.S. because the safety of the instrument will be compromised (Note 5 below describes some of the hazards that will result).

The front panel is clearly marked to ensure that the distinction is easily made between PM7000 hardware versions suitable for measurements to 1000 V A.C. R.M.S. and regular PM7000 units

For measurements to 1000 V A.C. R.M.S. use only a PM7000 instrument with an overlay that is clearly marked to indicate 1000 V A.C. R.M.S. capability. In 1000 V A.C. R.M.S. instruments a hardware lock inside the unit is fitted to the connectors that would normally carry BOTH of the fuses in a standard PM7000. The

lock is clearly marked to indicate its purpose and must not be removed.

The operator must understand the distinction between 'measurement category IV' and 'measurement category III'.

The installation to which the connection is made MUST be classified as CAT III or lower i.e. within the building installation.

The dielectric strength of the 'measurement circuits' in a PM7000 is adequate for use in 600V A.C. R.M.S. CAT IV installations or 1000 A.C. R.M.S. CAT III installations.

Do not use a regular PM7000. The 'mains circuit' (internal integral power supply) in a regular PM7000 is designed for operation up to 600V A.C. R.M.S. Attempts to complete connections to a regular PM7000 at a working voltage greater than 600V A.C. R.M.S. may cause one or both fuses to blow and the P.S.U. protection circuits could rupture or become permanently damaged. In the event that a single fuse remained intact under those circumstances the user would have no warning that parts of the instrument may become 'hazardous live'. Excessive leakage current could occur either because of damage to PSU components or when the 'PHASE A' voltage input exceeds 775 V A.C. R.M.S. - because of the intrinsic leakage capacitance in the mains transformer. These effects will occur even in CAT III installations.

## Environmental Considerations

### General environmental considerations

PM7000 may be used either indoors or outdoors. Much effort has gone into protecting the electronics inside the PM7000 box from ingress of moisture and dust. However the manufacturer makes no guarantee of waterproofness as much depends on how well the instrument and particularly the box seal is cared for by the operators.

The enclosure is protected against ingress of dust and moisture.

But please note the following features:

- The storage and operating environment must not exceed pollution level 2.
- PM7000 is not designed to operate in rarefied

atmospheres. The impedance protection networks are encapsulated. Power supply components operate with air spaced creepage and clearance limits of 14.5mm or greater.

- PM 7000 must be operated within temperature limits -20° C (-4° F) to 60° C (140° F) and relative humidity is not to exceed 95% RH (non condensing).
- PM7000 must not be subjected to MAINS supply RMS voltage fluctuations greater than  $\pm 10\%$  of the nominal voltage range 90-660 VA.C. RMS specified for the instrument .
- PM7000 is designed to withstand transient overvoltages typically present on the MAINS supply nominal voltage in environments of pollution level 2.

## Storage

For prolonged storage it is good to keep your logger in a cool, dry place. The batteries' self discharge current and capacity loss will accelerate at higher temperatures. Ensure that the logger batteries are fully charged before storing for any extended time period of one month or more.

## Performance

For optimum performance we advise you to take note of the following precautions:

- Your logger operates best in a cool environment. It will operate at a high temperature but as the temperature rises, the ability of the batteries to retain their energy will gradually deteriorate.
- Avoid direct sunlight.
- Operating temperature must be within  $-20^{\circ}\text{C}$  to  $60^{\circ}\text{C}$ .
- Maintain adequate air circulation paths to ensure proper cooling of the unit.
- Avoid sudden temperature swings of  $10^{\circ}\text{C}$  or more.

- Avoid high humidity. Relative humidity is not to exceed 95% RH non condensing.
- Use an outer protective sleeve designed by Outram to protect the instrument from rain, moisture and spillage of liquids. The PM7000 is not designed for unprotected use under those conditions.
- Avoid locations susceptible to vibration, shock, static, high magnetic, electro-magnetic, or radiation fields.
- PM7000 is designed withstand RMS voltage supply fluctuations within  $\pm 10\%$  of the nominal voltage operating limits.
- Avoid extremely dusty, dirty or corrosive gas environments.

**The PM7000 is not designed to withstand damage from nearby or direct lightning strikes, circuit-breaking, or exceptionally high electromagnetic radiation greater than specified in IEC 61326 in close proximity (p11 of IEC 61326 specifically excludes consideration of operation in those situations). General environmental considerations**

## General Maintenance

### Battery maintenance

For best practice maintenance and peace of mind we recommend the following:

- 1. Keep your internal batteries charged even when the logger is not in use.**  
Regularly check battery charge status in the menu. If the charge is low, recharge the batteries by plugging the logger into a power source and leave for up to 16 hours.  
When the logger is stored, plug it into your mains supply for a day every two months.

braided so that tangled and lost leads will become a thing of the past. Check regularly for any signs of damage or kinks in the leads. Keep accessories in the pouches in the roll.

- 4. Operating Environment**

Be aware of the environmental considerations as outlined in the section "Environmental Precautions".

NB Don't leave your logger in a hot car in the sun. High temperatures are the enemy of batteries. Batteries self discharge fast at  $70^{\circ}\text{C}$ !

### Further maintenance

- 2. Keep the logger clean**  
Wipe the overlay gently so as to retain its insulating properties and any warning markings. Use a damp, soft cloth and a mild soap or mild, nonabrasive detergent.
- 3. Keep your logger and kit in the bag**  
We have designed the bag with the welfare of your logger and sensors and cables in mind! Both the Rogowski coils and the voltage probes have been

## Appendix A Measurement Categories

The measuring circuits in the PM7000 are subjected to electrical stresses that increase the closer the connection point is to the source of the installation.

Safe operation of the instrument requires that account must be taken of BOTH the 'Measurement Category' at the point of connection AND the working voltage applied to the instrument at each of those connections. To assist in assessing the 'Measurement Category' that applies in any particular circumstances the following section (6.7.4) of the European IEC 61010 Standard for measuring instruments is quoted here as follows:-

### “Measuring” circuits

Measuring circuits are subjected to WORKING VOLTAGES and transient stresses from the circuit to which they are connected during measurement or test. When the measuring circuit is used to measure MAINS, the transient stresses can be estimated by the location within the installation at which the measurement is performed. When the measuring circuit is used to measure any other electrical signal, the transient stresses must be considered by the user to ensure that they do not exceed the capabilities of the measuring equipment.

In this standard, circuits are divided into the following measurement categories:

**Measurement category IV** is for measurements performed at the source of the low-voltage installation. NOTE 1 Examples are electricity meters and measurements on primary over-current protection devices and ripple-control units.

**Measurement category III** is for measurements performed in the building installation. NOTE 2 Examples are measurements on distribution boards, circuit-breakers, wiring, including cables, bus-bars, junction boxes, switches, socket-outlets in the fixed installation, and equipment for industrial use and some other equipment, for example, stationary motors with permanent connection to the fixed installation.

**Measurement category II** is for measurements performed on circuits directly connected to the low voltage installation. NOTE 3 Examples are measurements on household appliances, portable tools and similar equipment.

**Measurement category I** is for measurements performed on circuits not directly connected to MAINS. NOTE 4 Examples are measurements on circuits not derived from MAINS, and specially protected (internal) MAINS-derived circuits. In the latter case, transient stresses are variable; for that reason, 5.4.1 g) requires that the transient withstand capability of the equipment is made known to the user.”

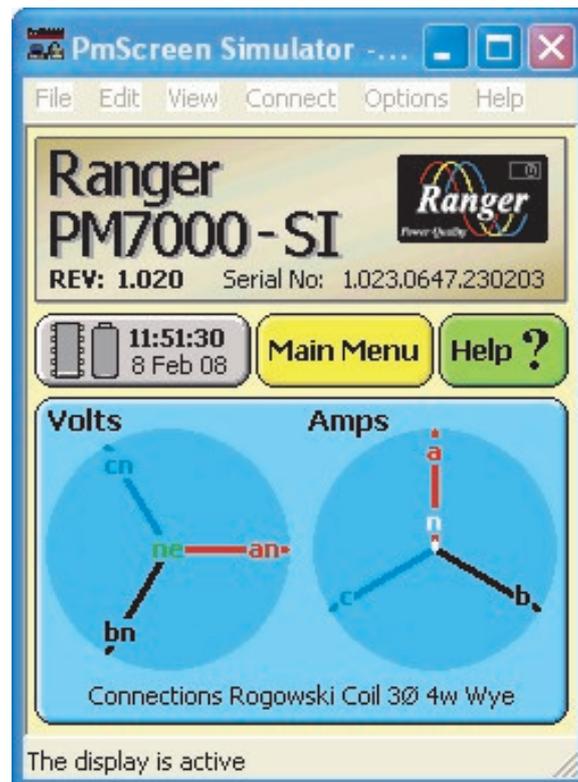
## Appendix B Graphic Symbols

Graphic Symbols used on the PM7000 and in this manual are used in accordance with this table. Table 1 of the Safety Standard IEC61010-1 part 1.

Number	Symbol	Reference	Description
1		IEC 60417 – 5031	Direct current
2		IEC 60417 – 5032	Alternating current
3		IEC 60417 – 5033	Both direct and alternating current
4			Three-phase alternating current
5		IEC 60417 – 5017	Earth (ground) TERMINAL
6		IEC 60417 – 5019	PROTECTIVE CONDUCTOR TERMINAL
7		IEC 60417 – 5020	Frame or chassis TERMINAL
8		IEC 60417 – 5021	Equipotentiality
9		IEC 60417 – 5007	On (Supply)
10		IEC 60417 – 5008	Off (Supply)
11		IEC 60417 – 5172	Equipment protected throughout by DOUBLE INSULATION or REINFORCED INSULATION
12			Caution, risk of electric shock
13		IEC 60417 – 5041	Caution, hot surface
14		ISO 7000 – 0434	Caution, risk of danger (See note.)
15		IEC 60417 – 5268	In position of a bi-stable push control
16		IEC 60417 – 5269	Out position of a bi-stable push control
17		CFR 47 part 15	FCC Rules Emissions and Susceptibility



## A Start Guide for the Ranger PM7000



PMScreen Simulator



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## First Step: Check Your Kit



## PM7000 and kit

- **Ranger PM7000** power quality analyzer
- Four 24" 6000 Amp Flexible Current Clamps (Rogowski coils) (max conductor size 8"), braided
- Five Voltage probes 1000V Cat III (600V Cat IV), braided
- Three Neutral Common Leads
- Mains lead or charger
- USB lead (in tool roll pocket)
- Pronto for Windows Analysis Software
- Customer CD (not shown)
- Customized bag and tool roll
- Portable Bluetooth device (Netbook/Windows compatible mobile phone) or Bluetooth Adaptor

## Second Step: Put Your PM7000 on Charge

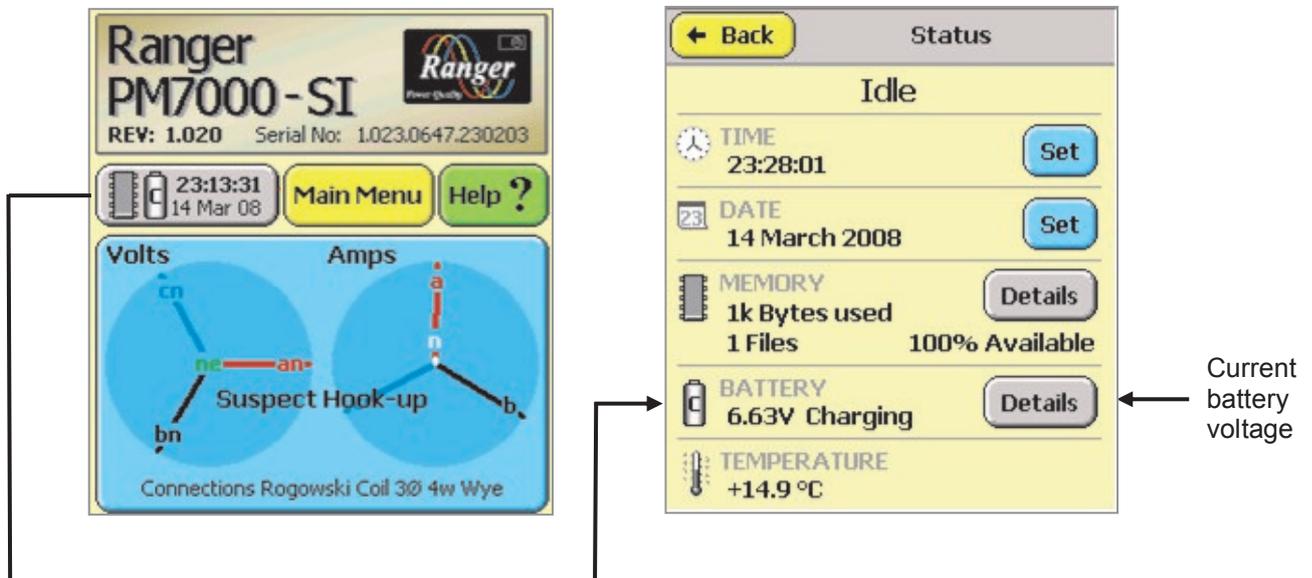
**Immediately you take delivery of your PM7000 plug it into the mains, using the mains lead or wall charger, to charge the batteries ready for use.**

Whenever your logger is in use, that is, attached to a voltage source above about 90 to 100 Volts, the batteries will be charging automatically. We recommend that at all other times the logger is plugged into a power source to keep the batteries well charged and the unit always ready for action. This is good practice. However, the PM7000 can start up with batteries pretty flat and function once power is applied. There will soon be enough charge to allow any activity to be closed down successfully and retained in memory.)

Below is the end plate of a PM7000 showing the two ends of the mains cable attached. Note the bottom row of BNC connectors for the Rogowski coil current sensors.



Once you have established your user interface, PMScreen (after [Fourth](#) or [Fifth Step](#)), you will be able to check the current battery voltage by clicking the grey status button (see below).



## Third Step: Put Your Portable Device on Charge

Whether you are using a Bluetooth adaptor on your laptop, a mobile phone with Windows Mobile 5, PDA or Netbook in order to 'talk' to your PM7000 in the field, make sure that your device is charged. Once it is charged or whilst it is still plugged in, you can make your connection with the logger.

recommend a car charger to charge your device as a useful addition to your kit if you will be using the logger at different geographical locations.)

After using it off the cable we recommend you leave your portable device on charge when not in use. (We

## Fourth Step: Make the Bluetooth Communication between Your Portable Device and the PM7000

### Prepare the PM7000

Opening the PM7000 lid will stimulate it and it will wake up the Bluetooth communication. The Bluetooth LED should flash twice every 4 seconds to show that the Bluetooth is awake. The Bluetooth will remain in this “Discovery Mode” for about 1 hour after the lid is opened. (Once the logger is stimulated you may close the lid again.)

### Prepare the Bluetooth connection

The next step is to open “PMScreen”, the application programme that brings the live PM7000 screens onto your computer, or portable device. If you have received your portable device from your distributor, PMScreen will have been preloaded onto the desktop or into the principle functions of the device. Once you have turned on your device, click on “START” or the little Windows symbol if the icon is not immediately obvious.

If you are using a Bluetooth adaptor with your own laptop you will need to install our software, Pronto for Windows, onto your computer by inserting the customer CD. (Loading necessary drivers for USB connection is covered later in the [Fifth Step](#) of this Quick Start Guide). You will find “PMScreen” in the Pronto4w directory.

Open “PMScreen”.

You will be invited to select the relevant COM Port. The COM port is COM 6 on the HP iPAQ114. Touch on “Reconnect to COM6”. (Other devices may use other COM ports).

The nominal range for Bluetooth communication is 10 meters (30 feet). It may be more in open line of site conditions or less if obstructions lie between the devices. If your portable device and logger are within range of each other, and if the logger is in discovery mode (the blue light on the front panel is flashing), the portable device should offer a list of any Bluetooth devices in range. The reference to the logger will come in the form of PM7000SNxxxx.

Depending upon how the portable device has been set up, this list may be in icon form, in which case the Serial Number part of the text may have been truncated. This will not matter if you have only one PM7000 but it could be ambiguous if you have more than one. To avoid the latter, we recommend you list a

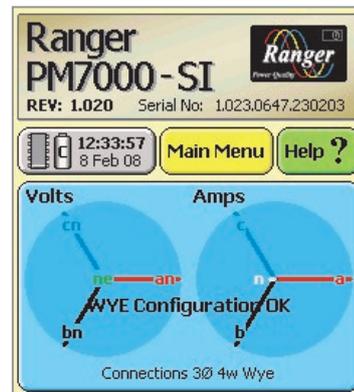
number of loggers in purely text form. To change between icon and text listing, touch on the ‘View’ option on the bottom right of the screen and select the “view by text”.

Touch on the Serial Number of the logger you wish to talk to. This will cause the portable device to connect to the logger and the Bluetooth light on the logger will go solid blue. Initially PMScreen may say the logger is not responding (actually the logger is waking up but can’t talk properly yet). Then it may say “Finding” and then “Connecting...” and then “Found SNxxxx”.

PMScreen will show one of the following:

- its initial screen (see below), if you have started a new session
- the screen that was active when you disconnected from the previous session.

At this point you are now in contact with the logger.



**A typical PM7000 initial screen as seen on your portable device or PC**

Now you can explore all the options that are available to you within your PM7000.

### Note

Before you go any further, you may wish to explore the PM7000 menu interface in some detail without involving the logger. You can do this via the PMScreen Simulator. For more information on the simulator see the [Sixth Step](#).

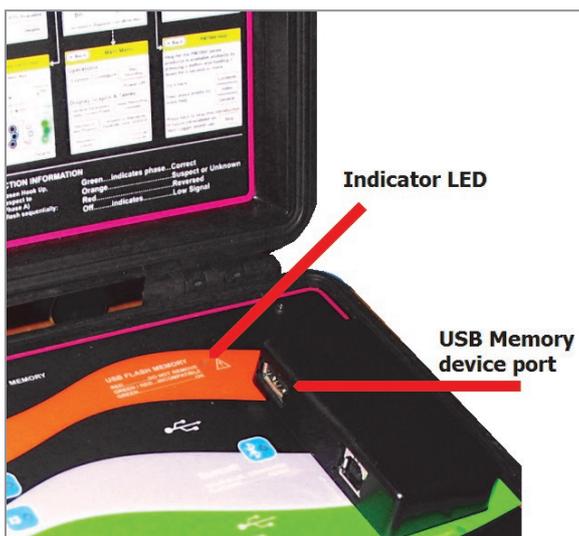
When you have finished with your portable device, IT IS IMPORTANT to release the Bluetooth communication on it or the device gets stuck. **Do this by leaving PMScreen by pressing “File”/“Exit”.**

You should do this BEFORE you go out of range.

## Fifth Step: Make the USB Communication Between Your Computer and the PM7000

To bring 'PMScreen' up on the computer, first attach the logger via the USB communication lead provided or activate your Bluetooth adaptor to search and find your logger.

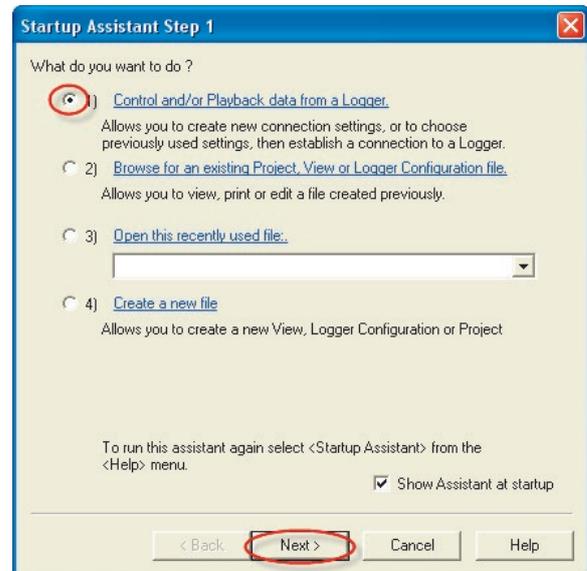
The USB port indicated will take a USB memory device (jump drive), the other port takes a USB lead to communicate with a PC.



Insert the customer CD. If the PM7000 is using the USB communication method you will need hardware drivers. They may already be on your computer but if they are not click on "Install PM7000 Hardware Drivers" and follow the instructions. If you are unsure whether or not you have the drivers install them anyway. There is no adverse effect from re-installing them. Then launch Pronto. Follow the "Start Up Assistant" to connect to your PM7000. The first time you make a new connection there are four steps.

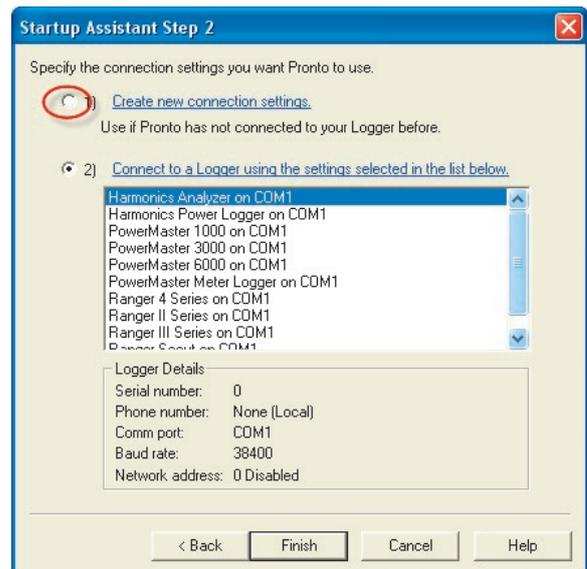
### Startup Assistant

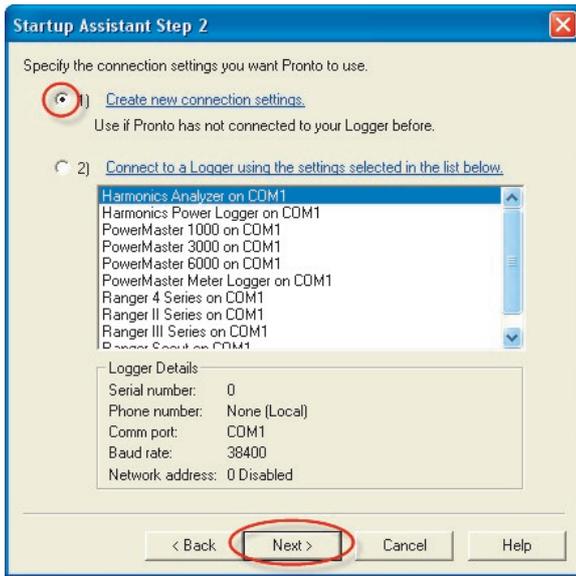
In Step 1 the default selection is "Control and/or Playback data from a logger". You do not yet have any data and files to browse for.



Click on 'Next'.

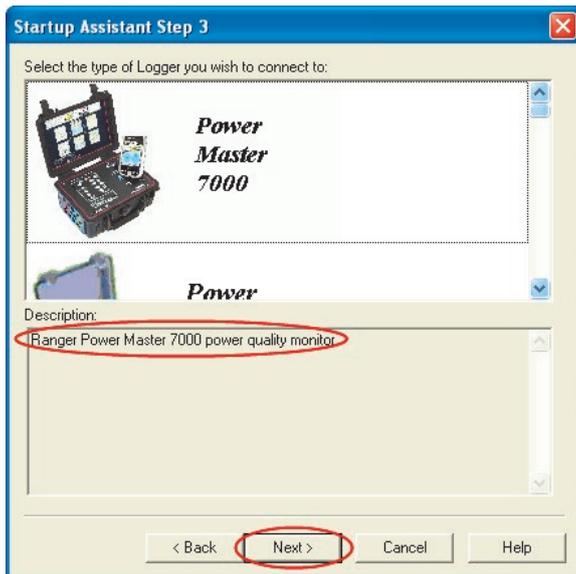
In the following Step 2 for this first connection select 'Create new connection settings'.



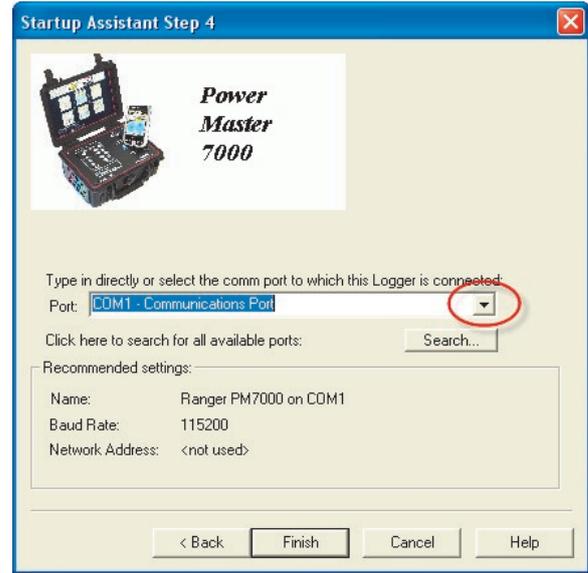


Click on 'Next' to bring up Startup Assistant Step 3. This will give you the list of Ranger products supported by Pronto.

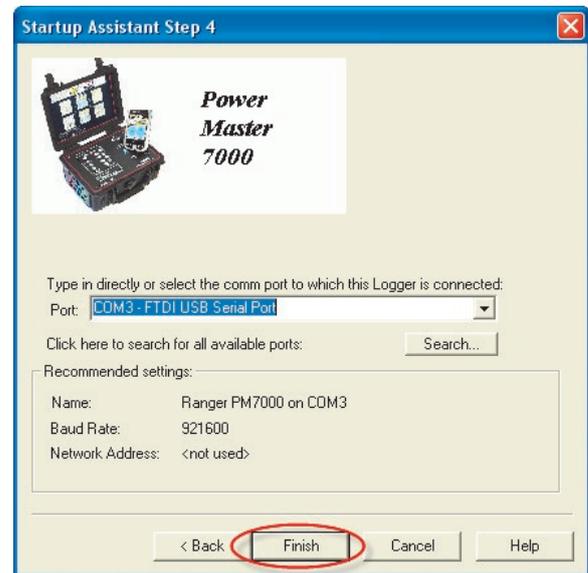
The PM7000 is at the top of the list and will appear in the window.



Click 'Next' to select it and bring up the final Startup Assistant Step 4 screen. Now you are going to search for the USB communication port.



Click on the port box. A dropdown menu will reveal the USB communication channel option. Select it. FTDI are the initials of the USB manufacturer.

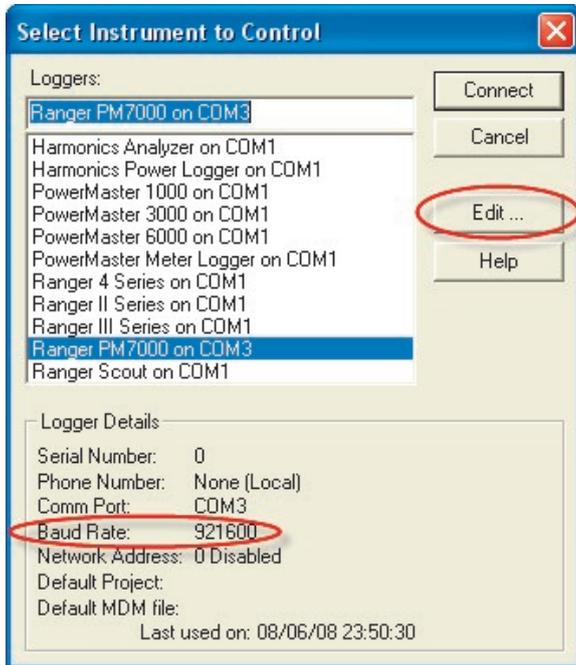


The USB port will be assigned a particular port number, in this case 3. Each time you connect your USB serial lead to the same port on your computer the port number will be 3. If your computer has multiple USB ports and you choose a different port next time the PM7000 and computer communicate, Pronto will have to find the new communication Port.

Note the Baud rate (the speed at which traffic flows between the logger and the computer). For the PM7000 it is 921600 and Pronto will choose this value for you when you select PM7000. (Different Ranger models may have different baud rates).

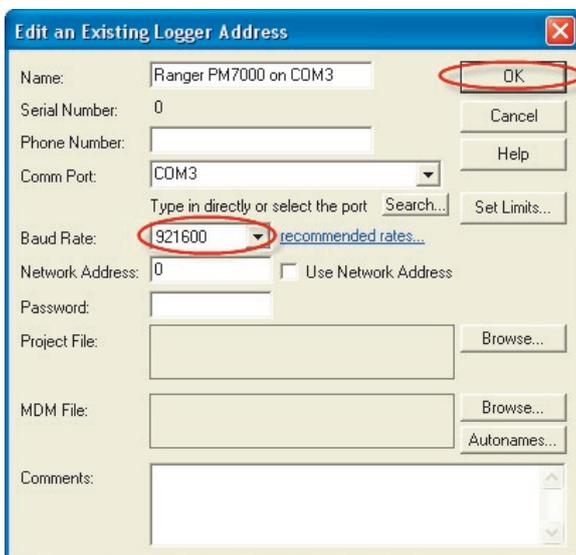
Click 'Finish'.

The following 'Select Instrument to Control' window may come up confirming the right instrument is connected to the right port. The following example of Pronto on a computer with more than one PM7000 attached.



Here is the opportunity to change the name, add comments or alter the baud rate if you ever need to do so.

Click on 'Edit' and bring up an 'Edit an Existing Logger Address' screen.

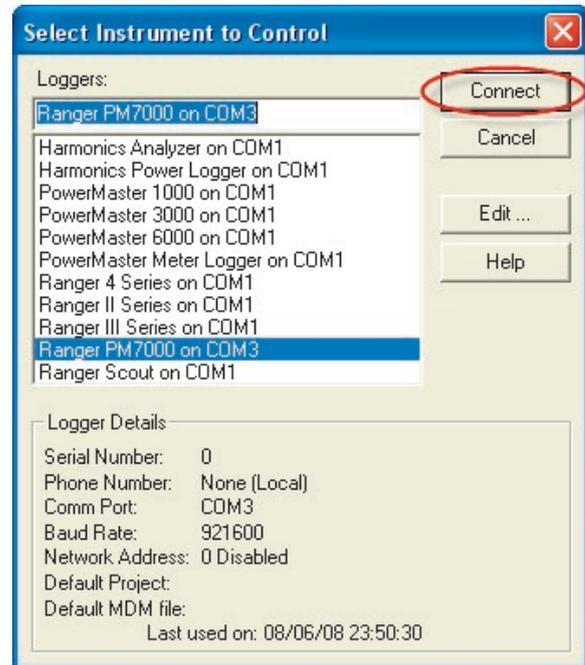


Clicking on 'recommended rates...' will bring up Pronto Help and advice on the correct baud rate). Currently the correct baud rate for the PM7000 is automatically

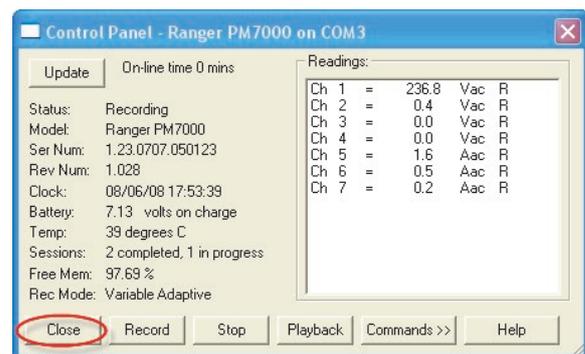
chosen by Pronto. In the future if further types of communication mode become available (such as over the mobile phone network) it may be necessary to change the baud rate.

Click OK to return to the 'Select Instrument to Control' window.

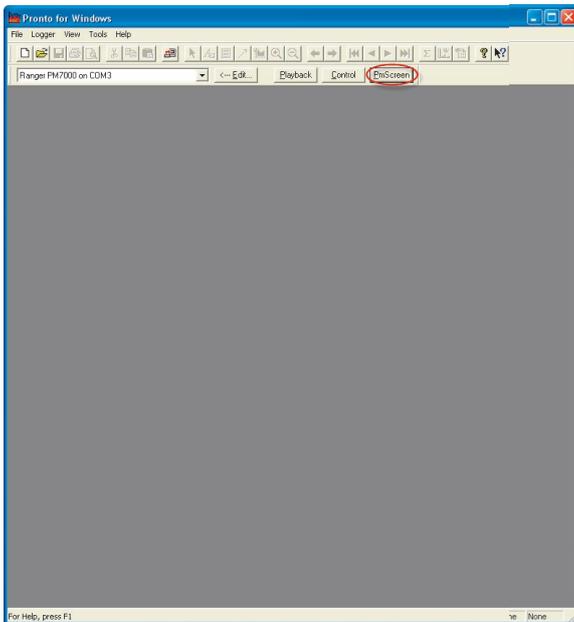
Finally click on 'Connect'....



and you'll see on the screen 'Pronto is connecting to the instrument'. 'Control panel' comes up next. The 'Control Panel' gives you useful information on the status of the logger such as how many sessions you have recorded. Historically this screen was used to communicate to Rangers before the latest models were given the display user interface, PMScreen. If your requirement is to play back data or start a recording click on the appropriate button here. To access PMScreen click 'Close'.



Up comes the main Pronto screen.



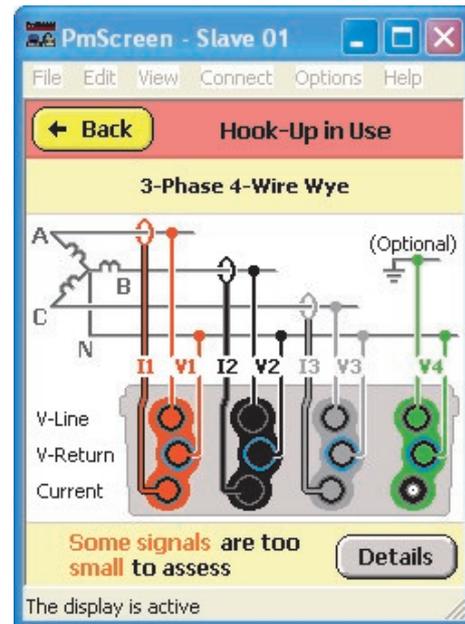
To bring up your PM7000 display click on 'PMScreen' on the tool bar.

Now you can talk to your Ranger via the computer. The screen to come up will be whichever you used the last time you talked to your PM7000. For the first time you will see the initial screen of your PM7000 on the computer in front of you. This is the default screen with a 3 phase 4w wye Hook Up.

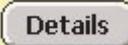
You can enlarge or contract the PMScreen area by clicking "View", "Zoom in" or "Zoom out". This screen is intended to give you an immediate indication of system status, and especially the connections you have made (the "Hook up"). The PM7000 does need to know what was *intended* so that it can assess the voltage and current phases it finds correctly.

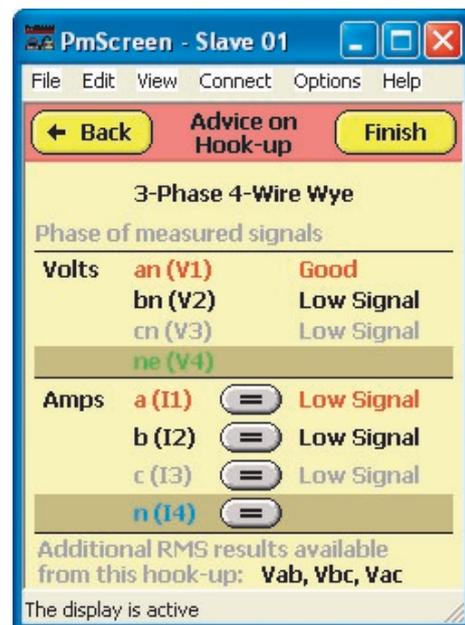
If you want further information click anywhere in the blue box and bring up a 'Hook-Up in Use' screen.

Please note that this example Hook-Up shows EU phase colours. These colours can change depending on the phase colours specified in PMScreen. These can be changed by clicking on "Main Menu", "Configure", "Preferences" then clicking on the phase colours preferred. Then press "Accept" to save your preferences and "Back" to get to the Main Menu.



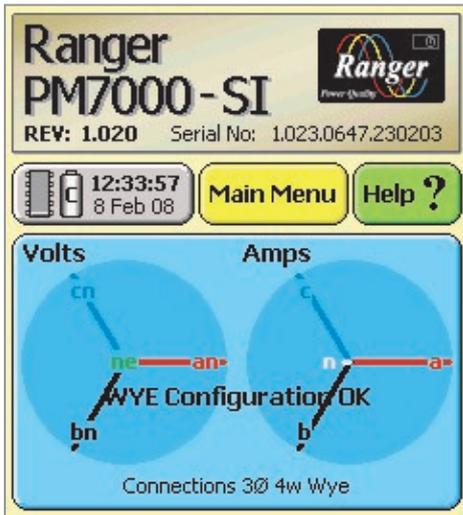
Note the default Hook Up.

Click on  to get...

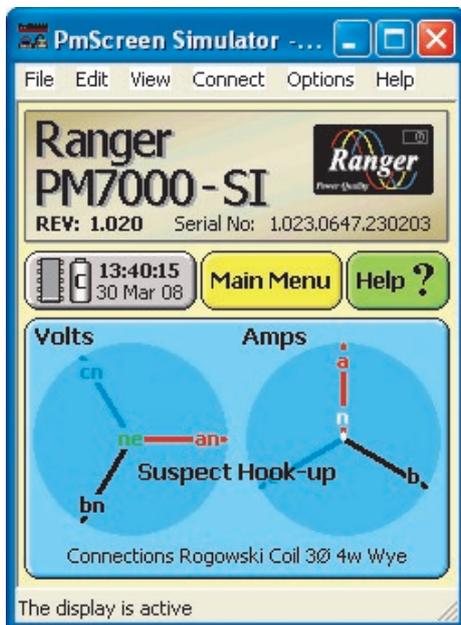


This screen confirms what we know; that only V1 has a proper signal in this case.

This is an example of the initial screen for a 3 phase 4 wire wye application showing the current correctly in phase with the voltage.

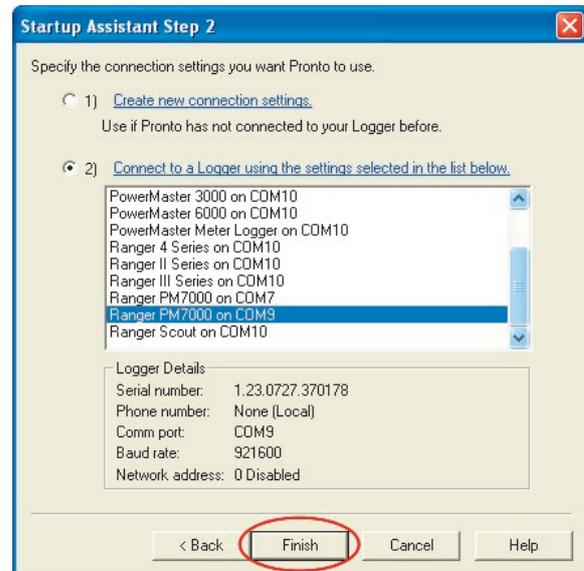


Here is another possible initial screen.



In this simulator example the phasor diagram shows 'Suspect Hook-up' to alert you to the likelihood you have fitted the wrong CTs. The give away is the current, 90 degrees out of phase with the voltage.

Subsequent Connection to the Computer.



Please note that NEXT time you open Pronto it will remember the previous connection information and four steps will become only two steps.

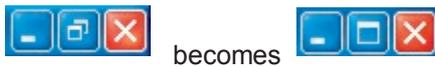
If however you use a different port subsequently, Pronto will ask you to go through a similar selection process, and then it will remember that connection also.

## Sixth Step (Optional): Using the Simulator

### Use the simulator for learning about PMScreen

Before you do your first recording (or after) you may wish to play with the PM7000 simulator. We suggest that as you read through the rest of this guide or the manual you have the Simulator open on the computer and follow the steps in parallel with the Simulator.

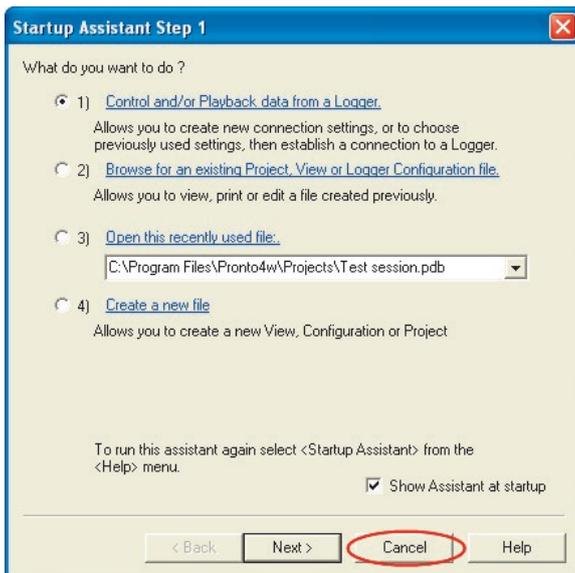
If you wish to have the instructions and the Simulator open at the same time 'Resize' the material by clicking on the middle box, top right of the screen...



... and make room for both programmes on the computer screen.

### To bring up the simulator

Insert the customer CD into your computer. Launch 'Pronto.exe'. Cancel the "Start up Assistant" as it isn't needed for this activity.

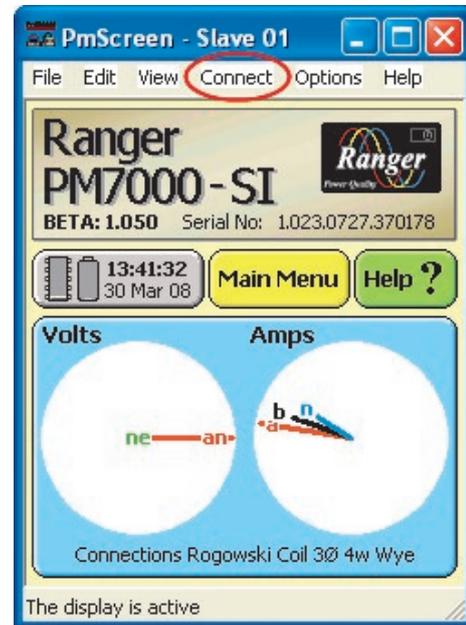


The main Pronto window will come up. Click on 'PMScreen' on the tool bar.



If you have a logger connected and are communicating with it, clicking on 'PMScreen' will bring up PMScreen on the computer screen. Select the

Simulator by clicking on 'connect' on the top tool bar of PMScreen.



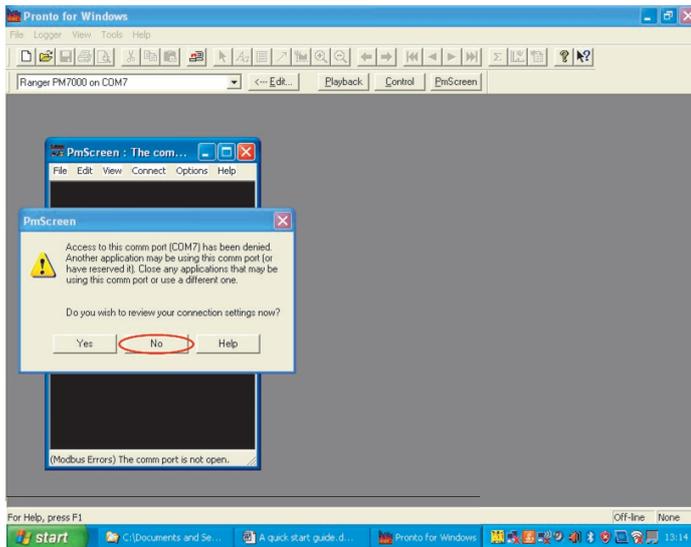
Follow the path from 'Launch Simulator' to 'PM7000' after which the Simulator screen will arrive. See below.

If no logger is connected, when you open Pronto the following advice window will come up:

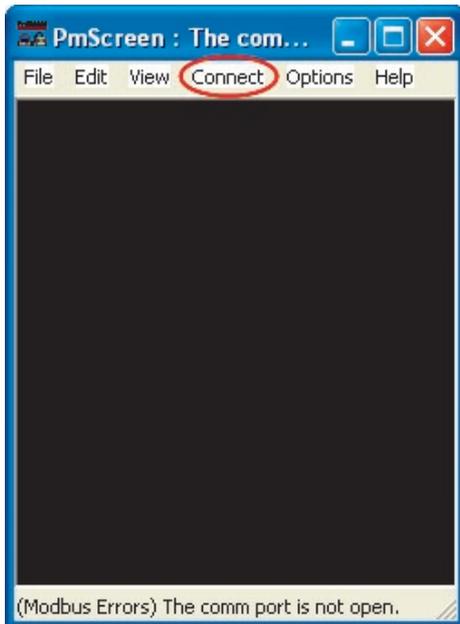


Click OK and it will go away. For the simulator we don't require a communication route.

Click on 'PMScreen on the Pronto tool bar.



For the same reason you are told "Access to this comms. port has been denied". Click on "No". This window will go away.

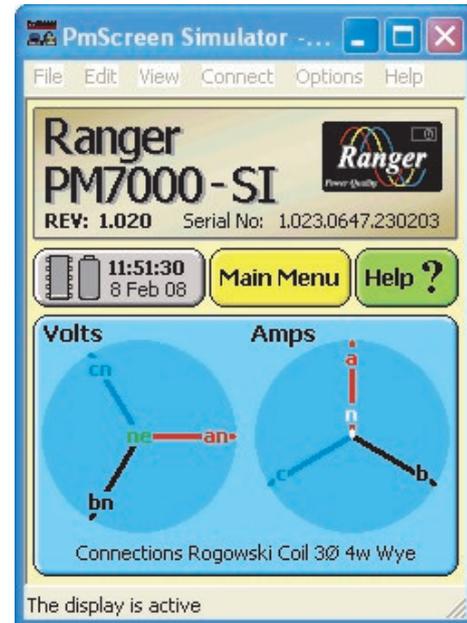


In this example there is no logger connected and therefore no live PMScreen

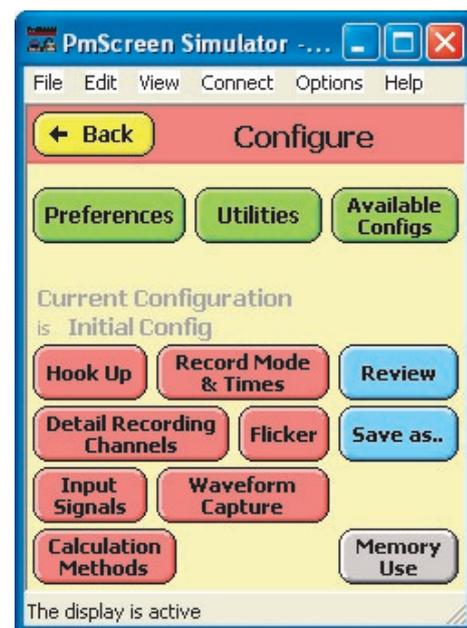
Click on "Connect" on the 'PMScreen' tool bar, then "Launch Simulator" and select "PM7000". The Simulator will arrive.

