

# MPD 600

## User Manual



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OMICRON electronics translates this manual from the source language English into a number of other languages. Any translation of this manual is done for local requirements, and in the event of a dispute between the English and a non-English version, the English version of this manual shall govern.

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## Using This Manual

This User Manual provides information on how to use the *MPD 600* Partial Discharge Measuring System safely, properly and efficiently. The *MPD 600* User Manual contains important safety rules for working with the *MPD 600* and gets you familiar with operating the *MPD 600*. Following the instructions in this User Manual will help you to prevent danger, repair costs and possible down time due to incorrect operation.

The *MPD 600* User Manual always has to be available on the site where the *MPD 600* is used. It must be read and observed by all users of the *MPD 600*.

Reading the *MPD 600* User Manual alone does not release you from the duty of complying with all national and international safety regulations relevant to working on high-voltage equipment.

## Symbols Used

In this manual, the following symbols indicate safety instructions for avoiding hazards.

Symbol	Description
	<b>Caution:</b> Equipment damage or loss of data possible
	<b>Warning:</b> Personal injury or severe damage to objects possible



# Safety Instructions

## Operator Qualifications

Working on high-voltage assets can be extremely dangerous. Testing with the *MPD 600* must be carried out only by qualified, skilled and authorized personnel. Before starting to work, clearly establish the responsibilities.

Personnel receiving training, instructions, directions, or education on the *MPD 600* must be under constant supervision of an experienced operator while working with the equipment.

Testing with the *MPD 600* must comply with the internal safety instructions as well as additional relevant documents.

In addition, observe the following safety standards, if applicable:

- EN 50191 (VDE 0104) "Erection and Operation of Electrical Equipment"
- EN 50110-1 (VDE 0105 Part 100) "Operation of Electrical Installations"
- IEEE 510 "IEEE Recommended Practices for Safety in High-Voltage and High-Power Testing"

## Safety Standards and Rules

Before operating the *MPD 600*, read the following safety rules carefully. If you do not understand some safety rules, contact OMICRON electronics before proceeding. Observe the safety rules in this User Manual when working with the *MPD 600*.

Maintenance and repair of the *MPD 600* is only permitted by qualified experts at OMICRON electronics repair centers.

**General:** Always observe the five safety rules:

- Disconnect completely
- Secure against re-connection
- Verify that the installation is dead
- Carry out grounding and short-circuiting
- Provide protection against adjacent live parts

Always obey the following warnings to avoid injury and damage to the MPD system:

- Rules for working in areas with high-voltage must be obeyed at all times.
- Never touch parts which are under high voltage.
- A high-voltage test setup must not be used without being grounded.

## Operating the Measurement Setup



**Warning:** Before switching on the high voltage, make sure to clear the high-voltage area. Always obey the five safety rules and follow the detailed safety instructions.

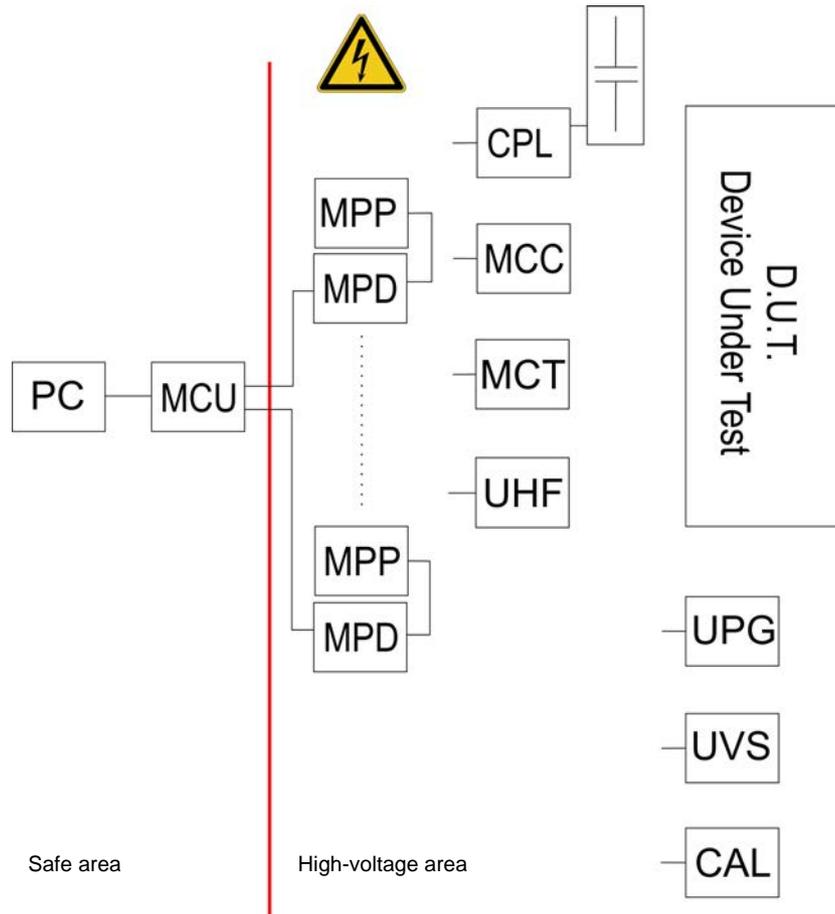


Figure 1-1 Example for the separation of safe area and high-voltage area using different OMICRON electronics devices

Before performing tests using high voltage, observe the following instructions:

- Do not insert objects (for example, screwdrivers, etc.) into any input/output socket.
- Do not operate the *MPD 600* and *MPP 600* under ambient conditions that exceed the temperature and humidity limits listed in 8 "Technical Specifications" on page 217.
- Check your additional equipment (PC) for environmental conditions before use.
- Make sure to position the test equipment on dry, solid ground.
- Always use dry and clean fiber-optic cables. In dusty regions, use protective caps. Make sure that the cables have earth contact to avoid leakage current.
- Use only the OMICRON electronics original accessories and cables.
- Do not operate the *MPD 600* and *MPP 600* in the presence of explosives, gas or vapors.
- Opening the *MPD 600* or other accessories invalidates all warranty claims. Risk of electrical shock!
- If the *MPD 600* or other accessories do not seem to function properly (for example, in case of cable damages, abnormal warning of the batteries during charging, or overheating of components), do not use them anymore. Please call the OMICRON electronics technical support.



**Warning:** The *MPP 600* is a rechargeable lithium battery. Risk of fire and burns. Do not drop or crush, do not short circuit, do not open, do not expose the battery to high temperatures. Must be disposed of properly, may explode if damaged or disposed of in fire. Do not immerse in any liquids, read the User Manual before charging, do not charge in flammable environment, do not charge below 0 °C (32 °F) and above 35 °C (95 °F) or discharge below -20 °C (-4 °F) and above 60 °C (140 °F), use specified charger only. Please refer to the User Manual or follow local ordinances and/or regulations for usage of lithium batteries.



**Warning:** Working in the area of high-voltage systems is very dangerous! Make sure to observe dangerous areas. Always obey the internal safety instructions for working in areas with high voltage to avoid injury.

## Orderly Measures

The digital *MPD 600* User Manual has always to be available on site where the *MPD 600* is being used. They must be read and observed by all users of the *MPD 600*.

The *MPD 600* may be used only as described in this User Manual. Any other use is not in accordance with the regulations. The manufacturer and/or distributor is not liable for damage resulting from improper usage. The user alone assumes all responsibility and risk.

Following the instructions provided in this User Manual is also considered part of being in accordance with the regulations.

## Disclaimer

If the equipment is used in a manner not specified by the manufacturer, the protection provided by the equipment may be impaired.



# 1 MPD 600 System

The MPD Partial Discharge Analysis System is an acquisition and analysis toolkit for detecting, recording, and analyzing partial discharge events in many applications. It is suited for laboratory and on-site measurements of high-voltage systems and power transformers, and rotating machines.

It is controlled by the integrated MPD/MI software featuring real-time visualization and analysis options of PD detection and system parameters.

This manual reflects version 1.6.0 and higher of the MPD/MI software.

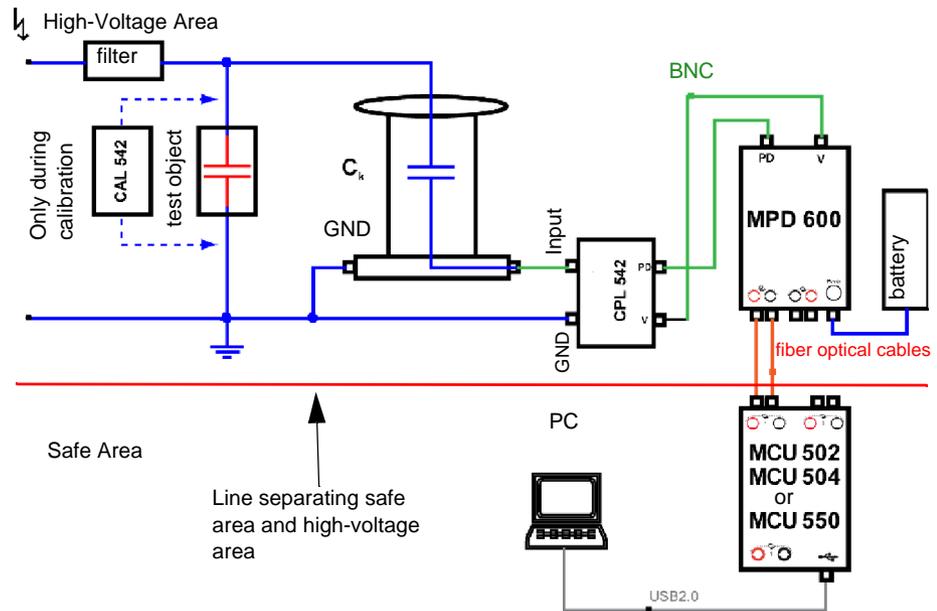


Figure 1-2 Connection diagram

**Note:** Keep all cables in the signal path (marked green) as short as possible.

## 1.1 System Overview

The *MPD 600* acquisition unit should be placed as close as possible to the coupling capacitor ( $C_k$ ) and the test object. Fiber optical cables (marked orange) connect the test setup to the control PC and provide complete electrical insulation. Fiber optical cables used with the *MPD 600* may be up to 2 km in length. Substitute the battery pack with the power supply if desired.

**Note:** In this case, the electrical insulation is lost.

## 1.2 Hardware Setup



**Warning:** Switch off the high voltage before setting up the system. Always observe the five safety rules (see "General: Always observe the five safety rules:" on page 16).

1. Connect the *MPD 600* acquisition unit (2) (at the plugs marked ) to the MCU 502/504/550 (1) control unit using fiber optical cabling (6).

**Note:** The plugs are color-coded.

2. Connect the MPP 600 (3) battery pack to the *MPD 600* acquisition unit using the battery cable (8). The red LED at the *MPD 600* unit starts flashing, indicating that the acquisition unit is ready for operation.



**Warning:** The *MPP 600* is a rechargeable lithium battery. Risk of fire and burns. Do not drop or crush, do not short circuit, do not open, do not expose the battery to high temperatures. Must be disposed of properly, may explode if damaged or disposed of in fire. Do not immerse in any liquids, read the User Manual before charging, do not charge in flammable environment, do not charge below 0 °C (32 °F) and above 35 °C (95 °F) or discharge below -20 °C (-4 °F) and above 60 °C (140 °F), use specified charger only. Please refer to the User Manual or follow local ordinances and/or regulations for usage of lithium batteries.

3. Connect the CPL 542 (5) quadripole/measuring impedance unit. Use two short BNC cables (7) and connect the PD and V outputs of the CPL 542 to the PD and V inputs of the *MPD 600*.
4. Connect the CPL 542 unit to a high-voltage coupling capacitor (for example, MCC unit) and ground the system. Keep the cable(s) as short as possible.
5. Connect the MCU unit to the computer using the USB cable (9).

6. Calibration: Only for calibration connect the CAL 542 (4) calibration unit to the test object.

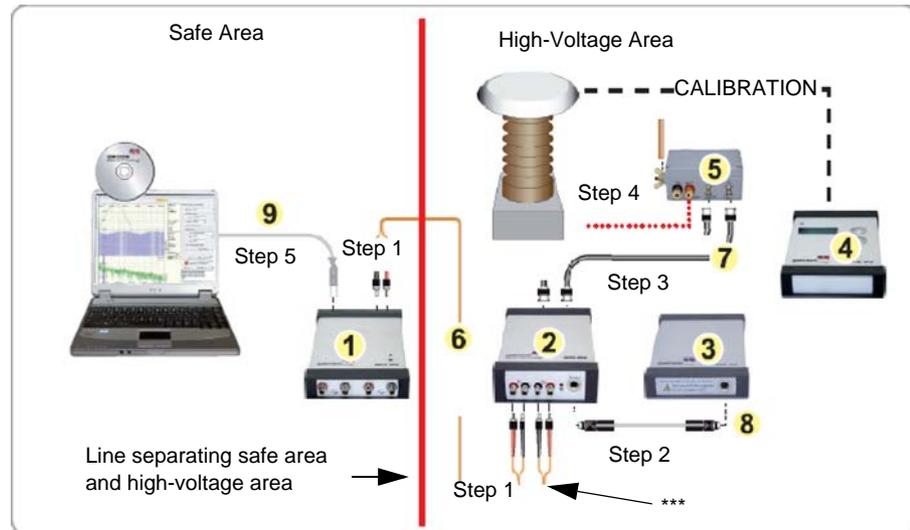


Figure 1-3 Hardware setup

\*\*\*It is possible to extend the MPD system. The maximum number of MPD acquisition units in one fiber optic network system is 30. The maximum distance between each unit is 2 km.

## 1.2.1 MPD 600 - LED Functions

Each *MPD 600* unit is equipped with 2 LEDs for displaying the unit's status. The red LED indicates both the power supply status as well as the status of the Fiber Optical link. A flashing red LED indicates that the *MPD 600* has power and is ready to be connected to computer via optical fiber. Once the *MPD 600* is connected to a computer, and the computer is running the MPD/MI software, the red LED stops flashing and instead remains continuously on. This indicates that the *MPD 600* has a good connection to the PC and that it can receive data on the fiber optical link without any problems.

As soon as the PC has detected and configured all connected *MPD 600* units, the green LED on each unit is turned on. This indicates that the *MPD 600* is ready to perform measurements.



Figure 1-4 *MPD 600* front panel with LEDs and fiber optical connectors

## 1.2.2 Connectors - Front Side

Each *MPD 600* is equipped with two sets of fiber optical connectors (see Figure 1-4 on page 24). Each set of connectors consists of two plugs, marked red and black, respectively. The first set of FO connectors is marked with a computer icon; this connector set is used for the “upstream” FO link (i.e. the link that connects this unit to the computer or the next unit that is nearer to the computer). The second set is marked with a unit icon, and is used to connect the downstream link, i.e. any additional *MPD 600* units. The downstream link can alternatively be used to supply an optical trigger signal whenever PD events are detected. This mode is enabled in the software via the Acquisition Unit Display.

**Note:** If the downstream link is used as a trigger out, no additional *MPD 600* units can be connected.

The power plug, marked with the word “Power”, is used to connect the MPP 600 battery pack or a power supply.

### 1.2.3 Connectors - Back Side



Figure 1-5 *MPD 600* back panel

There are two BNC inputs, marked **V** and **PD**, respectively. Those correspond to the BNC outputs found on the CPL542 and CPL543 quadripoles. The **V** output on the quadripole must be connected to the **V** input on the *MPD 600*. Likewise, the **PD** output on the quadripole must be connected to the **PD** input on the *MPD 600*. If no external quadripole is used, the coupling capacitor must be directly connected to the **PD** input, and the **V** input must be left open.



Figure 1-6 *MPD 600* auxiliary control connector

Also located on the back side of the unit is the auxiliary control connector, marked **AUX**. This plug is used to connect optional peripheral units, such as the UHF 608 or UHF 620 down-converters. The **AUX** connector is available with *MPD 600* units with hardware revision B or later.



Figure 1-7 *MPD 600* calibration control connector

Optionally, an additional BNC output is present on the unit's back side, marked **CAL**. This output carries a calibration impulse that is tied to the unit's test generator. The charge of the calibration impulse is approximately 500 pC. The CAL output is available with *MPD 600C* units.

## 1.2.4 MCU 5xx - LED Functions

All OMICRON control units (MCU 550, MCU 502, MCU 504) are equipped with a blue LED that indicates the status of the control unit.

When lit, the unit is connected to a PC, has good power, and has been configured for use on the computer. A flashing LED indicates a hardware or software problem with the MCU or the connected computer. If you encounter a flashing LED, please contact Technical Support.



Figure 1-8 MCU 5xx LED functions

**Note:** The MPD/MI software requires a lot of computing power. Therefore, when using the MPD/MI software on a laptop, please be sure to set your laptop to maximum performance. This can be done by left-clicking on the battery (or power plug) symbol in the task notification area and selecting “Always on” or “Maximum performance” as the power plan. Depending on the selected combination of options of the software and/or the duration of the measurement task it may be necessary to use the laptop only with a power supply.

## 1.3 Software Setup

### 1.3.1 System Requirements

- PC with Intel Pentium 4 ( $\geq 2.5$  GHz), Pentium M ( $\geq 1.5$  GHz), Core, Core 2 processor; or AMD Athlon 64 or Turion 64 processor
- 1 GB RAM required, 2 GB or more recommended
- USB 2.0 compatible
- Microsoft Windows XP SP2 and later (32-bit), Microsoft Windows 7 any SP level (32-bit and 64-bit)

### 1.3.2 Installation

- Insert the software CD into the CD/DVD drive of the computer.
- The installation starts automatically.
- Follow the instructions on the screen.

The capabilities of the MPD system can be tailored to fit exactly the needs of the tasks of the application by a combination of numerous options. These options must be announced when ordering the *MPD 600* system or can be added to an already existing hard- and software configuration later (see 9.3 on page 242).

**Note:** This manual describes the complete functionality of the system. Depending on the selected combination of options, the functionality of the software and the look of menus, screens, and tabs may differ from the description in this manual.

See a few examples on the next pages.

### 1.3.3 Different Options - Different Look

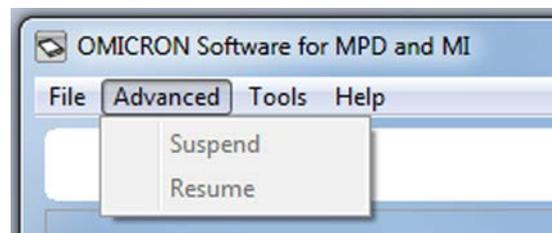


Figure 1-9 The Advanced menu

The **Advanced** menu, through the **Enable or Disable Features** option, allows the user to adapt the software functionality to the tasks of the application. For the selection or de-selection of features use the check boxes in the **Enable or Disable Features** window.

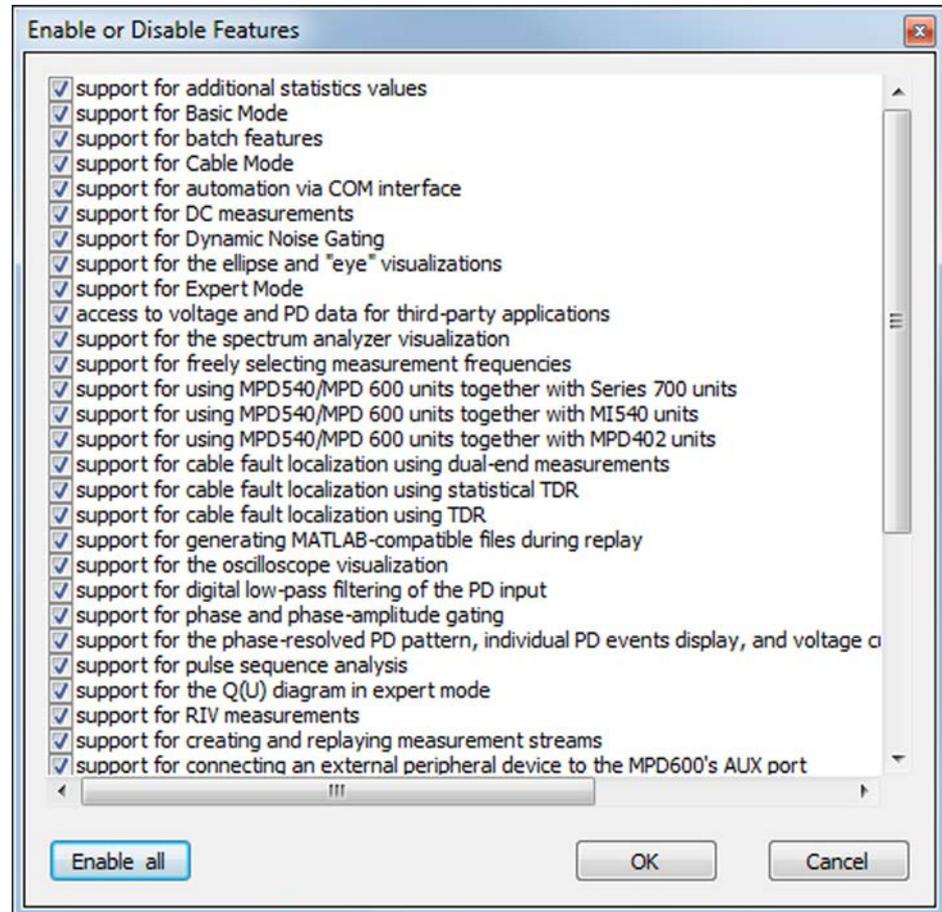


Figure 1-10 Enable or Disable Features

**Note:** The number of available functions may vary, depending on the purchased options.

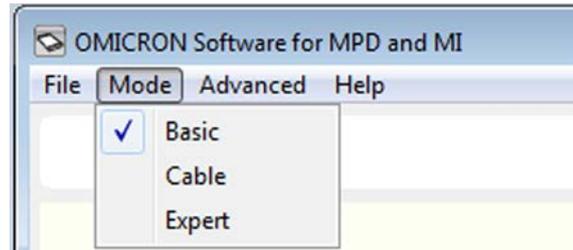


Figure 1-11 The Mode menu with all options selected and installed.

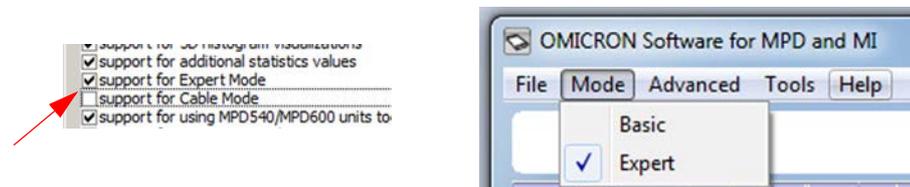


Figure 1-12 The Mode menu with Cable Mode disabled.

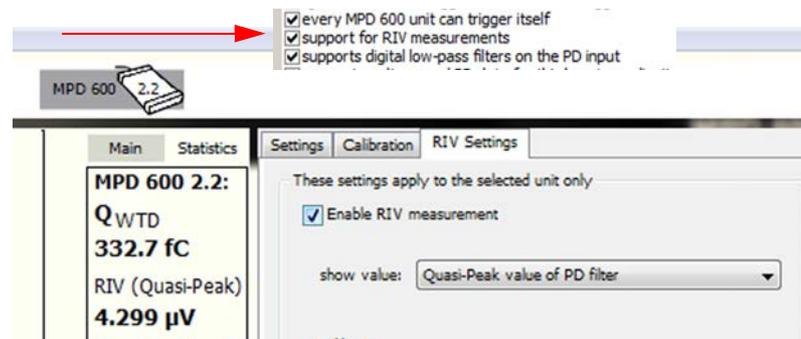


Figure 1-13 Control panel in Basic Mode with support for RIV measurements selected - note the RIV Settings tab.

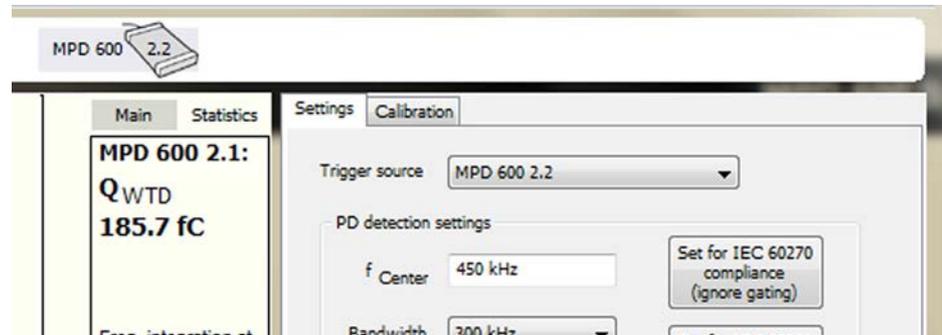


Figure 1-14 Control panel in Basic Mode with support for RIV measurements disabled.

**Note:** After enabling or disabling of features the MPD/MI software has to be restarted.

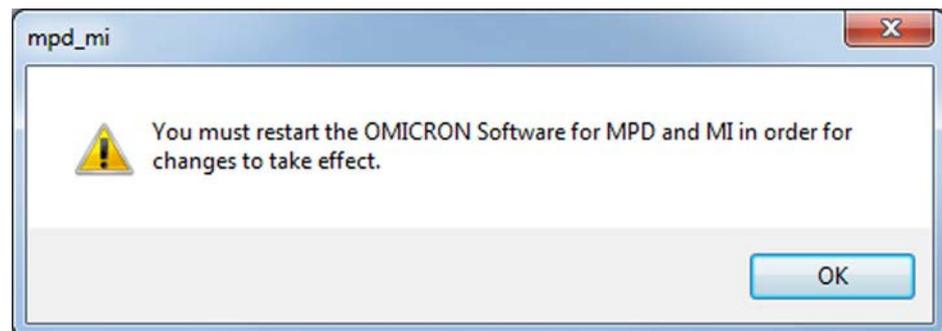
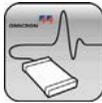


Figure 1-15 Restart software message



## 2 Software Overview

### 2.1 Starting the Software



To start the MPD/MI software double-click the MPD/MI software icon on your desktop.

The software main window can be made larger than the default, and can also be made to fill the whole screen. To resize the main window, grab the bottom right corner of the main window with the mouse and drag to the desired size. To maximize the window, double-click on the title bar.

#### 2.1.1 Without a Connected Unit

After starting the MPD/MI software without a unit connected, a screen will appear as shown below. The status display in the lower right corner indicates that the software runs in Offline Mode.

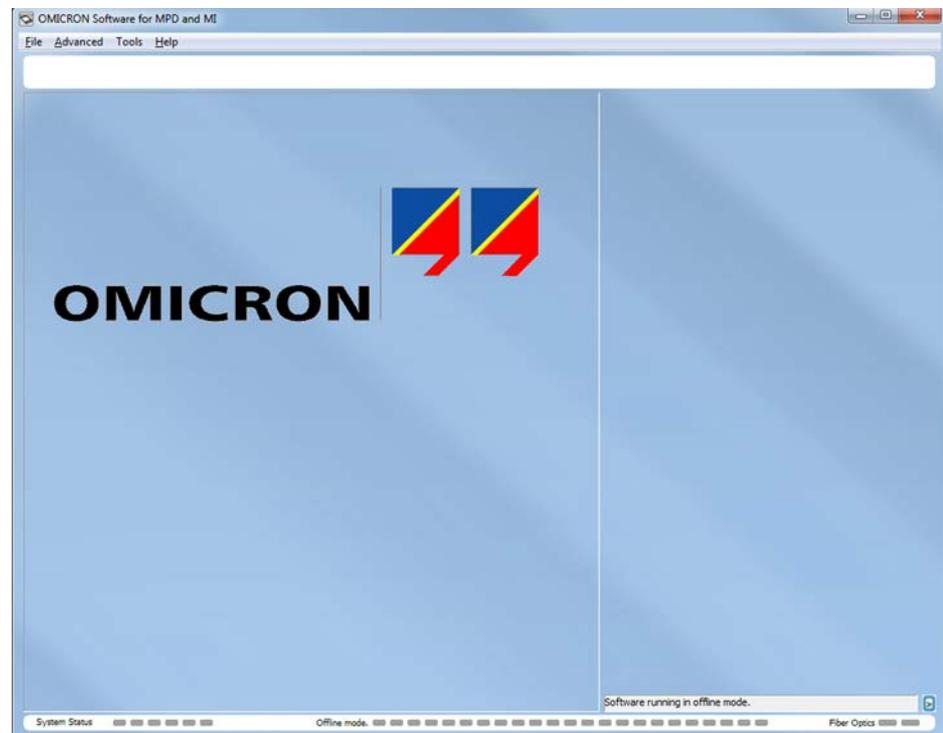


Figure 2-1 Offline Mode

## 2.1.2 File Menu Offline

The following functions are available in the File menu:

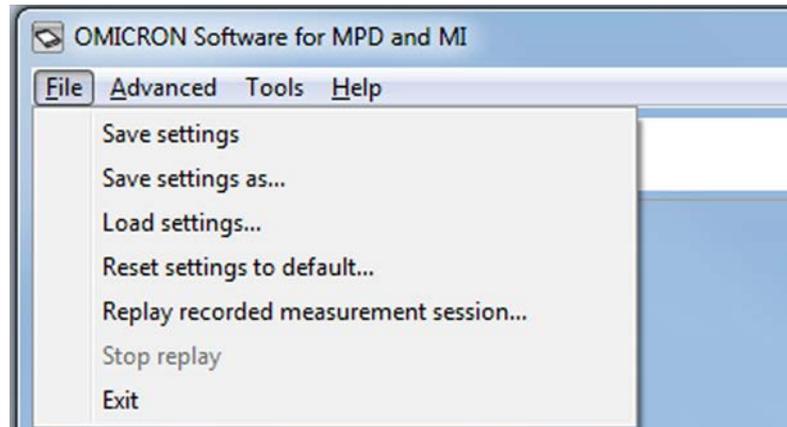
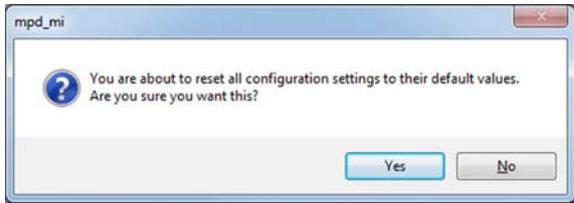


Figure 2-2 The File menu

Function	Description
<b>Save settings...</b>	Saves the current settings (default or loaded).
<b>Save settings as...</b>	Saves the current settings (default or loaded) with a new name. This is an easy way to use these settings for special tasks.

