

CT Lab

Power Quality Recorder Manager

User's Guide



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1 INTRODUCTION

This guide introduces the Power Quality Recorder Manager system and gets you up and running quickly. It shows you how to do the most common tasks and provides you with tips and troubleshooting. We recommended that you read this guide carefully rather than trying to work the system out by yourself. This chapter tells you about the components of the system and how to find what you need.

The CT Lab family of recorders are stand-alone 3-phase Power Quality Recorders that record Power Quality events, trends and statistics. Recordings are communicated to a database from where it can be viewed, printed and exported in different ways. The included PC software organises recordings and supports single roaming instruments and networks of remotely installed instruments.

1.1 System Components

The system consists of these components:

1. Power Quality recorder(s): Any combination of ImpedoGraphs, VectoGraphs and ProvoGraphs.
2. A Windows compatible computer for running the software applications. The computer and its operating system are not included. The minimum system requirement is:
 - Intel Pentium 2 (400 MHz) processor or equivalent.
 - 128 Mbytes of RAM.
 - 1 Gigabyte of free disk space.
 - CD-ROM drive.
 - Unused RS232 serial COM port.
 - Windows 2000 with Service Pack 3 or Windows XP. Many Windows 98, Windows ME and NT4 systems should be compatible, although they are not supported.
 - The computer must also be completely compatible with the Java[tm] 2 Platform v1.4.2 (J2SE). A compatibility guide is available at <http://java.sun.com/j2se/1.4.2/system-configurations.html>
3. A serial communications cable for connecting the recorder to the computer.
4. The PQRM application software on a CD.

Make sure that you have received all of the above items (PC and Windows Operating System not included). Contact your supplier if you are missing any of the components.

1.2 Summary of Contents

The main part of this guide is divided into 4 chapters, each of which is fairly self-explanatory:

- Power Quality: A short primer briefly describes the fundamentals of and background to the field of Power Quality.
- Overview of Power Quality Recording introduces important concepts in PQ recording.
- PQRM Software describes the PC Software in detail.
- ImpedoGraph Recorder provides a detail description of the ImpedoGraph recorder
- VectoGraph Recorder provides a detail description of the VectoGraph recorder.
- ProvoGraph Recorder provides a detail description of the ProvoGraph recorder.
- Getting started presents an introduction to working with a recorder for first time users.
- Operating Instructions gives step-by-step instructions for performing common tasks.
- Upgrading gives instructions for upgrading from previous software versions.

Appendices contain additional information, mainly for reference purposes.

2 POWER QUALITY: A SHORT PRIMER

The concept of Power Quality is important because of the increasing demand for energy, the proliferation of power electronic equipment and the increased sensitivity of modern industrial and mining plants. Poor Power Quality may result in financial losses in the form of poor reliability, poor productivity and equipment downtime and damage.

Power Quality is often defined (and therefore measured) in terms of anomalies, i.e. what constitutes poor Power Quality. Both the severity and number of occurrences of these anomalies are important. The symptoms, causes and effects are varied and application specific.

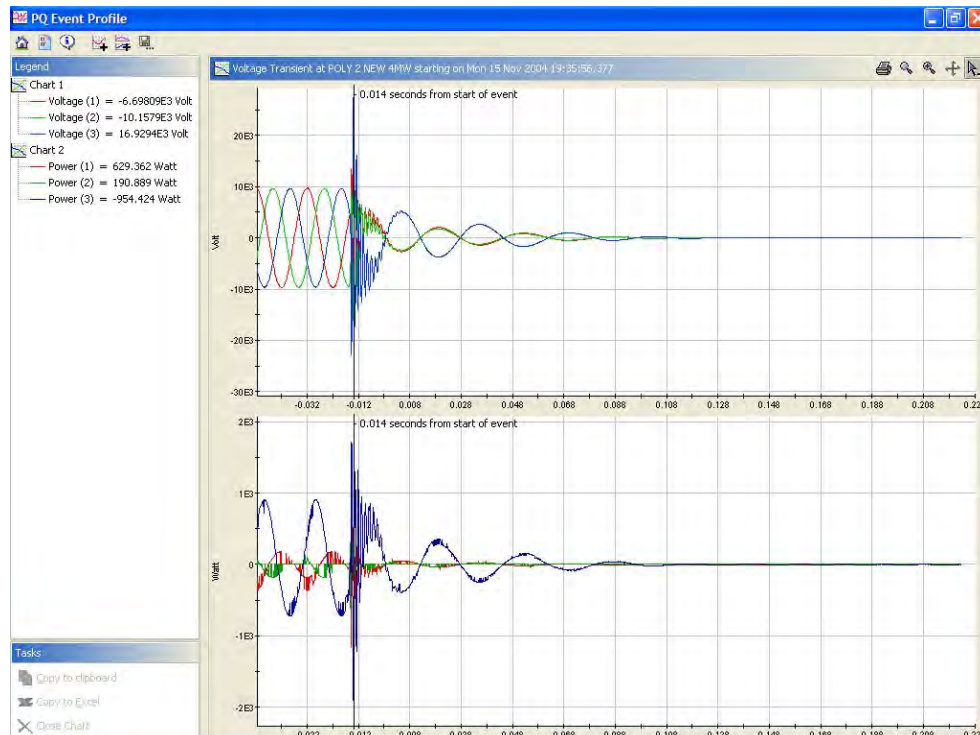
The most common and severe quality of supply anomalies can be divided into classes, according to their duration:

2.1 Momentary Anomalies

These anomalies are mostly voltage fluctuations of up to 3 seconds in duration. There are 4 subclasses:

2.1.1 Voltage Transients

These anomalies (also called spikes, impulses and notches) are high amplitude and/or very short duration (microseconds) voltage disturbances. They carry very little energy, are difficult to trace and propagate through travelling wave principles.

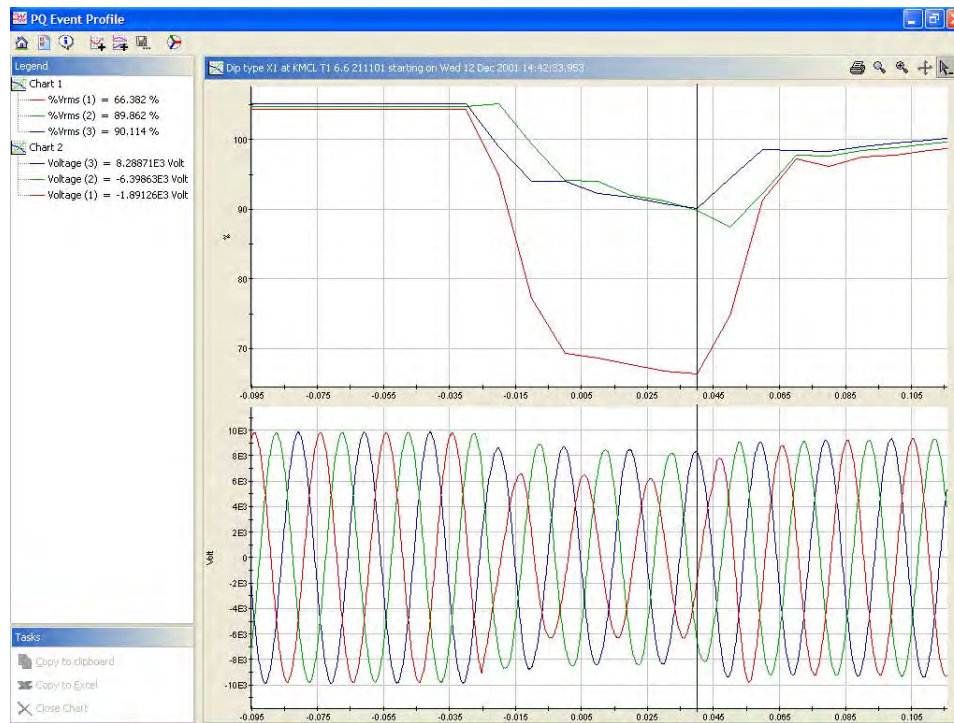


Switching of inductive loads, power factor correction capacitors, electronic equipment (PCs, microwave ovens, etc.) and lightning can all cause Voltage Transients. They can damage insulation in motors, cables and transformers, but affect mostly microprocessor-based equipment and can cause data loss or permanent damage.

2.1.2 Dips

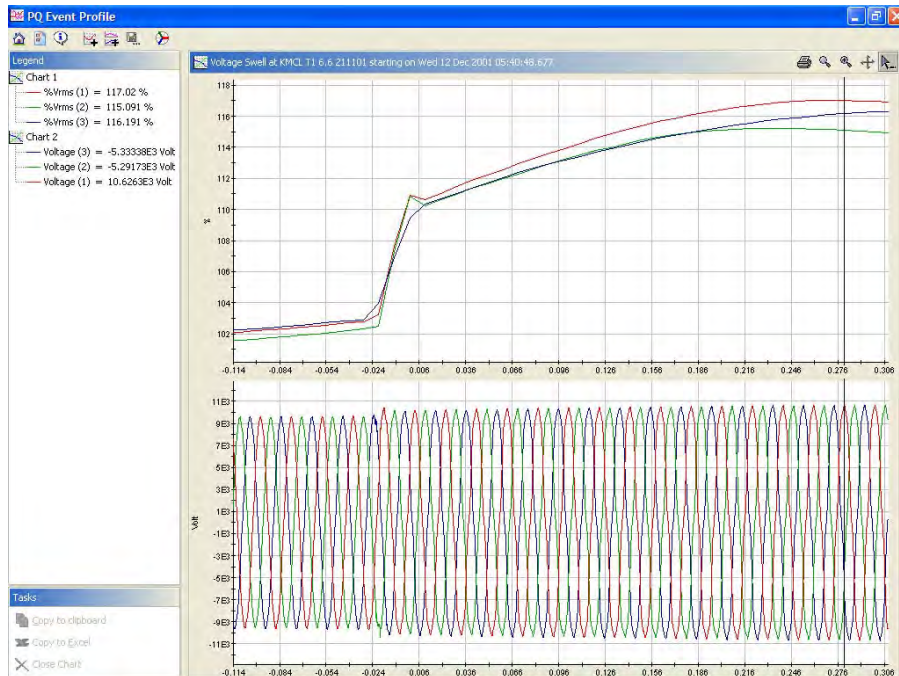
This is the most common power quality anomaly, accounting for almost 80% of power quality problems. A Dip (also called depression or sag) is a lower than normal voltage on one or more phases. It can have a variety of causes, including: starting of large loads, fuse and breaker clearing, lightning arrestors, fires, insulator flash-over, switching and ground faults. The voltage deviation decreases as the distance from the fault increases.

Dips are a common cause of power related computer systems failures, stalling of motors, reduced motor life and flickering of lights.



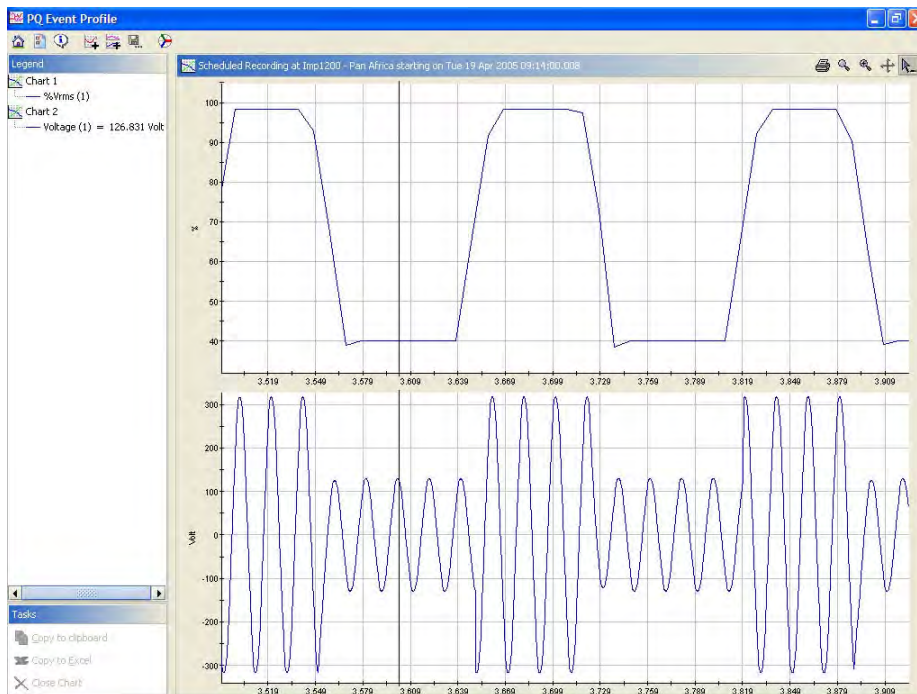
2.1.3 Swells

A Swell is a higher than normal voltage on one or more phases, normally caused by open neutral connections, insulation breakdown or faults on one phase causing voltage rise on other phases. Swells can cause degradation of electrical contacts and light flicker, but is generally not as troublesome as dips.



2.1.4 Flicker

Flicker is the repetitive voltage sags or swells, normally caused by large cyclic loads, such as arc-furnaces. Humans are the worst affected, since we are very sensitive to flicker in lighting.



2.2 Steady-state Anomalies

These types of anomalies manifest themselves over longer periods of time and can sometimes be semi-permanent.

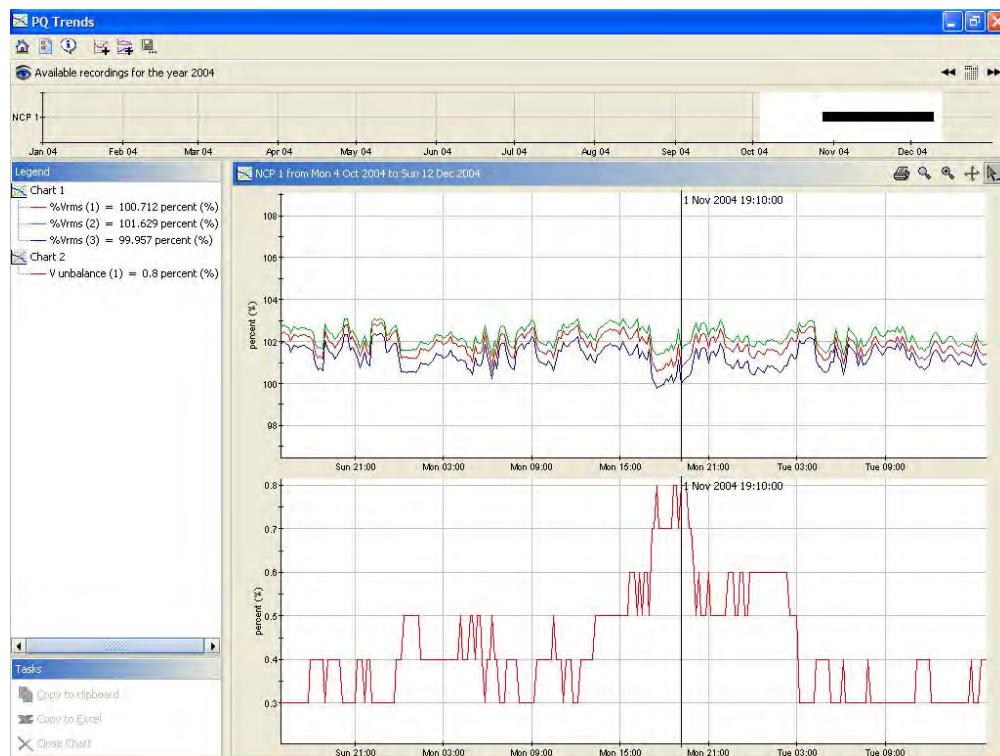
2.2.1 Deviations

Long-term over- and under-voltages are caused by overloaded distribution systems, incorrect transformer tap settings, unbalanced phase loading and improper application of power factor correction capacitors. It can cause low efficiency, overheating and reduced life in electrical equipment such as motors, heaters and lights.

Total power interruptions also fall in this class.

2.2.2 Phase Unbalance

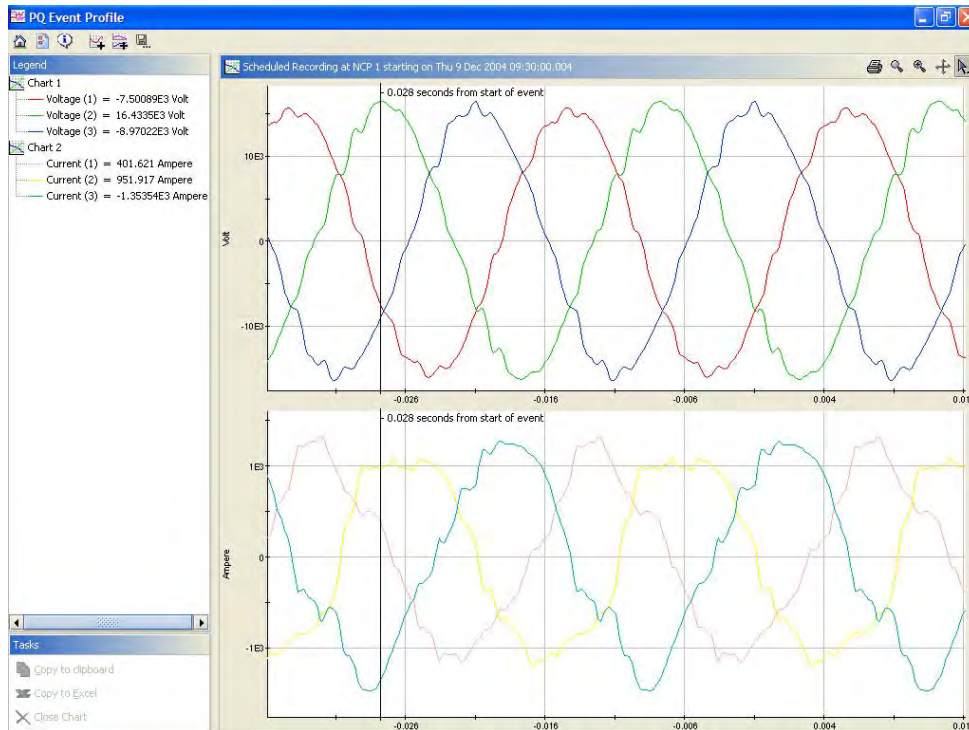
This is a 3-phase phenomena caused by unbalanced phase loading, defective transformers or ground faults. It causes premature failure of motors and transformers due to overheating



2.2.3 Harmonic Distortion

Harmonic Distortion is the deviation of voltage or current from a true sine wave due to the addition of frequencies that are multiples of the fundamental (50/60 Hz) frequency component. It is measured as percentage Total Harmonic Distortion (THD). It is caused by non-linear loads, such as static power converters, solid-state switches, variable speed drives, welding equipment, furnaces, battery chargers or saturated transformers. Effects

include serious damage to capacitors and transformers, decreased motor performance, and malfunctioning of control equipment.



2.3 Applications

Power quality measurements are useful to many people and requirements differ from application to application. Here are a few typical applications:

2.3.1 Investigations

The ImpedoGraph can record a variety of details of Power Quality anomalies, giving many pointers for finding the source of a problem:

- Half-Cycle time resolution RMS trends of dips and swells.
- Accurate time stamping of the start and end of anomalies.
- Phasor voltage, current and power readings every cycle.

2.3.2 Network Planning

The ImpedoGraph facilitates network planning by continuously monitoring power flow over long periods of time and recording the following:

- Trends of average true RMS voltages, Phase Unbalance, THD and Harmonic Spectrums together with global averages, standard deviations, minimum and maximum values, etc.
- Bad Regulation: Information on times during which the average RMS voltages (with or without harmonic components) is too far from nominal.

2.3.3 Statistics

The ImpedoGraph can record over 5000 events at a time when used for statistics only. The following are statistical features:

- Records dip/swell maximum deviation and duration.
- Presents events in NRS048-2 (2003), NRS048-2 (1996) and EN50160 (1994) scatter-plot format.
- Trended statistics, including averages, RMS averages, standard deviations, minimums and maximums.

2.3.4 Research

The ImpedoGraph introduces new measurement strategies for Power Quality. Fourier analysis (FFT) is performed on the waveforms of every cycle, yielding fundamental component phasors for each phase. Events can be triggered on these phasors. Events triggered by different measurement strategies can be stored for the same anomaly. This allows direct comparisons between different strategies. In this way CT Lab hopes to contribute towards a better understanding of Power Quality measurement.

3 OVERVIEW OF POWER QUALITY RECORDING

In order to utilize CT Lab Power Quality recorders correctly, several concepts must be mastered first:

3.1 Stand-alone recording

The ImpedoGraph, VectoGraph and ProvoGraph are stand-alone recorders. They are designed for permanent connection to a power network, and left alone to record power quality unattended for weeks, months and years at a time. Recordings are stored in internal non-volatile memory. Supply interruptions will stop recording, but no recordings are lost and recording continues as soon a supply is restored. It shares many similarities with the black box flight recorder of an aircraft.

3.2 Role of the PC

The recorders have no user interfaces, such as screens and keyboards, since they are used in an unattended manner. Instead, the recorder interacts with its operator by means of a personal computer (PC). The included software applications allow the operator to configure the recorder, retrieve stored recordings from it and it helps with the analysis of power quality recordings, all via his PC.

3.3 Communication

For the PC to work with the recorder, a data communications **connection** between the two is required. The type of communications used has a great impact on the whole system. Several options are available:

- **Serial Cable:** The included serial cable can be used to connect the recorder to the PC. This only works over short distances, which means that the operator will have to bring the PC (or more often a notebook computer) to the installed PQ Recorder.
- **Modems:** When modems are connected to the recorder and the PC, the telephone or cellular network can be used for communications. This brings the enormous advantage that the recorder can be operated remotely and connections can be made at will.
- **Network:** With the recorder and PC connected to a data communications network such as Ethernet, communication is online, instantaneous and fast. The ImpedoGraph has a built-in Ethernet interface. The VectoGraph and ProvoGraph can also be attached to Ethernet networks through the use of external serial-to-Ethernet adapters, such as those available from Multenet. (see <http://www.multenet.com/>)

Network communication is always the best option, since it allows instantaneous access to the recorder and its recorded measurements. Modem communication is almost as good, but connection times are slower and transfer speeds lower. Serial communication is the

least desirable, because the operator needs to travel to the installation, making regular communication unlikely.

3.4 Installation and Configuration

Before recording can start, the recorder must be **installed**, i.e. physically connected to the electrical network to be measured. This can be done either directly for low voltages and currents, or indirectly with the aid of external sensors such as Voltage Transformers (VTs) and Current Transformers (CTs).

The recorder also needs to be **configured** correctly via the PC software. This is a software process done from the PC. The configuration instructs the recorder when to record and what to record. This configuration can be changed many times after installation.

These are very important steps, since correct recordings cannot be made without proper installation and configuration.

3.4.1 Meter Points

The recording system organizes all measurements by **Meter Points**. A Meter Point uniquely identifies a location on the electrical network where measurements are taken. During configuration of a recorder, the name of the meter point (at which recordings are going to be taken) must be selected or entered. This is the unique title under which recordings for this installation will be stored, queried and retrieved. A descriptive title will make recordings made at an installation much easier to identify.

All recordings can be accessed via the name assigned to a Meter Point. This greatly simplifies the management of portable recorders, swapping of recorders, etc.

3.4.2 Configuration Templates

The VectoGraph and ImpedoGraph recorders allow the manner in which they record Power Quality parameters to be highly customised. This is to allow specialised recording for the different application areas described previously. The software allows many sets of configuration values to be created, saved and reused for many recorders. Such a set of configuration values is called a Configuration Template. It is common to create different templates for: NRS048 Requirements, Harmonic Investigations, Dip Investigations, Permanent Installations, etc.

3.5 Onboard Clock

Every recorder has an onboard real-time clock that is used for the time stamping of all recordings. Like all clocks this one drifts over time and need to be synchronised periodically to a reference clock. The accuracy of the recorded time stamps depends on the accuracy of the reference clock and the frequency of synchronisations.

3.6 Retrieval of Recordings

Recordings cannot be viewed and analysed while they are on the recorder. They must be **retrieved** to the PC first. The application software does this by copying the recordings to a database on the PC. Subsequent retrievals only copy new recordings. Retrieval does not interrupt recording, so that events that occur during retrieval are also captured.

It is good practise to retrieve recordings as often as possible, so as to have recordings available soon after each event. The recorder will automatically delete its oldest recordings to make space for new recordings, so recordings will be lost if retrieval is not done in time. This maximum time between retrievals depends on the recorder configuration and the number of Power Quality anomalies on the system and can vary between days and months.

4 PQRM SOFTWARE

The PQRM PC software is integral to the functioning of the CT Lab Power Quality Measurement System. It is the first component the user should get acquainted with. If you are upgrading from a previous version of the PC software see the appendix about Upgrading.