Yet another way into the Simulator is to click on PmStart on the customer CD and follow the steps indicated.

Now you have the initial Simulator screen in front of you.

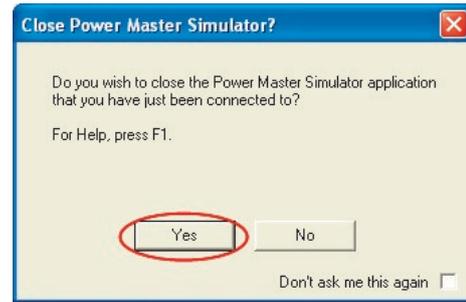
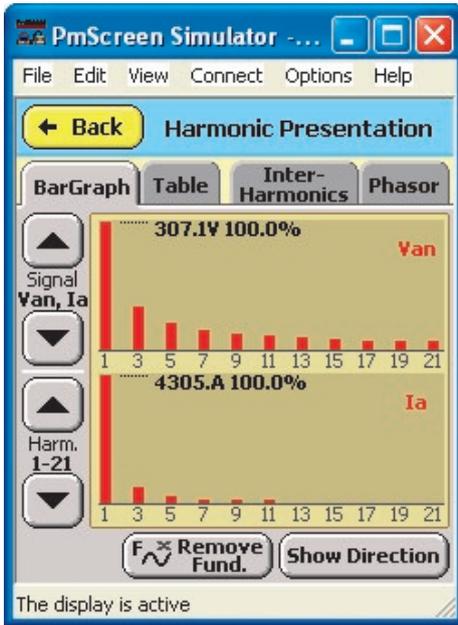


The Simulator will give you a comprehensive set of artificial readings. Use this facility to investigate the capability of your new PM7000.



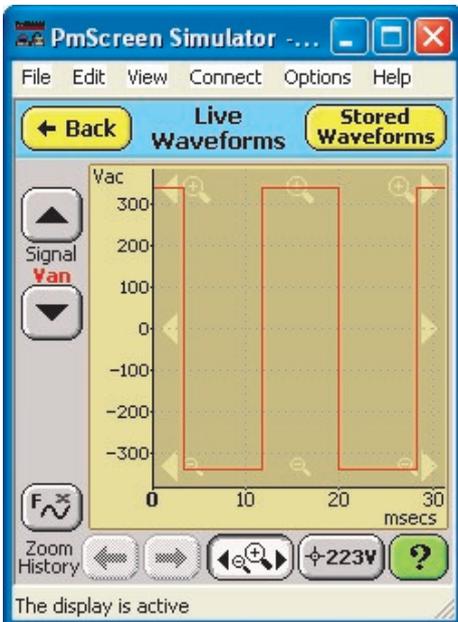
Here is an example screen, the 'Configure' screen, showing the extent of the options available to set up. Note the 'Hook up' button.

## Further example screens



## Button help

If you hold down a button on PMScreen for a few seconds, most of the time you will stimulate the popping up of a help message. This message will explain the function of the button you are pressing. We hope you find it useful.



Explore what is available to you as you use your PM7000.

When you close the Simulator the following window will appear. It is asking you to close down the executable programme running PMScreen. Click 'yes'. And the programme will close down.

## Seventh Step: Make a First Recording with the PM7000 by Measuring the Live Mains (or Using the Simulator)

Below we go through some basic steps to show you how to start a recording. These will be the same whether you are practicing on the Simulator or doing it for real on the logger itself.

If using the PM7000, plugging it into the mains will give you readings of Phase A voltage. Let us measure this voltage. If you don't have a mains cable you will need to clip voltage probes onto Phase A line and return.

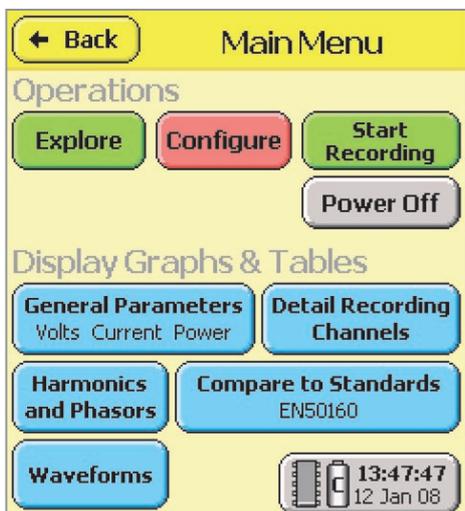
We'll use the default hook up connection that comes with the logger. This is 3 phase 4 wire wye. The initial screen always indicates the hook up connection. See the simulator screen in the previous section.

In a genuine 3 phase application it is valuable to check the vector diagram to make sure your connections are correct. If all your phases appear to be in error by 90 degrees, check that you have not physically installed voltage output CTs but selected flexible Rogowski coils in the logger set up, or vice versa. If your Rogowski coils (or CT's) are reversed this will be indicated on the vector diagram and you will have the opportunity to correct the orientation in PMScreen under 'Hook ups'.

Note. Using the simulator for this exercise will give you phase readings, doing a single phase live measurement of the mains will not.

**Main Menu**

Click on **Main Menu** to produce the following 'Main Menu' screen.



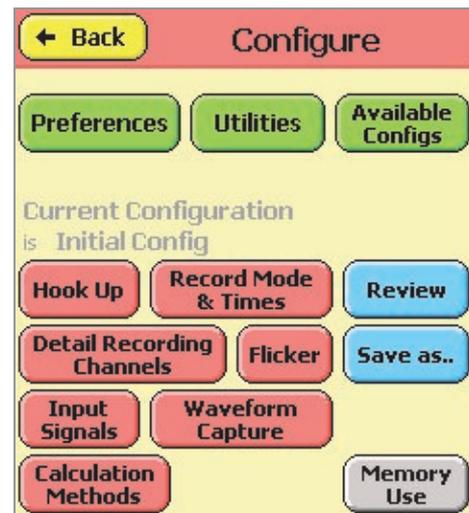
This main menu screen gives you the opportunity to

select **Explore** to explore your stored data, **Configure** to configure your different set ups, **Start Recording** to start a recording' or **Display Graphs & Tables** either historically or in some cases live. These latter buttons, the ones displaying your results, are all blue and their functions are explained in detail later in the manual.

As we are interested in doing a simple "start" we shall ignore these buttons for the time being and click on

**Configure**

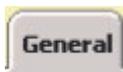
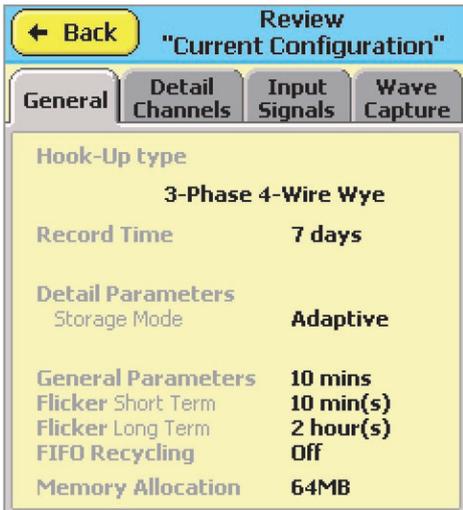
to bring up the screen that contains the pink 'set up' buttons:



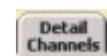
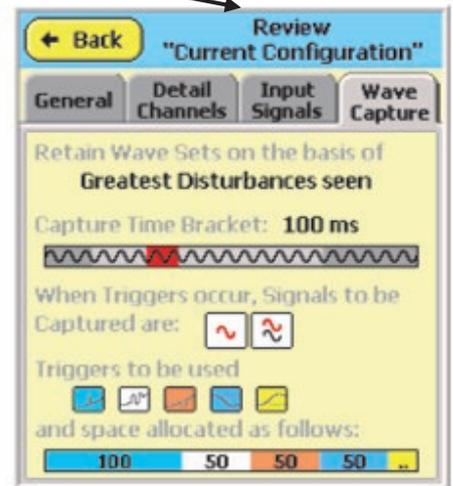
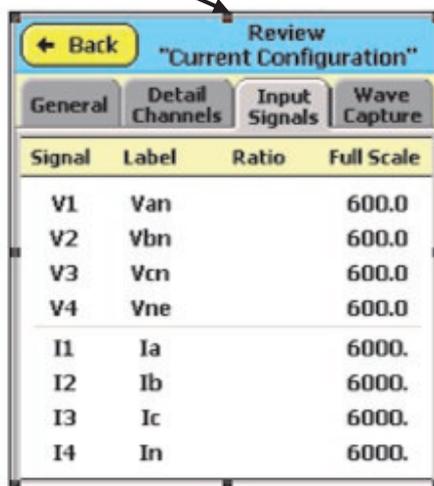
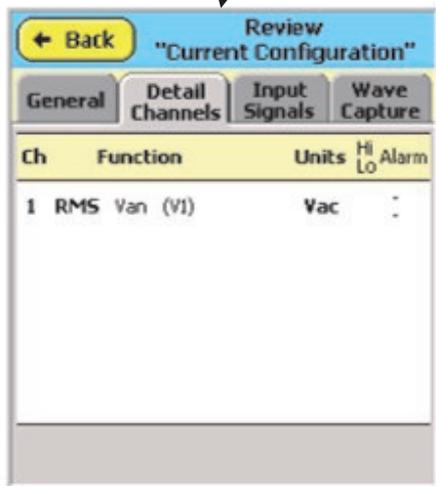
The pink buttons bring up our 'set up' screens and are described later in the manual.

**Review**

For the moment we want to **Review** our initial set up as configured by the factory.



The Review screen shows our general set ups such as duration of recording.



The Detail Channels screen shows the channels with functions selected to be recorded using the Adaptive Store process, in this case we are measuring voltage on Phase A only.



The Input Signals screen shows the input signals available to you with the particular hook up.

In the PM7000 you have the facility to rank the wave sets, choose a time during which the trigger is captured, allows you to decide which signals to capture, which type of fault condition to trigger and how much memory to allocate to each type. The

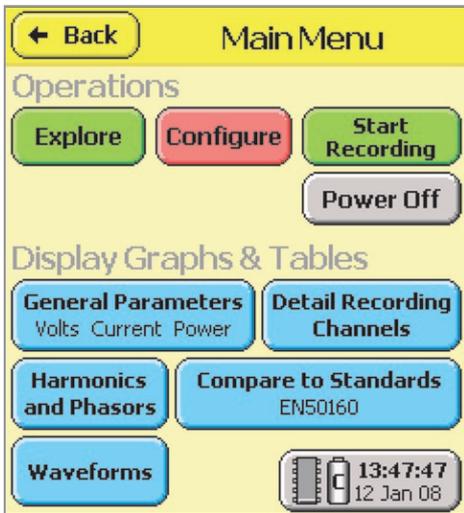


screen shows you how the logger is set up.

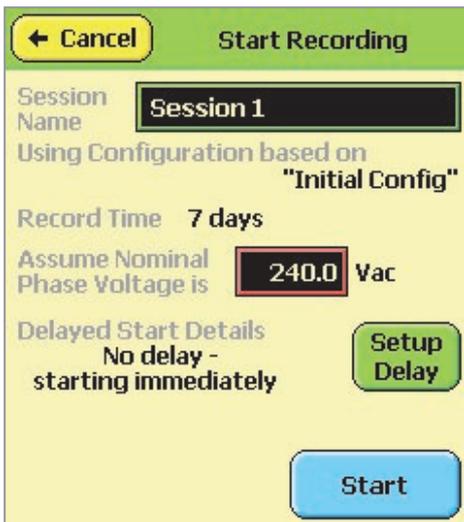
(How to set up Waveform Capture is explained in detail in the Manual).

We assume we are satisfied with the set ups (factory) for this initial exercise so we can now start the recording. To do this we go up the menu tree using the

 button until we arrive back at the Main Menu screen.



Now we touch  and bring up the 'start recording' screen.



If you want to give this first session a different name

touch the box  on the above screen and bring up the Keyboard screen.



Use the keyboard to 'clear' the box by pressing  and type in another name and press . A more detailed explanation of how to use the keyboard is found in the manual.

One key worth mentioning is the up arrow key . Pressing this will allow you to type in the file name and the first letter only will automatically be a capital letter.



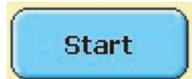
Now you have a screen showing you something similar to the above details. If you change your mind it is

possible to  your recording set up and redo it.

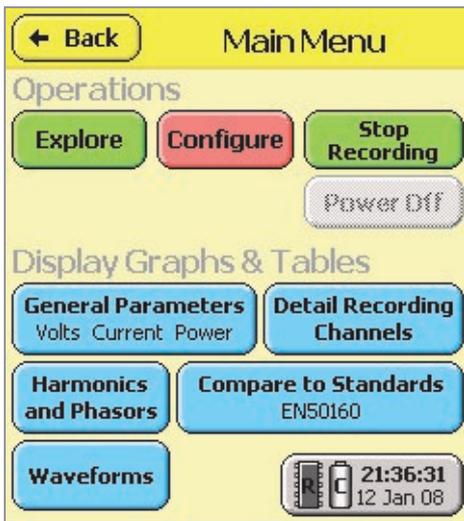
This screen gives you the opportunity to adjust the

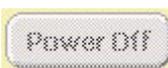
nominal phase voltage by pressing  or  
 delay the start by pressing .

See “USB Memory Device operations in the Ranger PM7000” in the manual for more information on the delayed start facility.



Now we can start recording. Touch  and the logger will start recording. The screen will revert to the ‘Main Menu’:



Note the recording button has changed to give you the option to  but the  button is greyed out so that you cannot inadvertently turn the power off while the logger is recording.

The PM7000 is now set to record for 1 week. If the recording logger is interrupted by a power outage, once power is resumed it will automatically restart in the same session for all the time the restart is within that set period.

At the end of the set period the recording will stop automatically but it is perfectly OK to stop the recording at any time to see the results, or download, and then ‘start recording’ again.

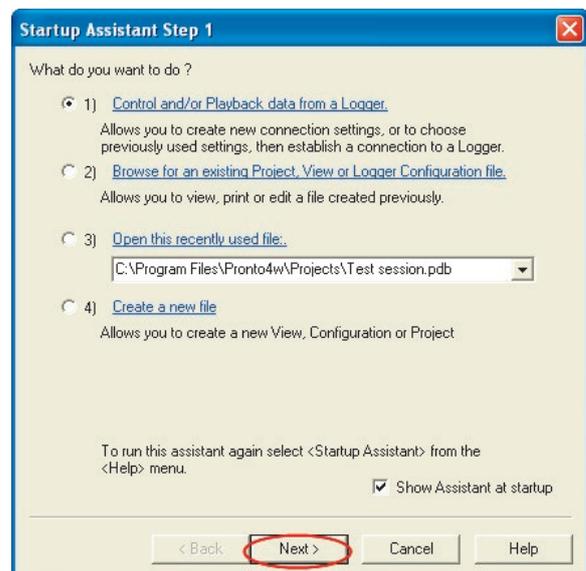
Your PM7000 can be configured and a recording started using either your portable device with its Bluetooth communication method or the computer with its USB serial link.

## Eighth Step: Download the PM7000 and Plot Results

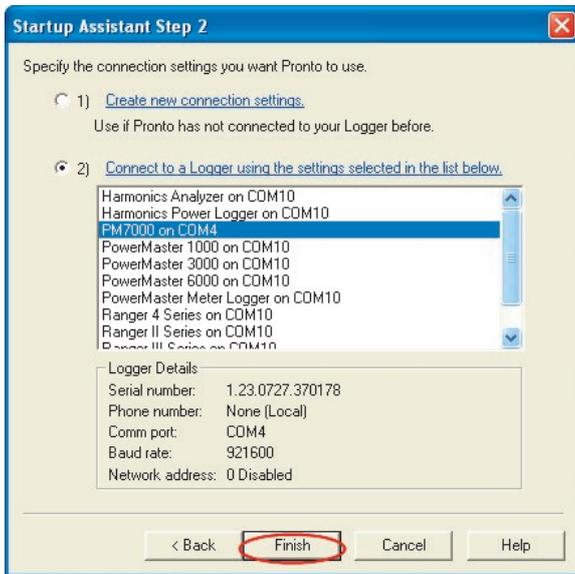
To take the data out of the PM7000 requires a computer and the USB serial link supplied or a USB memory drive. The recording will either have stopped because it reached the end of the recording period or because it was stopped manually, or the logger will still be recording. In the latter case Pronto will invite you to stop the recording prior to the download as part of the download process.

For this “Start” download we shall use the USB serial link to the computer. For more detailed information on using the USB memory device please see the section “USB Memory Device operations in the Ranger PM7000”.

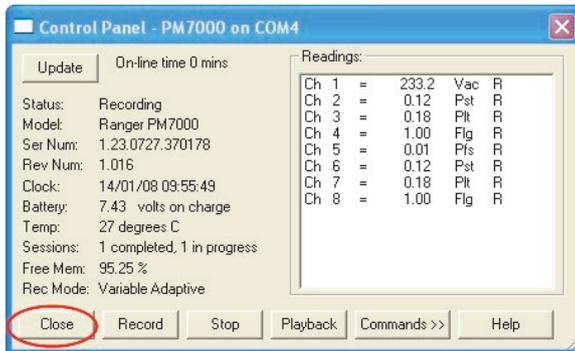
Attach the logger to the computer using the USB serial interface lead. Open ‘Pronto for Windows’. The Pronto ‘Start Up Assistant’ will appear.



The default is 'Playback data from a Logger' which is what we want so click on 'Next'.

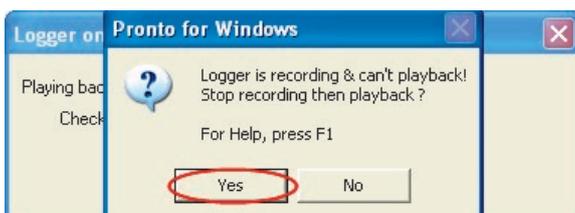


Use the list to select PM7000 if you have connected it to your computer previously.

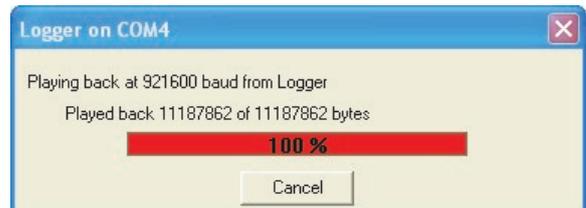
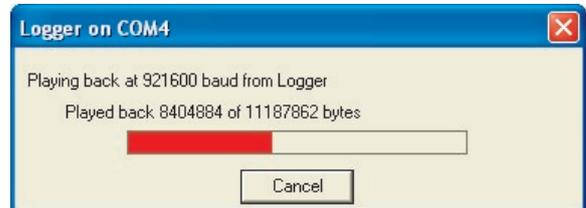


The control panel always gives you the current status of your recordings and will be useful in the future. For the quick start we can close it.

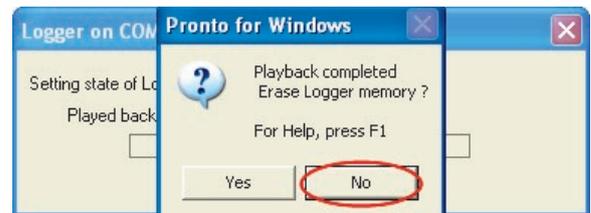
The next screen to come up invites us to stop the recording if we have not already done so.



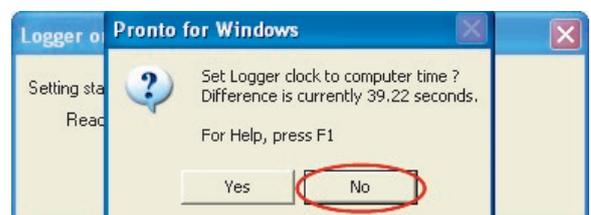
Click on 'yes'. Now we watch the playback.



Next you will be invited to 'Erase logger memory'



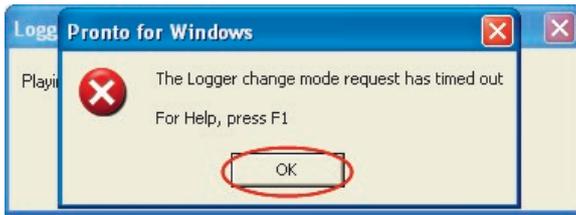
Normally we would recommend you to click 'No'.



Many computers these days have clocks updated automatically from reference clocks on the internet. If yours is one of these you may wish to click 'yes'. However, the Ranger loggers have good clocks that keep their time better than the average PC. So generally speaking, click on 'No'.

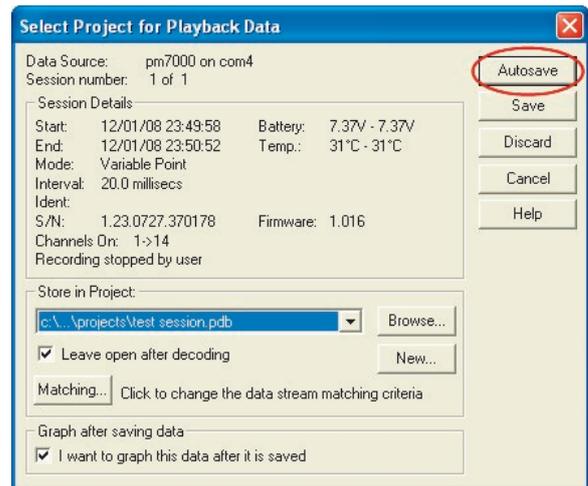


Unless you want a further recording click 'No'.



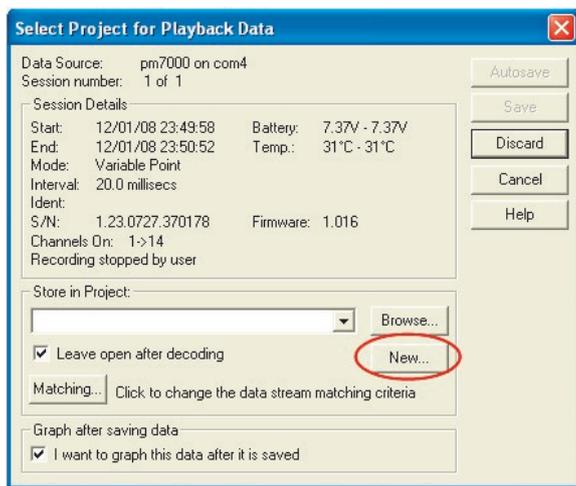
If you have taken a long time or gone off to get a cup of coffee this screen may come up. Click 'OK'.

The next screen offers us a place to save our recording. We create a folder. Pronto already has a default folder called 'Projects'.

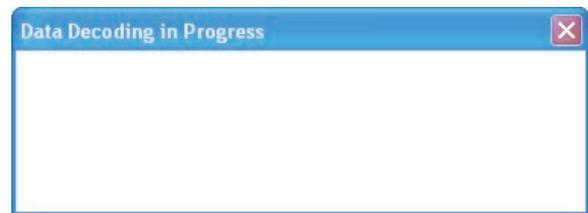


Click either 'Autosave' or 'save'.

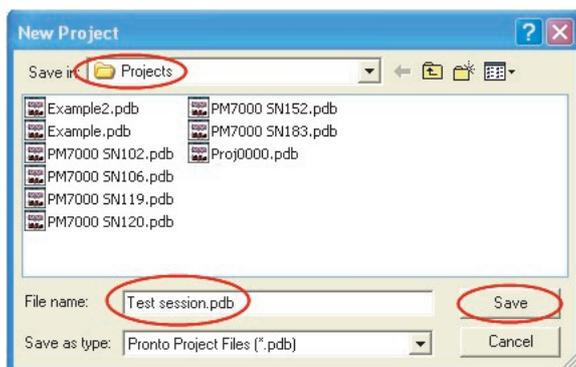
NB If you have multiple sessions in your logger, Autosave saves all of them to the same project.



Click on 'New' as it is a new project. The following screen will allow you to search for the folder you want. In the example we select the default folder, 'Projects'. Our first project can be called 'Test session'. Type it into the box 'File name:' (We can discard it later.) New recordings may go in a new or an existing project.



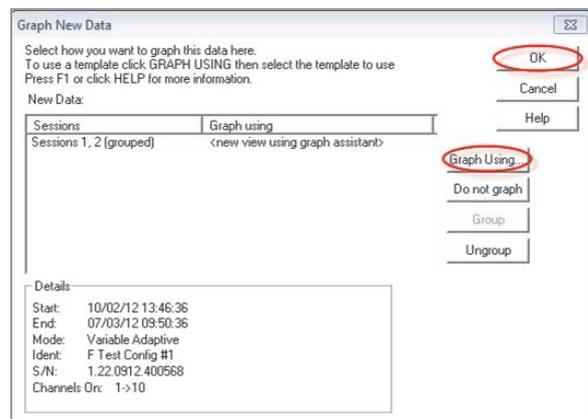
Patience while data decoding takes place. Finally we are asked how we would like to graph our data. We'll use the Graph Assistant.



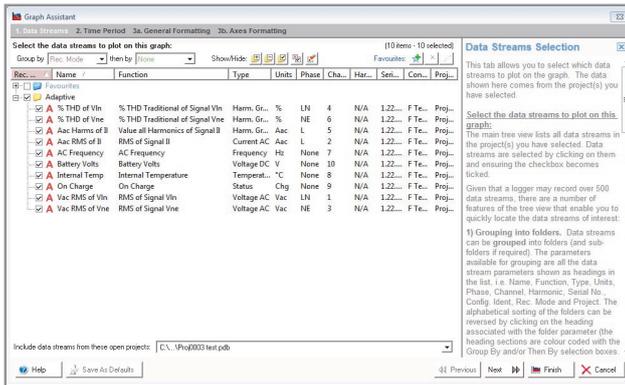
Your recording will go in the Projects folder. Click 'Save'.

Now we have a name and a location for our data.

This screen comes up.



At this stage we have not created any templates so we automatically select the only choice. This is '<new view using graph assistant>'. Click 'OK'. The 'graph assistant' will come up.



It has four steps.

In the first step you have the opportunity to select the data streams you want to graph. 'P' on the left hand side in the above example refers to Point Store. The Factory set up in your new PM7000 will show red 'A's, as the recording mode is Adaptive Store.

Below these 'detailed channels' in the 'graph assistant' list will always be found the entries labelled 'G' (green) for General Parameters, and 'T' (blue) if there are waveform recordings present. The 'detailed channels'

are the troubleshooting channels, either Adaptive Store or Point Store. The 'detailed channels' will be selected automatically for you within the 'graph assistant'. We have taken the view that as you especially selected these parameters, you are particularly interested in the results from them.

An account of the 'Storage Regimes' in the PM7000 is given in the manual.

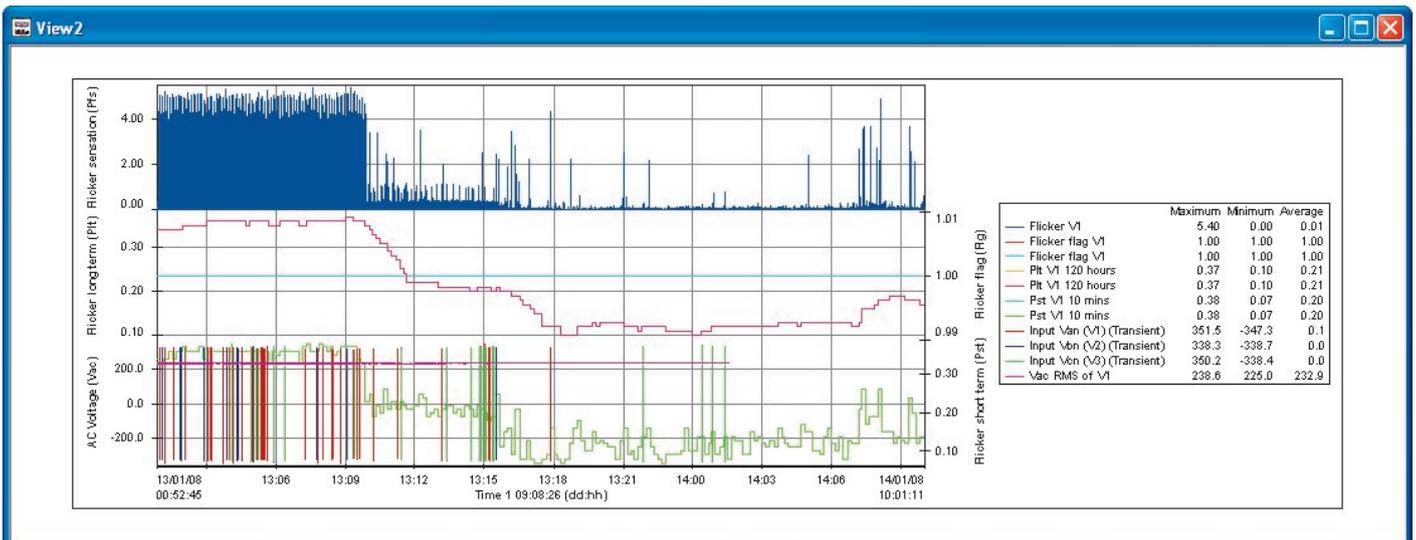
The other three steps enable you to format the graphs in different ways. You will want to familiarize yourself with the choices at a later stage.

Go straight to 'Finish' for this 'Start' activity.

Here is an example of a graph you might produce. Each different graph is called a 'view'.

As just mentioned you can play around with the different ways of formatting it and adding text. 'How to zoom in' and other facilities are covered in the Pronto video and manual.

Enjoy your PM7000. For further help see other sections in the PM7000 Manual or the Pronto for



Windows Manual on your customer CD.

You can also contact your distributor or Outram Research Ltd on +44 (0)1243 573050, email [support@outramresearch.co.uk](mailto:support@outramresearch.co.uk), website [www.outramresearch.co.uk](http://www.outramresearch.co.uk).



## PM7000 Storage Regimes



### PM7000 in the UK



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## Introduction: PM7000 Storage Regimes

There are three independent, but simultaneously operating, storage regimes in the PM7000, giving a comprehensive description of input signal activity.

**Waveform Capture** records just the direct input signals, and is normally used to describe sub-cycle events (events which may be too short to register in any other regime).

**Detailed Recording** system is aimed at whole cycle events, such as dips, swells etc. i.e. slower events. The Detailed Recording System can record 32 parameters at single cycle resolution, and choice of parameters is up to the user. You may select from many hundred (or even several thousand) parameters.

**General Parameter** recording. This is a slower

process still providing aggregated or averaged results on approximately 500 of the most useful parameters. These are not selectable, being chosen automatically for the particular connection hook-up specified. They are intended partly as a comprehensive safety net for users who are not sure what they want to record or what they might encounter.

Thus there are three regimes: High speed – sub-cycle: dealing with small numbers of parameters; Medium speed – whole cycle: up to 32 user selected parameters; and Low speed – large numbers of parameters.

---

## Waveform Capture

The system samples at high speed (up to 1.228MHz, 153.6kHz and 19.2kHz for the (T), (H) and (S) versions respectively. Samples are saved in contiguous groups over several cycles whenever an “Event” occurs worth recording. The number of cycles, and, which signals are to be stored, are selectable. Also user selectable are different types of event, several of which might

occur. Each is treated independently. The criterion or “level” for deciding if an event is “worth” recording can be user set, or can be managed automatically by the system. The major advantage of ‘automatic thresholding’ is that the user does not need to know in advance what characteristics to look for.

---

## Detailed Recording

This regime is applied to a selected number of parameters that may change rapidly and for which detailed visibility will assist network troubleshooting. These might include RMS voltages and currents, Instantaneous Flicker, Unbalance, Power parameters, plus more obscure parameters such as Interharmonics that are not recorded under General Parameters (see below). Two Storage modes are available for Detail Recording.

“Point Store” is a conventional indiscriminate method in which results are taken at the selected interval (down to one cycle) and stored verbatim until the allocated store is used up, or the selected recording period expires. This is useful for known short-term activities like motor start-up.

“Adaptive Store” is the patented method used by all *Ranger* logging devices. This method requires no set up and no prior knowledge of signal characteristics. It

employs an automatic thresholding method to determine if results are worth recording in detail. By monitoring past history (trend, general variation level) and predicting likely future values, the system continually compares its predictions with the reality.

While a prediction is valid, i.e. the input signal isn’t changing very greatly, the “envelope” of input signal extremes is recorded. When all predictions are considered to have failed, i.e. the signal has altered sufficiently in some way, details of the best prediction to that point and its conformance to the actual signal are recorded, and a new set of predictions established. The “Threshold” and conformance criteria continually “adapt” to the system dynamics (hence “Adaptive Store”) to give the best level of detail for the unpredictable events throughout the length of the recording. Each parameter to be recorded is treated independently, having its own thresholds and predictions.

This method has been in use very successfully for many years, primarily because it effectively mimics our own discriminating ability to decide whether something is worth looking at, setting its own thresholds based on the signal characteristics and prevailing system

dynamics.

Adaptive Store gives us the detail we would like when we want it and doesn't waste memory on information we won't be interested in.

---

## General Parameters

The General Parameter recording is the interval method found in many Power Quality Logging devices. All the normal parameters (Voltages, Currents, Powers, Harmonics etc.- a total of approximately 500) are serviced every cycle (Half cycle for Voltages and Current RMS) and results aggregated into an "Interval Average". The interval is selectable from 1 second to 2 hours. The typical interval will be 10 minutes, conforming to EN50160 requirements for "ten minute averaging".

Where appropriate these results are used for any comparison to standards, plus they provide a complete synopsis of the Power Quality environment over the recording period. Note that in addition to the "Interval Average", the half cycle maximum and minimum values in each interval are also stored for Voltages, Currents and Calculated Voltage RMS\* results.

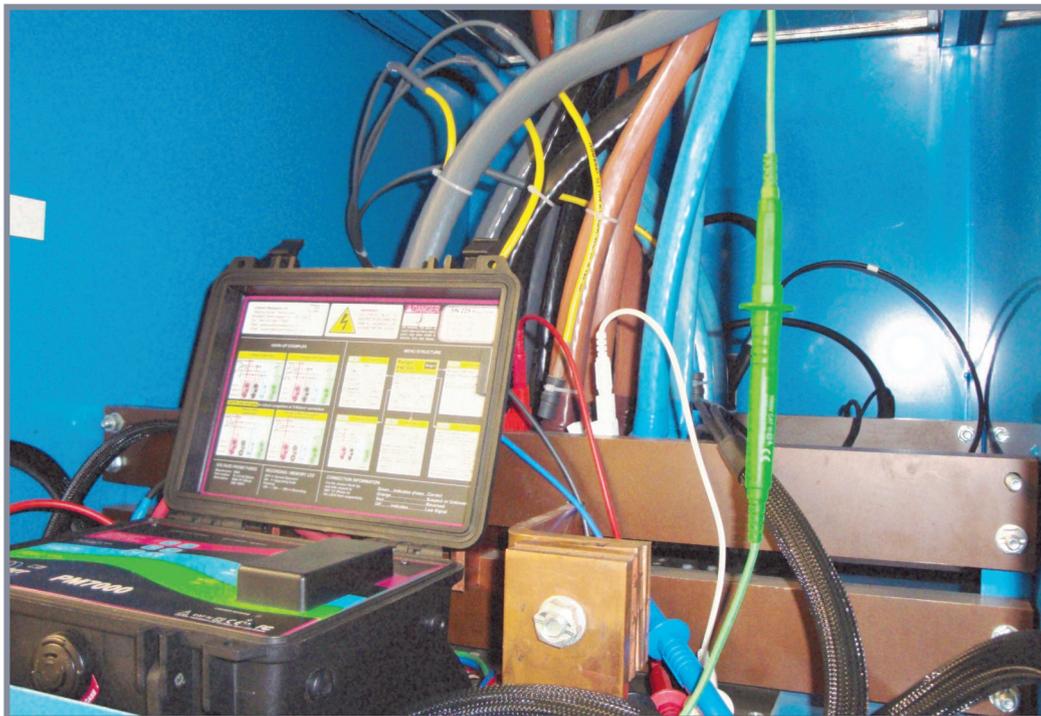
### \*Calculated voltages

In some hook-up arrangements it is possible to calculate phase-to-phase results from phase-to-neutral results and vice-versa. The PM7000 calculates these where possible and makes them available as "Calculated RMS" results. For information on what Calculated RMS results are available in each of the hook ups press the "Details" button on individual Hook-up selections, and look for the Additional RMS information at the bottom of the screen.

# High Speed Comprehensive Power Quality Analyzer



## PM7000 Measurement Systems



### PM7000 in the UK



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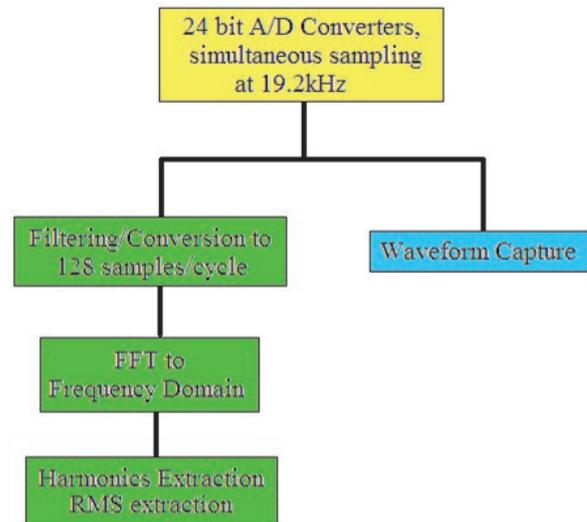
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## Introduction: PM7000 Measurement Systems

The standard speed functions of the PM7000 (including the Standard speed Waveform Capture) use results from the slow A/D systems. These sample at 19.2 kHz (per signal) giving typically 320 samples/cycle at 60Hz and 384 samples/cycle at 50Hz.

These results are used both for Standard Waveform Capture and RMS, Harmonic and other calculations.

This section describes the derivation of the various parameters.



## Calculations

### RMS Calculations

These are computed for each half cycle and for each whole cycle.

The General Parameter average RMS recording uses whole cycle results averaged over the specified interval. The Maximum and Minimum RMS results are the maximum and minimum half cycle results occurring in the interval.

The Adaptive Store recording process uses the whole cycle results.

### Harmonics Calculations

Note harmonics are currently available measured both wideband and with 5Hz bandwidth.

### Standard Harmonics Calculations

The Fast Fourier Transform results are made available every cycle (giving a bandwidth of 50 or 60Hz), and the various Harmonic parameters are derived each cycle.

Total Harmonic Value (THV)	= Square Root (sum of squares of all harmonic values 2 to 50)
Odds Value	= Square Root (sum of squares of all odd harmonic values 3 to 49)
Evens Value	= Square Root (sum of squares of all even harmonic values 2 to 50)
Triplens Value	= Square Root (sum of squares of all multiples of 3 harmonic values 3, 6, 9, 12 etc. up to 48)

Individual Harmonic Values are derived directly from the magnitude of the relevant FFT result. The percentage versions of these are obtained by dividing through by the Value of the fundamental term:

Total Harmonic Distortion (THD)	= (THV / Fundamental Value) * 100 %
Odds %	= (Odds Value / Fundamental Value) * 100 %
Evens %	= (Evens Value / Fundamental Value) * 100 %
Triplens %	= (Triplens Value / Fundamental Value) * 100 %
Individual Harmonic %	= (Individual Harmonic Value / Fundamental Value) * 100 %

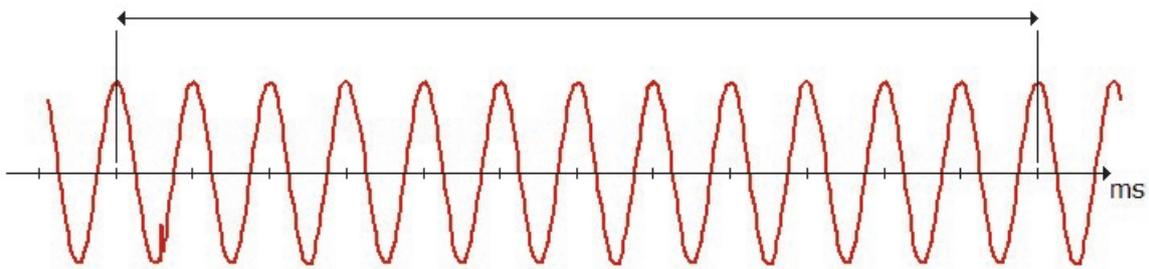
Directional Harmonics are obtained from the relevant individual harmonic result (magnitude element), and the sign is obtained from the phase relationship between Voltage and Current harmonics.

## InterHarmonics Calculations (where enabled)

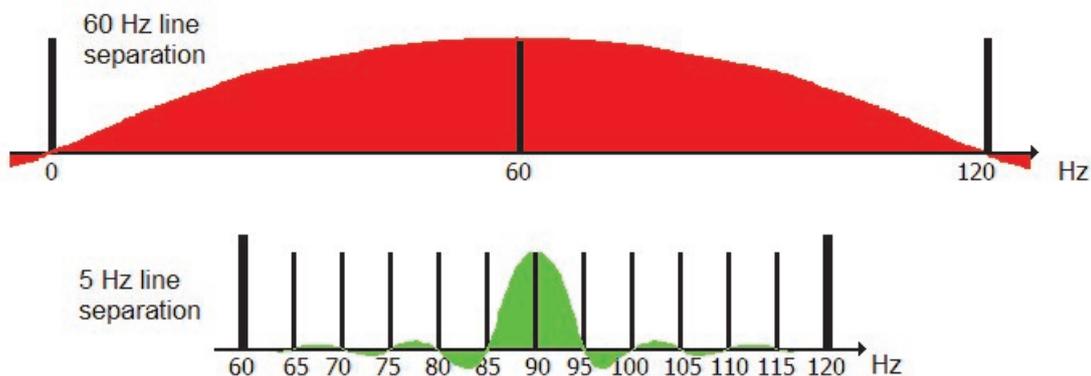
Harmonics, Harmonics Groups and Sub-groups; InterHarmonics, InterHarmonics Groups and Sub-groups are all available and calculated according to IEC61000-4-30 (which calls IEC 61000-4-7).

IEC 61000-4-7 calls for a Transform input time of ~200ms (10 cycles at 50Hz or 12 cycles at 60Hz) and hence the bandwidth is nominally 5Hz. The diagram below shows the 60Hz case:

Measure with Fourier Transform over ~200ms  
(actually 12 cycles of 60Hz nominal)



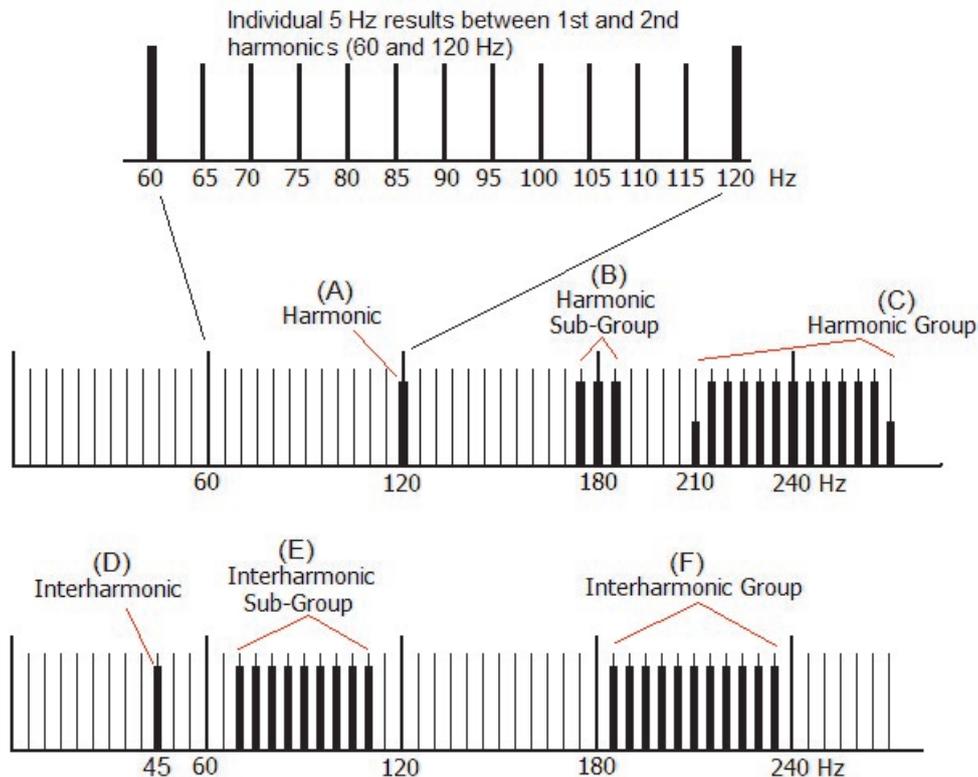
Means that in the frequency domain we can distinguish down to nominal  
5Hz (1/200ms) rather than the 60 Hz (1/16.66ms)



Note that as shown in the diagram the spectrum is in fact continuous, and not just a series of lines. However the transform methods usually used for computational convenience only yield results at the above line intervals (50Hz, 60Hz or 5Hz), so the spectrum is often represented as a line spectrum.

Having resolved the spectrum into 5Hz elements, the authors of the Standards defined various groupings of 5Hz elements to describe harmonic energy in the chunks appropriate to different applications. (See the IEC 61000-4-7 Standard for further application information).

The groupings are of six types (A) to (F), as shown below:



These are:

- (A) Individual Harmonics. This grouping is just the single line at an integer harmonic frequency. (In this case the 2<sup>nd</sup> Harmonic, 120Hz.)
- (B) Harmonic Sub-groups comprising integer harmonics plus the two adjacent interharmonics. This grouping shows the 3<sup>rd</sup> Harmonic Sub-group around 180Hz.
- (C) Harmonic groups. These Groups comprise all the energy from half-way between the harmonic below the nominal to half-way above. The components at 210 and 270Hz are halved so that between them, the Groups centered on (e.g.) the 3<sup>rd</sup> and 4<sup>th</sup> harmonics (which both have contributions from the interharmonic line at 210Hz) use 100% of all the available components.

The above three groupings are centered on actual harmonics. In addition to individual Interharmonics ((D) below) there are also two groupings centered halfway between harmonics to deliberately exclude harmonics themselves:

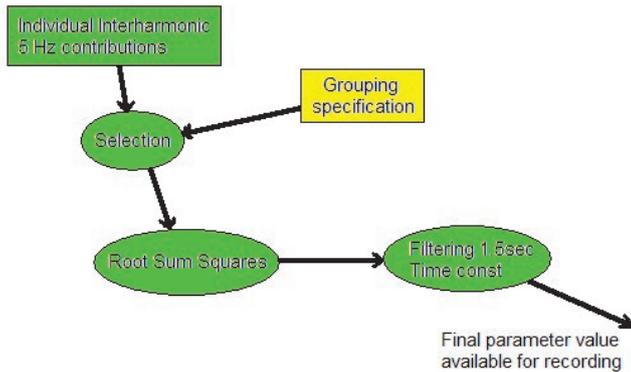
- (D) Individual Interharmonics. This grouping is just the single line at a non-integer harmonic frequency. (In this case at 45Hz.). [Individual Interharmonics are sometimes indexed as the Nth interharmonic of the Mth harmonic group, in this case 0:9 (9<sup>th</sup> interhar-

monic of the Zeroth harmonic =  $0 * 60 \text{ Hz} + 9 * 5\text{Hz} = 45\text{Hz}$ ). Because of the need to accommodate 50 and 60 Hz in the PM7000 and the possibility of this indexing being ambiguous, the frequency itself is used.]