Function	Description
<b>Load settings...</b>	Loads pre-defined settings made before.
<b>Reset settings to default...</b>	Resets all configuration settings to their default values. A pop-up window appears that has to be acknowledged 
<b>Replay recorded session...</b>	To replay a measurement session recorded previously.
<b>Stop replay</b> (becomes active when a recorded session is played)	Has to be used for switching back to online measurement mode after replaying a recorded stream.
<b>Exit</b>	Quits the program.

### 2.1.3 Advanced Menu Offline

The Advanced menu offers the following functions:

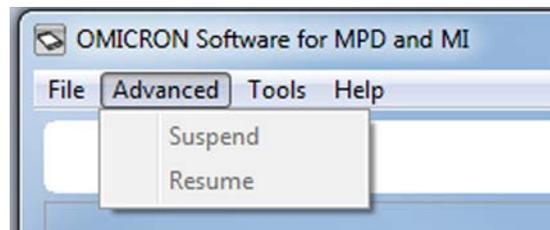


Figure 2-3 The Advanced menu

Function	Description
<b>Suspend</b>	Only available in online mode
<b>Resume</b>	Only available in online mode

## 2.1.4 Tools Menu Offline

The **Stop Watch...** function opens a window that provides a digital stop watch.

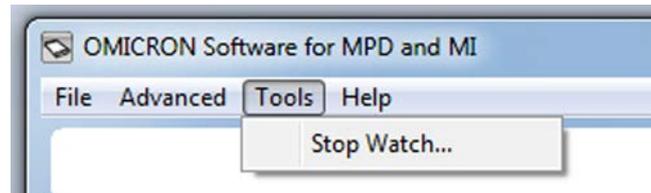


Figure 2-4 The Tools menu

## 2.1.5 Help Menu Offline

The **About OMICRON Software for MPD and MI...** function in the Help menu opens a window with actual information about the software and hardware status.

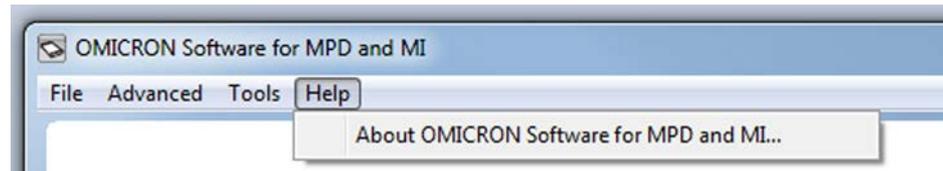


Figure 2-5 The Help menu

The information shown in this window may be different from the picture below, depending on the technical progress of soft- and hardware.

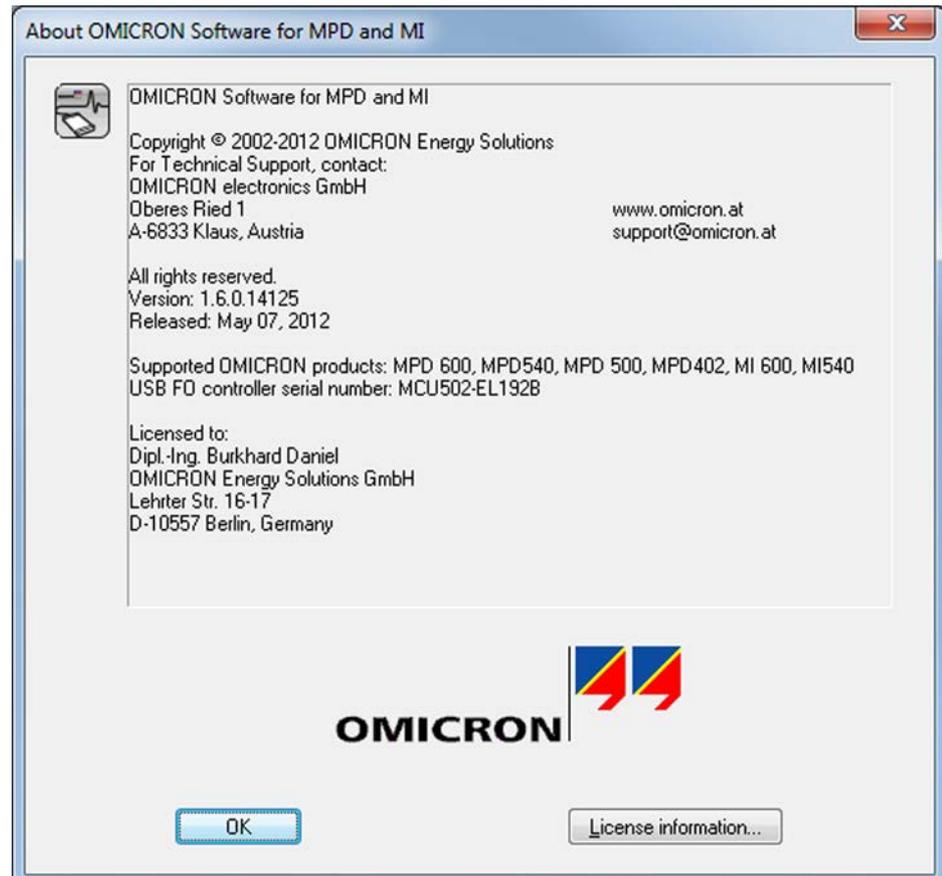


Figure 2-6 About window

A click on **License information...** opens a new window.

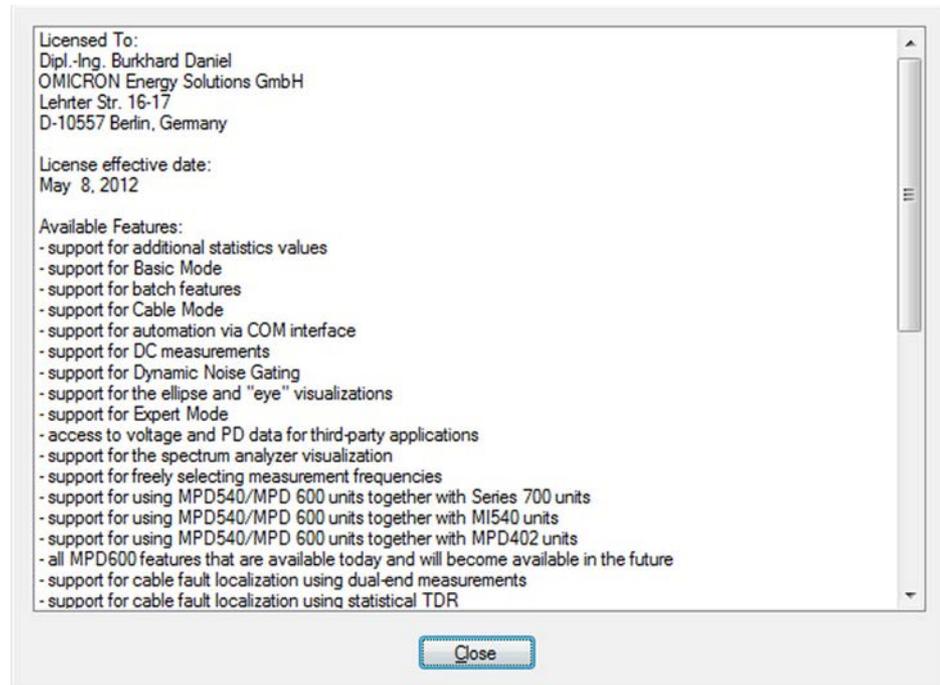


Figure 2-7 License information window

The window shows information about the license owner (customer) and the actual available software features. After adding new features to the MPD/MI software, these features will be listed here too.

## 2.2 The Different Modes

The software can be used in one of 3 modes:

- Basic Mode
- Cable Mode
- Expert Mode

If the software is used for the first time, it will start up in Basic Mode. When exiting, the software remembers the mode it was in and will start up into the same mode the next time it is run.

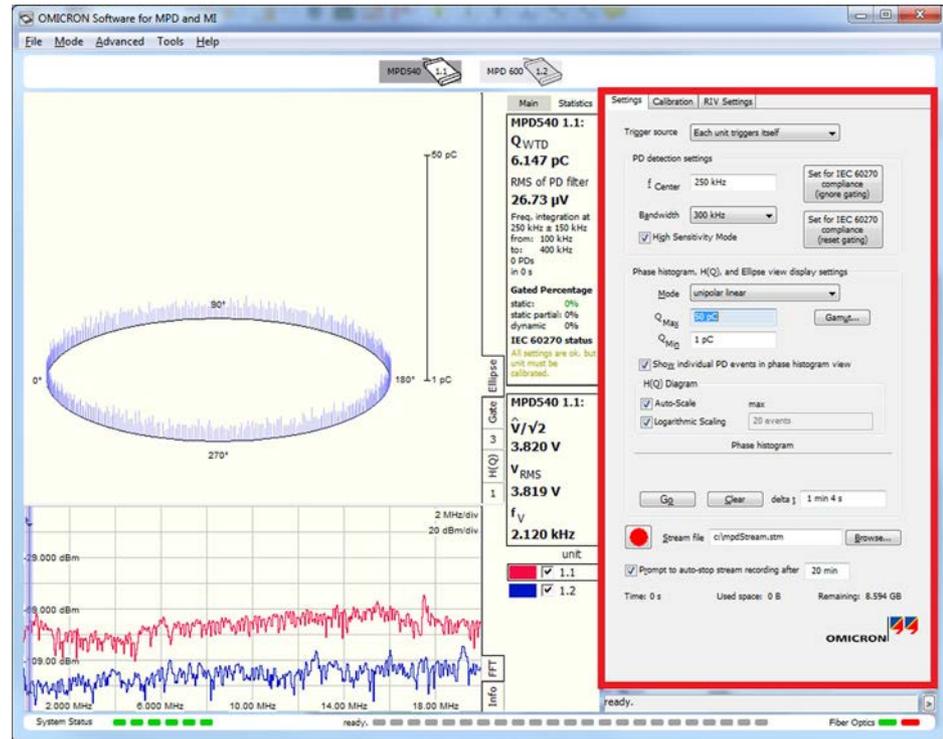


Figure 2-8 Basic Mode opening screen



Figure 2-9 Cable Mode opening screen

## 2.2.1 The Mode Menu

The mode can be changed at any time using the **Mode** function from the main menu.

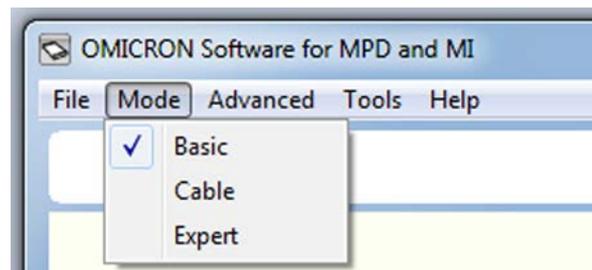


Figure 2-10 The Mode menu

**Note:** Please be aware that the Cable Mode is a protected mode. For leaving this mode, a password is necessary (for more information, see 6.1.2 on page 193).

## 2.2.2 General Information

The following hints apply to all software modes. Selected fields into which data can be entered appear with a blue background, unselected fields with a white background. Values in grey fields cannot be changed. These fields do not apply to the selected software and/or hardware configuration.

## 2.2.3 Acquisition Unit Display

This section at the top of the software window shows the units that have been detected automatically. To select a unit just click on the corresponding box. The frame behind the unit's icon will be darkened and the visualization and control panels for the selected unit are shown. To deselect a unit click anywhere on an empty space next to a unit's name. This action will also hide the visualization and control panels.

The Acquisition Unit Display shows additional important status information as icons overlaid over the actual unit display. These include:

- a battery symbol if the power supply voltage of the unit (or any attached peripheral devices) is too low
- an exclamation mark if the PD input of the corresponding unit is overdriven
- a check mark if IEC 60270 compliance indication is enabled in the Advanced menu and the unit's settings are conform to IEC 60270
- a barrier symbol if the corresponding unit is selected as a gating unit.



Figure 2-11 Acquisition Unit Display

**Note:** Deselecting of the unit will stop any measurements currently in progress. To continue measuring, re-select a unit.



Figure 2-12 Information window of the selected unit

To get more information about one of the units, just point with the mouse on the selected unit's box. An information window appears and shows the unit's status, supply voltage, and any pending warning messages.

Right-clicking a unit in the Acquisition Unit Display pops up a context menu that offers the option to rename the unit, and, if the unit supports it, the option to switch the secondary FO port from downstream link to trigger-out and back.

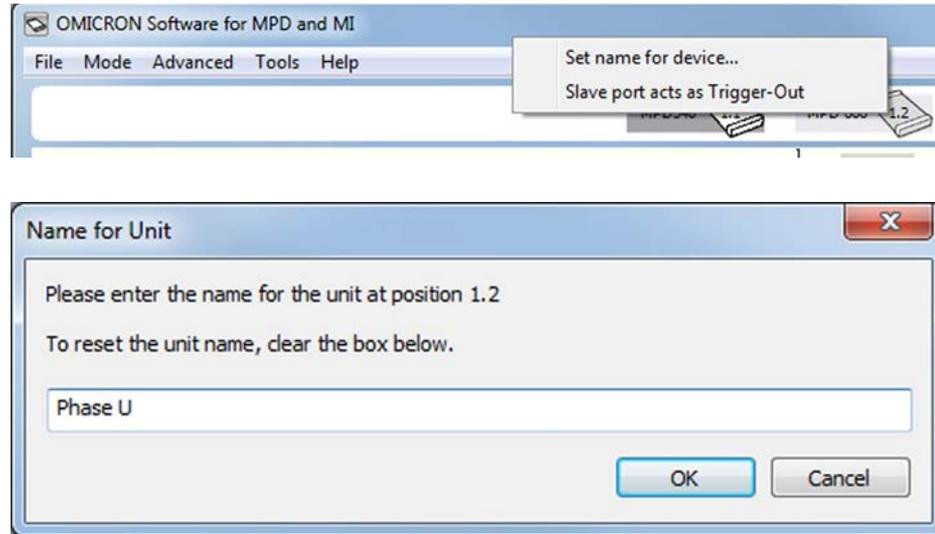


Figure 2-13 Context menu for each unit

## 2.2.4 System Information Displays

The system information displays show the status of the system.

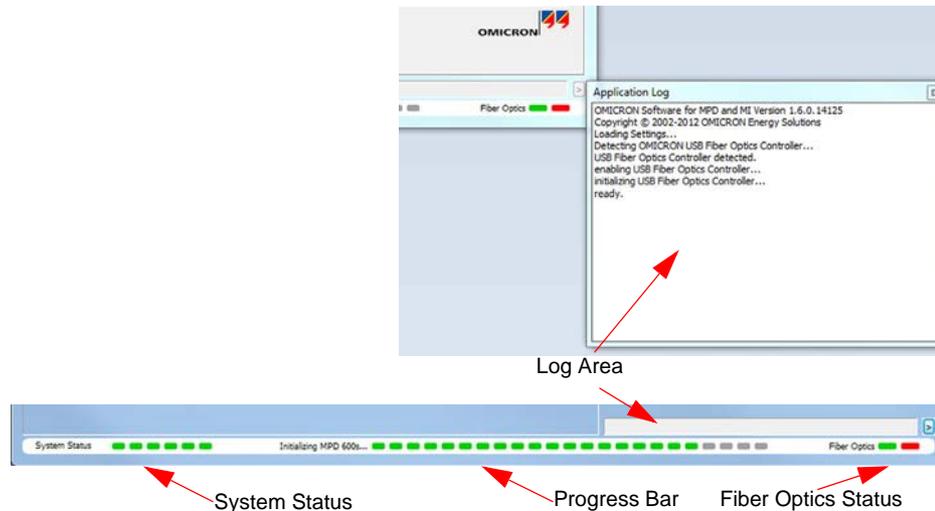


Figure 2-14 System information displays

**Expandable Log Area:** A single line shows the last log message and a small button to the right of the log line expands the log area and shows all messages. Right-clicking in the expanded log area gives you the option to clear all log entries.

All messages that are shown in the log area also get written to a log file. This file is named "log.log" and resides in the same folder as the application (typically C:\Program Files\OMICRON\OMICRON software for MPD and MI).

The **System Status** bar shows the initialization status of the software. During startup of the software, the 5 LEDs will be illuminated in succession until all of them are lit.

The **Progress Bar** visualizes the progress of the current operation. This is used, for example, to show the initialization process of newly connected units or the progress of a timed histogram acquisition. A message to the left of the progress bar shows what specific operation is being performed. If no operation is pending it shows "ready".

**Fiber Optics** signals the status of the optical connections as follows: The LEDs show the status of the fiber optical connection between the PC and the acquisition units. Green stands for a proper FO connection. Red means the connection is incorrect or there is no connection at all. A yellow LED informs about a temporary error in the FO network. For USB controllers that have more than one fiber optical bus, such as the MCU 502, the right LED shows the status of the secondary bus. On all other controllers it is disabled and will remain gray. The FO status is also gray during stream replay.

## 2.2.5 The File Menu

The following functions are available in the File menu. For your convenience, some of these functions can also be initiated by using shortcuts - **F2**, **F3**, **F4**, **Ctrl+F3**.

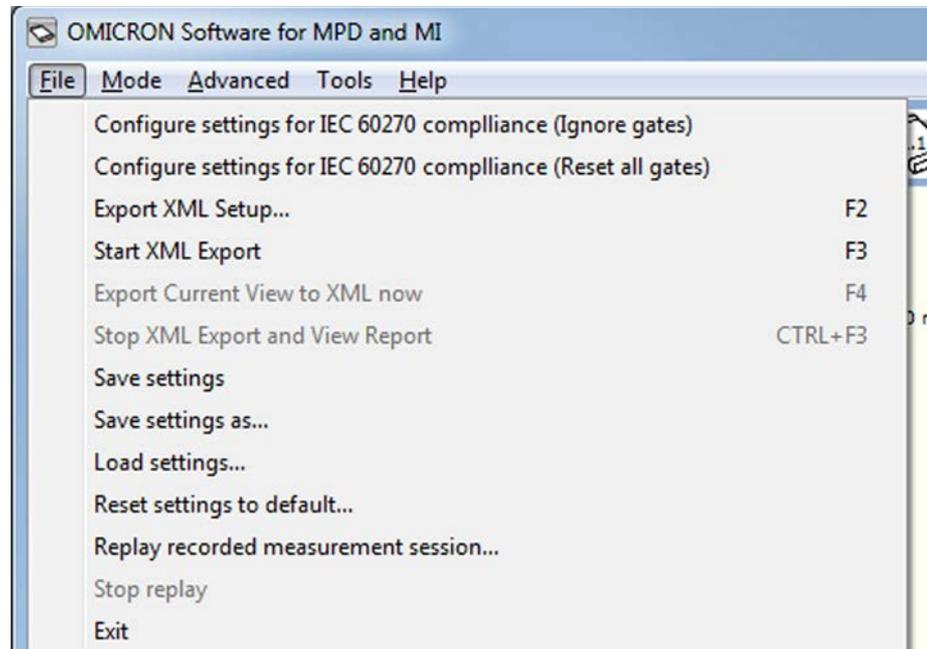
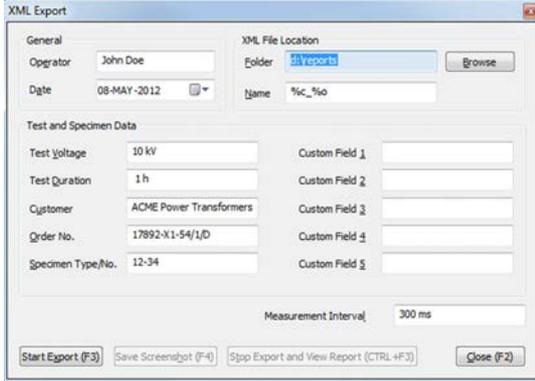
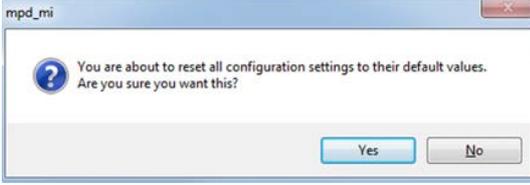


Figure 2-15 The File Menu

Function	Short-cut	Description
Configure settings for IEC 60270 compliance (Ignore gates)		When selected, all options for all connected units will be set to be in accordance with IEC 60270. Any gates that were set (phase/amplitude gates, dynamic noise gating, unit gates) are left alone.
Configure settings for IEC 60270 compliance (Reset all gates)		Acts like the function above but additionally removes all gates and turns dynamic gating functions off.
Export XML Setup...	F2	Opens the following setup window. 
Start XML Export	F3	Starts the XML export and creates a report. The command <b>Start</b> will change to <b>Stop</b> and the next two functions are available now.
Export Current View to XML now	F4	Is only available if an export is already running and creates a screenshot of the current diagram and includes it into the XML report file.

Function	Short-cut	Description																																																																																																			
<p>Stop XML and View Report</p>	<p>ctrl + F3</p>	<p>Stops the export and opens the report in the <b>MPD/MI Report Viewer</b>. It is possible to save this report as PDF file.</p>																																																																																																			
<p><b>PD Measurement Report</b></p> <p>Order No. 1 Specimen No. and Type 2 Customer GKN Operator Mark Test Date 03/21/2012 Test Voltage 10.0 kV Test Duration 1 h Custom Field 1 c1 Custom Field 2 c2 Custom Field 3 c3 Custom Field 4 c4 Custom Field 5 c5</p> <p>measurement duration: 1 m 54.9 s</p> <table border="1"> <thead> <tr> <th rowspan="2">Time</th> <th colspan="3">MPD540 1.1 (SN: (unassigned))</th> <th colspan="3">MPD540 1.2 (SN: (unassigned))</th> <th colspan="3">MPD540 1.3 (SN: (unassigned))</th> </tr> <tr> <th>Qacc</th> <th>Vmax</th> <th>f<sub>v</sub></th> <th>Qacc</th> <th>Vmax</th> <th>f<sub>v</sub></th> <th>Qacc</th> <th>Vmax</th> <th>f<sub>v</sub></th> </tr> </thead> <tbody> <tr> <td>March 21, 2012, 11:26:36 (UTC)</td> <td>Average: 16.63 nC</td> <td>Average: 5.79 kV</td> <td>Average: 50.0 Hz</td> <td>Average: 18.82 nC</td> <td>Average: 5.80 kV</td> <td>Average: 50.0 Hz</td> <td>Average: 26.64 nC</td> <td>Average: 5.80 kV</td> <td>Average: 50.0 Hz</td> </tr> <tr> <td>+ 0.2 s</td> <td>16.51 nC</td> <td>5.79 kV</td> <td>50.0 Hz</td> <td>18.66 nC</td> <td>5.80 kV</td> <td>50.0 Hz</td> <td>25.22 nC</td> <td>5.80 kV</td> <td>50.0 Hz</td> </tr> <tr> <td>+ 0.5 s</td> <td>17.13 nC</td> <td>5.79 kV</td> <td>50.0 Hz</td> <td>17.68 nC</td> <td>5.80 kV</td> <td>50.0 Hz</td> <td>25.70 nC</td> <td>5.80 kV</td> <td>50.0 Hz</td> </tr> <tr> <td>+ 0.8 s</td> <td>17.85 nC</td> <td>5.79 kV</td> <td>50.0 Hz</td> <td>18.11 nC</td> <td>5.80 kV</td> <td>50.0 Hz</td> <td>26.76 nC</td> <td>5.80 kV</td> <td>50.0 Hz</td> </tr> <tr> <td>+ 1.1 s</td> <td>18.26 nC</td> <td>5.79 kV</td> <td>50.0 Hz</td> <td>18.22 nC</td> <td>5.80 kV</td> <td>50.0 Hz</td> <td>27.50 nC</td> <td>5.80 kV</td> <td>50.0 Hz</td> </tr> <tr> <td>+ 1.4 s</td> <td>17.77 nC</td> <td>5.79 kV</td> <td>50.0 Hz</td> <td>18.53 nC</td> <td>5.80 kV</td> <td>50.0 Hz</td> <td>28.13 nC</td> <td>5.80 kV</td> <td>50.0 Hz</td> </tr> <tr> <td>+ 1.7 s</td> <td>17.09 nC</td> <td>5.79 kV</td> <td>50.0 Hz</td> <td>19.42 nC</td> <td>5.80 kV</td> <td>50.0 Hz</td> <td>27.81 nC</td> <td>5.80 kV</td> <td>50.0 Hz</td> </tr> <tr> <td>+ 2 s</td> <td>16.38 nC</td> <td>5.79 kV</td> <td>50.0 Hz</td> <td>19.64 nC</td> <td>5.80 kV</td> <td>50.0 Hz</td> <td>27.35 nC</td> <td>5.80 kV</td> <td>50.0 Hz</td> </tr> </tbody> </table> <p>OMNICON Report Viewer</p> <p>successful threshold: 1.00 nC inception/extinction threshold: 5.79 kV</p> <p>Qacc(f) Vmax(f)</p>			Time	MPD540 1.1 (SN: (unassigned))			MPD540 1.2 (SN: (unassigned))			MPD540 1.3 (SN: (unassigned))			Qacc	Vmax	f <sub>v</sub>	Qacc	Vmax	f <sub>v</sub>	Qacc	Vmax	f <sub>v</sub>	March 21, 2012, 11:26:36 (UTC)	Average: 16.63 nC	Average: 5.79 kV	Average: 50.0 Hz	Average: 18.82 nC	Average: 5.80 kV	Average: 50.0 Hz	Average: 26.64 nC	Average: 5.80 kV	Average: 50.0 Hz	+ 0.2 s	16.51 nC	5.79 kV	50.0 Hz	18.66 nC	5.80 kV	50.0 Hz	25.22 nC	5.80 kV	50.0 Hz	+ 0.5 s	17.13 nC	5.79 kV	50.0 Hz	17.68 nC	5.80 kV	50.0 Hz	25.70 nC	5.80 kV	50.0 Hz	+ 0.8 s	17.85 nC	5.79 kV	50.0 Hz	18.11 nC	5.80 kV	50.0 Hz	26.76 nC	5.80 kV	50.0 Hz	+ 1.1 s	18.26 nC	5.79 kV	50.0 Hz	18.22 nC	5.80 kV	50.0 Hz	27.50 nC	5.80 kV	50.0 Hz	+ 1.4 s	17.77 nC	5.79 kV	50.0 Hz	18.53 nC	5.80 kV	50.0 Hz	28.13 nC	5.80 kV	50.0 Hz	+ 1.7 s	17.09 nC	5.79 kV	50.0 Hz	19.42 nC	5.80 kV	50.0 Hz	27.81 nC	5.80 kV	50.0 Hz	+ 2 s	16.38 nC	5.79 kV	50.0 Hz	19.64 nC	5.80 kV	50.0 Hz	27.35 nC	5.80 kV	50.0 Hz
Time	MPD540 1.1 (SN: (unassigned))			MPD540 1.2 (SN: (unassigned))			MPD540 1.3 (SN: (unassigned))																																																																																														
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+ 0.5 s	17.13 nC	5.79 kV	50.0 Hz	17.68 nC	5.80 kV	50.0 Hz	25.70 nC	5.80 kV	50.0 Hz																																																																																												
+ 0.8 s	17.85 nC	5.79 kV	50.0 Hz	18.11 nC	5.80 kV	50.0 Hz	26.76 nC	5.80 kV	50.0 Hz																																																																																												
+ 1.1 s	18.26 nC	5.79 kV	50.0 Hz	18.22 nC	5.80 kV	50.0 Hz	27.50 nC	5.80 kV	50.0 Hz																																																																																												
+ 1.4 s	17.77 nC	5.79 kV	50.0 Hz	18.53 nC	5.80 kV	50.0 Hz	28.13 nC	5.80 kV	50.0 Hz																																																																																												
+ 1.7 s	17.09 nC	5.79 kV	50.0 Hz	19.42 nC	5.80 kV	50.0 Hz	27.81 nC	5.80 kV	50.0 Hz																																																																																												
+ 2 s	16.38 nC	5.79 kV	50.0 Hz	19.64 nC	5.80 kV	50.0 Hz	27.35 nC	5.80 kV	50.0 Hz																																																																																												
<p>It is possible to select which items to display in the report, and to re-order items. To this end, a small "Options" menu is shown in the top-left corner of the viewer. When clicked, it opens a dialog that allows you to change the position of items by dragging their description to the desired position, and to enable or disable the display of items (devices, header data, etc.)</p>																																																																																																					

Function	Shortcut	Description
<b>Save settings</b>		Saves the settings made for the running session.
<b>Save settings as...</b>		Allows to save the settings for the running session to a user-specified file.
<b>Load settings...</b>		Loads settings from a user-specified file.
<b>Reset settings to default...</b>		Resets all configuration settings to their default values. A pop-up window appears that has to be acknowledged in order to continue. 
<b>Replay recorded session...</b>		Makes it possible to replay a measurement session recorded previously.
<b>Stop replay</b> (becomes active when a recorded session is played)		Has to be used for switching back to online measurement mode after replaying a recorded stream.
<b>Exit</b>		Quits the program.