4.1 PQRM software Installation

The PQRM Software Suite can be installed on any number of PCs. It can be installed from the Internet via <http://www.ctlab.com/pqrm> or from the supplied CD as follows:

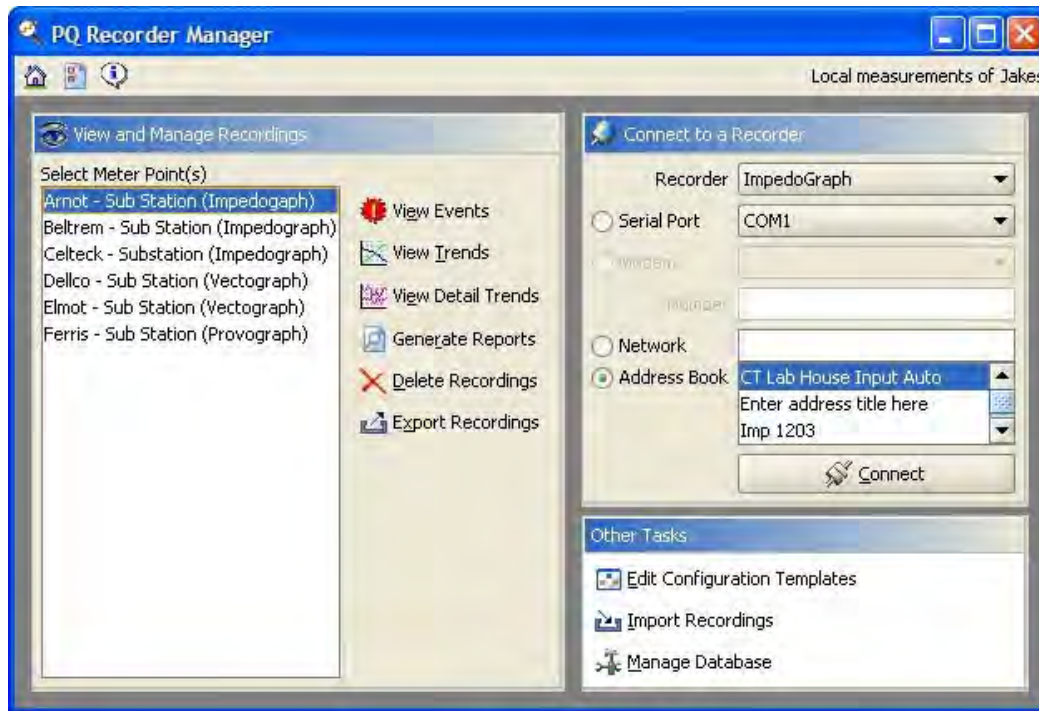
1. Make sure the PC complies with the requirements stated in *System Components*.
2. Start the PC and log on with an account that has administrator privileges.
3. Verify that you do not already have a newer version of the PQRM Software installed on your PC. **Do not continue if this is the case.**
4. Exit any other Windows programs currently running on your computer.
5. Insert the PQRM CD-ROM in your computer and wait for the CT Lab Software Installation Page to appear. If this does not happen automatically, open My Computer and double-click the Compact Disk icon.
6. Start the installation program by clicking the PQRM link and selecting **Open** from the **File Download** window. Follow the instructions. The default options are appropriate for most users.

PQRM utilises the Java Web Start deployment technology, which supports automatic updating via the Internet. When the PQRM application is launched from a PC connected to the Internet, new versions are automatically detected and downloaded. This ensures that you always have the latest version of PQRM on every PC.

Recordings are always automatically imported into each new version. Recording files are never automatically deleted, even when you uninstall the PQR software.

4.2 Main Menu

When the PQR software is launched, a main menu will always be displayed. This is the main window from which all functionality is accessed. It looks like this:




Three panels group associated functionality, with a toolbar at the top.

4.2.1 Toolbar

The main toolbar is always visible in all windows of the PQR Software. It will always display 3 buttons:



 **Home:** Opens a new Main Menu Window




 **Preferences:** Adjusts default preferences and settings

 **About:** Shows information about the PQR Software in a new window.

4.2.2 View and Manage Recordings

This panel allows Power Quality recordings to be viewed and manipulated. Recordings are always categorised by Meter Point with all known Meter Points listed to the left and buttons for different tasks to the right. To start these tasks, select the Meter Point(s) in the list and then click the appropriate button on the right. Multiple Meter Points can be selected by holding down SHIFT or CONTROL while selecting.

-  **View Events:** Displays the most recent events recorded at the selected Meter Point(s).
-  **View Trends:** Displays the most recent trended parameters (at 10-minute intervals) recorded at the selected Meter Point.

- **View Detail Trends:** Displays the most recent trended parameters (at 3-second intervals) recorded at the selected Meter Point.
-  **Generate Reports:** Generates reports for the selected Meter Point.
-  **Delete Recordings:** Deletes recordings from the selected Meter Point(s).
-  **Export Recordings:** Exports recordings from the selected Meter Point(s) to a variety of formats.

4.2.3 Connect to a recorder


All communication with recorders is initiated from this panel. Connections already saved in the address book can be double clicked to start the connection process. To make a new connection, follow these steps:

1. Select the recorder type you want to connect to: ImpedoGraph, VectoGraph or ProvoGraph.
2. Select the communications medium. Four options are available
 - **Serial Port:** Attempts to make a connection through a serial cable. The correct serial port of the PC should be selected.
 - **Modem:** Attempts a connection through a modem or similar device. Both the device and the modem number must be entered.
 - **Network:** Attempts a connection through the default TCP/IP network. The correct IP address or network (DNS) name must be entered.
3. Click the Connect button

The window will now change to display the status of the connection attempt. Once a connection is established all online recorder tasks can be performed.

4.2.4 Other Tasks

Various miscellaneous tasks can be performed through this panel:

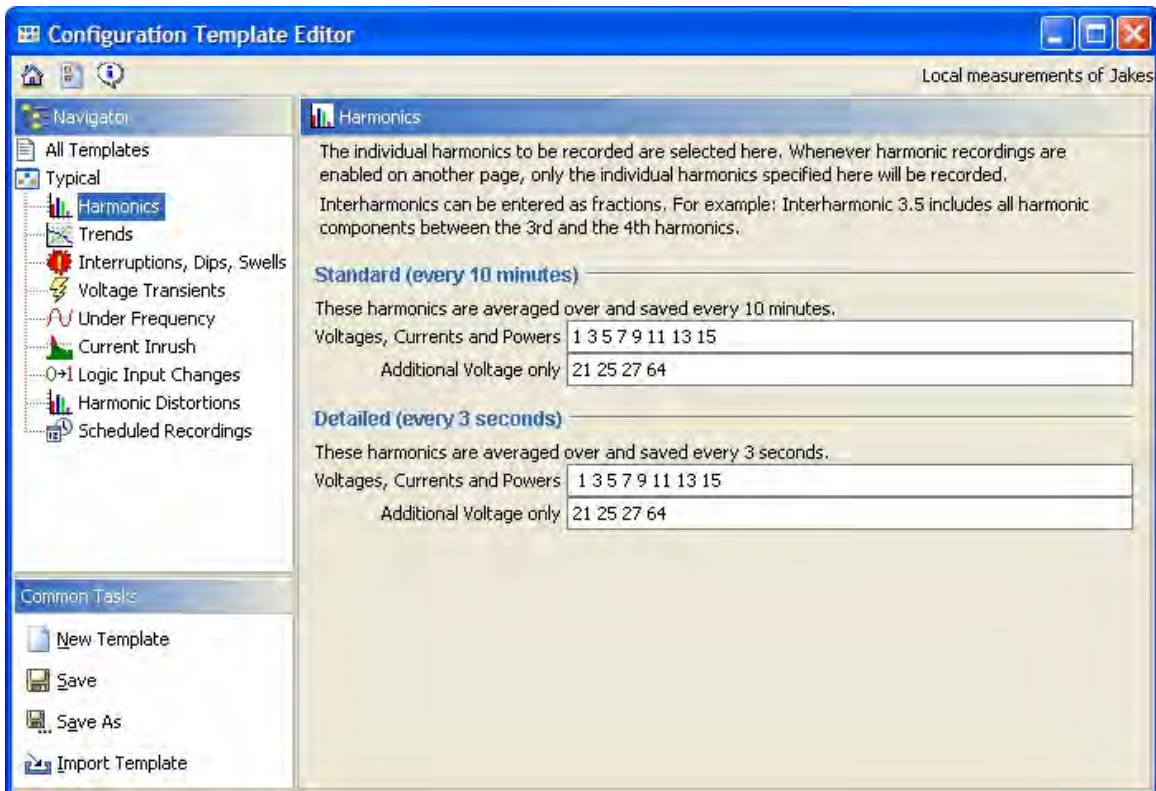
 **Edit Configuration Templates:** Invokes the Configuration Templates Editor where Configuration Templates can be created, edited, saved and deleted.


 **Import Recordings:** Recordings can be imported from a file.


 **Manage Database:** Various database management tasks.

4.3 Configuration Template Editor


The Configuration Template Editor is used to view, create, edit and delete Configuration Templates. On start-up it lists known templates that can be opened or deleted. New templates can also be created. Once a template is opened, its categories are listed in the Navigator Panel. Each category contains configuration settings that can be accessed by selecting the category in the Navigator panel.





 **Template Details:** A description for this template can be entered or edited.


 **Harmonics:** The harmonics and inter-harmonics to be recorded are set here. Individual settings can be made for voltages, currents, 3-second and 10-minute intervals.


 **Trends:** The parameters selected here are recorded continuously.


 **Interruptions, Dip and Swells:** All cycle by cycle RMS triggered events are configured here, including trigger modes, trigger thresholds and related trends.

 **Voltage Transients:** The capture of high frequency voltage transient events (also called spikes or impulses) is configured here. Recording of related trends can also be enabled.

 **Under Frequency:** Detection of low system frequencies is configured here, also with related trends.

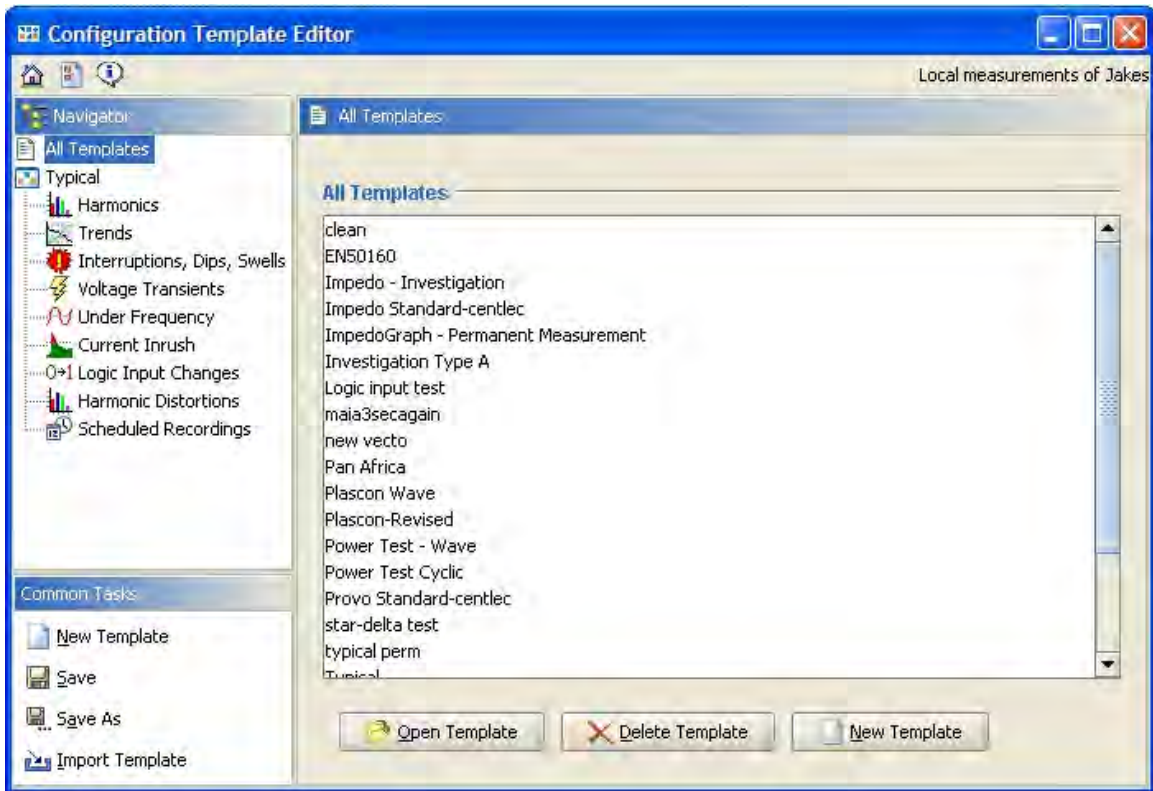
 **Current Inrush:** Record events when instantaneous currents are high and/or low.

 **Logic Input Changes:** Record events when the logic inputs to the recorder changes.

 **Harmonic Distortion:** Record events when THD voltages and/or currents are high and/or low.


 **Scheduled Recordings:** Regular recording can be scheduled here. These recordings are also marked as events.

Many sets of configuration values can be created saved reused between ImpedoGraphs and VectoGraphs, according to the application (e.g. NRS048 requirements, Harmonic or Dip Investigations, Voltage or Current Measurements, and so forth).



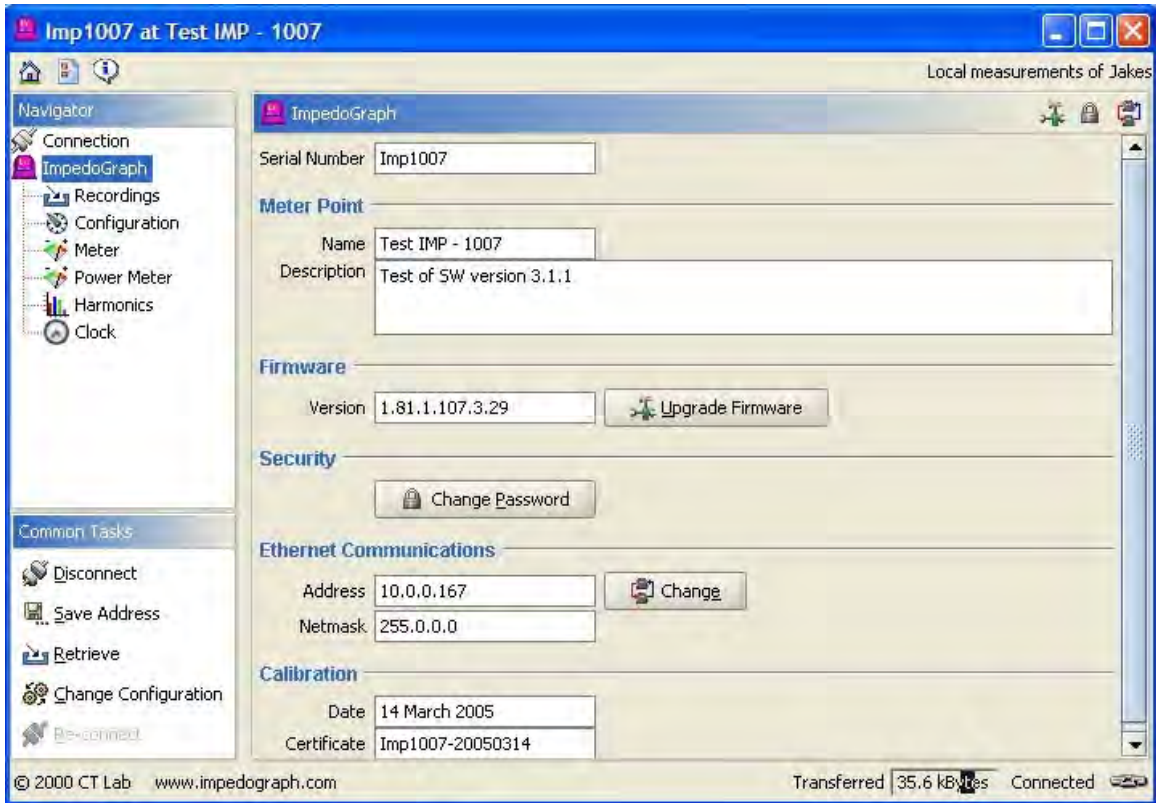
VectoGraph configuration files can also be added to your templates by clicking the **Import Template** button on the left.

4.4 Address Book








The address book stores communication settings, such as modem numbers and IP addresses. After connecting to a recorder, the connection's settings can be saved by clicking **Save Connection** and entering a title. The new entry becomes available from the address book in the Main Menu. Re-connection is now easy. Select your title in the address book and click the  **Connect** button.


4.5 Online Tasks

Many tasks can only be done once communication with a recorder has been established. After such a communication link is established, different online recorder windows are available for each recorder type. This is the ImpedoGraph window:



The navigator panel in the top left allow different views to be selected. Each view represents a different aspect of the ImpedoGraph recorder:

-  **Connection:** This panel shows the connection history and the connection details can also be saved to the address book from here.
-  **ImpedoGraph:** This is the default panel and shows basic information about the ImpedoGraph being communicated with. Various actions can be performed from here, including the Upgrade of ImpedoGraph Firmware, Changes to Security Passwords and Changes to Ethernet Communications Settings.
-  **Recordings:** This panel gives a breakdown of the recording currently stored by the recorder. It allows the recordings to be retrieved (transferred to the PC) and then viewed.
-  **Configuration:** Shows the current ImpedoGraph configuration and allows changes to be made.
-  **Meter:** Show real-time measurement as made by the ImpedoGraph.
-  **Power Meter:** More real-time measurement, specifically power related parameters.
-  **Harmonics:** Real-time harmonic measurement for voltage, current and power. An individual harmonic can also be selected and its readings displayed. Simply click on the harmonic on the chart or select it from the Harmonic Number field.

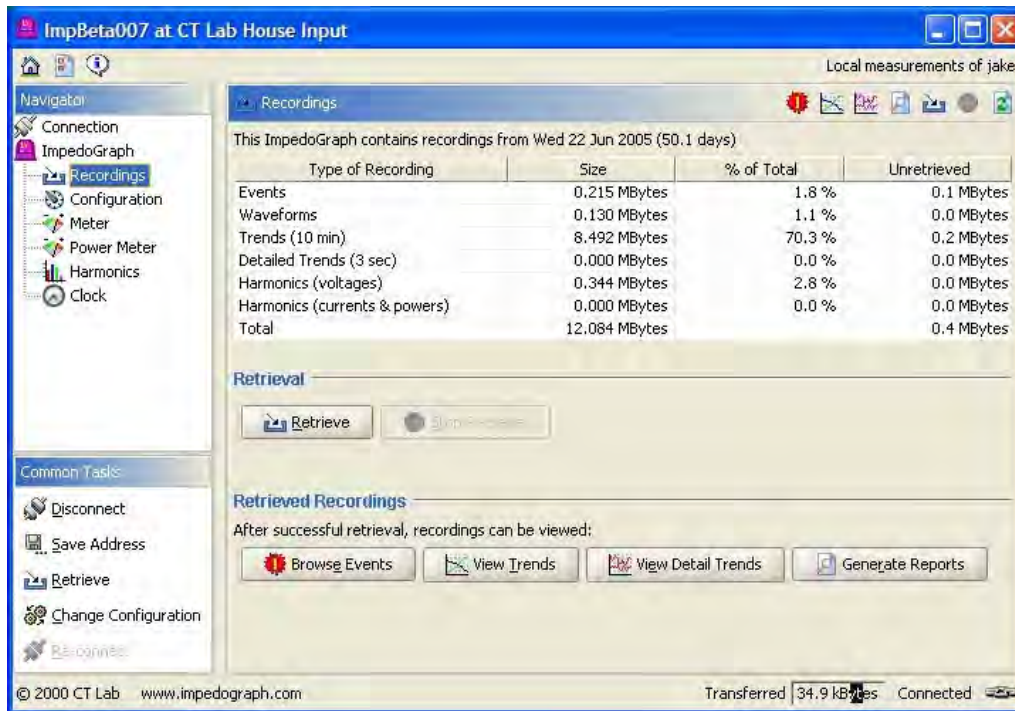
 **Clock**: Displays the status of the ImpedoGraph real-time clock and allows clock synchronisation to be configured and initiated.

Common Tasks are displayed at the bottom on left.

The Disconnect task will break the communications link to the recorder and all online options will be unavailable until the link is re-established.

4.6 Retrieving Recordings


Recordings can be retrieved, i.e. downloaded onto the PC by clicking the **Retrieve** button on the **Recordings** panel.



The screenshot shows the 'ImpBeta007 at CT Lab House Input' window. The 'Recordings' panel is active, showing a table of recording statistics. Below the table is a 'Retrieve' button and a progress bar. The 'Common Tasks' panel at the bottom left includes 'Disconnect', 'Save Address', 'Retrieve', 'Change Configuration', and 'Re-connect'.

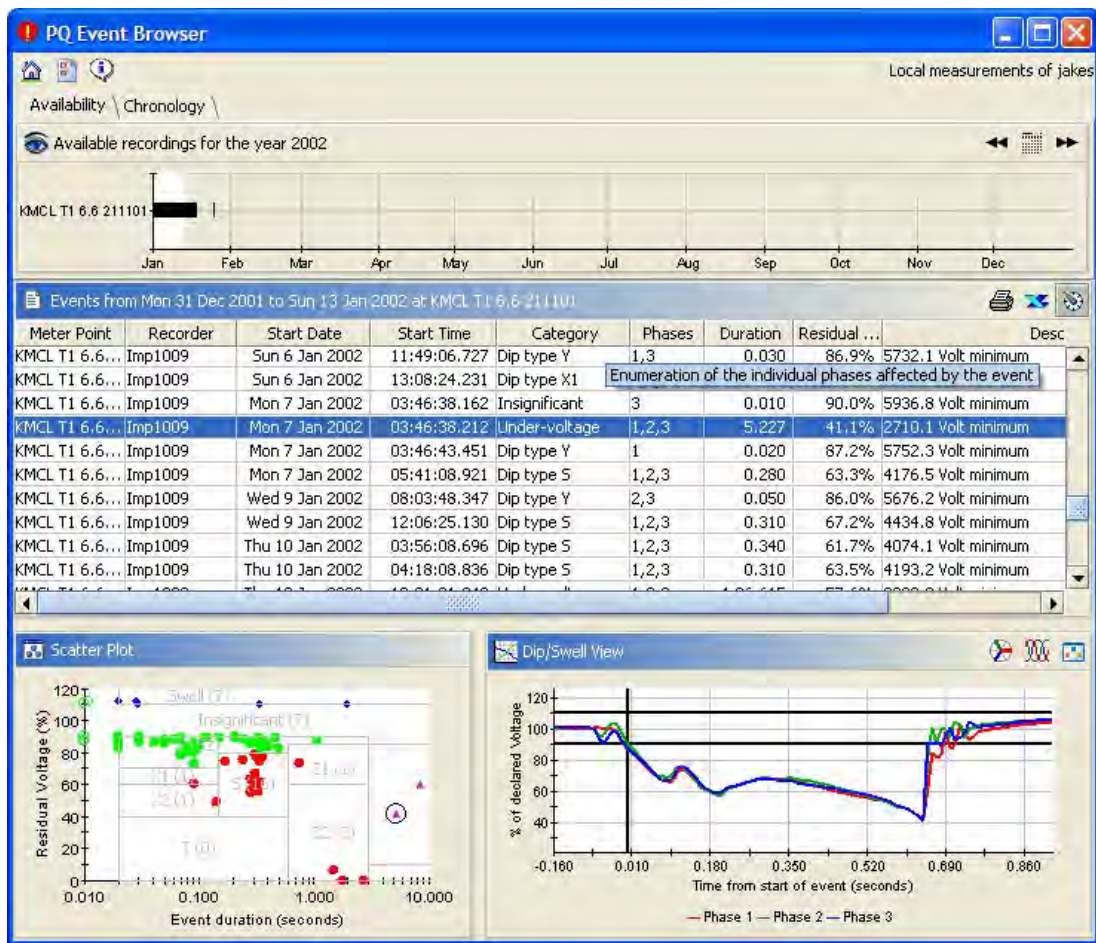
Type of Recording	Size	% of Total	Unretrieved
Events	0.215 MBytes	1.8 %	0.1 MBytes
Waveforms	0.130 MBytes	1.1 %	0.0 MBytes
Trends (10 min)	8.492 MBytes	70.3 %	0.2 MBytes
Detailed Trends (3 sec)	0.000 MBytes	0.0 %	0.0 MBytes
Harmonics (voltages)	0.344 MBytes	2.8 %	0.0 MBytes
Harmonics (currents & powers)	0.000 MBytes	0.0 %	0.0 MBytes
Total	12.084 MBytes		0.4 MBytes

Retrieval is incremental, so that recordings that were retrieved previously will not be retrieved again. A progress bar will indicate the progress of the retrieval. It could be a lengthy process.