- (E) Interharmonic Sub-groups. These Sub-groups contain the lines not included in the Harmonic Sub-groups. The Sub-group shown (E) comprises the 70 Hz to 110 Hz contributions, and for the PM7000 this is described as the Sub-group below the 2<sup>nd</sup> Harmonic.
- (F) Interharmonic Groups. These Groups contain all the lines between integer harmonics. The Group shown (F) has contributions from 185 to 235 Hz, and in the PM7000 nomenclature is described as the Group below the 4<sup>th</sup> Harmonic.

Notice how the Interharmonic Sub-group and Group contributions complement the Harmonic Sub-group and Individual Harmonics respectively.

Parameter values for group and sub-groups combinations are calculated from the Root Sum Squares of the relevant individual interharmonics, and each final result is filtered with 1.5 sec time constant first order filter.



## Recording Interharmonics in the PM7000

Interharmonics are available to be recorded as individuals (specified by Harmonic if an integer number or by frequency), and/or as Interharmonic or Harmonic Groups and Sub-groups. They may be referenced to the appropriate fundamental grouping if desired. In all there are 12 selection methods:

RMS Value	% of Fundamental (or Fundamental Group/Sub-group)	
Harmonic	Interharmonic	
Individual	Sub-Group	Group

Gives 12 possibilities (any combination) from 30Hz to 3kHz

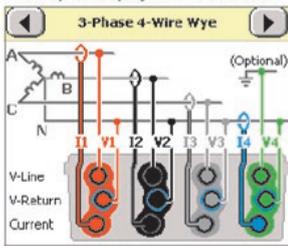
Because Interharmonics are not commonly recorded and when they are they are generally narrowly specified, Interharmonics are not included in the General Parameters. Instead Interharmonics are recorded in the PM7000 as Detail Troubleshooting Channels using the Adaptive Store or Point Store methods. When Interharmonics are enabled, the Interharmonics Function Group selection screen is populated with the twelve selection possibilities. Choosing any of these functions leads to choice of relevant parameters, signal and harmonic etc., thus complete flexibility is available.

[In the event that you need further interharmonic grouping functions not specified in the Standard, please advise Outram Research. Application and use of interharmonics is somewhat in its infancy and the above facilities are considered as a set of tools to enable you the user to help define what else needs to be added or changed.]

## Voltage Operations and Hook-ups

### 3-Phase 4-Wire Wye

Hook-up as displayed on PMScreen



A successful hook-up (based on physical connections and corresponding instrument configuration) is demonstrated via:

- sequentially flashing green LEDs on the top of the instrument
- vector outputs as seen on PMScreen.

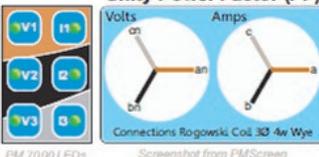
Connections are made using:

- 4 Rogowski Coils,
- 5 Voltage Leads

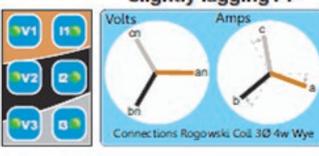
with the common Neutral connected via 3 link leads (blue or white).



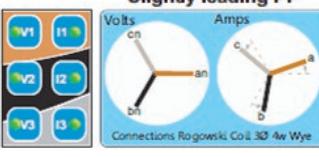
**Unity Power Factor (PF)**



**Slightly lagging PF**



**Slightly leading PF**



### PM7000 Hook-up Aid



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## Introduction: High Voltage Operation

We have 4 independent, symmetrical, voltage measuring systems. Each can measure greater than 1000VRMS.

The PSU is normally connected to phase A but is limited to 600V RMS continuous. Power may also be taken from a 12V dc wall cube and if that external power source is detected by the unit, an internal relay automatically disconnects the PSU from phase A.

Spike blocking circuitry exists BETWEEN the line input and the PSU so that the PSU does not load the line for short spikes, however for continuous operation above 600V the 12V Wall cube should be used as the power source AND, IN ADDITION, THE INTERNAL FUSES SHOULD BE REMOVED TO PROTECT against failure of the relay, the wall cube or the external power detection circuit.

## Measurement and Hook-up

We have 4 independent, symmetrical, voltage measuring systems.

Circuit 1 (V1)	Circuit 2 (V2)	Circuit 3 (V3)	Circuit 4 (V4)
V1 Line	V2 Line	V3 Line	V4 Earth
V1 Return	V2 Return	V3 Return	V4 Return

Note: The V4 Earth is NOT a protective earth. It is NOT connected to chassis. Its input impedance is as for the other measurement circuits. All 4 voltage measurement circuits are symmetrical and high impedance. It is merely defined to be the earth connection point.

Since the circuits ARE independent, different connection options may exist for common measurements.

The following section lists the hook up arrangements and describes the power calculations assumed to be correct for each one.

### 1. Uncommitted.

No assumptions are made. Any of the power calculation methods can be chosen which may yield incorrect results if they are inappropriate for the actual physical hook-up.

### 2. Four wire wye

All 3 phases and a current carrying neutral are present.

Circuit 1 (V1)	Circuit 2 (V2)	Circuit 3 (V3)	Circuit 4 (V4)
V1 Phase A Line	V2 Phase B Line	V3 Phase C Line	V4 Earth
V1 Neutral	V2 Neutral	V3 Neutral	V4 Neutral

V4 measurement is expressed as Neutral to Earth, Earth being the absolute reference, however the Neutrals are all kept on a single line (i.e. all in a row) to minimise getting the connections wrong.

$$\text{Total kW} = \text{kW}(\text{Van}, \text{Ia}) + \text{kW}(\text{Vbn}, \text{Ib}) + \text{kW}(\text{Vcn}, \text{Ic})$$

$$\text{Total kVAR} = \text{kVAR}(\text{Van}, \text{Ia}) + \text{kVAR}(\text{Vbn}, \text{Ib}) + \text{kVAR}(\text{Vcn}, \text{Ic})$$

$$\text{Total kVA} = \text{kVA}(\text{Van}, \text{Ia}) + \text{kVA}(\text{Vbn}, \text{Ib}) + \text{kVA}(\text{Vcn}, \text{Ic})$$

$$\text{PF} = \frac{\text{total kW}}{\sqrt{(\text{total kW}^2 + \text{total kVAR}^2)}}$$

Line to line voltages may be calculated from the line to neutral results.

Circuit 1 (V1)	Circuit 2 (V2)	Circuit 3 (V3)	Circuit 4 (V4)
V1 Phase A Line	V2	V3 Phase C Line	V4
V1 Phase B Line	V2	V3 Phase B Line	V4

### 3. Ungrounded delta: 3 wire, no earth

In this case 3 phases are present but there is NO current carrying neutral, and it is assumed NO measurement earth connection is to be made. Power has to be calculated assuming the system is balanced since there are only 3 current carrying cables present.

$$\text{Total kW} = \text{kW}(V_{ab}, I_a) + \text{kW}(V_{cb}, I_c)$$

$$\text{Total kVAR} = \text{kVAR}(V_{ab}, I_a) + \text{kVAR}(V_{cb}, I_c)$$

$$\text{Total kVA} = \text{kVA}(V_{ab}, I_a) + \text{kVA}(V_{cb}, I_c)$$

$$\text{PF} = \frac{\text{total kW}}{\sqrt{(\text{total kW})^2 + (\text{total kVAR})^2}}$$

Only line-to-line voltages are available. Vac Line-to-line can be calculated.

Circuit 1 (V1)	Circuit 2 (V2)	Circuit 3 (V3)	Circuit 4 (V4)
V1 Phase A Line	V2	V3 Phase C Line	V4 Earth
V1 Phase B Line	V2	V3 Phase B Line	V4 Phase B Line

### 4. Grounded or ungrounded delta: 3 wire, earth measurement point available.

In this case 3 phases are present but there is NO current carrying neutral. A measurement earth connection is assumed to be made. Power has to be calculated assuming the system is balanced since there are only 3 current carrying cables present.

$$\text{Total kW} = \text{kW}(V_{ab}, I_a) + \text{kW}(V_{cb}, I_c)$$

$$\text{Total kVAR} = \text{kVAR}(V_{ab}, I_a) + \text{kVAR}(V_{cb}, I_c)$$

$$\text{Total kVA} = \text{kVA}(V_{ab}, I_a) + \text{kVA}(V_{cb}, I_c)$$

$$\text{PF} = \frac{\text{total kW}}{\sqrt{(\text{total kW})^2 + (\text{total kVAR})^2}}$$

Vac Line-to-line can be calculated. Line to earth may be calculated for each of the three phases.

## Hook-up Checklist (USA Colours)

Please print out this Hook-up Checklist and take it with you when setting up your PM7000. It is designed to help you visually with your hook-up, but also to give you piece of mind that the recording is underway correctly. It is also available in [USA](#), [European Union](#) and [Asian/Australasian](#) colours on our website, [www.outramresearch.co.uk](http://www.outramresearch.co.uk).

For printing purposes, the downloadable PDFs on our website will give you a sharper picture.



### Hook-up Checklist for the Ranger PM7000 (USA)

**Step 1.** Establish type of installation (e.g. no. of phases).

**Step 2.** Establish type of transducers (PTs, CTs etc.).

**Step 3.** Choose one of the ten following hook-up options:

- 1) 3-Phase 4-Wire Wye
- 2) 3-Phase 4-Wire Delta
- 3) Full 3-Phase 3-Wire Delta (3 element for all Ph-Ph)
- 4) 3-Phase 3-Wire Ungrounded (with Equipment Gnd)
- 5) 3-Phase 3-Wire Ungrounded
- 6) 3-Phase 2.5-Element Wye
- 7) 3-Phase 1-Element Wye
- 8) Single Split Phase
- 9) Single Phase
- 10) Uncommitted.

**Step 4.** Configure instrument for relevant hook-up.

**Step 5.** Verify physical connections along with instrument LED and PMScreen vector outputs (see pp. 1-10 of these notes).

**Step 6.** If required, refer to Phase Angle Summary (p. 11).

**Step 7.** If vectors or LED configurations do not match what is expected or you see the 'Suspect Hook-Up' message, refer to possible explanations and action to be taken (pp. 12-13).



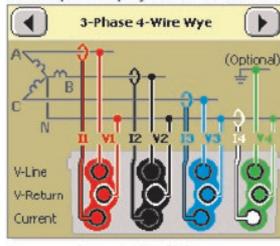
### Ranger PM7000

Hook-up 1/10



## 3-Phase 4-Wire Wye

Hook-up as displayed on PMScreen



*Screenshot from PMScreen*

A successful hook-up (based on physical connections and corresponding instrument configuration) is demonstrated via:

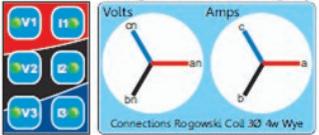
- a) sequentially flashing green LEDs on the top of the instrument
- b) vector outputs as seen on PMScreen.

Connections are made using:

- 4 Rogowski Coils,
- 5 Voltage Leads
- with the common Neutral connected via 3 link leads (white).

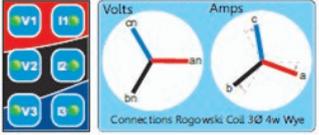


**Unity Power Factor (PF)**



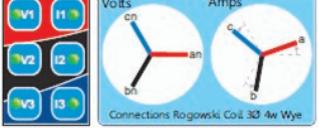
*Screenshot from PMScreen*

**Slightly lagging PF**



*Screenshot from PMScreen*

**Slightly leading PF**



*Screenshot from PMScreen*

PM 7000 LEDs

Something not looking right?  
See pp. 12 & 13 for possible solutions.

1

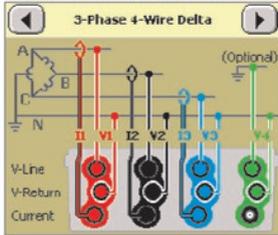
Ranger  
PM7000

Hook-up 2/10



## 3-Phase 4-Wire Delta

Hook-up as displayed on PMScreen



Screenshot from PMScreen

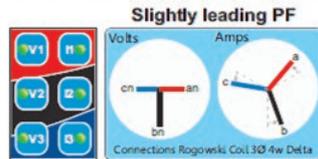
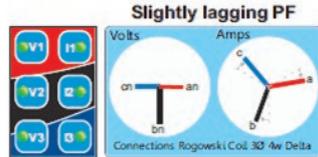
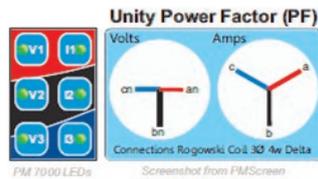
Connections are made using:  
3 Rogowski Coils,  
5 Voltage Leads  
with the common Neutral connected  
via 3 link leads (white).



Something not looking right?  
See pp. 12 & 13 for possible solutions.

A successful hook-up (based on physical connections and corresponding instrument configuration) is demonstrated via:

- sequentially flashing green LEDs on the top of the instrument
- vector outputs as seen on PMScreen.



Option: Although not essential it may be useful to connect up the 4th Rogowski coil (blue) as the current could flow along the Neutral.

2

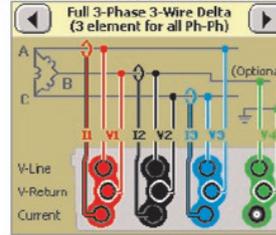
Ranger  
PM7000

Hook-up 3/10



## Full 3-Phase 3-Wire Delta (3 element for all Ph-Ph)

Hook-up as displayed on PMScreen



Screenshot from PMScreen

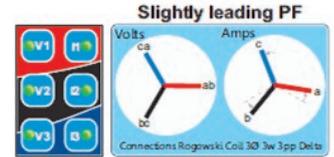
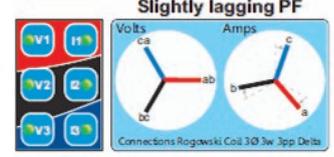
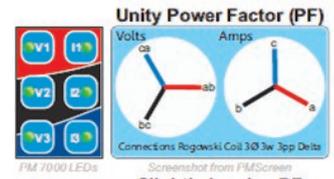
Connections are made using:  
3 Rogowski Coils,  
3 Voltage Leads  
with link leads (white) connecting  
the return through each of the 3 phases.



Something not looking right?  
See pp. 12 & 13 for possible solutions.

A successful hook-up (based on physical connections and corresponding instrument configuration) is demonstrated via:

- sequentially flashing green LEDs on the top of the instrument
- vector outputs as seen on PMScreen.



Option: To make use of the 4th voltage channel to measure with respect to earth there are 2 voltage leads left over with which to make the final connection.  
e.g. Blue = VB = V4 line,  
Green = Earth = V4 Return

3

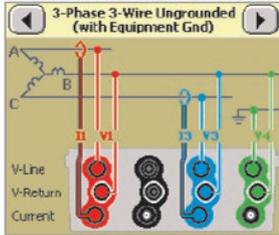
## Ranger PM7000

Hook-up 4/10



### 3-Phase 3-Wire Ungrounded (with Equipment Gnd)

Hook-up as displayed on PMScreen



Screenshot from PMScreen

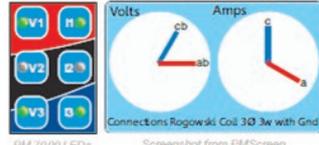
Connections are made using:  
2 Rogowski Coils,  
4 Voltage Leads  
with the return along the B phase  
connected via 2 link leads (white).



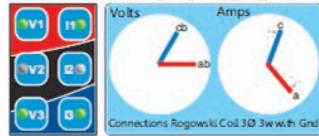
A successful hook-up (based on physical connections and corresponding instrument configuration) is demonstrated via:

- sequentially flashing green LEDs on the top of the instrument
- vector outputs as seen on PMScreen.

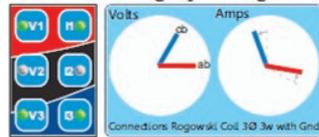
#### Unity Power Factor (PF)



#### Slightly lagging PF



#### Slightly leading PF



Something not looking right?

See pp. 12 & 13 for possible solutions.

4

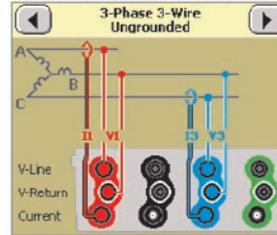
## Ranger PM7000

Hook-up 5/10



### 3-Phase 3-Wire Ungrounded

Hook-up as displayed on PMScreen



Screenshot from PMScreen

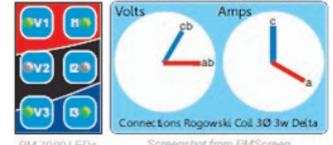
Connections are made using:  
2 Rogowski Coils,  
3 Voltage Leads  
with the return along the B phase  
connected via 1 link lead (white).  
No Earth.



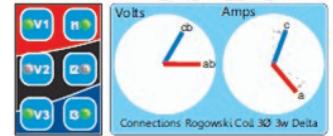
A successful hook-up (based on physical connections and corresponding instrument configuration) is demonstrated via:

- sequentially flashing green LEDs on the top of the instrument
- vector outputs as seen on PMScreen.

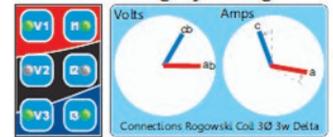
#### Unity Power Factor (PF)



#### Slightly lagging PF



#### Slightly leading PF



Something not looking right?

See pp. 12 & 13 for possible solutions.

5

**Ranger PM7000**

Hook-up 6/10

## 3-Phase 2.5-Element Wye

Hook-up as displayed on PMScreen

A successful hook-up (based on physical connections and corresponding instrument configuration) is demonstrated via:

- sequentially flashing green LEDs on the top of the instrument
- vector outputs as seen on PMScreen.

**Unity Power Factor (PF)**

PM 7000 LEDs

**Slightly lagging PF**

PM 7000 LEDs

**Slightly leading PF**

PM 7000 LEDs

Connections are made using:

- 3 Rogowski Coils,
- 3 Voltage Leads
- with the common Neutral connected via 1 link lead (white).

Something not looking right?  
See pp. 12 & 13 for possible solutions.

6

**Ranger PM7000**

Hook-up 7/10

## 3-Phase 1-Element Wye

Hook-up as displayed on PMScreen

A successful hook-up (based on physical connections and corresponding instrument configuration) is demonstrated via:

- sequentially flashing green LEDs on the top of the instrument
- vector outputs as seen on PMScreen.

**Unity Power Factor (PF)**

PM 7000 LEDs

**Slightly lagging PF**

PM 7000 LEDs

**Slightly leading PF**

PM 7000 LEDs

Connections are made using:

- 1 Rogowski Coil,
- 2 Voltage Leads
- with the return along the B phase

Something not looking right?  
See pp. 12 & 13 for possible solutions.

7

**Ranger PM7000**

Hook-up 8/10

## Single (Split) Phase

Hook-up as displayed on PMScreen

A successful hook-up (based on physical connections and corresponding instrument configuration) is demonstrated via:

- sequentially flashing green LEDs on the top of the instrument
- vector outputs as seen on PMScreen.

**Unity Power Factor (PF)**

Connections Rogowski Coil 2Ø 2Ø Split

**Slightly lagging PF**

Connections Rogowski Coil 2Ø 2Ø Split

**Slightly leading PF**

Connections Rogowski Coil 2Ø 2Ø Split

Connections are made using:

- 2 Rogowski Coils,
- 3 Voltage Leads

with the common Neutral connected via 1 link lead (white).

Something not looking right?  
See pp. 12 & 13 for possible solutions.

8

**Ranger PM7000**

Hook-up 9/10

## Single Phase

Hook-up as displayed on PMScreen

A successful hook-up (based on physical connections and corresponding instrument configuration) is demonstrated via:

- sequentially flashing green LEDs on the top of the instrument
- vector outputs as seen on PMScreen.

**Unity Power Factor (PF)**

Connections Rogowski Coil Single

**Slightly lagging PF**

Connections Rogowski Coil Single

**Slightly leading PF**

Connections Rogowski Coil Single

Connections are made using:

- 1 Rogowski Coil,
- 3 Voltage Leads

with the common Neutral connected via 1 link lead (white).

Something not looking right?  
See pp. 12 & 13 for possible solutions.

9

Ranger PM7000
Hook-up 10/10

## Uncommitted

Hook-up as displayed on PMScreen

Screenshot from PMScreen

V-Line  
V-Return  
Current

You can use whichever connections are required.

A successful hook-up (based on physical connections and corresponding instrument configuration) is demonstrated via:

- sequentially flashing green LEDs on the top of the instrument
- vector outputs as seen on PMScreen.

**Unity Power Factor (PF)**

Connections Rogowski Coil Uncommitted

Screenshot from PMScreen

**Slightly lagging PF**

Connections Rogowski Coil Uncommitted

Screenshot from PMScreen

**Slightly leading PF**

Connections Rogowski Coil Uncommitted

Screenshot from PMScreen

10

Ranger PM7000

## Phase Angle Summary

Expected phase angles are with respect to the reference vector of ChV1

Hook-Up Description	V1	V2	V3	I1	I2	I3
1 3-Phase 4-Wire Wye	0°	240°	120°	0°	240°	120°
2 3-Phase 4-Wire Delta	0°	-90°	180°	30°	-90°	150°
3 Full 3-Phase 3-Wire Delta (3 element for all Ph-Ph)	0°	240°	120°	-30°	210°	90°
4 3-Phase 3-Wire Ungrounded (with Equipment Gnd)	0°		60°	-30°		90°
5 3-Phase 3-Wire Ungrounded	0°		60°	-30°		90°
6 3-Phase 2.5-Element Wye	0°		120°	0°	240°	120°
7 3-Phase 1-Element Wye	0°					90°
8 Single Split Phase	0°	180°		0°	180°	
9 Single Phase	0°			0°		
10 Uncommitted	?	?	?	?	?	?

**Voltage Tolerances**

Phase angle wrt expected	Hook-Up	LED on top of instrument
0 ± 10°	Good	Green
180 ± 10°	Reversed	Red
All else	Suspect	Orange

**Current Tolerances**

Phase angle wrt expected	Hook-Up	LED on top of instrument
0 ± 45°	Good	Green
180 ± 45°	Reversed	Red
All else	Suspect	Orange

If "Suspect Hook-Up" shows, click on the PMScreen vector diagram where it will show the hook-up that the instrument is anticipating. Click on [Details](#) for specific information and advice.

It is possible at this point to reverse the current phases by clicking . This is recommended for correction only when manual reversal is not possible.

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**Ranger  
PM7000**

## Example Errors & Possible Explanations: Vectors

Examples made using a 3-Phase 3-Wire Ungrounded Circuit

EXPECTED	WHAT YOU SEE	EXPLANATION & SOLUTION
<p><b>Unity Power Factor (PF)</b></p> <p>Connections Rogowski Coil 30 3w Delta</p>	<p><b>Unity Power Factor (PF)</b></p> <p>Connections Rogowski Coil 30 3w Delta</p>	<p>The CTs are on the wrong phases. Swap the CTs around to align voltage and current Phasing.</p>
<p><b>Unity Power Factor (PF)</b></p> <p>Connections Rogowski Coil 30 3w Delta</p>	<p><b>Unity Power Factor (PF)</b></p> <p>Connections Rogowski Coil 30 3w Delta</p>	<p>The CB voltage phase has a bad connection. Try reconnecting.</p>
<p><b>Unity Power Factor (PF)</b></p> <p>Connections Rogowski Coil 30 3w Delta</p>	<p><b>Severely Lagging PF</b></p> <p>Connections Rogowski Coil 30 3w Delta</p>	<p>Power Factor is severely lagging (beyond 45°). "Suspect Hook-Up" message displayed. THIS MAY BE CORRECT so no solution needed.</p>
<p><b>Slightly lagging PF</b></p> <p>Connections Rogowski Coil 30 3w Delta</p>	<p><b>Slightly lagging PF</b></p> <p>Connections Rogowski Coil 30 3w Delta</p>	<p>Power Factor is lagging and both CTs are reversed. Turn round the CTs to face them in the correct direction.</p>

For further information and advice in PMScreen click on the vector diagram (which brings up the hook-up the instrument has been set up for) and then on [Details](#).

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**Ranger  
PM7000**

## Example Errors & Possible Explanations: LEDs

Examples made using a 3-Phase 3-Wire Ungrounded Circuit

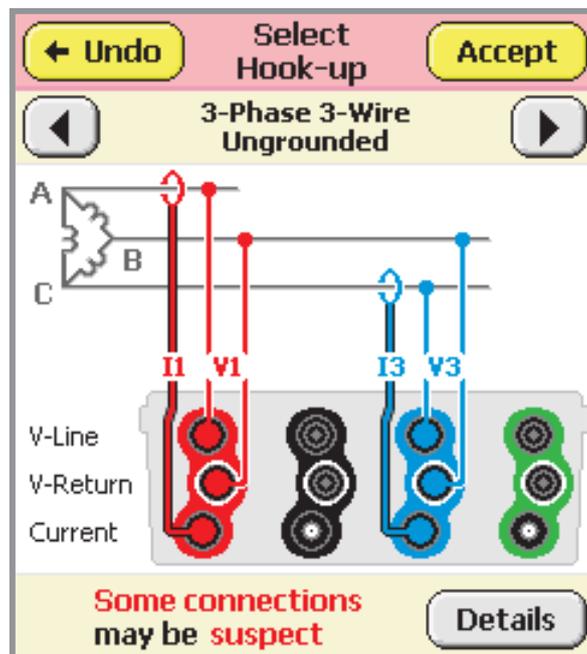
EXPECTED	WHAT YOU SEE	EXPLANATION & SOLUTION
		<p>No signal received by CB phase voltage lead. Check connection.</p>
		<p>Current phase A is probably reversed. Try changing it round.</p>
		<p>Current phases A &amp; C may be swapped over OR possibly have very bad Power Factor due to excessive lagging current. In the latter case the phases may be correct. If necessary try swapping CTs over. Refer to Vector diagrams if unsure.</p>

For more information and advice as well as details of further products in our range please visit our website at [www.outramresearch.co.uk](http://www.outramresearch.co.uk)

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## How to Create a Three Phase Three Wire Delta Hook-up and Save it to Flash Memory



PM7000 Hook-up from PMScreen



### OUTRAM RESEARCH LTD

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Tel: 0044 1243 573050  
Email: support@outramresearch.co.uk

### SYNERGY SYSTEMS INC

4101 Pierce Dr.  
Shelby Twp., MI 48316  
USA  
Tel: 800-338-4505  
Email: sales@synergy-mi.com

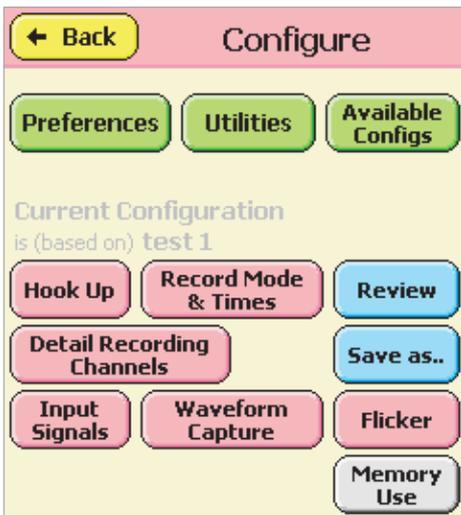
## Contents

Creating the Hook-up.....	58
Detailed recording channels	
Input signals	
Waveform capture parameters	
Flicker	

## Creating the Hook-up

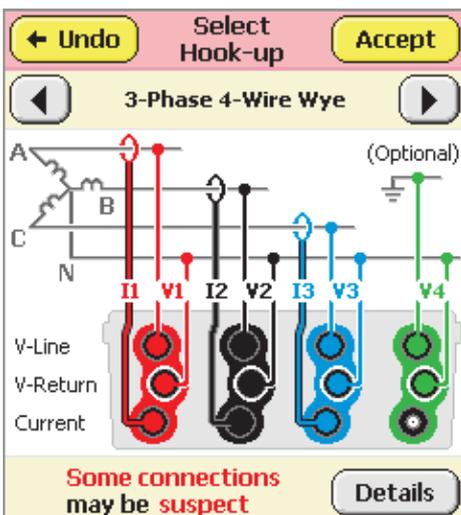
Assume that we wish to create and save a suitable configuration for a 3 phase 3 wire delta installation, in which we will monitor volts (nominal 415V phase-phase), current (say to 1500A max), power and instantaneous flicker in detail (**detailed recording**). All other parameters will be monitored by the **General Parameter** system over 5 minute intervals, and the overall recording will be set up to last 14 days. For this example we are not particularly interested in capturing waveforms.

From the introductory screen, select "Main Menu", then "Configure", to bring up the Configure screen with the Configuration menu.



We can now work round the configuration options setting up the chosen parameters.

Select the "Hook Up" button.

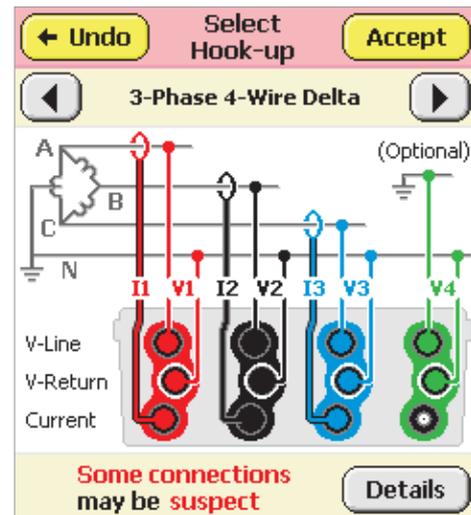


This will show whatever was previously selected. Use the grey selection buttons

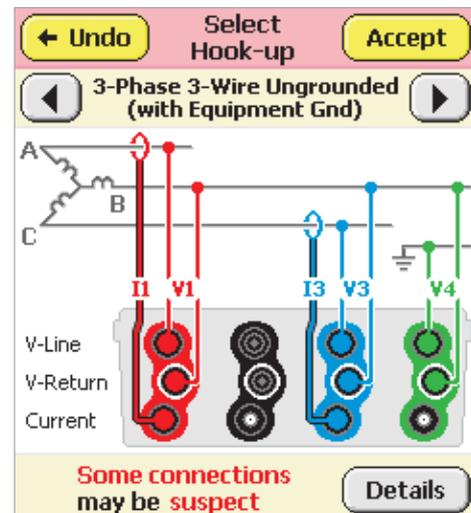


to step through the available options until you find "3-Phase 3-Wire Delta".

Stepping from "3-Phase 4-Wire Wye" through "3-Phase 4-Wire Delta",



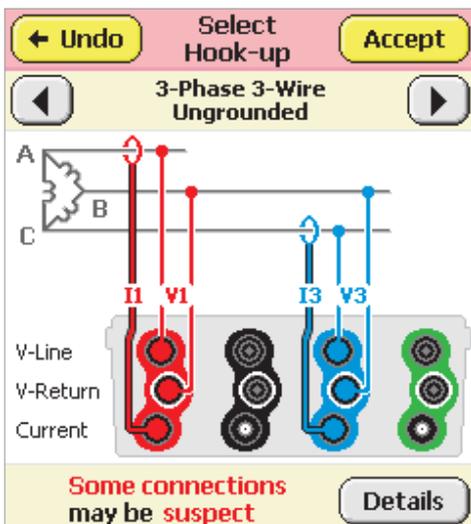
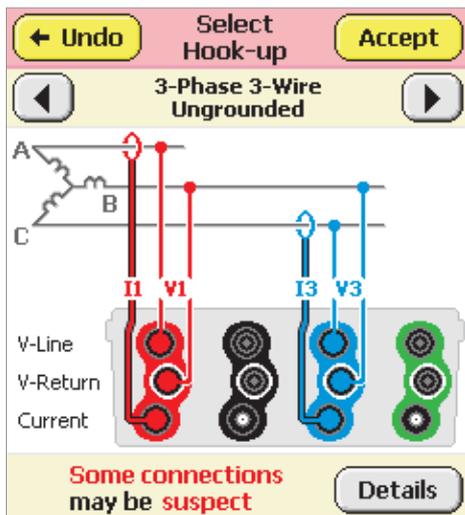
to "3-Phase 3-Wire Ungrounded (with equipment ground)",



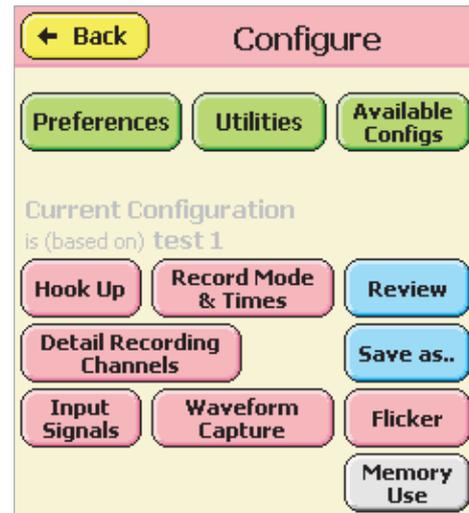
to "3-Phase 3-Wire Ungrounded", which is what we want. See below.

You will notice that over a few seconds the "Delta" configuration will change to a "Wye" and back again. This is to show that this hook-up is suitable for both

situations. The significant thing is that neither has a neutral connection so there are only three current carrying wires, and the Power Maths calculations do not distinguish between transformer configurations. Here are the two presentations. As far as the PM7000 is concerned they are both the same hook-up.



Press the “Accept” button to accept this hook-up type. This takes us back to the Configuration menu.



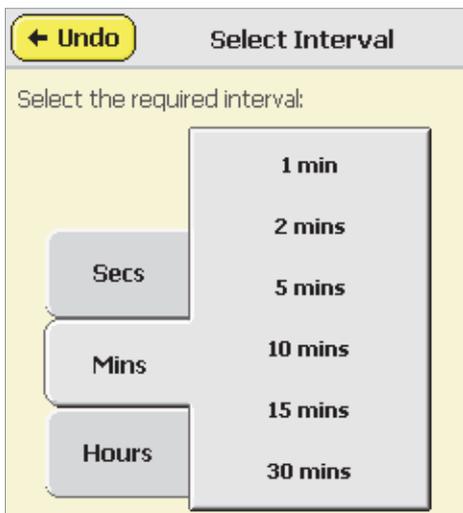
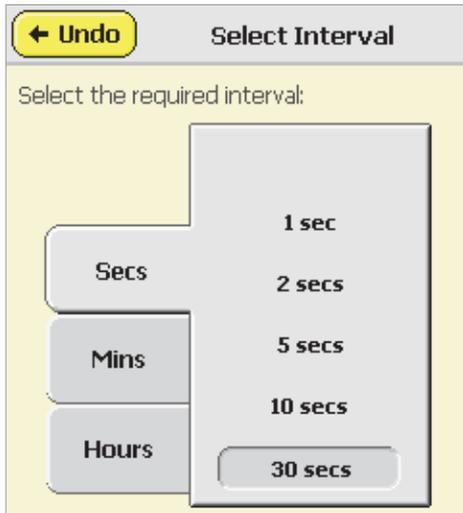
Select the next option by pressing the “Record Mode & Times” button.



At the moment this has a number of things wrong for our purposes.

The red 5 days \* shows that with the present parameter combination we can't have a 14 days recording period or even 7 days as currently selected. The reason is shown by the other \* beside the grey “30 secs” for “General Parameters Record Every”. This is because the memory presently available will be used up after approximately 5 days if we record the many General Parameters at 30 second intervals.

We can either allocate more memory (up to 16MB is available for General Parameters), or change the interval. A typical interval is 10 minutes, but we specified 5 minutes originally so we will change to that. Press the grey “30 secs” button on the screen above, followed by “Mins” and finally “5 Mins”:



recording time period (currently shown as 7 days). If we change the recording time “Period” to > 57 days, the Currently achievable 57 days will revert to red showing that again there is a conflict. However for our configuration we want 14 days so press the “7 days” since that is what we need to change.



The “Days” button is already selected (shown depressed), so press “Clear” to leave just the flashing cursor.



Now enter “1” followed by “4”,

Now the currently achievable 5 day constraint has disappeared along with the asterisks (\*) to be replaced by “57 days” in black. The black indicates that this is no longer significant in relation to the present

then “Accept” to complete the selection.

We will keep the “Adaptive Store” and “FIFO Off” selections. “Adaptive Store” is almost always a better selection than “Point Store”, simply because it is good

at accommodating the unknown.

We could examine the “Memory Use” because clearly the memory allocated to General Parameters is more than enough for the 14 days, and we might choose to reduce the memory allocation all round.

Pressing “Memory Use” we get:

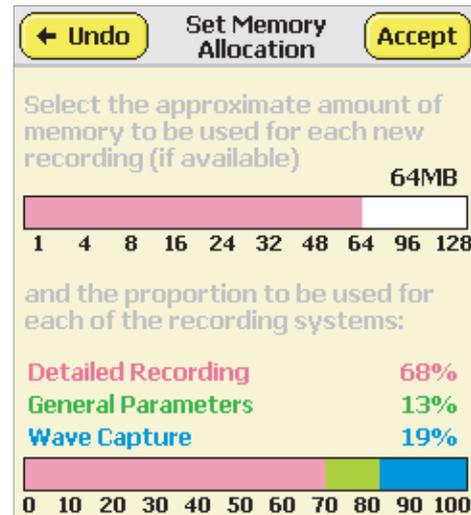
This screen shows that a total of 64MByte has previously been allocated, and of that, 25% (16MByte) was intended for the General Parameters. In fact if 16MByte can provide for 57 days, 4MByte will suffice for 14 days. Similarly, depending on the waveform capture detail required, 16MByte (25%) for that might also be considered generous. For the moment we will accept it and acknowledge that if we subsequently curtail the total wave data to be examined, we may not use it all.

To re-allocate the bulk of the General Parameter provision to the Detailed Recording, we want to move the “Pink / Green” boundary on the lower bar to the right. We want to give 12MB (~18% of the 64MB total) from Green (General Parameters) to Pink (Detailed Recording).

We have to do this in several steps. We press on the bar to tell the PM7000 to change the memory allocation, and if we press within either the Pink or Blue zones, the message is unambiguous, but if we press in the Green zone, the PM7000 has to choose which boundary to move. If we press in the left quarter or right quarter of the green zone, the boundary affected is the left or right respectively. If we press within the central half, it might go either way. In fact the algorithm sets a decision point (a sort of “watershed”) based on the existing size of the Pink and Blue zones, so that if the Blue Zone is comparatively small, the decision threshold is closer to the PINK boundary (i.e.

favoring the Blue zone). Conversely, the Pink zone is favored if the existing Pink zone is smaller than the Blue.

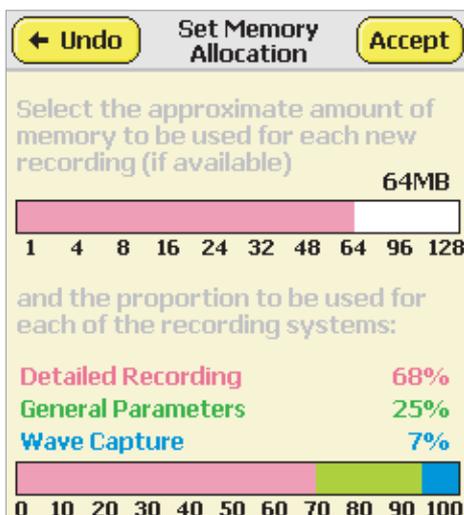
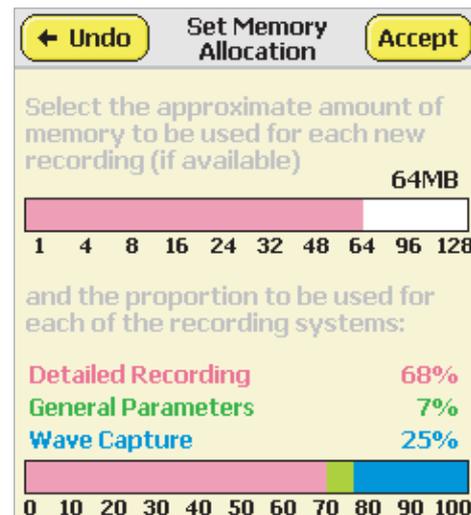
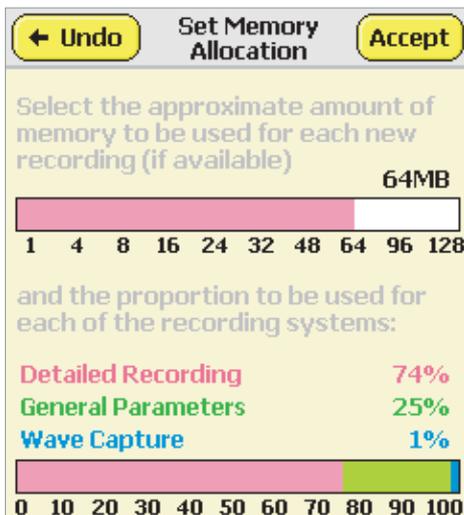
Thus we can't just touch the bar at the 68% point, because that is closer to the Blue zone than the Pink, and the watershed (decision point) is already closer to the 50% point than the 75% point i.e. at < 62.5% because the Pink zone is bigger than the Blue. The fastest way to reallocate the green section is to first reduce the Blue allocation to almost nothing by pressing at the extreme right hand end of the bar close to 100%. Because the maximum allocation of memory to the General Parameter section is 16 MByte, the Pink/Green boundary moves towards the 75% point, i.e. well past the 68% target. We can then press unambiguously on the 68% point. (Notice how the numbering guide is slightly squashed up towards the middle of the screen so that the bar can make full use of the screen width – to get 68% we have to press nearer the 70 mark.)



This gives the desired Detailed Recording allocation.

We can now press in the centre of the Green zone confident that this will be interpreted as allocating some of the Green 25% to the Blue, since the Blue is very much smaller than the Pink which means Blue is favored.

We now want to halve the Green section once more to cut its allocation from 13% to 7%, and since Pink is still much bigger than Blue, we can press in the center of Green again to finish the job.

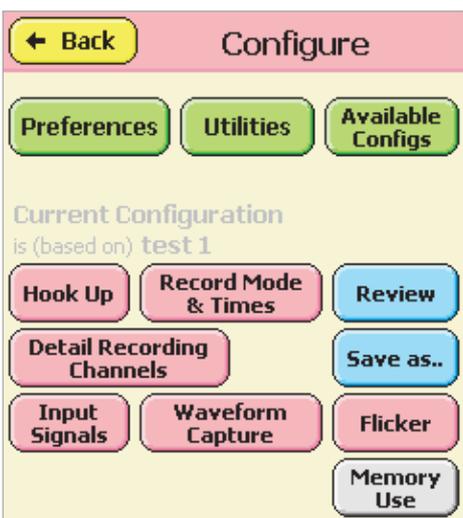


This process is a bit fiddly but readily mastered once the decision-making reasoning is known, and it's not usual for the precise memory allocation to be critical. During the design stage several algorithms were tried, but none was considered wholly satisfactory. This one was chosen in the end because it showed the proportions at a glance, you could see how one allocation change affected the others, and the proportions sum to 100%. If you can think of a better way to do it, please let Outram Research or your

distributor know!

Note that the proportions are maintained if you reduce the total memory available (subject to the 16MB maxima applied to General Parameters and Waveform Capture). So once you have an arrangement you like, you can reduce the memory consumed on a short recording simply by altering the total memory available to the recording process.

Having made the desired memory allocation, press “Accept” then “Accept” again to return to the configuration menu.



## Detail recording channels

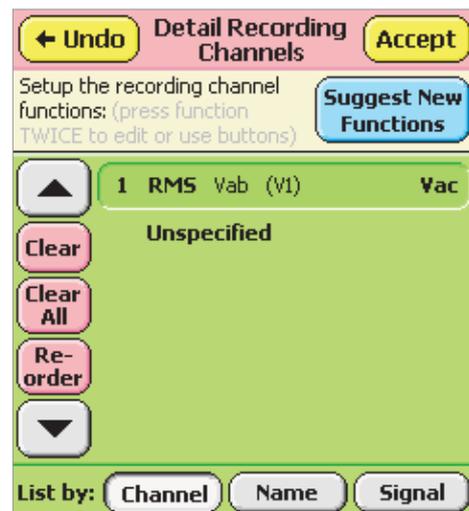
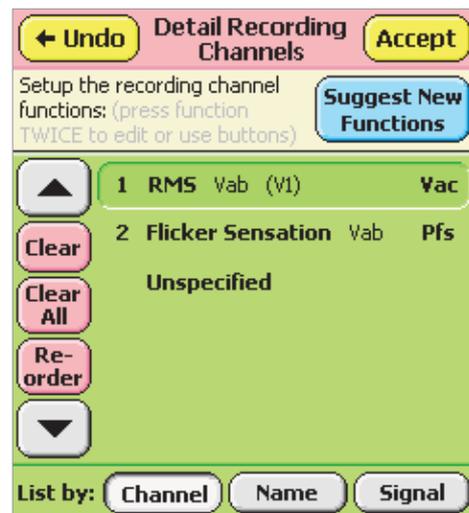
Here we set up the parameters to be recorded in detail by the Adaptive Store process. These parameters are recorded in the same way as in other Power Master products from Outram Research. The difference is that in the PM7000 it is probably not necessary to specify

any parameters for which you don't need detail, since they are almost certainly recorded as part of the General Parameters. This especially applies to Harmonics since there are a lot of them, they ARE recorded as General Parameters and they may not mean much in the very short term.

Conversely, as well as voltage and current, Instantaneous Flicker is valuable in the very short term where it can be directly compared with voltage and current activity to help determine the source of Flicker but, as a stand alone parameter, is better served by recording Pst and Plt (Short Term and Long Term Perceptibility), both of which are available as General Parameters.

Referring back to our specification, we choose to record detail on Volts, Current, Power and Instantaneous Flicker as appropriate to this 3-phase 3-wire Delta installation.

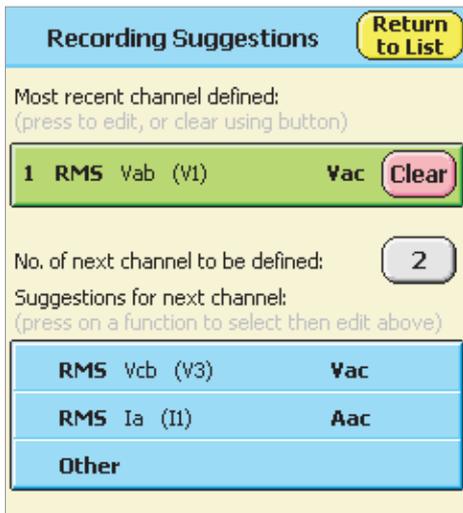
Press “Detail Recording Channels”. This resultant screen may show any combination of parameters so, to start with a clean sheet, next press “Clear All”.