## 2.2.6 The Advanced Menu

The Advanced menu offers the following functions:

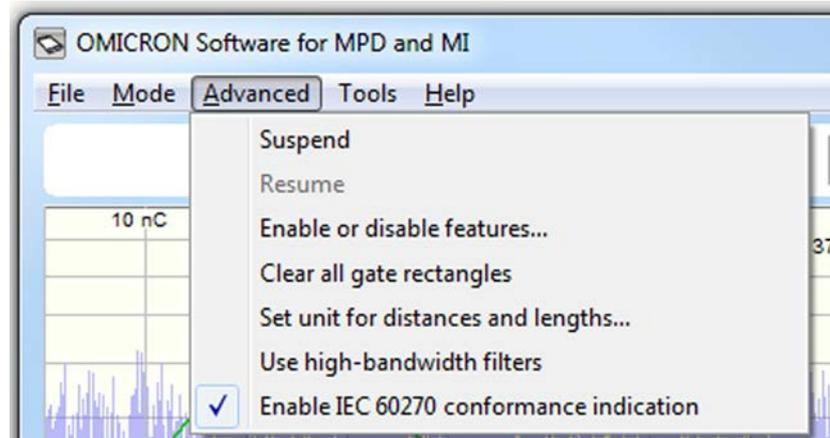
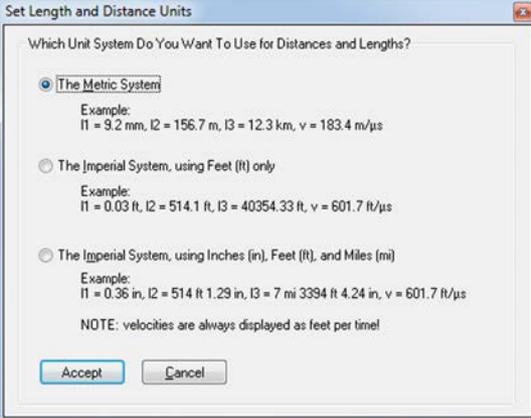


Figure 2-16 The Advanced menu

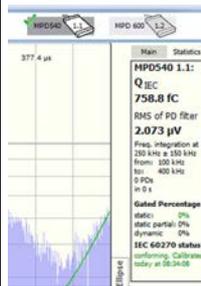
Function	Description
<b>Suspend</b>	Stops the running session but keeps the software running. The USB controller and all measurement units are turned off. Any connected <i>MPD 600</i> units will begin to flash their red LEDs, indicating that they are in power-save mode. While suspended, the software does not update any measurement displays or diagrams.
<b>Resume</b>	Becomes active after suspending a session and resumes the measurement session. The USB controller and all connected <i>MPD 600</i> units are restarted and the software continues to perform measurements.
<b>Enable or disable features...</b>	Opens a window where the software functionality can be adapted to the tasks of the application.
<b>Clear all gate rectangles</b>	Clears all rectangles set in the gate display of the large scope view.

Function	Description
<b>Set unit for distances and lengths...</b>	<p>Opens a setup window to configure the unit system of lengths for all measurements which use distances as such as Location and Cable Mode measurements.</p> 
<b>Use high-bandwidth filters</b>	<p>When enabled, reconfigures all connected <i>MPD 600</i> units to allow the use of a different set of bandwidths, including 1 MHz and 3 MHz. This option provides compatibility with versions of the software prior to 1.5 and should only be used if strict compatibility with pre-1.5 version is required.</p> <p><b>Note:</b> When this option is enabled, RIV measurements (see chapter 4.13 on page 93) and the use of peripheral devices connected to the AUX port (such as the UHF 608 and UHF 620 down converters), as well as the 3FREQ measurement mode are not available (see chapter 5.14 on page 161).</p>

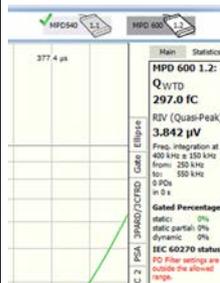
Function	Description
----------	-------------

**Enable IEC 60270 conformance indication**

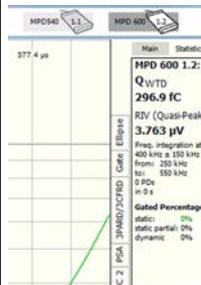
When enabled, the software indicates for every MPD unit whether its measurement parameters conform to IEC 60270. Conformance is indicated by showing a green check mark on the unit and noting the conformance in the IEC 60270 status section of the measured quantities display.



Non-conformance is indicated by the absence of the check mark and a note in the IEC 60270 status section of the measured quantities display.



When the option is disabled, no indication is made.



## 2.2.7 Data Gathering and Stream Recording

In all modes, pressing **F5** or toggling the **Go** button enabled begins PRPD histogram acquisition. In replay mode, doing so also begins replay of the stream at the selected position. In all modes all of the data gathered during a measurement may be recorded for later analysis by clicking on the **Record** button. The resulting file is called a measurement stream, or stream for short, and contains all data that was measured while the file was being recorded, such as AC curve samples, PD events, PD scope data, and settings changes. The buttons are located at different places in the different modes. Please refer to the respective mode descriptions.

When streaming is actually started, the file name will be modified to contain the date and time of the moment at which the stream file was created.

If the **Select for display setting** is disabled in Expert Mode, and the unit's **V** input does not act as a trigger source, the AC curve is not acquired. When recording data to a stream, this means that voltage data will not be available for triggering or display upon replay. If you need to have voltage data available on replay, make sure that either the **Select for display** option is enabled or the unit acts as a trigger while the stream is being recorded.



## 3 Calibration

### 3.1 Introduction

Before measuring PD, the test setup has to be calibrated. The calibration can be done without high voltage or under high voltage conditions and has two main steps:

- VOLTAGE calibration
- CHARGE calibration

### 3.2 Charge Calibration without High Voltage



**Warning:** Switch off the high voltage and temporarily ground the high-voltage test setup observing safety procedures before connecting the charge calibrator.

Connect the calibrator CAL 542 to the test object as shown in Figure 1-2 on page 21. Remove the temporary ground from the high-voltage setup.

Now perform the charge calibration. After calibration, disconnect the calibrator unit from the test object.

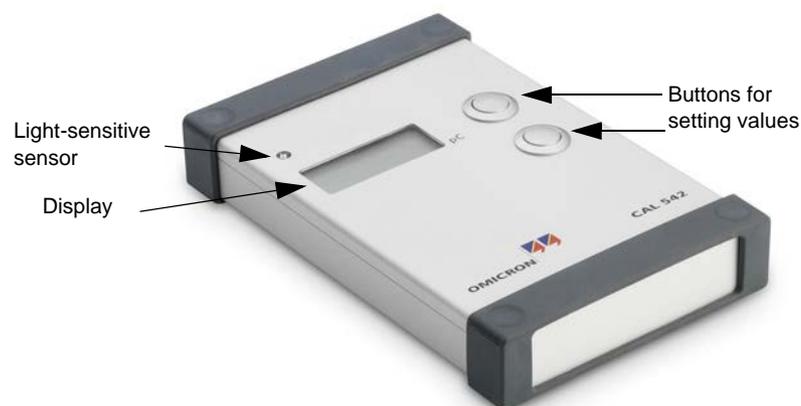


Figure 3-1 CAL 542 charge calibrator



**Warning:** Secure the high-voltage test setup observing safety procedures.

For more information on how to do a complete calibration in each mode, refer to the respective chapters.

### 3.3 Charge Calibration under High Voltage Conditions

With the calibrator CAL 543 it is possible to do the calibration while high voltage is running. The CAL 543 is completely software controlled.



Figure 3-2 CAL 543 charge calibrator

When using an MCU 504 controller, the MPD/MI software presents an additional menu, CAL 543:

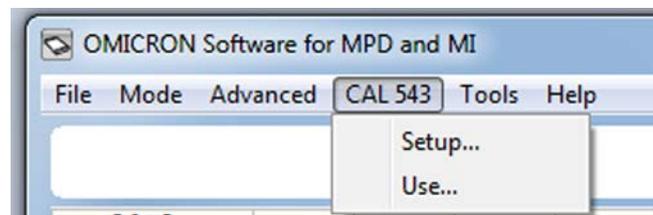


Figure 3-3 CAL 543 - Additional menu item

Before using the CAL 543 for the first time, and whenever the test setup has changed, the CAL 543 must be set up for use. Click on **Setup...** to get into the setup routine. Then follow the Setup Wizard. The initial setup is necessary because the charge output of the CAL 543 online calibrator depends on the test setup. The CAL 543 uses the stray capacitance between its spherical case and the test bay ground, which is not known beforehand. During setup of the CAL 543, the online calibrator's charge output is measured and compared to that of the handheld calibrator, and is adjusted such that it matches the handheld calibrator's output.

**Note:** When running the setup wizard, all previously configured charge levels will be discarded.

**Note 2:** The initial setup should be performed without a test subject.

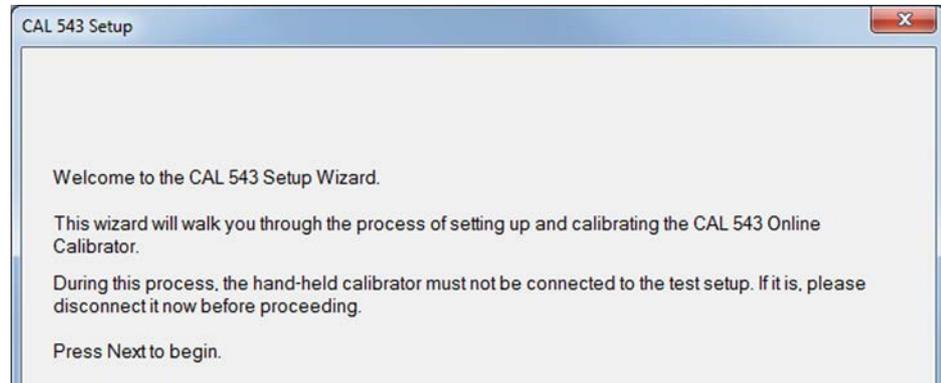


Figure 3-4 CAL 543 - Setup Wizard Step 1

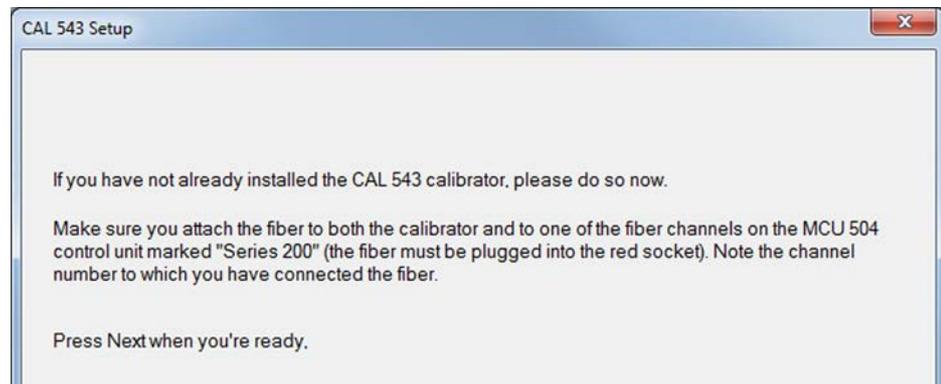


Figure 3-5 CAL 543 - Setup Wizard Step 2

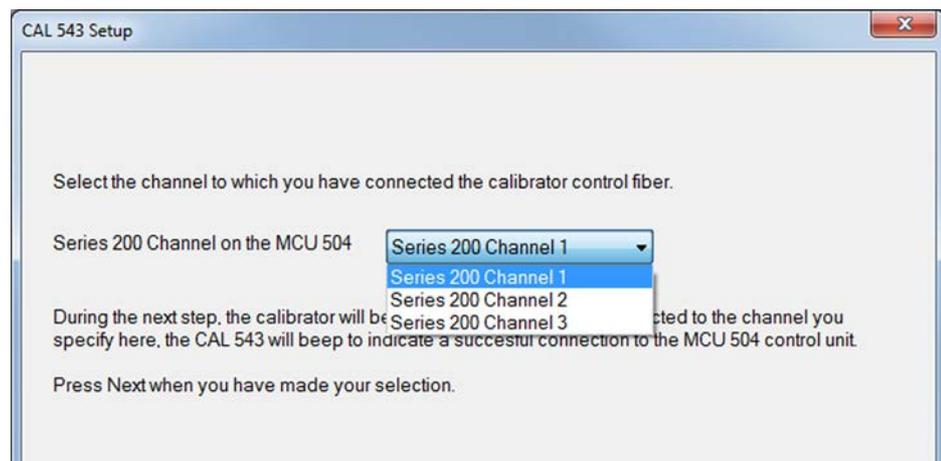


Figure 3-6 CAL 543 - Setup Wizard Step 3

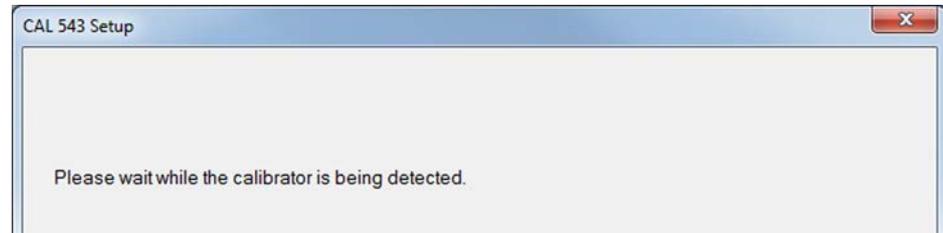


Figure 3-7 CAL 543 - Setup Wizard Step 4 Begin

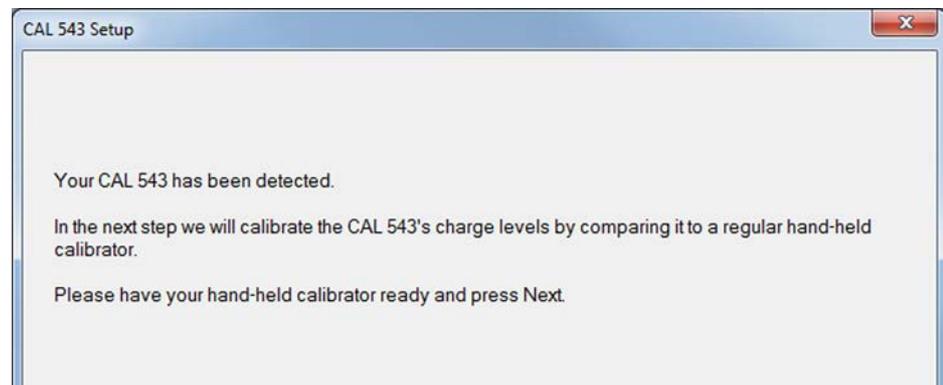


Figure 3-8 CAL 543 - Setup Wizard Step 4 End

If the hand-held calibrator cannot be detected, the window depicted in Figure 3-9 is shown. In that case, ensure that the handheld calibrator is turned on and properly connected to the test setup. Then click on **Back** to retry the process. Alternatively, pressing **Cancel** will abort the calibration process.

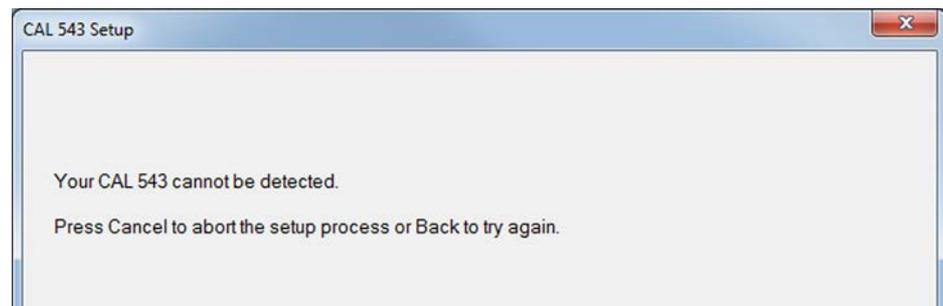


Figure 3-9 CAL 543 - Setup Wizard Step 4 (calibrator not detected)

**Note:** At this point have your hand-held calibrator ready and connect it directly to the coupling capacitor.

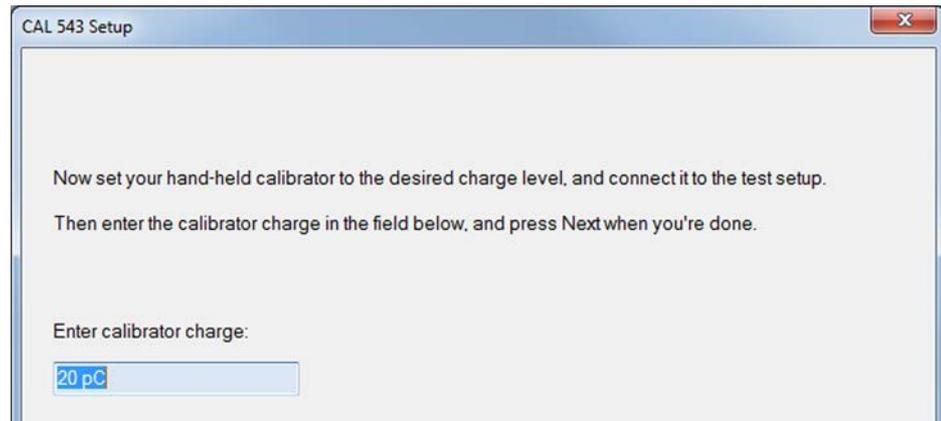


Figure 3-10 CAL 543 - Setup Wizard Step 5

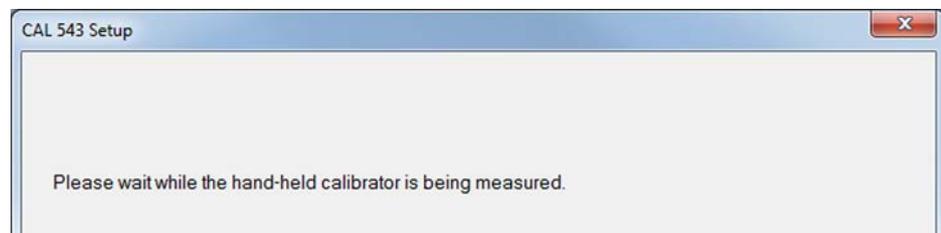


Figure 3-11 CAL 543 - Setup Wizard Step 6 Begin

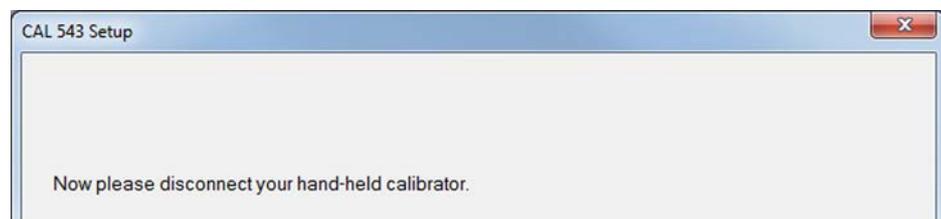


Figure 3-12 CAL 543 - Setup Wizard Step 6 End

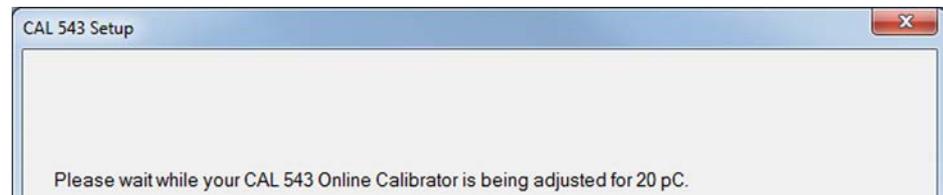


Figure 3-13 CAL 543 - Setup Wizard Step 7 Begin

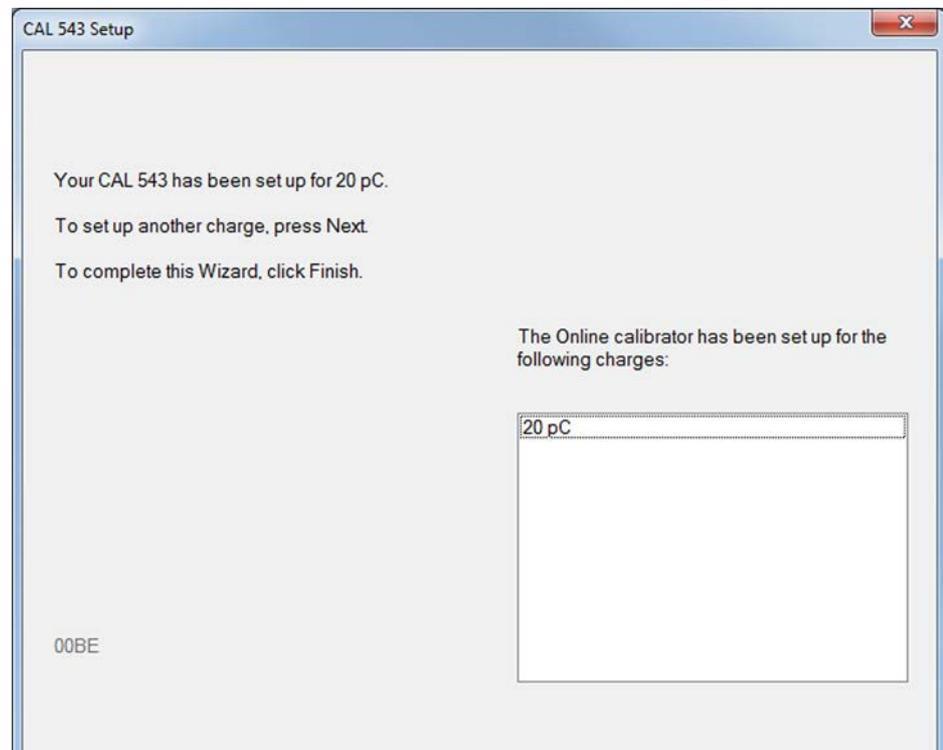


Figure 3-14 CAL 543 - Setup Wizard Step 7 End

At this point, the CAL 543 online calibrator has been set up for a single charge level. If you don't need more than one charge level, you can click on **Finish** now. If you need additional charge levels, click on **Next** to go back to step 5.

Please note that once you click on **Finish** the charge levels you have calibrated the CAL 543 for are locked, and cannot be changed or added to. If you re-run the setup wizard, all previously configured charge levels will be discarded, and you will have to perform the calibration again for all charge levels you require.

After finishing the adjustment process select **Use...** from the **CAL 543** menu.

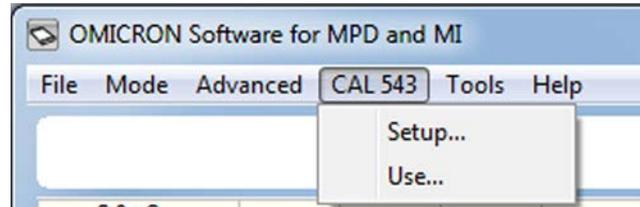


Figure 3-15 CAL 543 Menu

The **Online Calibrator** window opens.

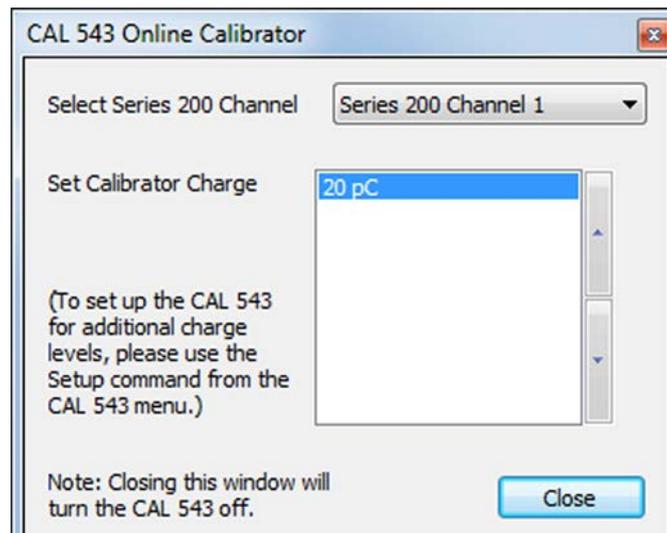


Figure 3-16 CAL 543 - Online Calibrator - Charge Setting

Now select the MCU 504 channel to which the calibrator is connected and choose the charge level the CAL 543 should put out. You can choose between all charge levels you set up during the setup phase.

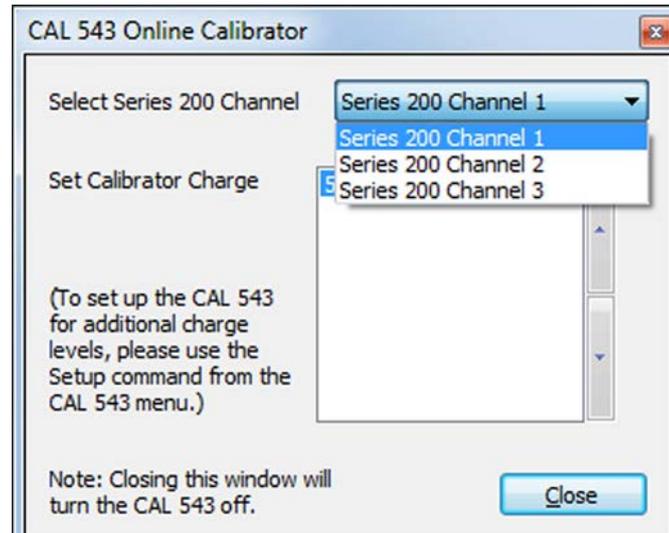


Figure 3-17 CAL 543 - Online Calibrator - Channel Selection

**Note:** Closing the **CAL 543 Online Calibrator** window will turn the CAL 543 off.



## 4 Basic Mode

### 4.1 Introduction

Basic Mode provides a simple user interface for PD measurements. It can be used to measure any type of electrical equipment but does not show advanced options.

### 4.2 Starting Basic Mode

Basic Mode is only available if at least one MPD unit is connected and running as described in chapter 1.2 on page 22. Proceed as follows:

Start the software and select **Mode** from the main menu in the menu bar. Then choose **Basic**.

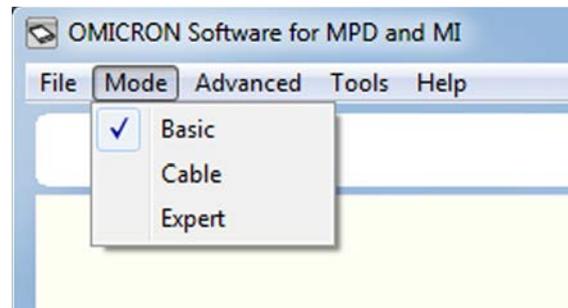


Figure 4-1 Basic Mode selection

## 4.3 Control Panel

Basic Mode provides control over many aspects of the operation of the *MPD 600* measurement system. The controls are arranged into tabs. The tabs are named according to their primary purpose. Just click on the tab head to bring it to the front.