The  **Refresh** button (ImpedoGraph only) on the **Recordings** page will refresh the storage usage statistics displayed on this page. This is useful if the instrument is tested in a lab to confirm the correct activation of PQ parameters.

4.7 Event Browser

The Event Browser tool lists, categorises and displays Power Quality events. It is normally started from the Main Menu or the Online Communications Window. The window is divided into five panels.




The **Availability Panel** at the top indicates the availability of event information. Time periods during which recordings are available are marked in black. The time period for which events are currently on display is highlighted in white. This time period can be moved so as to view the parameters during different time intervals. Use the buttons on the right of the title bar:

- ◀ **Left Arrow:** Shows events from the previous time interval.
- ▶ **Right Arrow:** Shows events for the following time interval.
- 📅 **Calendar:** Shows a calendar where any date can be selected. Events around that day will be displayed.


The **Chronology Panel** can be selected instead of the Availability Panel. It shows a Gantt chart of the events over time, grouped by Meter Point. It shows the selected time interval and all the events listed.


The **Event Table** shows all events in a single table with one row per event. The table can be sorted by clicking on a column heading. This will resort the table using the selected column as criteria. Clicking again will reverse the sort order. Right-clicking on the header columns allow any columns to be hidden or made visible. The table can be


exported and printed by using the buttons on the right of the title bar. Recorder events can be hidden by toggling the  **Show/Hide Recorder Events** button.

The **Scatter Plot Panel** shows a statistical overview of all events by representing each event as a dot in a deviation vs. duration scatter plot. Area definitions of common Power Quality standards are superimposed. The classification standard to be used is selected in the Preferences dialog.

The **Event View Panel** in the bottom right corner shows a preview of the selected event. The nature of this preview depends on the type of event selected. Additional event details can often be viewed by clicking the buttons on the right of the title bar. Common buttons are:

 **View trends and phasors:** Opens the Trend Viewer and loads the default event layout (as selected in Preferences) including phasor views if possible.

 **View waveforms:** Opens the Trend Viewer and loads the default waveform layout (as selected in Preferences)

 **View Configuration Template:** Views the configuration template used to configure the recording instrument that recorded the selected event.

Selecting an event will show details about that event in the Event View Panel. An event can be selected by selecting its row in the Event Table or by clicking on it in the Chronology or Scatter Plot panels. When an event is selected in one panel it will automatically be selected in all panels.

4.8 Trend Viewer

The Trend Viewer is a tool that displays charts of parameters trends over time. It can be started from:






- **View Trends** in the Main Menu
- **View Detail Trends** in the Main Menu
- **Phasor View** of an event in the Event Browser
- **Waveform View** of an event in the Event Browser
- **Recordings Panel** of the ImpedoGraph online communications window.

The Trend Viewer window contains 4 panels:



4.8.1 Charts and Legend




The **Charts Panel** is the main panel, which contains one or more charts. Each chart can display one or more series, each of which draws the values of a single parameter values over time. To the left is the **Legend Panel**, which shows information about all these chart elements. Buttons on the right of its title bar allow the charts to be manipulated:

-  **Print:** Prints the charts to a colour printer
-  **Zoom Out:** Resets the default zoom of the charts
-  **Zoom In:** Switches on Zoom mode where an area of a chart can be enlarged by drawing a rectangle on the chart while holding the left mouse button down.
-  **Pan:** Switches on Pan mode where the chart can be moved by holding the left mouse button down while dragging on the chart
-  **Cursor:** Switches on Cursor mode where a reading can be taken by clicking on any point in a chart. Parameter values can be read from the Legend Panel

4.8.2 Available Recordings

The **Available Recordings Panel** at the top of the window indicates the availability of measurements in a Gantt chart. Note that this panel is not visible when viewing event trends. Available recordings are indicated with dark bars. The time period currently displayed in the Chart Panel is highlighted in white. This time period can be moved so as




to view the parameters during different time intervals. For this, the buttons on the right of the toolbar are used:

-  **Left Arrow:** Shows the same charts during the previous time interval.
-  **Right Arrow:** Shows the same charts during the following time interval.
-  **Calendar:** Shows a calendar where any date can be selected. The same charts are showed for that date.

4.8.3 Phasors

The Phasor Panel is only visible when viewing event trends for which phasor recordings are available. It shows two full 3 phase phasors plots for a single cycle. The top plot contains fundamental component voltages and currents and the bottom plot fundamental complex power.




The timestamp of the phasor is the same time as the chart cursor, so that this phasor display can be viewed as another cursor reading. The cursor can be moved as usual and this phasor view will be updated automatically. Three tools are available on the right of the title bar to move the cursor:

-  **Start:** Starts an animation of the event by moving the cursor forward in time every second.
-  **Pause:** Stops the animation by freezing the cursor at its current position.
-  **Next:** Increments the cursor with a single cycle. This allows single stepping through an event.


The phasor panel can be hidden with the  **Show/Hide Phasors** button on the main toolbar. This can be used to free up more screen space for the charts.

4.8.4 Tasks Panel

The **Tasks Panel** shows tasks that can be performed with any single chart. First select the chart in the Legend. Note that a single chart must be selected, not merely a series. These tasks are available:

-  **Copy to clipboard:** Copies the values of all the series of a chart to the system clipboard. From there it can be pasted into another applications, such as a spreadsheet or word processor.
-  **Copy to Excel:** This works only if Microsoft Excel is installed on the PC. It opens a new Excel worksheet and copies the values of all the series of the selected chart into the worksheet.
-  **Close Chart:** Removes the selected chart from the display. The recordings are not deleted, but merely hidden.

4.8.5 Adding parameters to a chart


To add a new series to the chart simply click on the  icon at the top of the window. This will open an *Add New Trend Series to Chart* dialog.




Here you can select a new parameter to be displayed and also choose how and where it will be displayed. Every category has different parameters, although many of them overlap. After selecting the series colour and marker and parameter details, choose a chart on which the new series should be added and then click Add Series.

More than one series can be added at a time, but this window must be closed to return to the main windows. It is also important to remember that not all parameters can always be successfully displayed. This is because of limitations imposed by configurations and limitations of specific instruments and configurations.

4.8.6 Layouts


It is time consuming to manually build up a multi-chart view in this series-by-series way. There is an easier way, by utilising the Layout concept. A layout is an already defined set of charts, completed with series parameters and colours. Several predefined layouts are always installed and always available. User defined layout can also be created and saved for use in the future. To save the current view as a layout, click the  **Save Layout** button on the main toolbar. You will be asked to give to the layout a title under which it will be known.

A layout can be recalled or applied, by clicking the  **Load Layout** button on the main toolbar. It allows a layout to be chosen from a list and then displayed with recordings from the current Meter Point and time period. Be warned that the previous chart layout will be gone unless it has been saved!

Every trend interval (10-minute trends, 3-second detail trends and event trends) stores a separate set of layouts.

When the Trend Viewer is opened, a default layout is always displayed. This default layout can be selected in the Preferences dialog.

4.9 Preferences

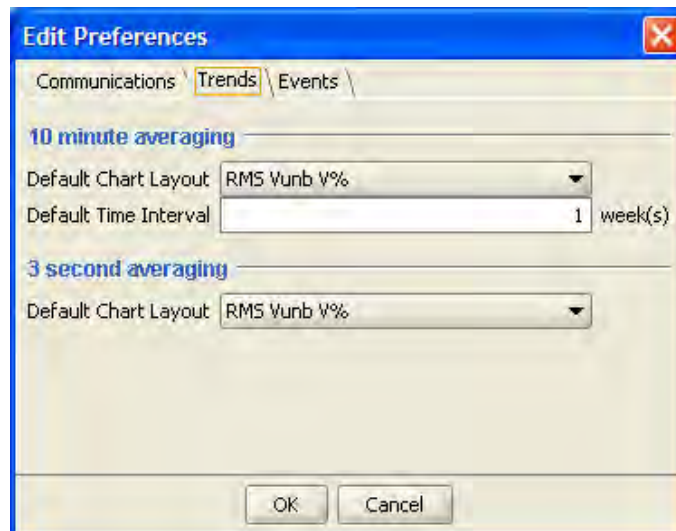
Clicking the  **Preferences** button on the main toolbar opens the Preferences Dialog. This dialog contains user adjustable global settings grouped into categories:

Communications: The default serial and modem devices can be selected here. These devices are the default selection on the Main Menu. Note that there is two modem categories:

- Serial Port Modems are used for communication with VectoGraph and ProvoGraph recorders. They must be detected manually, by clicking on the **Search** button. The software will then search all available serial ports for modems. Please close all applications accessing modems before doing this.
- PPP connections are used for communications with ImpedoGraph recorders over the TCP/IP protocol. These connections are set up using the host Operating System. Under Windows they are called Dial-Up Connections. Setup of these connections is described in another chapter. Only the default one can be selected here.

Trends: These settings influence the way Trend Viewer initially displays recordings. Different default layouts are specified for every time interval. The time interval for a chart is also adjustable. Remember that longer time intervals will result in slower performance, since more recordings need to be retrieved and displayed at a time.

Events: These settings influence the Event Browser. Its classification schema, time interval and preview margins are all adjustable. Default layouts for viewing event trends can also be adjusted.



4.10 Adjust the PC Date and Time

When synchronising a recorder clock, the clock of the PC is used as reference. It is therefore important that the PC clock is accurate. It can be adjusted in 2 ways:

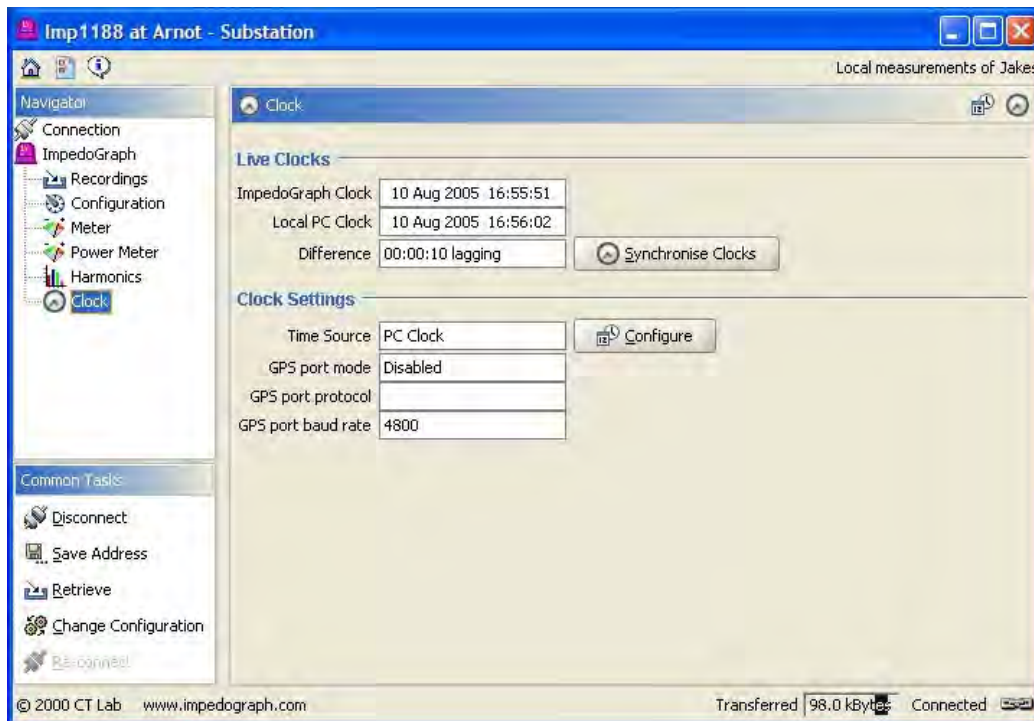
1. Manually: Double-click the clock display on the Windows toolbar (normally in the bottom right corner). This will bring up a dialog in which the clock can be adjusted.
2. Automatically: Many software tools are available that will synchronise the PC clock to very accurate time sources via the Internet. A common one is NISTIME, which is available at <http://www.boulder.nist.gov/timefreq/service/its.htm>.

It is also vital that the time zone of your PC clock is set correctly. To verify this, double-click the clock display on the Windows toolbar (normally in the bottom right corner) and look at the Time Zone page.

4.11 Synchronise the Recorder Clock

Every recorder has its own internal clock. This clock timestamps all recordings, but like any clock, it will eventually lose or gain time. This clock can be adjusted by synchronizing it with the clock of the PC from which communication originates. On configuration, the recorder clock is automatically synchronized. After configuration, the clock can be adjusted (without reconfiguration) through a button on the **Clock** panel.

4.11.1 ImpedoGraph



The difference between the PC and recorder clocks will be displayed, and when the **Synchronise Clocks** button is clicked, a *gradual* synchronization will start. Note that the clocks will *NOT* synchronize immediately. This is to prevent a discontinuity in time, which will cause loss or overlapping of recordings. It is important to note that the timestamp of the recordings can only be as accurate as the clock to which the

ImpedoGraph is synchronized. It is therefore *VERY* important to make sure the PC clock is correct.

If a GPS based time source is available, it can be connected to the ImpedoGraph via the GPS Serial Port. Pressing the **Change** button on the **Clock** tab will allow continuous synchronisation.

4.11.2 VectoGraph and ProvoGraph

Clock synchronisation on the VectoGraph and ProvoGraph happens immediately when the **Synchronise Clocks** button on the Clock page is clicked. Trended recording for the current 10-minute averaging period is discarded, so a gap in the trend recordings will be seen.

Please note that clock synchronisation will not happen when events are in progress, in order to preserve event durations.

4.12 Change a password of a recorder

1. Start the PQRM software.
2. Connect to the recorder and click **Change Password**. If the recorder already has a password set, you will be asked to enter it before proceeding. The Change Password dialog will appear



3. Select the access level for which the password will be changed and then type the password twice before clicking **OK**. To disable the password enter blank values.
4. The password will be changed immediately.


4.13 Upgrade Recorder Firmware

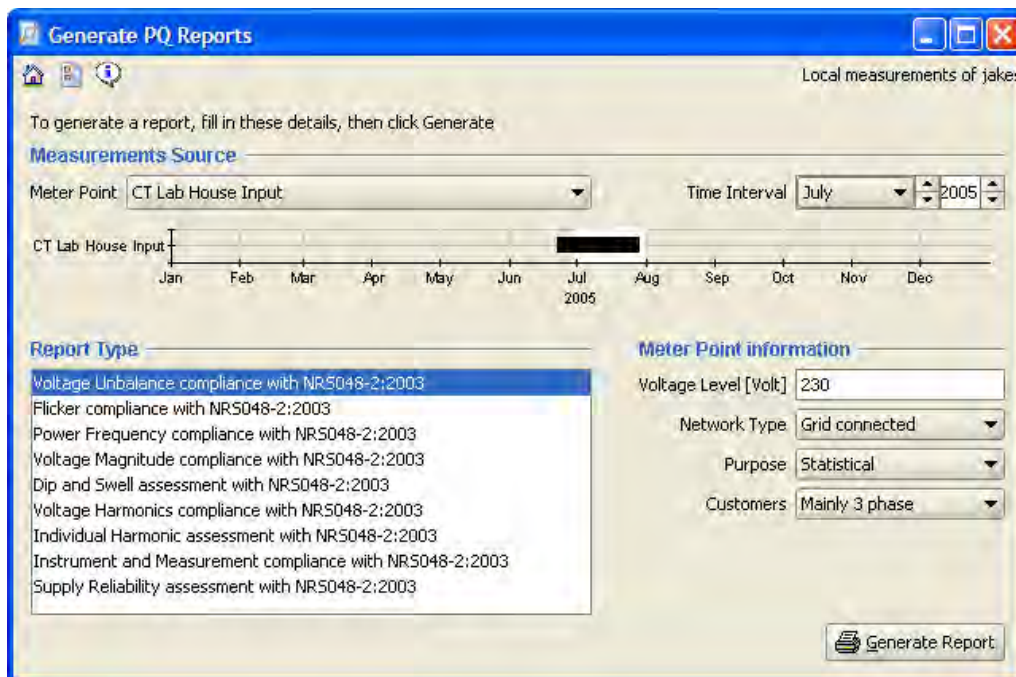
Firmware upgrades are distributed as files with the **impedoupgrade**, **rev** and **rep** extensions. To apply these upgrade to a recorder first make a connection, then click **Upgrade Firmware** on the recorder page.

You will be asked for the upgrade file and then the upgrade will be uploaded and applied. Upgrades can take several minutes, during which recording will be interrupted. Afterwards the recorder will reset by itself.

It is very important not to interrupt this process!

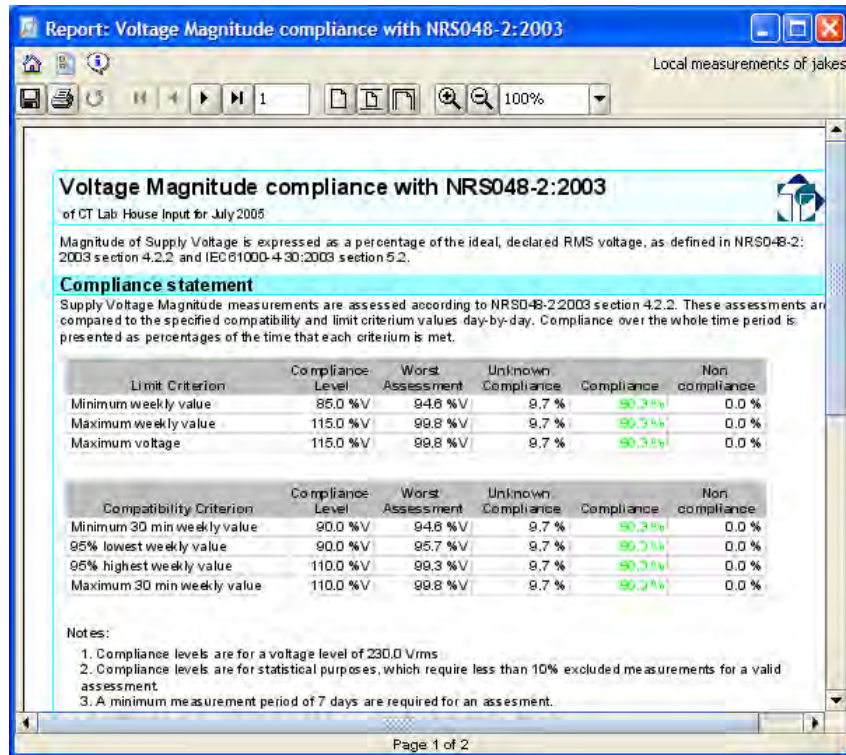
4.14 Generate Reports

1. Open the PQRM Software Main Menu.
2. Select the Meter Point in the list on the left.
3. Click  **Generate Reports**, and the Main Menu Window will change to the Report Selection Window.



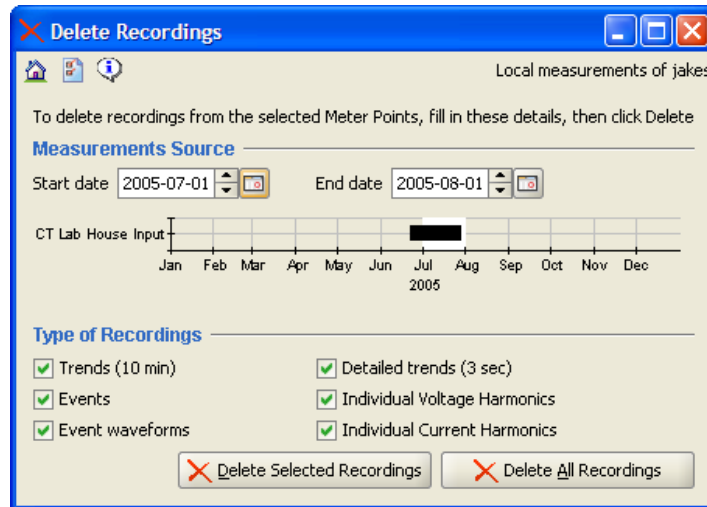
The screenshot displays the 'Generate PQ Reports' software interface. At the top, it says 'Local measurements of jakes'. Below that, it instructs the user to fill in details and click 'Generate'. The 'Measurements Source' is set to 'CT Lab House Input'. The 'Time Interval' is set to 'July' for the year '2005'. A Gantt chart below shows the recording period for 'CT Lab House Input' from June to August 2005. The 'Report Type' list includes various compliance and assessment reports, with 'Voltage Unbalance compliance with NR5048-2:2003' selected. The 'Meter Point information' section shows 'Voltage Level [Volt]' as 230, 'Network Type' as 'Grid connected', 'Purpose' as 'Statistical', and 'Customers' as 'Mainly 3 phase'. A 'Generate Report' button is at the bottom right.

4. Select the reporting period. The Gantt chart will show available recordings and selected reporting period.
5. Select the type of report to be generated from the list.
6. Click Generate Report.
7. The report will now be generated. This can take a few minutes, depending on the complexity of the report and the amount of measurements involved. The resulting report will be presented in a preview window. From here it can be browsed, saved to PDF, Excel (XLS) and CVS files or printed.







4.15 Delete Recordings

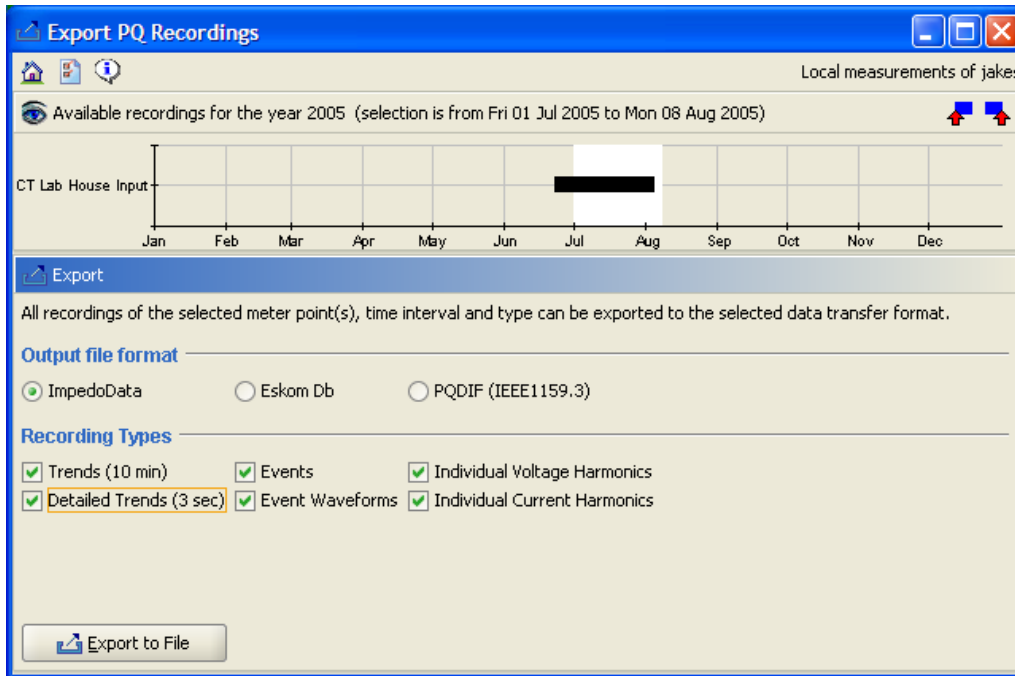
1. Open the PQRM Software Main Menu.
2. Select the Meter Points from which recordings will be deleted in the list on the left. Hold down the CTRL or SHIFT keys while clicking to select multiple Meter Points.
3. Click **X Delete Recordings**, and the Main Menu Window will change to the Delete Selection Window.
4. Select the type of recordings to be deleted from the list.
5. Choose whether to **X Delete Selected Recordings**, which will only delete the selected recordings for the selected time interval, or **X Delete All Recordings**, which will delete all recordings ever made at the selected Meter Point.



Be careful with the delete function, because the deleted recordings will be gone forever. It is not possible to restore deleted recordings.

4.16 Export Recordings

1. Open the PQR Software Main Menu
2. Select the Meter Points from which recordings will be exported in the list on the left. Hold down the CTRL or SHIFT keys while clicking to select multiple Meter Points.
3. Click  **Export Recordings** and the Main Menu Window will change to the Export Selection Window.
4. Select the time period for which recordings will be exported by changing the start and end dates with the  **Start Date** and  **End Date** buttons. The Gantt chart will show available recordings.
5. Select the output file format.
6. Select the type of recordings to be exported.
7. Click  **Export to File** and choose a file to export into.
8. Click **Save** and exporting will begin. If a large export is requested, a warning dialog will show the estimated output file size.