Notice that you can't eliminate ALL selections, there must be at least one. The logger assumes that at the very least you will want to record the Volts on V1. In this case that will be Vab, since it is a Delta installation.

Whereas in other previous PM products, you had to select and specify all the details for each channel you wanted to see recorded, the PM7000 has an automatic means of anticipating what you might want to record based on what you have already chosen. It is not entirely comprehensive but we hope it will reduce the button pushing dramatically when you want to create new configurations like this.

In the above case, the logger assumes you have selected Vab for Channel 1. (WE know we didn't apparently have any choice, but the logger has to start somewhere.) To select the next channel function as in previous products, you can press on the "Unspecified" line twice (once to select it, and the second time to change it). However we will see what the PM7000 can offer to reduce our button pushing. Press "Suggest New Functions".



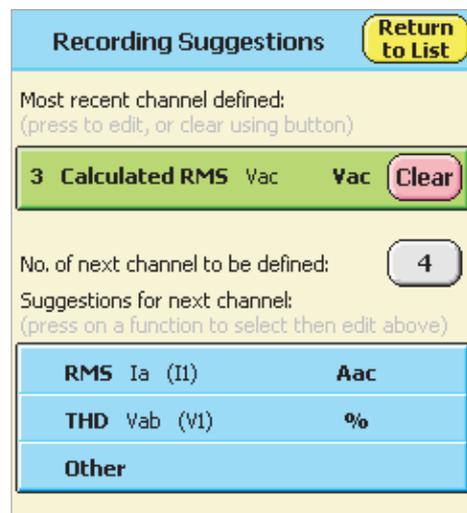
This screen shows the latest selection made (RMS Vab applied to channel 1). Based on that it offers two suggestions which might logically follow, in this case "Vcb the logical next voltage and Ia which would be the first relevant current. If you DON'T want to record Vcb then don't press it – but don't blame the logger if you don't get offered it for quite such little effort again! Of course we DO want it, it's part of our specification. Press "RMS Vcb (V3)".



This now becomes the most recent selection and it has been allocated to channel 2 since we left the "2" unchanged in the screen above.

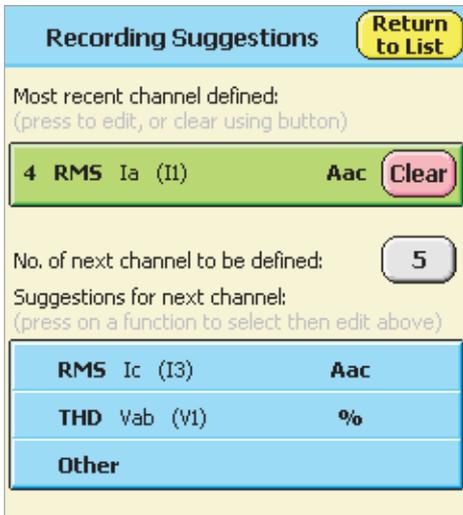
The PM7000 also calculates Vac from the vector result of (Vab – Vcb), and we can record that if we wish to. (We could also record it directly by using V2, but these recording suggestions are based on the Hook-up selection we made, and that assumes we don't have probes attached to V2.)

We will record the "Calculated" version of Vac, as it is often useful to have the third phase-to-phase result. Press "Calculated RMS Vac".



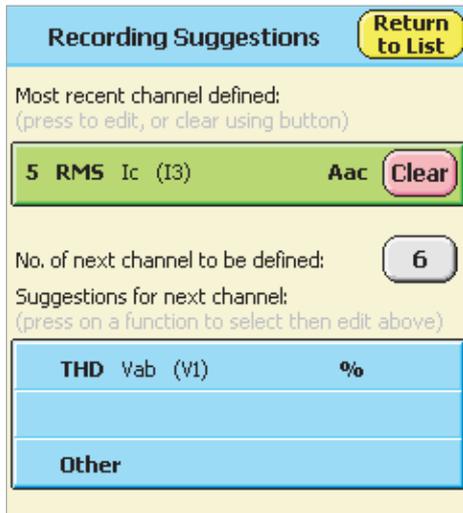
Note that we don't have to specify things in this order and the system is very flexible. Any of these selections can be made in the conventional manner and you may change the channel allocation. But here we are using the automatic suggestion process and you will note that we are using just a single press to make each channel selection.

Now we have all the voltages. Press “RMS Ia (I1)” to add this for channel 4.



This leads on to Channel 5, for which we will take up the next suggestion.

Press “RMS Ic (I3)”.



We are now running out of logical suggestions. The logger doesn't know what to offer next so it's time for you, the user, to give some guidance. We want to specify power parameters. That isn't THD so we can either Press “Return to List” or the alternative selection “Other”. Press “Other”.

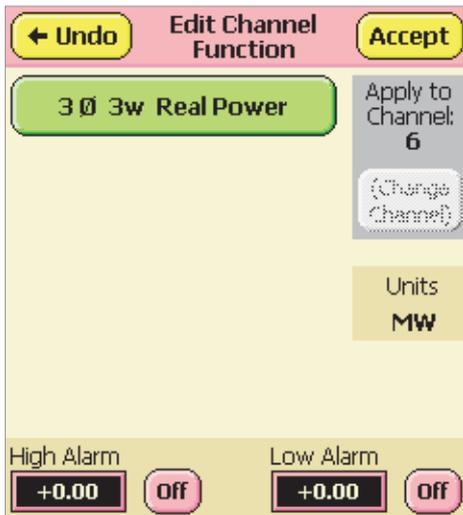


This is the same point we would normally reach on selecting a previously unspecified channel directly from the “Detail Recording Channels” screen. We need to select Three Phase power functions so press “AC Three Phase”.

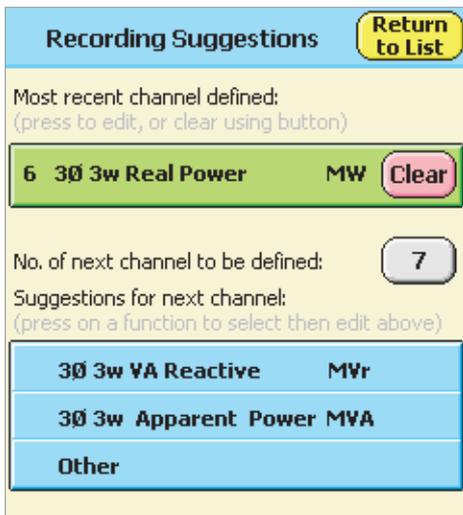
This brings up the list of three phase functions applicable to the Hook-up we have chosen.



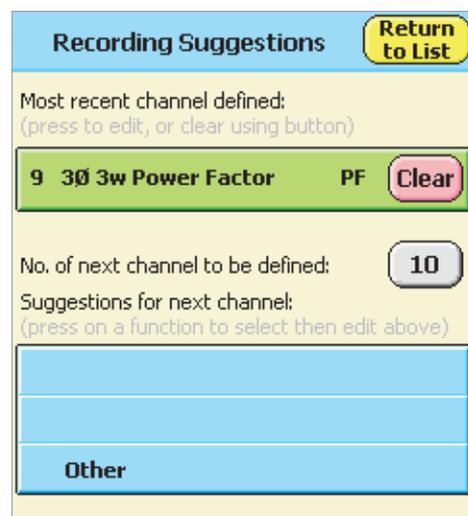
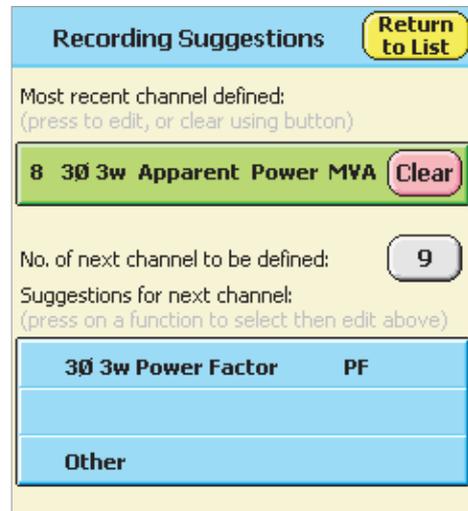
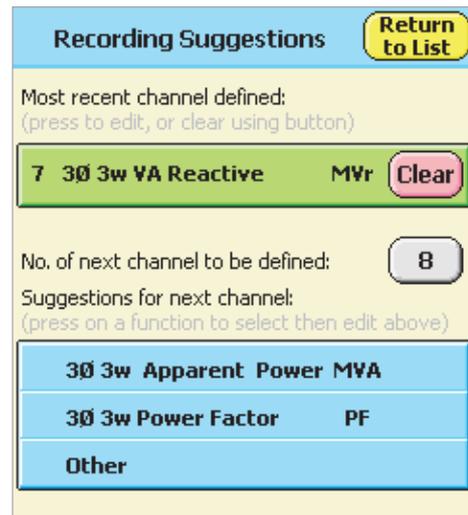
We will choose Real Power first. Press the “3 phase 3w Real Power” button.



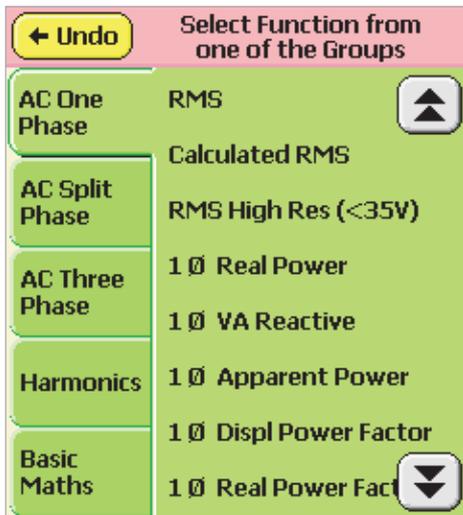
Follow by “Accept”.



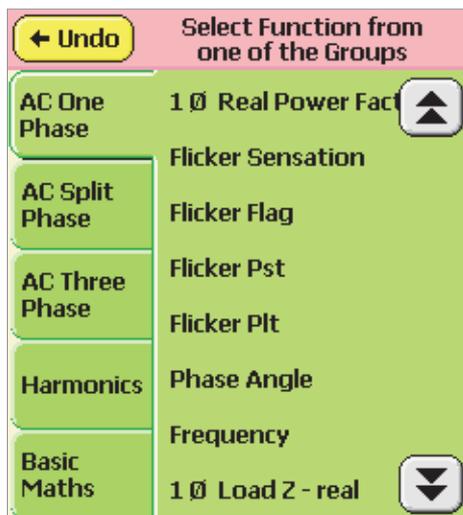
We now have 3 phase 3 wire Real Power allocated to channel 6 and the logger is again able to offer suggestions for the next channel. Press “3 phase 3w VA Reactive”. Follow with “3 phase 3w Apparent Power” and then “3 phase 3w Power Factor” to complete the power selections.



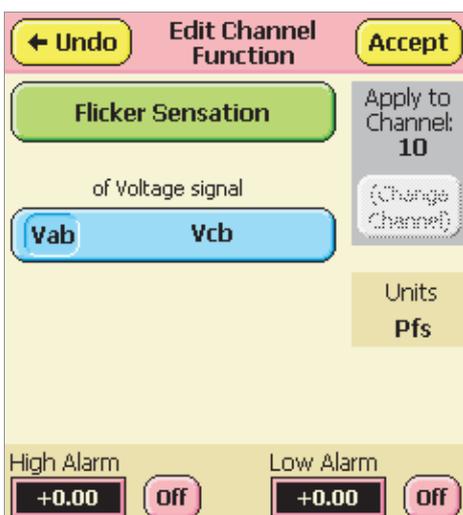
We need the Flicker functions, but the logger has no idea of that, so again press “Other”.



Instantaneous Flicker IS an AC One Phase function, press the grey double down arrow to see more AC One Phase selection possibilities.



Press on "Flicker Sensation".



Vab is the obvious first Voltage signal choice so if it's not already selected, select it now, then press "Accept". Having given the logger some guidance again, it is able to offer the second voltage channel Vcb for channel 11, so we press "Flicker Sensation Vcb".

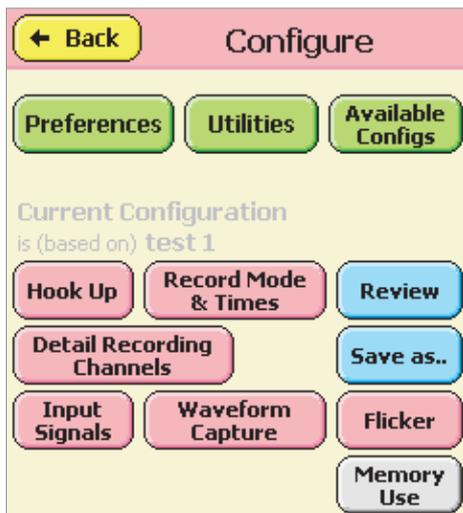


We could at this stage record Plt, Pst etc. as detailed channels, but it's not necessary as, for the chosen intervals, we won't get any more information than we will get in the General Parameter recording. We therefore press "Return to List" which shows the later channels selected.



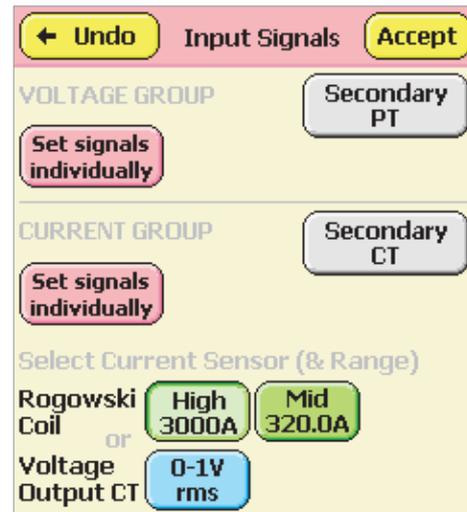
We can scroll up and down this list, or order it by name or by signal. We can add additional functions or change ones already specified. Remember that pressing a button AND HOLDING IT DOWN for more than one second will usually bring up some relevant help to guide you.

We have made all our selections so we can press "Accept" to return to the main configuration menu.

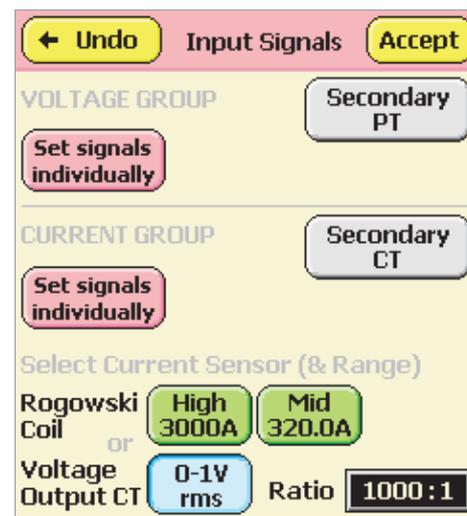


## Input signals

We should verify that the input signals are appropriate for the 415V, 1500A ranges we specified. Press "Input Signals" to come up with the input signal set up menu.

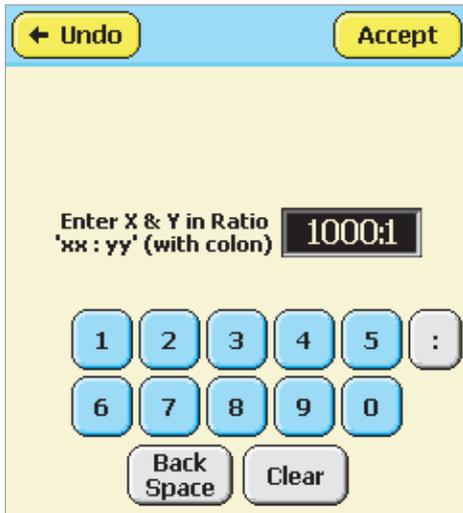


In fact the input signals are appropriate. Since Secondary PT s and Secondary CT s are not in use (Press on one of them to see what happens, then press on it again to turn it off), the input voltage range is the nominal 0-600V, and the Current Sensor is already selected to be the Rogowski Coil on the 3000A (now 6000A and 400.0A for mid) range. If you wish to use Voltage Output Current Transformers, press "0-1V RMS" to turn off the High Range Rogowski coil selection and enable the choice of CT ratio, as in the screen below.

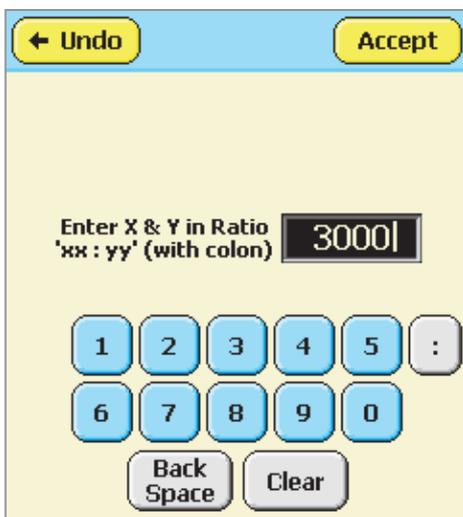


You will see that as with the selection of Secondary PT or CT, a ratio selection box becomes available when you need one. Since in this case we may need to see 1500A, and the input range to the PM7000 is 1VRMS, we cannot use 1000:1 CTs: we will need ratios of at least 1500A : 1V. Let us assume we have 3000:1 CTs available.

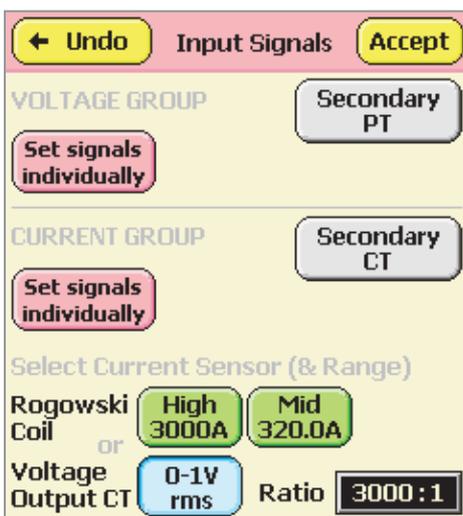
We need to enter the ratio 3000:1. Press on "1000:1", i.e. inside the ratio box.



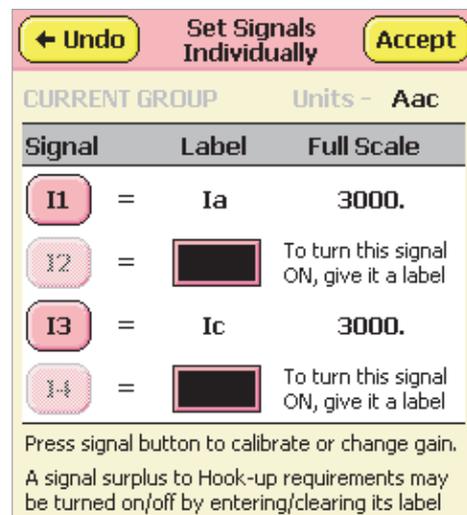
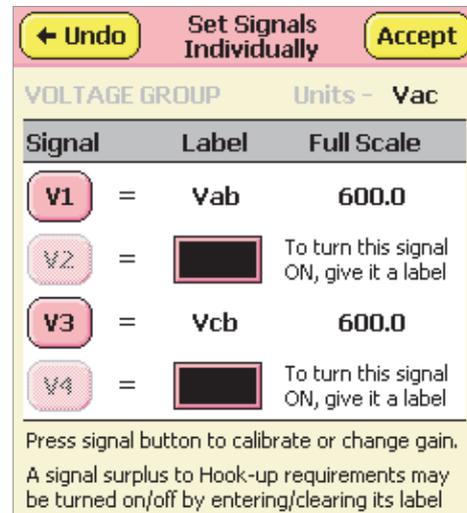
Press "Clear", then enter "3", "0", "0", "0". (intermediate screens not shown)



You may accept "3000" directly. The PM7000 will assume the second part of the ratio is ":1". If it is NOT to be ":1", then you must enter the "." and the second number. When you are ready press "Accept".



If you wish to confirm the full scale ranges now available, you can press either of the "Set signals individually". Here is what happens for the voltage and current groups.

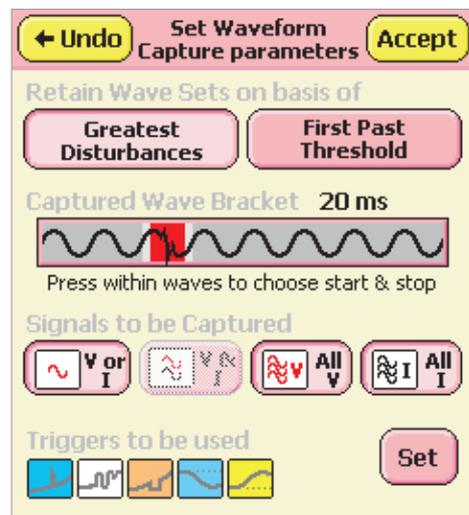
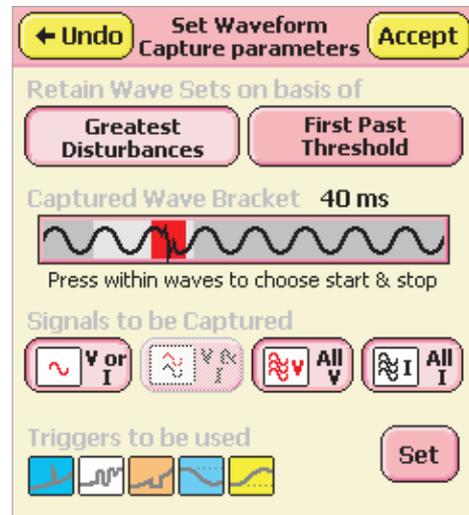
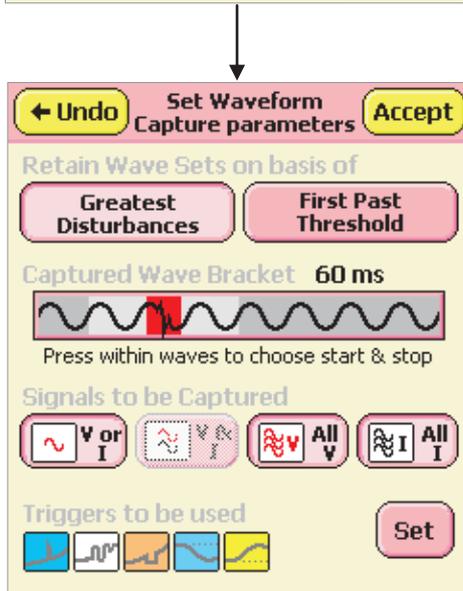
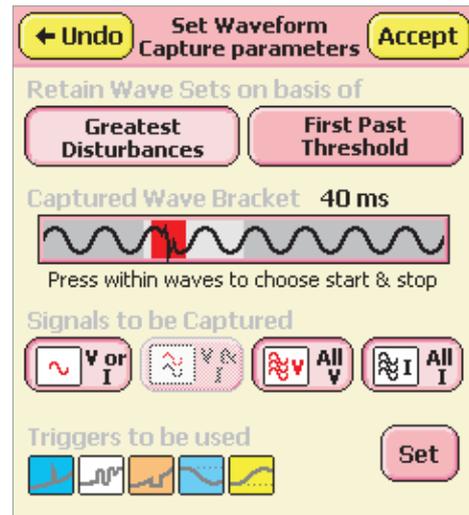
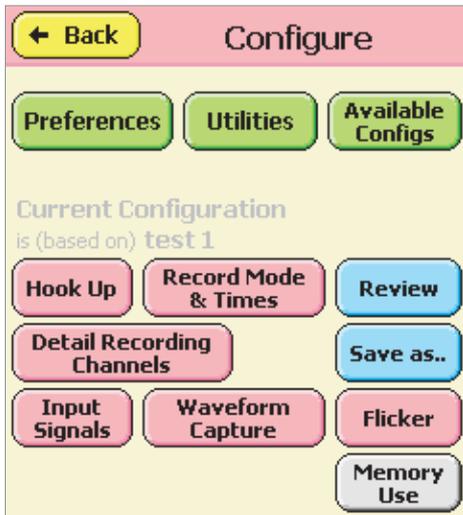


Notice that because of the hook-up we have chosen, only V1, V3, I1 and I3 are active. The other signals can be used but while the label remains blank, they remain turned off. We confirm that the ranges we need (415V & 1500A) are indeed available and reasonably matched to the logger full scales.

Press "Accept" to return to the configuration menu.

### Waveform capture parameters

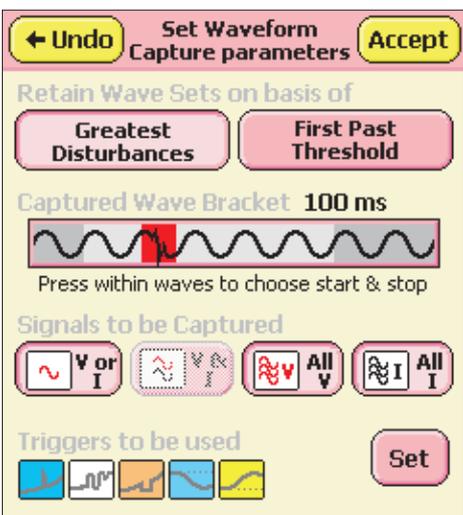
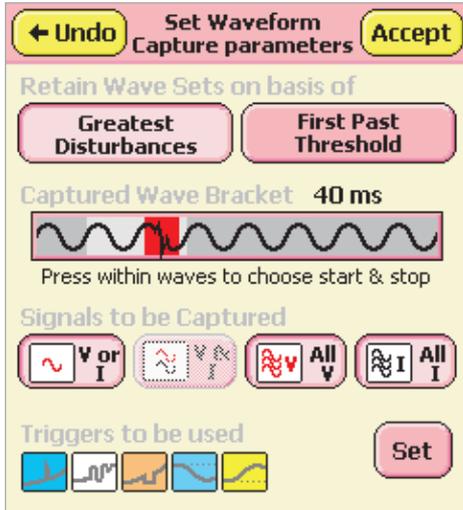
On the configuration menu, press "Waveform Capture" to bring up the 'Set Waveform Capture parameters'.



We will retain wave sets on the basis of “Greatest Disturbances”, because that means we don’t have to think about threshold levels. In this case the logger will automatically rank events seen in each of the trigger categories, and discard the smallest. All we have to do is decide how much data we want to examine when the recording is complete. We can adjust the pre- and post- trigger capture periods: press in the middle of the red “spiky” section of the captured Wave Bracket bar to reduce it to a minimum (20 msec). (Pressing on the left or right side of the red “spiky” section will collapse just that side.)

Press within the Captured Wave Bracket bar to the left of the red “spiky” section on the point where you would like the capture to start. If we wish to capture say 20ms before and 60ms after the cycle containing the event, press approximately one whole cycle ahead, and then

three whole cycles behind the red event section. Include the captured wave itself and the total bracket will last 100ms.

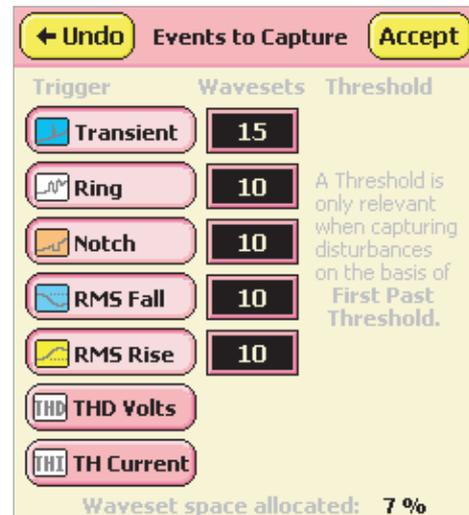


The bracket is adjustable in 6.66ms steps, so press within the bar to obtain the desired wave bracket.

Select the signals to be captured when an event is detected. Typically this will be “All V” and “All I” (All the relevant voltage signals and all the relevant current signals). These “Signal selection” buttons are inclusive. If “All V” and “All I” are selected it does not matter whether the individual signal causing the trip (“V or I”) or the complementary signal (“V & I”) are selected. They will all get saved anyway.

Finally select the triggers you wish to use. In the diagram above, five triggers are in use.

Access these, and the amount of data to be associated with them, by pressing “Set”.



There are seven user selectable triggers. Six are associated with voltage and one with current. The five most common voltage ones are shown selected above. Pressing on the selection button turns them on or off. We will turn off the Total Harmonic Current selection. Press “TH Current”.

Each of the triggers has its own space into which its own “captures” are stored. Each “Capture” consists of the 100ms bracket previously selected, on whatever signals are chosen to be captured, in this case “All V” and “All I” (which is two of each, since V2, V4, I2 and I4 are not in use). This combination is called a “Waveset”. Thus each capture event captures one “Waveset” comprising 100ms worth of data on four signals. The number of Wavesets to be retained by each trigger is selectable here.

Remember that the ranking and automatic discard process operates independently for each trigger so “RMS Falls” and “Rises” [1] will be retained regardless of the more spectacular transients etc., (unless the transients are so significant that they seriously affect RMS rise and fall and hence cause Rise and Fall triggers.)

[1] “RMS Falls” and “RMS Rises” are really Sags and Surges, Dips and Swells by other names. The latter names do tend to have thresholds associated with them (commonly +/- 10% from nominal), and since these triggers are typically searching for any effects to capture, often much smaller than +/- 10%, it was not felt appropriate to use the more formal names.

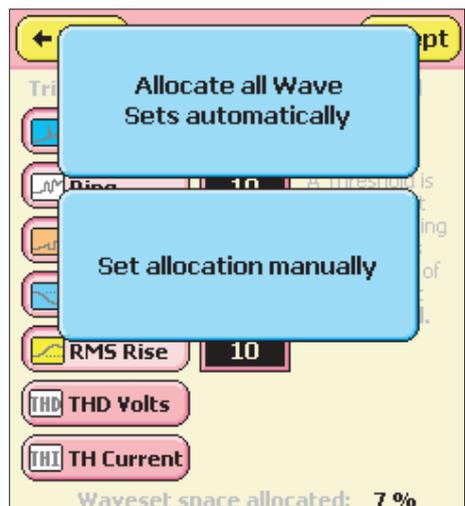
So to avoid confusion they are not used here but these formal names ARE used in the Standards Comparison processes where the appropriate thresholds are applied.

Selection of the Waveset associations can be made manually or automatically. Each time you enter the

“Events to Capture” screen from the “Set Waveform Capture parameters” screen you have the option to choose manual or automatic.



Since we have only 7% of the available memory allocated, we will raise the number of transient wavesets. Press on the “15” (beside “Transient”).



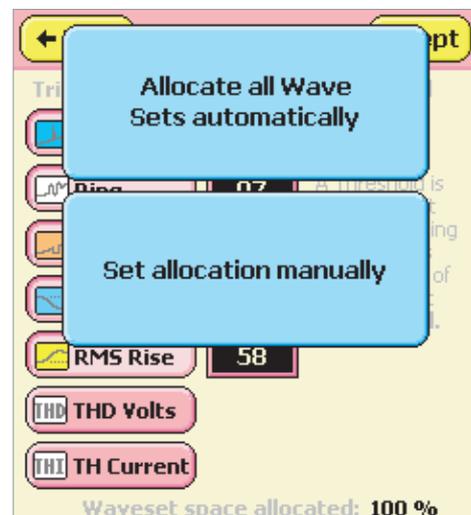
Here is the manual or automatic allocation option.

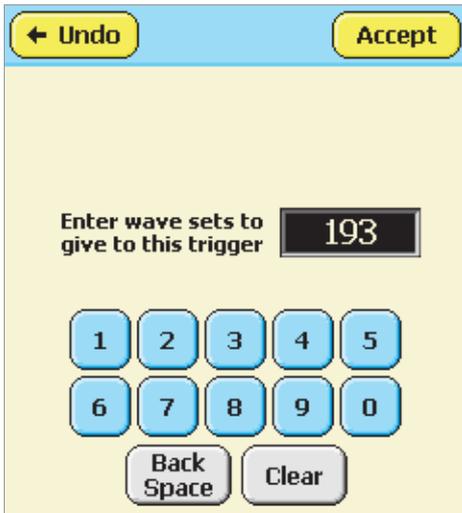
If you choose “Automatic”, all the memory you have made available will be allocated in pre-defined proportions to the triggers you have currently selected. Press “Allocate all Wave Sets automatically”.



This may be useful to you or you may consider the proportions inappropriate. (The automatic allocation becomes more useful when you restrict the amount of memory available to the waveform capture process, because again you don't have to think about it).

If you don't like the automatic allocation numbers, press on any of the numbers (e.g. The “193”), and this time press “Set allocation manually”

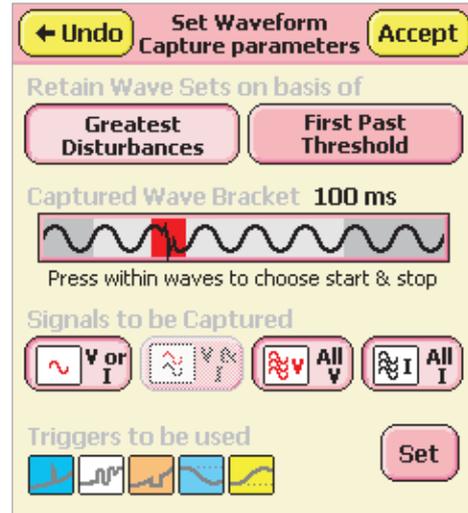




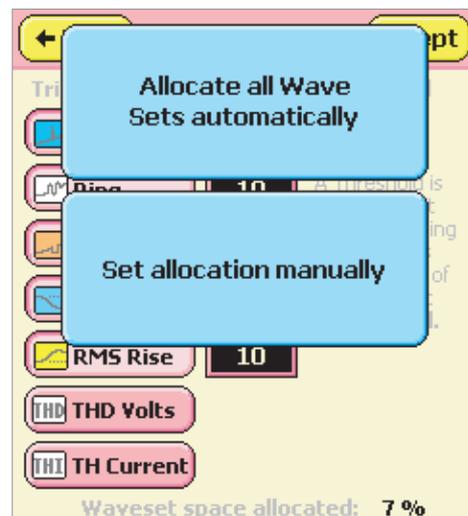
You may now change each of the numbers individually.

You could also go back to the original number allocation if this is closer to your intentions by pressing "Undo" to return to "Events to Capture" (see below), then "Undo" again to return to "Set Waveform Capture parameters".

Press "Set" again to have a whole second chance:



Now press "15" and follow that with "Set Allocation manually". Change the "15" to "150" by appending a "0" and Accepting.



← Undo Accept

Enter wave sets to give to this trigger 15

← Undo Accept Events to Capture

Trigger	Wavesets	Threshold
<input checked="" type="checkbox"/> Transient	<span style="border: 1px solid black; padding: 2px 10px;">150</span>	A Threshold is only relevant when capturing disturbances on the basis of First Past Threshold.
<input checked="" type="checkbox"/> Ring	<span style="border: 1px solid black; padding: 2px 10px;">150</span>	
<input checked="" type="checkbox"/> Notch	<span style="border: 1px solid black; padding: 2px 10px;">10</span>	
<input checked="" type="checkbox"/> RMS Fall	<span style="border: 1px solid black; padding: 2px 10px;">100</span>	
<input checked="" type="checkbox"/> RMS Rise	<span style="border: 1px solid black; padding: 2px 10px;">10</span>	
<input type="checkbox"/> THD THD Volts		
<input type="checkbox"/> THD TH Current		

Waveset space allocated: 50 %

This will give plenty of material for examination and you are very unlikely to miss any significant event. Press "Accept" then "Accept" again to return to the configuration menu.

← Undo Accept Events to Capture

Trigger	Wavesets	Threshold
<input checked="" type="checkbox"/> Transient	<span style="border: 1px solid black; padding: 2px 10px;">150</span>	A Threshold is only relevant when capturing disturbances on the basis of First Past Threshold.
<input checked="" type="checkbox"/> Ring	<span style="border: 1px solid black; padding: 2px 10px;">10</span>	
<input checked="" type="checkbox"/> Notch	<span style="border: 1px solid black; padding: 2px 10px;">10</span>	
<input checked="" type="checkbox"/> RMS Fall	<span style="border: 1px solid black; padding: 2px 10px;">10</span>	
<input checked="" type="checkbox"/> RMS Rise	<span style="border: 1px solid black; padding: 2px 10px;">10</span>	
<input type="checkbox"/> THD THD Volts		
<input type="checkbox"/> THD TH Current		

Waveset space allocated: 23 %

This has still only increased the memory used to 23% so perhaps we shall boost the number of Rings and Falls we capture too.

Raise them to say 150 and 100 respectively. Press on the "10" beside the "Ring" selection button. "Back Space", "5" and "0" followed by "Accept" will raise the Ring allocation to 150 and pressing on the "10" beside the "RMS Fall" selection button, appending a "0" followed by "Accept" will raise the RMS Fall allocation to 100.

← Undo Accept Set Waveform Capture parameters

Retain Wave Sets on basis of

Captured Wave Bracket 100 ms

Press within waves to choose start & stop

Signals to be Captured

V or I  V & I  All V  All I

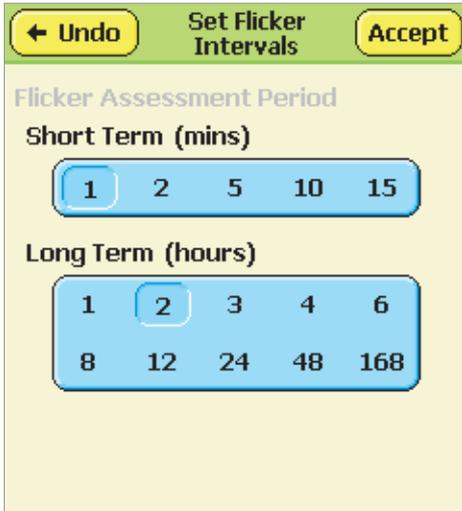
Triggers to be used

← Back Configure

Current Configuration is (based on) test 1

## Flicker

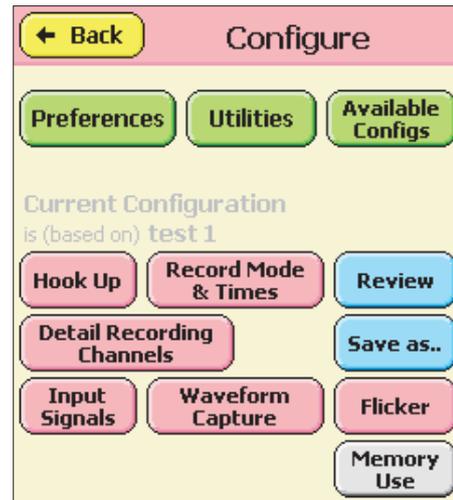
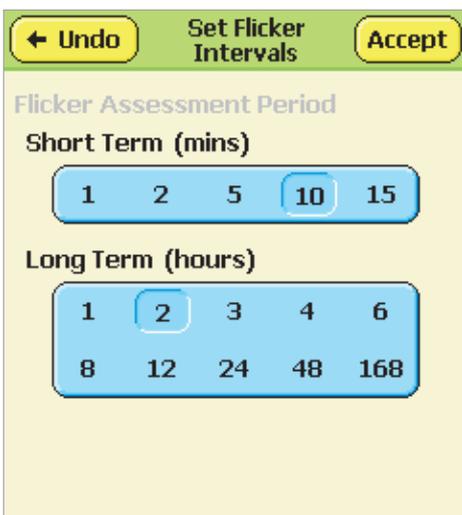
The final parameters to set are the Flicker assessment periods. Press “Flicker”.



These Flicker assessment periods change very little because the internationally prescribed periods for Supply quality assessment are 10 minutes for Pst (Perceptibility Short Term), and 2 hours for Plt (Perceptibility Long Term).

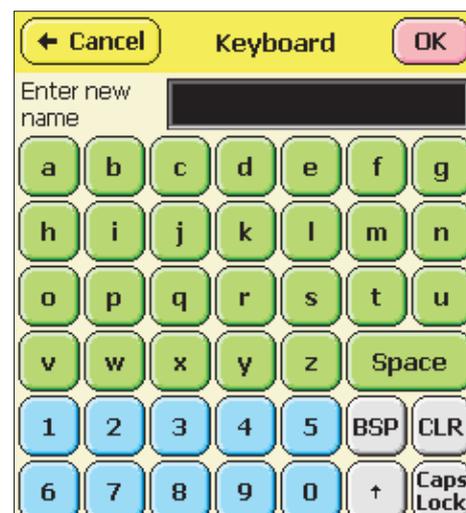
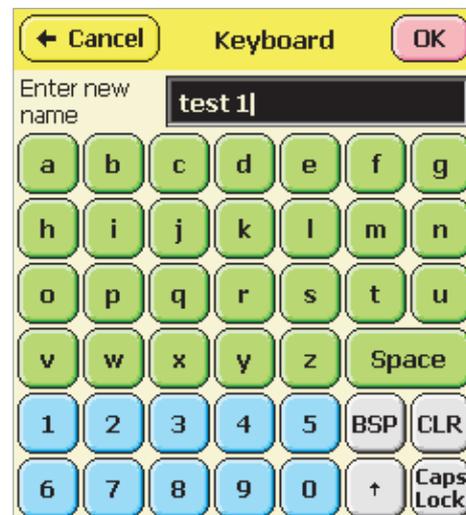
However they may be occasions where you want to apply different periods – the IEEE 1453 and IEC 61000-4-15 Standards both require these additional options to be available.

Here we choose 10 minutes and 2 hours. Press on “10” in the Short Term selection box. The Long Term selection is already 2 hours, so press “Accept” to return to the Configuration menu.



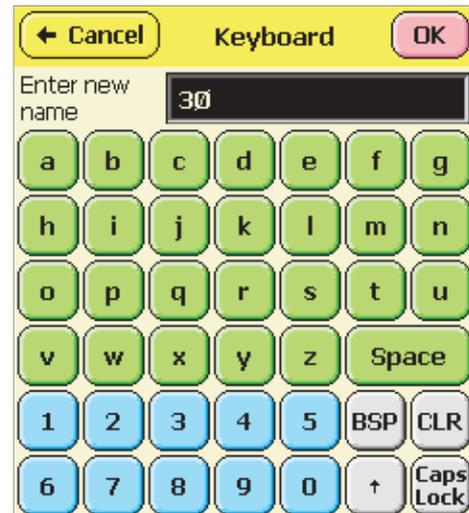
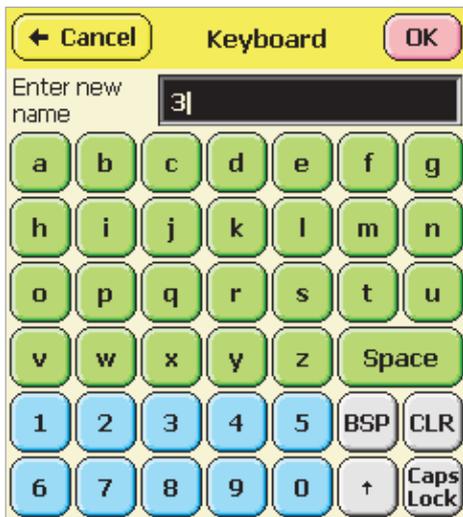
The configuration is now complete.

It can be saved to the Flash memory as follows: press “Save as”, and think of a name. Press “CLR” to remove the old name.



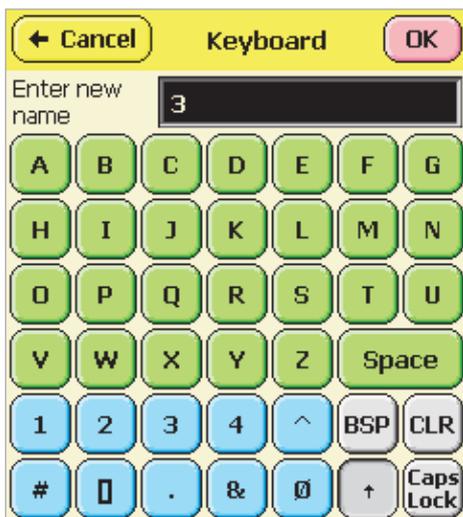
Then enter the new name. Note that pressing “Caps Lock” will show and use the Upper case screen until you press “Caps Lock” again. Pressing the “Up Arrow” button will show and use the Upper case screen just for the next character. This is ideal for titles and names.

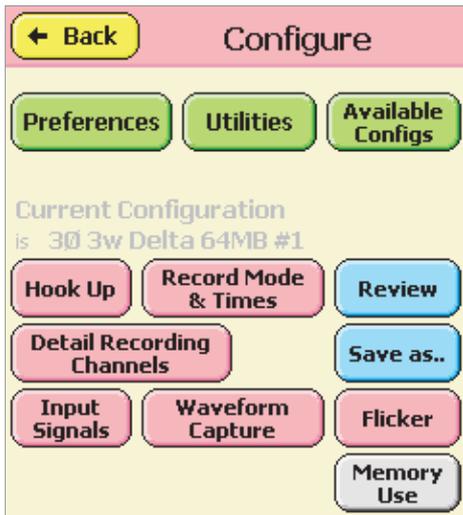
We will choose the name “3 phase 3w Delta 64MB #1”. Press “3”, then the “Up arrow” button to make the “phi” symbol available for “phase”. Press on “phi”.



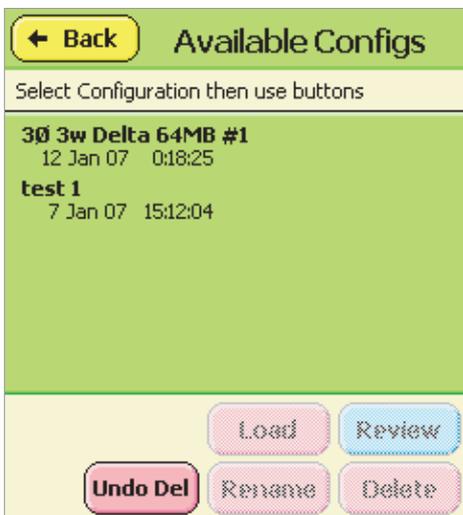
Notice how the keyboard went to upper case for just one character. Enter “Space”, “3”, “w” “Space”, and the “Up Arrow” button again. Enter “D”, “e”, “l”, “t”, “a”, “Space”, “6”, “4”, then “Caps Lock”. You can complete the name by pressing “M”, “B”, “Space” “#” and finally “1”.

Press “OK” to save the configuration with this name. Notice how the current configuration now has this name instead of being “based on” the old “test 1”.