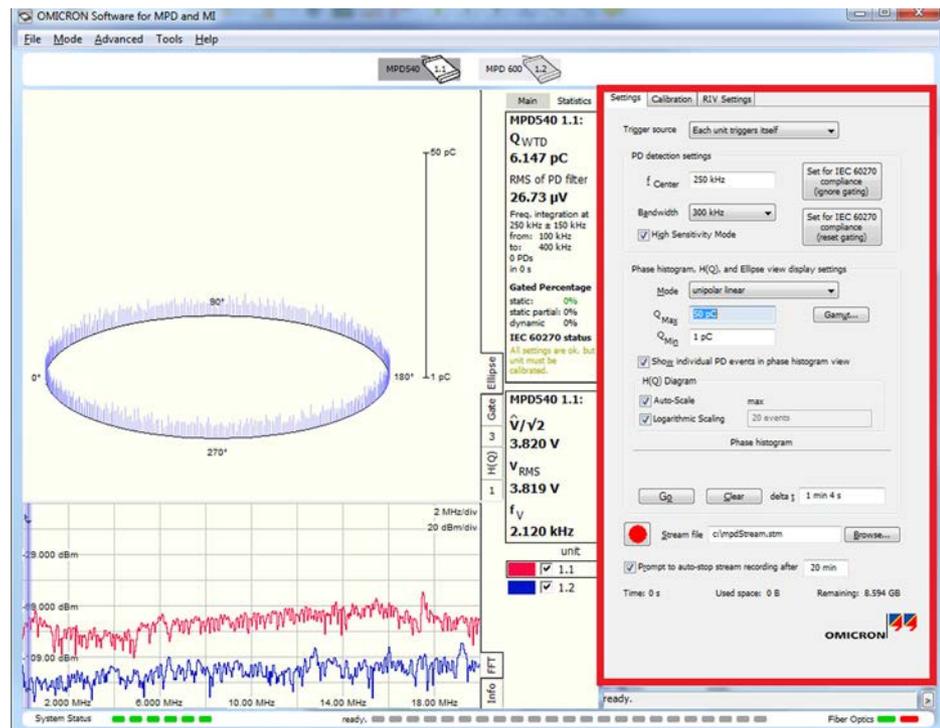


Figure 4-2 Control panel

**Note:** The control panel settings will be stored in the file `MPD.conf` when the software shuts down. After restarting, the software uses this configuration file and loads the settings from this file. An administrator may install a different read-only configuration file that will be used instead of `MPD.conf`.

## 4.4 Visualization Display

The visualization display (see highlighted area below) is only visible if a unit is selected. It contains:

- the large scope view
- the small scope view
- the measured quantities display and statistics view.

The displays of both scope views can be selected independently as is appropriate for the measurement task.

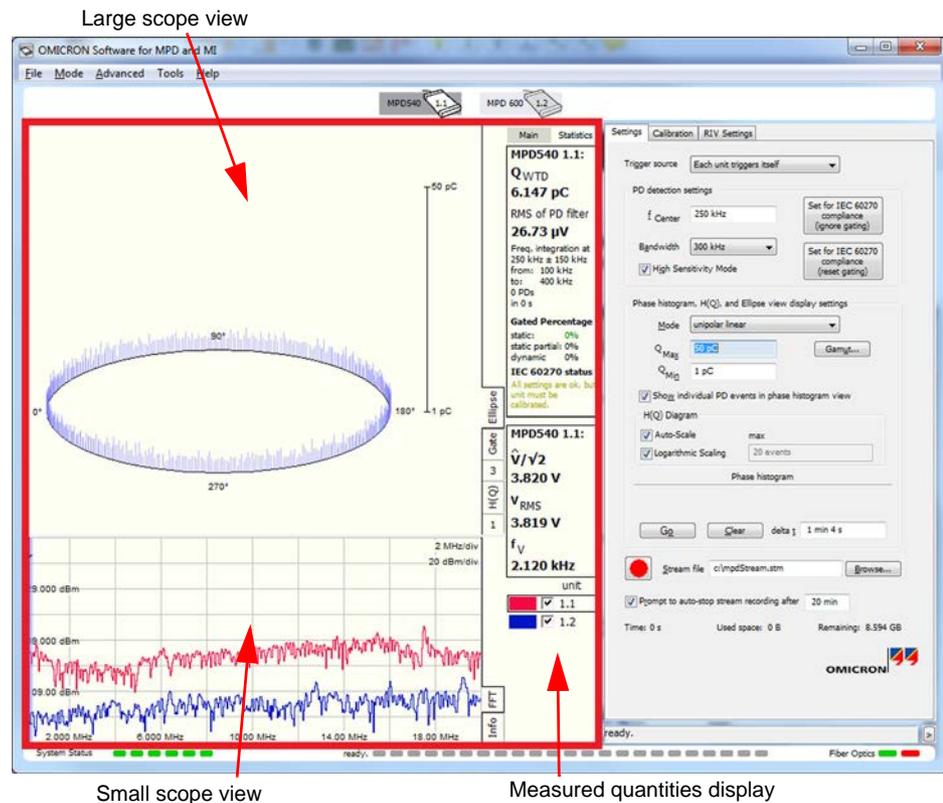


Figure 4-3 Visualization display

## 4.5 Large Scope View

The large scope view provides displays that present Partial Discharge activity measured by the currently selected unit, including a Lissajous (ellipse) figure and a phase-resolved PD (PRPD) histogram pattern overlaid with the high-voltage curve. Alternatively, the large scope view may be used to view overview diagrams showing the phase-resolved histograms of the connected acquisition units.

### 4.5.1 Ellipse Display

The **Ellipse** display shows the Lissajous ("ellipse") figure known from analog PD detectors.

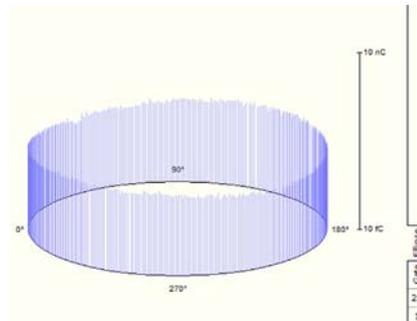


Figure 4-4 The Ellipse display

### 4.5.2 "1" Display

The "1" display shows the high-voltage curves of the connected units (if enabled in the control panel), as well as the phase-resolved PD patterns and the histogram of the currently selected unit. If enabled in the control panel, individual PD events are also shown as needles, or "spikes", that extend from the diagram's bottom margin to the point in the diagram that corresponds to their charge value.

Pointing the mouse onto the display for more than two seconds will pop-up an information box which shows the precise coordinates of the data point under the mouse cursor.

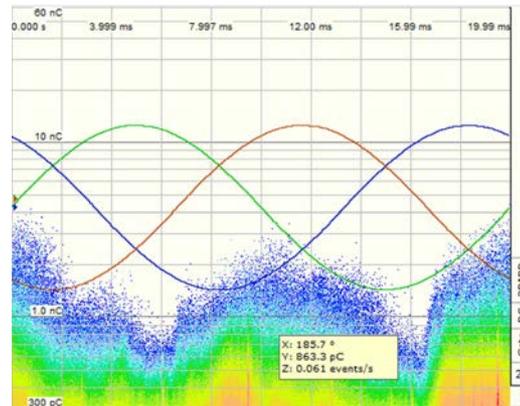


Figure 4-5 The "1" display

### 4.5.3 Save Current View

After clicking with the right mouse button on the "1" display of the large scope view it is possible to save the histograms together with additional information into PNG files.

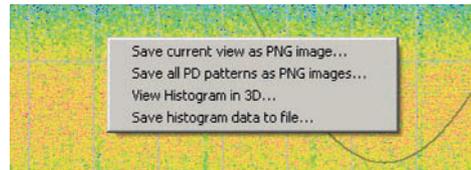


Figure 4-6 Save current view

**Save current view as PNG image...** takes a snapshot of the display currently shown and saves it to a PNG file on your computer.

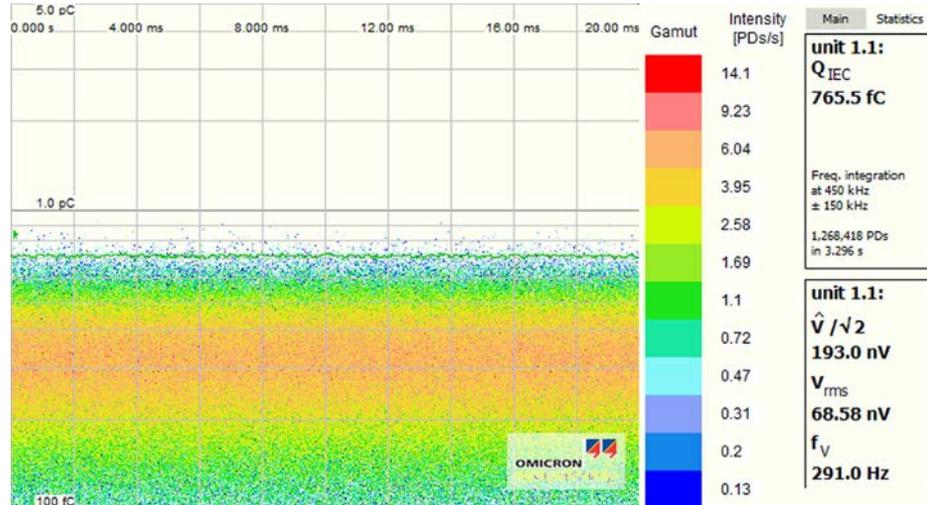


Figure 4-7 Display of current view

#### 4.5.4 Save PD Patterns

**Save all PD patterns as PNG image...** takes snapshots of the phase-resolved pattern and voltage curves of all connected MPD units and saves them to PNG files on your computer. Additionally, an overview image of all connected units is saved.

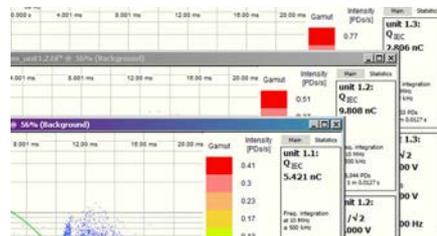


Figure 4-8 Snapshots of all PD patterns

## 4.5.5 3D Visualization

**View Histogram in 3D...** opens a new window and presents a 3D visualization of the histogram.

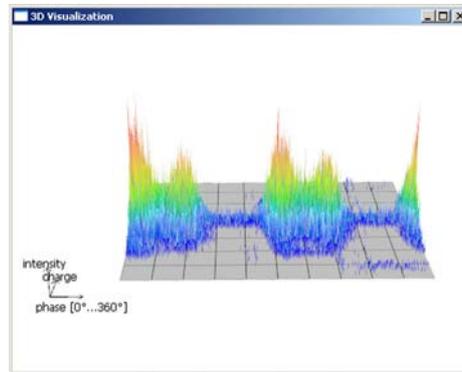


Figure 4-9 3D Visualization

You can use the keyboard and mouse to change the camera position and direction. Press **h** to show which keys and mouse actions are available:

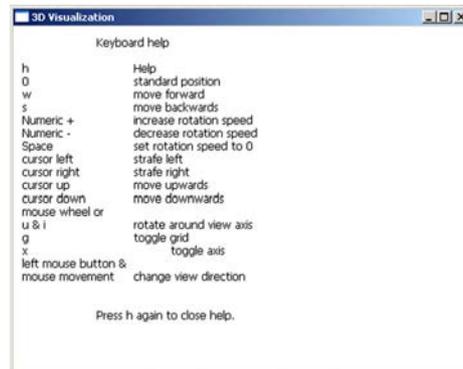


Figure 4-10 Adjustment options

## 4.5.6 Overview Displays

Depending on the number of connected *MPD 600* units, there are various overview displays available. These displays show phase-resolved PD patterns of the connected units. Therefore, one unit of interest has to be selected in the **Acquisition Unit Display** above the **Large Scope View**.

The selected unit will be highlighted in the view. Some of the units may be hidden. To see those, use these arrow keys.



Figure 4-11 Acquisition Unit Selection

### 4.5.7 "3" Display

The "3" display shows the phase-resolved PD patterns for 3 units in real-time. Depending on the settings, voltage curves and spikes are shown too. The unit's number is shown in the upper left corner of each diagram. Optionally, the current  $Q_{IEC}$  value is displayed in the upper right corner of each diagram (see Q Tab chapter 5.9 on page 127) and the current RIV value is displayed in the upper left corner of each diagram (see also **Show RIV value in overview ...** on page 95).

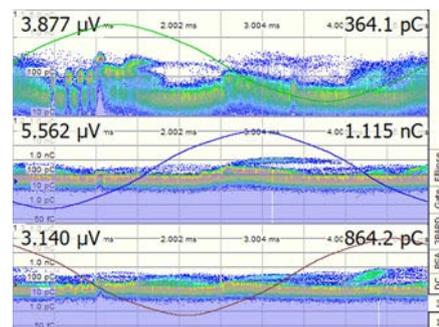


Figure 4-12 The "3" display

### 4.5.8 "4" Display

The "4" display shows the phase-resolved PD patterns for 4 units in real-time. Depending on the settings voltage curves and spikes are shown too. The unit's number is shown in the upper left corner of each diagram. Optionally, the current

$Q_{IEC}$  value is displayed in the upper right corner of each diagram (see Q Tab chapter 5.9 on page 127) and the current RIV value is displayed in the upper left corner of each diagram (see also **Show RIV value in overview ...** on page 95).

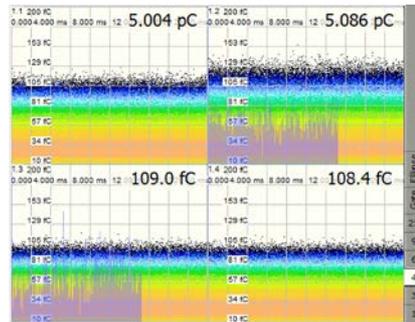


Figure 4-13 The "4" display

### 4.5.9 "6" Display

The "6" display shows the phase-resolved PD patterns for 6 units in real-time. Depending on the settings, voltage curves and spikes are shown too. The unit's number is shown in the upper left corner of each diagram. Optionally, the current  $Q_{IEC}$  value is displayed in the upper right corner of each diagram (see Q Tab chapter 5.9 on page 127) and the current RIV value is displayed in the upper left corner of each diagram (see also **Show RIV value in overview ...** on page 95).

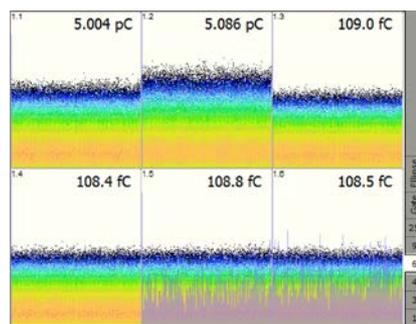


Figure 4-14 The "6" display

### 4.5.10 "9" Display

The "9" display shows the phase-resolved PD patterns for 9 units in real-time. Depending on the settings, voltage curves and spikes are shown too. The unit's number is shown in the upper left corner of each diagram. Optionally, the current

$Q_{IEC}$  value is displayed in the upper right corner of each diagram (see Q Tab chapter 5.9 on page 127) and the current RIV value is displayed in the upper left corner of each diagram (see also **Show RIV value in overview ...** on page 95).

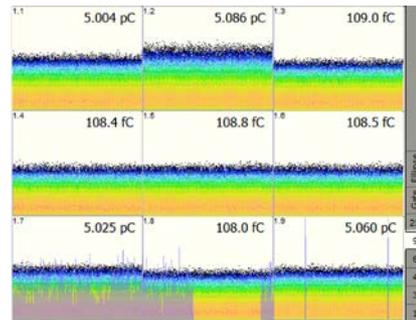


Figure 4-15 The "9" display

### 4.5.11 "25" Display

The "25" display shows the phase-resolved PD patterns for 25 units in real-time. Independent of the settings, there are no voltage curves and spikes. The unit's number is shown in the upper left corner of each diagram. Optionally, the current  $Q_{IEC}$  value is displayed in the upper right corner of each diagram (see Q Tab chapter 5.9 on page 127) and the current RIV value is displayed in the upper left corner of each diagram (see also **Show RIV value in overview ...** on page 95).

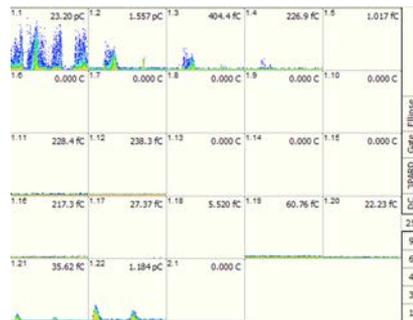


Figure 4-16 The "25" display

### 4.5.12 Gate Display

The **Gate** display allows the user to draw rectangles on the PD histogram that are interpreted as phase or phase-amplitude gates. To draw a rectangle, click and drag the mouse across the desired area of the screen. A frame will be drawn around the selected position as you drag the mouse. After releasing the mouse

button, the rectangle will be shown in gray, indicating the gated area. Using the right mouse button, it is possible to create a phase gate, which extends across the entire height of the screen.

More than one gate can be created in this way. Gates can overlap and can be freely mixed between phase amplitude and phase gates. To remove a gate, double-click on it (using the left mouse button). You can remove all gating windows using the function **Clear all Gate rectangles** from the **Advanced** menu (see 5.5.1 on page 103). Pointing the mouse over an existing gate displays the gate's coordinates and type (phase or phase-amplitude).

**Note:** Enabling gating may compromise IEC 60270 conformity.

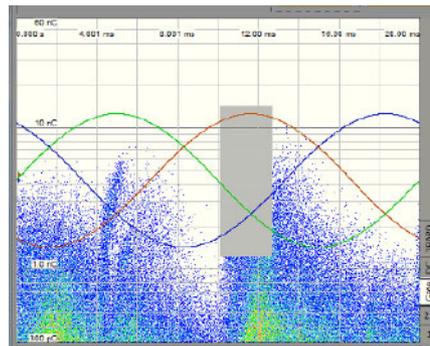


Figure 4-17 The Gate display

## 4.6 H(Q) View

The H(Q) View displays the contents of the PRPD histogram of the currently selected unit as a diagram plotting the number of PD events over the charge. The x-axis corresponds to the charge and uses the same scaling as the PRPD histogram that is visible under the "1" view, including display mode

(bipolar/unipolar, linear/logarithmic). The y-axis plots the number of all PD events. Thus, each point in the diagram represents the total number of PD events (its y-coordinate) with a charge level corresponding to its x-coordinate.

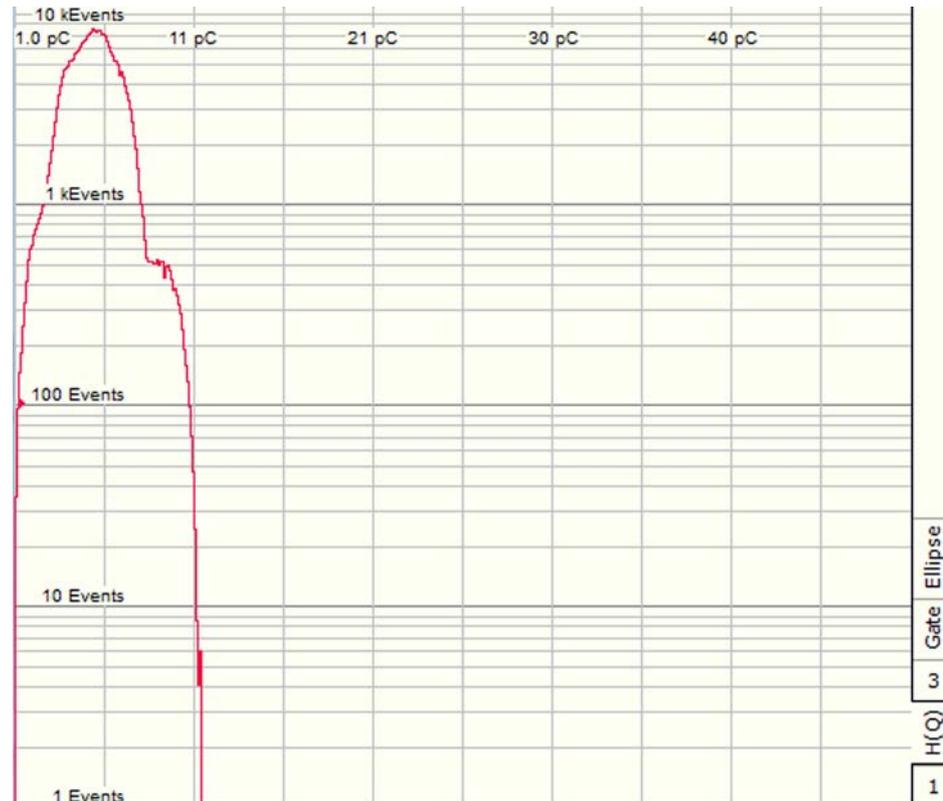


Figure 4-18

## 4.7 Small Scope View

The small scope view contains the displays for the inception and extinction voltage as well as the graph of the frequency spectrum. When the software is in replay mode, the small scope view contains an additional replay display. Each of these displays is described below.

### 4.7.1 Info Display

The **Info** display shows the voltage at which PD activity becomes higher than the threshold (the PD inception voltage) and the voltage at which PD activity drops below the threshold (the PD extinction voltage). For reference, it also shows the threshold value, adjustable in the **Calibration** tab as well as the Pass/Fail status of each of the 3 user-configurable Pass/Fail thresholds.

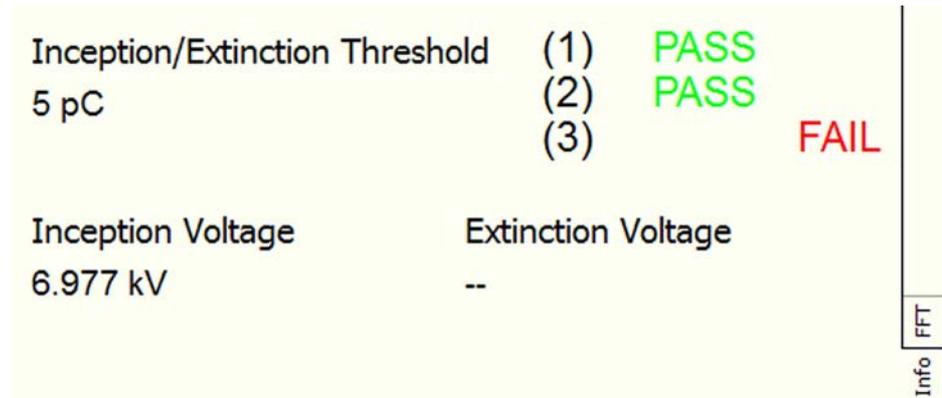


Figure 4-19 The Info display

### 4.7.2 FFT Display

The **FFT** display shows the frequency spectrum as seen by the unit's PD input. This represents the combined spectrum of any PD activity, noise, and any other signals that are present in the test setup. The FFT display also shows a cursor at the measurement frequency. The cursor corresponds to the center frequency of the PD filter; the shaded area around the cursor represents the filter's bandwidth. In online mode (i.e. while not replaying a stream file), the cursor can

be moved by dragging it with the mouse; this will change the PD filter's center frequency accordingly. The mouse must point to the arrow of the cursor line for moving.

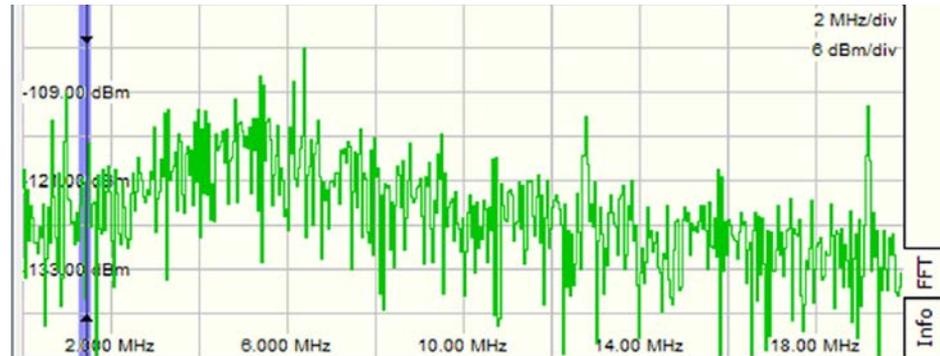


Figure 4-20 The FFT display

### 4.7.3 Replay Display (Replay Mode Only)

The **Replay** display gives an overview over the measurement data contained in the stream file that is currently being replayed. It plots the voltage level and the  $Q_{IEC}$  value over time, showing the values that were measured while the stream file was recorded. Keep in mind that any gates that were in effect while the stream file was recorded will also affect the overview curves stored in the stream file. This means that if, for example, while recording a stream file you draw a phase/amplitude gate that affects the  $Q_{IEC}$  value displayed, the displayed value will also be stored as the overview value in the stream file. However, the gate you drew will not be stored in the stream file (because the stream was already recording when you drew the gate). So during replay, the value shown in the overview diagram will not match the  $Q_{IEC}$  value being displayed when the replay reaches the place where you drew the gate while recording. The voltage displayed depends on the setting for the dominant voltage that was in effect when the stream file was recorded. This can be either the RMS value, the Peak/ $\sqrt{2}$  value, or the DC value. There are two cursors on the **Replay** tab that can be used to limit the Replay range. The mouse must point to the arrow of the cursor line for moving. Moving the left-hand cursor (which indicates the replay

start position) will automatically move the right-hand cursor (indicating the replay end position), so the right-hand cursor must be moved first in order to limit the replay range.

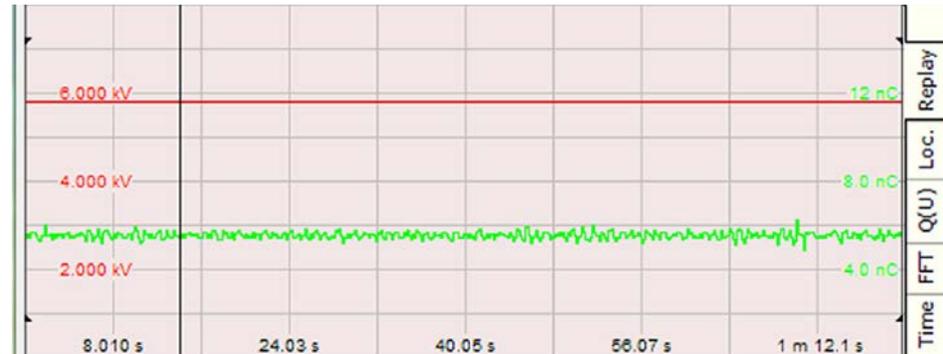


Figure 4-21 The Replay display

## 4.8 Measured Quantities Display

Click on the **Main** tab to show the two boxes that show the current values for the quantities being measured, such as IEC 60270-conformant apparent charge, voltage, high-voltage frequency, etc. Depending on different settings or the kind of measurement, the display may vary.

### 4.8.1 Upper Box

The upper box of this display shows:

- the designation of the selected unit. If the unit was assigned a name, then that name is shown here. Otherwise, the unit's type and position is used (e.g. "MPD 600 1.1")
- the current  $Q_{IEC}$  value (the apparent charge as defined in IEC 60270), if the current measurement settings conform to IEC 60270. Otherwise the value shown is computed the same way as the  $Q_{IEC}$  value, but is called  $Q_{WTD}$  in order to indicate that the value does not conform to IEC 60270.

**Note:** During stream playback, after finishing replaying the selected replay range, the average value of the range that was replayed is shown.

**Note:** The  $Q_{IEC}$  (and  $Q_{WTD}$ ) value is a statistical value computed over a certain duration. When certain settings change, for example the PD divider factor, or when moving to a different position during stream replay, the software will not have enough information to conclusively compute that value. In that case, the value is shaded in yellow, and the value will use the

information it has to compute the value. Once enough information is available (because the required duration's worth of data has been collected), the value will be displayed without the shading.

- RIV (radio interference voltage) value (if selected in the control panel)
- PD filter settings
- number of PD events seen over time while a pattern is being recorded.
- percentage of gated PD activity (due to phase or phase/amplitude gates, DyNG, unit gating, or dead time settings)
- if enabled in the Advanced menu, information about IEC 60270 compliance of the current measurement settings

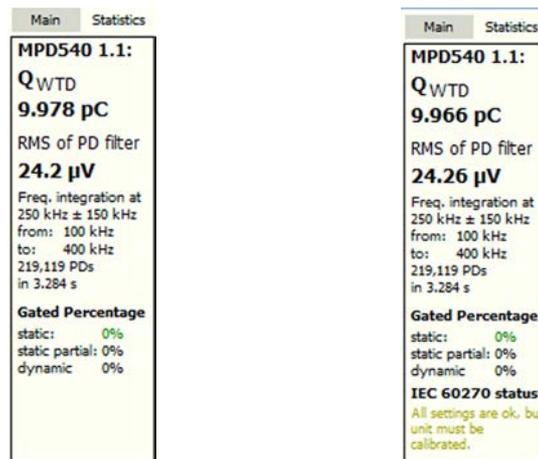


Figure 4-22 Upper box of the measured quantities display

## 4.8.2 Lower Box

The lower box shows:

- the designation of the unit that is currently used as the trigger source. If the unit was assigned a name, then that name is shown here. Otherwise, the unit's type and position is used (e.g. "MPD 600 1.1")
- the value of the triggering unit's peak voltage divided by  $\sqrt{2}$
- the RMS value of the triggering unit's voltage. During a DC measurement (see Expert Mode chapter 5.19 on page 177), the DC portion of the voltage applied to the *MPD 600*'s **V** input is displayed rather than the RMS value.
- the frequency of the triggering unit's voltage
- the unit's position in the FO hierarchy (e.g. "1.1" for the first unit on the first FO bus), a user-clickable check box controlling whether the unit is visible in the PD scope and FFT displays, and the color used for each of the units' curves. Clicking on the colored rectangles pops up the color selection window which allows the user to change the color that is used for displaying a unit's curves.