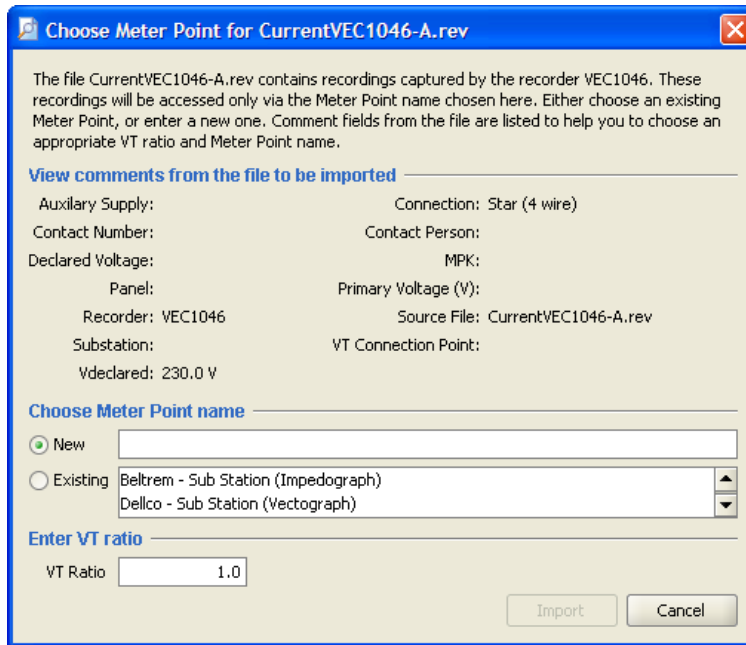
Due to the nature of PQ data, large amounts of recordings can take a long time to export. Please be patient.

4.17 Importing VectoGraph and ProvoGraph recordings

The VectoProvo software suite retrieved recordings from VectoGraph and ProvoGraph recorders into .REV and .REP files. These legacy files can be imported into the PQRM software if (and only if) the recorder was set up to record trend samples every 10 minutes.

First click **Import** on the main menu and select the file(s) to import. Remember to change the **File of Type** settings at the bottom of the file chooser dialog to the type of the file you want to import. Multiple files can be selected. They will be imported one by one.

REV and REP files do not contain enough information to be imported automatically. The user must supply the Meter Point and VT Ratio information. The following dialog will be shown for each file:



A list of fields from the file is shown to help the importer with his decision. He must select an existing Meter Point or enter a new one. Then the VT ratio must be entered. When selecting an existing Meter Point, its last used VT Ratio will be filled in automatically. It can still be changed though.

When these values have been entered, click Import and the import will start. Status messages will be shown in the Import window.

Note: If a file is re-imported with a different Meter Point or VT Ratio, the previously imported measurements are automatically overwritten.

4.18 Automating scheduled retrieval

Retrieving recordings regularly from a large number of recorders is a time consuming process. If the recorders are accessible via modem or a network this process can be automated. The automation works by creating a Windows batch (BAT) file that does the retrieval and then scheduling it for regular execution with the Windows Scheduler. Here are the step-by-step instructions:

4.18.1 Create addresses

A connection to a recorder can only be automated for connections that are saved to the address book. The first step is therefore to manually connect to all recorders and save these connections to the address book.

4.18.2 Create batch file

Next we will create the batch file to start the retrieval:

Create a new directory, e.g **c: /pqrm**

Then create a batch file in **c: /pqrm**, e.g. **daily_retrieve.bat**, containing this command on a single line:

```
javaws -Xnosplash -offline -wait -open cmds.txt  
http://www.ctlab.co.za/pqsoftware/pqrm_su_testing.jnlp
```

Create another text file in **c: /pqrm** called **cmds.txt**. It should contain these lines:

```
-retrieve "Address1"  
-retrieve "Address 2"
```

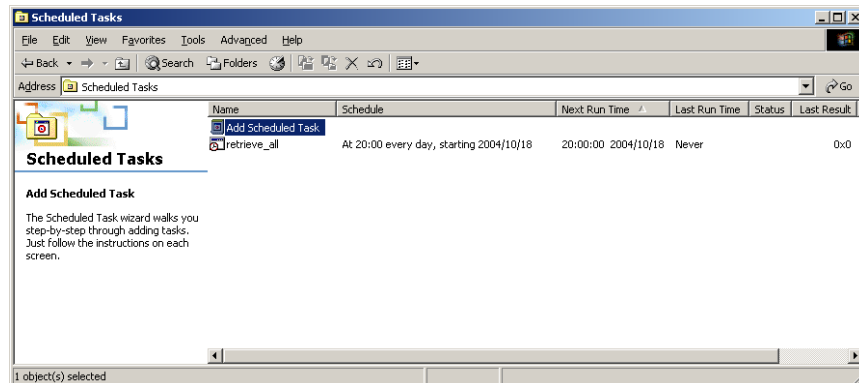
The first line in this file tells the PQR software to retrieve all new recordings from the recorder at Address1. After this is finished, the next line will execute, and all recordings from the recorder at Address 2 will be retrieved. This file can be modified at any time to include new instructions. The batch file can now be executed at any time to retrieve these recordings.

There are other options that can also be used:

- **-syncclock** When specified, this option will synchronise the recorder clock to the PC clock. If this is used, it is very important to ensure that the PC clock is accurate. We recommend regular NTP synchronisation of the PC to a guaranteed time source. You will need configuration access to the recorder – see the configpassword option.
- **-configpassword <password>** This option is required when configuration access to a recorder is guarded with a password. Replace **<password>** with the real password.
- **-retrievepassword <password>** This option is required when access to a recorder is guarded with a password. Replace **<password>** with the real password.

4.18.3 Schedule with Windows Scheduler

Now that we have a way of retrieving from multiple recorders, we must tell Windows to run it regularly. Open Scheduled Tasks from the Windows Control Panel. It looks like this:



Click **Add Scheduled Task**, which will show the **Scheduled Task Wizard**. Hit **Next**, and then click **Browse** to tell it which file should be executed. Pick the batch file you just

created at **c:/pqrm/daily_retrieval.bat**. Now choose how often this task should be executed. Daily is the most common choice. Next pick a start time, typically some time after hours when calls are cheaper. Next you will need to enter your username and password and then **Finish** the wizard.

There are also useful advanced options to set by double-clicking an entry:

- The task can also be run if the PC is in sleep mode: See Power Management in the **Settings** page
- The list in the Security page determines the users who are allowed access to the task. It is important that the user name under which this task is run is entered here.

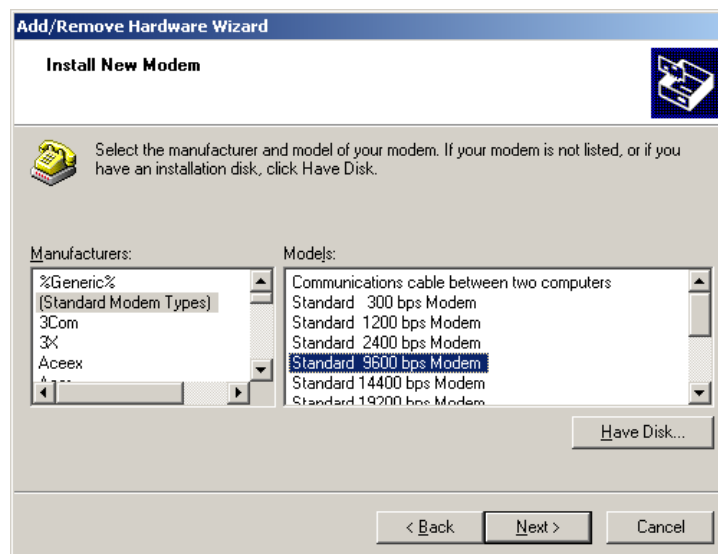
Retrieval should now happen automatically, if you don't forget to leave the PC on. It is important that the PQR application **MUST** be closed for the retrieval command to

4.19 Configure the PC for modem communication

Before connecting to a Power Quality Recorder via modem, modem support must be set up properly on the PC.

The PQR software uses Windows Dial-up Networking to make connections to Recorders via a modem. Follow these steps to set it up:

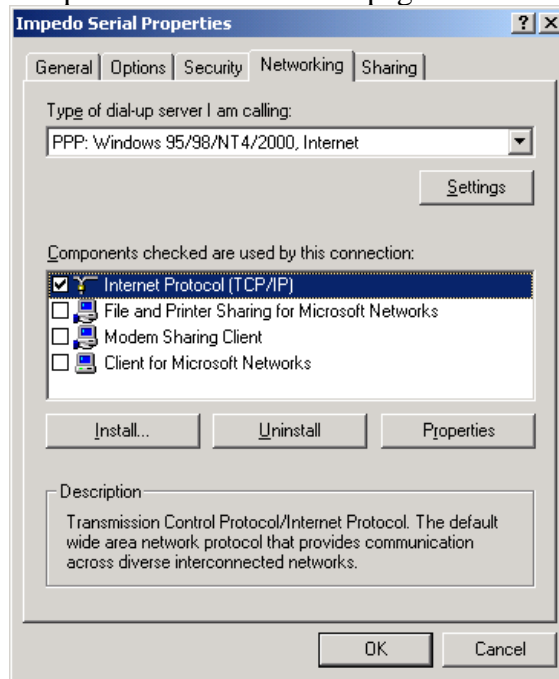
1. Connect the modem to the PC and make sure it is switched on.
2. Install the modem driver as described in the modem documentation. GSM modems should be installed with the **Standard 9600 bps Modem** driver:



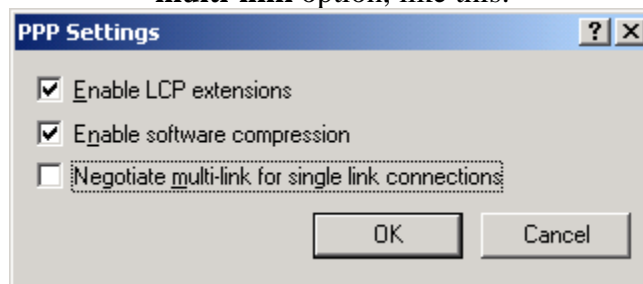
3. Create a new Dial-up Networking connection and give it an appropriate title, such as **PQR via Modem**. Follow the detailed instructions for your Operating System in the next sections.

4.19.1 Configuring Dial-up Networking in Windows 2000

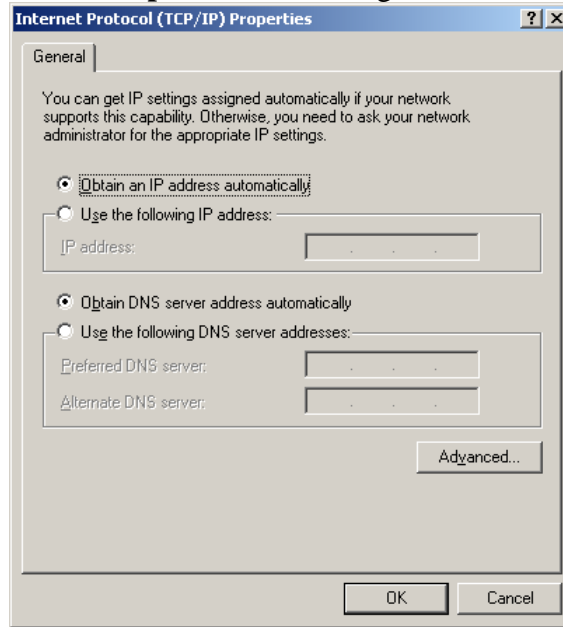
1. Click Start | Settings | Network and Dial-up Connections | Make New Connection which will start up the setup wizard.
2. Select **Next**, **Dial-up to private network** and **Next** again.
3. Check the modem through which you want to connect. Make sure only that device is checked. Click **Next**.
4. Ignore the phone number (it does not matter) and click **Next** and **Next** again.
5. Enter a descriptive name for the connection, e.g. **PQ Recorder via Modem** or **PQ Recorder via COM1** for a legacy serial connection, and then click **Finish**.
6. The Connect Dialog will now appear. Choose **Properties**.
7. Go to the **Networking** page and make sure only the **Internet Protocol (TCP/IP)** component is checked. The page should look like this:



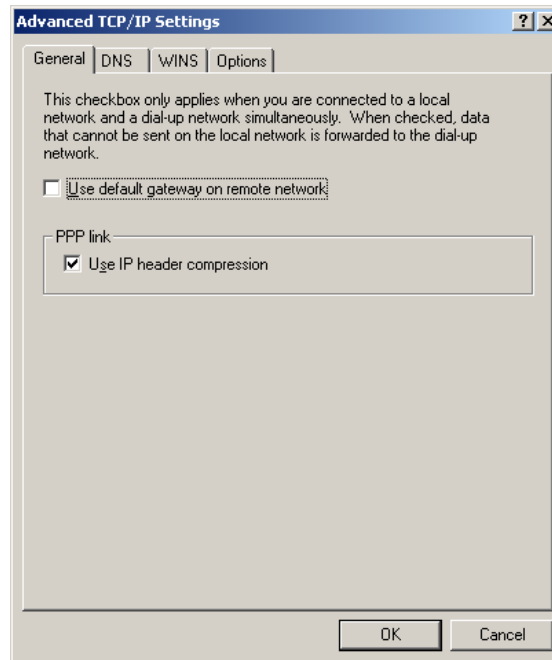
8. Click **Settings**. A dialog will appear for PPP settings. Uncheck the **Negotiate multi-link** option, like this:



9. Click **OK** to close the **PPP Settings** dialog, then select Internet Protocol (TCP/IP) and click **Properties**. You will get another dialog, like this:



10. Click **Advanced** and uncheck the **Use default gateway on remote network** option in the new dialog:



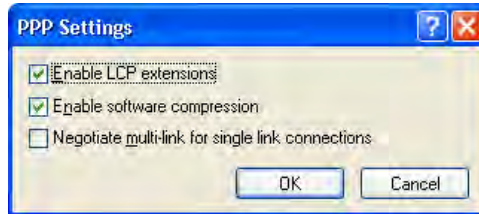
11. Click **OK** three times to close all these dialogs. We do not want to make a connection now, so **Cancel** the **Connect To** dialog.

4.19.2 Configuring Dial-up Networking in Windows XP

1. Click Start | Settings | Connect To | Show all Connections, which will show the Network Connections Window.
2. Click Create a new connection in the Network Tasks panel on the left. This will start the New Connection wizard.
3. Click **Next**, select **Connect to the Internet** and click **Next** again.
4. Select **Set up my connection manually** and click **Next**.
5. Select **Connect using a dial-up modem** and click **Next**.
6. Check the modem with which you want to connect. Make sure only that device is checked. Click **Next**.
7. Enter a descriptive name for the connection, e.g. **PQ Recorder via Modem** or **PQ Recorder via COM1** for a legacy serial connection, and then click **Next**.
8. Click **Next** (no phone number is required).
9. Uncheck all the options and leave the fields blank, then click **Next** and **Finish**.
10. The Connect Dialog will now appear. Choose **Properties**.
11. Go to the **Networking** page and make sure only the **Internet Protocol (TCP/IP)** component is checked. The page should look like this:



12. Click **Settings**. A dialog will appear for PPP settings. Uncheck the **Negotiate multi-link** option, like this:



13. Click **OK** to close the **PPP Settings** dialog, then select Internet Protocol (TCP/IP) and click **Properties**. You will get another dialog, like this:



14. Click **Advanced** and uncheck the **Use default gateway on remote network** option in the new dialog:



15. Click **OK** three times to close all these dialogs. We do not want to make a connection now, so **Cancel** the **Connect** dialog.
16. The new connection will now be listed in the Network Connections window.

4.20 Configure the ImpedoGraph for Modem Communication

The ImpedoGraph communicates with attached modems through its serial Modem Port. Different modem types require different serial port configurations in order to function optimally. The configuration of the Modem Port can be changed using the same instruction as for upgrading the ImpedoGraph firmware. Different modem types with instructions are listed here:

- GSM cellular modems: These modems work better with a serial port speed equal to the network throughput, i.e. 9600 baud. The supplied **modem_9600baud.impedoupgrade** file will configure the modem port for 9600 baud.
- Analog (PSTN) modems: These modems work better with a higher serial port speed. The supplied **modem_57600baud.impedoupgrade** file will configure the modem port for 57600 baud.

Connect the modem to the Modem Port of the ImpedoGraph with the serial cable supplied with the modem. The ImpedoGraph will reset an attached modem automatically on start-up.

4.21 Communicate via Serial Cable

1. Connect the correct serial cable to the PC Port of the recorder and an unused port of the PC. Make sure that you know which serial port of the PC you are using.
2. Start the **PQRM** application.
3. Choose the recorder you are connecting to in the *Connect to a Recorder* panel.
4. Select the correct serial port in the *Connect to a Recorder* panel then click on **Connect**.

4.22 Communicate via Modem

1. Make sure that modem support has been installed.
2. Make sure that the PC modem is plugged in, powered and connected to the phone line.
3. Make sure that the recorder modem is powered, connected to the ImpedoGraph **Modem** port and connected to phone line.
4. Start PQRM software.
5. Choose the recorder you are connecting to in the *Connect to a Recorder* panel.
6. Select the Modem device in the *Connect to a Recorder* panel, enter the phone number and click **Connect**.
7. Be patient while the connection is made.
8. The recorder item will appear when the connection is made. The phone number can now be saved to the address book for future use.

4.23 Communicate via Ethernet network

1. Make sure the PC is connected to the network and its IP is set properly. Contact your System Administrator if this is not the case.
2. Start PQRM software.
3. Enter IP address or name of the ImpedoGraph in the **Network** field on the **Connect to an Recorder** panel and click **Connect**. If you don't know the IP address of the ImpedoGraph, connect to it via serial cable and read the address from the ImpedoGraph panel.
4. The ImpedoGraph Online Window will appear when the connection is made. The IP address can now be saved to the address book for future use.

4.24 Change the Ethernet Settings of an ImpedoGraph

If the ImpedoGraph shares an Ethernet network with other devices or PCs, the network administrator must allocate and reserve an IP address, subnet mask and gateway address for the ImpedoGraph. These settings should be applied by clicking on the **Change** button in the **Ethernet Communications** section on the **ImpedoGraph** panel while connected, and filling in these values. When pressing the **Accept** button, the communication to the

ImpedoGraph will be disrupted and the session closed. You would have to reconnect to the ImpedoGraph using the newly applied Ethernet settings.

Note: The changing of the IP address rudely disrupts the current communication session. Depending on the TCP/IP time-out settings of your PC, the PQRM application might lock up for a few minutes. Recording is NOT interrupted.

Note: ImpedoGraph with firmware version before 0.80 might have problems setting the subnet mask correctly. Upgrading the ImpedoGraph firmware will solve this problem.

5 IMPEDOGRAPH RECORDER



The ImpedoGraph is a three-phase power quality recorder. It is a stand-alone instrument, designed to record power quality anomalies for weeks or even months at a time. Anomalies are recorded as **events** (including pre- and post event recordings) or as **trends** (10-minute and 3-second intervals) and are stored in onboard memory. Supply interruptions longer than 10 seconds interrupt recording, but no recordings are lost and recording continues as soon as the supply returns.

5.1 Hardware Interfaces

All external connections to ImpedoGraph are made on these terminals.



5.1.1 Power Supply

The Power LED on the front panel indicates the presence of mains supply. Valid mains voltages are 80 to 150 V_{RMS} or 150 to 270 V_{RMS} depending on the position of the mains voltage selector switch at the back. The valid frequency range is from 40 to 70 Hz.

The ImpedoGraph consumes 45 VA. An internal electronic fuse protects the ImpedoGraph. If over-voltage is applied, the ImpedoGraph will shut down automatically.

for a few minutes. After these protections have operated it needs a few minutes to cool, during which the ImpedoGraph will not restart even with valid mains voltage.

During dips and short interruption an internal high voltage capacitor bank supplies power to the ImpedoGraph for up to 10 seconds. If the interruption is longer than 10 seconds, the ImpedoGraph will shut itself down without any loss of recordings. This capacitor bank needs no maintenance.

5.1.2 Voltage Inputs

The ImpedoGraph has four resistive differential voltage inputs. The inputs are available on an eight terminal barrier strip connector on the front panel of the instrument.

High impedance inputs prevent the accidental shorting of VT inputs to system ground and ground loops are eliminated. A single 460 VAC voltage input range with 10 mV resolution simplifies installation and ensures good accuracy for both the fundamental component and harmonics. The differential input stage assures a safe, stable analog input stage with minimum phase error, high bandwidth and no temperature drift.

Each of the four voltage inputs has a built-in high-speed peak detector that captures positive and negative polarity fast voltage transient events of up to 2kV.

5.1.3 Current Inputs

The ImpedoGraph has four galvanically isolated current inputs. High accuracy Hall-effect current transducers form the heart of the current input stage. These transducers provide galvanic isolation, excellent AC and DC response, very low input impedance and a high fault level withstand capability.

The instrument also has four voltage output current transducer (CT) inputs available via eight protected banana plugs. These voltage inputs can be used to interface with voltage output clamp-on CT's or to other external current transducers.

These two current input interfaces (voltage and current) are mutually exclusive. Either the current inputs or the voltage output current transducer inputs can be used, but they cannot be mixed in the same installation.

5.1.4 Status Inputs

Eight high impedance differential voltage inputs are used to capture external status events like breaker status, etc. The digital status recordings can be used to study the effect of voltage dips on processes or equipment. Each input has a threshold of 9V and an input range of up to 300 VDC. The on-board 15 VDC power supply can be used to energize *dead* contacts.

5.1.5 PC Port

This is a galvanically isolated RS232C serial port. This port is used for communication with a PC/Laptop through a standard serial cable at 115200 baud.

5.1.6 Modem Port

This is a galvanically isolated RS232C serial port. This port is used to interface to external modems or any other modem-like communications devices.

The default Modem Port setup is compatible with standard Hayes-compatible modem commands at 57600 baud with hardware flow control. PPP (Point to Point protocol) is used for incoming connections.

5.1.7 Ethernet Port

This is a 10Base-T UTP connector for connecting to Ethernet networks. The IP address, subnet mask and gateway address can be set via the included software application.

5.1.8 GPS Ports

This is a RS232C serial port dedicated to time synchronisation. It is typically connected to a GPS time source (RS232 or RS422) for very accurate absolute time stamping of recordings. The on-board real time clock will automatically synchronise onto this external time source. The NMEA0183 protocol is required.

The port can also be used as a multi-drop bus for clock synchronisation of adjacent recorders. A network of ImpedoGraphs can therefore synchronise clocks onto one external GPS or onto each other.

5.1.9 SCADA Interface Port

This is a general purpose RS232C serial port with a built-in RS232 to RS485 converter. It is software configurable, but no protocols are available by default. Contact CT Lab with your specific protocol requirements.

5.2 Calibration

Every ImpedoGraph is individually software calibrated. These calibration settings are stored on-board every instrument and are unique to each instrument. Each instrument is compared to a traceable calibration reference before leaving the factory. A copy of the test certificate with its readings is supplied with each instrument.

5.3 Recordings Storage

The ImpedoGraph has a large memory storage capacity. When available storage is nearly exhausted, it automatically deletes the oldest recordings to make space for the newer recordings. In this way the latest recordings is always preserved.

The ImpedoGraph can record a large number of parameters very frequently. This can even fill up the storage within a day. It is therefore very important to configure the instrument correctly for your application. Configurations such as the capture of full harmonic spectrums every 3 seconds should not be used for long term installations.

5.4 Firmware

The ImpedoGraph uses internal software called firmware to provide its functionality. The version number of this firmware can be viewed with the ImpedoGraph PC Software. This firmware is also upgradeable through this software. New firmware is released periodically to fix problems and to provide new features and parameters. Please contact your supplier for a full range of firmware options.

5.5 Access Control

The ImpedoGraph provides a basic mechanism for protecting access to its recordings and settings. It is not a foolproof mechanism and must be part of a larger strategy for protecting sensitive recordings.

Every ImpedoGraph has 5 access levels, with access to each level protected by a password. This table indicates which functions are allowed at each access level.