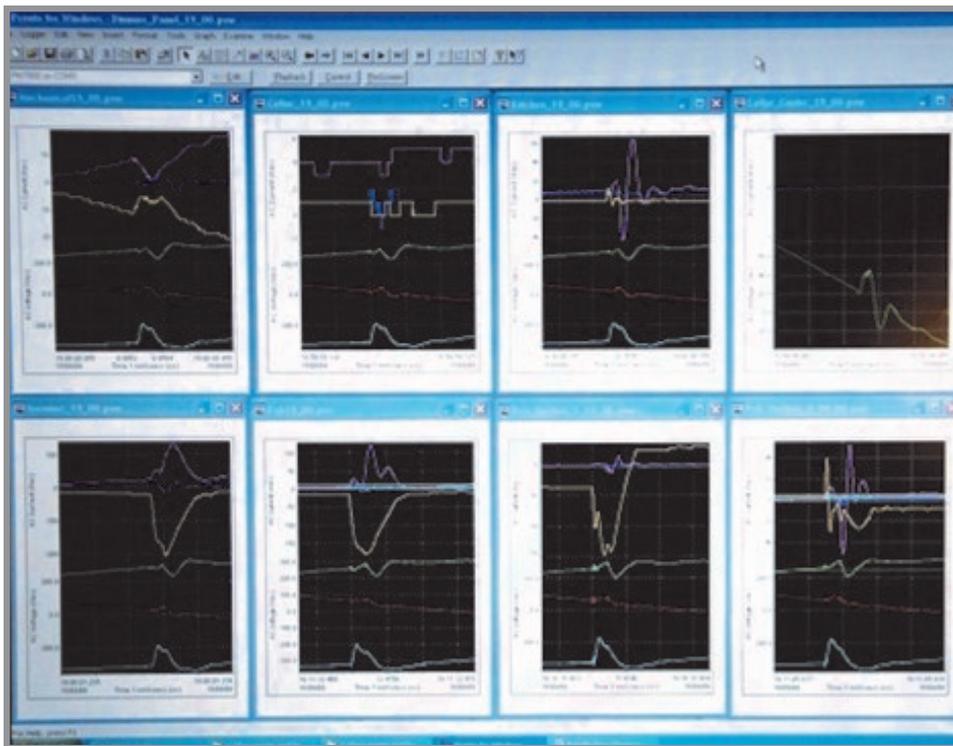
You can confirm that this configuration is saved and now available by pressing the “Available Configs” button:



Voila!



## Displays in the PM7000



Multiple PMScreen displays each showing a different parameter on one computer screen



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## Introduction: Displays

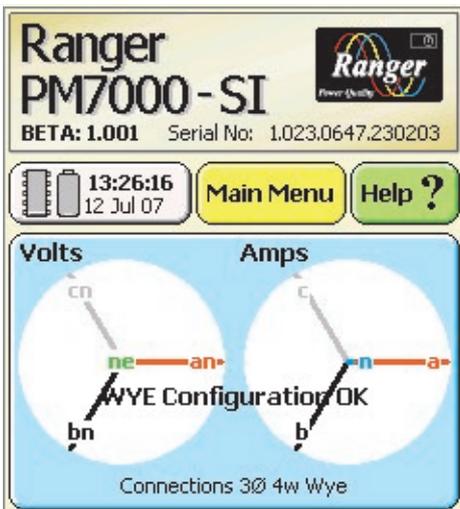
This document discusses the rich variety of data displays both real time and for stored data available in the PM7000, and shows how these are reached, and the ways to get the best out of them.

See also the documents:  
 “Creating a Configuration in the PM7000”  
 “PM series Phase Measurement

There are displays and graphs for almost all of the parameters measured by the PM7000. Some are real time only, showing the current measured values, others are of stored value only, and some graphs can be both, depending on what timescale has been selected.

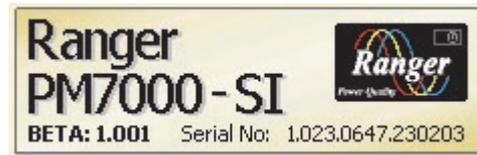
There are displays showing the current configuration, system status e.g. memory used up, time, elapsed recording period and so on, but this document is mainly about the AC parameters for whose measurement the PM7000 system is normally being used.

### Initial screen and status



This opening screen shows the Ranger unit’s personal information, some general summary information on the system status and the state of the input signals compared with what ought to be present for the Hook-Up currently selected.

The general purpose Help is accessible from this screen, as is the Main Menu.

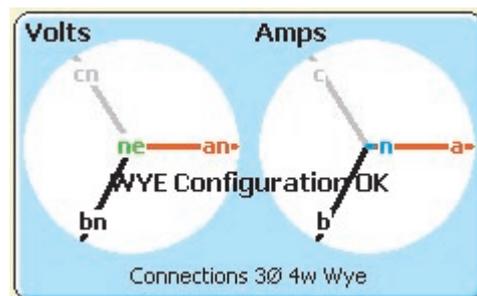


The Ranger Boiler plate is also a button. Press on this to get at Product sub-type and calibration.



The Hook-Up assumed to be in use i.e. the Hook-Up that was last selected, prescribes the relative phase angles between the various voltage and current input signals.

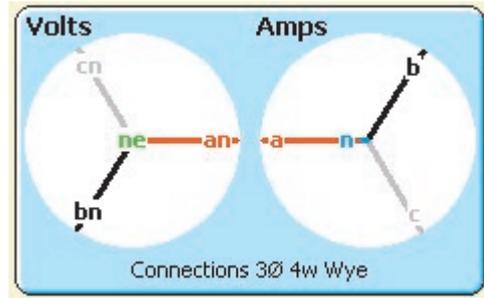
The Connection button shows dynamically the present phase angles with respect to the A phase voltage (in this example, “Volts an “ —an”), and attempts to make an assessment of whether the probes have in fact been attached correctly.



Each phase has a tolerance and provided the phases are approximately correct, the “Configuration OK” message is flashed onto the button as on this screen.

If the phase is reversed, this can also be detected (see below), but if the word “Suspect” is shown, it simply means that the PM7000 cannot be sure what is intended, though the phases don’t appear to be appropriate for the hook-up selected.

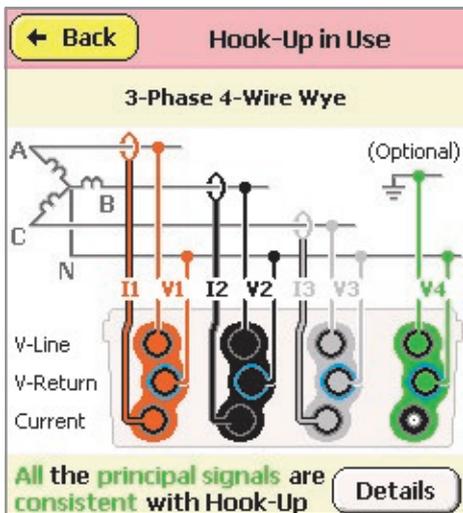
If we deliberately reverse the current phases – easily done by connecting the clamp or Rogowski coil back to front – we get Suspect Hook-up advice:



## Hook-up in Use and Advice on Hook-up Screens

Pressing on the Connections button brings up a diagram of the chosen hook-up. Use this to compare with the actual physical installation, because this is what the PM7000 is assuming you intended to do!

The Details button **Details** allows you to see the phase comparison results for the individual signals:



← Back		Advice on Hook-up		Finish	
<b>3-Phase 4-Wire Wye</b>					
Phase of measured signals					
<b>Volts</b>	<b>an (V1)</b>			<b>Good</b>	
	<b>bn (V2)</b>			<b>Good</b>	
	<b>cn (V3)</b>			<b>Good</b>	
	<b>ne (V4)</b>				
<b>Amps</b>	<b>a (I1)</b>	<input type="checkbox"/>			<b>Reversed</b>
	<b>b (I2)</b>	<input type="checkbox"/>			<b>Reversed</b>
	<b>c (I3)</b>	<input type="checkbox"/>			<b>Reversed</b>
	<b>n (I4)</b>	<input type="checkbox"/>			
Additional RMS results available from this hook-up: <b>Vab, Vbc, Vac</b>					

In this case the input phases for the currents were deliberately reversed, and now, where a “connection statement” can be made about each signal individually, we show that the signals are reversed.

We can correct a reversal in software by clicking on

the  button. The button as shown indicates that the signal and return wires are connected “straight through”, whereas after pressing, the wires are

“crossed”,  and the advice changes to

**a (I1)**  **Good**, indicating that the phase is now suitably correct.

Note that the reversal in software (a *soft* reversal) will *remain operational* while the unit remains switched on or recording (and in the special case of switch off during recording due to power loss followed by power recovery and automatic recording restart). But normally you are encouraged to make the current connections correctly and consequently the soft reversal is removed when the unit is switched off.

A final piece of information on this screen is the 'Additional RMS results' advice.

Additional RMS results available from this hook-up: **Vab, Vbc, Vac**

The choice of Hook-up may allow more signals to be calculated from the actual measured signals. A 4 wire Wye hook-up requires measurement of A, B and C phases with respect to Neutral. If **Van** and **Vbn** are measured simultaneously, **Vab** can be calculated from **Van - Vbn**. Similarly **Vac** and **Vbc** can also be calculated. The 'Additional RMS result' advice on

this screen shows which additional calculations can be made. [Of course the gain or accuracy of each individual measurement has a bearing on the calculated result, so the same signal presented to say Van and Vbn may not produce a Vab of zero, even though it should.]



The Status button shows time, and the flashing Recording and Charging symbols indicate the unit is Recording or On Charge respectively.

## Status and Status Recording Screens

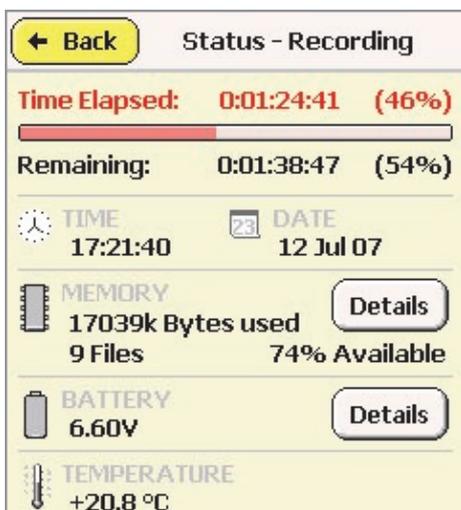
Pressing the button brings up a Status screen, the content depending on what the unit is doing.



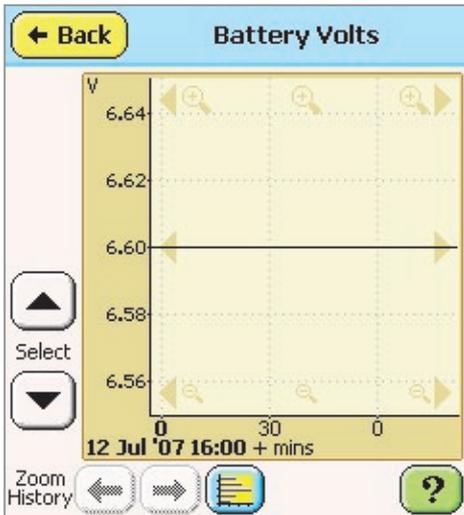
The above two screens show (left) the idle condition, in which Date and Time can be adjusted; and the recording condition (right), in which they cannot. Instead the elapsed recording time and that still remaining are shown. Further details on both memory occupied and battery charge status are available under the respective Details button.

### Hidden graphs

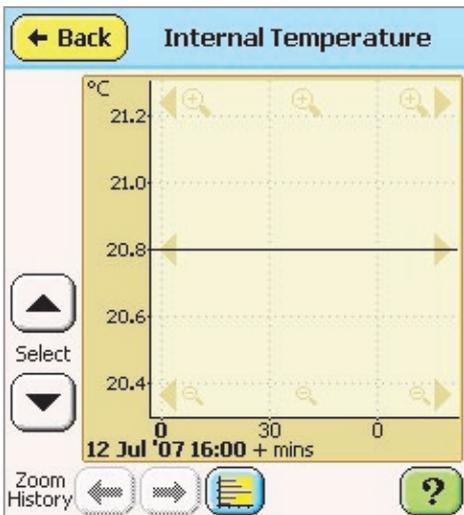
One of the strengths of the PM7000 user interface is its ability to access the underlying database for individual parameters and to show the graph of that parameter against time (assuming a recording exists in memory or is under way). We have tried to make most of these graphs available from the most logical place in the menu structure as will become clear later, but occasionally there is apparently no obvious point to which to attach a graph.



Two graphs are available from this status screen: Battery level and Temperature. Pressing on the Battery voltage digits **6.60V** will bring up the Battery Voltage graph. Similarly pressing on the Temperature digits **+20.8 °C** will graph temperature.



Pressing on the “Select” up or down arrows will also step between these graph types (and other miscellaneous graphs). These types of graph, and functions available within them are common to many other parameters, and they will be discussed later. At this stage the intention is to make you aware that there may well be graphs available underneath odd numbers shown on the screen, even though there may be no such indication – as you see in this case, the actual Battery Voltage and Temperature numeric values both have hidden graphs behind them.

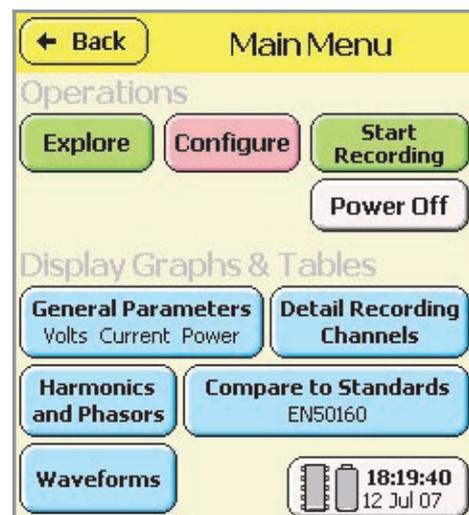


## Real Time Displays

Real Time displays are available for all the parameters recorded. From the Initial screen, select

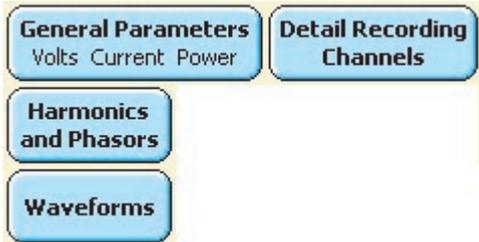
**Main Menu**

, to bring up the headings:





The **Compare to Standards** functions are strictly historical, but the other four buttons



all yield real time results, and in many cases, historical results too.

As discussed elsewhere there are three simultaneous recording regimes operating in the PM7000,

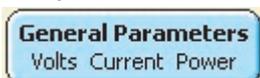
**General Parameters** (many parameters recorded at relatively long sample intervals – as low as 1 sec, but more typically 5 or 10 minute intervals),  
**Detail Parameters** (modest number (up to 32) parameters at up to cycle rate),  
 and **Waveforms** (the actual input signals (up to 8) at speeds up to 1.228 MS/s.)

The Waveforms, or verbatim input signals unprocessed, are accessible under the “Waveforms” button.

All the derived parameters, VRMS, IRMS, Harmonics, Flicker, Power etc. are accessible under the “General Parameters” or “Harmonics and Phasors” buttons. The latter is concerned with individual harmonics as opposed to RMS results, though groups of harmonics, e.g. THD, Odd Harmonics, TripleNs etc. are also available under this button.

The “Detail Recording Channels” button accesses all the channels chosen to be recorded at cycle rate. This typically includes VRMS and IRMS, Power parameters and perhaps Unbalance or Instantaneous Flicker Sensation. Any of the more obscure parameters available e.g. Directional Harmonic or Interharmonics (where available) may be included in this list if selected.

Working up from the simplest most common



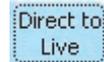
parameters, select **General Parameters**. This brings up the options for immediate display. Note that once an option has been selected here, the button appears



slightly differently next time, e.g.



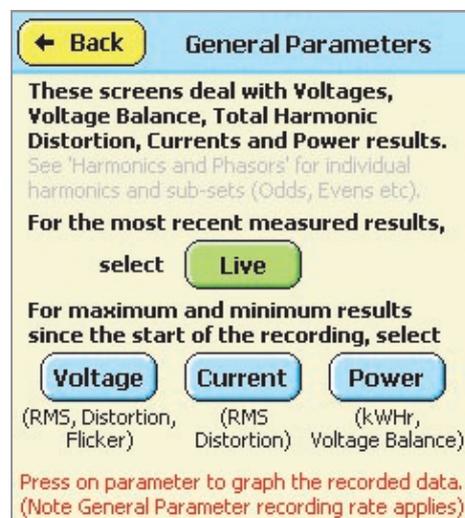
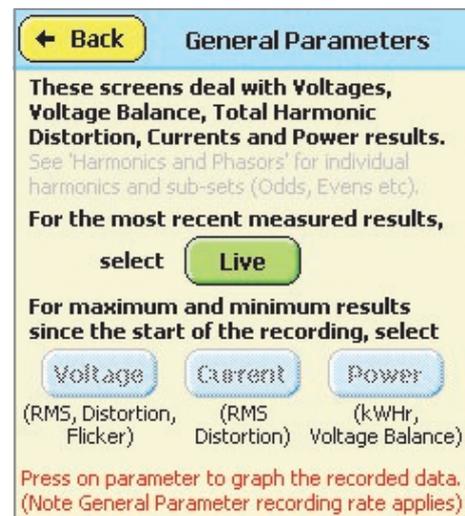
In this case, the **Live** option had been previously selected, so by pressing within the dotted



area **Direct to Live**, the preliminary options screen (shown below) may be by-passed. If one of the other options had been chosen for instance “Voltage” or “Power”, they would have been given the “direct” path,



The two versions of the General Parameters preliminary screen are shown below.



Before a recording is present in the General Parameter database, the max and min “Voltage”, “Current” and “Power” options are greyed out (unavailable) as shown on the left. If you need reminding why a button is greyed out, press on it for

advice:

The Database is empty. Begin recording to start filling it, or if recording has just started, try again after the first scan interval has passed.

For the most recent measured results, select **Live**

For maximum and minimum results since the start of the recording, select

Voltage

Current

Power

(RMS, Distortion, Flicker)      (RMS Distortion)      (kWhr, Voltage Balance)

Press on parameter to graph the recorded data. (Note General Parameter recording rate applies)

This shows the result of pressing on the “Voltage” button.

Almost all of the functions are accessible behind the “Live” button as well when there is data in the



database, so **Live** is the normal starting point.

Pressing this button the first time will bring up the General Parameters screen showing the live “Summary” of results, see below.

← Back    General Parameters - Live Summary				
Summary		Volts	Current	Volts Flicker
Signal	V-rms [V]	Signal	I-rms [A]	
<b>Van</b>	339.6	<b>Ia</b>	590.5	
<b>Vbn</b>	337.5	<b>Ib</b>	586.9	
<b>Vcn</b>	339.7	<b>Ic</b>	590.8	
<b>Vne</b>	0.1	<b>In</b>	34.2	
Parameter		Parameter		
<b>Unbal %</b>	0.42	<b>kW</b>	-199.	
<b>NPS/PPS</b>	0.75	<b>kVar</b>	+0.	
<b>PF</b>	-0.99	<b>kVA</b>	199.	
<b>Freq. (Hz)</b>	60.00	<b>kWhr</b>	-77.	

This and similar screens are normally updated four times per second if communications bandwidth permits. Unless specifically stated, the results are generally produced from a single cycle without any filtering, thus these are raw dynamically changing figures. In the live “Summary” screen only Frequency is derived over multiple cycles (200ms typically.)

Please note that results screens are NOT necessarily representative of real situations nor consistent with each other. They have been chosen to show particular features. For example this screen shows negative PF, kW and kWhr because the current phases were reversed.

Selection of the “Volts” tab concentrates on Voltage results, and “Current” on Current results:

← Back    General Parameters - Live Voltages				
Summary		Volts	Current	Volts Flicker
<b>Direct Measurements</b>				
Signal	V-rms [V]	THV-rms [V]	THD%	
<b>Van</b>	336.9	141.7	46.4	
<b>Vbn</b>	338.1	144.7	47.3	
<b>Vcn</b>	339.1	146.8	48.0	
<b>Vne</b>	0.1	0.0	0.0	
<b>Calculated Values</b>				
Signal	V-rms [V]	Parameter		
<b>Vab</b>	550.9	<b>Unbal %</b>	0.35	
<b>Vbc</b>	556.1	<b>NPS/PPS</b>	0.47	
<b>Vac</b>	552.3			

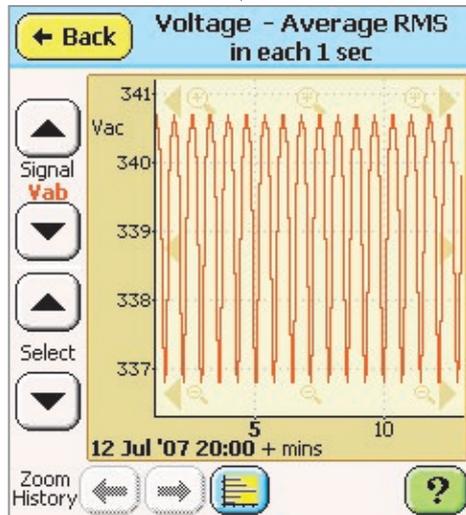
← Back    General Parameters - Live Currents				
Summary		Volts	Current	Volts Flicker
Signal	I-rms[A]	THI-rms[A]	THD%	K-Factor
<b>Ia</b>	590.0	255.8	48.1	26.14
<b>Ib</b>	589.4	251.4	47.2	19.86
<b>Ic</b>	585.9	246.9	46.5	15.27
<b>In</b>	34.2	14.8	48.1	25.95

The Calculated Values for Voltage (Vab, Vbc, Vac) are only available if appropriate, so these lower lines may be empty. So indeed may other lines be if the signals are not present in a hook-up. Labels change to suit the hook-up (The **Van**, **Vbn**, **Vcn** lines may become **Vab**, (blank) and **Vcb** if those are the only measurements required for that hook-up.)

General Parameters - Live Voltages			
Summary	Volts	Current	Volts Flicker
<b>Direct Measurements</b>			
Signal	V-rms [V]	THV-rms [V]	THD%
Vab	336.8	141.6	46.3
Vcb	338.4	145.3	47.5
<b>Calculated Values</b>			
Signal	V-rms [V]	Parameter	
Vac	551.1	Unbalance	
		NPS/PPS	49.58

General Parameters - Live Summary			
Summary	Volts	Current	Volts Flicker
Signal	V-rms [V]	Signal	I-rms [A]
Vab	339.8	Ia	590.8
Vcb	339.6	Ic	590.6
Parameter		Parameter	
Unbalance		kW	-403.
NPS/PPS	51.02	kVar	+0.
PF	-0.99	kVA	403.
Freq. (Hz)	60.00	kWhr	-53.

General Parameters - Live Flicker			
Summary	Volts	Current	Volts Flicker
Signal	Pfs	Pst	Plt
Van	0.00	0.04	0.03
Vbn	0.00	0.12	0.04
Vcn	0.00	0.04	0.03



The final screen above right shows the normal Flicker parameters including the instantaneous flicker sensation Pfs available under the “Volts Flicker” tab.

As discussed earlier, if data is present in the database, i.e. a recording is under way or just stopped and not discarded, most of these numbers have graphs behind them.

### Graphs against time

Where the parameter is recorded as part of the General Parameter set (applies to all the above parameters except kWhrs and Instantaneous Flicker Sensation Pfs), it may be graphed if the data is

available. Pressing on the Vab result **339.8** in the screen below left produces the graph shown on the right.

The time base is initially offered to encompass the whole recording. If the recording is still in progress, data is graphed up to the present time. The above graph runs from approximately

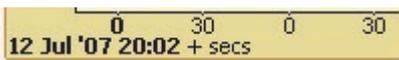
20:01 on 12<sup>th</sup> July to 20:13. The timebase descriptor

**12 Jul '07 20:00** + mins

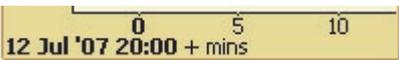
is made up of a

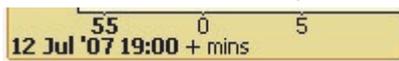
base time **12 Jul '07 20:00**, a unit mins, and the axis markers in the appropriate units. The value of marker in bold **5** should be added to the base time to obtain the actual time at that marker. In this case, it is 12<sup>th</sup> July 2007, 20:05.

[Beware that assuming that the graph starts at the base time shown is wrong and can be misleading. In the case above it is straightforward: the base time predates the left hand axis and the error is only about 1 minute, less than 10% of the screen width, but this may not always be true. Consider the following

descriptor  . In this

case the bold zero  is added to the base time to give the time *at that marker*, viz. 12<sup>th</sup> July 2007, 20:02:00. The left hand axis of the graph is approximately 13 seconds *before* this and therefore *before* the base time, at 12<sup>th</sup> July 2007, 20:01:47.

In this one,  the left hand axis is at 19:57, again before the base time. Here is a case in which the base time is *long* before

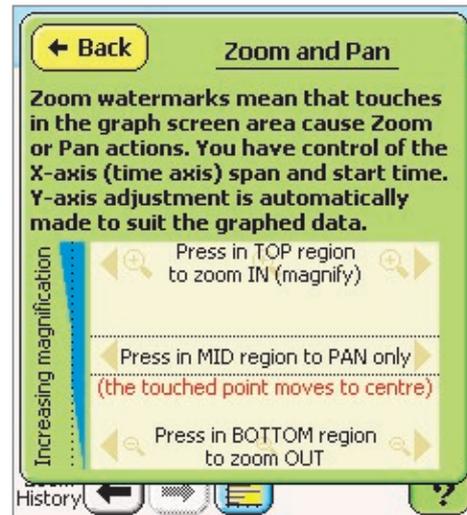
the left hand axis:  . The timebase *is* described unambiguously, but you should be aware that it's the first marker, the **bold** one, which is the focus, *not* the left hand axis.]

## Zooming

The detail shown on the graph depends on the time described across the time base and the recording rate or interval at which the data was recorded. A recording may last from a few seconds to weeks (or more), and The General Parameters recording interval may be from once per second to once per 12 hours. Consequently there may be far too much or far too little detail in the graph.

The Y-axis scale factor is automatically determined by the extremes of the data over the period to be graphed. The X-axis, the time axis, is under user control. The time axis may be zoomed in to approximately 4 usecs and out to several months across the screen. Two "History" buttons, forwards and back, are provided to make retracing your steps easy – particularly useful for comparing events across different signals.

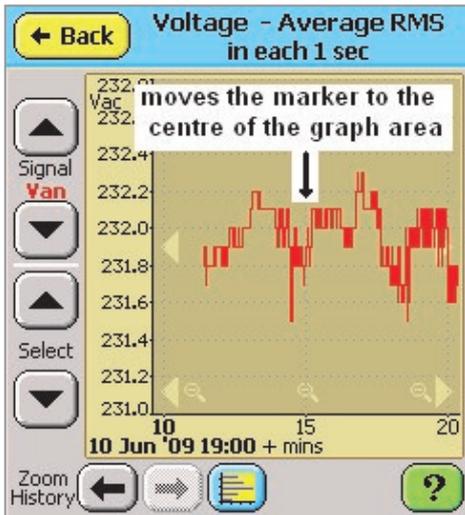
If you forget how to operate the zoom process, the  button brings up specific help for this screen. See below



Originally two buttons "Zoom in" and "zoom out" were provided, each magnifying/contracting by a factor of 2, but this proved tedious if trying to zoom in or out far. Accordingly a variable zoom algorithm was adopted, to give very fast zoom if required, and also gentle or no zoom. As described on the left, the zoom "strength" depends on how close to the top or bottom of the graph area you press. Press at the top (or bottom) to zoom in (or out) by factor of 16. Pressing in the mid region does not zoom at all, and in between, the zoom action gets gradually stronger as you press nearer to the top or bottom of the area.

The Pan function applies all the time. It places the time at point pressed into the centre of the graph area. Thus





As can be seen in the graph above, we have embraced the start of this recording, ie there is no data before 10<sup>th</sup> June 09, at 19:11:40. (See previous section for description of time axis labelling.)

If we zoom out and/or pan to the left, we can reveal blank space on the right hand side of the screen, corresponding to time in the future. If recording is continuing, then that space will be filled in a time passes. The graphing is dynamic, ie refreshed as required when new data becomes available, hence the screen can present static data, entirely in the past, or it can be a live display, updated in real time, and the time across the screen, ie the zoom detail, is entirely at the users discretion (subject to the rate at which data is sent to the database.)

It also zooms in a little in this case because the point pressed was above the centre “pan only” band.

Pressing near the top of the graph area (as shown below) zooms in from 10 minutes across the screen to about 50 secs.



## Time displays of other parameters

All of the General Parameters may be graphed against time and the zoom functions described above apply to all of them. See also the Statistics Graphing section for statistical representation of the same data.

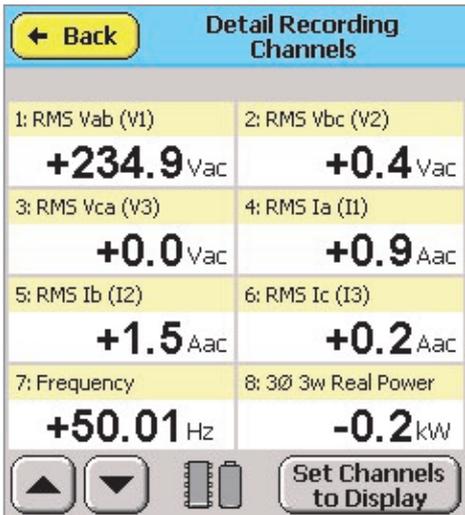


## Detailed recording channels

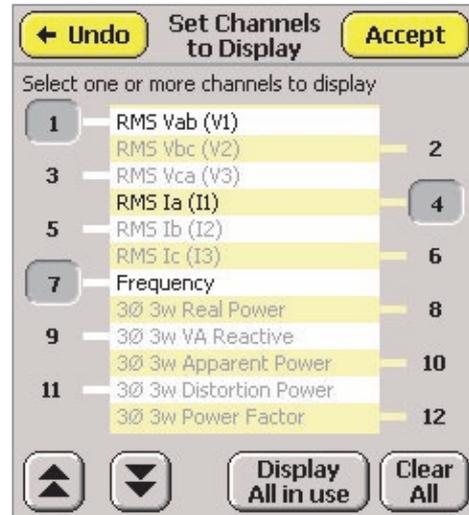
The user specified detailed recording channels are also available for real time display. From the Main



Menu press to display them in table form.



Turning off all except channels 1, 4 and 7 as shown below



There may be up to 32 detailed recording channels, and when you enter this screen for the first time, the list of all the detailed channels specified is copied to a "channels for display" list. This list is used to control which channels are shown on screen. You may have up to eight channels, and as few as one. When more than eight channels are switched on for display, the

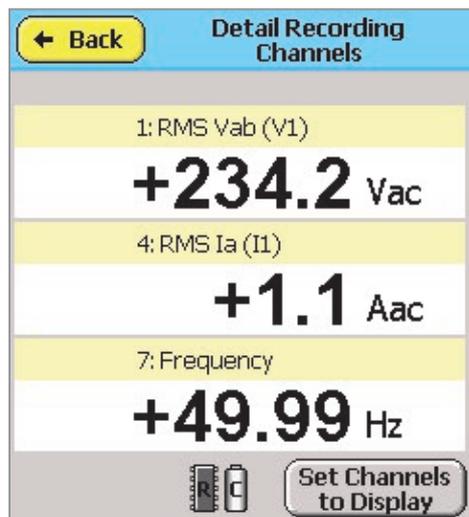


scroll keys are used to scroll through the list. Initially the display shows the first eight parameters.

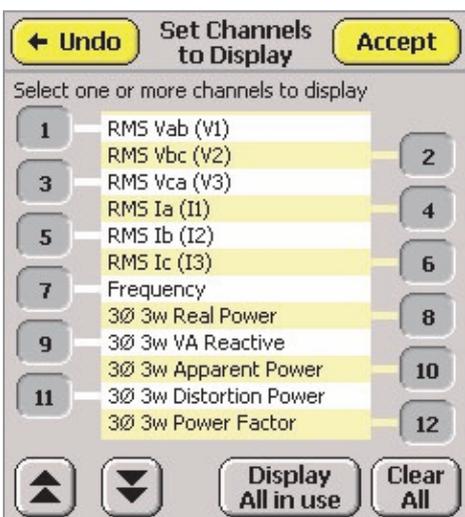
To turn off one or more channels on the display list,



press



and accepting the selection yields the reduced screen above right. Access the channels not immediately available by using the page up and down buttons



You may now remove channels or turn them back on as you wish. The screen above shows channels 1 to 12 all switched on. Click on the button or the label to toggle the state of a particular channel.

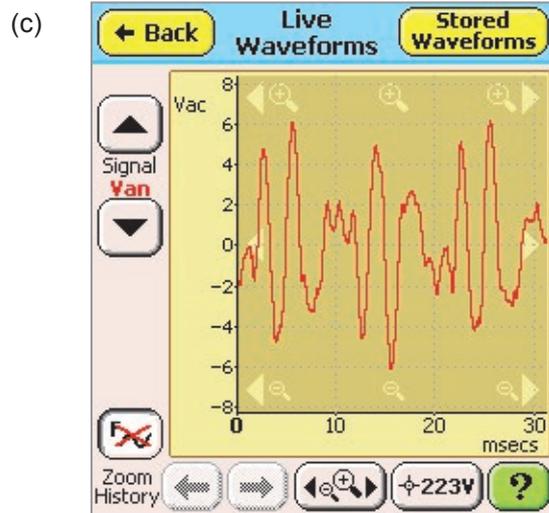
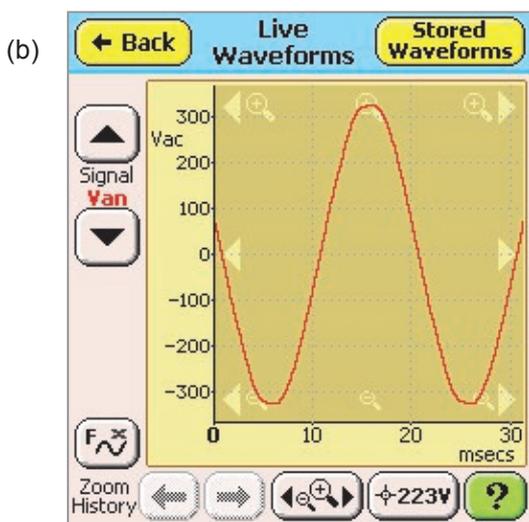
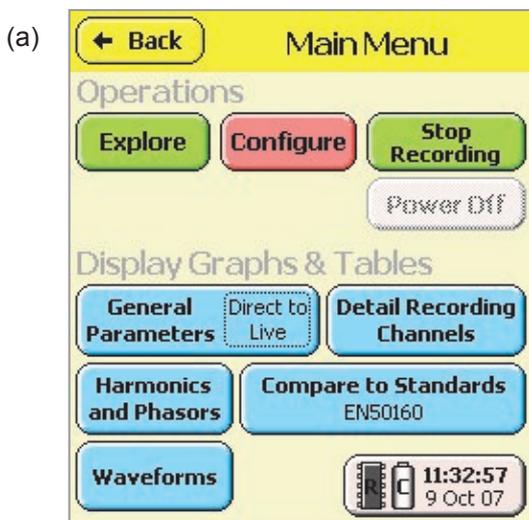
## Waveforms

We can show live waveforms, recorded waveforms, with and without the fundamental, and select them by a variety of methods.

One graph that seldom fails to intrigue even the most disinterested lay observer answers the question 'what is WRONG with the mains'.

### To show live waveforms:

From the Main Menu (Fig (a)), select "Waveforms". The default presentation includes the fundamental (50Hz in some countries, 60Hz in others), and normally the wave shape is sinusoidal (Fig (b)).



We can remove the fundamental by pressing the button.



This turns off the fundamental, but leaves behind everything else, so we are left with what *shouldn't* be there (Fig (c)).

When shown live, the screen is refreshed at up to about 4 times per second, so the normal display (as shown in (c) above), is of the residual harmonics. It is unlikely that a random display will show anything in the nature of a transient, and even if it did, it would be overwritten immediately, so this display is the time domain equivalent of a harmonic bar graph, which is also available with and without the fundamental (see below).

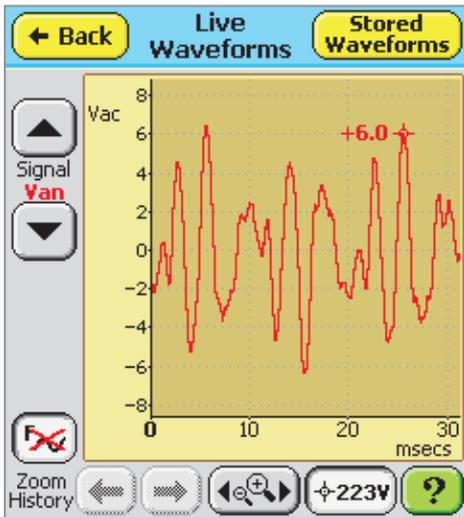
Additional options on these screens include selection of other inputs (use the scroll buttons to select individual voltages or currents, or all volts or currents), zooming in or out (when the zoom button is selected), or selecting the cursor function and obtaining precise values for characteristics on the waves.

The "Help" button



will show the options for the two lower buttons.

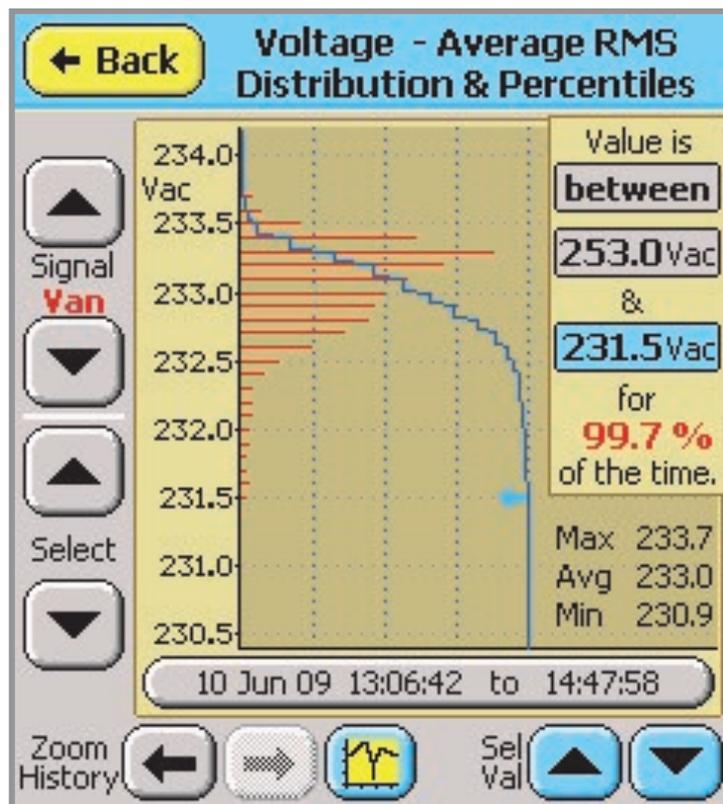




An explanation about cursors and zooming is already covered above.



## Statistics Displays in the PM7000



PM7000 Statistical Display in PMScreen



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## Introduction: Statistic Displays

The PM7000 has a statistics processor that is able to generate Probability Density Functions (PDFs) and Cumulative Density Functions (CDFs) for any of the General Parameters. These graphs are available from the time graph for the parameter of interest. In addition the percentile values and the percentage time between values can be displayed.

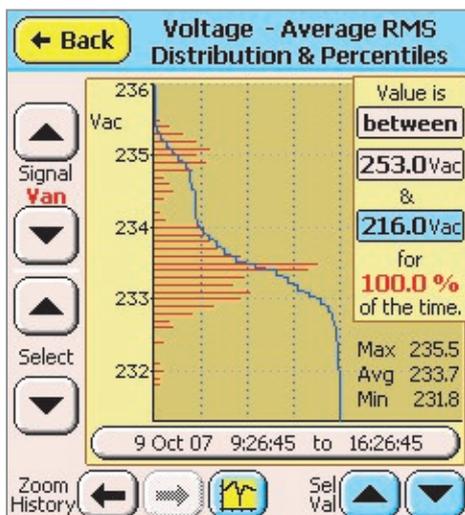
The figure below shows the typical time graph of average voltage on phase A for a period of 6 hours.



Pressing on the “Statistics” button

will put the time data presented in the above graph into the Statistics Processor, and draw the resulting PDF and CDF graphs.

See the graph below.



The Probability Density Function (PDF) is shown in red, and the Cumulative Density Function (CDF) in blue. The vertical grid lines divide the CDF into regions, each 25% wide, and the blue CDF graph begins at the top of the screen on the left and runs to the bottom right. The maximum and minimum values seen are 235.5V and 231.8V respectively, so these two values represent boundaries for the CDF. The blue CDF graph may be interpreted two ways, depending on whether you wish to express the percentage value of time for which the input is *below* or *above* a specific level. The graph begins at 0% or 100% at 235.5V (or strictly speaking just above, since there IS a point at 235.5V), and finishes at 100% or 0% at 231.8V (or strictly speaking, just below). If you wish to express the percentage value of time for which the input is *below* a specific value, then the 235.5V point (the left side of the blue graph) represents the 100%, and the 231.8V represents 0%.

If you wish to express the percentage value of time for which the input is *above* a specific value, then the 235.5V and 231.8V points represent 0% and 100% respectively.

(Because of this uncertainty of presentation, the graph does not show the percentage for the grid lines 0%, 25%, 50% and 100%, however they ARE spaced 25% apart!

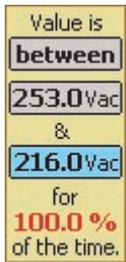
As discussed below there are occasions when it is appropriate to label the vertical grid lines, and these are added as required.

From the above red graphs we can see that the bulk of the time was spent with a value of 233.4 or 233.5, and this is where the CDF (Blue) crosses the 50% line.

In fact the value population is clustered into two areas – the main bulk around 233/234V, and the second smaller cluster around 235V. We can see the average value was 233.7V.

## Obtaining Precise Results

The panel on the right hand side of the screen shows precise results for specific conditions. These conditions can be changed to obtain different statistics. The items in the boxes can be changed to yield different results.

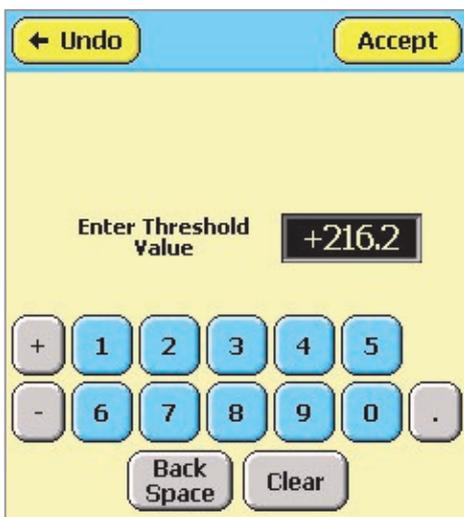


The top button, presently labeled **between**, specifies the “function” to be calculated. The two buttons shown below that specify parameters. One or other of these buttons may have a blue background e.g. **216.0Vac**. The blue button, in this case the lower one, has the “focus”, that is to say it can be

altered. By clicking on the upper button **253.0Vac** we can transfer the “focus” and make its background blue, viz **253.0Vac**.

Remaining with the function “between”, the panel tells us that the input value is BETWEEN 253.0V and 216.0V for 100% of the time. These are the +10% and -6% limits in the UK for a nominal 230V service (actually 216.2V). To change the lower limit to 216.2V we can do a number of things. However to change it at all, it must have the focus. Therefore we click on it.

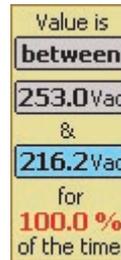
1. Once it has the focus, by clicking on it again we can enter the desired limit directly.



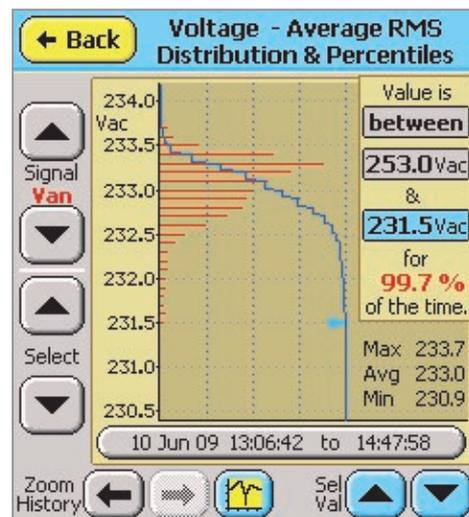
2. Alternatively we can use the up/down arrow keys to

select the value incrementally .

Clicking the Up arrow twice raises the value to 216.2V.



3. A third method of specifying a limit is by direct pointing on the screen. Pointing anywhere in the graph area will change the value of the button which has the focus to the vertical value at the point position. For instance pressing around 231.5V brings a blue arrow on the graph area right hand side.



Notice that the numeric lower limit inside the blue button also changes. The blue arrow can be moved up and down with the up /down keys, i.e. blue arrow

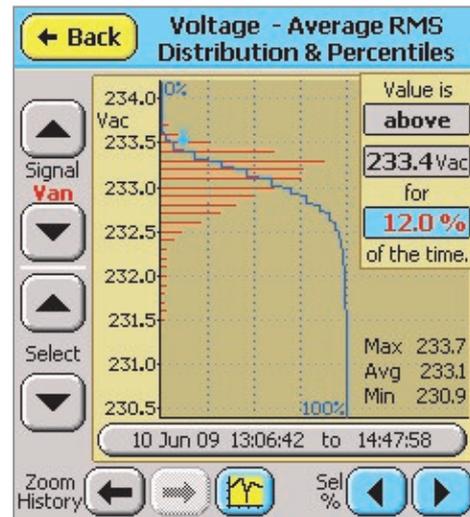
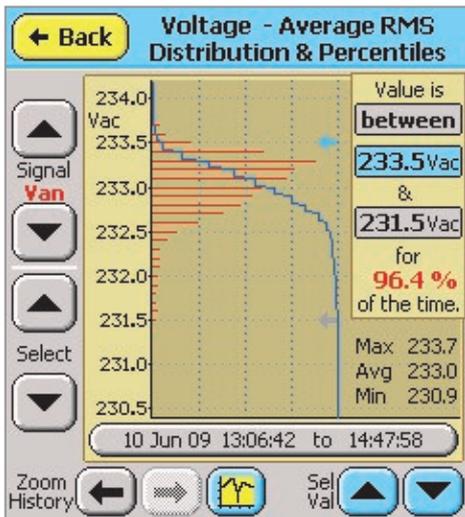


change in step.

We can do the same for the upper limit, once we have given it the focus. Change that to 233.5V.

Do this by clicking on the upper button to give it the focus (changes the blue arrow to grey, indicating that like the lower button, it no longer has the focus), then point at the screen, level with the 233.5V axis marker. This inserts a blue arrow on the 233.5V axis line, and changes numeric value to suit.