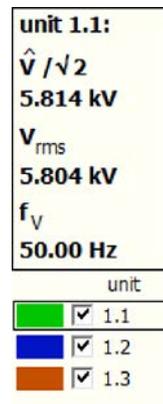


Figure 4-23 Lower box of the measured quantities display

### 4.8.3 Lower Box Line View

The lower box changes to the line trigger view if **Line trigger 50/60 Hz** is selected as the trigger source in the **Settings** tab (for more information, see 4.10 on page 82). Clicking on the colored box opens the color selection window which allows the user to change the color that is used for displaying the line curve.

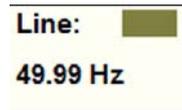


Figure 4-24 Lower box line view

### 4.8.4 Lower Box Internal Trigger View

The lower box changes to internal trigger view if the **Internal Trigger** is selected as the trigger source in the **Settings** tab (for more information see 4.10 on page 82).

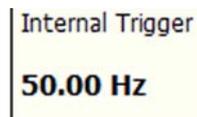
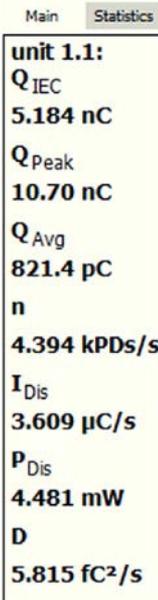


Figure 4-25 Lower box internal trigger view

## 4.9 Statistics View

If enabled in Expert Mode (see 5.9.14 on page 140), additional PD measurement statistics are computed over a configurable evaluation interval. These statistics can be viewed by clicking on the **Statistics** tab in the Measured Quantities display. The computed statistics are:

- $Q_{Peak}$ : the largest absolute charge of any PD event seen during the evaluation interval,
- $Q_{Avg}$ : the average  $Q_{IEC}$  (or  $Q_{WTD}$ ) value for the evaluation interval
- $n$ : the pulse repetition rate, averaged over the evaluation interval
- $I_{Dis}$ : the average discharge current over the evaluation interval
- $P_{Dis}$ : the average discharge power (discharge current times instantaneous AC voltage) over the evaluation interval
- $D$ : the quadratic rate over the evaluation interval.



Quantity	Value
<b>unit 1.1:</b>	
$Q_{IEC}$	5.184 nC
$Q_{Peak}$	10.70 nC
$Q_{Avg}$	821.4 pC
$n$	4.394 kPDs/s
$I_{Dis}$	3.609 $\mu$ C/s
$P_{Dis}$	4.481 mW
$D$	5.815 fC <sup>2</sup> /s

Figure 4-26 Statistics view

These values are defined in the IEC 60270 standard.

When statistics are first enabled, and after they have been reset, the displayed values are shaded in yellow until one evaluation interval's worth of data has been considered. This is done to indicate that until that time the values displayed are produced from a smaller interval than what was set by the user.

## 4.10 Settings Tab

The **Settings** tab contains settings related to PD detection and display of PD in the large and small scope views. Additionally, it contains the buttons for building histograms (phase-resolved PD patterns) and for recording measurement streams to a file.

The **Trigger source** is used to compute the frequency of the AC voltage and to map PD events to a phase position (for use with phase-resolved histograms and the spikes view).

Figure 4-27 Settings tab

## 4.10.1 Trigger Source Settings

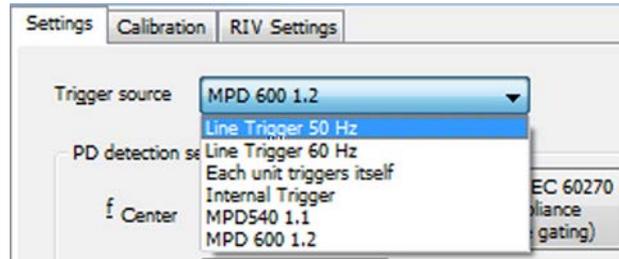


Figure 4-28 Trigger source settings

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<b>unit x.x</b>	<p>If a unit has been given a name, that name is listed here. Otherwise, the unit is shown as "&lt;type&gt; &lt;bus&gt;.&lt;position&gt;", as in "MPD 600 1.1"</p> <p>Any <b>V</b> input of one of the connected units can be selected as a trigger to synchronize all other units.</p>
<b>Each unit triggers itself</b>	<p>Means that every MPD unit is triggered independently by their own <b>V</b> input.</p>
<b>Line Trigger 50 Hz or Line Trigger 60 Hz</b> (in accordance to the local AC net)	<p>If one of these options is selected, the built-in light-sensitive sensor of the MCU controller is used as the trigger source. This sensor uses the light emissions from light bulbs operating with AC and deduces the line frequency from that.</p> <p><b>Note:</b> The Line Trigger mode does not work if frequency-modulated light is used.</p>
<b>Internal Trigger</b>	<p>Means that the PD acquisition unit synthesizes its own "AC" frequency. This is useful if the original AC net frequency is not stable or there isn't any frequency at all. The frequency value can be entered in the field behind <b>Int. trigger freq.</b> in the <b>V</b> tab after switching to Expert Mode (see 5.7.5 on page 112)</p>

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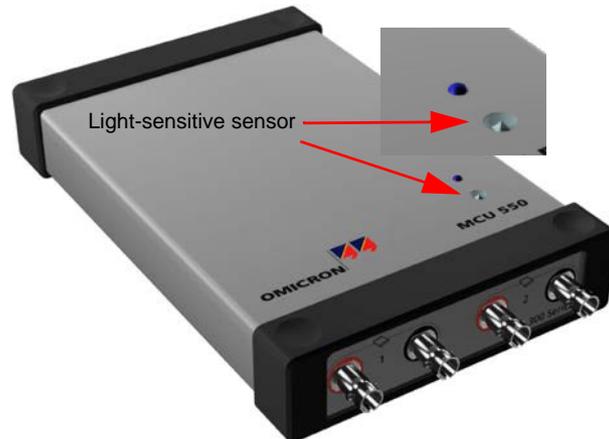


Figure 4-29 MCU controller with light-sensitive sensor

## 4.10.2 PD Detection Settings

The center frequency ( $f_{\text{Center}}$ ) sets the nominal frequency at which the charge integration takes place; the bandwidth selects the frequency range around the center frequency. You can select the following bandwidths: 1.5 MHz, 1 MHz, 800 kHz, 650 kHz, 300 kHz, 160 kHz, 100 kHz, 40 kHz, 9 kHz. When the option **Use high-bandwidth filters** is enabled (see page 48), the available bandwidths are 3 MHz, 1 MHz, 300 kHz, 100 kHz, 30 kHz, and 9 kHz.

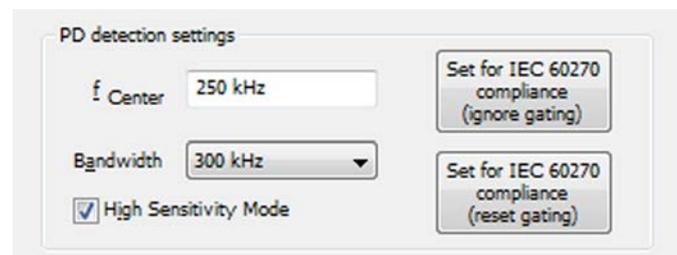


Figure 4-30 PD detection settings

Before enabling the **High Sensitivity Mode** read the information in 5.8.2 on page 119.

**Note:** The two buttons **Set for IEC 60270 compliance (ignore gating)** and **Set for IEC 60270 compliance (reset gating)** duplicate the functionality from the File menu. Clicking on any of these buttons will configure all connected units to be compliant with IEC 60270, while leaving gates alone (the top button) or resetting all gating-related options (the bottom button).

### 4.10.3 Display Settings

**Mode** allows to select unipolar or bipolar and logarithmic or linear view for the large scope view. Unipolar means that the polarity of the PD events is ignored, and only their absolute charge is considered. With bipolar selected, the polarity of the event is also taken into account.

Enter  $Q_{Max}$  and  $Q_{Min}$  values to set display boundaries. With the function **Show individual PD events in phase histogram view** checked, the software will show individual PD events as phase and amplitude resolved “spikes” in real-time.

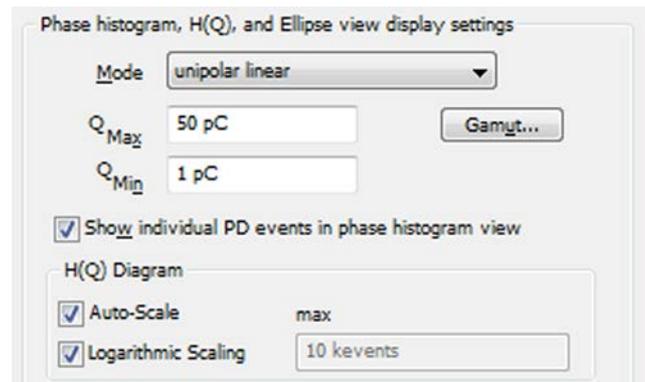


Figure 4-31 Display settings

**Note:** These settings apply to the PRPD and the H(Q) diagram. For the PRPD they control the vertical axis, for the H(Q) diagram they control the horizontal (x) axis.

The H(Q) section contains the setting for the vertical scale of the H(Q) diagram. **Auto-Scale** enables automatic scaling of the y-axis so that everything is visible, and **Logarithmic Scaling** enables or disables logarithmic scaling of the y-axis. If **Auto-Scale** is deactivated, the **max** field can be set to the number of PD events that should correspond to the top margin of the diagram.

#### 4.10.4 Gamut Settings

Clicking on the **Gamut** button brings up the window shown below, which allows to modify the way that colors are assigned to the various histogram classes.

The gamut (color map) consists of a number of classes which each have a color, and which corresponds to a specific number of PD events per second (a.k.a. PD rate). As the histogram is built, a point gets assigned the color of the highest gamut class whose PD rate is lower than the histogram point's PD rate. The gamut can be set to automatically compute class boundaries for all classes in a logarithmic or linear fashion, with the top class corresponding to the maximum value for the histogram. For this select **Auto-compute** in the **Classification Boundaries** box, and select either **Linear** or **Logarithmic**. By selecting the **Auto-assign maximum** setting, the gamut can also be set to track the maximum PD rate in the histogram and adjust the class boundaries accordingly.

Enabling the **Apply Dithering** setting causes the histogram points to become approx. 16 times "bigger" (i.e. PD events are counted not only by the histogram point to which they belong, but to a lesser extent also by neighboring points). This causes the histogram to form a significant pattern more quickly, but will produce a "fuzzier" pattern.

**Anchor to measure time** adjusts the class coloring such that the proper coloring is only reached at the end of histogram acquisition (i.e. at the end of the measure time). As the histogram is built, the coloring will become progressively

more red (if red is the top class's color). To select every class boundary manually, select **Set Manually** in the **Classification Boundaries** box. Then you can enter the value for each color class.

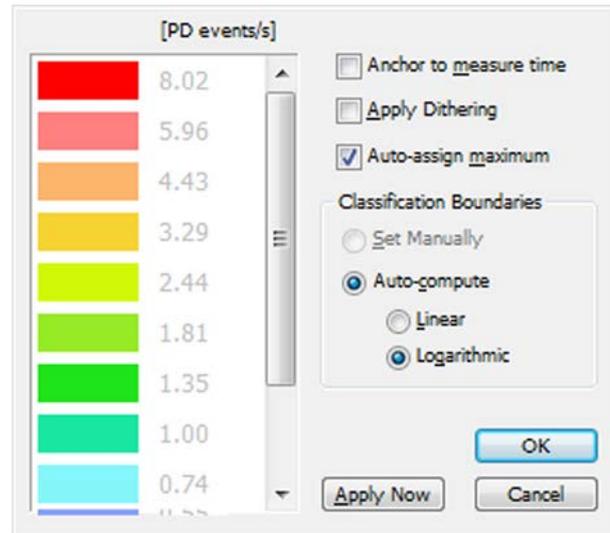


Figure 4-32 Gamut settings

The **Show individual PD events in phase histogram view** option enables or disables the display of PD event "spikes" (or "needles") that show individual PD events as a line drawn from the diagram base to the point in the diagram that corresponds to the PD event's charge.

The **H(Q) Diagram** section configures the vertical scaling of the H(Q) diagram. Enabling **Auto-Scale** will automatically adjust the vertical scaling such that the maximum value is visible and a reasonable amount of the diagram space is utilized. Enabling **Logarithmic Scaling** will scale the y-axis logarithmically. Disabling that option scales the y-axis linearly. If **Auto-Scale** is disabled, the field labeled **max** accepts the number of PD events that should correspond to the diagram's top border.

## 4.10.5 Histogram Acquisition Controls

Toggleing the **Go** button on begins generating the PRPD histogram. Toggleing it off stops it. Histogram generation continues for the duration specified in the **delta t** field.

**Note:** Pressing the F5 key anywhere in the application has the same effect as clicking on the  button.

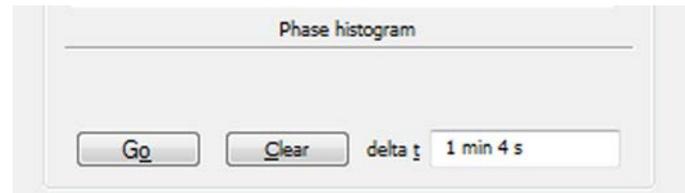


Figure 4-33 Histogram acquisition controls

## 4.11 Streaming

With the **Streaming** function it is possible to record and save all data acquired by the computer to a file for later use. The streaming function is available in all modes (Basic, Expert, Cable).

### 4.11.1 Stream Controls

The **Stream file** setting contains the full path name of the stream file.

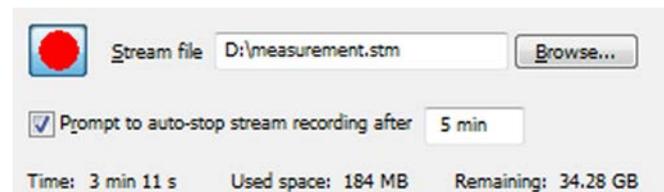


Figure 4-34 Stream controls

**Note:** When streaming is actually started, the file name will be modified to contain the date and time of the moment at which the stream file was created.

The **Prompt to auto-stop stream recording after** field selects whether the software automatically displays a warning after having recorded a stream for a certain time, asking the user whether stream recording should continue. The time can be set in the field next to the option.

The **Time** field displays the time that the stream has been recording for, the **Used space** field indicates the space used up so far by the stream file, and the **Remaining** field shows how much space is available on the drive on which the stream is being recorded.

Clicking on the  button will start the streaming process. Clicking **Browse** allows to navigate to a folder and enter a name for the stream file.

While a stream is being recorded, an indication is shown in the large scope view, as shown in Figure 4-35.

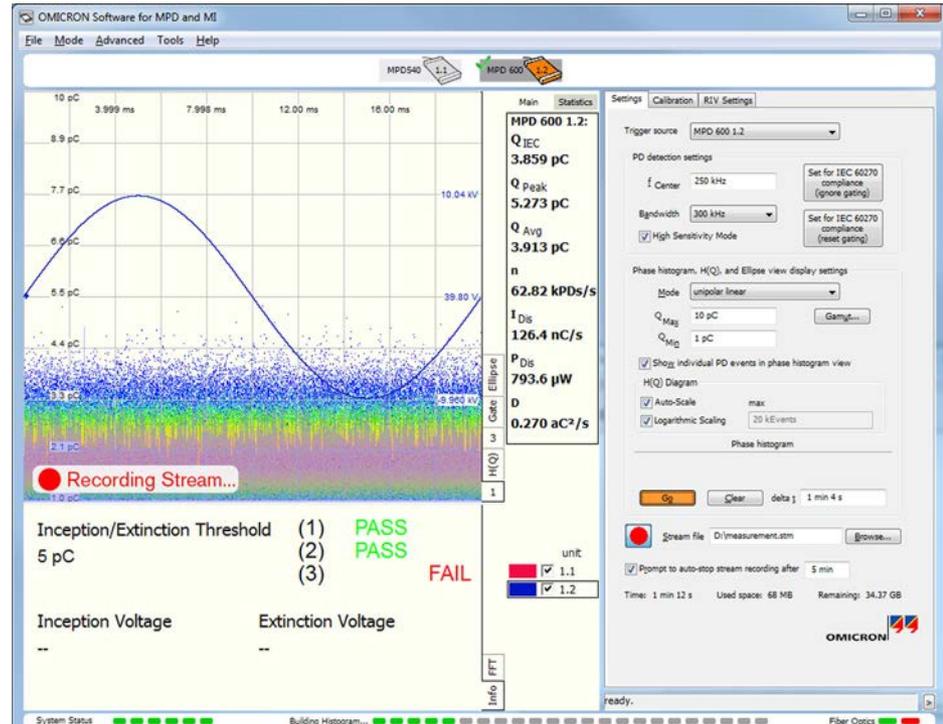


Figure 4-35 Stream recording

When the **Prompt auto-stop stream recording after** option is enabled and the chosen time has elapsed, a window pops up.



Figure 4-36 Stream recording warning

Clicking on **Continue** will close the window and continue recording the stream. The window will then reappear after another interval of the chosen time has elapsed.

Clicking on **End Recording Session** will end the recording session and close the stream file. If no action is taken within 20 s of the window appearing, the stream recording session will be automatically ended.

## 4.12 Calibration Tab

The **Calibration** tab contains the settings to perform a system calibration.

**Note:** The calibrations apply to the selected unit only.

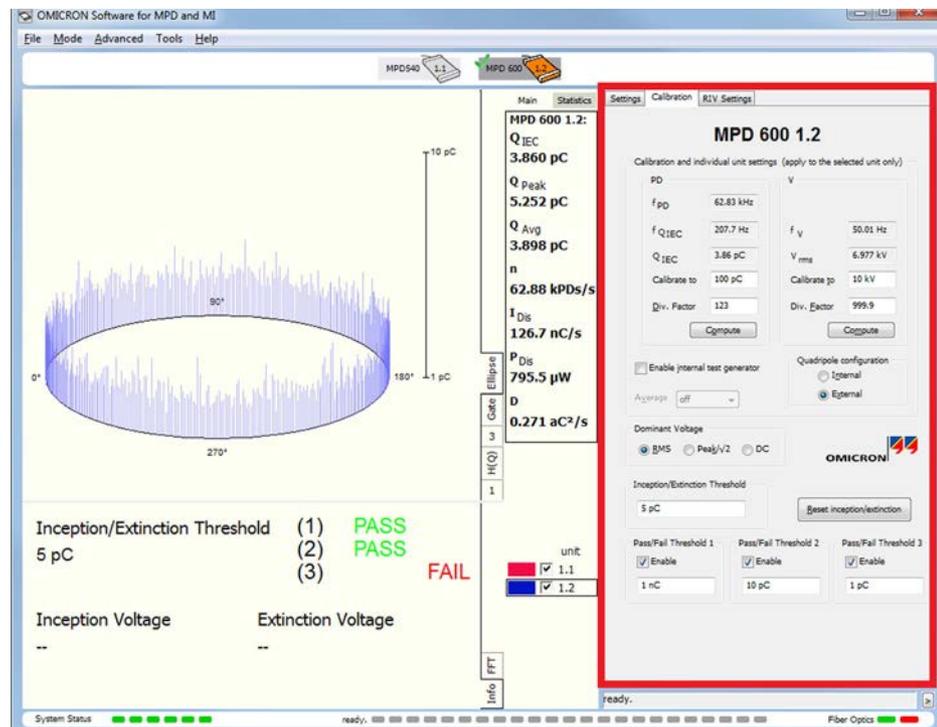


Figure 4-37 Calibration tab

## 4.12.1 Charge Calibration



**Warning:** Switch off the high voltage and temporarily ground the high-voltage test setup observing safety procedures before connecting the charge calibrator.

Clear the **Enable internal test generator** option. Check **External** under **Quadrupole configuration**. Now the calibration of the test object can start.

Connect the calibrator to the test object. Select a charge of 100 pC or another suitable value at the calibrator. Remove the temporary ground from the high-voltage test setup.

Calibrator pulses should clearly extend from the background noise as “spikes” (see blue lines in the figure above). If the noise floor covers pulses, change PD detection settings (**Settings** tab) or select a higher charge at the calibrator.

Enter the calibrator charge (e.g. 100 pC) into the **Calibrate to** field in the **PD** section.

Click on the  button in the **PD** section. The display value for  $Q_{IEC}$  should now correspond to the calibrator charge.

Disconnect the calibrator.

**Note:** Charge calibration must be performed for every test subject.

## 4.12.2 Voltage Calibration

Turn on the high-voltage supply. Set voltage to a known level (e.g. max. 10% of the rated voltage to avoid damage to the test object).

Enter this voltage level into the **Calibrate to** field in the **V** section. Click on the  button in the **V** section. The display value  $V_{RMS}$  for the voltage should now correspond to the actual voltage.



**Warning:** Secure the high-voltage setup observing safety procedures.

**Note:** Voltage calibration only needs to be performed before first use or when a different coupling capacitor is installed.

### 4.12.3 Setting the Dominant Voltage

The dominant voltage determines the "calibration target" of the voltage calibration (the value the **Calibrate to** field applies to). This can be set to the RMS voltage (the default), the Peak/SQRT(2) voltage or the DC voltage.

### 4.12.4 Setting the Inception/Extinction Threshold

Inception is the term used to describe the point at which PD activity starts occurring. This point is associated with a voltage, called the inception voltage. Likewise, extinction is the point at which PD activity ceases, and it is also associated with a voltage, called the extinction voltage. The inception/extinction threshold is the PD level that marks the onset of PD activity. Any PD event below that threshold is not considered PD activity, while all PD events at or above that level indicate the presence of PD activity. Once the threshold is set, the software monitors PD events and the voltage of the trigger source and when the apparent charge value first crosses the threshold, the corresponding voltage is recorded and designates the inception voltage. As soon as the apparent charge value drops below the threshold, the extinction point is recorded. Note that it is possible for PD activity to recur after extinction has been detected. In this case, the software no longer considers extinction to have occurred and waits for the next time that the apparent charge value drops below the threshold.

To reset all inception and extinction records and restart the process described above, click on the **Reset inception/extinction** button.

### 4.12.5 Pass/Fail Thresholds

The software provides three separate pass/fail thresholds that can be independently configured. A pass/fail threshold is a charge level that limits the permissible PD activity of a test subject. If a subject exhibits PD activity in excess of a pass/fail threshold, it is considered to fail the PD test, otherwise it passes.

You can set each pass/fail threshold to a different value, and can choose whether to enable one or more of the thresholds. The result of the pass/fail evaluation for each threshold is displayed in the Info Display.

**Note:** The result of the pass/fail evaluations is also stored in the XML file created during XML export.

## 4.13 RIV Settings Tab

The **RIV Settings** tab contains settings to control **Radio Interference Voltage** (RIV) measurements. RIV expresses Partial Discharge activity as a voltage that can be picked up using a radio receiver at a certain frequency.

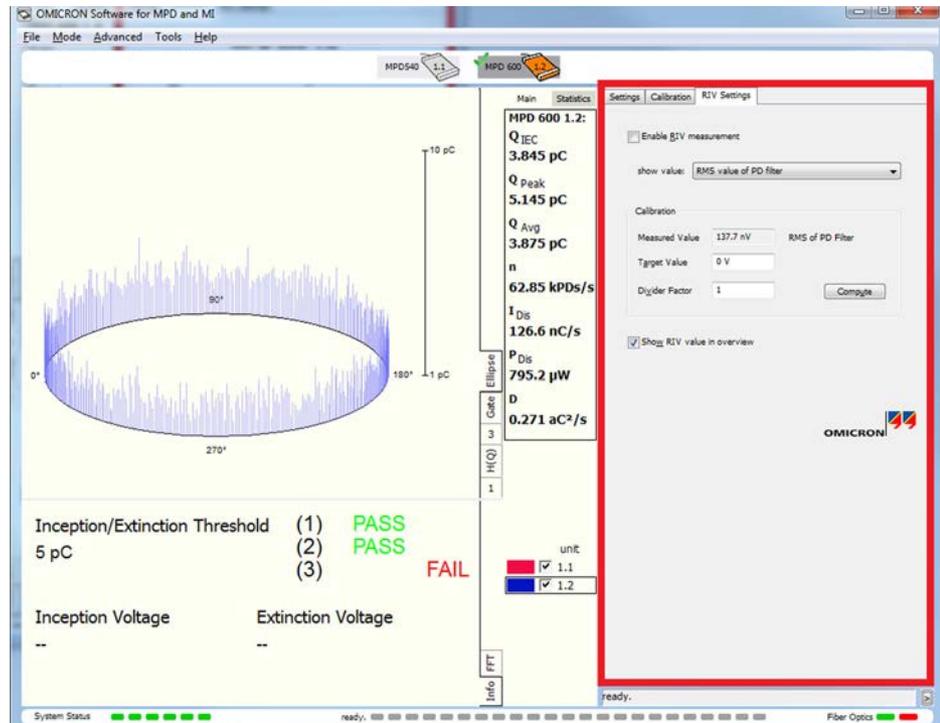


Figure 4-38 RIV Settings tab

### 4.13.1 RIV Measurement Calibration

Use the **Calibration** section to adjust the RIV readout. Connect an RIV calibrator (often, a function generator is used) to the two terminals of the test object, typically the high-voltage connector and ground. Set it to a suitable voltage (for example, 54 dB $\mu$ V, corresponds to 501  $\mu$ V). Enter the value of that voltage into the **Target Value** field.

Set the RIV calibrator to a suitable measurement frequency (typically 1 MHz).

Set the MPD unit to the same center frequency as the RIV calibrator and set the measurement bandwidth to 9 kHz. Change the frequency of the calibrator slightly up and down until the MPD generates a maximum value.

Press the **Compute** button to automatically set the **Divider Factor** such that the **Measured Value** is the same as the **Target Value**. Alternatively, you can enter the **Divider Factor** directly. In the **show value** drop-down box you can select the value to be shown in the large scope view. Please be aware that only the selection of **Quasi-Peak value of PD filter** is CISPRE-compliant. The filter list is not available when **Use high-bandwidth filters** is enabled in the Advanced menu, in which case the RMS value is always used. Therefore, deactivate **Use high-bandwidth filters** when performing RIV measurements.

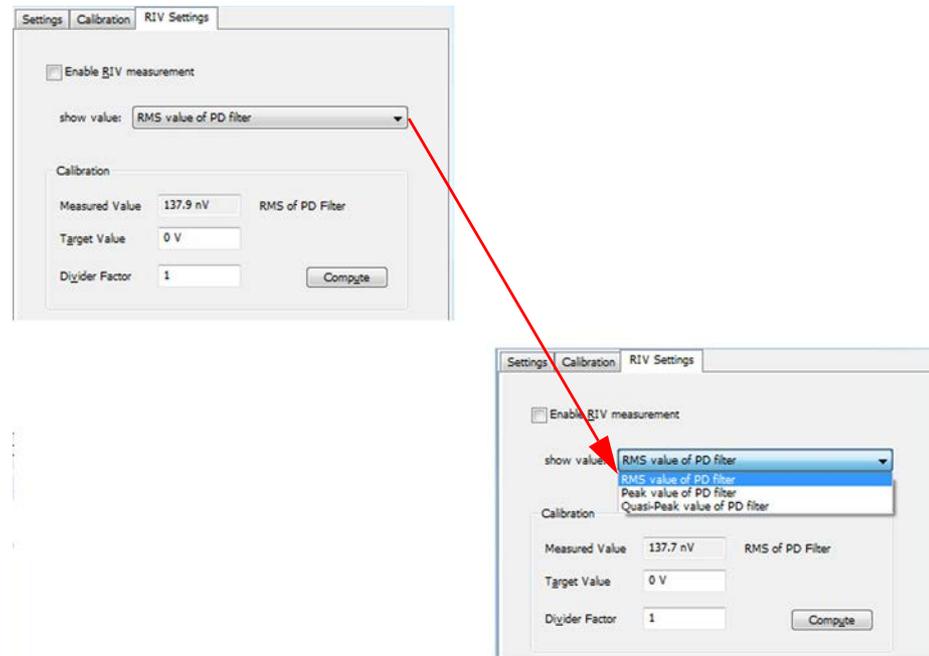


Figure 4-39 RIV measurement calibration

Selecting **Show RIV value in overview** means that this value will be also shown in the upper left corner of the overview diagrams.