Function vs. Access Level	None	View	Re-trieve	Configure	Admini-stration
Connect	No	Yes	Yes	Yes	Yes
View Meters and configurations	No	Yes	Yes	Yes	Yes
Retrieve Recordings	No	No	Yes	Yes	Yes
Synchronise Clock	No	No	No	Yes	Yes
Change Configuration	No	No	No	Yes	Yes
Configure Clock Synchronisation	No	No	No	Yes	Yes
Change Passwords	No	No	No	No	Yes
Change Ethernet settings	No	No	No	No	Yes
Upgrade Firmware	No	No	No	No	Yes

Whenever a function is requested the user is prompted for the applicable password before the function is performed. Passwords can only be changed after entering the Administrator password. Changing the password of an access level to a blank value will disable password checking for that level. This is the default setting.

5.6 Measurement

The ImpedoGraph measures voltage and current waveforms with very high accuracy and 16-bit resolution. All the analog inputs are sampled simultaneously at a sampling rate of 128 samples per cycle with 4 times over-sampling to reduce the background noise levels. These waveforms are then condensed into other power parameters such as true RMS voltages, fundamental phasor sets and harmonic spectrums.

The ImpedoGraph measures power quality according to the international IEC61000-4-30 class A standard.

5.6.1 Power Measurement

The ImpedoGraph has 4 voltage and 4 current inputs. When connected in star configuration (4 wires), the 4 voltage and current input combinations will be grouped together to form 4 individual power meters.

When connected in delta, the ImpedoGraph will measure in 2-wattmeter configuration:

- Channel 1: Wattmeter #1 (Voltage 1 and Current 1)
- Channel 2: Wattmeter Disabled (always reads zero)
- Channel 3: Wattmeter #2 (Voltage 3 and inverse of Current 2)
- Channel 4: Independent (Voltage 4 and Current 4)
- Total (3 phase) = Wattmeter #1 + Wattmeter #2

5.6.2 Trended Parameters

The ImpedoGraph calculates trended parameters continuously (gapless) and averages these readings over three time intervals:

- Every cycle of the fundamental frequency.
- Approximately every 3 seconds – actually every 150 cycles at 50 Hz and 180 cycles at 60 Hz.
- Every 10 minutes, synchronised to the internal clock.

The following table lists recorded parameters and shows at which intervals they are available:

Parameter	RMS	Fundamental frequency	Per Harmonic
Voltages	All intervals	All intervals	3 sec and 10 min
Currents	All intervals	All intervals	3 sec and 10 min
Active powers	All intervals	All intervals	3 sec and 10 min
Reactive powers	All intervals	All intervals	3 sec and 10 min
Apparent powers	All intervals	All intervals	3 sec and 10 min
Power factors	All intervals	All intervals	3 sec and 10 min
Power angles	All intervals	All intervals	3 sec and 10 min
Voltage unbalance		All intervals	
Current unbalance		All intervals	
Voltage THD	3 sec and 10 min		
Current THD	3 sec and 10 min		
Frequency		All	
Flicker (Pst)	10 min		

Any combination of voltage and current harmonics and inter-harmonics up till the 64th harmonic can be captured simultaneously. The ImpedoGraph can also trend the 3-second

minimum and maximum reading obtained during a 10-minute interval for all directly measured parameters.

5.6.3 Events

The ImpedoGraph can measure these types of power quality events as defined in IEC61000-4-30:

- Interruptions
- Dips
- Swells
- Poor Voltage Regulation
- Voltage Transients
- Under Frequency
- Current Inrush

An additional type of events indicates changes in the ImpedoGraph recorder. These Recorder Events reveal clock synchronisations, configurations and power downs.

6 GETTING STARTED WITH AN IMPEDOGRAPH

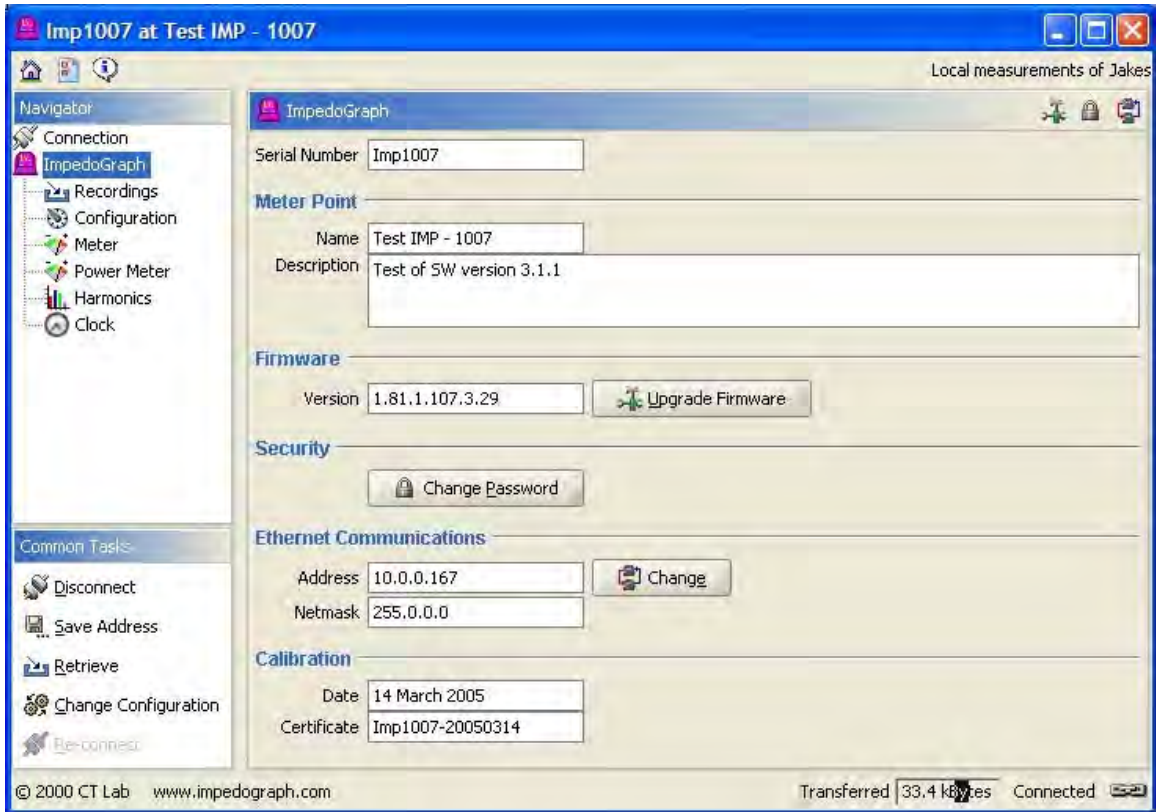
This chapter is for first time users. If you are upgrading from a previous version of the PQRM System Software, follow the instructions in the chapter on upgrading instead.

First install the PQRM Software on your PC. Full instructions are given the [PQRM software Installation](#) chapter.

After you are familiar with the information that can be recorded with the ImpedoGraph, it is time to work with your ImpedoGraph.

First you need to make a serial cable connection to the ImpedoGraph from the software on your PC, as follows:

1. Connect the ImpedoGraph recorder to mains power. About 30 seconds after power up it will play a short melody after which the status light will start flashing and the ImpedoGraph will be ready.
2. Connect the serial cable to the PC Port of the ImpedoGraph and an unused port of the PC. Make sure that you know which serial port of the PC you are using.
3. Start the **ImpedoGraph** application.
4. Select the correct serial port in the *Connect to an ImpedoGraph* panel then click on Connect.
5. The window will change to display the status of the connection and after a while the window will change to indicate that a connection is established. You will see an ImpedoGraph icon in the navigator panel with options underneath. Browse through the items listed to become familiar with them. Closing this window will disconnect you from the ImpedoGraph.



You now have the ImpedoGraph online application in front of you. Select the Meter page that will show you what is currently measured on the inputs of the ImpedoGraph in real time. Remember to always **Disconnect** the software before you remove power from the ImpedoGraph.

Connect a voltage to the voltage inputs and watch the Meter panel display change. The next big step is the full 3-phase install:

1. Take the ImpedoGraph, laptop and serial communications cable to the site.
2. Connect the ImpedoGraph as described in the [ImpedoGraph Electrical Installation](#) section of the [Getting Started with an ImpedoGraph](#) chapter.
3. Next configure the ImpedoGraph as described in [Configure the ImpedoGraph](#), then verify your installation as described in [Verify Installation](#).

Now for the ImpedoGraph to record, retrieve the recordings (see [Retrieving Recordings](#)) and view them (see [Event Browser](#) and [Trend Viewer](#)).

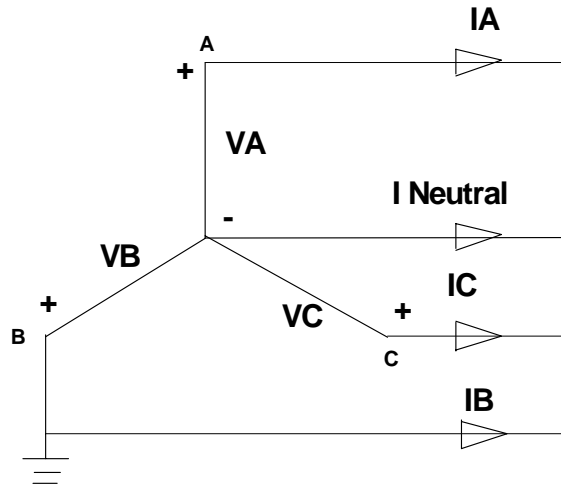
6.1 ImpedoGraph Electrical Installation

This step describes the installation of an ImpedoGraph at a 3-phase meter point.

1. Connect the earth stud to the distribution ground.
2. Connect the ImpedoGraph to the wiring, starting with the neutral voltage according to the instructions in the following settings.

6.1.1 Connecting to a 4 Wire Star System

Connect the voltage and current inputs as in this diagram:



6.1.1.1 Voltage Inputs

Link all 4 negative voltage inputs together and connect them to the Neutral terminal of the circuit to be measured. The Neutral terminal is now the reference node so that all voltages are referred to Neutral.

Note: VT circuits normally have the White phase earthed, while 400V circuits have the Neutral earthed.

Connect the positive terminals as follows:

- (V1+) – VA - Red
- (V2+) – VB - White
- (V3+) – VC - Blue
- (V4+) – Earth or short it out by connecting to Neutral

6.1.1.2 Current Inputs

If you want to measure the secondary current of current transformer (CT) circuits, make sure that you never open the circuit while under load.

Note: The current must enter the measurement circuit through the positive terminal to obtain a positive power reading.

Make sure that the circuit to be measured is not loaded.

Connect the current inputs as follows:

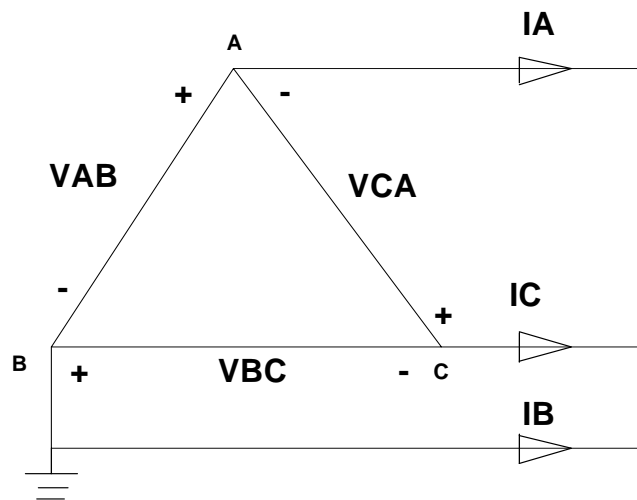
- Ia through I1
- Ib through I2
- Ic through I3,
- In through I4 (optional)

6.1.1.3 Connecting Voltage Output Current Transducers

1. Connect the sensor positive output to the red (positive) ImpedoGraph input.
2. Connect the sensor negative output to the black (negative) ImpedoGraph input.
3. Connect to the current as follows:
Ia through Transducer 1
Ib through Transducer 2
Ic through Transducer 3
4. Optional: In through Transducer 4.
5. **Short a voltage input if there is no transducer connected to it.**

6.1.2 Connecting to a 3 wire Delta system

Three-phase power measurements on delta connections are done using the 2 watt meter method. Connect the voltage and current inputs as in this diagram:



6.1.2.1 Connecting the Voltage Inputs

1. Make sure that the instrument is powered down (switched off)
2. Link the voltage input terminals together as follows:
 - a. (V1-) to (V2+)
 - b. (V2-) to (V3+)
 - c. (V3-) to (V1+)
3. Short out (V4+) and (V4-).
4. Connect the positive terminals as follows:

- a. (V1+) – VA - Red
- b. (V2+) – VB - White
- c. (V3+) – VC – Blue

On 3-wire Delta circuits you can either find a star connected VT configuration (3 VT's) or an open delta configuration (2 VT's). If a star connected VT configuration is used – PLEASE IGNORE THE NEUTRAL. This fictitious neutral point is not stable under transient conditions and will cause incorrect measurements to be taken. Consider using this rule of thumb:

- If three wires feed the energy – Connect in Delta.
- If four wires feed the energy – Connect in Star.

6.1.2.2 Connecting the Current Inputs

If you want to measure the secondary current of current transformer (CT) circuits, make sure that you never open the circuit while under load. Rather use external clamp-on probes or use a qualified technician that knows how to break into CT circuits.

Note: Current must enter the measurement circuit through the positive terminal to obtain a positive power reading.

1. Make sure that the instrument is powered down (switched off).
2. Make sure that the circuit to be measured is not loaded.
3. Connect current as follows:
Ia through I1,
Ib through I2,
Ic through I3.

Note: Normally there are only two CT's installed on a delta network. The ImpedoGraph has the ability to derive the third current from any of the two available currents via a software configuration option.

4. Leave the unconnected channel open. It will be derived internally.

6.1.2.3 Connect Voltage Output Current Transducers

1. Make sure that the instrument is powered down (switched off).
2. Connect the sensor positive output to the red (positive) ImpedoGraph input.
3. Connect the sensor negative output to the black (negative) ImpedoGraph input.
4. Connect to the current as follows:
Ia through Transducer I1,
Ib through Transducer I2,
Ic through Transducer I3.

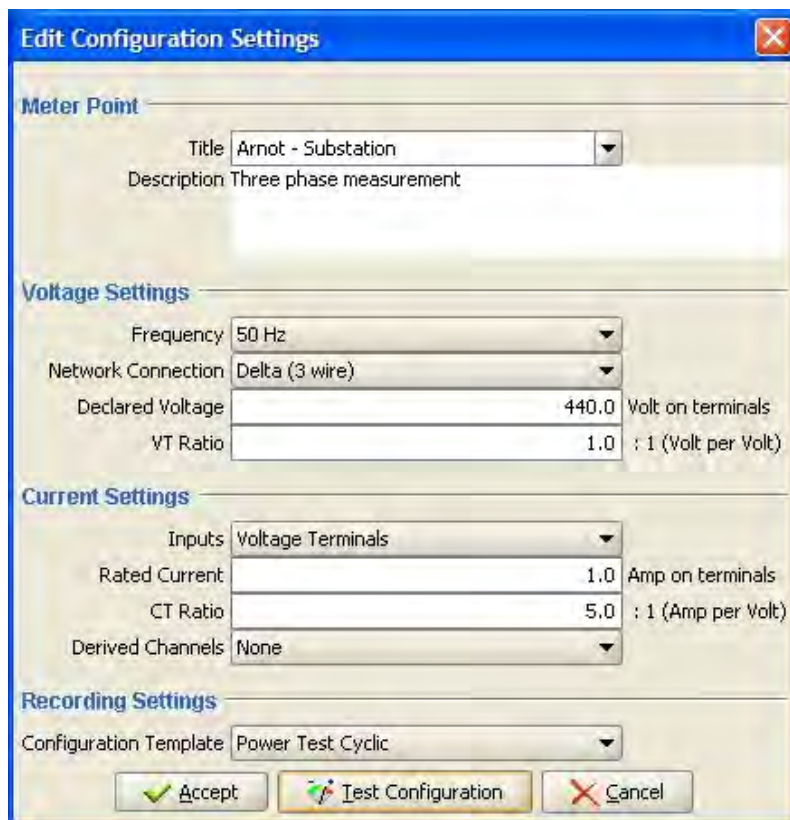
Note: Only two transducers are actually required to measure the current of a three-wire system. The ImpedoGraph will derive the third current from the two available currents.

Short a voltage input if there is no transducer connected to it.

6.2 Configure the ImpedoGraph

In addition to being physically installed at a meter point, the ImpedoGraph also needs to be configured properly:

1. Power-up the Instrument, observe the start-up sequence and wait for the melody.
2. Establish communication with instrument.
3. Click **Change Configuration** and wait for the ImpedoGraph to go into Configuration mode. Please be patient – this can take up to 5 minutes since the ImpedoGraph through a self-testing process. Please note that when in configuration mode no recordings will be made and all previously captured recordings still stored on the instrument will be discarded. If you disconnect at this stage, the ImpedoGraph will stay in this mode and no recordings will be made.
4. The Configuration Settings dialog will now appear where all configuration information must be entered:



Edit Configuration Settings

Meter Point

Title: Arnot - Substation
Description: Three phase measurement

Voltage Settings

Frequency: 50 Hz
Network Connection: Delta (3 wire)
Declared Voltage: 440.0 Volt on terminals
VT Ratio: 1.0 : 1 (Volt per Volt)

Current Settings

Inputs: Voltage Terminals
Rated Current: 1.0 Amp on terminals
CT Ratio: 5.0 : 1 (Amp per Volt)
Derived Channels: None

Recording Settings

Configuration Template: Power Test Cyclic

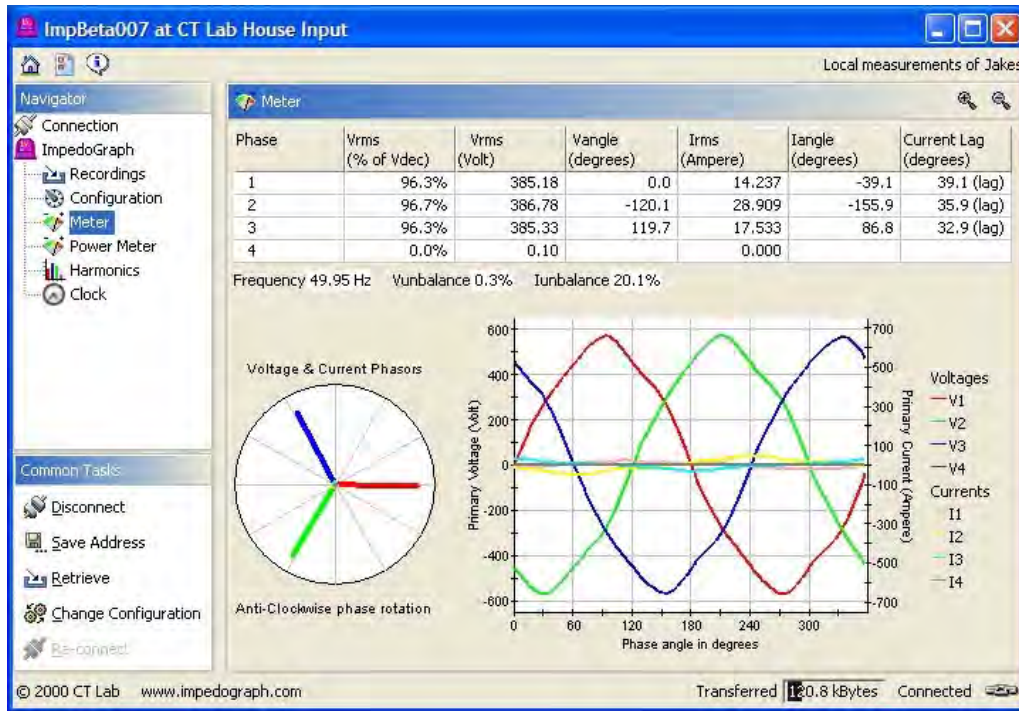
Accept Test Configuration Cancel

5. Changes can now be made to the configuration and the impact can be viewed by clicking on the **Test** button, which will take you to the Meter panel to inspect their effect. Return to the **Edit Configuration Settings** dialog by clicking **Change Configuration** again.

6. Select or enter a title and description for this Meter Point. This is important since the title will be used to pick out these recordings from those made at other meter points.
7. Frequency – Select 50 or 60Hz.
8. Network Connection – Select Star (4 wire) or Delta (3 wire) Connection.
9. Declared Voltage (secondary) – specify the declared RMS value of the voltage directly connected to the ImpedoGraph, e.g. 63.5V or 110V or 114.4V or 230V.
10. VT Ratio – Voltage transformer ratio, e.g. an 11kV to 110V VT will have a VT Ratio of 100. Make sure you use only line voltages on delta systems and only phase voltages on star connected systems to determine VT Ratios.
11. Current Input Terminals – Select usage of either Current- or voltage input terminals.
12. Current transformer (CT) ratio – for current terminal inputs this will be Ampere per Ampere and for the voltage terminal inputs it will be Ampere per Volt.
13. Derive Current Channels – With star connected systems the neutral current can be derived by summation of the phase currents. With delta connected systems any one of the three line currents can be derived through summation of the other two currents.
14. Select an appropriate Configuration Template. **Very Important!! (Refer to appendix on Configuration Templates before selecting a Configuration Template)**
15. Click Finish in the **Edit Configuration Settings** dialog when the configuration is complete. The ImpedoGraph will return to recording mode within a few seconds and from then on the ImpedoGraph is active.

6.3 Verify Installation

1. It is good practise to verify all input connections and configuration after installation and periodically after that. It can be done remotely (e.g. via modem) as well:
2. Connect to the ImpedoGraph and make sure it is not in Configuration mode.

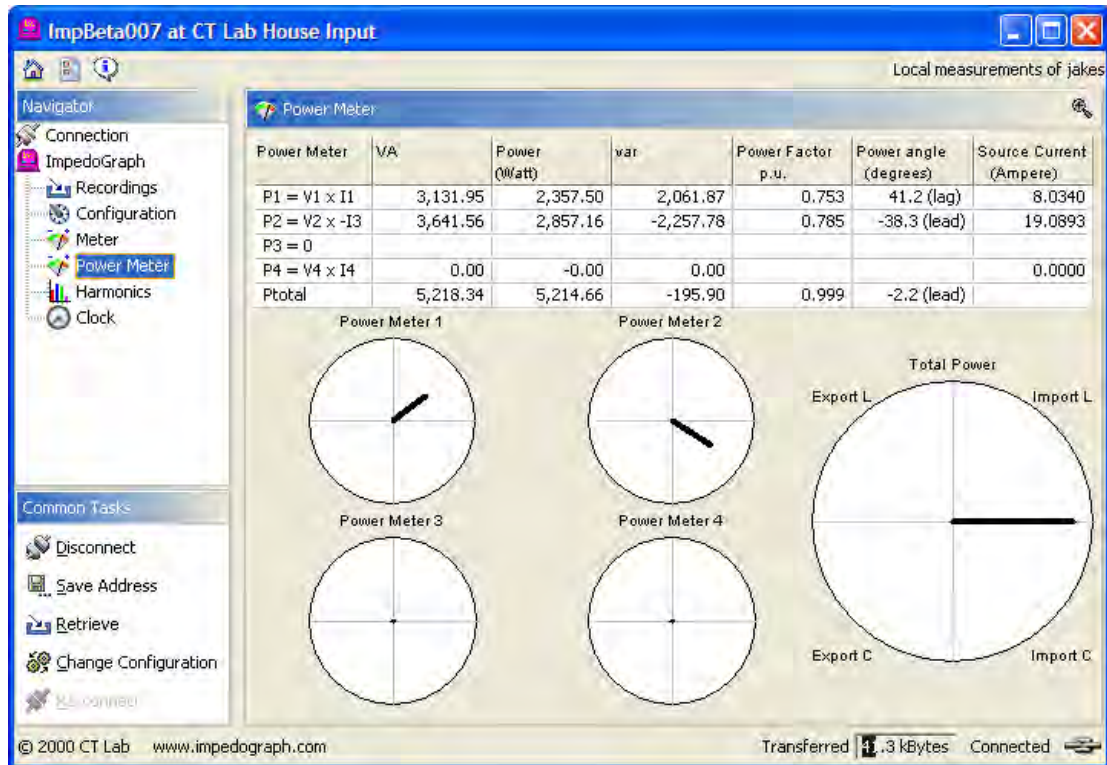


- Go to the Meter display and verify that all 4 voltages at the terminals of the ImpedoGraph are present and as expected.
- Inspect the waveforms and expect to see exactly one cycle of voltage and current waveforms for each phase.
- Verify Phase Rotation. With counter clock-wise rotation you have the following **Vangle (degrees)** readings:

Phase 1	0 degrees
Phase 2	+120 degrees
Phase 3	-120 degrees

- Inspect **Vrms (% of Vdec)**. Its value should be close to 100% if all voltages are connected and the **Declared Voltage** setting is correct.
- Inspect **Vrms (Volt)**. It should reflect the primary voltage if the VT Ratio is correct.
- When using the voltage terminal inputs, make sure that all unused channels are shorted. If this is not the case, high DC currents will be observed.
- Inspect **Irms (Ampere)** of all 4 channels. Make sure they are present and as expected. They should be properly scaled so as to read the actual line current. If not, check the CT ratio.