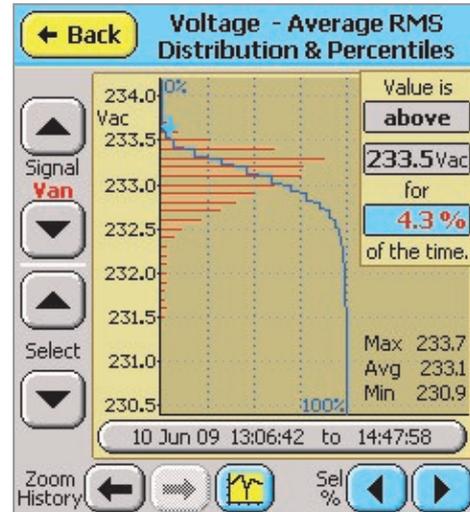
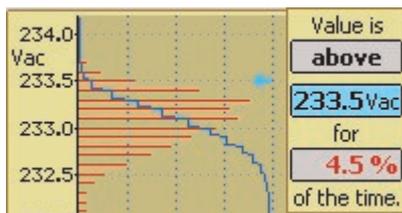
You will notice that the calculated percentage value in red **96.4%** has changed from 100% to whatever the present statistic is.



(Notice that the blue and grey arrows were present originally, they just couldn't be seen because the automatic zooming process restricted the view.)

## Other functions

The “between” button can also be changed. Clicking on it toggles to “above”, and then to “below”. In this way we can change functions.



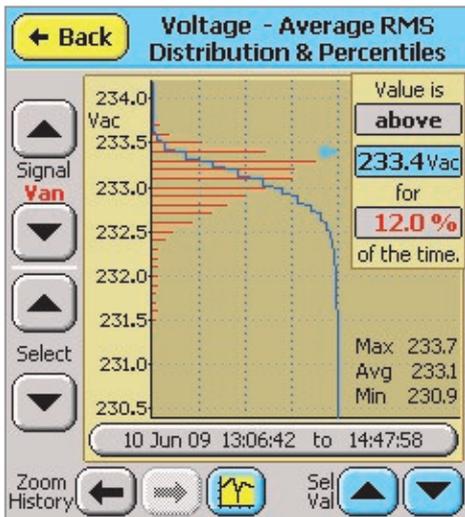
As shown here, the level parameter 233.5V retains the focus, and pointing at the screen will cause the vertical point position to be used for the level. You will notice that the percentage figure is also in a button

**4.5 %**. We can also specify the percentage figure to find out for instance what value is the input above for say 10% of the time, but as for changing levels, it needs the focus. Clicking on it removes the horizontal arrow, and substitutes a vertical arrow as well as giving the button the blue “focus” background. Notice also that the Up/Down buttons have been replaced by



Left/Right buttons. We can change the percentage figure using the same three options as for level above. Pressing once on the left button moves the arrow.

However notice that for the percentage, we may not be able to specify the precise figure we want because the distribution of results is too narrow to allow us to distinguish adequately. You can appreciate this by observing how the percentage figure changes as the level is altered by a single step, or as the percentage is changed by single clicks on the left or right buttons. For instance at the time of writing and with the data present in the PM7000, it is not possible to specify precisely 10%. Above 233.4V is worth 12%,

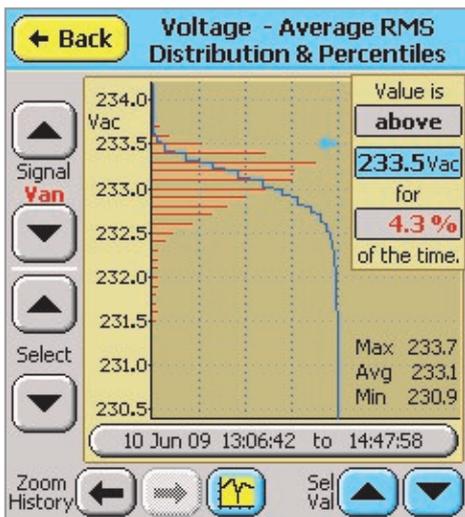


each General Parameters interval, the Frequency of graph update also depends on the General Parameters interval specified.

### Parameters to which the statistics function may be applied

All the parameters presently in the General Parameter Database may be graphed against time, and consequently their statistics may be reported as above.

and above 233.5V, 4.3% .



When the focus is on percentage, pointing directly at the screen affects the arrow's horizontal position. The arrow does move vertically too but that is in response to the change in relevant position on the Cumulative Distribution graph.

### Changing the reporting interval

The Interval for which the statistics are being reported can be changed by pressing the "interval button"

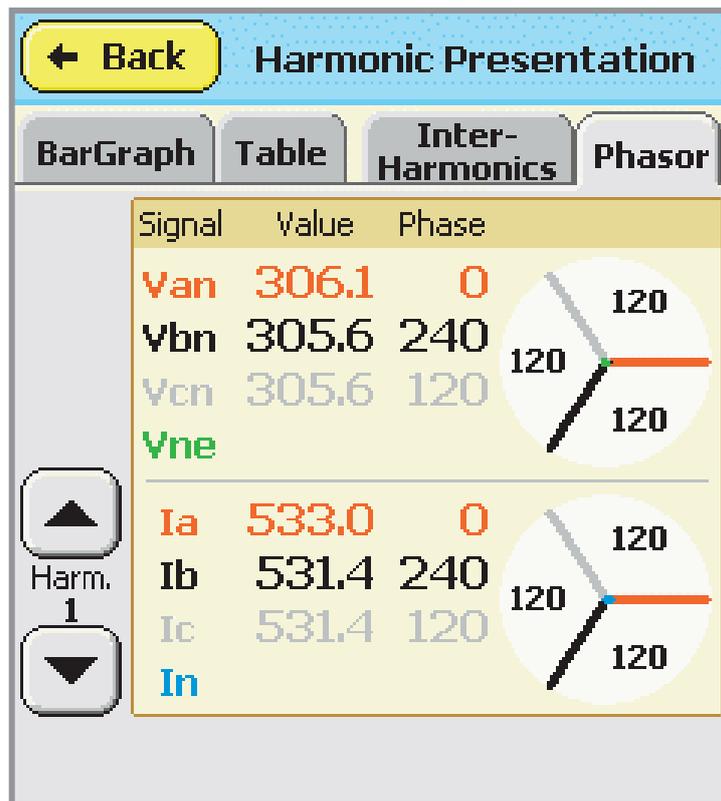
10 Jun 09 13:06:42 to 14:47:58

### Making the display live

By specifying an end time in the future, the graph becomes "live", and the statistics are updated continually as new data is added to the database. Since new data is stored in the database at the end of



## Phase Measurement and Display Functions in the PM7000



PM7000 Phasor Display in PMScreen



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## Introduction: Phase Measurement

This chapter discusses the phase measurement and display functions in the PM7000. The same measurement principles are used in all Ranger PM

products. However the PM7000 has more extensive ways of displaying phase information.

## General

Phase is described, tabulated etc. in such a way that the input wave may be reconstructed from the amplitude, phase and harmonic numbering displayed, by using the Fourier series summation:

$$f(t) = (\text{Real part of}) \sum_{n=1}^m A_n * e^{j\omega n t + \phi_n}$$

where  $n$  = harmonic number  
 $m$  = top harmonic available  
 $A_n$  = amplitude of nth harmonic  
 $\phi_n$  = phase of nth harmonic  
 $\omega = 2\pi F$  ( $F$  = fundamental frequency)  
 $t$  = time

In the above formula phase is in radians, but for user convenience the Ranger PM products express phase in degrees. This needs to be taken into account if reconstructing waves from harmonic constituents.

## Measurement Method

Phase measurement in the PM Series products is generally by examination of results from a Fast Fourier Transform (FFT). The FFT is performed on one or more cycles of the input signal, where the input phase is assumed to be unknown and time is therefore arbitrary. Data for all the signals under test are taken for exactly the same time period (with synchronous sampling) so although the input signal phases are initially unknown, the phase relationships between

signals are preserved. The FFT process refers time to the START of the measurement period. This is not appropriate for the reconstruction formula above so a time shift of  $T/2$  ( $T$  = measurement period) to the centre of the measurement period is applied by linear phase shift for all of the complex FFT results.

## Display

### Single signal displays

Display and tables of phase results for single signals are self-consistent, and for convenience are referenced to a fundamental phase of zero. Thus a square wave (see Figure 1(a) below)

produces harmonics as shown in Figures 1(b) and 1(c) (Harmonics 1 – 10 and 11-20 respectively)

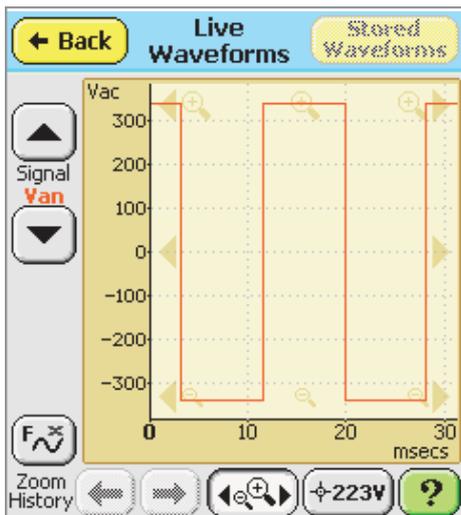


Figure 1(a) Input

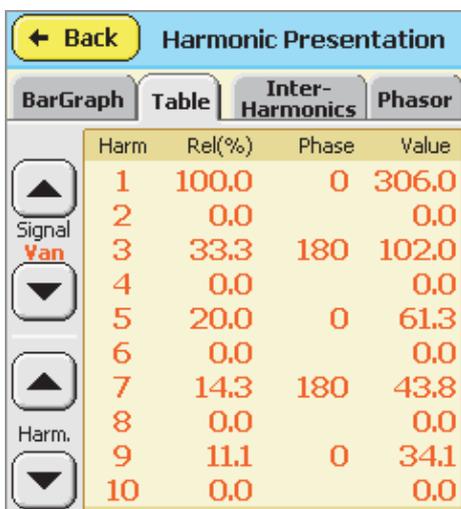


Figure 1(b)

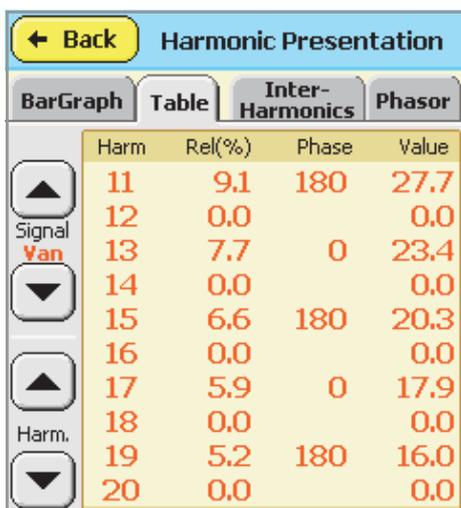


Figure 1(c)

Harmonics of a square wave. Self-consistent and referenced to a fundamental phase of 0.

Applying the values from (b) and (c) into the reconstruction formula in Section 1 above generates the graph of Figure 2.

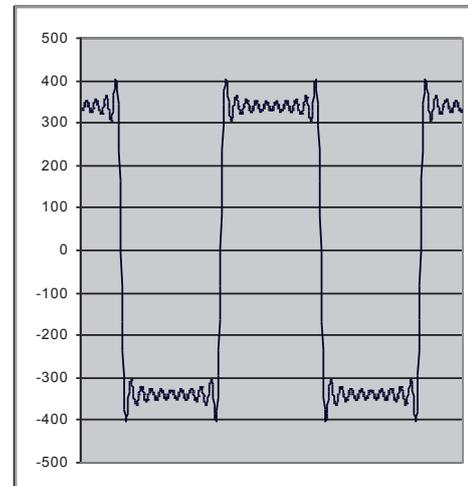


Figure 2. Reconstruction.

Wave reconstructed from tables of Fig 1 (b) & (c)

The original wave had square corners, and infinite harmonics, whereas the reconstruction has used only the first 20 harmonics from the tables. Gibb's phenomenon\* (the overshoot) is in evidence along with the ripples at top and bottom, but the symmetry and general shape confirm that phase is correctly represented for the general reconstruction formula above. As noted above, for user convenience the phases in the tables of Fig 1 are referred to the fundamental, and hence actual time position for the reconstruction is not available from the table (though it is available internally). In this case a time shift of 0.00094 secs may be added to make Fig 2 line up with Fig 1 (a).

[\* A convergence phenomenon occurring when a function with a discontinuity is approximated by a finite number of terms from a Fourier series.]

### Multiple signal displays

It is also possible to display the table of results for a particular harmonic on all the signals present. This table is obtained by changing the "Signal" in the Harmonic Presentation Tables above until "All" is shown. Figure 3 refers.

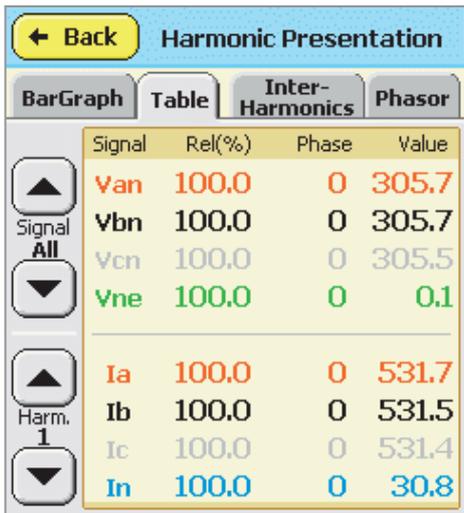


Figure 3 (a) Multiple Signal Harmonic Display

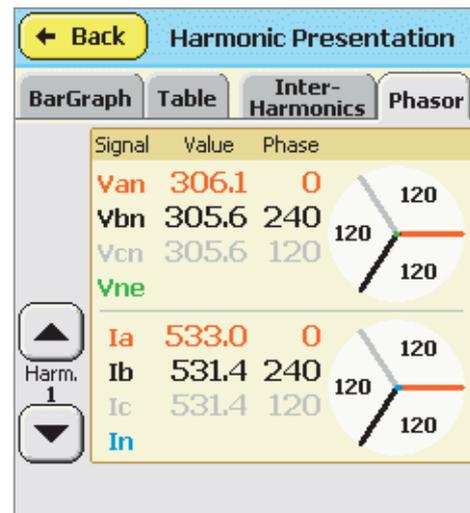
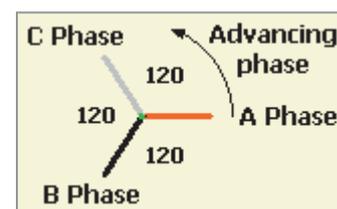


Figure 4. Phasor Diagram for Three Phase four wire Wye Hook-up.

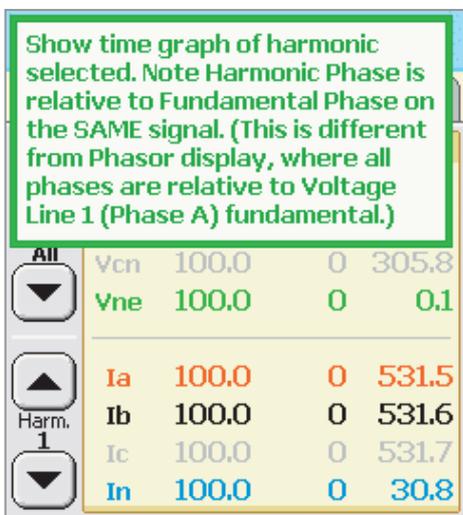
The “Value” and “Phase” columns in Figure 4 above show Amplitude and Phase for each signal with respect to the fundamental on Phase A. Figure 4 shows results for Harmonic 1, i.e. the fundamental, so Phase for Van will always be 0, since this IS the fundamental on Phase A, and everything else is with respect to this.

The values “120” shown in between vectors in the right hand section of the screen give the phase separation between the nearest two vectors. The “120” is a *relative* phase separation. If there is insufficient room to display the number, it is omitted.



As shown, all three vectors are correctly disposed around the diagram for a three phase system, so their separations are all 120 degrees. In this conventional phasor diagram, phase rotation is counter-clockwise. Phase A, (zero degrees,) is drawn at 3 o'clock. A leads B, and B leads C, so B (-120 degrees) is retarded at 7 o'clock, and C (-240 degrees) further retarded at 11 o'clock.

This Harmonic Presentation of Phasors can show not only the fundamental phase relationships but also the harmonic relationships. The three square waves notionally 120 degrees apart show how this is useful in demonstrating the importance of minimising tripleN harmonics. Where Figure 4 shows the fundamental relationships, Figure 5 (a), (b) show the 3<sup>rd</sup> and 5<sup>th</sup> harmonics.



(b) Reminder that phase is with respect to the relevant fundamental.

In this case each line of results *again* refers to its own fundamental. Pressing on the table and holding it pressed to see the “button help” reminds us of this (Figure 3 (b)). The second part (bracketed) of the help concerns an alternative phase display type, as follows.

Another presentation is the PHASOR diagram display as shown in Figure 4. In this case the display shows that the three phases are actually at 120 degrees with respect to each other.

If we wish to tabulate phase so that a multiphase reconstruction can be drawn, we must take into account the time shift represented by this fundamental phase difference and rotate the harmonics (from the tables e.g. Figures 1 (b) and (c)) accordingly. (See Reconstruction below)

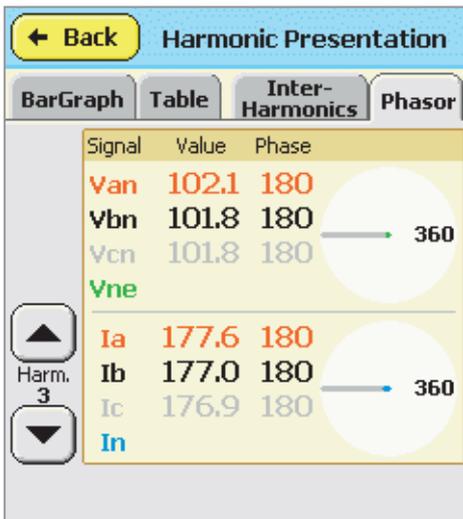


Figure 5 (a) 3<sup>rd</sup> Harmonic additions

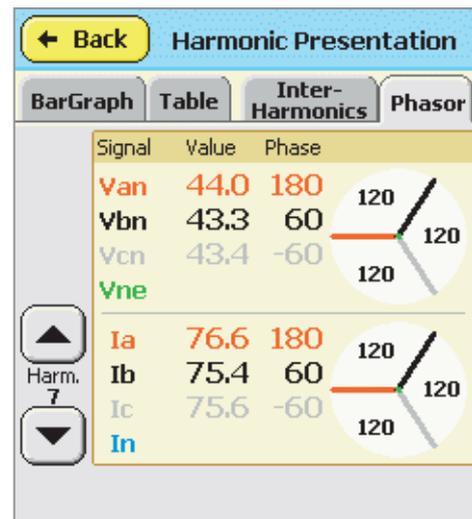


Figure 6 (a) 7th Harmonic

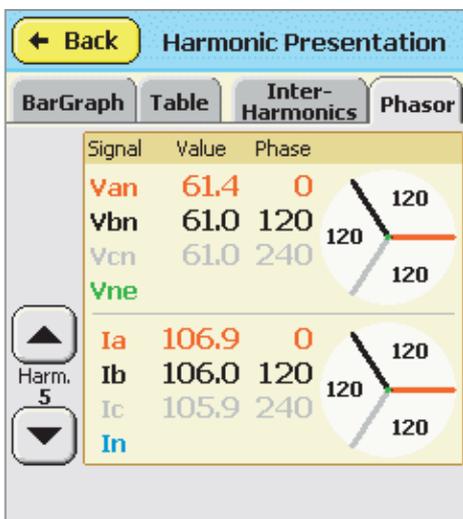


Figure 5 (b) 5<sup>th</sup> Harmonics

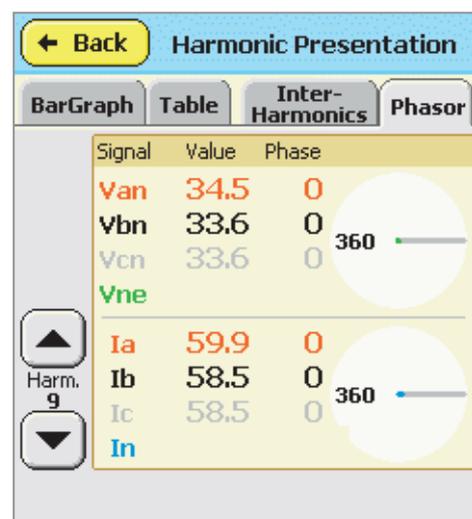
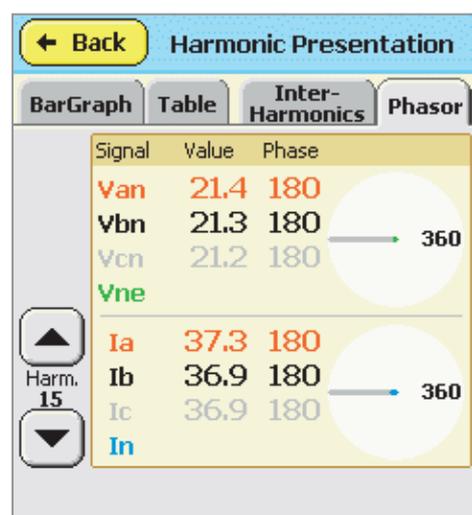


Figure 6 (b) 9<sup>th</sup> Harmonic additions

Figure 5 (a) shows all three vectors at 180 degrees, hence instead of equal amplitude current signals cancelling in the neutral, they sum coherently. Note that the 360 in Figure 5 (a) refers to the *relative* separation between vectors. If all three vectors lie at 180 degrees, the separation can be described as 0, or 360 degrees (which amounts to the same thing).

Figure 5 (b) shows the 5<sup>th</sup> harmonic vectors again distributed, though in the reverse rotation order compared with the fundamental. The 7<sup>th</sup> harmonic vectors are again different. See Figure 6 (a). Figure 6 (b) shows the next significant tripleN, the 9<sup>th</sup> harmonic and again the vectors sum instead of cancel (The 6<sup>th</sup> is also a tripleN but being an even harmonic should have no significant current.)



## Reconstruction

The following reconstruction is included to illustrate how the linear phase delay may be added to the harmonics, and the resulting time shift on the reconstructed wave.

To reconstruct a multiphase wave diagram, the individual tables must be converted from the self-referenced phases to a single reference phase. In the case shown in Figure 4 above, B and C phase have the same tables as shown for phase A in Figure 1., if considered in isolation. To delay the harmonics of B phase, whose fundamental is 120 degrees BEHIND A phase, we rotate them BACKWARDS by  $120 * n$ , where n is the harmonic number.

Thus Tables 1.b and 1.c (for B phase) convert as shown in Figure 8.

Self Consistent				Shifted Backwards
Harmonic	Amplitude	Phase	Adjustment	Phase
1	306	0	-120	240
3	102	180	-360	180
5	61.3	0	-600	120
7	43.8	180	-840	60
9	34.1	0	-1080	0
11	27.7	180	-1320	300
13	23.4	0	-1560	240
15	20.3	180	-1800	180
17	17.9	0	-2040	120
19	16	180	-2280	60

Figure 8. The linear adjustment moves the wave from Figure 9(a) to (b)

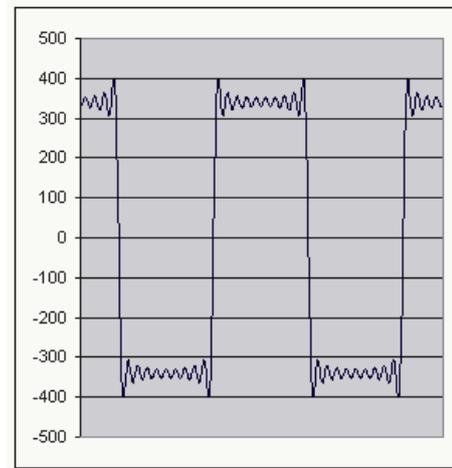


Figure 9(a) reconstructed before delaying

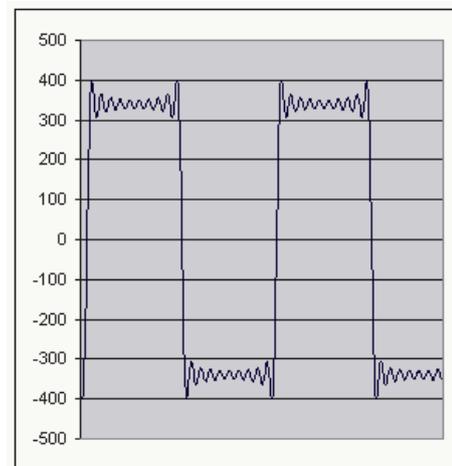


Figure 9(b) reconstructed after shifting backwards

The waveform of Figure 9(b) is the same as that of 9 (a), except for a 1/3 cycle delay.

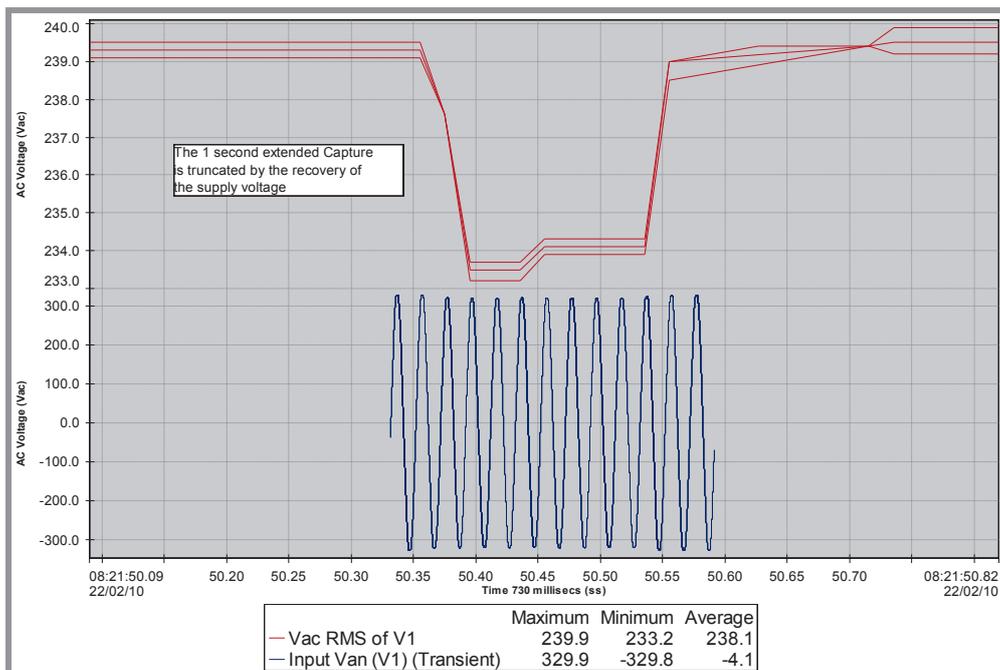
## Significance of tripleN harmonics

The curious characteristic of Figure 8 is that in spite of applying an adjustment of 120 degrees at the fundamental, the 3<sup>rd</sup>, 9<sup>th</sup> and 15<sup>th</sup> harmonics remain at the same phase as before, i.e. their entries in columns 3 and 5 apparently don't change. In fact of course they do, but because the change is one or more whole cycles, there is no net effect. The 120 degrees separation at the fundamental turns into 360 degrees for the 3<sup>rd</sup> harmonic, 1080 degrees (= 3 \* 360) for the 9<sup>th</sup> and so on. Hence for similar wave shapes on each of three phases apparently properly "separated" (by

120 degrees), the tripleN harmonics in the three phases MUST add up in the common current return path, i.e. in the neutral cable.



## Operation of the PM7000 Waveform Capture system



### Waveform Capture System at work in the PM7000



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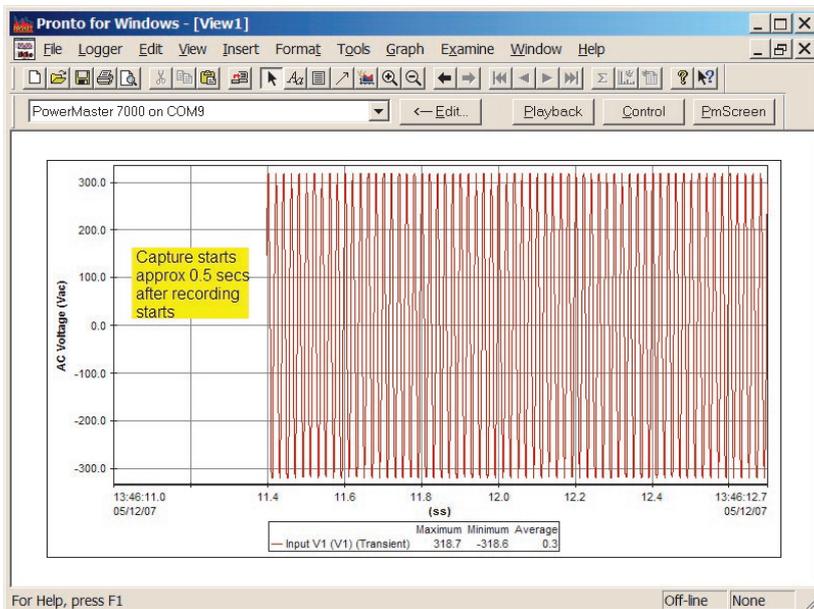
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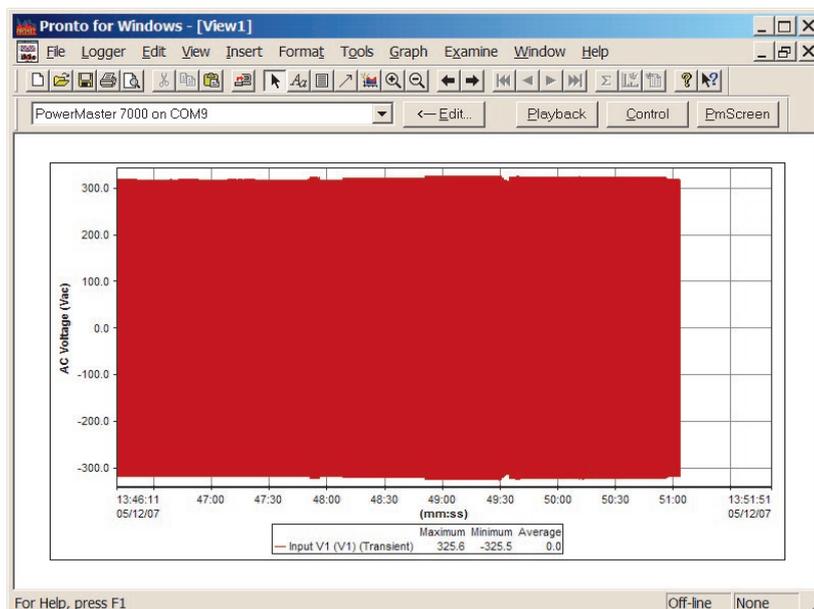
Operation of the PM7000 Waveform Capture system to capture continuously (indiscriminately) from the start of recording until the allocated memory is used up.

## Introduction: Waveform Capture

The PM7000 can be used to record waveforms irrespective of events or disturbances. If this function is selected the effect is to begin the capture at the start of the recording (typically about 0.5 sec after the beginning), and to capture the specified number of events in a continuous stream until the memory allocated to waveforms is used up. The recovered data is shown in Pronto as continuous waveforms. The first graph shows 1.7 seconds of the typical start of the recording.



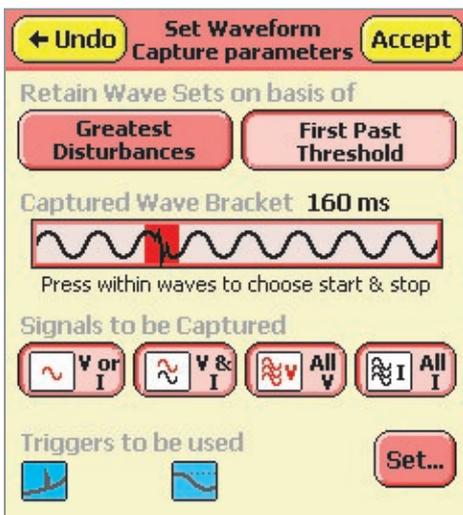
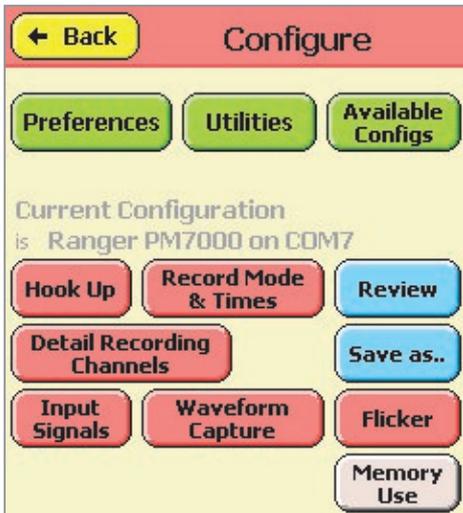
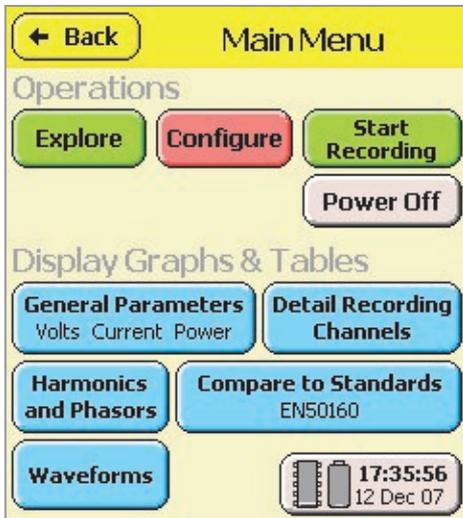
Then zooming out:



## How to Configure

From “Configure”, select “Waveform Capture”. Within the Set Waveform Capture Parameters screen, choose to retain wave sets on the basis of “First Past Threshold”.

That disables the automatic ranking process (“Greatest Disturbances”) and enables comparison against a fixed threshold. At the line ‘Triggers to be used’, click on “Set”, to bring up the “Events to Capture” screen.



This screen will now have a column for “Threshold”. To force continuous capture simply set the threshold level of the chosen triggers to 0. This removes any discrimination and all waves are forced to meet the trigger criterion.

If you wish to allocate all available space to the continuous capture, you can, OR you can mix continuous capture with normal comparison against threshold.

Example 1. You wish to allocate all available space to continuous capture. It is not necessary to specify more than one trigger type since the system will not pay attention to a trigger’s distinctive features if its threshold is set at 0. Therefore turn off all triggers except “Transient”. (Clicking on a trigger button turns that trigger on and off.)

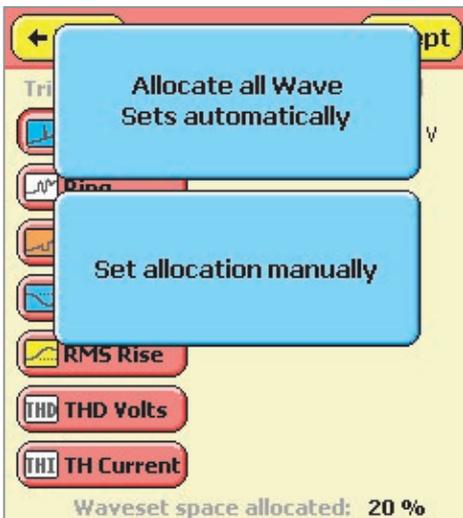
Click on the ‘Wavesets’ number, and then the “Allocate all wavesets automatically”.



Each event is as long as the captured wave bracket, and will contain all the signals appropriate to the selection of “Signals to be captured”.

**Example 2.** You wish to record some waveforms continuously, but also to be responsive to large disturbances of some kind not necessarily at the start of a recording. You may combine a threshold of 0 on one trigger type with a non-zero threshold on another. For example you might want 10 seconds of continuous waves to characterise some process and also to detect transients greater than 25V.

Turn on both “Transient” and (say) “Ring” triggers. Specify thresholds of 25V and 0V in the two triggers respectively. Allocate the number of ‘wavesets’ in the desired proportions.



This will give all the memory allocated to the waveform capture function to the selected trigger (in this case “Transient”), and show the number of events available.



(62 wavesets at 160ms / set is 9.92 seconds)

At the start of the recording the “Ring” threshold will be seen as zero and cause continuous capture of the chosen wave sets allocated to “Rings”, and at the same time, the “Transient” threshold will be used for comparison against transients, and the chosen wave sets allocated to “Transients” will only be captured when the threshold is exceeded. Hence the final result may have the transient captures anywhere. They may all lie on top of the continuously captured “Rings”, or they may be distributed throughout the recording, or there may be none at all if the threshold was set too high.

Note that if you set two triggers with a threshold of 0, the continuous capture process uses up one wave set allocation first then the other. They do not lie on top of each other. Thus allocating 100 wave sets each will produce a continuous recording of 200 sets.



## Advanced Tricks

### Capturing one voltage only

A threshold of zero is automatically exceeded by the first voltage waveform to be tested. Consequently if you know that the waves of Vb are the only ones of interest, you can specify Signals to be Captured as “V or I” only, then turn off Va. The entire continuous waveform set will then be given to Vb since Vb will be the voltage tested first. You will need to select the “Uncommitted” Hook-Up connection to be able to turn

off Va (which will be labelled V1 in the uncommitted naming convention). Of course under normal circumstances Va is not turned off and is consequently the first voltage waveform to be tested. Specifying Signals to be Captured as “V or I” only will therefore produce a continuous capture of only Va. If you must capture Vb, and Va must also be present, you should specify Signals to be Captured to include “All V” and “All I” as appropriate.

---

## Waveform Capture Extension - Rev 1.094 onwards

Rev 1.094 for the PM7000 adds the possibility of extending the waveform capture brackets beyond the 160ms available in the standard product.

Although most transients and waveform events are over in less than three or four cycles, occasionally it is useful to capture longer periods to see consequential effects. Examples include recovery from sag after e.g. reclosures, or slow time reaction of downstream

control systems, e.g. wind turbine control.

The Waveform Capture Extension introduced in this revision allows for selective extension of up to 60 seconds, if adequate resources have been allocated. Extensions of the different capture triggers can be set individually, and for Sags and Surges, extensions may be terminated automatically when the Sag/Surge is over.

---

## Implementation

Wave Capture Extension is selected by the user in the Wave Capture Menu as shown in the next section. Extensions of between 0.1 and 60 seconds are selected in small steps. They may be turned off, or applied selectively to one or more trigger types. Usually the number of discrete events captured will be reduced as clearly more resources are committed for any one trigger event.

Capture Extension is implemented in units of the Capture Bracket selected as part of the normal capture specification. If the capture bracket has been chosen to be 100ms, and the extension to be 1 second, typically ten additional Capture Brackets ( $10 \times 0.1 = 1$  sec) will be appended to the relevant event. There will not always be 10 additional brackets for various reasons, perhaps because two or more events of identical trigger magnitude may find themselves sharing bottom spot in the rankings, or because a second legitimate trigger occurs before the extension for the first has been exhausted. Dealing with the ranking of new triggers in the presence of existing extensions is quite complicated and although straightforward situations produce correspondingly straightforward captures, it is not always obvious how the process has handled the potentially large numbers of competing insignificant triggers.

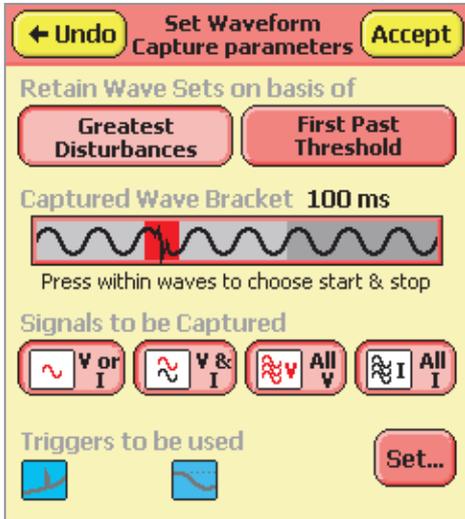
Before the recording starts, the user's selections are examined and for each trigger type, an “Extension Count” parameter is calculated. In the example above this would be = 10 (= 1 sec / 100ms).

When a trigger occurs, the normal capture follows, lasting for the selected capture bracket. This is unchanged from previous operation. The magnitude of the trigger is noted and when appropriate the captured data is transferred to the database.

When the initial capture bracket is complete, the “Extension Count” parameter is used to manage the capture of additional brackets. As each succeeding bracket is captured, it is given a ranking fractionally smaller than its predecessor. Thus the initial trigger bracket gets the highest ranking, and (in the case above) the 10<sup>th</sup> extension gets the smallest. Compared with typical trigger variation this difference is miniscule so that normal trigger ranking is not affected by this subtlety. However the gradual reduction in ranking level the further the delay from the actual trigger, means that in the event of competition, the least justified data is also the lowest ranked, and hence the first discarded.

## The User Interface – Selection of Extensions

From the Configure Menu, select the “Waveform Capture” button.



Make normal selections, and use the “set” button to control individual triggers.

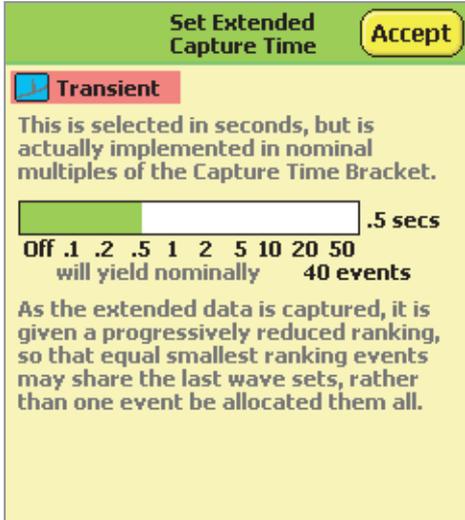


Wave set specification is unchanged from previous revisions, but the Threshold Function (inappropriate in this case because of the “Greatest Disturbances” selection on the previous screen, and consequently greyed out) now shares its space with “Extension”. Extensions are only shown for triggers switched on. Both the extension tab and the extension selection buttons will toggle approximately every second to show the number of events to be recorded with this combination of Capture Bracket (previous screen), Wave Sets allocated, and Extension selection. See below:



The selection buttons are active in both conditions,

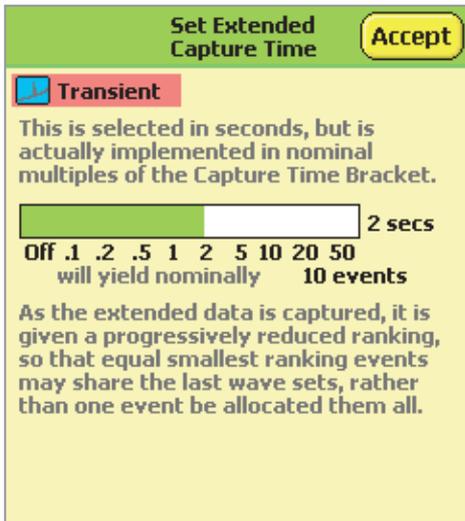
and pressing on (for example) the “Transient” Extension button will bring up the “Set Extended Capture Time” screen for Transients:



Click within the central selection bar above the time extension required. Selections available are

Off, and  
 .1, .12, .15, .2, .25, .3, .4, .5, .6, .8, 1, 1.2, 1.5, 2, 2.5, 3, 4, 5, 6, 8, 10, 12, 15, 20, 25, 30, 40, 50, 60 secs.

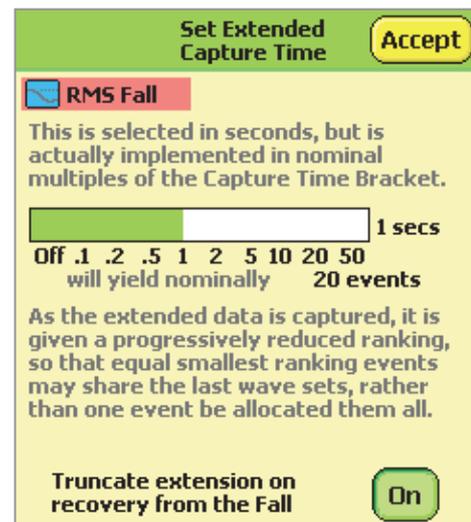
This selection is used with the Wave Capture Bracket to compute the nearest whole number “Extension Count”. Clicking above the “2” changes both the extension and the number of events likely to be yielded:



Press “Accept” to return to the previous screen. (Note if you don’t like your selection, you may “Undo” your selections here.) Note how the toggling extension button reflects the change.