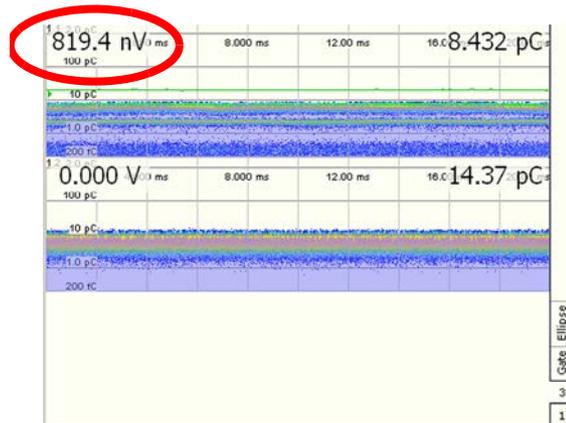


Figure 4-40 RIV value shown

**Note:** The **RIV Settings** tab is also included in the Expert Mode and works exactly in the same way as described above.



## 5 Expert Mode

### 5.1 Introduction

Expert Mode of the software allows to control every aspect of the operation of the MPD measurement system.

### 5.2 Starting Expert Mode

Expert Mode is only available if at least one MPD unit is connected and running or if a measurement session has been loaded.

Start the software and select **Mode** from the main menu in the upper menu bar. Then choose **Expert**.

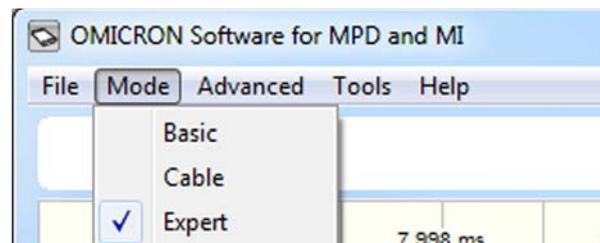


Figure 5-1 Expert Mode selection

Expert Mode contains a lot more controls than Basic Mode. These controls are arranged into tabs in the control panel at the right hand side of the software window (see highlighted area below). The control panel provides access to all measurement and display options.

### 5.3 Control Panel

Just click on the desired tab head to bring it to the front. Hovering the mouse over a tab shows a tooltip with information about the contents of that tab. The tabs are named according to their primary purpose. The sets of options follow these purposes (see Table 5-1 on page 100).

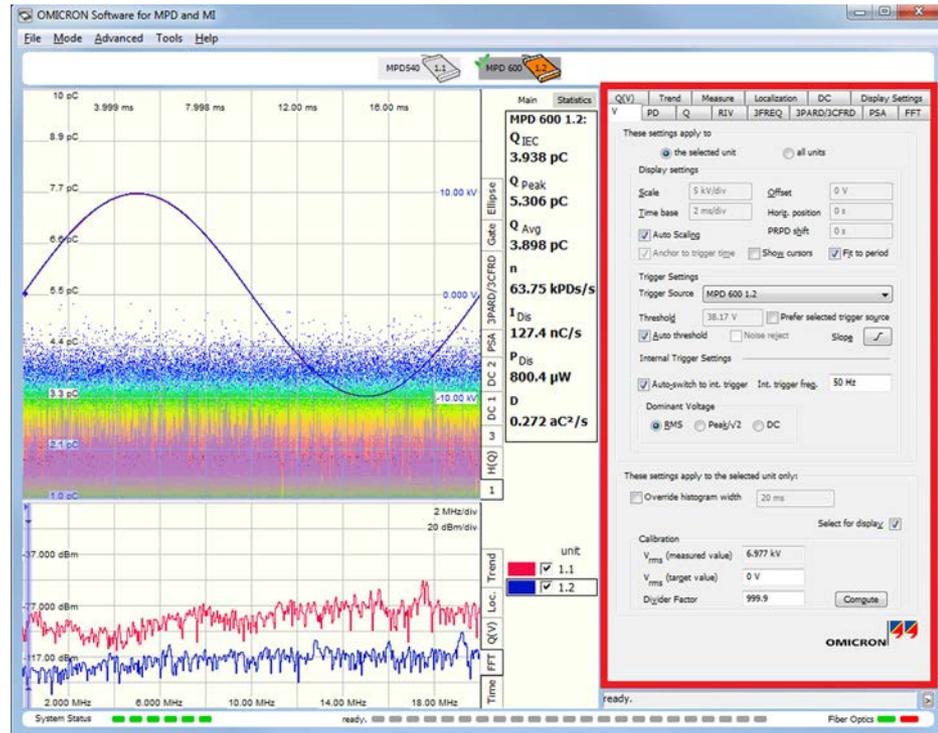


Figure 5-2 Control panel

**Note:** Control Panel settings are stored in the file `MPD.conf` when the software shuts down. After restarting, the software uses this configuration file and loads the settings from this file. An administrator may install a different read-only configuration file that will be used instead of `MPD.conf`.

Tab Name	Tab Function
V	The <b>V</b> tab contains all settings related to the measurement of the AC voltage curve in the "1" display of the large scope view as well as trigger and calibration settings.
PD	Settings on the <b>PD</b> tab control the measurement and oscilloscope display options of the high-frequency PD current that is applied to the PD input of the MPD unit. Additionally, the <b>PD</b> tab also controls the built-in test generator. The oscilloscope display of the PD input is located on the Time display of the small scope view.
Q	The <b>Q</b> tab contains settings that govern the detection, quantification and display of PD events (including settings for the phase-resolved PRPD histogram). Other functions include PD calibration, gating options, and recording stream files. Phase-resolved patterns and histograms are shown in the large scope view.  <b>Note:</b> The <b>Q</b> tab is renamed to $V_{UHF}$ if a UHF 608 or UHF 620 down-converter is connected to the MPD unit in order to reflect the fact that no direct charge measurements are possible when measuring in the UHF frequency range.
RIV	The <b>RIV Settings</b> tab contains settings to control Radio Interference Voltage (RIV) measurements (see 4.13 on page 93).
3FREQ	The <b>3FREQ</b> makes it possible to create a "Star" graph for one acquisition unit, using three different frequencies, which is shown on the 3PARD/3FREQ display of the large scope view.
3PARD/3CFRD	The <b>3PARD/3CFRD</b> tab controls the 3PARD and 3CFRD diagram used to separate different PD sources.
PSA	The <b>PSA</b> tab controls the display settings and computation options to form a PSA ( <b>P</b> ulse <b>S</b> equences <b>A</b> nalysis) histogram of the PD events applied at the PD input of the selected acquisition unit(s). The histogram is shown on the PSA display of the large scope view.

Tab Name	Tab Function
FFT	The <b>FFT</b> tab controls the display settings and computation options for the frequency spectrum of the voltage applied at the PD input. The spectrum is shown on the FFT display of the small scope view. The <b>FFT</b> tab also shows configuration settings for any connected UHF 608 converters.
Q(V)	The <b>Q(V)</b> tab controls the display options for the Q(V) display of the small scope view, and contains the control that turns the graph on or off.
Trend	The <b>Trend</b> tab contains settings that apply to trending. It turns trending on or off, controls the display settings for the various trending quantities, and selects whether trends are recorded to a file or not. The trending diagram is available at the Trend display of the small scope view.
Measure	The <b>Measure</b> tab contains controls that allow the user to measure the distance and voltage between two measurement cursors that work on the voltage measured on the PD input (i.e. the data being shown by the display Time of the small scope view).
Replay	Only available when a recorded stream file is opened in the file menu. The <b>Replay</b> tab controls display options and settings for replaying measurement sessions from a file.
Localization	The <b>Localization</b> tab contains controls for performing PD event source localization using a statistical time-domain reflectometry (TDR) approach or time difference measurement using multiple sensors. The corresponding localization/correlation histogram is shown at the Loc. display of the small scope view.
DC	The <b>DC</b> tab controls DC measurements, and contains the display settings for the various diagrams that are shown at the DC display of the large scope view.
Display Settings	The <b>Display Settings</b> tab controls colors and miscellaneous display settings such as label positions and grid visibility.
UHF	The <b>UHF</b> tab is only available when a UHF 608 or UHF 620 down-converter is connected. It provides access to the features of the UHF down-converter, and controls the UHF display in the small scope view.

Table 5-1 Tab functions

## 5.4 Visualization Zone

The visualization zone (see highlighted area below) contains:

- the large scope view
- the small scope view
- the measured quantities display and statistics view.

The displays of both scope views can be selected by clicking on the corresponding tab.

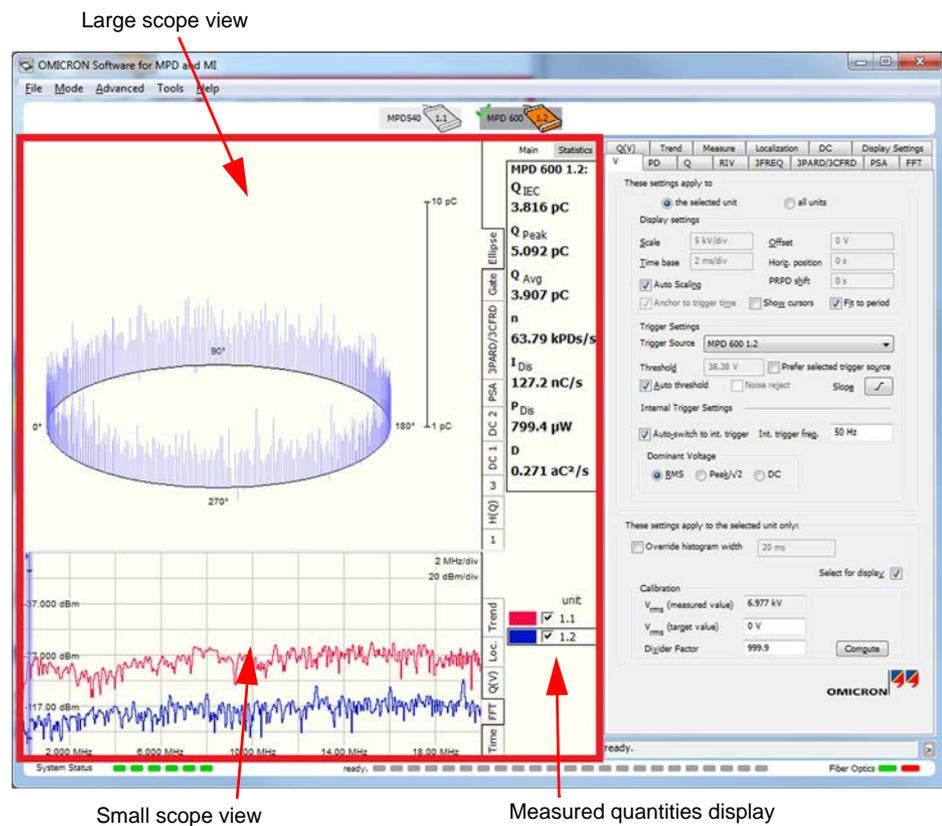


Figure 5-3 Visualization zone

## 5.5 Large Scope View

The large scope view provides displays that present Partial Discharge activity measured by the currently selected unit, including a Lissajous (ellipse) figure and a phase-resolved histogram pattern overlaid with the high-voltage curve.

Alternatively, the large scope view may be used to view overview diagrams showing the phase-resolved histograms of the connected acquisition units as already described in 4.5 on page 66 and following. Additionally, the following displays are available in Expert Mode.

## 5.5.1 DC Displays

The **DC 1** and **DC 2** displays show the results of DC measurements with various diagrams following the settings in the DC tab. (see 5.19 on page 177)

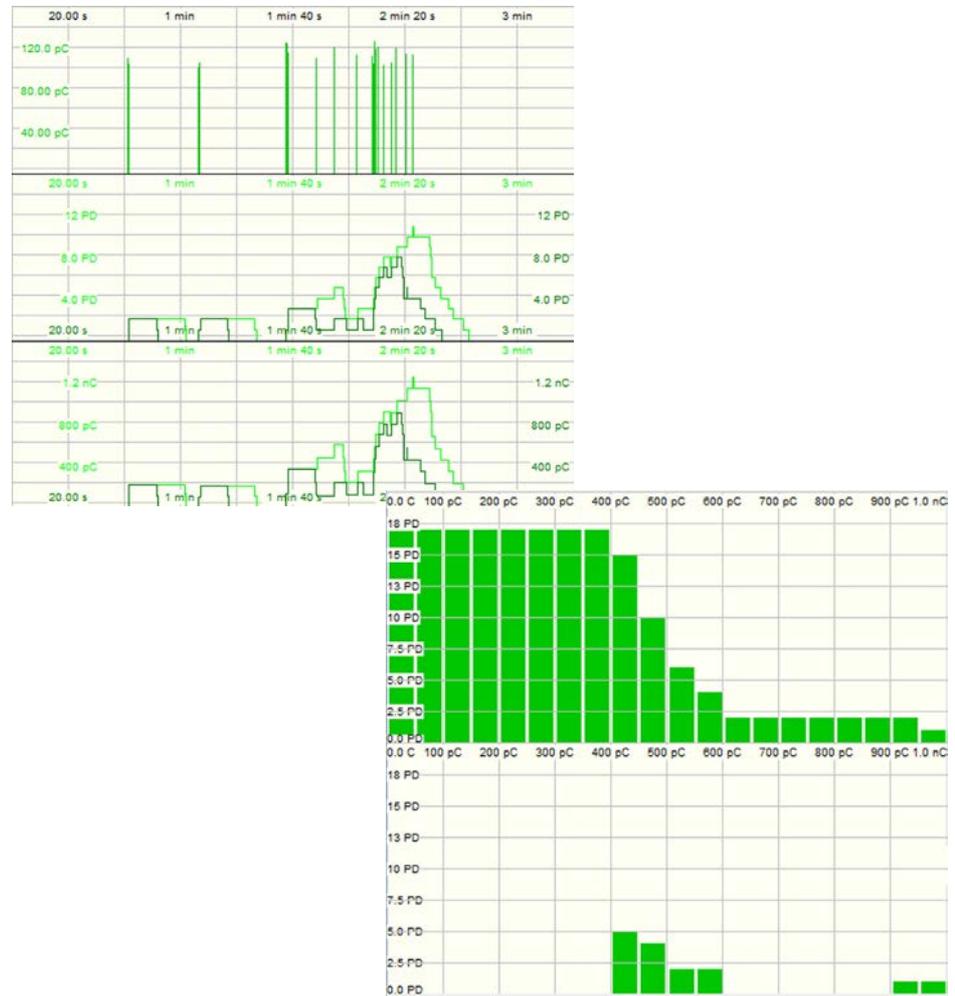


Figure 5-4 DC 1 and DC 2 displays

## 5.5.2 3PARD/3CFRD Display

The **3PARD/3CFRD** display shows the 3-Phase Amplitude Relation Diagram or the 3-Channel Frequency Relation Diagram, depending on which units and measurement channels are used to construct it. These diagrams can be used to differentiate between different PD sources and is described in 5.10 on page 143.

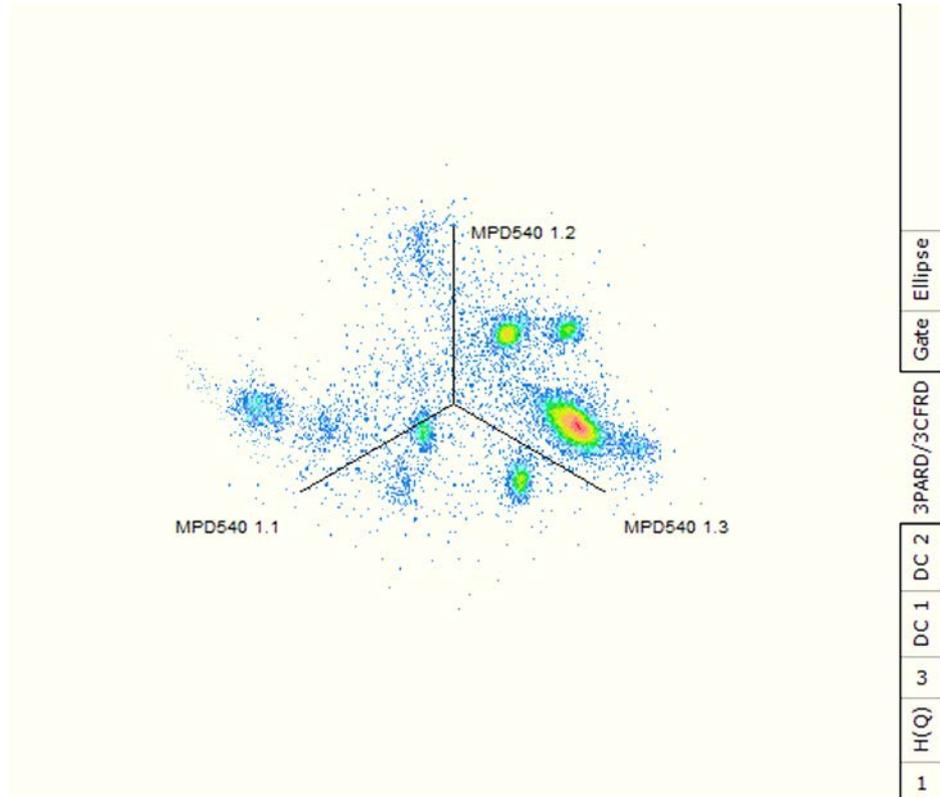


Figure 5-5 3PARD display

### 5.5.3 PSA Display

The **PSA** display shows the PSA (**P**ulse **S**equences **A**nalysis) diagram in accordance with the settings on the **PSA** tab.

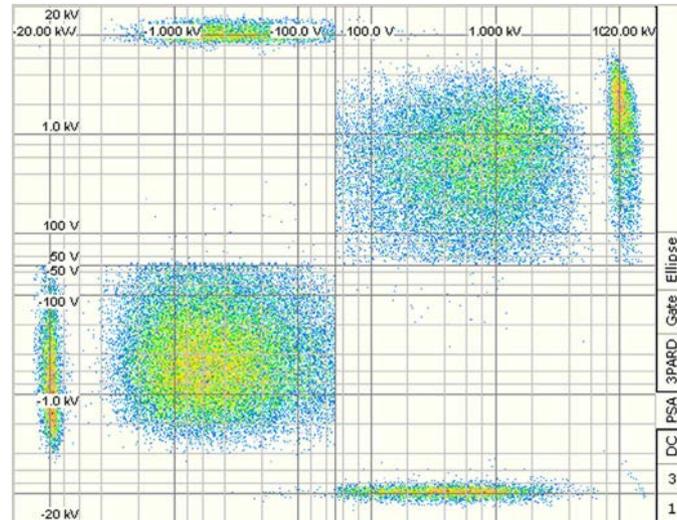


Figure 5-6 PSA display

## 5.6 Small Scope View

The small scope view can be configured with the help of the control panel settings (see 5.3 on page 98) to show many curves: the signal at the unit's PD input, the spectrum of the signal at the unit's PD input (DC through 32 MHz), the  $Q_{IEC}$  value plotted over the voltage, the PD event correlation diagram, a replay log (in Replay mode only), and trend curves for a variety of measurement quantities. When a UHF 608 or UHF 620 down-converter is connected, it can also show the result of a frequency sweep over the frequency range supported by those peripheral devices. Therefore, it has different displays as described below.

## 5.6.1 Time Display

The **Time** display shows the signal at the MPD unit's PD input similar to an oscilloscope. The signal from several units (up to 6) can be shown simultaneously.

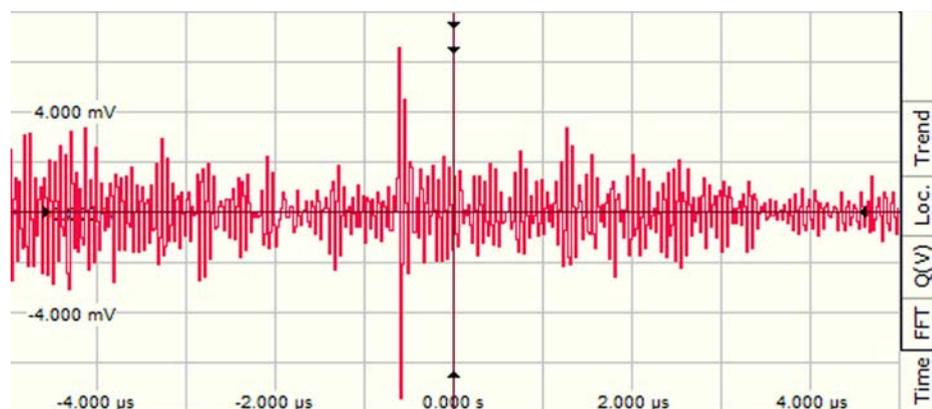


Figure 5-7 Time display

## 5.6.2 Q(V) Display

The **Q(V)** display shows the results of plotting the  $Q_{IEC}$  value over the voltage. This is especially useful for PD inception/extinction voltage tests.

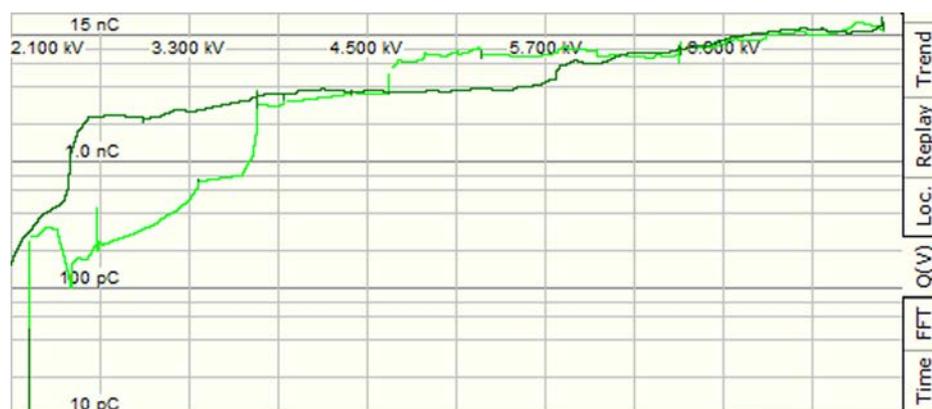


Figure 5-8 Q(V) display

### 5.6.3 Loc. (Localization) Display

The **Loc.** display shows the statistical PD correlation diagram which is used during fault localization.

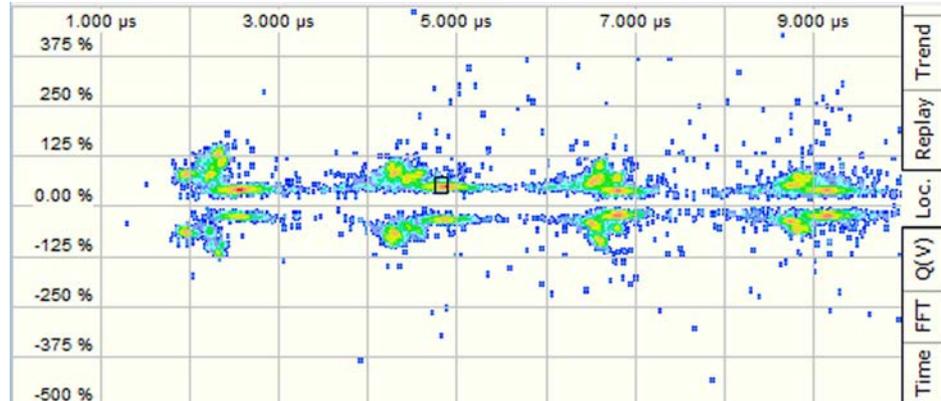


Figure 5-9 Localization display

### 5.6.4 Trend Display

The **Trend** display can be configured to show the trends of various measured quantities over time or over one another. Trends can be stored to files.

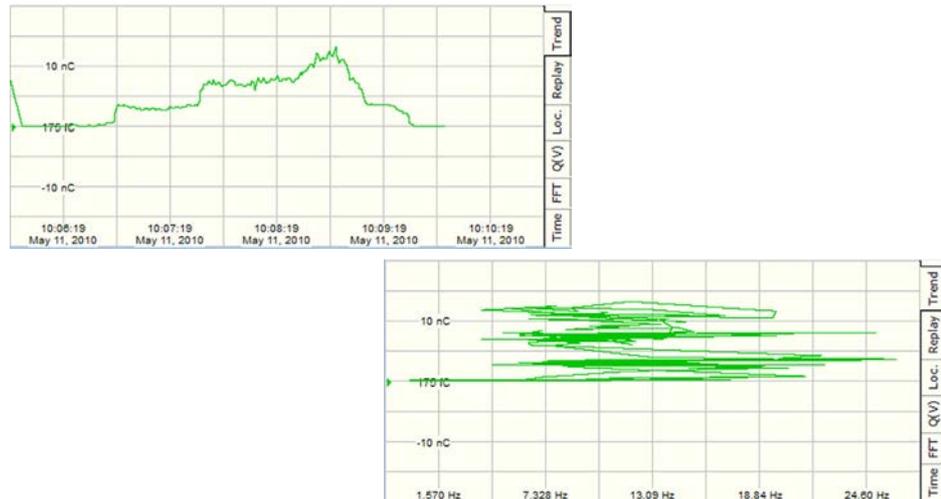


Figure 5-10 Trend display

## 5.7 The V Tab

The **V** tab contains all settings related to the measurement of the AC voltage applied to the **V** input of the MPD unit. It includes settings for the oscilloscope view of the AC voltage curve in the "1" display on the large scope view as well as trigger and calibration settings. These settings influence the display in the same way as known from regular oscilloscope.

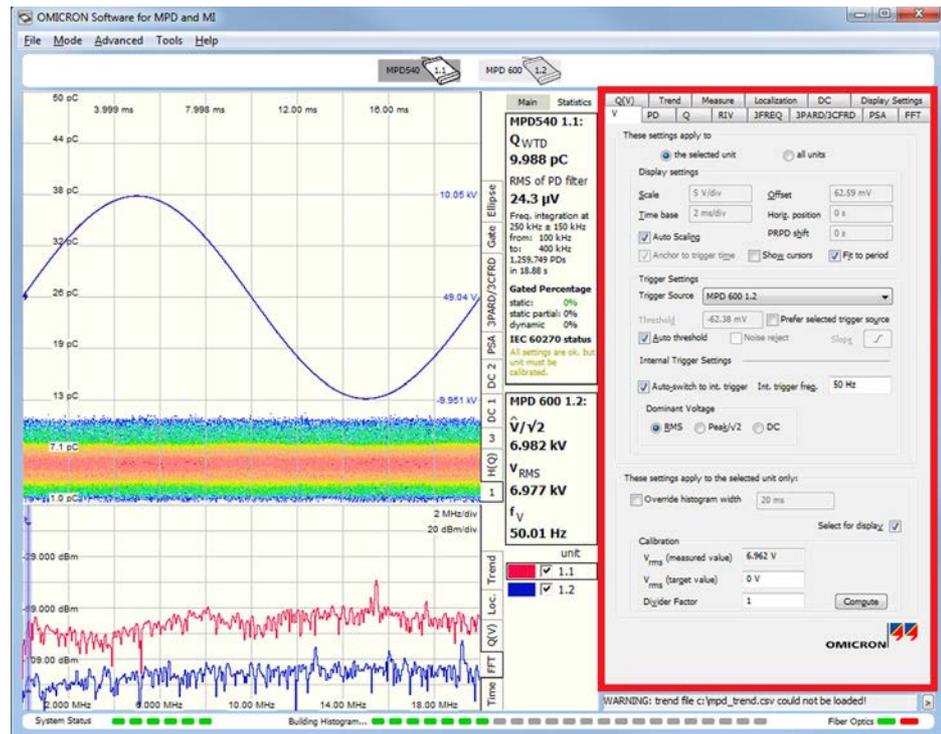


Figure 5-11 The V tab

## 5.7.1 Selection of Settings Applicability

There are two possibilities. Either these settings apply to the selected unit only or they influence all units. If a setting is different for one of the units, the font appears in blue or the check boxes are shaded grey.

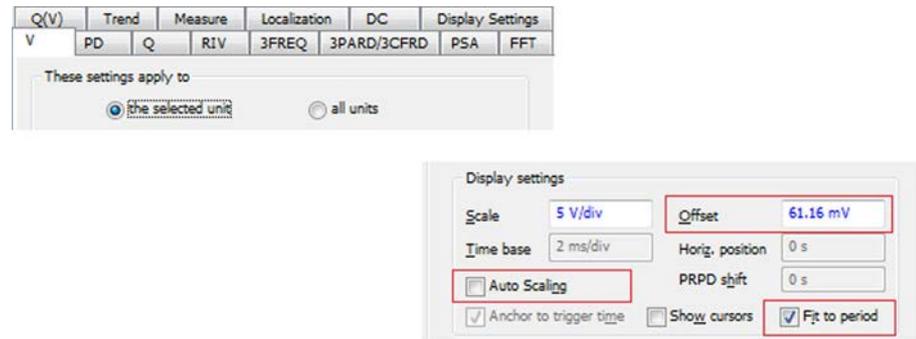


Figure 5-12 Settings applicability

**Note:** Units that operate as gating units are not affected by changes that apply to all units.

## 5.7.2 Display Settings

It is possible to adjust the vertical scale and the vertical offset of the curve shown in the large scope view area.