10. Inspect polarity by looking at the voltage and current phasors and the Current Lag.
11. Inspect the Power Meter display. Verify the power angles, but note that the individual power meters for delta connections will seem counter intuitive, with one meter show a 30 degree positive power angle offset and another one 30 degrees negative offset, but the total power phasor will seem correct



12. With delta-connected systems, one of the single-phase power-meters should read zero. The other 2 power meters are used in the 2 power-meter calculation. The Ptotal reading should be positive and have the correct magnitude.
13. Verify that the total Power (Watt) and VA readings are correct

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7 VECTOGRAPH RECORDER



The VectoGraph is an instrument designed to record voltage quality related parameters. The instrument can trigger and record instantaneous events such as voltage transients and dips and on averaged values like 10-minute phase unbalance and THD.

The VectoGraph can be connected to line and phase voltage networks (3 and 4 wire).

7.1 Hardware Interfaces

7.1.1 Power Supply

The VectoGraph can be powered from 90 - 300 Vac 50Hz as well as from 50 - 150 Vdc. A CVT (constant voltage transformer) is used to step up the supplied AC voltage. The secondary voltage is then rectified and applied to high voltage capacitors. These capacitors are used to store the energy required to ride through dips and short outages. A high efficiency DC/DC converter is then used to supply power to the instrument. An electronic fuse protects the CVT in the event of overloading.

When powered from DC, the VectoGraph consumes 3 Watt.

The use of a CVT and high voltage capacitors has the following advantages:

- No replacement of batteries
- High rejection to mains carried transients and disturbances
- Low cost
- High reliability
- No inrush current
- Low harmonic content in load current

7.1.2 Communications Port

This is a galvanically isolated RS232C serial port. This port is used for communication with a PC/Laptop through a standard serial cable at 115200 baud.

7.2 Calibration

Every VectoGraph is individually software calibrated. These calibration settings are stored on-board every instrument and are unique to each instrument. Each instrument is compared to a traceable calibration reference before leaving the factory. A copy of the test certificate is supplied with each instrument.

7.3 Recordings Storage

The VectoGraph has a large memory storage capacity. When available storage is nearly exhausted, it automatically deletes the oldest recordings to make space for the newer recordings. In this way the latest recordings is always preserved.

The VectoGraph has 220000 memory locations. These can be filled as follow:

Description	Locations used per event	Available memory Space
RMS Dip/Swell without trends	17	12 941 Events
THD Event	86	2 558 Events
Unbalance event	11	20 000 Events
Regulation event	15	14 666 Events
Voltage Transient event	6	36 666 Events
Trend per sample (minimum)	6	36 666 Intervals
Trend per sample (maximum)	37	5 945 Intervals

Trends are averaged over 10-minute intervals. The duration is between 41 and 254 days.

7.4 Firmware

The VectoGraph uses internal software called firmware to provide its functionality. The version number of this firmware can be viewed with the Power Quality Recorder Software. This firmware is also upgradeable through this software. New firmware is released periodically to fix problems and to provide new features and parameters. Please contact your supplier for a full range of firmware options.

7.5 Access Control

The VectoGraph provides a basic mechanism for protecting access to its recordings and settings. It is not a foolproof mechanism and must be part of a larger strategy for protecting sensitive recordings.

Every VectoGraph has four access levels, with access to each level protected by a password. This table indicate which functions are allowed at each access level

Function vs. Access Level	None	View	Retrieve	Configure	Administration
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Connect	No	Yes	Yes	Yes	Yes
View Meters and configurations	No	Yes	Yes	Yes	Yes
Retrieve Recordings	No	No	Yes	Yes	Yes
Synchronise Clock	No	No	No	Yes	Yes
Change Configuration	No	No	No	Yes	Yes
Configure Clock Synchronisation	No	No	No	Yes	Yes
Change Passwords	No	No	No	No	Yes
Upgrade Firmware	No	No	No	No	Yes

Whenever a function is requested the user is prompted for the applicable password before the function is performed. Passwords can only be changed after entering the Administrator password. Changing the password of an access level to a blank value will disable password checking for that level. This is the default setting.

8 GETTING STARTED WITH A VECTOGRAPH

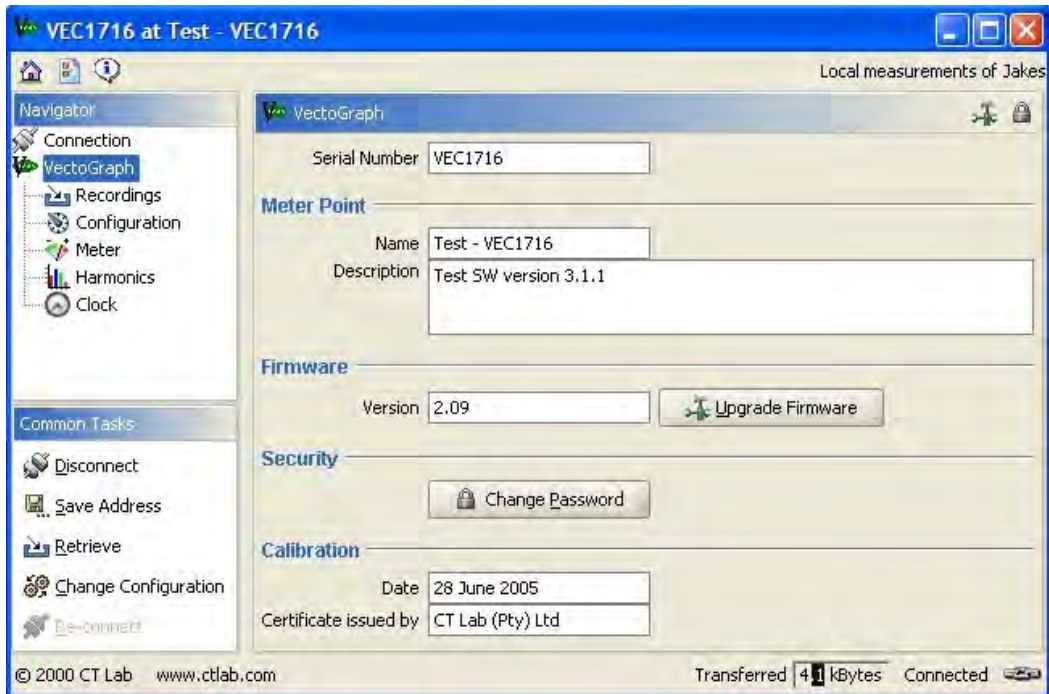
This chapter is for first time users. If you are upgrading from a previous version of the PQR System Software, follow the instructions in the chapter on upgrading instead.

First install the PQR Software on your PC. Full instructions are given the [PQR software Installation](#) chapter.

After you are familiar with the information that can be recorded with the VectoGraph, it is time to work with your VectoGraph.

First you need to make a serial cable connection to the VectoGraph from the software on your PC, as follows:

1. Connect the VectoGraph recorder to mains power or DC power . About 5 seconds after power up the status light will start flashing and the VectoGraph will be ready.
2. Connect the serial cable to the PC Port of the VectoGraph and an unused port of the PC. Make sure that you know which serial port of the PC you are using.
3. Start the **PQR** application.
4. Select the correct serial port in the *Connect to a VectoGraph* panel then click on Connect.
5. The window will change to display the status of the connection and after a while the window will change to indicate that a connection is established. You will see a VectoGraph icon in the navigator panel with options underneath. Browse through the items listed to become familiar with them. Closing this window will disconnect you from the VectoGraph.



You now have the VectoGraph online in front of you. Select the Meter page that will show you what is currently measured on the inputs of the VectoGraph in real time. Remember to always **Disconnect** the software before you remove power from the VectoGraph.

The VectoGraph Voltage Quality Recorder is very easy to physically install. The accompanied software allows the operator to double-check each installed virtual recorder.

This procedure provides guidelines for the installation of VectoGraphs and also serves as a double-check procedure to ensure proper configuration of all the virtual recorders.

8.1 Physical Installation

1. Remove the VectoGraph from shipping and packaging.
2. Check the contents of the parcel. It should contain the instrument, a user's guide, a comms cable and software.
3. Mount the instrument
 - 19" rack unit has two swivel plates on the sides.
 - Surface mount unit has an aluminium bracket screwed onto the bottom of the instrument. This can be rotated and used as a mounting surface.

8.2 Single Phase Connection

1. **Ensure that the power is switched off or that panel fuses are removed !!!**
2. **Check that the voltage input range written on the instrument label correspond to the voltage to be measured at the particular installation.**
3. Earth the instrument to a safe earthing point using the earth- stud.
4. Link voltage measurement N input to auxiliary N input and connect them to system Neutral.
5. Link all three voltage measurement inputs as well as the L auxiliary input together (L + A + B + C) and connect them to system Live.
6. Select voltage selector switch for correct voltage input range. 50-150VRMS on 120V range ; 150-300VRMS on 240V range (50/60Hz) .
7. Switch-on the power.

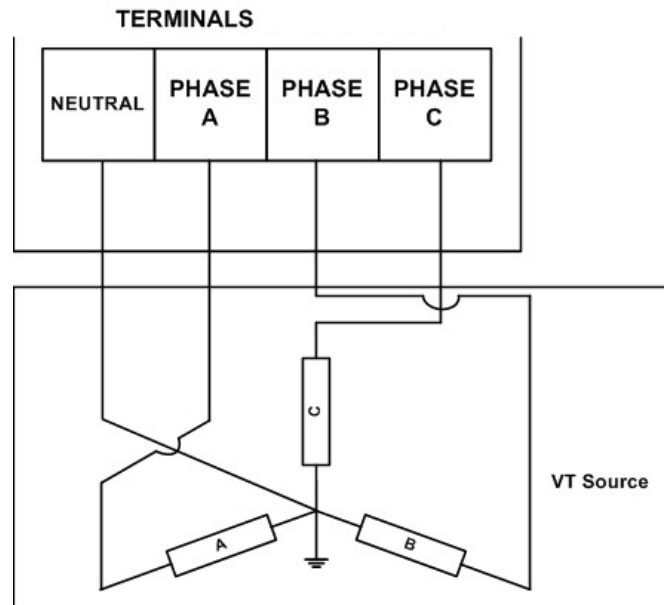
8.3 Three-Phase Star Connection (4 - Wire)

NB: Three phase star connections can only be made onto four-wire systems !

It is very common to find star connected VT's on three-wire systems. In this configuration the star point of the VT is floating and **must not be used at all.** Use the Delta (3-wire) connection described in the next paragraph.

1. **Ensure that the power is switched off and that the VT panel fuses are removed !!!**
2. **Check that the voltage input range written on the instrument label correspond to the voltage to be measured at the particular installation.**
3. Make sure that the VT's are connected to a 4-wire system and not a 3-wire system.
4. Earth the instrument to a safe earthing point using the earth- stud. Now connect voltage measurement N input to the star point of the VT and connect the 3 three voltage measurement inputs to the remaining VT outputs.
5. Connect the Auxiliary L and N input to the System L and N if a separate auxiliary supply is available. OR Connect the Auxiliary L and N input to the Red and White phase (110V line to line) if the unit is to be powered directly from the VT's.
6. Select voltage selector switch for correct voltage input range. 50-150VRMS on 120V range; 150-300VRMS on 240V range (50/60Hz).
7. First switch-on VT-supply and then auxiliary supply if possible. (If the machine is powered before the VT's are connected, the instrument will record a dip – no damage can be caused if this sequence is changed).

Three-Phase Star Connection (4-Wire)



8.4 Three-Phase Delta Connection (3 - Wire)

NB: Three phase delta connections can be made onto both three-wire and four-wire systems !

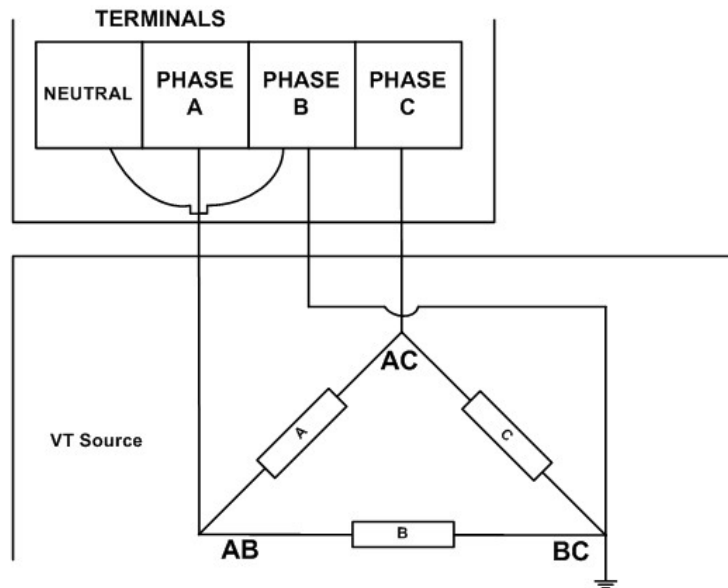
It is very common to find star connected VT's on three-wire systems. In this configuration the star point of the VT is floating and **must not be used at all.**

It is also very common to find the white phase connected to earth. NB: The VectoGraph voltage input N must be tied to the phase that is earthed.

1. **Ensure that the power is switched off and that the VT panel fuses are removed !!!**
2. **Check that the voltage input range written on the instrument label correspond to the voltage to be measured at the particular installation.**
3. Earth the instrument to a safe earthing point using the earth- stud.
4. Connect voltage measurement N input to the VT phase that is earthed or to White phase if the system is not earthed.
5. Connect the 3 three voltage measurement inputs to the remaining VT outputs.
6. Connect the Auxiliary L and N input to the System L and N if a separate auxiliary supply is available OR Connect the Auxiliary L and N input to the Red and White phase (110V line to line) if the unit is to be powered directly from the VT's.

7. Select voltage selector switch for correct voltage input range.
8. First switch-on VT-supply and then auxiliary supply if possible. (If the machine is powered before the VT's are connected, the instrument will record a dip – no damage can be caused if this sequence is changed).

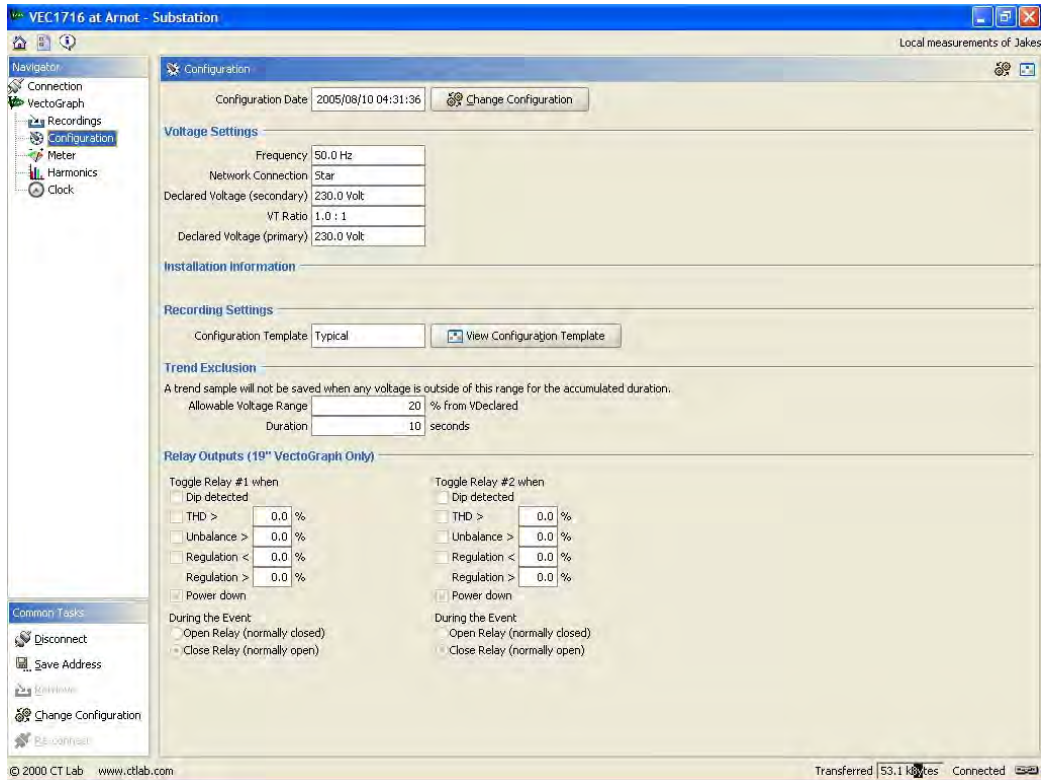
Three-Phase Delta Connection (3-Wire)



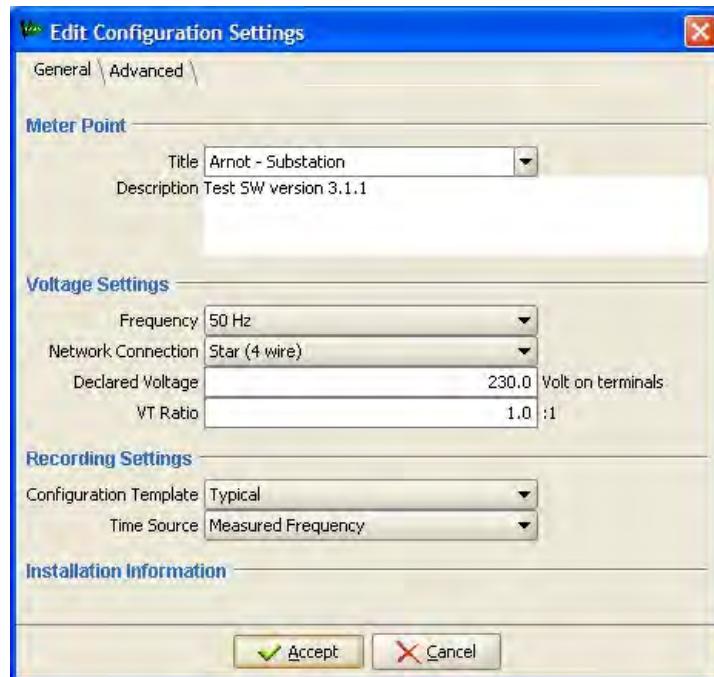
8.5 Configure the VectoGraph

In addition to being physically installed at a meter point, the VectoGraph also needs to be configured properly:

1. Power-up the Instrument, observe the start-up sequence and wait for status light to flash.
2. Establish communication with instrument.
3. Click **Change Configuration** and wait for the VectoGraph to go into Configuration mode. Please note that when in configuration mode no recordings will be made and all previously captured recordings still stored on the instrument will be discarded. If you disconnect at this stage, the VectoGraph will stay in this mode and no recordings will be made.
4. The Configuration Settings dialog will now appear where all configuration information must be entered:

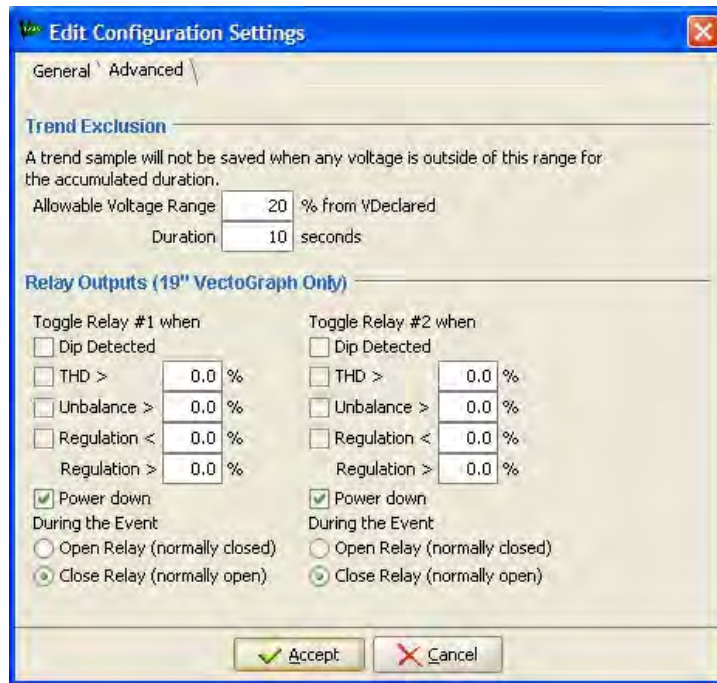


- Changes can now be made in the **Edit Configuration Settings** dialog by clicking **Change Configuration**. First select the General page in the **Edit Configuration Settings** dialog.



- Select or enter a title and description for this Meter Point. This is important since the title will be used to pick out these recordings from those made at other meter points.

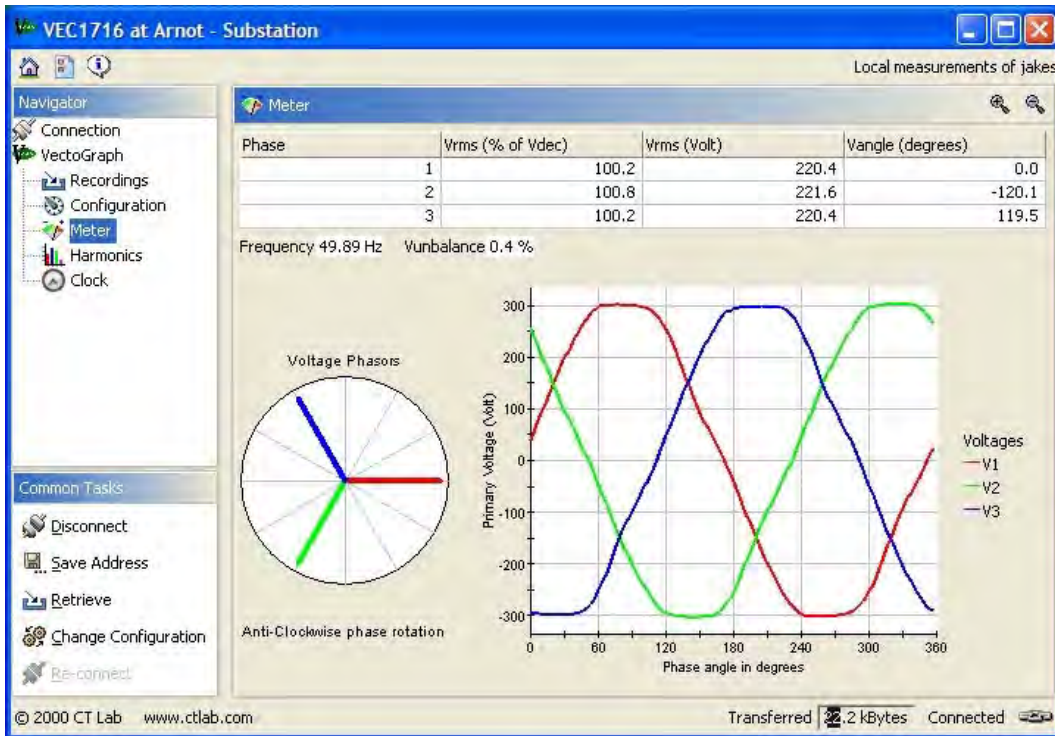
7. Frequency – Select 50 or 60Hz.
8. Network Connection – Select Star (4 wire) or Delta (3 wire) Connection.
9. Declared Voltage (secondary) – specify the declared RMS value of the voltage directly connected to the ImpedoGraph, e.g. 63.5V or 110V or 114.4V or 230V.
10. VT Ratio – Voltage transformer ratio, e.g. an 11kV to 110V VT will have a VT Ratio of 100. Make sure you use only line voltages on delta systems and only phase voltages on star connected systems to determine VT Ratios.
11. Select an appropriate Configuration Template. **Very Important!! (Refer to appendix on Configuration Templates before selecting a Configuration Template)**
12. To set the Trend exclusions and Relay output operation on a 19” VectoGraph, select the advanced page in the **Edit Configuration Settings** dialog.



13. Click Accept in the **Edit Configuration Settings** dialog when the configuration is complete. The VectoGraph will return to recording mode within a few seconds and from then on the VectoGraph is active.

8.6 Verify Installation

1. It is good practise to verify all input connections and configuration after installation and periodically after that. It can be done remotely (e.g. via modem) as well:
2. Connect to the VectoGraph and make sure it is not in Configuration mode.