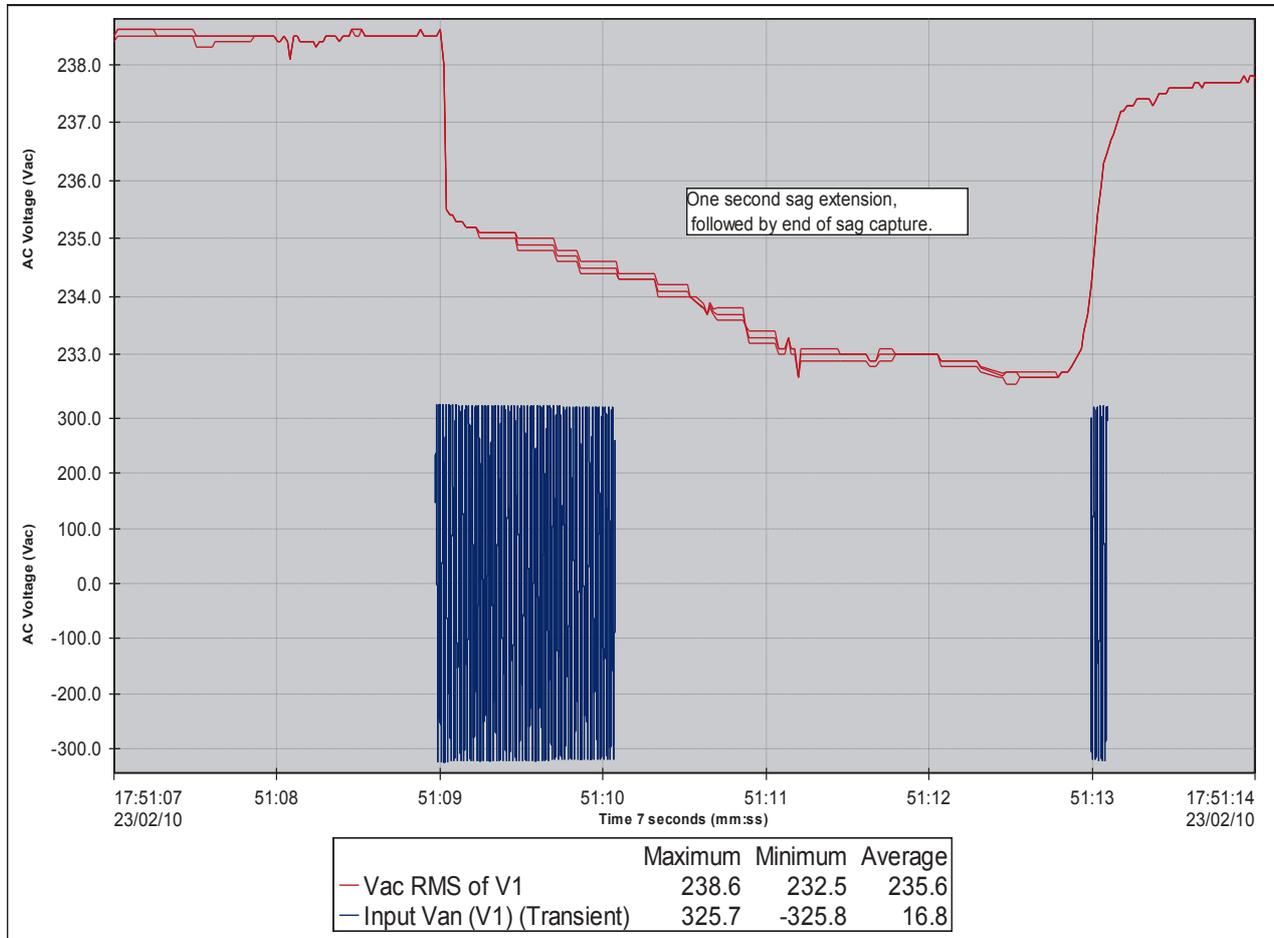


Selecting extensions for “RMS Fall” or “RMS Rise” enables an additional option on the “Set Extension” screen:



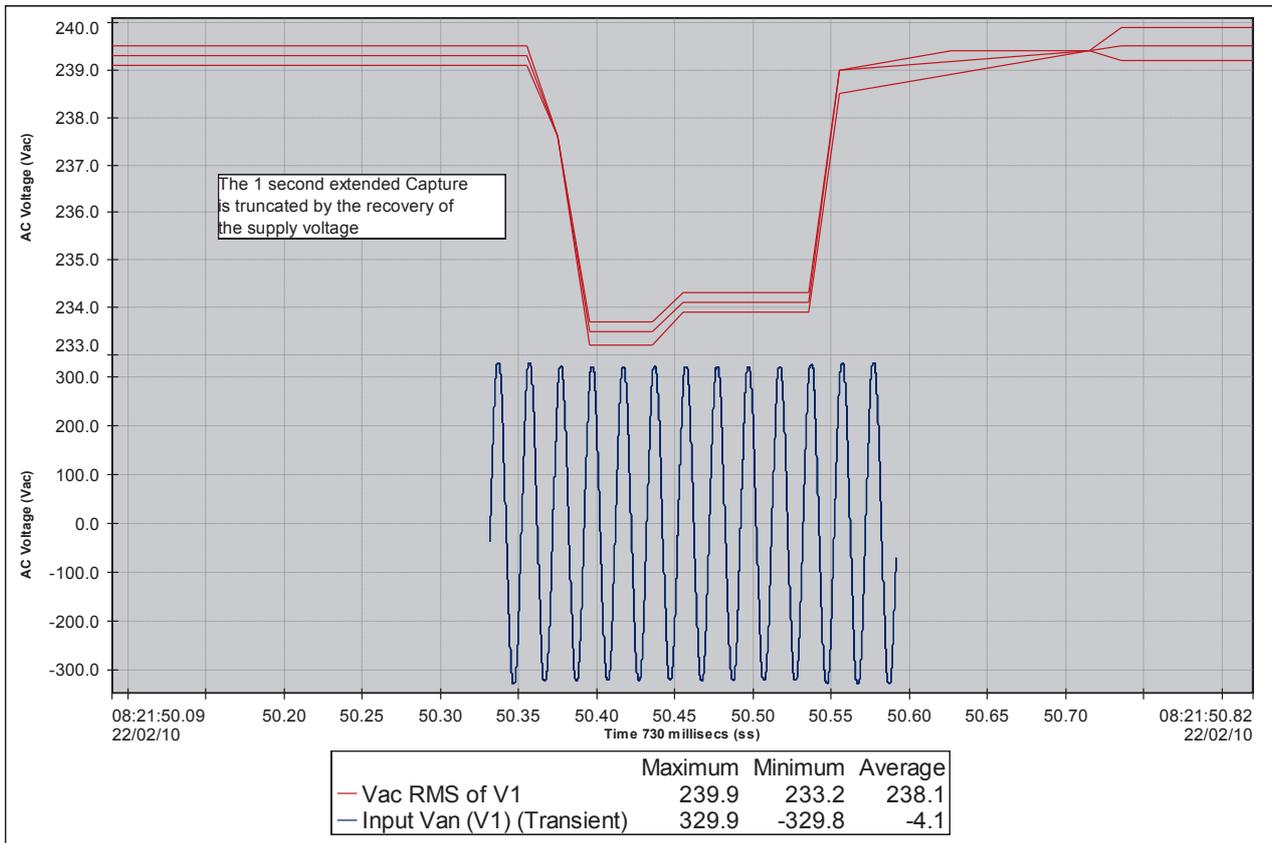
In these two cases you may choose to truncate the extension early when the system detects that the Fall or Rise has disappeared.

The graph below shows a small fall lasting about 4 seconds.



Remember that the system attempts to capture waveforms both at the start and on completion of the Fall. In this case an extension of 1 second was selected, with truncation, so the initial fall at 51:09 produced a 1 second capture. The recovery from the Fall was not detected until 51:13, and a single capture bracket was used to describe it.

The graph below shows the other situation in which the fall is over in much less than one second, so the extension is truncated.



## Compatibility with Existing Configurations

Existing configurations are compatible with the new Revision, and configurations created by the new firmware can be used with previous revisions of firmware. Old configurations will all have their

extensions switched off, and extensions in new configurations loaded into older firmware will simply be ignored.

## Operation of Continuous Wave Capture (Forced Capture)

This is unaffected and works as before. The “First Past Threshold” retention criterion should be selected and a threshold of zero set for the applicable trigger type(s), with the necessary number of wave sets allocated to obtain the desired duration of the forced capture.

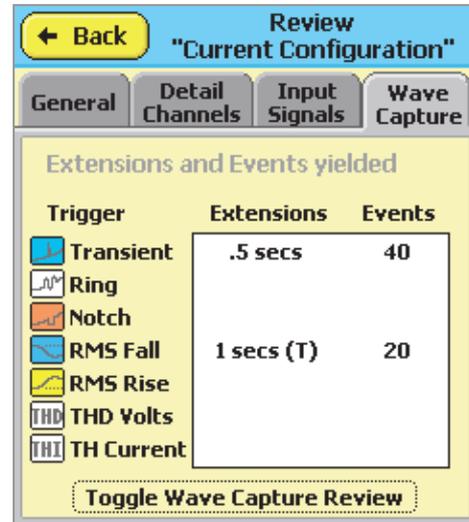
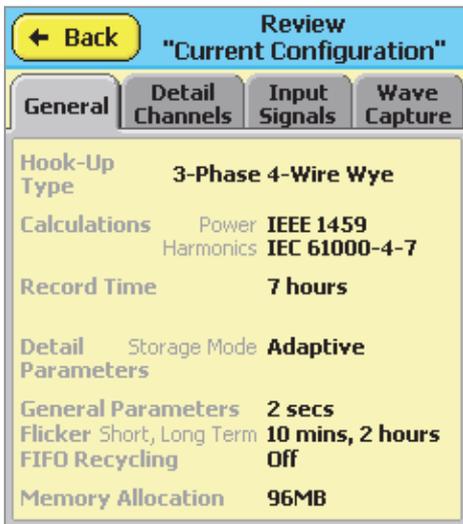
Remember that the capture typically begins approximately 0.5 secs after the start of recording. Extensions are meaningless where the threshold is set to zero, so they may be ignored (or better still, switched off).

## Reviewing the Configuration – Waveform Capture parameters

You may review the Extension settings with PMScreen as part of the Waveform Capture parameters even when recording is in progress. An additional screen has been added to show the extensions in operation and the likely number of events to be recorded.

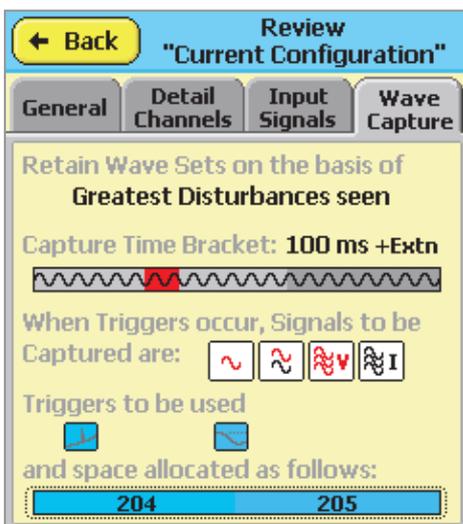
From the “Configure “ screen, select “Review”. This produces the “Review configuration” screen, with Tabs for the selection of Detail Channel settings, the Input Signal configurations, and the Wave Capture parameters.

Pressing on this gives the “Extensions” screen:



You may toggle back to the previous screen with the **Toggle Wave Capture Review** button.

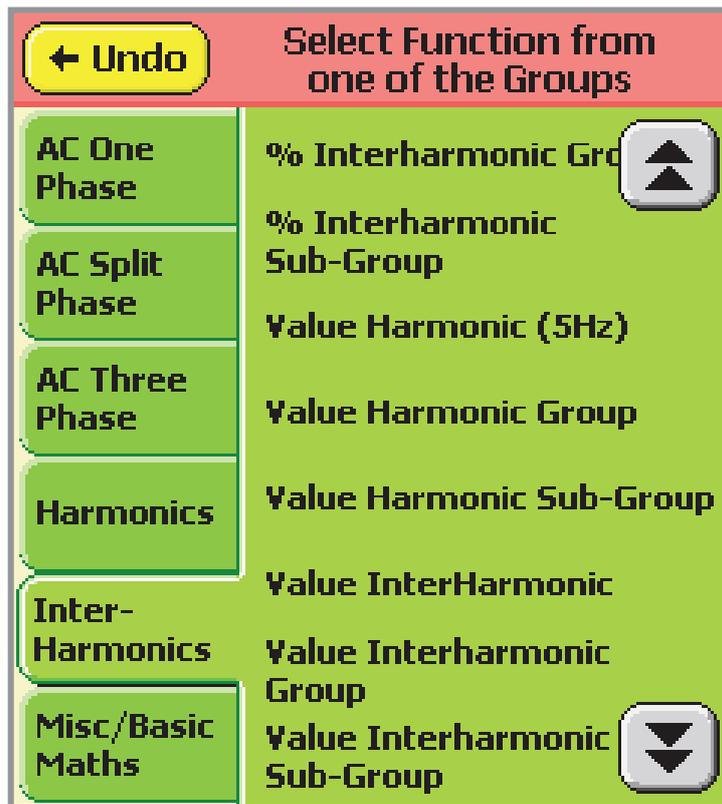
Select the “Wave Capture” tab.



This screen is the same as for previous firmware revisions, except that the Space Allocation bar at the bottom **204 205** has become a button (notice the dotted surround).



## Interharmonics



Interharmonic screen in PMScreen



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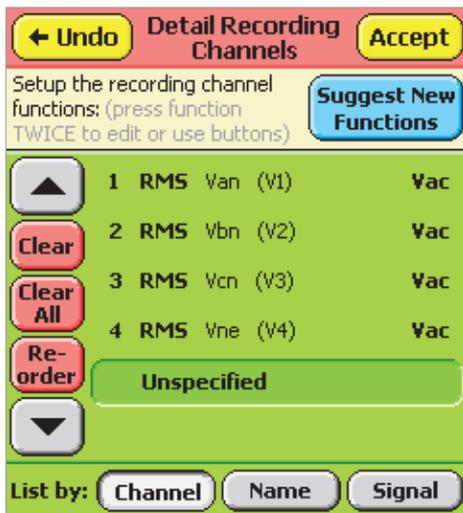
## Setting Up to Record Interharmonics

Interharmonics are recorded as Detail Recording Channels because this regime gives plenty of flexibility.

In the event that you don't know what you are looking for, you can look at the live Interharmonics screen first. You will find this screen under "Main Menu", "Harmonics and Phasors", "Interharmonics". Look at the frequency where there is interharmonic activity, for instance, and decide on a useful interval to measure within.

To record for example voltage interharmonics in the range up to the 3<sup>rd</sup> harmonic, then we need to select interharmonic groups on each of the voltage signals up to the 3<sup>rd</sup> harmonic. (Assume you have been told, or have noted from the live screen, that there might be something at around 74Hz on Phase B, but otherwise you don't know what to expect – you just want to see if there is anything specifically NOT harmonic related),

Under "Configure" / "Detail Recording Channels", choose an "Unspecified" channel.



Click on it once to select it, and a second time to edit it.



Select the "Interharmonics tab on the left hand side.

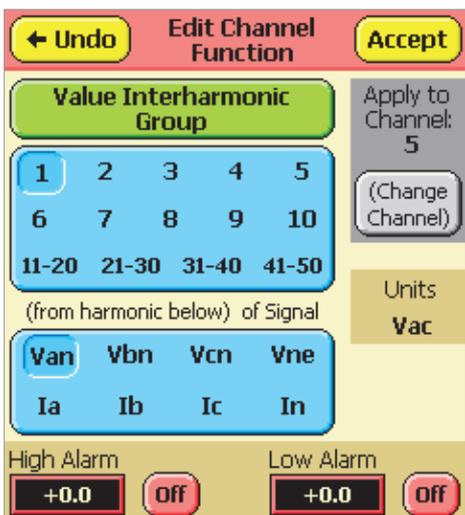


This will bring up the function group from which you may select Interharmonic Group, either as a %age of the fundamental group or directly as a value.

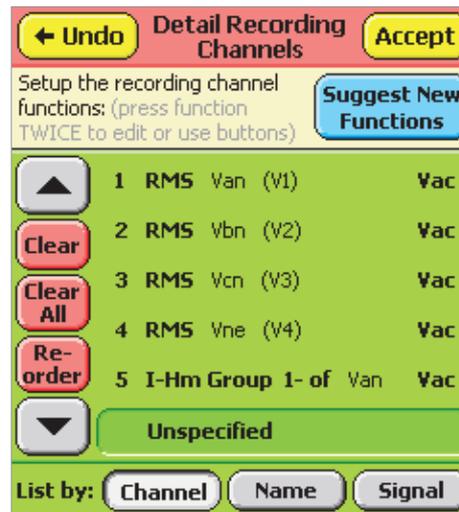


Assume we want to know the interharmonics voltage rather than its %age of the fundamental.

Use the double arrow up and down buttons to access all options. Select "Value Interharmonic Group", see right hand screen.



We need to select three groups for each voltage phase. The first will be up to the 1<sup>st</sup> harmonic. Actually this will be "sub-harmonics" because they are below the fundamental (1<sup>st</sup> Harmonic). Select "1" as shown, and select Van for the signal. Then press on "Accept".



This adds the harmonic group below the fundamental, for Van, to channel 5.

We can either specify the next group (this time below the 2<sup>nd</sup> Harmonic) manually as we have just done for the 1<sup>st</sup> group, or we can exploit the Auto Suggestion process. We will use the Suggestion process, as it is much quicker.

Click on "Suggest New Functions". This will offer us two possibilities, both of which we want.



If we choose the top one to apply to Channel 6, the lower one will remain an option next time.

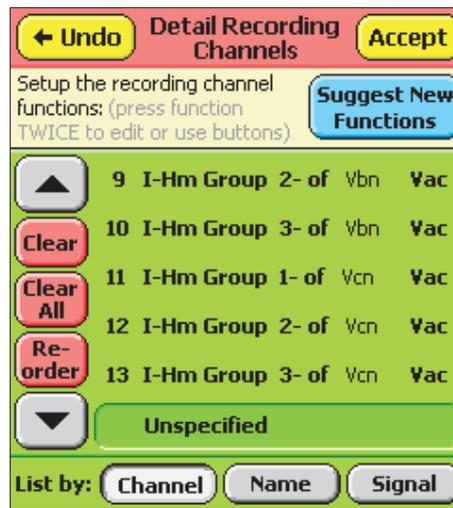


Select the TOP option again this time to apply the group up to the 3<sup>rd</sup> Harmonic to Channel 7.

And NOW, we can choose the 1<sup>st</sup> Group of B phase to apply to Channel 8. Follow this with groups 2 and 3 of B phase to channels 9 and 10.



Complete the job by selecting Group 1- from C phase, then Groups 2- and 3-. Click "Return to list".



Use the scroll up and down keys to confirm your selections. If you have made a mistake, click on the offending channel and re-specify. Now you have made use of 13 channels.

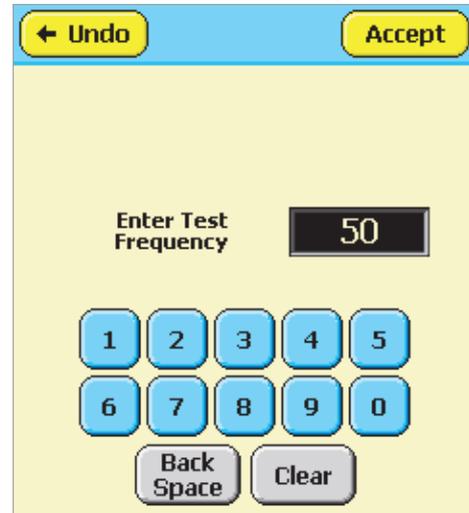
Let us say at this stage that you change your mind and decide also to look specifically at 74Hz on Phase B. Assuming you are in the Detail Recording Channels Listing screen, scroll up or down to the next unspecified channel, and click on it twice (again the first click is to select it, the second click (once selected) takes you to the edit screen).



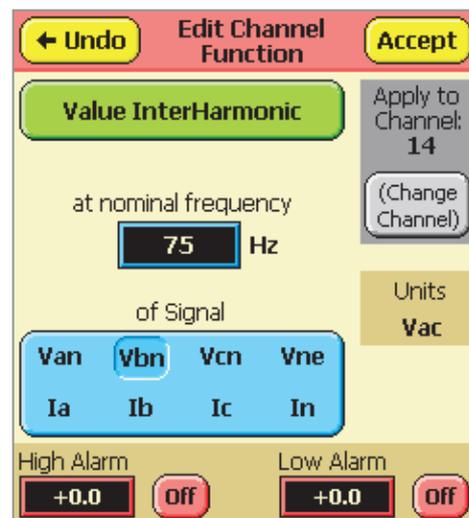
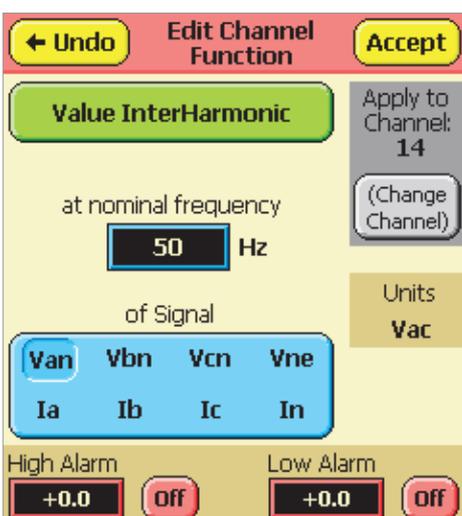
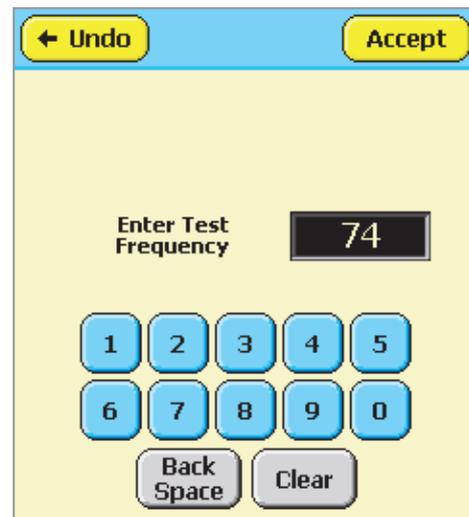
Again choose "Inter-harmonics",



this to 75Hz, being the nearest interharmonic actually calculated .



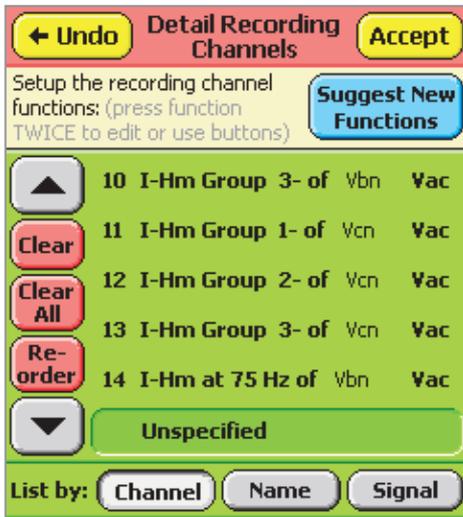
then press on the down double arrow (to access the second set of options) and this time choose "Value Interharmonic".



If you enter 74Hz as shown, the system will change

Click "Accept" to add this to the list as (in this case)

Channel 14.



When you are comfortable with your selections, click “Accept” to return to the full “Configure” menu, then “Back” to load the revised (edited) configuration into the current working configuration.

# High Speed Comprehensive Power Quality Analyzer



## USB Memory Device operations in the Ranger PM7000



PM7000



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## Introduction: USB Memory Device

A USB Memory device (variously known as a Jump Drive, Cruzer, Memory Stick etc.) may be used to transfer data from the PM7000 to a computer instead of performing the download over the serial USB or Bluetooth links.

## Choice and Formatting of Memory Devices

Clearly large devices are more useful than small ones. However some large devices may be built using a multi-level cell technology (MLC) which may make them slower than other single level cell devices (SLC).

The device is divided into “sectors” or “clusters”. The number of sectors and the size of each one (from 512 bytes up to 65536 bytes) are set in the device formatting process. Each sector is used to hold one file or part of a file. Large files are held in multiple sectors, and the sequence of sectors as well as other file details is held in the “File Allocation Table” (FAT). Because an entire sector is the minimum space allocated to a single file, small memory devices tend to come formatted with relatively small sectors. This enables a large number of small files to be stored efficiently, whereas larger sectors are inefficient and wasteful if typical files are small. However there is a speed overhead associated with the housekeeping of small sectors which is reduced when sector size is increased. Consequently larger devices tend to be formatted with larger sectors, since speed is likely to be more significant than the waste associated with small files.

PM7000 files come into the large category, therefore whatever size of device is chosen, it should be formatted with the largest sectors possible, ideally 32kByte.

To format (or reformat) a device AND to specify the sector size,

1. Insert the USB device into a USB port on your PC, then under Windows “My Computer”, select “Control Panel/Administrative Tools/Computer Management/Disk Management”.
2. Allow the PC to find the disk drives present, which should include the USB Memory Device. You may have to expand the size of the window pane offered.
3. Identify the relevant drive and BE CERTAIN that it is not crucial to the computer’s operation.

Beware the format function is very powerful and if you format the PC’s hard drive inadvertently you will lose all your data and your programs.

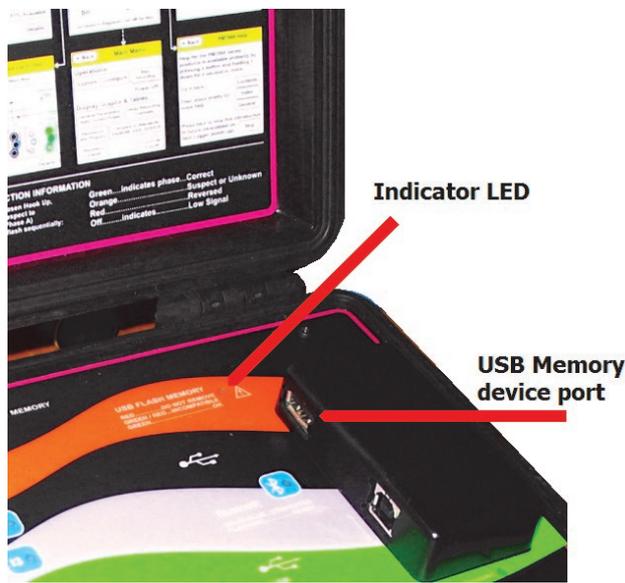
4. Having identified the correct Drive, right click on it, and select “Format”. You will be asked “are you sure you want to format this partition?” Click yes.
5. The volume label may be left as it is. If the File system offers “FAT”, choose this rather than “FAT32”, as it is slightly faster in operation. Large devices are likely to be FAT32 and you won’t have any choice. For the Allocation Unit Size (sector size), choose 32k. Click OK.
6. At the warning message, click OK.
7. If the operating system is happy to format the drive with the cluster size selected, it will format the drive and return to the display of all the disk drives present. If you get the error message “The Cluster size is too big for the selected file system”, you should repeat the process from step (4) and select the next cluster size down. If that also produces the same “Cluster size too big” message, repeat the process from (4) again, selecting smaller and smaller cluster sizes until the operating system is happy.

Close down successive windows until you are back at the desktop again.

Note that a slow drive, formatted with small clusters, may be as much as 20 times slower than a large device optimally formatted.

## Manual Copy

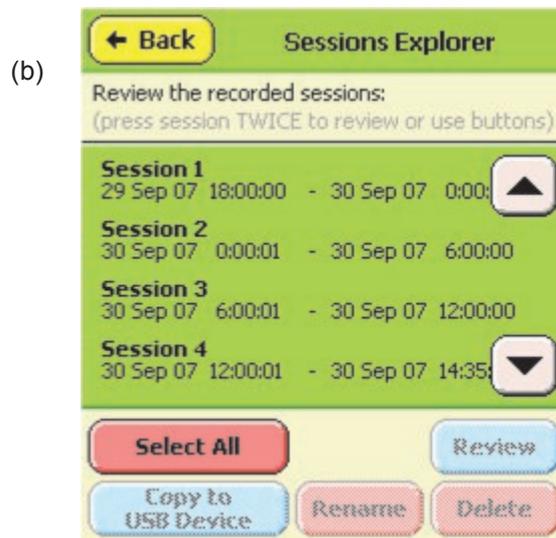
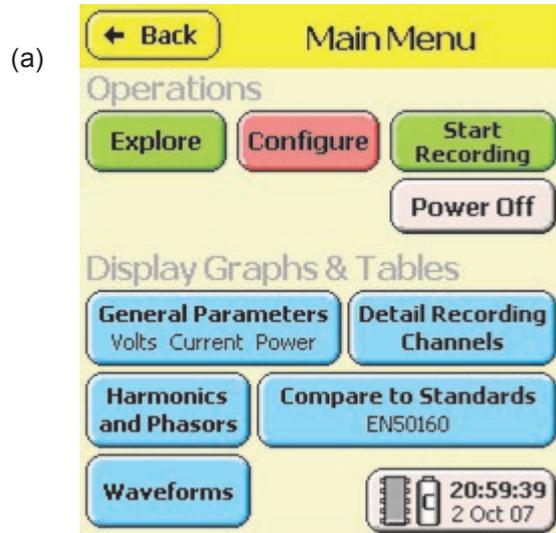
To copy recorded sessions from the PM7000 to the USB Memory Device, insert the memory device into the “host” slot in the PM7000 communications bulge towards the back of the unit.



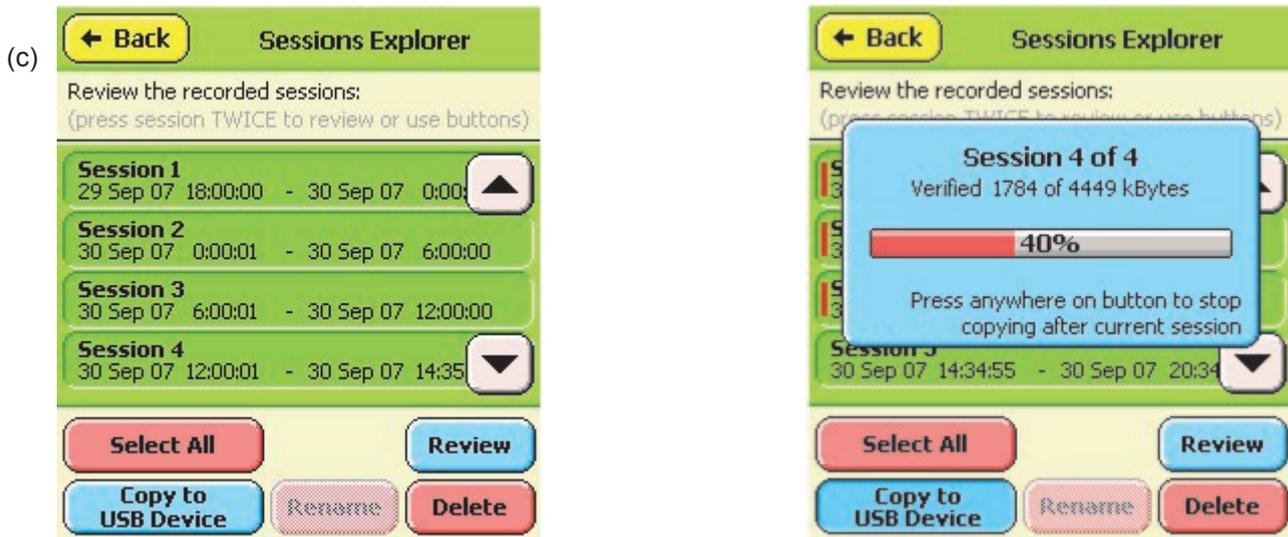
The Memory device will only slot in one way up. It is usually with the  USB symbol uppermost.

With PMScreen running either on a PC or a portable device, stop the recording (you may only copy completed recordings) and allow the copy of wave capture data from RAM to internal Flash memory to finish.

From the logger “Main Menu”, select “Explore” (a). This will display all the sessions held on the logger’s Flash Drive, and available for copy to the memory device (b).



To copy all of them, choose “Select All”. If you want to copy only one, select that session by pressing on it. If there are more sessions than fit on the screen, you may use the scroll buttons to bring the sessions of interest onto the screen, where you can select one by pressing on it.



If the system has recognised the Memory Device, the LED on the PM7000 front panel will have gone green, and the Button “Copy to USB Device” will be active (c). Select this button to start the copy process. Note the front panel LED will go red during the copy process and the MEMORY DEVICE SHOULD NOT BE

DISTURBED while copy or verify is in progress. When copy is complete and verified the LED will become green again, and the device may be removed.

Note that the internal PM7000 USB interface circuit is energised only during the “Explore” mode, and all the time the LED is off or green, the Memory Device may be removed.



## Automatic Copy at the End of a Session

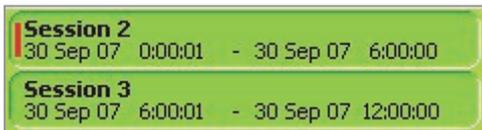
The USB Memory device may be inserted or withdrawn at any time provided the LED is not red.

An Automatic copy process occurs simply if a USB memory Device is detected when a recording ends

automatically. Thus if a device is inserted during a recording, and is still in place at the end of a recording, any sessions in the PM7000 not already copied will be copied to the USB device. This does NOT apply if the recording is stopped by the user deliberately. It DOES

apply if the recording shuts down for any other reason including time expiry, loss of power, or exhaustion of memory.

When a session has been copied to a USB device, an attribute is set against that session in the PM7000's Flash Drive, and the session is shown with a red bar beside it in the PM7000's explorer window (e.g. Session 2 has been copied, Session 3 has not).



The Auto-Copy process only copies sessions not previously copied, however the manual process can copy any session.

Note that the USB device is normally energised approximately 15 seconds before the end of a recording, so the green LED will typically come on at that point. It will go red during the copy process, go briefly green at the end and then turn off again.

## File Structure on the USB Device

The sessions are copied one at a time onto the USB device, together with the appropriate configuration, to create a single file for that session. The process is as follows:

The logger reads its own serial number, and creates (if it doesn't already exist) a directory (folder) on the USB device with the name including the serial number. E.g. for files from logger serial number ending 0114, it would be \PM7S0114.

The session file is placed in this directory, and automatically given a name similar to that used by Pronto for the data files read over the serial USB link. It also has the same form and the same file extension (.MDM). This naming arrangement is intended to uniquely identify the source, date and type of each file and to minimise the likelihood of file name conflicts.

The PM7000 first checks for the existence of the appropriate directory on the USB drive (creates it if

necessary), and looks for files already in it with the same date. The file naming convention is YYMMDDXX.mdm, where YY is the year (e.g. 06 for 2006), MM is the month, and DD the day of the month. XX is a suffix which begins at 00 for the first file of the day, and counts upwards for successive files. Thus the first file to be copied on 2<sup>nd</sup> December 2006 is named 06120200.mdm, and the second 06120201.mdm.

If the logger finds files of the same date already present it uses the next available index. In the event that there are more than 100 files copied from a single logger during a day, the index XX is extended to use the least significant of the DAY digits. Thus the number sequence always advances with later files saved.

## Import into Pronto

The simplest way to import the .mdm files into Pronto is to have Pronto already open on your PC, then to select them (the .mdm files on the USB device) with Windows Explorer, and drag and drop them into Pronto. Pronto will automatically import them as

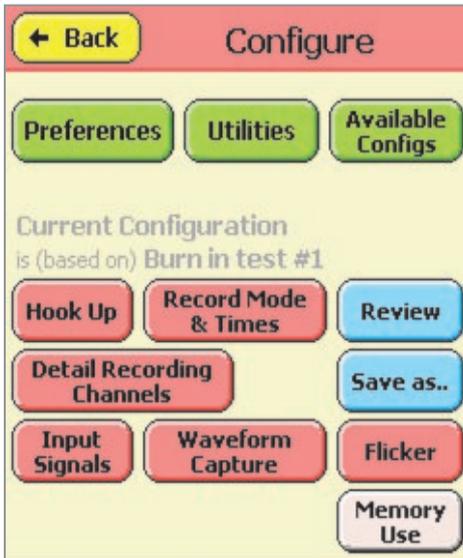
though they were from the direct serial connection to a logger. You have the same opportunity to select suitable projects etc. in which to place the data, and for multiple sessions from the same logger, you may use the AutoSave function to append new data to old.

## Memory Extension by Automatic Copying

By the simple expedient of selecting FIFO (recycling) mode, the PM7000 can effectively extend its memory up to the capacity of the memory device. FIFO is found under the Configure / Record Mode and Times menu.

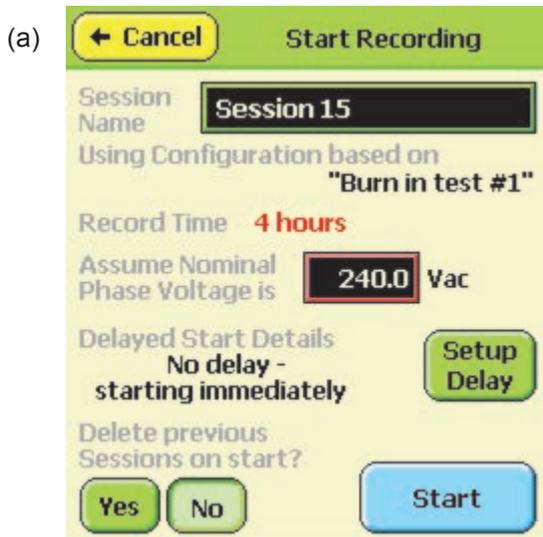
As discussed above a device present at the end of a recording causes a copy of any uncopied sessions into the device (provided it wasn't user-terminated). If FIFO is in operation the PM7000 will re-start recording automatically when a previous one is complete, deleting space in its own memory if necessary, and all the time the system finds a memory device present at the end of each recording, that recording (initially "uncopied") is copied to the device. This process can continue until the memory device is full.

The memory allocation in the PM7000 is suggested to be approximately 32 - 48 MB. This ensures that a recording just completed does not have to be deleted straight away (since there will be 80 - 96MB spare space – plenty of room for another file of 32 or 48MB), hence the new recording can start immediately the previous wave capture data has been saved, and does not have to wait while the file is copied. In this way the time lost between recordings is a few seconds maximum rather than the full file copy time.

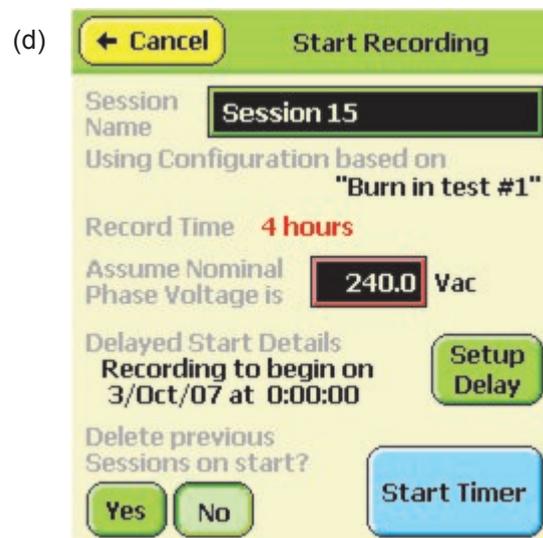


## Specifying Start and Stop Times

A tidy way to obtain recordings starting and stopping at convenient times is to use the Delayed Start facility. Choose e.g. 24 hours or 7 days for the recording time, and use “setup Delay” (a) to set a delayed start to occur at a precise future time (b).



Arrange the start time to be the next convenient time IN THE FUTURE, e.g. the next midnight (c). When you “Accept” that, the “Start” (recording) process becomes “Start Timer” (d).



Then the first recording will run midnight to midnight, and the second recording, though starting a second or two after midnight, will nevertheless run to midnight again. (In FIFO mode a new recording Stop Time is set by consideration of the “desired” stop time based on the previous Stop Time plus the chosen “Record time”. Thus the short period between recordings does not cause a gradual drift in recording start and stop times.)

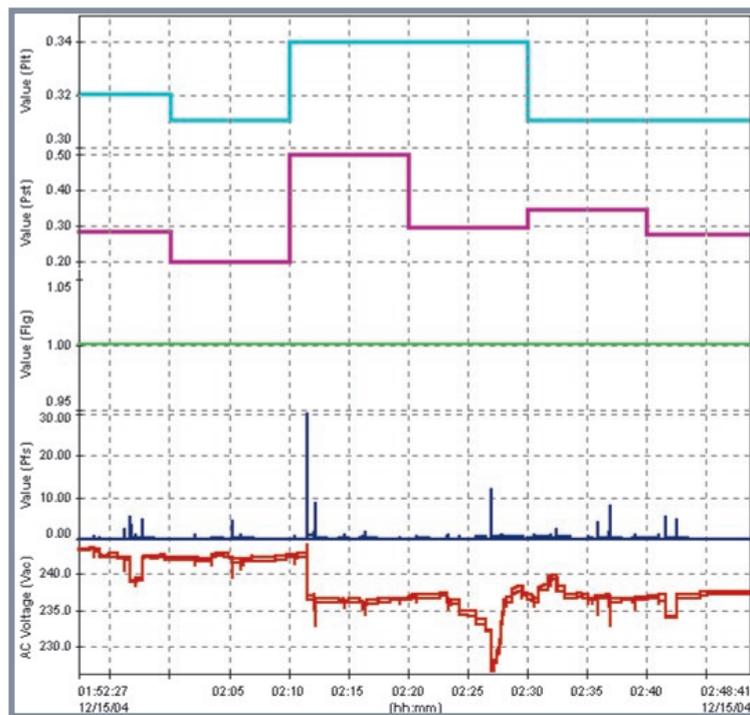
## Temperature of Operation

Note that USB Memory Devices are not usually specified to work outside the normal PC operating temperature range (typically 0-40 °C). We have had

mixed fortune trying to operate devices during product burn-in (>60 °C). Some work and some don't.



## Flicker in the PM7000 (and all other Power Master Series products)



### PM7000 Flicker Testing



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## Standards

The Flicker Measurement Function is described in IEC61000-4-15 with Amendment for 230V 50Hz and 120V 60Hz systems. The PM series flicker filters have been implemented to conform to the “Flickermeter” model described in detail in the IEC

specification. In addition supplementary test data for detailed conformance testing has been taken from draft working documents in preparation by other organisations [1].

## Outputs Available

The IEC Flickermeter specification calls up a number of optional and three mandatory outputs. The optional outputs come from intermediate stages of the somewhat complex filtering process and are useful only during trouble shooting or Flickermeter testing. The mandatory outputs provide useful information when a (presumed working) system is applied to real life voltages. A further “flag” output indicating input signal relevance is also provided.

For the user, Flicker is assessed using the three mandatory parameters and the flag:

**1) Instantaneous Flicker Sensation**, whose units are defined as **PFS**, is a very short term measure of how the (model of the) eye-brain responds to flickering incandescent lights, assuming that such a light will flicker if the voltage applied is itself varying. 1 unit of Pfs corresponds to the flicker level at which the average person begins to become aware that Flicker is present. It is the threshold of Perceptibility for half the population. The Flicker level at which humans actually become irritated is somewhat higher so although the Instantaneous Flicker Sensation (Pfs) is used to obtain cumulative irritation levels, a value of just 1 for Pfs is not considered high enough to produce irritation in an observer.

Pfs is an immediate indication of Voltage quality as perceived by humans, and as such is a valuable parameter showing quantitatively whether an installation may or may not suffer flicker problems. It is particularly valuable when related in time to load variations at an installation. Significant Pfs coincident with household appliance switching immediately suggests local line impedance may be too high.

**2) PST is Short Term Flicker Perceptibility**. It is the measure over a short period (few minutes) of how irritating Flicker is thought to be. It is based on statistics of Pfs, in an attempt to assess the cumulative effect of Pfs levels reaching into the region causing irritation. Irritation may be caused by consistent minor flicker or occasional major flicker events. The statistical

treatment used to obtain Pst is intended to model the way humans react. One perceptibility unit of Pst is considered to be the borderline irritation level for half the population.

**3) Finally PLT, Long Term Flicker Perceptibility**, is a further measure for cumulative irritation caused by very occasional gross flicker events, which may be too infrequent to cause meaningful Pst (Short Term Perceptibility) results. Plt is derived from Pst and is usually measured over a period of hours. If Pst is constant over the long term period,  $Plt = Pst$ .

**4) The “Flag” function** is used to signal to the user that input conditions which should not be part of the Flicker assessment are present, and have been excluded from the Short and Long Term calculations. The Conditions which are Flagged (and excluded) are variations in excess of 20% from the mean. Dips, Surges and Brown-outs and the like could otherwise have an overwhelming effect on the flicker results, and potentially make the normal low level flicker assessment impossible. They can also cause loss of arithmetic precision. To prevent “chatter” on the Flag result, 2% hysteresis is applied so that the once flagged, a variation must fall back under 18% from the mean to be re-admitted to the assessment process. The normal Flag condition indicating good input signals is “Raised” with a value of 1.00. Bad input conditions cause the flag to fall to 0.00. The Flag assessment is made on the whole cycle RMS result before that cycle’s data is passed to the Flicker Processing system.

As presently implemented the Instantaneous Flicker Result DOES receive all the input data. The Short Term classifier is starved of input data during flagged conditions, however the statistics obtained while *unflagged* are still processed at the end of each Short Term Interval so Pst and Plt may still change even though the voltage conditions are bad and the flag is down.

## Processing applied under conditions of voltage variation

Voltage condition	Flag	Pfs processing	Transfer Pfs to Pst processing	Pst, Plt calculated on available data
Normal	Good/Hi (1.00)	Yes	Yes	Yes (all data)
Within +/- 20% of mean	Good/Hi (1.00)	Yes	Yes	Yes (all data)
> 20% from mean	Bad/Lo (0.00)	Yes	No	Yes (excludes Flagged data)
> 18% from mean *	Bad/Lo (0.00)	Yes	No	Yes (excludes Flagged data)

\* Once Flag is Bad, voltage must return within 18% from Mean to reinstate flag.

If, for presentation purposes, the entire Short Term or Long Term interval should be “black-listed” because of any Flag activity during the interval, Pronto’s reporting or Max/Min trace generation facility may be used to create the necessary results/graphs.

## Interval Selection and Long Term Flicker Result Processing

The IEC Standard requires that Short Term intervals may be specified from 1 to 15 minutes, and that Long Term intervals from 1 hour to 1 week be available. Normally 10 minutes and 2 hours are used.

<b>Short Term Intervals available in the PM7000 (minutes)</b>	1
	2
	5
	10
	15

Any Long Term interval from 1 to 168 hours (1 week) may be selected. All time interval boundaries are arranged to coincide with convenient clock times. For instance short term results for an interval specified of 10 minutes become available “on the hour” and at 10 minutes, 20, 30 ,40 and 50 minutes past the hour.

As previously discussed, Long Term results are based on Short term results. It is understood that the intention behind the specification was for the Long Term Flicker result to be updated whenever a new Short Term result becomes available, by processing with a “rolling box-car” such that for Short and Long term intervals of 10 minutes and 2 hours respectively,

a new Long term result would become available every 10 minutes based on the previous two hours, i.e. the previous 12 Short Term results only.

The PM products apply box-car equal-weight processing for all combinations of Short and Long Term intervals up to a ratio of 144 as shown in the table below. This readily accommodates the standard 10 mins/2 hours, as well as 1 min / 2 hours, or 10 mins / 24 hours. The PM products can also accommodate combinations even more extreme than this, however the box-car processing is not available, and only one Long Term result is available per Long Term interval.

## Box-car Processing and Interval Combinations

Short Term selection (mins)	Long Term selection (hours)	Ratio LT/ST	Box-car processing	Result updated every (mins)
1	1	60	yes	1
2	1	30	yes	2
5	1	12	yes	5
10	1	6	yes	10
15	1	4	yes	15
1	2	120	yes	1
2	2	60	yes	2
5	2	24	yes	5
<b>10</b>	<b>2</b>	<b>12</b>	<b>yes</b>	<b>10</b>
15	2	8	yes	15
2	4	120	yes	2
5	12	144	yes	5
10	24	144	yes	10

For Long Term intervals > 1 day, only one result per Long interval is usually available.