**Note:** The settings of horizontal scale (**Time base**) and horizontal position (**Horiz. position**) are only available if the **Auto Scaling** option is disabled.

**Note:** These settings are only available if the Auto Scaling and the **Fit to period** options are disabled.

The **PRPD shift** option determines the time offset at which the PRPD is generated. The offset is given with respect to the trigger time, so 0 corresponds to the trigger point and thus to 0°.

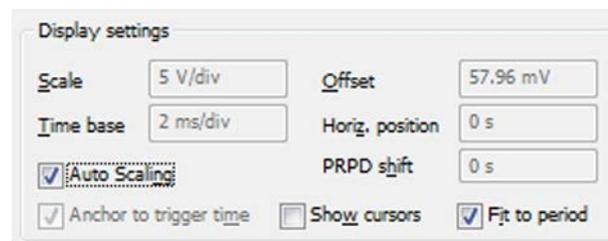


Figure 5-13 Display settings

### 5.7.3 Large Scope View Area

With the **Auto Scaling** option enabled, the amplitude and the period of the curve are fitted to the large scope view area automatically. **Fit to period** influences only the period of the curve, while the offset is set to 0. **Show cursors** shows or hides the trigger cursor at the position where the curve crosses the trigger threshold in the selected direction (see trigger settings below). To move the cursor, point with the mouse on one of the arrows and drag it up or down (see red arrows in Figure 5-14 on page 110). The horizontal position of the curve will be moved too. Be sure that the **Anchor to trigger time** function is disabled. Enabling the **Anchor to trigger time** option will modify the horizontal position in such a way that the cursor will remain at the same display position (i.e. at the same percentage of the curve before the changes were made).

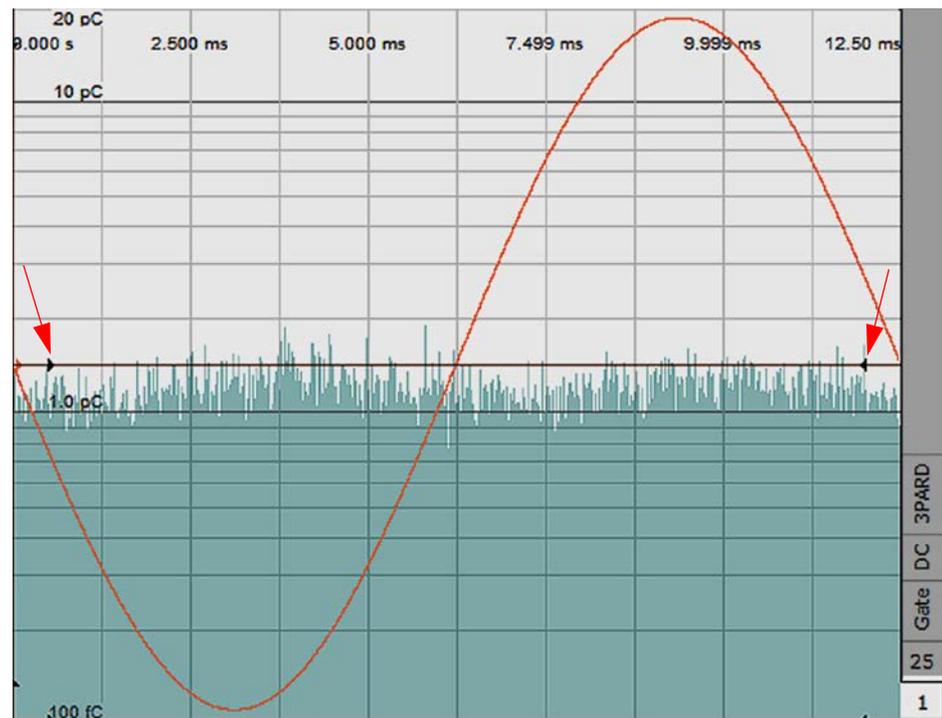


Figure 5-14 Large scope view area

## 5.7.4 Trigger Settings

The **Trigger Source** is used to compute the frequency of the AC voltage and to map PD events to a phase position (for use with phase-resolved histograms and the spikes view).

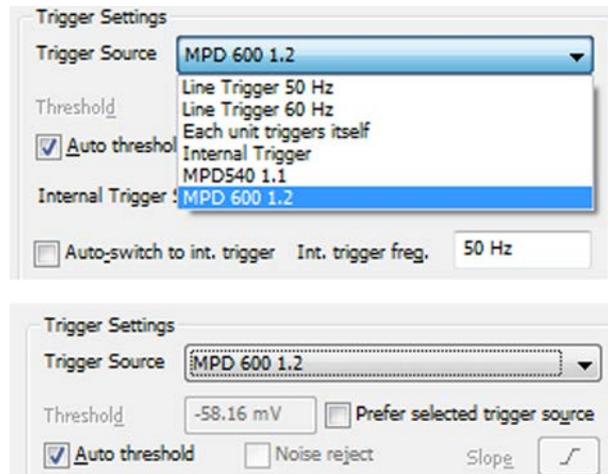


Figure 5-15 Trigger settings

## 5.7.5 Selecting the Trigger Source

---

<b>unit x.x</b>	<p>If a unit has been given a name, that name is listed here. Otherwise, the unit is shown as "&lt;type&gt; &lt;bus&gt;.&lt;position&gt;", as in "MPD 600 1.1"</p> <p>Any <b>V</b> input of one of the connected units can be selected as a trigger to synchronize all other units.</p>
<b>Each unit triggers itself</b>	<p>Means that every MPD unit is triggered independently by their own <b>V</b> input.</p>
<b>Line Trigger 50 Hz or Line Trigger 60 Hz</b> (in accordance to the local AC net)	<p>If one of these options is selected, the built-in light-sensitive sensor of the MCU controller is used as the trigger source. This sensor uses the light emissions from light bulbs operating with AC and deduces the line frequency from that.</p> <p><b>Note:</b> The Line Trigger mode does not work if frequency-modulated light is used.</p>
<b>Internal Trigger</b>	<p>Means that the PD acquisition unit synthesizes its own "AC" frequency. This is useful if the original AC net frequency is not stable or there isn't any frequency at all. The frequency value can be entered in the field behind <b>Int. trigger freq.</b> in the <b>V</b> tab.</p>

When the **Prefer selected trigger source** option is enabled, the trigger source highlighted in the **Trigger Source** drop-down box is marked as the preferred trigger source. When a selected trigger source is disconnected, the system automatically selects a different one and updates the **Trigger Source** drop-down box accordingly. When the preferred trigger source is reconnected later, it is automatically selected as the trigger source.

**Note:** Manually changing the trigger source with the **Prefer selected trigger source** option enabled will use the newly selected trigger source as the preferred trigger.

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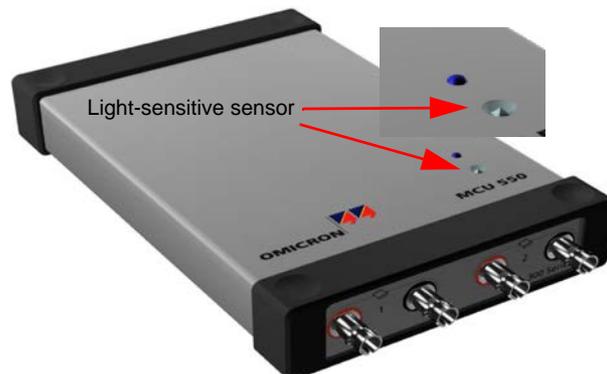


Figure 5-16 MCU controller with light-sensitive sensor

## 5.7.6 Slope and Threshold Options

The **Slope** setting allows to trigger on a rising or falling slope. The value in the field **Threshold** (only available if **Auto threshold** is turned off) determines the trigger threshold. **Auto threshold**, if enabled, adjusts the trigger threshold automatically to the average (DC) value of the curve.

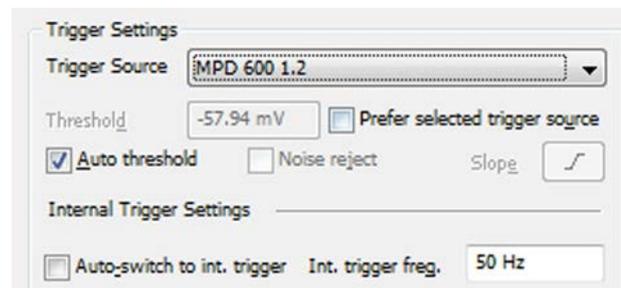


Figure 5-17 Slope and threshold options

## 5.7.7 Dominant Voltage Settings

The dominant voltage determines which value is taken for the high voltage: the **RMS** voltage, the **Peak**/ $\sqrt{2}$  voltage or the **DC** voltage. This setting also determines which voltage trend is displayed in the **Replay** tab when replaying a stream.

**Note:** This is decided at the time the stream is recorded, not when it is replayed.



Figure 5-18 Dominant Voltage settings

### 5.7.8 Noise Reject and Auto-Switch to Internal Trigger

The **Noise reject** option can be used to increase the trigger's robustness in the presence of considerable noise on the input voltage. The option is only available if the **Auto threshold** setting is disabled.

**Note:** For small input signals, the noise reject option can cause the trigger to become unreliable, because the small signal might be rejected as noise.

If the **Auto-switch to int. trigger** option is enabled, the trigger frequency can be forced to the frequency of the Internal Trigger if the trigger source does not produce a stable frequency (e.g. because no voltage is being applied).

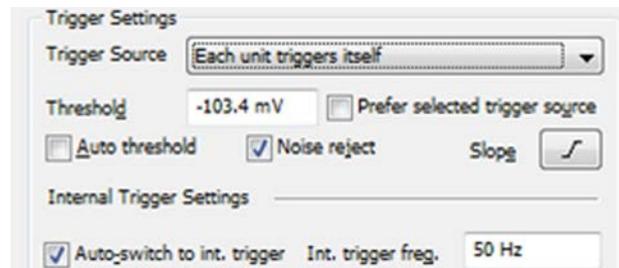


Figure 5-19 Noise reject and Auto-switch to int. trigger

Under those circumstances, the value specified in the **Int. trigger freq.** field will be used to map PD events to a phase in the phase-resolved diagrams, and the frequency value in the measured quantities display is shaded yellow.

**Note:** The trigger settings apply to all connected units, independent of the selection under **These settings apply to** at the top of the **V** tab.

### 5.7.9 Override Histogram Width

The **Override histogram width** function enables users to exert finer control over the histogram width. By default, the histogram covers one period of the voltage curve, i.e. for a 50 Hz curve it will map 0° (the left histogram border) to

0 s and 360° (the right histogram border) to 20 ms<sup>1</sup>. When this option is enabled, the histogram width can be set manually, and the histogram will be mapped to the specified size.

This is useful for VLF measurements with a cos-rect waveform, where the polarity change occurs with a sinusoidal of 50 or 60 Hz and which then stays on the maximum level for many seconds. In this case, the "interesting" area is when the polarity change occurs, which only takes a short time. Mapping the histogram to the entire VLF period reduces the available resolution in the interesting area and is undesirable. In such a case the histogram width can be set to, for example, 20 ms, and the trigger threshold for the voltage curve will be set such that the entire polarity change is captured. The histogram would then map 0° to the trigger time and 360° to 20 ms.

**Note:** Setting the histogram width to a value that is larger than one period is not supported, and will not work as expected. Always set the histogram width to a single period or less.

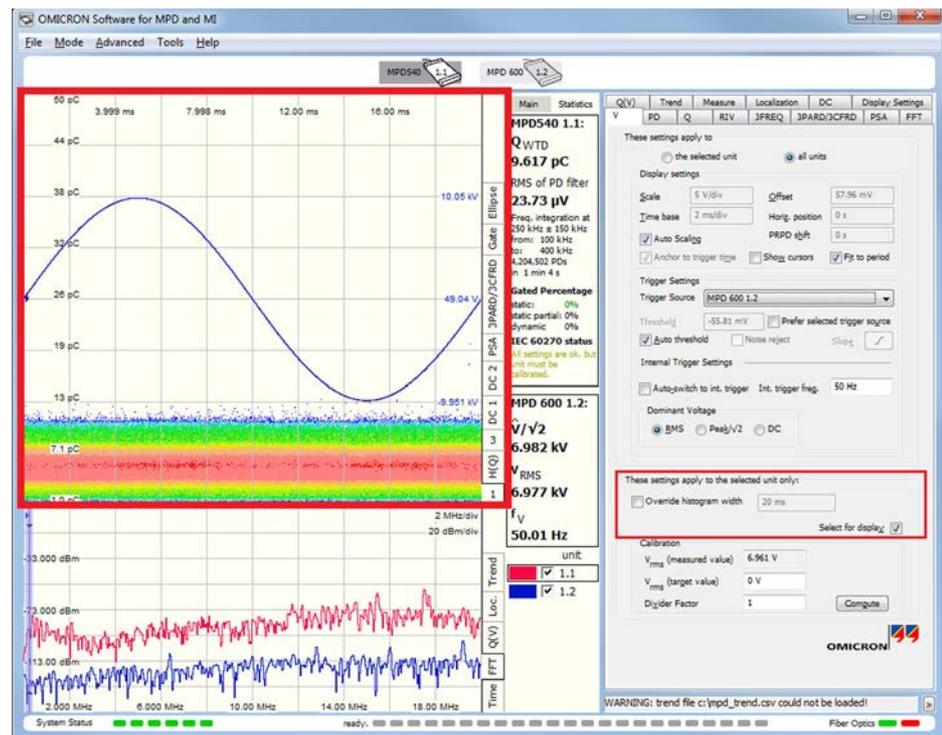


Figure 5-20 Override histogram width

1. Except when a PRPD shift is in effect, as described above, in which case 0° is mapped to the PRPD shift and 360° to the period of the voltage curve plus the PRPD shift.

## 5.7.10 Calibration

Use the **Calibration** settings to match the voltage display with the voltage that is actually being applied. To calibrate the voltage, apply a known voltage to the circuit, then enter the RMS value of that into the **V<sub>rms</sub> (target value)** field, and hit the **Compute** button.

This will automatically set the **Divider Factor** for the voltage measurement so that the measured value of the dominant voltage (**V<sub>rms</sub>**, **V<sub>pk</sub>** or **V<sub>DC</sub> (measured value)**) and the target value match. Alternatively, you can also enter the **Divider Factor** directly. If the divider factor is “1” the software shows the true measured voltage value for the **V** input.

The figure shows three separate calibration panels, each with a title 'Calibration' and three input fields followed by a 'Compute' button.

- Panel 1 (RMS):**
  - V<sub>rms</sub> (measured value): 7 kV
  - V<sub>rms</sub> (target value): 7 kV
  - Divider Factor: 1006
  - Compute button
- Panel 2 (Peak):**
  - V<sub>pk</sub> (measured value): 7.005 kV
  - V<sub>pk</sub> (target value): 7 kV
  - Divider Factor: 1006
  - Compute button
- Panel 3 (DC):**
  - V<sub>DC</sub> (measured value): -57.91 V
  - V<sub>DC</sub> (target value): 7 kV
  - Divider Factor: 1006
  - Compute button

Figure 5-21 Calibration

## 5.7.11 Other Settings

The **Select for display** setting just above the calibration settings box determines whether the AC voltage for the selected MPD unit is shown or not. It is possible to select up to 7 voltage curves to be shown in the “1” display of the large scope view.

**Note:** If the **Select for display** setting is disabled, and the unit's **V** input does not act as a trigger source, the AC curve is not transmitted from the MPD unit to the PC. When recording data to a stream, this means that voltage data will not

be available for triggering or display upon replay. If you need to have voltage data available during replay, make sure that either the **Select for display** option is enabled or the unit acts as a trigger while the stream is being recorded.

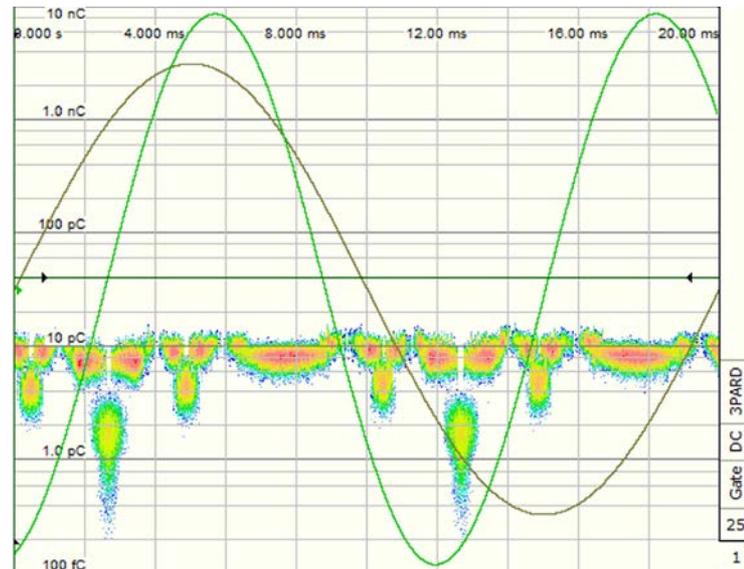


Figure 5-22 Other settings

**Note:** If **Line Trigger 50 Hz** or **Line Trigger 60 Hz** is selected as the trigger source, the software will always plot a synthetic sine curve of the line frequency. The AC voltage is also shown, overlaying the synthetic line curve, if the **Select for display** option is checked.

## 5.8 The PD Tab

Settings on the **PD** tab control the measurement and oscilloscope display options of the high-frequency PD current that is applied to the PD input of the MPD unit. Additionally, the **PD** tab controls the built-in test generator. The oscilloscope display of the PD input is located on the **Time display** of the small scope view.

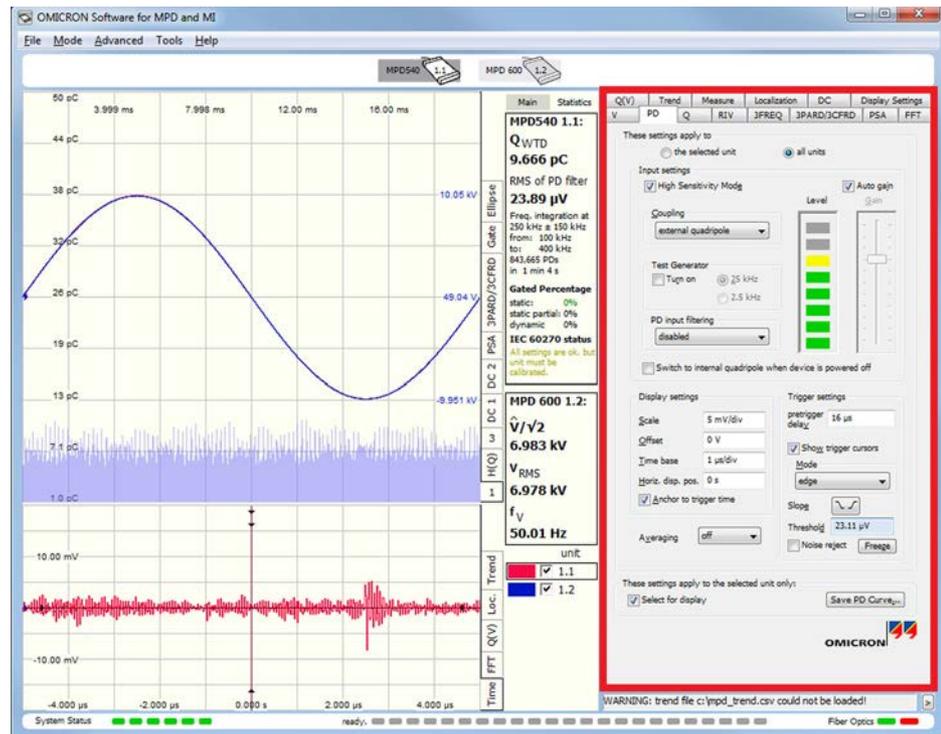


Figure 5-23 The PD tab

### 5.8.1 Selection of Settings Applicability

There are two possibilities. Either these settings apply to the selected unit only, or they influence all units.

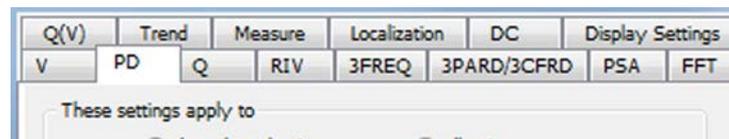


Figure 5-24 Selection of settings applicability

**Note:** Units that operate as gating units are not affected by changes that apply to all units.

## 5.8.2 Input Settings

When **Auto gain** is checked, the software will automatically adjust the PD input gain to a level which is as high as possible without overdriving the input. Otherwise, use the **Gain** slider to set the gain manually. It is possible to set the three highest gain levels only if the **High Sensitivity Mode** option is enabled.

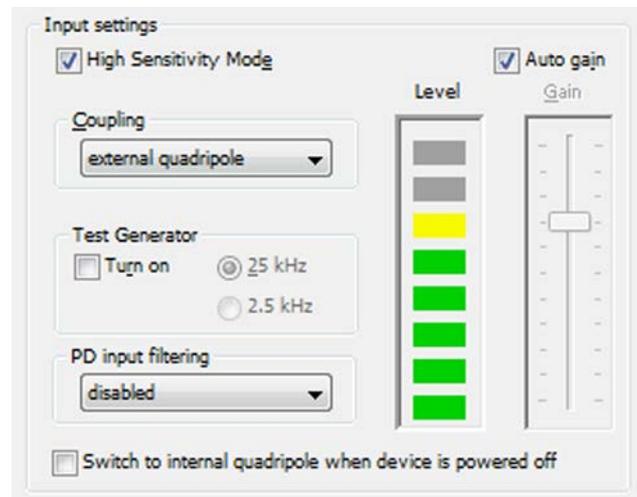


Figure 5-25 Input settings



**Caution:** When in **High Sensitivity Mode**, the MPD unit is much more susceptible to be damaged by flashovers.

**Note:** When a UHF 608 converter is connected, the five highest gain settings are not available.

### 5.8.3 Coupling Settings

The **Coupling** setting determines whether an **external quadripole** is used or the MPD unit should deploy its **internal quadripole**.



Figure 5-26 Coupling settings

**Note:** When the internal quadripole is used, only the PD input of the MPD unit is in use. The **V** input must not be connected. The internal quadripole, which is equipped with a 1 $\mu$ F low-arm capacitor, will extract the 50/60 Hz AC voltage component from the signal at the **PD** input. All settings related to the measurement of the AC voltage have to be adjusted on the **V** tab.

### 5.8.4 PD Input Filtering

The **PD input filtering** option can be used to subject the PD input signal to a digital low-pass filter of one of the following bandwidths: **4.7 MHz** or **2.3 MHz**. When the **Use high-bandwidth filters** option is enabled (see page 48), the following bandwidths are available: **6 MHz**, **3.7 MHz**, or **2.1 MHz**. This filter takes effect on both the PD oscilloscope view and the actual PD detection engine.



Figure 5-27 PD input filtering

### 5.8.5 Test Generator

The **Test Generator** box contains the settings that control the MPD unit's internal test generator. The frequency of the test generator can be set to 2.5 kHz or 25 kHz. The test generator consists of a synchronous pulse (of alternating

polarity) with a magnitude between 5-10 pC if the **Divider Factor** on the **Q** tab is set to "1". This impulse is injected directly at the PD input, so it can be used to exercise the entire signal path from the input to the software.



Figure 5-28 Test generator

### 5.8.6 Switch to internal quadripole when device is powered off

By default, when an MPD unit is disconnected from the FO bus or the software is shut down, the MPD unit switches to its internal quadripole. It does this as a safety measure, because the internal quadripole offers some protection from surges and overvoltages. However, doing so changes the effective impedance that the PD input of the MPD unit represents.

In some cases, it is desirable for an MPD unit that is turned off to keep its internal quadripole disengaged, e.g. when the MPD unit's **PD** input is connected in parallel with other measurement equipment that depends on the impedance of the MPD being constant. In those cases, the option **Switch to internal quadripole when device is powered off** can be disabled, and the MPD unit will subsequently no longer change the quadripole setting when it is turned off.

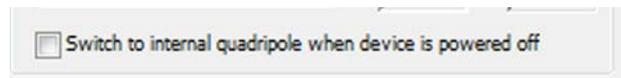


Figure 5-29 Switch to internal quadripole when device is powered off

### 5.8.7 Display Settings

The **Display settings** work just like those of an oscilloscope; (vertical) **Scale**, (vertical) **Offset**, **Time base** (horizontal scale) and **Horiz. disp. pos.** (horizontal offset) determine the location and scaling of the curve on the **Time** display of the small scope view. If the **Anchor to trigger time** setting is set, the trigger time

will remain at the same relative position on the diagram if the time base is changed. To this end, the horizontal position will be adjusted accordingly. If the option is turned off, the horizontal position is not modified.

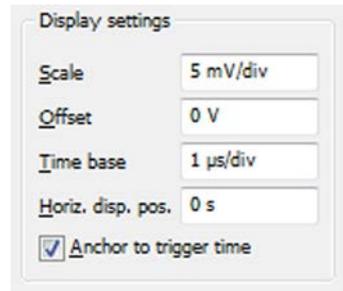


Figure 5-30 Display settings

The **Select for display** option determines whether or not the PD curve of the selected MPD unit is shown in the **Time** display of the small scope view. You can select up to 6 PD curves. This setting is duplicated in the lower box of the the measured quantities display.

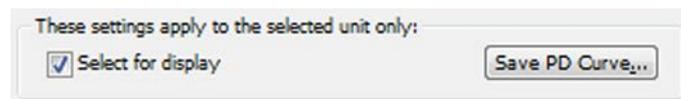


Figure 5-31 Select for display option

**Note:** This setting also applies to the FFT diagram.

## 5.8.8 Averaging

It is possible to average the PD input signal. Averaging occurs on the input curve after it is triggered. This can be used to reduce noise and see useful signals that are "buried" beneath the noise.

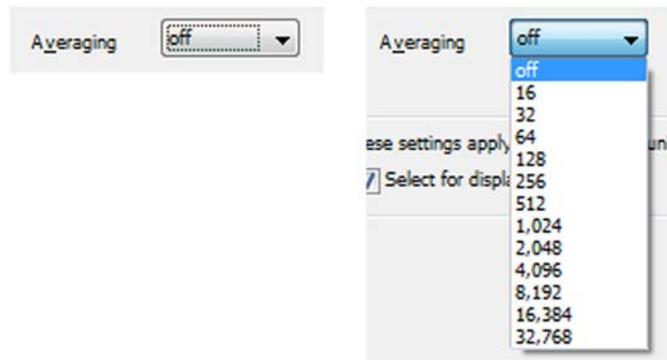


Figure 5-32 Averaging

The **Average** selection box contains all supported settings. **Off** turns averaging off (every trigger event directly leads to a curve being displayed), numbers (**16, 32, 64, 128, 256, 512, 1024, 2048, 4096, 8192, 16384, and 32768**) indicate the number of triggered curves that are averaged to produce a single display curve.

**Note:** As you increase the averaging value, the trigger frequency will reduce, as indicated by the trigger indicator flashing more slowly. With high averaging settings it can take a very long time until a display curve is produced, especially if the trigger does not occur frequently.

## 5.8.9 Trigger Settings

These settings work similar to an oscilloscope's trigger settings and determine what event will cause a 32  $\mu$ s snapshot of the PD input data to be transferred to the PC and displayed on the Time display of the small scope view.

### 5.8.10 Pre-Trigger Delay

The **pre-trigger delay** setting governs how much time is recorded prior to the actual trigger event when recording PD input data. This value must be between -262.1 ms and 47.5  $\mu$ s.

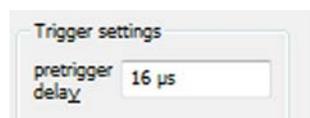


Figure 5-33 Pre-trigger delay

### 5.8.11 Mode Selection

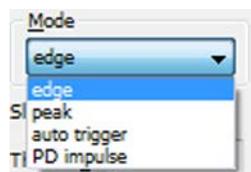


Figure 5-34 Mode selection

The **Mode** setting selects a trigger mode:

edge	This is a slope-trigger with selectable slope and threshold.
peak	Sets the trigger to fire on a local maximum or minimum (depending on the polarity setting). The threshold setting sets a voltage that the peak must be greater than (for positive triggers) or smaller than (for negative triggers).
auto trigger	Triggers synchronously with the test generator (depending on what frequency the test generator is set to with a frequency of either 2.5 kHz or 25 kHz); this is essentially a free-running trigger. The <b>Polarity</b> option is used to determine which of the test generator impulses (positive or negative) the trigger should fire on.
PD impulse	The PD input is triggered with the detection of (any) PD impulse. In this case, the threshold setting does not apply. Any event that is detected (and is above the PD detection threshold that can be set on the Q tab) can cause the trigger.

## 5.8.12 Additional Settings

**Polarity** decides which polarity a PD impulse must have in order to trigger the PD input.

**Note:** The **Polarity** setting only applies if the **auto trigger**, **peak** or **PD impulse** mode is selected. **Slope** decides which slope the edge trigger fires on (rising edge, falling edge). It is only available when the edge trigger is selected.