- Go to the Meter display and verify that all 4 voltages at the terminals of the VectoGraph are present and as expected.
- Inspect the waveforms and expect to see exactly one cycle of voltage and current waveforms for each phase.
- Verify Phase Rotation. With counter clock-wise rotation you have the following **Vangle (degrees)** readings:

Phase 1	0 degrees
Phase 2	+120 degrees
Phase 3	-120 degrees

- Inspect **Vrms (% of Vdec)**. Its value should be close to 100% if all voltages are connected and the **Declared Voltage** setting is correct.
- Inspect **Vrms (Volt)**. It should reflect the primary voltage if the VT Ratio is correct.
- When using the voltage terminal inputs, make sure that all unused channels are shorted. If this is not the case, high DC currents will be observed.

9 PROVOGRAPH RECORDER



The ProvoGraph II is an instrument designed to comply with NRS048 Class 2. The instrument is capable of recording voltage dips, swells and voltage trends. Voltage unbalance is automatically extracted from the voltage trend information.

The instrument is housed in a small aluminium extrusion. The auxiliary supply and the voltage inputs are available on screw terminals. Three LEDs and a RS232 port are the other external inputs and outputs.

The ProvoGraph II calculates the true RMS value of each input phase once every $\frac{1}{2}$ cycle. The sampling rate is 32 samples per cycle. Two thresholds bound the RMS voltage upper and lower limits. If any one of the three voltages exceeds the thresholds, an event is triggered.

The captured event contains the following measurements:

- Date + Time of occurrence
- Duration of event for each phase
- Averaged RMS voltages just before the event
- Minimum and Maximum $\frac{1}{2}$ cycle RMS value of each phase during the event

The $\frac{1}{2}$ cycle RMS readings are averaged (RMS) over a 10-minute interval to obtain a voltage trend.

An internal lithium battery is used to power the non-volatile RAM and the on-board real time clock during the absence of mains power. A separate rechargeable battery is used to support the instrument for up to 5 seconds during long voltage dips or short outages.

The ProvoGraph II is field-upgradeable. New firmware can therefore be downloaded to the instrument if required. The instrument and its included software support modem and serial port communication. An optional three level password scheme protects the ProvoGraph from unauthorised access.

10 GETTING STARTED WITH A PROVOGRAPH

This chapter is for first time users. If you are upgrading from a previous version of the PQRM System Software, follow the instructions in the chapter on upgrading instead.

First install the PQRM Software on your PC. Full instructions are given the [PQRM software Installation](#) chapter.

First you need to make a serial cable connection to the ProvoGraph from the software on your PC, as follows:

1. Connect the ProvoGraph recorder to mains power. About 5 seconds after power up the status light will start flashing and the ProvoGraph will be ready.
2. Connect the serial cable to the PC Port of the ProvoGraph and an unused port of the PC. Make sure that you know which serial port of the PC you are using.
3. Start the **PQRM** application.
4. Select the correct serial port in the *Connect to a ProvoGraph* panel then click on Connect.
5. The window will change to display the status of the connection and after a while the window will change to indicate that a connection is established. You will see a ProvoGraph icon in the navigator panel with options underneath. Browse through the items listed to become familiar with them. Closing this window will disconnect you from the ProvoGraph.



You now have the ProvoGraph online in front of you. Select the Meter page that will show you what is currently measured on the inputs of the ProvoGraph in real time. Remember to always **Disconnect** the software before you remove power from the ProvoGraph.

10.1 Physical Installation

1. Remove the ProvoGraph from shipping and packaging.
2. Check the contents of the parcel. It should contain the instrument, a user's guide, a comms cable and software.
3. Mount the instrument to a flat surface using the holes provided on the casing. Orientation can be in any direction.

10.2 Single Phase Connection

1. **Ensure that the power is switched off or that panel fuses are removed !!!**
2. **Check that the voltage input range written on the instrument label correspond to the voltage to be measured at the particular installation.**
3. Earth the instrument to a safe earthing point using the earth- stud.
4. Link voltage measurement N input to auxiliary N input and connect them to system Neutral.
5. Link all three voltage measurement inputs as well as the L auxiliary input together (L + A + B + C) and connect them to system Live.
6. **Select voltage selector switch for correct voltage input range. 50-150VRMS on 120V range ; 150-300VRMS on 240V range (50/60Hz) .**
7. Switch-on the power.

10.3 Three-Phase Star Connection (4 - Wire)

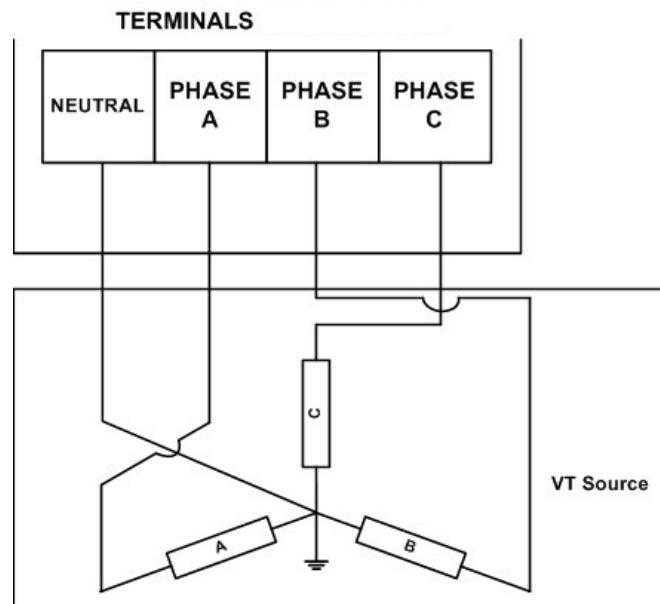
NB: Three phase star connections can only be made onto four-wire systems !

It is very common to find star connected VT's on three-wire systems. In this configuration the star point of the VT is floating and **must not be used at all.** Use the Delta (3-wire) connection described in the next paragraph.

1. **Ensure that the power is switched off and that the VT panel fuses are removed !!!**
2. **Check that the voltage input range written on the instrument label correspond to the voltage to be measured at the particular installation.**

3. Make sure that the VT's are connected to a 4-wire system and not a 3-wire system.
4. Earth the instrument to a safe earthing point using the earth- stud. Now connect voltage measurement N input to the star point of the VT and connect the 3 three voltage measurement inputs to the remaining VT outputs.
5. Connect the Auxiliary L and N input to the System L and N if a separate auxiliary supply is available. OR Connect the Auxiliary L and N input to the Red and White phase (110V line to line) if the unit is to be powered directly from the VT's.
6. Connect the power supply to suit either 120V range or 240V range (50/60Hz).
7. First switch-on VT-supply and then auxiliary supply if possible. (If the machine is powered before the VT's are connected, the instrument will record a dip – no damage can be caused if this sequence is changed).

Three-Phase Star Connection (4-Wire)



10.4 Three-Phase Delta Connection (3 - Wire)

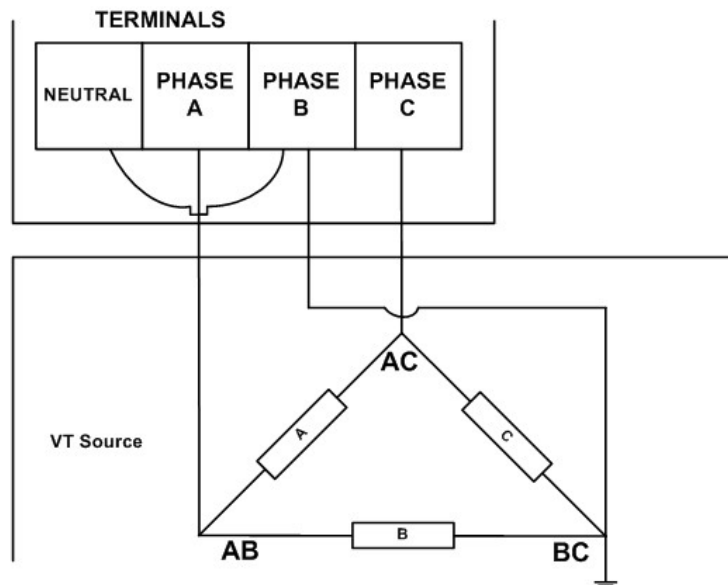
NB: Three phase delta connections can be made onto both three-wire and four-wire systems !

It is very common to find star connected VT's on three-wire systems. In this configuration the star point of the VT is floating and **must not be used at all.**

It is also very common to find the white phase connected to earth. NB: The ProvoGraph voltage input N must be tied to the phase that is earthed.

1. **Ensure that the power is switched off and that the VT panel fuses are removed !!!**
2. **Check that the voltage input range written on the instrument label correspond to the voltage to be measured at the particular installation.**
3. Earth the instrument to a safe earthing point using the earth- stud.
4. Connect voltage measurement N input to the VT phase that is earthed or to White phase if the system is not earthed.
5. Connect the 3 three voltage measurement inputs to the remaining VT outputs.
6. Connect the Auxiliary L and N input to the System L and N if a separate auxiliary supply is available OR Connect the Auxiliary L and N input to the Red and White phase (110V line to line) if the unit is to be powered directly from the VT's.
7. Select voltage selector switch for correct voltage input range.
8. First switch-on VT-supply and then auxiliary supply if possible. (If the machine is powered before the VT's are connected, the instrument will record a dip – no damage can be caused if this sequence is changed).

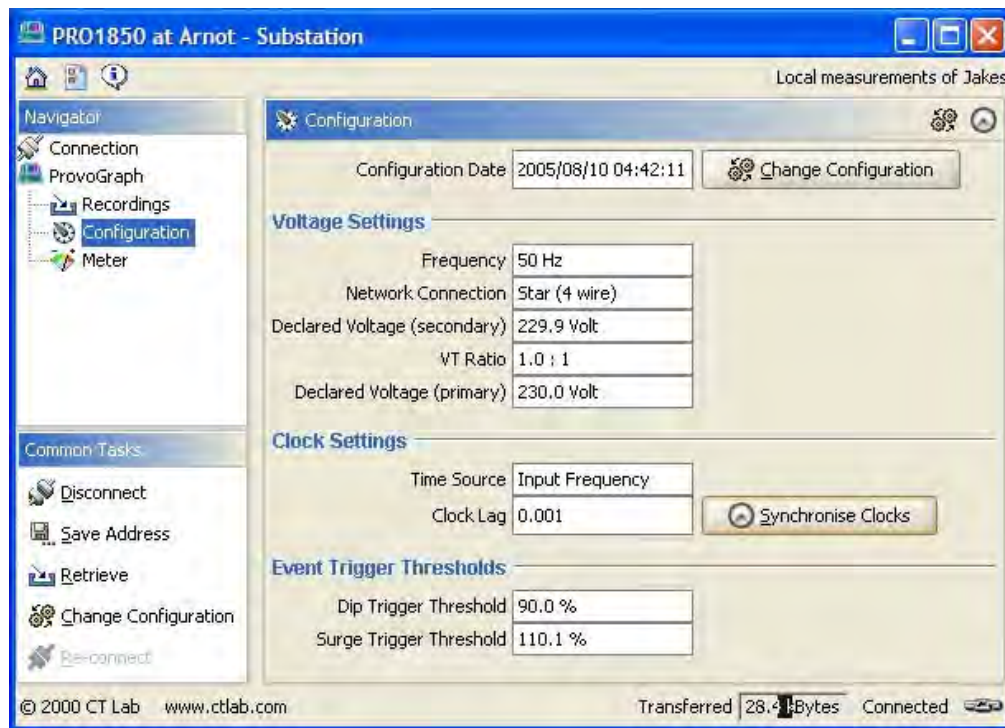
Three-Phase Delta Connection (3-Wire)



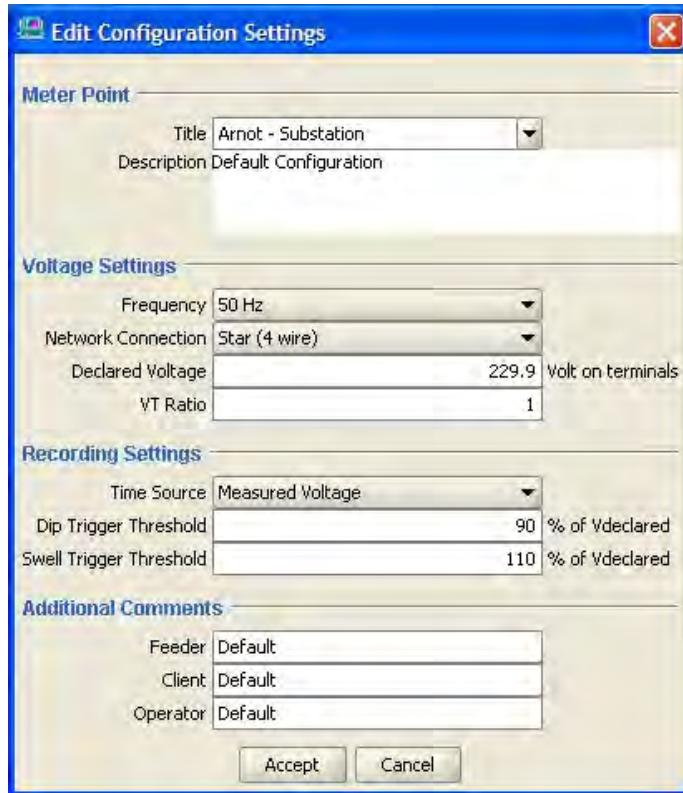
10.5 Configure the ProvoGraph

In addition to being physically installed at a meter point, the ProvoGraph also needs to be configured properly:

1. Power-up the Instrument, observe the start-up sequence and wait for the status light to flash.
2. Establish communication with instrument.
3. Click **Change Configuration** and wait for the ProvoGraph to go into Configuration mode. Please note that when in configuration mode no recordings will be made and all previously captured recordings still stored on the instrument will be discarded. If you disconnect at this stage, the ProvoGraph will stay in this mode and no recordings will be made.
4. The Configuration Settings dialog will now appear where all configuration information must be entered:



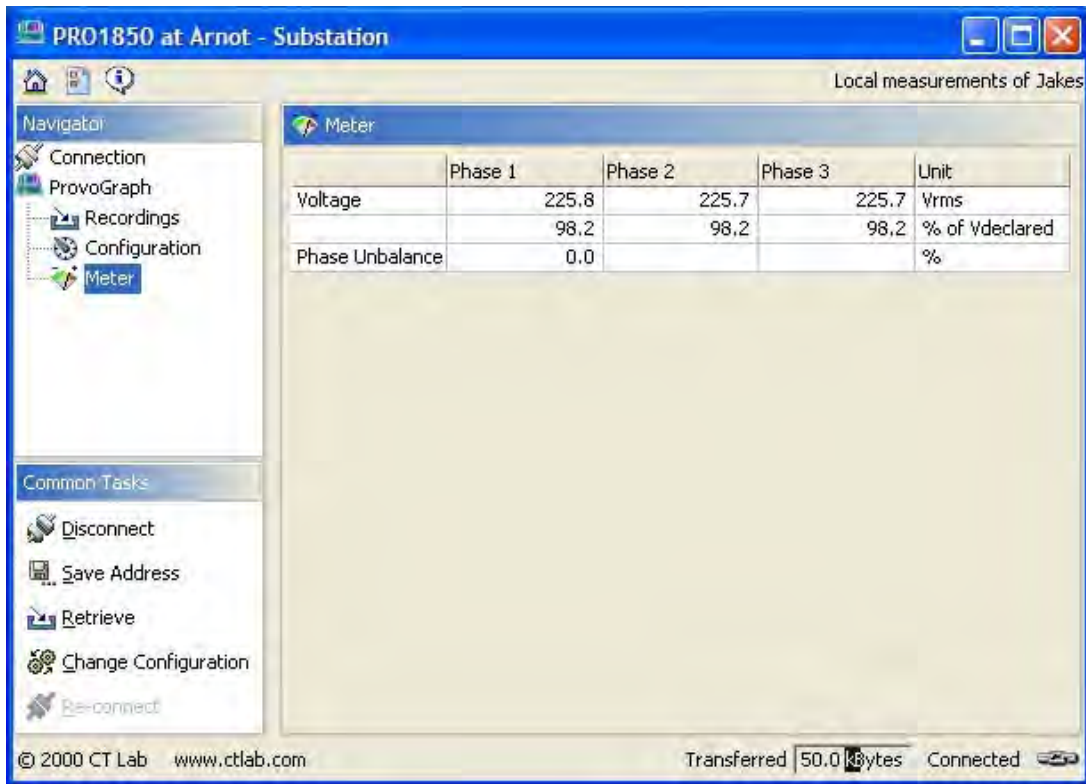
5. Changes can now be made to the configuration and the impact can be viewed by clicking on the **Test** button, which will take you to the Meter panel to inspect their effect. Return to the **Edit Configuration Settings** dialog by clicking **Change Configuration** again.



6. Select or enter a title and description for this Meter Point. This is important since the title will be used to pick out these recordings from those made at other meter points.
7. Frequency – Select 50 or 60Hz.
8. Network Connection – Select Star (4 wire) or Delta (3 wire) Connection.
9. Declared Voltage (secondary) – specify the declared RMS value of the voltage directly connected to the ProvoGraph, e.g. 63.5V or 110V or 114.4V or 230V.
10. VT Ratio – Voltage transformer ratio, e.g. an 11kV to 110V VT will have a VT Ratio of 100. Make sure you use only line voltages on delta systems and only phase voltages on star connected systems to determine VT Ratios.
11. Note that the ProvoGraph does not make use of a Configuration Template. (Refer to Appendix on Configuration Templates)
12. Click Accept in the **Edit Configuration Settings** dialog when the configuration is complete. The ProvoGraph will return to recording mode within a few seconds and from then on the ProvoGraph is active.

10.6 Verify Installation

1. It is good practise to verify all input connections and configuration after installation and periodically after that. It can be done remotely (e.g. via modem) as well:
2. Connect to the ProvoGraph and make sure it is not in Configuration mode.



3. Go to the Meter display and verify that all 4 voltages at the terminals of the ProvoGraph are present and as expected.
4. Inspect **Vrms (% of Vdec)**. Its value should be close to 100% if all voltages are connected and the **Declared Voltage** setting is correct.
5. Inspect **Vrms (Volt)**. It should reflect the primary voltage if the VT Ratio is correct.
6. Inspect **V% Unbalance** It should be very low in a 3 phase system.

11 APPENDIX: CONFIGURATION TEMPLATES


11.1 What is a Configuration Template


The configuration template can be seen as the mask through which the recorder looks at the electrical network. The relevant recorders makes use of the configuration template to evaluate the power quality parameters and stores the events and profiles in accordance with the configuration settings.


Configuration Templates of various complexities can be set-up and stored for later use on both a VectoGraph and ImpedoGraph Power Quality Recorder. The ProvoGraph being a much less complicated machine has only a few configuration settings that have been included in the network configuration editor window.


11.2 Configuration Template Elements


A few standard configuration templates are included in the software. These templates are typical templates to be used with recordings on VectoGraphs and ImpedoGraphs. The different elements of a configuration template is described below:


 **Template Details:** A description for this template can be entered or edited. It is good practice to include as much descriptive information in the template header to enable the user to identify the role of the template at a glance.


 **Harmonics:** The harmonics and inter-harmonics to be recorded are set here. Individual settings can be made for voltages, currents, 3-second and 10-minute intervals. This page can be seen as the harmonic mask. This mask is activated when required by other configuration settings. (Impedo and VectoGraph only)


 **Trends:** The parameters selected here are recorded continuously. Two options are available. 10 minute trends and 3 sec trends. Newer use only the 3 sec trend, but combine it with the 3 sec trend. Both 10 min and 3 sec trending is activated during a detailed investigation. **Important note: Do not leave the recorder for long periods un-retrieved when the 3 sec trends are switched on.** The recorder memory can fill-up in a day due to the massive amount of information captured.


 **Interruptions, Dip and Swells:** All cycle by cycle RMS triggered events are configured here, including trigger modes, trigger thresholds and related trends. Note that different thresholds are normally selected for Transmission and Distribution networks.


 **Voltage Transients:** The capture of high frequency voltage transient events (also called spikes or impulses) is configured here. Recording of related trends can also be enabled. (Impedo and VectoGraph only)

 **Under Frequency:** Detection of low system frequencies is configured here, also with related trends. (ImpedoGraph only)

 **Current Inrush:** Record events when instantaneous currents are high and/or low. (ImpedoGraph only)

 **Logic Input Changes:** Record events when the logic inputs to the recorder changes. (ImpedoGraph only)

 **Harmonic Distortion:** Record events when THD voltages and/or currents are high and/or low. (ImpedoGraph only)

 **Scheduled Recordings:** Regular recording can be scheduled here. These recordings are also marked as events. (ImpedoGraph only)

11.3 Standard Configuration Templates

A few standard configuration templates are included in the software. These range from a standard configuration for a long term statistical measurement to a fairly detailed site assessment investigation. Advanced configuration templates must be set-up by the user for a specific investigation. The standard Templates include:

- NRS 048 Permanent Measurement - Distribution Network
- NRS 048 Permanent Measurement - Transmission Network
- NRS 048 Site Assessment Investigation – Distribution
- NRS 048 Site Assessment Investigation – Transmission

12 APPENDIX: UPGRADING OLDER IMPEDOGRAPHS

This step is only necessary for upgrading an ImpedoGraph with a firmware version smaller than 0.63. First install the new software ([PQRM software Installation](#)) and then follow these steps:

12.1 Install a Driver for a legacy Serial Port connection

All ImpedoGraphs with firmware of 0.63 or later use a new serial cable communication protocol. This protocol requires less setup on the PC and is easier to use. The ImpedoGraph Software 2.2 and later supports both protocols. It is recommended that all existing ImpedoGraphs be upgraded to the protocol.

To upgrade an older ImpedoGraph via its PC port, you first need to communicate with it using the old protocol. This protocol needs an installed modem driver for communication through the serial port. This section describes how to do the setup.

1. Open the Windows **Control Panel** and then open **Modems** (or **Phone and Modem Options** under Windows 2000).
2. Choose **Add** under the Modems panel.
3. Select **Don't detect my modem**, then **Next**.
4. Click **Have Disk** and choose the folder into which you installed the ImpedoGraph software (c:\Program Files\Impedo by default) and click **OK**.
5. Select **ImpedoGraph** and then **Next**.
6. Select the Communications Port you want to use for communications (e.g. COM1) followed by **Next** and **Finish**.
7. The next step is to install Dial-up Networking support for this virtual modem driver. See the **Error! Reference source not found.** chapter for detailed instructions.
8. To start a serial connection with an ImpedoGraph still using the older protocol, select the appropriate modem device on the ImpedoGraph Main Menu, enter any number (does not matter) and click connect.

12.2 Upgrade ImpedoGraph Firmware

This software release introduces a much simpler form of direct serial port communication with ImpedoGraph recorders. This new feature is only enabled in ImpedoGraph firmware version 1.67 or higher and PC Software version 2.2 or higher. Existing ImpedoGraph recorders may not have this firmware version installed, and therefore need to be upgraded first. Here is the procedure:

1. Connect to the ImpedoGraph. To connect via the serial port if the ImpedoGraph's still uses the older protocol, select the **ImpedoGraph Serial Port** (or equivalent)

dial-up connection from the **Modem** drop-down box in the ImpedoGraph Main Menu and click **Connect**. No special setup is required for Ethernet and modem connections.

2. After connection, click **Upgrade Firmware**, and select the file *modem_57600baud.impedoupgrade.impedoupgrade* in the install folder (*C:\Program Files\Impedo* by default)
3. Wait for the upgrade to complete.
4. You should now be able to connect simply by selecting the correct COM port from the Main Menu and clicking **Connect**.
5. If the firmware version of the ImpedoGraph is less than 1.67, upgrade it with the supplied *1_67b.impedoupgrade* file.

13 APPENDIX: MIGRATING FROM VECTOPROVO SOFTWARE

The PQRM software replaces the VectoProvo software as the preferred and supported PC software for working with ProvoGraph and VectoGraph recorders. There are several differences between these software suites. This section provides help for users migrating from the VectoProvo Software Suite.

13.1 Why upgrade?

PQRM has many advantages to the older VectoProvo software suite. Here are the main advantages:

- Multi-recorder: PQRM integrates all ProvoGraph, VectoGraph and ImpedoGraph functionalities into a single software suite.
- Single application: All functionality is now accessible from a single application and menu, instead of the several applications of the VectoProvo software.
- Feature rich: Many more options for connecting, viewing, exporting and reporting.
- No more file based recordings storage: Recordings of a recorders are stored in a single data store, which can be accessed via recorder or Meter Point.
- Modern: PQRM runs on modern PCs and operating systems (Windows XP) and is under active development

13.2 Limitations

The structure of the PQRM software system imposes some limitations on the use of the VectoGraph and ProvoGraph that the VectoProvo software did not:

- The duration of the averaging interval is not configurable any more, but fixed at 10-minute interval, which is required by all modern Power Quality standards.
- The VectoGraph cycle-by-cycle phasor trends, captured during events, cannot be accommodated in the PQRM, so they become unusable.
- A VectoGraph can no longer be configured to stop recording when its memory is full. The oldest recordings will always be replaced with new recordings when necessary, so the VectoGraph will always keep the most recent recordings possible given its storage capacity.
- The ProvoGraph could be set up for single-phase measurements, but this configuration is not currently supported by the PQRM system, so a ProvoGraph must be configured as either 3 phase star (4 wire) or 3 phase delta (3 wire).