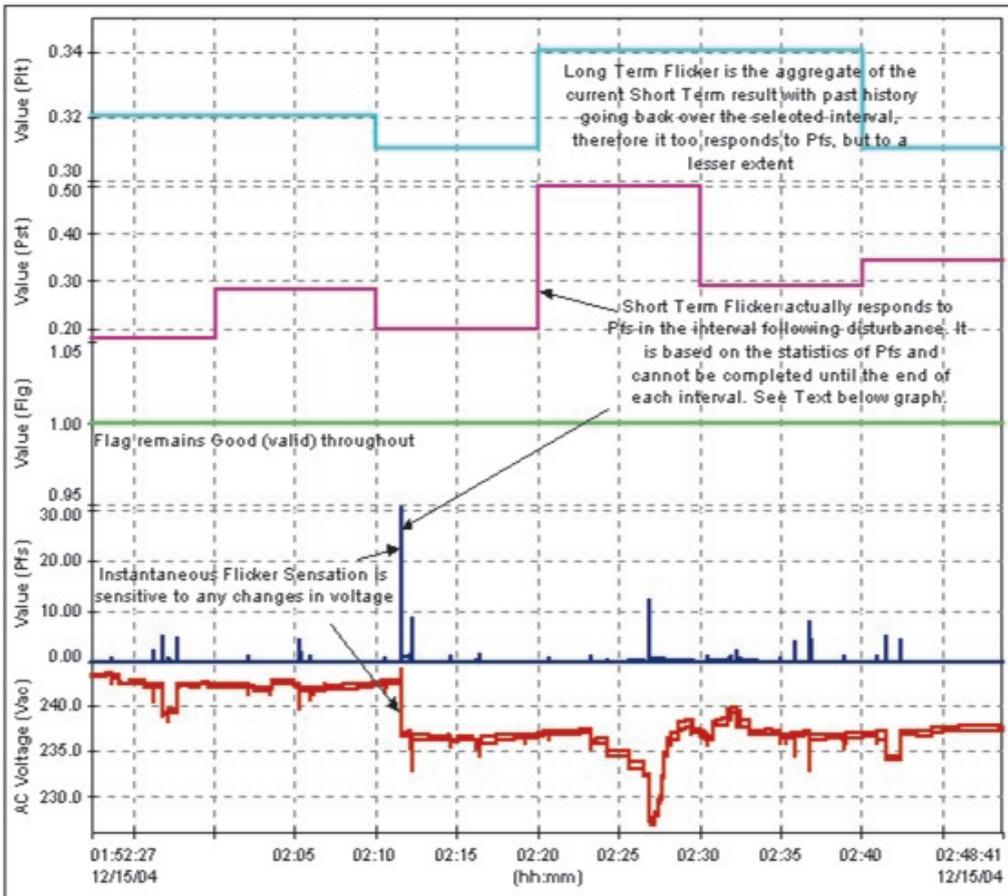
Short Term selection (mins)	Long Term selection (hours)	Ratio LT/ST	Box-car processing	Result updated every (hours)
10	48	288	no	48
10	72	432	no	72
10	168	1008	no	168

## Timing Relationships and Presentation of Results

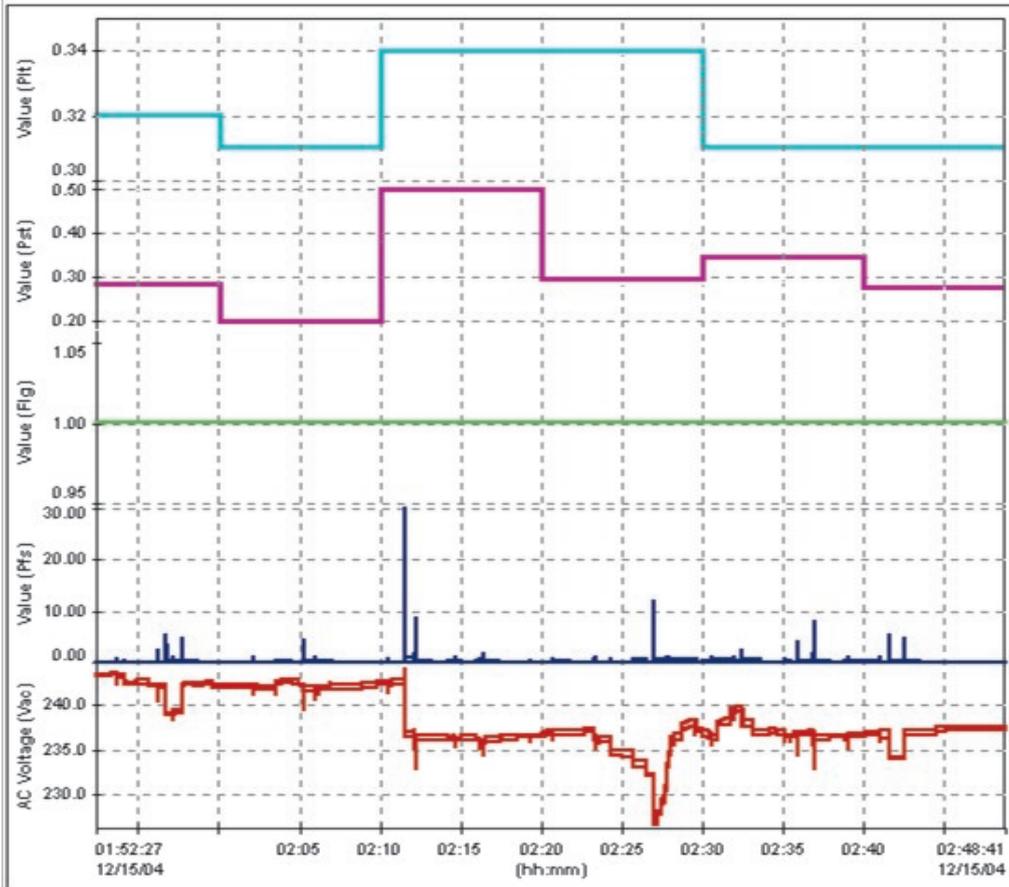
The following graph shows a short section of typical results from measurements using the “Standard Line only plus Flicker” PM1000 Configuration on a residential installation. At the foot of the graph the line voltage can be seen varying from 243V down to 227. The next trace up is Instantaneous Flicker Sensation. This is normally very small, < 0.01 perceived units, but any step change in the RMS voltage clearly generates an immediate flicker sensation signal, with the voltage

drop at 2:12 causing a high value of 30 p.u. There are no significant dips during the recording so the flag (middle channel) remains high (good) throughout.

The graph shows the *actual* recorded relationship between the Short Term Flicker result (Pst) and the Instantaneous Flicker Sensation (Pfs) on which it is based.



Clearly the statistics on the period from 2:10 to 2:20 are not complete until 2:20. *For visual convenience*, Pronto is able to bring forward both Long and Short term results by one Short Term interval, so that the Short Term result (and also the Long Term) show the effect of a spike on Pfs in the same interval in which it occurred. The following graph shows the revised presentation:



In this graph the voltage step (at ~2:12), the resulting Pfs, and the consequent effects on Pst and Plt are all shown in the same 10 minute interval, even though clearly the step change in Pst from 0.2 to 0.5 shown at 2:10 cannot have occurred *before* the event causing it!

## Input Voltage Range

The system is designed to provide high quality Flicker Measurements over the input range 100V to 270V. The “Voltage Adaptor” feature required by the Standard allows for long term variations of input

voltage so that Flicker intensity is (relatively) independent of absolute RMS voltage.

## Performance

There has been much controversy over the way different manufacturers’ Flickermeters respond differently to the same input, and various proposals are under consideration in both Cigre and IEEE to try to define tests, conformance to which should promote more consistent measurement results across different models when all are exposed to the same particular flicker scenario.

In the PM products all three parameters are derived using the IEC61000-4-15 model for human behaviour. The measurement process meets all the Flicker Tests specified in the standard (Tables 1, 2 and 5) and in addition meets the new test points at 33.333/40Hz for 50/60Hz systems currently being proposed by both Cigre and IEEE as well as all the numerous intermediate points currently being considered by the

IEEE. Dynamic Range is in excess of the levels required for the highest class of instrument meeting the proposed Cigre tests from a Pst of <0.2 to >20.0. The internal classification system is based on 1024 bins (IEC specifies a minimum of 64), and Pfs is sampled for the classifier at  $\geq 200$  Hz (IEC specifies 50Hz minimum).

**Graphs 1 and 2** show complete conformance to Tables 1 and 2 from the IEC Standard. **Graph 3** shows conformance to the 8 points specified in Table 5 from

the IEC Standard, and in addition shows conformance to all further 23 points understood to be specified in forthcoming IEEE Standard.

Linearity has been tested using the CIGRE proposed test. [The section **Linearity Results** (at the end of this appendix) shows that PM flicker filter performance easily meets the requirements for the highest class of instrument.]

## Displayed/Recorded Range of Pfs (Instantaneous Flicker Sensation)

Note that Pfs is a volatile parameter corresponding to the square of voltage fluctuations. In order to display a useful result in the borderline irritation region, this is expressed (like Pst and Plt) to 2 places of decimals. Consequently Pfs may collapse to zero even though

Pst is non-zero, or exceed the 299.99 upper display limit for severe events even while Pst is modest. Pfs is maintained internally to very much greater precision than is displayed.

## Demonstration Modes

The PM products have flicker demonstration modes. The following section describes these using the PM1000 as an example.

The PM1000 has a flicker demonstration mode for distributors to make demonstrations to customers, or for knowledgeable customers to conduct their own tests. Presently there are two regimes: static or swept. In both cases the user specifies the modulation level to be applied.

The demonstration mode is entered using the serial port from a PC running a terminal communications program like "Termview", "Hyperterminal" or "Windows Terminal". [If you do not have such a program contact Outram Research who will be pleased to send you "Termview" which was written for communications to the Outram Research products and is ideal for this purpose.]

The commands to enter the Flicker Demonstration mode are (at the prompt):  
PM1000> Flicker <Changes per minute> <Modulation level (%)>

The parameter "Changes per minute" is used to control the regime.

Specifying Changes per minute POSITIVE requests a static rectangular modulation test at the change rate figure specified. This may be set from 0.1 to 4900 Changes per minute, enabling the entire span of tests in the spec to be applied.

Specifying Changes per minute NEGATIVE specifies a fast sweep. The frequency range of 1 to > 4000/4800 (50/60Hz) changes per minute is swept logarithmically in about 23 minutes. When it reaches the highest rate it starts again. IF this mode is selected on a PC running a *simulation* of the PM1000, then the modulation is applied SINUSOIDALLY for examination of conformance with Table 1 of the IEC61000-4-15 specification. Examine or Record the Instantaneous Flicker Sensation.

Specifying Changes per minute as ZERO specifies a slow sweep from very low frequency in which the modulation is always rectangular. The frequency begins at 1 change every 10 minutes and sweeps logarithmically up to > 4000/4800 (50/60Hz) changes per minute. The sweep time is nearly four hours, so that conformance both Table 2 Pst and Pfs can be assessed for the very slow changes.

Modulation level is specified in percent to up to 4 decimal places.

The mains frequency present when the test is invoked specifies the frequency to be applied during the test and the selection of Flicker processing parameters. (which are different for 50 and 60 Hz applications)

Examples:

With the PM1000 attached normally to 50Hz mains, type PM1000> Flicker 1620 0.402 will apply 0.402% pk-pk rectangular modulation at 1620 changes per minute, i.e. testing point 6 from spec Table 5 for a 50Hz system.

PM1000> Flicker -1 1.00 will apply 1% pk-pk rectangular modulation swept from 1 to 4000 changes per minute.

---

## Simulator Running on a PC

If the SIMULATION is running on a PC, the same things can be done, except that the test PM1000> Flicker -1 1.00 will apply 1% pk-pk *sinusoidal* modulation swept from 1 to 4000 changes per minute.

It is particularly useful to record results for subsequent analysis – this can be done on the Simulator by making a recording in the usual way (through PMScreen), then using the PM1000 text window

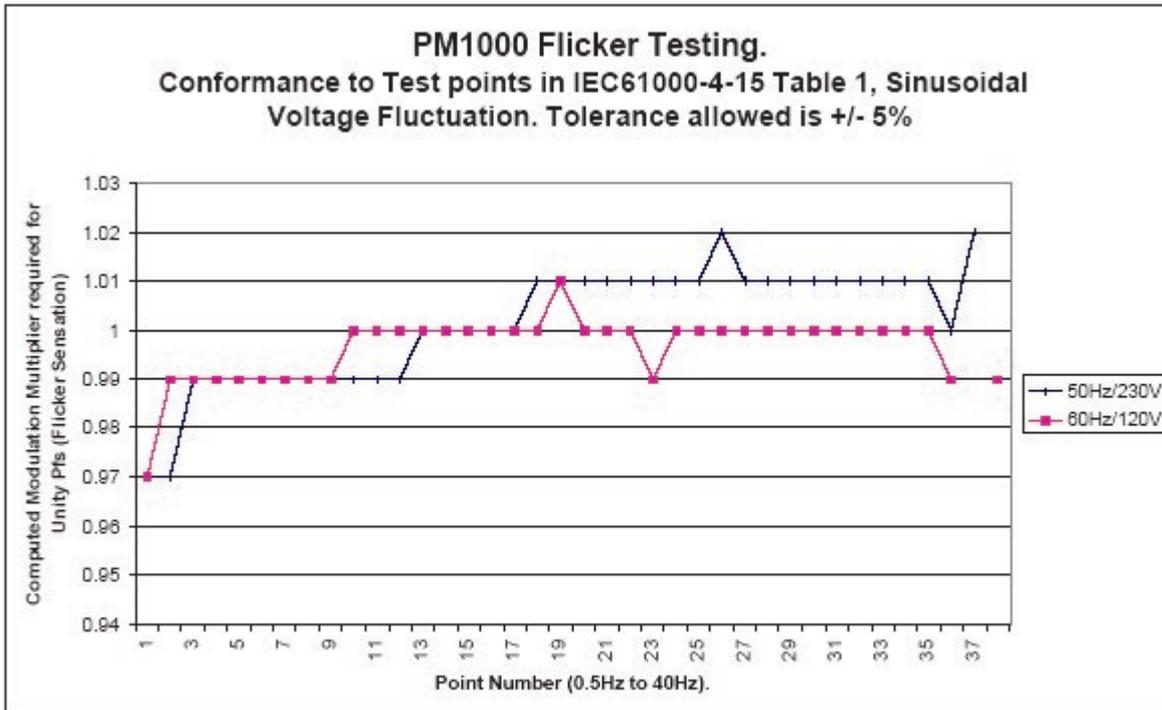
command “mirrorrd” (which stands for “Mirror the Ram Drive”) to assemble and copy the recorded data into a directory called c:\aaa\mirrorrd on the PC. Note that this directory path MUST exist beforehand. These are engineering conveniences and not “whole world user friendly solve all problems allow for ignorant users” commercial programs! The resulting .MDM file can then be drag-and-dropped into Pronto as a normal .MDM file.

---

[1] Both IEEE (WG 1453) and CIGRE are working on extending the tests required to demonstrate conformance to the IEC Flickermeter model. Information available on some of these tests have been used to increase the scope of tests applied to the PM Series Flickermeter filter. It is understood that a computerised model of the IEC Flickermeter is considered to be the “Gold Standard” by which manufacturer’s hardware Flickermeters may be

judged, and the extended tests proposed above will be applied to both the Computer Model and manufacturer’s hardware for results comparison. The PM Series Flickermeter discussed in this note is implemented very closely in conformance with the IEC model and with the computerised version, as evidenced by the quality of the results shown. Consequently it is expected that extended tests will yield similar levels of conformance.

## Graph 1: Table 1 Conformance



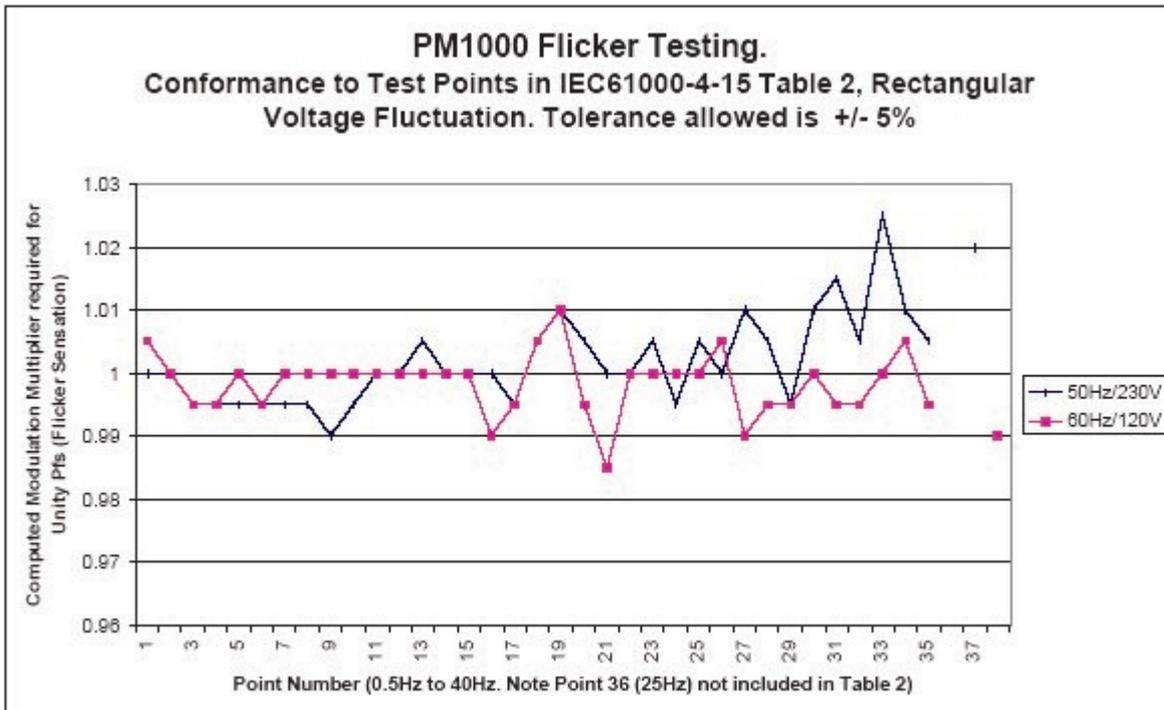
**Notes:**

The IEC61000-4-15 Table 1 lists 37 frequencies at which the Flickermeter should conform to the specification. The Flickermeter is said to conform if the nominal modulation level specified in the table has to be adjusted by no more than 5% to achieve the required output. The less adjustment that is required, the better the conformance.

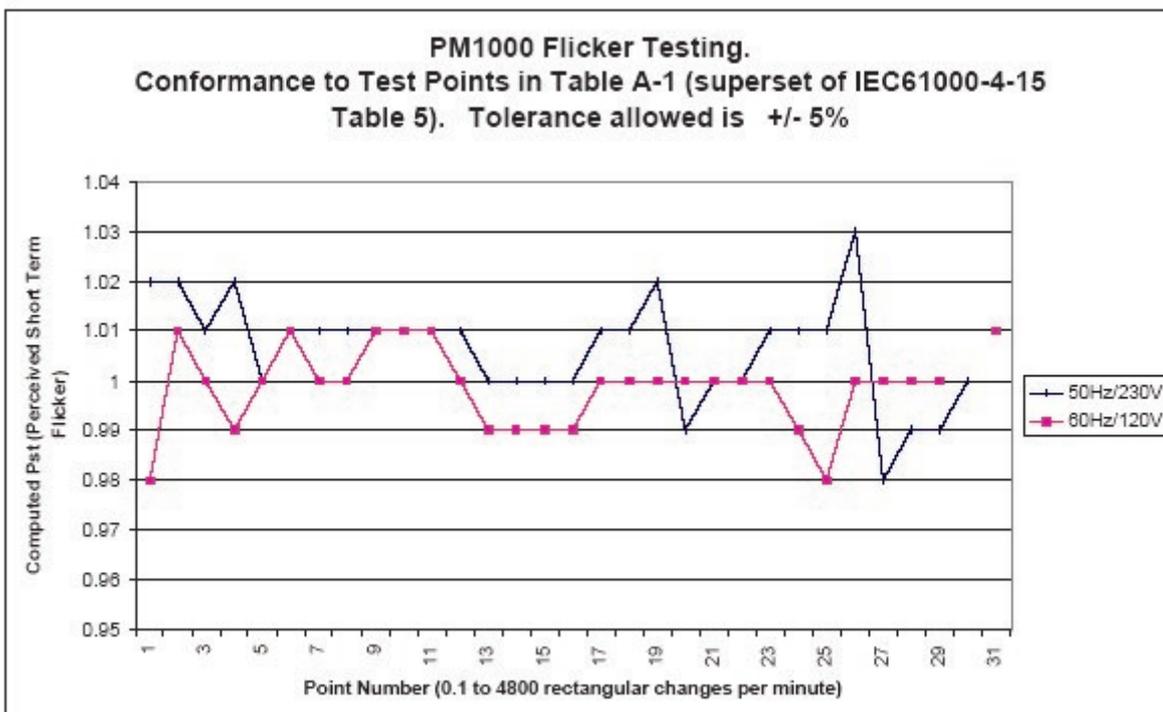
For example, the first point in the table tests 0.5Hz. A nominal sinusoidal modulation level of 2.340% (50Hz) or 2.457%(60Hz) should give an output of 1 precisely. For consistency of test results, the authors/designers of the tests specified that rather than permit the *output* to vary by a limited amount, they would allow the *input* to be varied to achieve the output figure of 1. From Graph 1 above, it can be seen that in order to achieve the output of 1, it is necessary to reduce the input modulation level by a factor of 0.97 for both the 50 and 60 Hz cases. An adjustment factor of 0.97 is less than 5% therefore that point conforms. As can be seen that very low frequency point is actually the worst.

At the top of the frequency band the final frequency points are 25Hz, then 33.33Hz for 50Hz systems and 40Hz for 60Hz systems. On the above graph these are points 36, 37 and 38 respectively. Consequently there is no result for point 37 at 60Hz, nor for point 38 at 50Hz. The same applies to Graph 2 below, and in addition, the 25 Hz point 36 is not specified in IEC61000-4-15 Table 2 consequently that is also missing from Graph 2.

## Graph 2: Table 2 Conformance



## Graph 3: Table 5 Conformance



## Linearity Results

### PM flicker linearity tests at Cigre Test frequencies, 6th Dec 04

Note: To make the tests possible precision computed values at the correct resolution are substituted for the actual Input A/D results. A/D Linearity and inherent noise floor are apparent when normal A/D output is used - during quiet periods Pfs is  $\ll 0.01$ , Pst floor is  $\leq 0.07$ p.u. For pure sinusoidal 230V input, total harmonic content on A/D output is unmeasurable ( $< 0.05V$ ).

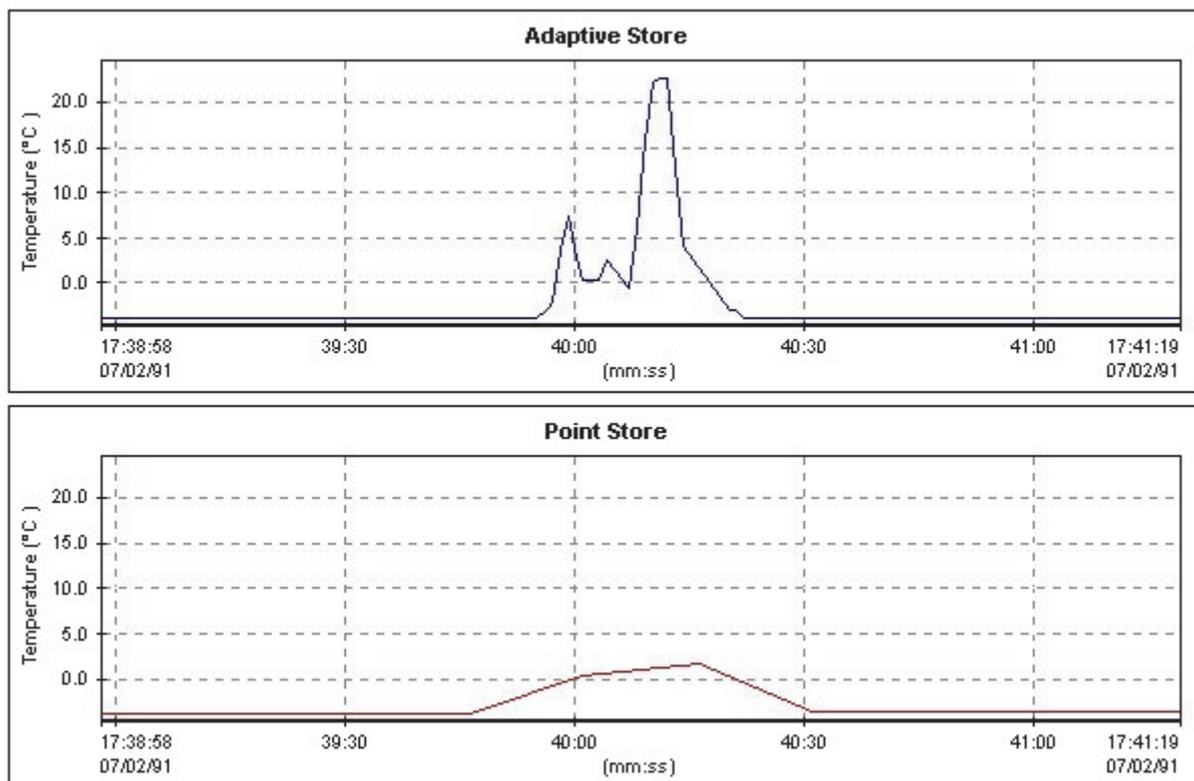
Mains Frequency used for tests: 50Hz

Changes per minute		<b>1620</b>				
Nominal Modulation for Unity Pst (%)		<b>0.402</b>				
		PM1000	Tolerance			
Modulation level multiplier		Pst Observed	Lo	Hi	In Tolerance	Normalised Results
0.05		0.04	0.04	0.06	Yes	
0.1		0.10	0.09	0.11	Yes	
0.2		0.19	0.19	0.21	Yes	
0.5		0.49	0.47	0.53	Yes	
Region Required to meet highest (Class 3) performance	<b>1</b>	<b>0.99</b>	<b>0.95</b>	<b>1.05</b>	<b>Yes</b>	<b>0.990</b>
	<b>2</b>	<b>1.97</b>	<b>1.90</b>	<b>2.10</b>	<b>Yes</b>	<b>0.985</b>
	<b>5</b>	<b>4.90</b>	<b>4.75</b>	<b>5.25</b>	<b>Yes</b>	<b>0.980</b>
	<b>10</b>	<b>9.80</b>	<b>9.50</b>	<b>10.50</b>	<b>Yes</b>	<b>0.980</b>
	<b>20</b>	<b>19.59</b>	<b>19.00</b>	<b>21.00</b>	<b>Yes</b>	<b>0.980</b>
	30	29.47	28.50	31.50	Yes	
	40	39.17	38.00	42.00	Yes	

changes per minute		<b>1</b>				
Nominal Modulation for Unity Pst (%)		<b>2.724</b>				
		PM1000	Tolerance			
Modulation level multiplier		Pst Observed	Lo	Hi	In Tolerance	Normalised Result
0.05		0.05	0.04	0.06	Yes	
0.1		0.10	0.09	0.11	Yes	
Region Required to meet highest (Class 3) performance	<b>0.2</b>	<b>0.20</b>	<b>0.19</b>	<b>0.21</b>	<b>Yes</b>	<b>1</b>
	<b>0.5</b>	<b>0.50</b>	<b>0.47</b>	<b>0.53</b>	<b>Yes</b>	<b>1</b>
	<b>1</b>	<b>1.00</b>	<b>0.95</b>	<b>1.05</b>	<b>Yes</b>	<b>1</b>
	<b>2</b>	<b>2.00</b>	<b>1.90</b>	<b>2.10</b>	<b>Yes</b>	<b>1</b>
	<b>4</b>	<b>4.03</b>	<b>3.80</b>	<b>4.20</b>	<b>Yes</b>	<b>1.0075</b>
	5	5.13	4.75	5.25	Yes	
	6	6.27	5.70	6.30	Yes	



## Adaptive Store in the PM7000 (& all other Power Master Series products)



**Adaptive Store vs Point Store in the PM7000**



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## The Patented Ranger Exclusive

Ranger's patented Adaptive Store recording mode is designed to make the best use of available memory, to meet two conflicting requirements:

- To provide long-term trend data, observing the worst extremes of maximum and minimum values, and;
- To provide detail where new activity occurs, i.e., detecting and capturing transients.

Adaptive Store does not require any prior knowledge of signal conditions. The only required parameter is the total time of the record.

Adaptive Store recognizes the *unpredictability* of future signal activity by employing its 13 predictive

algorithms, against which all samples are tested as they are received. This unique method of *anticipating* the possible signal path and testing each sample for conformity has these advantages:

- It spreads out the computational load uniformly over time
- It allows for immediate reaction to transients
- It works with extremely long recording periods.

The Ranger Adaptive Store recording mode is the most powerful automatic data compression system available on any data logger.

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## Introduction: Adaptive Store

The patented Adaptive storage technique has proven to be an exceptionally good performer in the field. The main attributes of this technique is its ability to accurately reproduce trend data and at the same time sample at a fast enough rate over long periods of time to faithfully reproduce anomalies and deviations from the trend. The ability to do this is not present in any other storage technique. This is a very rigorous requirement for conventional recording techniques and becomes more and more rigorous as the length of the recording time increases. The following discussion explains the functionality of the adaptive storage technique.

The patented Adaptive Storage used in the PM series is designed to make the best use of the store available, in reconciling two conflicting requirements:

Provide long term trend data, observing worst extremes of maximum and minimum values seen, and Provide detail where new activity occurs, i.e. detect and capture "transients".

If "transients" are slow moving, and the "long term" is relatively short, then the above requirements can both be met with a conventional Data Logger operating a sample and store process at a fixed sample rate. In technical terms, if the sample rate chosen can give a long enough recording period given the number of channels in use and the amount of store available, AND if the maximum frequency of the input

signal can be defined to be less than half the sample rate, then a regular sample and store process does provide an adequate record of the input signal, from which the actual input signal can be reconstructed.

If the above conditions cannot be met at the same time, something else must be done.

In the PM series, there is a way of improving on the regular sample and store process, "Adaptive Store".

## Adaptive Store

Adaptive Store does not require any prior knowledge of signal conditions. The only parameter it takes is the total time of the record.

It then applies a storage rate of 1 cycle for the whole recording period. The PM3000 samples 64 times per cycle and calculates the true RMS value over the time period of each cycle for the adaptive store process.

This sample rate is applied regardless of the number of channels. Thus for 4 channels, recording for 1 week, a total of  $60 \times 86400 \times 7 \times 4 = 145.152$  million samples are taken. At two bytes per sample, a store requirement of nearly 300 MBytes would be required in the classical sample and store method.

The PM's adaptive store process reduces this number by reducing the number of times it records anything. If a value can be predicted from past history, the new value is not recorded. All the time a set of values CAN be predicted, it is sufficient to define them on the basis of the past history, how the past history is being used, the length of time for which the prediction is valid, and the prediction tolerance (or better still, the worst case deviations from the prediction). In PM language, we call such a combination of Data a "record".

Clearly there are a number of factors to be considered:

- Recording time requested
  - Number of channels in use
  - Amount of store available
- } Basic statistics

These items set the frequency with which recording of some sort can occur. That also depends on how much store is used each time a "record" is placed in memory.

If some kind of prediction tolerance is to be applied in order to distinguish "more useful" values from "less useful" ones, then we also have to include in our list of factors:

- Typical noise on the signal
  - Dynamics of any apparent trends
- } Data Dynamics

Clearly the process has to be able to perform equally well with large signals and large signal activity, and small signals, etc. It should be able to distinguish transients whether they are simple steps from an otherwise static signal, or on top of some trend already covered in noise.

The Adaptive Store process operates by initially

1. Assessing the Basic Statistics to give the typical worst case "record" time.
2. Dividing the total available store into 2, and allocating one part to "transients"

During recording, the Logger assesses the "normal signal activity" within a "worst case record time", and attempts to define a prediction tolerance based on that activity. To begin with, the tolerance is set tight, so that predictions fail frequently. When the signal can no longer be predicted within the "tolerance", a "record" is taken, and the statistics revised.

The control Loop is designed to set the tolerance at the level which will NOT cause normal activity to fail, yet will respond the moment a signal fails outside the "normal activity" envelope. Thus when the system has established the right tolerance, and that tolerance is confirmed after each record, a departure from prediction of the normal activity envelope will be sufficient to be recognized as a transient.

When a transient is seen, loop parameters are modified again taking into account

- Whether this is a new transient, and
- Its size.

If this is not a new transient, the system desensitizes itself by increasing the tolerance level. If it is a new one, it actually INCREASES sensitivity to allow detail on this transient to be captured.

## Over and Under Detection of Transients

If signal activity continues to increase over a long period of time, an excess of transients may be detected and stored. In this case the system becomes insensitive to rapid pulse type signals (though the worst case envelope still reflects them), while remaining responsive to step type excursions. At the

other extreme, for the situation of so much "normal signal activity" that small step changes are undetectable, the store allocated to transients remain unused. If the unused store builds up, it is reallocated to normal recording.

## Worst Case Envelope and Multiple Predictions

At all times, the extremes of the signal seen by the sampling process are included in the "worst case envelope". This envelope comprises the maximum and minimum deviations from the best prediction that the PM Logger has been able to use to describe the signal activity in the relevant record. Thus the max/min plot from the Pronto software shows the extremes of signal excursion, and all samples taken lie within that envelope. (i.e. all > 30 million samples over the whole week in the example mentioned on page 2.

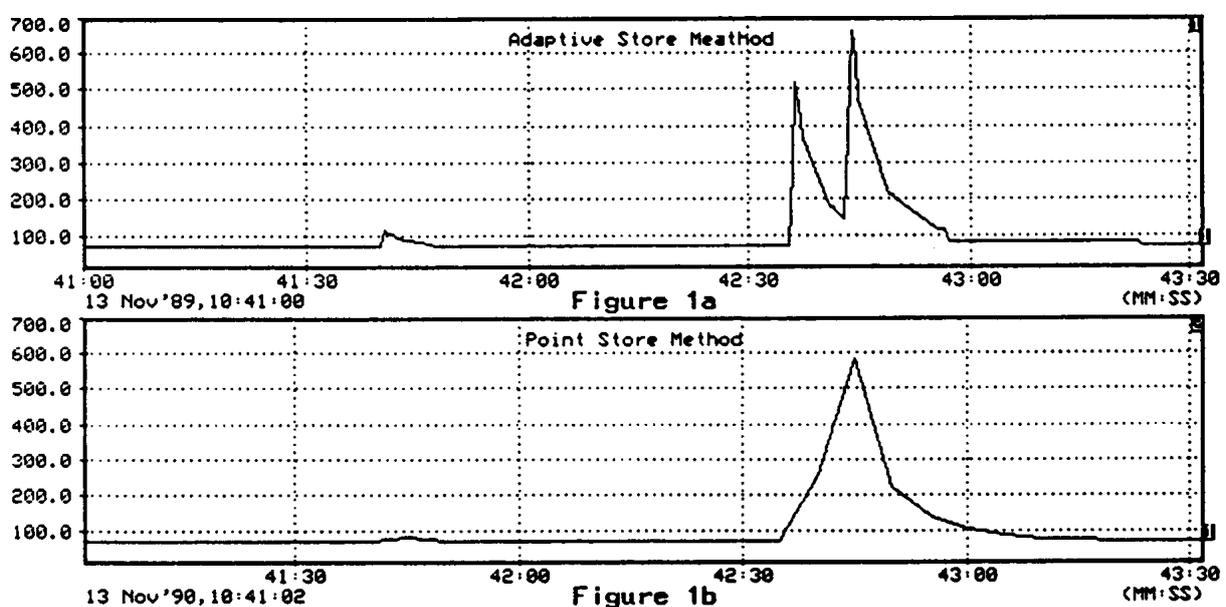
The uncertainty as to actual signal value at any one time depends upon the difference between the maximum and minimum lines, i.e. the height of the envelope. For a given length of time allocated to each record (which is the ultimate constraint imposed by finite store), the height of the envelope is controlled by the quality of the prediction.

The PM3000 caters for the UNPREDICTABILITY of future signal activity by employing multiple predictive mechanisms, against which all samples are tested as they are received. Though they are all loosely based on past history, some of those predictions are worse than others, and the poor ones are discarded.

This method of ANTICIPATING the possible signal path and testing each sample for conformity:

- Spreads the computational load out uniformly over time
- Allows for immediate reaction to transients
- Works with extremely long recording periods

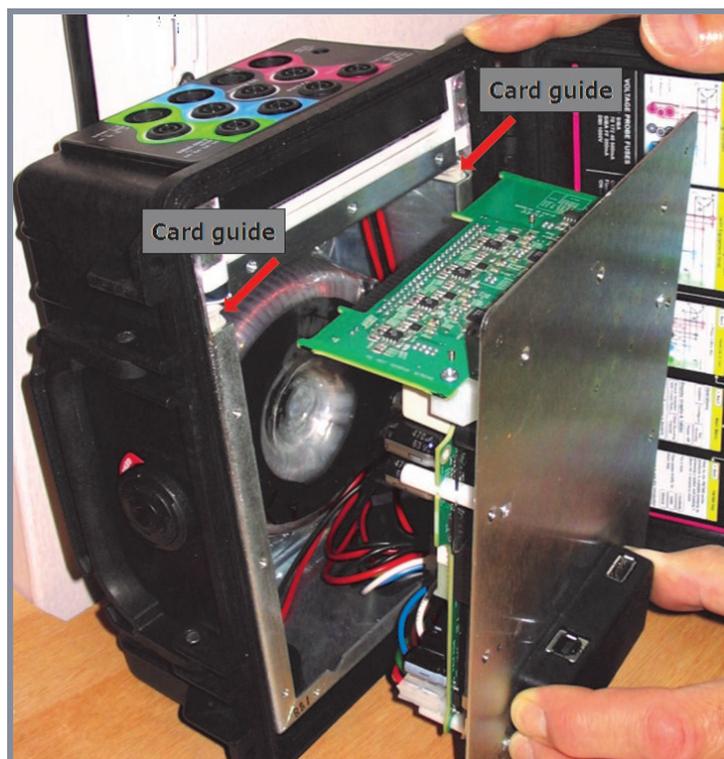
Figures 1a and 1b show actual results of adaptive and point store. You can see that the adaptive process is much better at catching anomalies by comparing the two graphs.



The PM Adaptive Store System has shown itself to be the most powerful automatic data compression system seen in any of today's Data Loggers.



## How to Change fuses in the PM7000



### PM7000 Fuse Changing



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## Introduction: Fuse Change

There are three user replaceable fuses in the PM7000:

- Two SIBA type FF800mA 700V Fast Blow and
- One SIBA type T315mA 240V Slow Blow.

The fuses are mounted on the underside of the Power Supply circuit board. They are accessible after the electronics module is separated from the chassis.

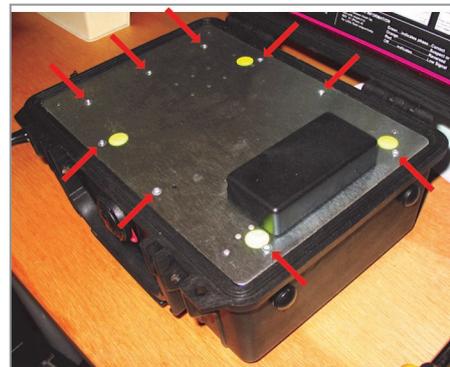
## To Separate the PM7000 Electronics Module from the Chassis:

1. Remove and keep safely the four (4) black 2.5mm corner screws securing the front panel overlay.



2. Remove the overlay. [Note that the overlay may be lightly stuck to the metal front panel plate by double sided tape. This tape is present purely for cosmetic reasons to hold down the overlay which otherwise can bubble up when warm. It may be replaced afterwards if desired but it has no electronic significance at all.]

You will see nine countersunk screws around the periphery of the front panel and four (4) yellow coverings over the heads of four screws. (These four covered screws hold the board sandwich pillars in place and should NOT be undone.)

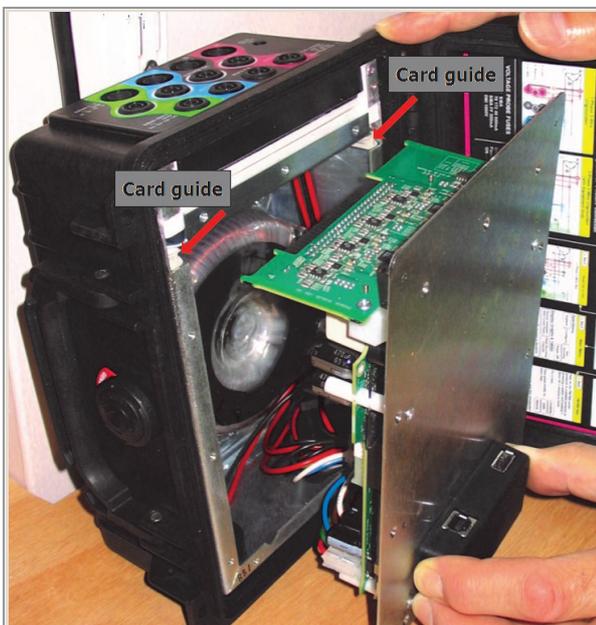


3. Remove and keep safely the nine (9) countersunk 2.5mm screws holding down the front panel.
4. Stand the unit on end as shown in the picture below. It is helpful to lean the unit against a wall or solid object as the weight of the metalwork and transformer in the chassis make it prone to fall over.

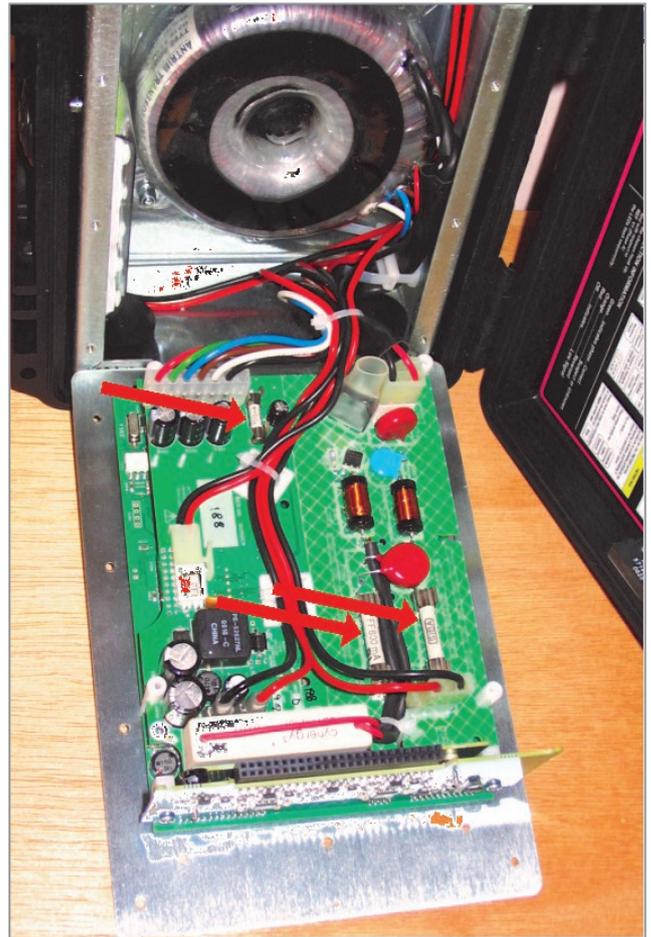


5. Holding the black communications housing, twist it gently from side to side (as though trying to twist along the longitudinal axis of the box – first pushing with the thumb and pulling with the fingers, then pushing with the fingers and pulling with the thumb) At the same time pull the whole front panel away from the chassis. Ensure the front panel remains parallel to the chassis even as they separate. The resistance to extraction is from the seating of the analogue PCB in its connector, and the rocking motion will gradually unseat it, allowing you to withdraw it up its card guides and to separate the electronics assembly from the chassis.

If the electronics module is not extracted centrally from the chassis you may encounter some sticking at the lower end of the box as the board pillars slide over the metal work. Look for where any catching occurs and ease the panel to the appropriate side to free the obstruction.



Lower the top end of the front panel down to the bench without straining the wiring.

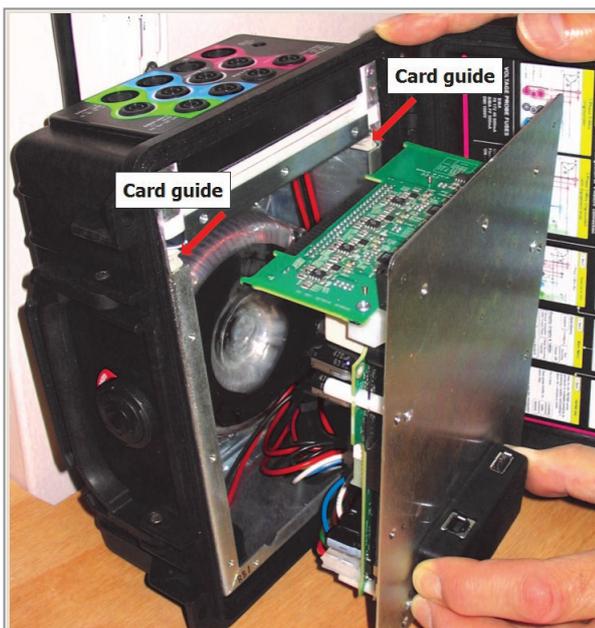


The fuses are now visible and may be removed by gently prising them out of their clips with a small screwdriver. Take care not to scratch or damage the circuit board.

## To Replace the Electronics Module:

The reverse process is somewhat simpler because it is easier to push the analogue PCB home than to extract it.

1. Carefully raise the open end of the electronics/ front panel assembly and offer the perpendicular analogue board into its card guides. Ensure the wiring tucks neatly down into the gap beside the transformer. (If the temperature is very cold, the wires may be stiff and unbending. Take the unit into a warmer environment where the insulation will become softer and more pliable.)



Once the analogue board is about to engage it may be easier to lay the unit on its base again.

Keeping the front panel parallel with the chassis lip, lower the analogue board down its card guide, easing the other end of the module past the lip of the chassis. Do not force. The front panel will slide into place but you will be compressing the wiring into its normal position so expect a little resistance from the lower (right hand) end, and a little resistance from the left hand end as the analogue board connector mates.

2. Insert the front panel screws.

Caution: The fitting sequence is best done as described below. If you choose a different sequence you may find you have difficulty in lining all the holes up. Ensure you use the correct screwdriver. Using a worn screwdriver or the wrong size may damage the screw heads.

It is a good idea to fit the four overlay screws loosely into position before tightening up the front panel countersunk screws. This way the holes in the front panel and the chassis behind will automatically be aligned to take the black screws when the overlay is fitted.



### Screw sequence

Loosely fit three (3) screws down the left hand strip (B). These attach to the vertical metal plate underneath which has a high degree of compliance and needs these screws for its final location. You may find that you need to line the front panel up on these screw holes and fit the screws before attempting to line up the front panel on the other holes.

Fit the four (4) black overlay screws loosely into their corner positions (A). Loosely fit the remaining six (6) screws into their respective holes (C).

Tighten the nine (9) countersunk screws (B), (C). Without removing them, ensure the four (4) black overlay screws (A) can be screwed up and down in their holes easily. [If any are particularly stiff, ease off the countersunk screws (B), (C). Screw down the overlay screws (A) tight. Retighten countersunk screws (B), (C) and try again.]

Finally remove the four (4) black overlay screws (A), and fit the overlay, adding double sided adhesive tape in the centre if desired. Replace and tighten the four (4) black overlay screws.