13.3 No more file management

Users of the VectoProvo Software Suite are used to saving Power Quality recordings to files for storage. These files must be managed manually and viewed individually. This often results in lost and/or unstructured measurement files distributed over a number of directories or even PCs.

PQRM brings the ImpedoGraph recordings storage model to VectoGraph and ProvoGraph recordings. All recordings are stored and accessed from one application, via a Meter Point attribute.

The user will no longer be prompted to supply a file name when retrieving recordings. The retrieved recordings are automatically stored under the recorder serial number and its Meter Point as entered during configuration.

13.4 Migrating existing recordings

Users of the VectoProvo software will keep their measurements in collections of REV and REP files. These recordings can and should be imported into PQRM. Once imported the improved PQRM event browsing, trend browsing and reporting tools can be used on the existing measurements. Simply follow the instructions in the section on REP and REV importing.

13.5 Shared Configuration Templates

VectoGraph users are used to the concept of Configuration Templates. PQRM expands on this feature. Configuration Templates are now recorder neutral, i.e. the same Configuration Template can be used on a VectoGraph or an ImpedoGraph. The template fields and also the layout of the template editor have also changed. The differences are:

- Voltage thresholds are now always shown and entered in the new IEC61000-4-30 format, which is as *% of $V_{declared}$* , instead of *% from $V_{declared}$* . For example, where a dip threshold was previously specified as *-10% from $V_{declared}$* , the same threshold is now *90% of $V_{declared}$* .
- Averaged trends always average over 10-minute intervals as required by all modern Power Quality standards.

Of course, all recorders cannot support all template settings. If a recorder cannot do the recording required by a template setting (e.g. VectoGraph cannot record currents or pre-dip cyclic trends) no recordings of that type is made.

Existing VectoGraph template files can be imported into PQRM. Clicking **Import Template** in the Configuration Template Editor and selecting the **cfv** template file (usually stored in **c:\vectodata**).

13.6 Connecting to a recorder

Interactive connections to all recorders can now be initiated from the main window of the PQRM application. Simply select the recorder type and the correct serial port, and then click Connect.

The menu window will now change to a connection window (similar to VectoComms and ProvoComms)

After successful connection, the available recorder panels will be listed in the Navigator panel to the left. These are similar to the tabs in VectoComms and ProvoComms and clicking them will select different view panels.

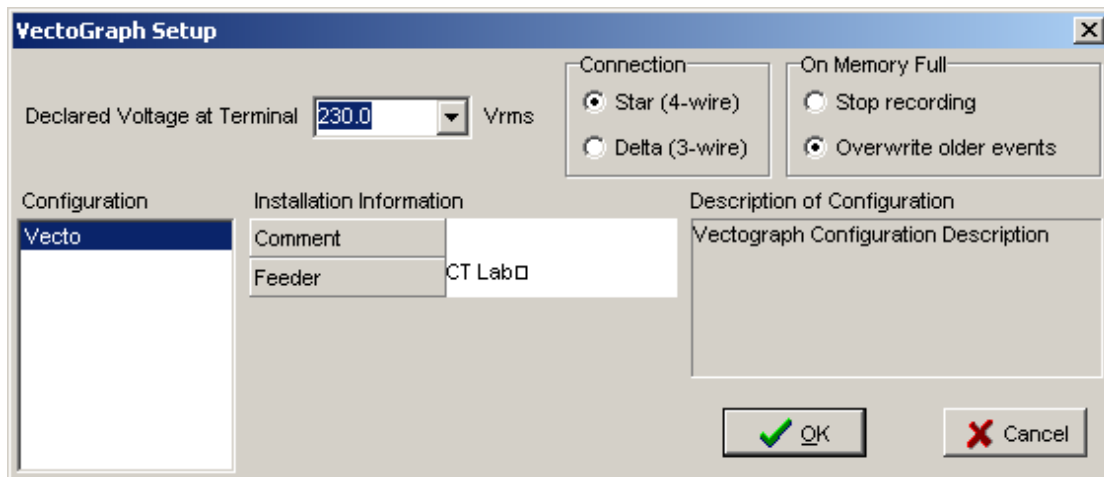
In contrast to VectoComms and ProvoComms, this window will remain open after disconnection or unsuccessful connection. This allows you to view the connection history on the Connection panel and also to reconnect from the Common Tasks menu.

Once a connection is attempted it can be saved to the address book by clicking Save Address in the Common Tasks menu. Saved addresses are visible in the main menu and can be used by double-clicking the address there. This single address book contains connection information for all recorders in a single location.

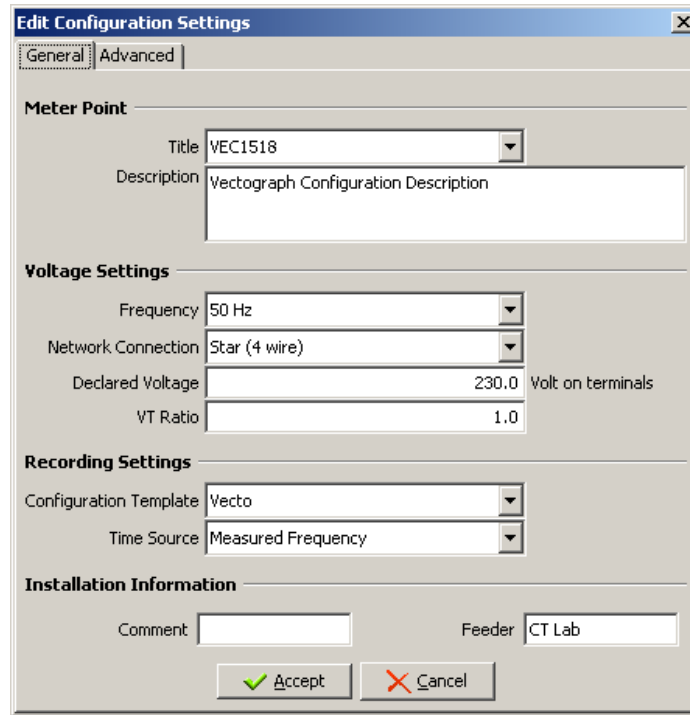
Automatic retrieval can be scheduled for any recorder in the address book. This process is described elsewhere in this guide.

13.7 VectoGraph Configuration

Users of the VectoProvo software are used to completing this dialog during configuration of a VectoGraph recorder:



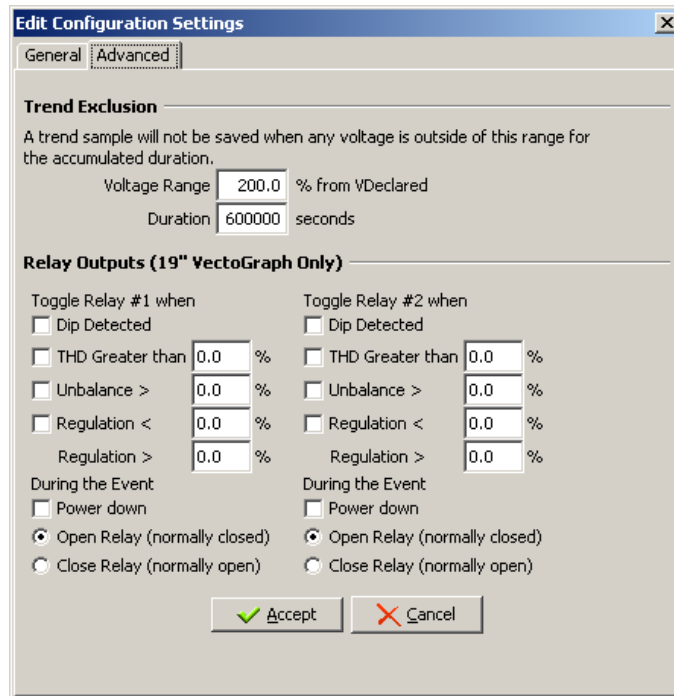
PQRM replaces this dialog with one that is very similar to the new ProvoGraph and ImpedoGraph configuration dialog:



Here are the important changes:

- A Meter Point must now be specified during configuration. This is a very important setting, since all recordings made with this configuration will be “filed” under the Meter Point title specified here. You can either select a Meter Point from a list of known and already used Meter Points, or enter a new one.
- VT Ratio: A VT Ratio can now be specified. All recorded voltages will be shown as primary voltages, which is after all the real voltage being measured.
- A VectoGraph can no longer be configured to stop recording when its memory is full. From now on the oldest recordings will always be replaced with new recordings when necessary, so the VectoGraph will always keep the most recent recordings possible given its storage capacity.
- The averaging interval is not configurable any more, but fixed at 10-minute interval, which is required by all modern Power Quality standards.

The configuration dialog also contains this second page, where advanced settings can be adjusted:

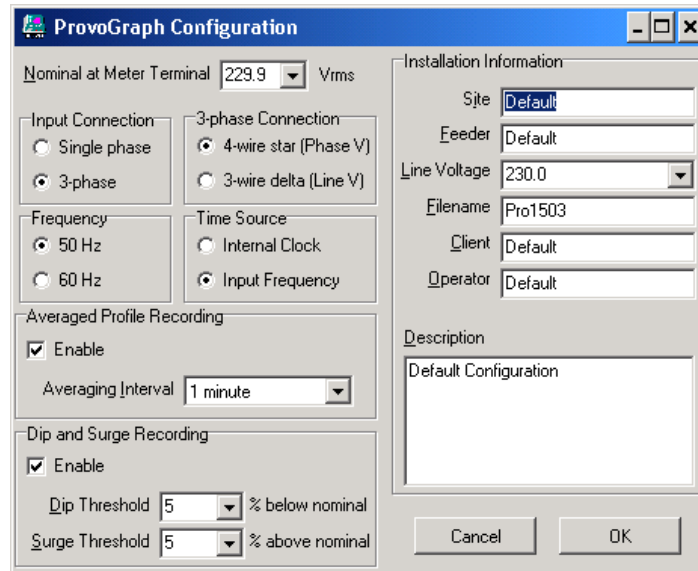


This page contains settings that were previously made in the configuration Template Editor. These settings are specific to the VectoGraph and are now adjustable during configuration:

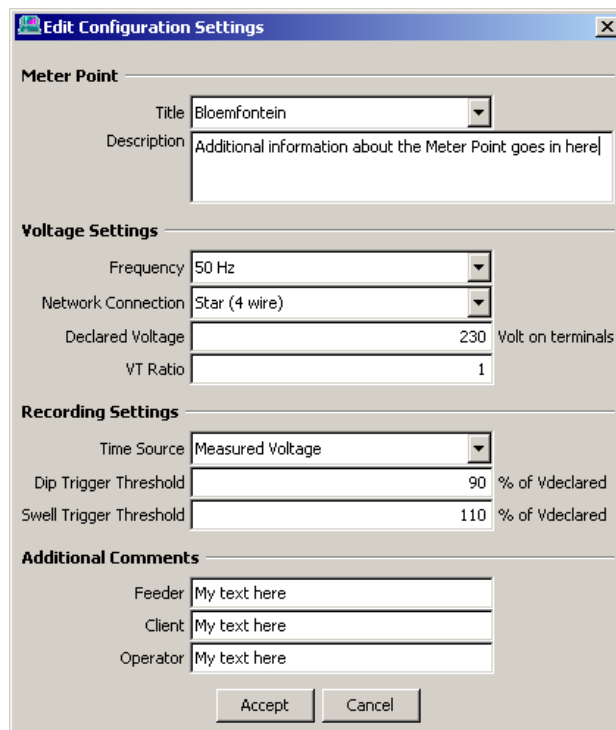
- Trend exclusion: This feature used to be known as Averaging Validation Criteria and is used to discard trend samples that meet these criteria. The settings are still the same.
- Relay outputs: These settings are identical to those from the previous Configuration Template editor. Just remember that the regulation thresholds are now specified in the new **% of V_{declared}** format.

13.8 ProvoGraph Configuration

Users of the VectoProvo software are used to completing this dialog during configuration of a ProvoGraph recorder:



PQRM replaces this dialog with one that is very similar to the new VectoGraph and ImpedoGraph configuration dialog:



Here are the important changes:

- A Meter Point must now be specified during configuration. This is a very important setting, since all recordings made with this configuration will be “filed” under the Meter Point title specified here. You can either select a Meter Point from a list of known and already used Meter Points, or enter a new one.
- VT Ratio: A VT Ratio can now be specified. All recorded voltages will be shown as primary voltages, which is after all the real voltage being measured.

- The averaging interval is not configurable any more, but fixed at 10-minute interval, which is required by all modern Power Quality standards. Trend recording can also not be disabled any more.
- Single-phase Meter Points are not currently supported by the PQRM system, so the previous single-phase configuration is no longer possible.
- Dip thresholds are now entered in the new **% of V_{declared}** format.

13.9 Connecting via Modem

Modem support in the VectoProvo software was built on top of the Microsoft Telephony technology (TAPI), which involved installing standard Windows modem drivers.

PQRM takes a different approach. It uses modems directly via the PC serial port. This allows more direct control over the modem being dialled from, which results in higher reliability.

To set up modem(s) for use, connect and switch them on, then open the Preferences dialog from the toolbar and hit the **Search** button under the heading **Serial Port Modems**. After a few seconds, your modem(s) will appear in the **Default Modem** drop-down box, and you can select a default modem.

To connect using this modem, open a new main menu (the **Home** toolbar button), first select the target recorder type, then select the modem, then enter the phone number and hit **Connect**. The address book is very useful for saving modem connections.

13.10 Viewing recordings

Recordings can be viewed directly from a connected recorder window, by using the **Browse Events** and **View Trends** buttons on the **Recordings** panel. A new window will open, showing the most recent retrieved recordings from that Meter Point.

Alternatively, recordings can be accessed from the main menu, by selecting one or more Meter Points, and hitting one of the buttons next to the list. You will always be taken to the most recent recordings of that Meter Point(s).

The PQRM event browser has several new features not found in the VectoProvo event browser:

- **Multiple event classifications:** PQRM can classify events by different standards (currently NRS048-1994, NRS048-2003 or EN50160-1994). VectoProvo only supported NRS048-1994. The preferred standard can be selected in the Preferences dialog.
- **Multiple Meter Points:** Events from more than one Meter Point can be shown in the same window.
- **Selectable viewing period:** Events are displayed for a user selectable time period, which can be adjusted.
- **Available Recordings:** A Gantt chart shows for which dates recordings are accessible. It superimposes the selected time period for which events are listed.

- Combined event list: All events are shown in a single list, where in the VectoProvo software events of each type were listed separately.
- Sortable event list: The event list can be sorted according to any column by clicking on the column header.
- Chronology View: The event start times of all events in the selected time interval can be seen on this Gantt chart.

Likewise, the PQRM Trend Browser also has some differences:

- Available Recordings: A Gantt chart shows for which dates recordings are accessible. It superimposes the selected time period for which events are listed.
- Week at a time: Trend charts are displayed in week intervals, with options for next and previous weeks.
- Multiple charts: More than one chart can be displayed underneath each other, but still sharing the same time axis. The secondary (right side) axis is no longer used, because it is difficult to zoom and pan independently.
- Excel export: Trends can be directly exported into Microsoft Excel by selecting a chart from the legend to the left, and then hitting the **Copy to Excel** button.

The ProvoGraph user initiated cyclic trends are now displayed in the PQRM Event Browser as events entitled **Manual Recording**. They can be browsed from there by hitting the phasor view button.

13.11 Compatibility with VectoProvo software

The VectoProvo software can still be used along with the PQRM software, with a few provisions:

- Recorder configuration should be done with the PQRM software: If a configuration is done with the VectoProvo software, recordings could be inaccessible from the PQRM software, because of invalid Meter Point names or configuration settings. Non 10-minute trend interval, in particular, will not be retrievable with PQRM.
- PQRM cannot generate REV or REP retrieved files like the VectoProvo software. Recordings retrieved using PQRM can therefore not be viewed with VectoViews or ProvoViews.
- As stated previously, VectoGraph cyclic phasor trends (during events) cannot be accommodated in the PQRM, so these recordings are not retrieved into the PQRM.
- If a ProvoGraph is set up for single-phase measurement using VectoProvo software, its recordings will be imported into PQRM as if it was configured as 3-phase star connect (4 wire). See section 13.2 for more information.

14 APPENDIX: RECOMMENDED CALIBRATION PROCEDURE

This appendix provides guidelines on verification and calibration of CT Lab power quality recorders.

Modern instruments such as the ImpedoGraph use electronic calibration methods to store and digitally process measurement correction constants for linear error terms. High quality instrument designs minimize non-linear error terms by design such that no user corrections are necessary to compensate for these non-ideal behaviours.

In addition, digital circuits, software algorithms and digital signal processing techniques whose characteristics do not change with time, temperature and other factors, have replaced traditionally analog behaviours of instruments. Therefore, many of the historical beliefs and experiences of users and calibration laboratories that developed with past generations of measuring instruments are becoming increasingly obsolete and outdated; particularly when inferring sources of measurement error in modern instrument designs.

In particular, some AC measuring characteristics are determined by fixed, digital signal processing algorithms (DSP) and therefore do not require user verification. These behaviours have been verified earlier through extensive product design validation testing.

Since independent verification of every possible measured value is, and always will be, impractical by end users, one must rely on the guidance and integrity of the instrument manufacturer to specify appropriate calibration procedures for the instrument, given their detailed knowledge of design limitations and instrument failure modes.

Users should augment the manufacturer's verification procedures, as they deem necessary, to achieve higher verification confidence at application-critical measurement points.

14.1 Testing

CT Lab calibrates and tests every instrument before delivery. The company's verification procedures are designed to achieve >99% confidence that the instrument conforms to all published measurement specifications and that it is fully functional for use.

The accuracy of each instrument is verified before delivery and a Test Certificate is issued as proof of this. However, this verification is done in a controlled environment, and CT Lab cannot guarantee the accuracy of the instrument during operation, due to unknown external factors and operating conditions.

It is the responsibility of the client to ensure the instrument remains accurate during its life cycle.

14.2 Periodic Verification

CT Lab makes recommendations for periodic verification based upon our extensive statistical analysis of both characterization data gathered during design verification testing and through on going monitoring of production processes. During manufacturing, significantly more verification data are gathered and used to monitor product performance and to assure our outgoing product quality.

Based on these factors CT Lab recommends that the accuracy of every instrument should be verified every three to five years.

Please note that this is a recommendation only, and that users should decide on verification procedures based of the application of the instrument and also in accordance with its own calibration policy.

CT Lab offers such a verification service and will issue a new Test Certificate after verifying calibration.

15 APPENDIX: PQ RECORDER SPECIFICATIONS



ImpedoGraph Specifications

ImpedoGraph Specifications

Voltage Inputs

Number of channels	4 x differential voltage inputs
Input range	0 - 300 V _{RMS}
Accuracy	0.1% on reading (50-300V _{RMS})
Resolution	20 mV _{RMS}
Input Impedance	> 1M Ω m (purely resistive)
Impulse Measurement range	6.0 kV
Impulse accuracy	1% of full scale (> 10ms rise time)

Current Inputs

Number of channels	4 x galvanically isolated current inputs
Input range	7.5 A _{RMS}
Accuracy	250 μ A _{RMS}
VA loading	< 0.1VA @ 7.5 A _{RMS}
3 Sec Over-current withstand	50 A _{RMS}
Continuous over-current withstand	10 A _{RMS}

Alternative Current Transducer Inputs

Number of channels	4 x differential voltage inputs
Input range	2.0 V _{RMS}
Accuracy	100 μ V _{RMS}
Input Impedance	> 1M Ω m (purely resistive)

Analog to Digital Conversion

ADC resolution	16 bits
Maximum analog noise	0.05% of full scale
Sampling rate	128 samples per cycle (phase locked) with 4 times over-sampling
Frequency locking range	40-70 Hz

Status Inputs

Number of channels	8 x Differential Voltage inputs
Input range	\pm 300 VDC
Logical threshold	9.0 VDC
Continuous withstand capability	300 V _{RMS}

Data Storage

Capacity	64 Mbytes Flash RAM
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Real Time Clock

Type	5-year battery backed
Sync source	External GPS or mains
GPS input port	RS232 + RS422
Accuracy	10 PPM (unsynchronised)

Communications

Serial Ports	1 x RS232 (direct) 1 x RS232 (modem)
Ethernet	TCP/IP (RJ45 UTP)
Telemetry port	RS485 + RS232

Supply voltage

Input range	80 - 270 V _{RMS}
Frequency range	40-70 Hz
Dip "Ride through" capability	10 seconds (during complete power failure) or longer with suitable external UPS
Internal energy storage medium	High voltage capacitors (zero maintenance)

Note: Specifications may change without prior notification.



VectoGraph Specifications

Voltage Input

Voltage input range (phase to earth)	15 - 150V _{RMS} 30 - 300V _{RMS}
RMS accuracy	0.1% of full scale
Input impedance	purely resistive > 1M Ω
Frequency range	48 - 52 Hz or 58 - 62 Hz
Connection	3 wire or 4 wire (phase or line voltage)

Spike Input

Spike voltage input range (phase to earth)	2.0 kV peak every cycle (300V Model)
Spike resolution	1.0 V
Spike accuracy (1 μ s rise time)	5% of full scale
Spike accuracy (5 μ s and longer rise time)	2% of full scale
Connection	4 wire (phase voltage)

Analog to Digital Converter

ADC resolution	12 bit (0.05% of full scale)
Sampling rate	128 times fundamental frequency

Memory

Memory	512KB battery backed non-volatile SRAM
Retention time	5 years

Real Time Clock

Type	5-year battery backed
Accuracy	100 PPM (when not synchronized to mains)
Sync source	A phase voltage input (sync to mains)

Communications Ports

Type	RS232 and RS485 twisted pair port
Modem	support 3 wire modem interface
Isolation	opto-isolated (1kV)
Baud	rate 9600 baud

Supply voltage

AC Voltage input range	85 - 135 V _{RMS} and 170 - 270 V _{RMS} (50/60Hz)
DC Voltage input range	50 - 150 VDC
Dip ride through capability	10 seconds after complete power failure
Internal energy storage medium	high voltage capacitors

Other

Voltage and power input terminals	screw type barrier connectors
Dimensions	300 x 220 x 75 mm

PC Software

Operating System	Windows 95, 98, 2000, XP
Data presentation	Graphical and textual
Data Output	Screen, file and printer

Note: Specifications may change without prior notification.



ProvoGraph Specifications

Voltage Inputs

RMS voltage input range (phase to earth)	30- 300V _{RMS} accuracy 0.2% of full scale
Input impedance purely resistive	> 1M Ω
Frequency range	48 - 52 Hz or 58 - 62 Hz
Connection	3 wire or 4 wire (star or delta)

Analog to Digital Converter

ADC resolution	12 bit (0.05% of full scale)
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Memory

Memory	64 Kbytes battery backed SRAM
Retention time	5 years

Real Time Clock

Type	5-year battery backed
Accuracy	100 PPM

Communications Ports

Type	RS232
Modem support	3 wire modem interface
Isolation	opto-isolated (1kV)
Baud rate	9600 baud

Supply voltage

AC Voltage input range	85-135 V _{RMS} 170-270 V _{RMS}
Dip ride through capability	10 seconds

PC Software

Operating System	Windows 95, 98, 2000, XP
Data presentation	Graphical and textual
Data Output	Screen, file and printer

Note: Specifications may change without prior notification.

16 GLOSSARY

What does this word actually mean?

16.1 Anomaly

A deviation from expected voltage quality, whether it is transient, momentary or steady state.

16.2 Dialog Box

A window which appears and prompts one to open a file, save a file etc.

16.3 Dip

RMS under-voltage that lasts from one cycle up to a few seconds (also called a depression or sag).

16.4 Event

A voltage quality anomaly captured and saved by a virtual recorder.

16.5 Exceedance

A steady-state voltage anomaly.

16.6 Profile

A continuous graphable set of samples of a certain parameter.

16.7 Surge

RMS over-voltage that lasts from one cycle up to a few seconds.

16.8 Virtual Recorder

An independent event recorder implemented in software within the ProvoGraph.