The **Noise reject** option is available only for the **edge** trigger; if enabled, it reduces the trigger's susceptibility to jitter on the PD input.

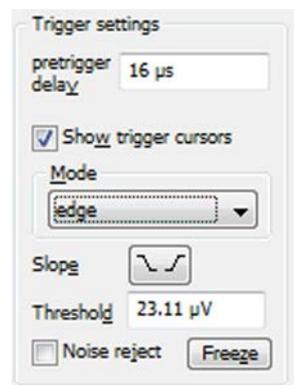


Figure 5-35 Additional settings

Enabling **Show trigger cursors** will show a cursor for the trigger threshold and a cursor for the trigger time. Both cursors will appear on the **Time** display of the small scope view and can be dragged with the mouse. The trigger threshold cursor will change the trigger threshold setting, and the trigger time cursor will change the horizontal display position setting.

Pressing the **Freeze** button will suspend the trigger process and will show the data from the last trigger event. To restart triggering, release the **Freeze** button. Clicking on **Save PD Curve...** will save the currently visible PD curve to a text file. All 2048 samples (each corresponding to a 15.625 ns sample of the PD input data) are written as individual lines (for more information see 9.7 on page 249).



Figure 5-36 Time display of the small scope view

## 5.9 The Q Tab

The **Q** tab contains settings that govern detection, quantification and display of PD events (including settings for the phase-resolved histogram). Other functions include PD calibration, turning on or off unit gating, and recording stream files. Phase-resolved histograms are shown at the large scope view on the “1”, “3”, “4”, “6”, “9”, “25”, and **Gate** displays.

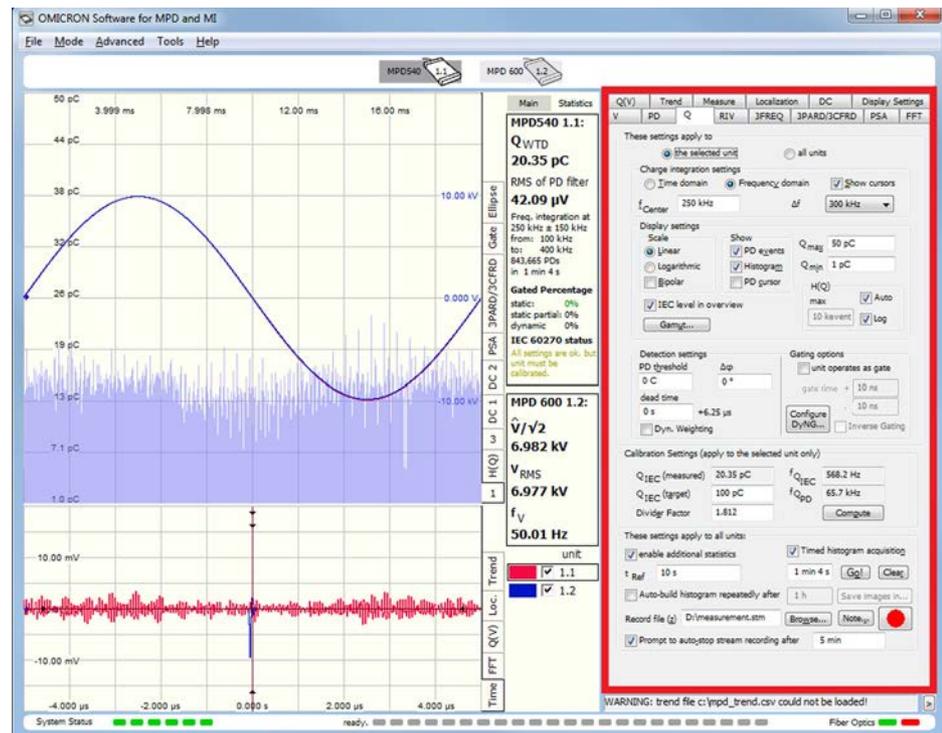


Figure 5-37 The Q tab

**Note:** When a UHF 608 or UHF 620 down-converter is connected, the **Q** tab is renamed to  $V_{UHF}$ , and appears as shown in Figure 5-38.

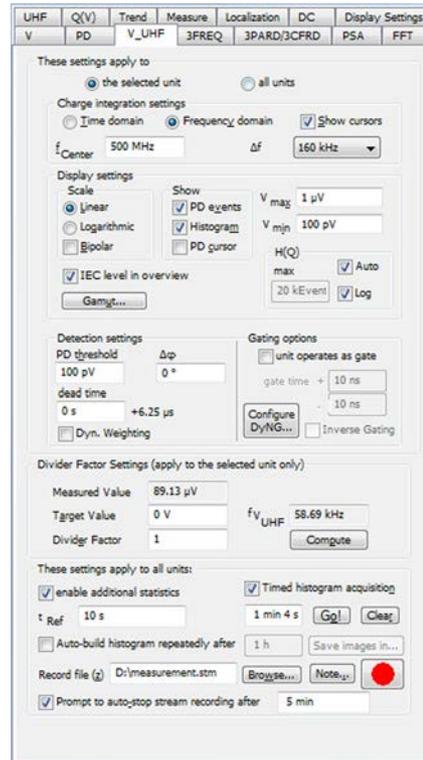


Figure 5-38 The  $V_{UHF}$  tab

### 5.9.1 Selection of Settings Applicability

There are two possibilities. Either these settings apply to the selected unit only, or they influence all units.



Figure 5-39 Selection of settings applicability

**Note:** Units that operate as gating units are not affected by changes that apply to all units.

## 5.9.2 Charge Integration Settings

These settings select the integration mode which is used to obtain a charge value from the PD input current. **Time Domain** integration will integrate the area under the PD input current between the times **t1** and **t2** (both are with respect to the time of the maximum of the PD current). Time domain integration is rarely used, and is not endorsed by the IEC 60270 standard for compliant measurements.

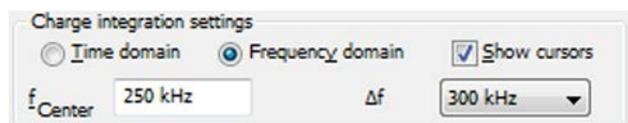


Figure 5-40 Charge integration settings

**Frequency domain** integration works by measuring the spectral amplitude density of the PD input current and will thus consider only certain frequency components of the input data. This is the method used in almost all applications. The center frequency ( $f_{\text{Center}}$ ) sets the nominal frequency at which the charge integration takes place; the bandwidth ( $\Delta f$ ) selects a window around the center frequency. You can select the following bandwidths: 1.5 MHz, 1 MHz, 800 kHz, 650 kHz, 300 kHz, 160 kHz, 100 kHz, 40 kHz, and 9 kHz. If the **Use high-bandwidth filters** option (see page 48) is enabled, the following bandwidths can be used: 3 MHz, 1 MHz, 300 kHz, 100 kHz, 30 kHz, 9 kHz.

Example: Setting a 1 MHz bandwidth and a 2 MHz center frequency means that the charge is computed from those frequency components of the PD input data that are between 1.5 MHz and 2.5 MHz.

**Note:** IEC 60270-compliant measurements are usually done at a center frequency of 250 kHz and a bandwidth of 300 kHz.

### 5.9.3 Display Settings

**Linear** or **Logarithmic** scaling of the PD event views applies to the charge of the events. Additionally it is possible to choose whether to plot the polarity of the events. **Unipolar** (**Bipolar** box is not checked) means that the polarity of the PD events is ignored, and only their absolute charge is considered. With **Bipolar** checked, the polarity of the event is also taken into account.

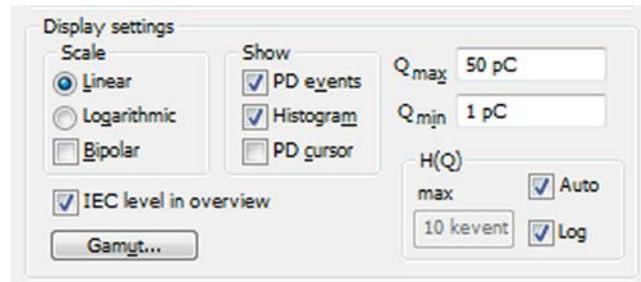


Figure 5-41 Display settings

The settings in the **Show** box turn various visualizations of the PD events on or off: the spike view (showing individual PD events as semi-transparent lines from 0 to a position corresponding to their charge), the phase-resolved histogram, and the PD cursor (corresponding to the PD detection threshold; see 5.9.6 on page 132).

The **H(Q)** section configures the vertical scaling of the H(Q) diagram. Enabling Auto-Scale (**Auto**) will automatically adjust the vertical scaling such that the maximum value is visible and a reasonable amount of the diagram space is utilized. Enabling Logarithmic Scaling (**Log**) will scale the y-axis logarithmically. Disabling that option scales the y-axis linearly. If Auto-Scale is disabled, the field labeled **max** accepts the number of PD events that should correspond to the diagram's top border.

### 5.9.4 "1" Display Bipolar View

The  $Q_{max}$  and  $Q_{min}$  settings determine the absolute scaling of the display;  $Q_{max}$  corresponds to the top margin of the diagram, while  $Q_{min}$  either corresponds to the bottom margin of the diagram (in the unipolar view) or to the minimum charge

that can be plotted in the diagram (in the bipolar logarithmic view). In the bipolar logarithmic view, the line in the middle of the diagram actually corresponds to a range of charge levels, between  $-Q_{min}$  and  $+Q_{min}$ .

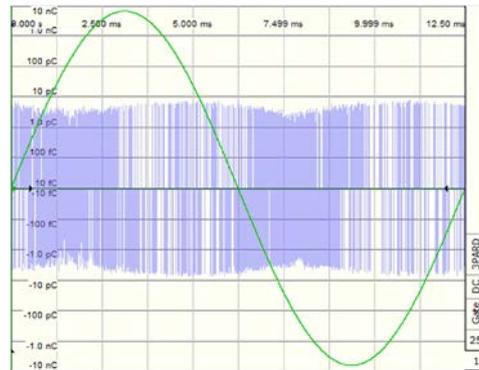


Figure 5-42 "1" display bipolar view

## 5.9.5 Gamut Settings

Clicking on the **Gamut...** button brings up the window shown below, which allows to modify the way that colors are assigned to the various histogram classes.

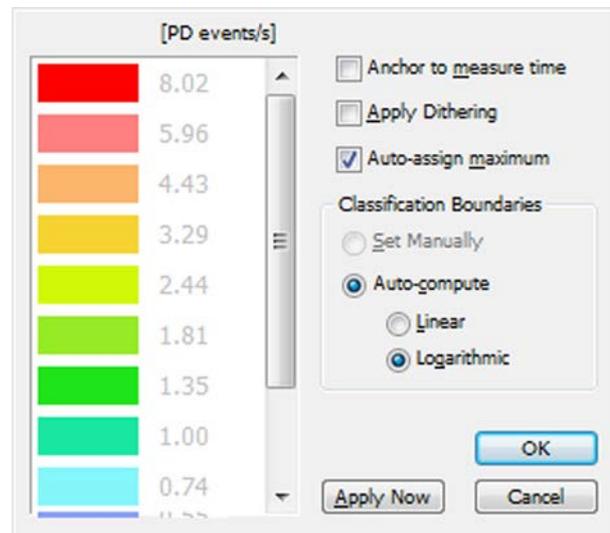


Figure 5-43 Gamut settings

The gamut consists of a number of classes which each have a color, and which corresponds to a specific number of PD events per second (a.k.a. PD rate). As the histogram is built, a point gets assigned the color of the highest gamut class whose PD rate is lower than the histogram point's PD rate. The gamut can be set to automatically compute class boundaries for all classes in a logarithmic or linear fashion, with the top class corresponding to the maximum value for the histogram.

For this, select **Auto-compute** in the **Classification Boundaries** box, and select either **Linear** or **Logarithmic**. By selecting the **Auto-assign maximum** setting, the gamut can also be set to track the maximum PD rate in the histogram and adjust the class boundaries accordingly.

Enabling the **Apply Dithering** setting causes the histogram points to become approx. 16 times "bigger" (i.e. PD events are counted not only by the histogram point to which they belong, but to a lesser extent also by neighboring points). This causes the histogram to form a significant pattern more quickly, but will produce a "fuzzier" pattern.

**Anchor to measure time** adjusts the class coloring such that the proper coloring is only reached at the end of histogram acquisition (i.e. at the end of the measure time). As the histogram is built, the coloring will become progressively more red (if red is the top class's color). To select every class boundary manually, select **Set Manually** in the **Classification Boundaries** box.

## 5.9.6 Detection Settings

Checking **unit operates as gate** in the **Gating options** box sets the selected MPD unit as gate. All other units run in normal mode. The time range entered in the **gate time** fields establish a gating window that determines for how long the gate unit suppresses PD events of the other units if a PD event occurs at the gate unit. This means that as long as the gate time is active, only the PD events of the gate unit will be considered (see diagram below). This function can be used for instance to detect and suppress interfering PD events.

The beginning and end of this gating window can be set separately, given with respect to the time of the PD event that causes the gate. The beginning of the gating window is set in the **-** field, the end in the **+** field.

The **Inverse Gating** option indicates the gating process should be reversed; i.e. all pulses that do not fall into the window established by the gate time fields should be suppressed.

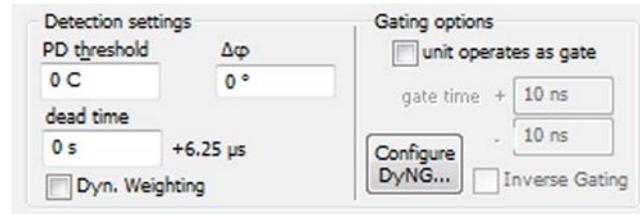


Figure 5-44 Detection settings

The **PD threshold** setting controls the amount of data transferred by each unit. Only PD events whose charge is higher than the PD threshold are acquired and transmitted to the PC. A low value corresponds to a large number of PD events. Since processing many PD events is computation-intensive, setting this value to a very low value may adversely affect processing speed. On slower computers, it should therefore be set to a value that is slightly lower than the noise floor.

The detection **dead time** establishes a time within which only the largest PD impulse is considered, and all other PD events are discarded.

This setting is useful for acoustic measurements. When an acoustic sensor is connected to the *MPD 600* to detect PD acoustically, each acoustic event may be detected as a series of PD impulses by the MPD because of the comparatively slow waveform and long duration of acoustic PD. To detect only a single pulse when using acoustic sensors, the dead time can be set to the expected longest duration of acoustic PD pulses.

Also shown is the dead time that is inherent to the selected PD filter. This time cannot be changed, and determines the maximum double pulse resolution that is possible with the selected PD filter.

The **Dyn. Weighting** setting is an advanced option that modifies the weighting that is applied to the apparent charge of each PD event. As mandated by the IEC 60270 standard, PD events are subjected to a weighting factor that depends on the event's pulse repetition rate. Above approx. 100 pulses per second that factor is 1, but as the pulse repetition rate drops, so does the weighting factor. This weighting is meant to reduce the reading for very rare PD events and is based on an AC frequency of 50 and 60 Hz.

When using a significantly different AC frequency, especially a much lower one, such as 0.1 Hz, the described weighting parameters do not work very well. In such cases, the **Dyn. Weighting** option can be set which modifies the weighting parameters in such a way that they are dependent on the trigger curve. In particular, the pulse repetition rate at which weighting begins to take effect will

be set to  $1/20^{\text{th}}$  of the trigger source's period. For a 50 Hz AC curve, this behavior is identical to the normal case, but for higher or lower frequencies the computed  $Q_{\text{WTD}}$  value can differ significantly.

**Note:** If this option is enabled, the measurement is no longer generally compliant with IEC 60270.

**$\Delta\phi$ :** Sometimes a phase offset must be applied to the PD pattern. This is necessary, for example, if a current transformer is used (to decouple PD events from the test circuit or to synchronize to the voltage). In such a case, the current transformer introduces a phase shift to the test circuit which can be compensated by entering a suitable value into the phase offset field. The value can be specified between  $-180^{\circ}$  and  $+180^{\circ}$ .

### 5.9.7 Diagram MPD Unit as Gate

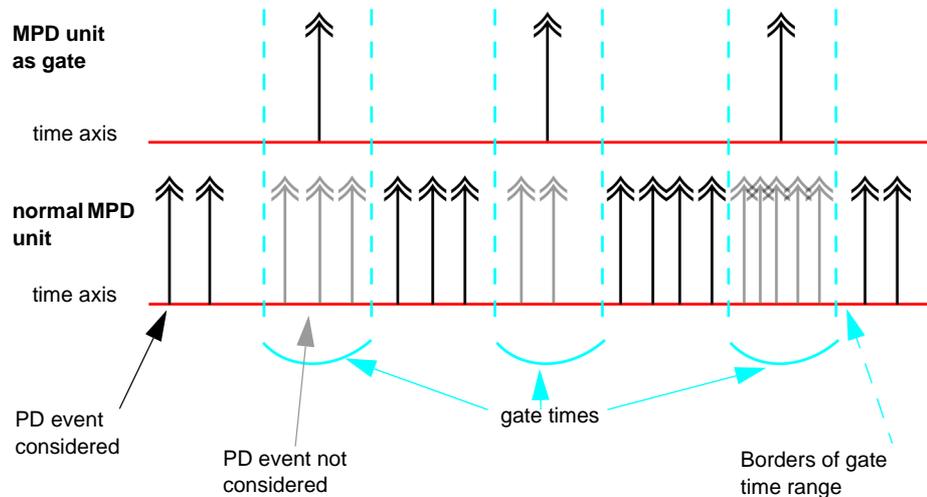


Figure 5-45 Gate events

**Note:** Enabling gating may compromise IEC 60270 conformity.

## 5.9.8 Dynamic Noise Gating



**Caution:** In the presence of bursty noise or noise that is not correlated with the phase of the test voltage, dynamic noise gating (DyNG) can be used to improve the effective measurement selectivity of the MPD system. With DyNG turned on, only periodic PD events that consistently happen at the same phase position are considered.

More specifically, DyNG divides the phase space of the PRPD between 0 and 360° into a number of phase classes. There is a PD event count associated with each phase class. Each incoming PD event is attributed to a phase class, based on its phase position, and if its charge is above the noise level, is considered eligible. If during an 80  $\mu$ s interval at least one eligible PD event was seen, the phase count is incremented. DyNG suppresses PD events corresponding to any phase class whose count is below a settable threshold. To ensure that only periodic signals are considered, every phase class' count automatically decays at a settable rate.

## 5.9.9 Count PD Events per Phase Position

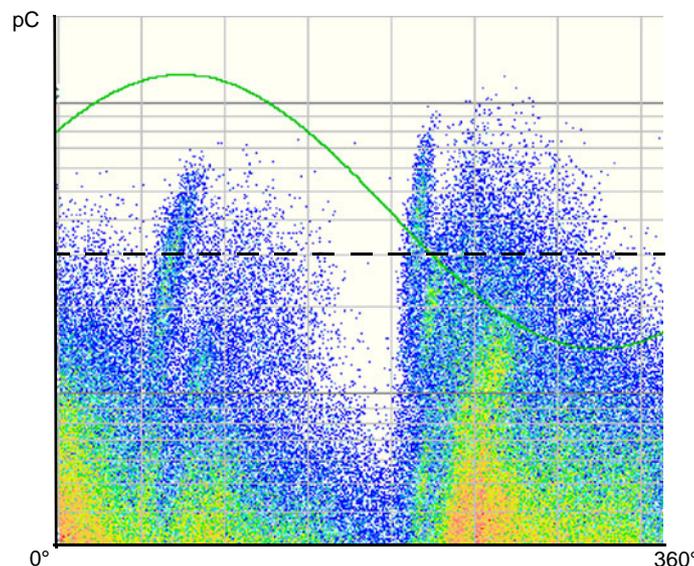


Figure 5-46 (Noise) charge threshold (for explanation see 5.9.11 on page 137)

## 5.9.10 Count Histograms

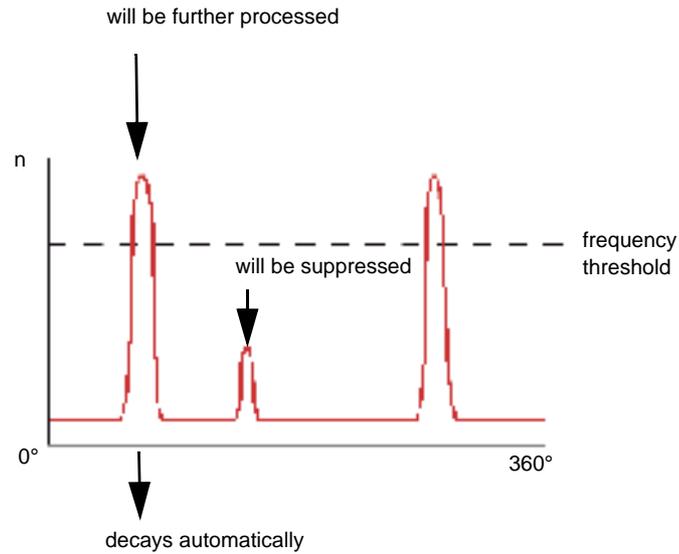


Figure 5-47 Count histograms (for explanation of decay rate and frequency threshold see 5.9.11 on page 137)

To visualize the DyNG phase class count, enable **show phase gate histogram**. See Figure 5-48 on page 137.

## 5.9.11 DyNG Configuration

After clicking on the `Configure DyNG... (+)` button the following options related to DyNG operation can be configured:

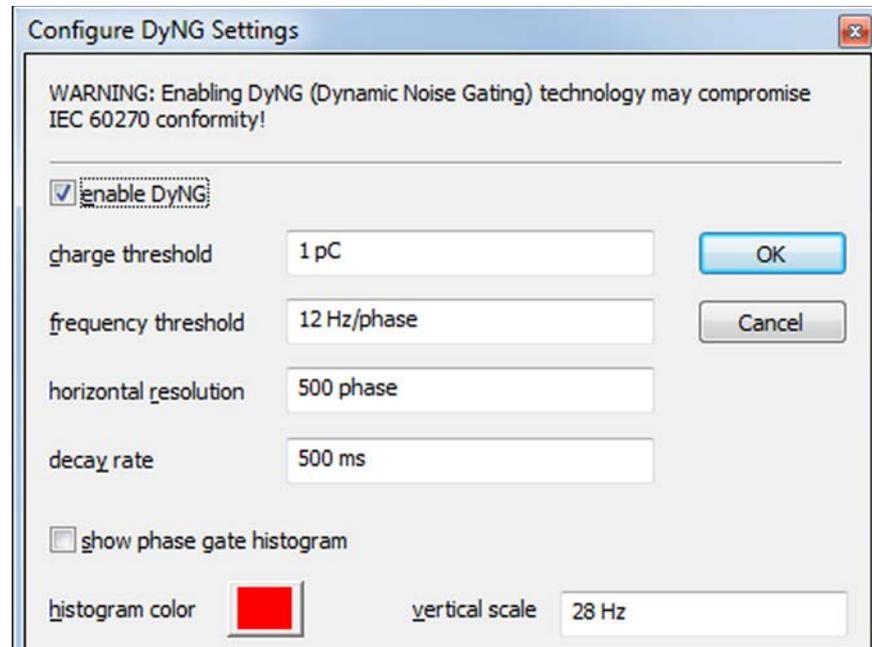


Figure 5-48 Configure DyNG settings

**Horizontal resolution** (number of phase classes): This determines the width of each phase class. A good value (and the default) is 500 phase classes, which means that every phase class has a width of  $360^\circ/500 = 0.72^\circ$ .

(Noise) **charge threshold**: This value determines the minimum charge of each PD event for it to be considered as PD (as opposed to noise). Anything with a lower charge level is allowed to pass through the DyNG algorithm unchanged. Anything at or above that level will be subjected to DyNG processing.

**Frequency threshold**: A PD event attributed to a phase class and whose charge is above the noise threshold will only be further processed if the phase class count is consistently higher than the frequency threshold. This value determines, in Hz/phase class, how many events per second must be attributed to a phase class.

**Note**: This threshold cannot be higher than 12.5 kHz/phase class, because the count is incremented at most once every 80  $\mu$ s.

**Decay rate**: this value determines the time constant with which the phase class count automatically decays. The decay follows the equation:

$$count = count \cdot e^{-\Delta t/\tau}$$

with  $\tau$  being equal to the decay rate. The decay is applied every 80  $\mu\text{s}$  ( $\Delta t = 80 \mu\text{s}$ ).

It is also possible to visualize the DyNG phase class count on the "1" display. To do this enable **show phase gate histogram**. The curve shows the phase class count, with the value given under **vertical scale** corresponding to the top of the main diagram pane. The color of the curve can be selected under **histogram color**.

To continue with the measurement process close the DyNG window.

## 5.9.12 Charge Calibration Settings



**Warning:** Switch off the high voltage and secure the high-voltage test setup observing safety procedures before connecting the charge calibrator.

Connect the calibrator to the test object. Unsecure the high-voltage test setup. Select a charge of 100 pC or another suitable value at the calibrator.

Calibration Settings (apply to the selected unit only)			
$Q_{IEC}$ (measured)	20.85 pC	$f_{Q_{IEC}}$	246.5 Hz
$Q_{IEC}$ (target)	100 pC	$f_{Q_{PD}}$	65.71 kHz
Divider Factor	1.812	Compute	

Figure 5-49 Charge calibration settings

Enter the calibrator charge in the  **$Q_{IEC}$  (target)** field and click compute. The software will compute a **Divider Factor** and multiply the charge values of the events it detects by it. After calibration, the  **$Q_{IEC}$  (measured)** field should show the same value as the calibrator charge.

You can also enter the divider factor directly. The  **$f_{Q_{IEC}}$**  display shows the number of PD events per second that contribute to the  $Q_{IEC}$  (or  $Q_{WTD}$ ) value; the  **$f_{Q_{PD}}$**  display shows the total number of PD events per second detected by the MPD unit.

The CAL 542 calibrator produces 300 PD events per second. During calibration, this value should be visible in the  $f_{Q_{IEC}}$  display.

Disconnect the calibrator. Secure the high-voltage test setup observing safety procedures.

### 5.9.13 Histogram Acquisition Controls

There are several controls that govern histogram acquisition. The histogram will start when the **Go** button is pressed (Pressing the F5 key anywhere in the application has the same effect.). Clicking the **Clear** button clears the histogram. Selecting **Timed histogram acquisition** and entering a time value into the field next to it will cause the histogram acquisition to stop automatically when the corresponding time has elapsed. If the **Auto-build histogram repeatedly after** setting is selected and a time value is entered into the field next to it, the software will wait for the specified time, then record histograms of all units and save images of these histograms as PNG files automatically. This process of automatically creating histograms must be started by pressing the **Go** button. Additionally, an overview file will be saved for every cycle acquisition. It will then repeat this procedure indefinitely. Click on **Save images in...** to select the folder where the image files should be saved to. The file names consist of unit number, serial number, date, and time.

Note that this feature is designed for online mode (i.e. when not replaying a stream file) and will not work as described during stream replay. Instead, during stream replay, the described histogram will be built once and saved, and the replay will stop. This is because this feature automatically turns the **Go** button on and off, and during stream replay turning off the **Go** button also stops replay.

**Note:** If an XML export is active, the histogram screenshots are embedded in the XML file rather than being saved to PNG files.

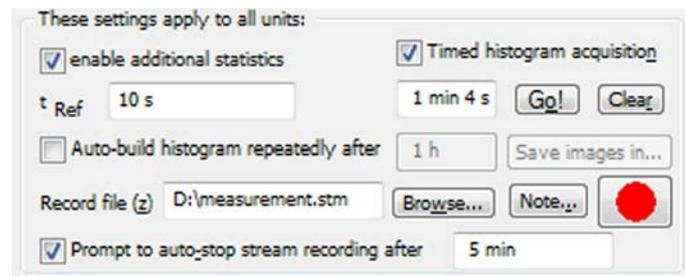


Figure 5-50 Histogram Acquisition Controls

### 5.9.14 Statistics Settings

For using the statistics view enter the value for the reference time interval into the field behind  $t_{Ref}$  and set **enable additional statistics** to on by clicking into the check box. To see the results of this action go to 4.9 on page 81.

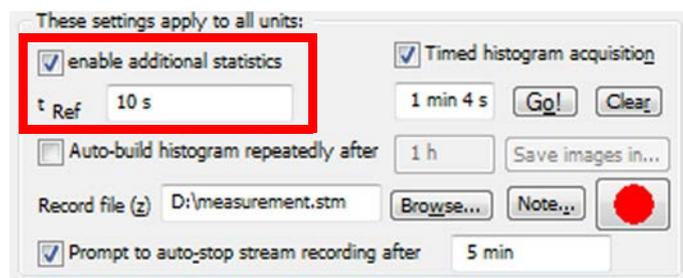


Figure 5-51 Statistics settings

### 5.9.15 Stream Controls

The **Record file (z)** setting contains the full path name of the stream file.

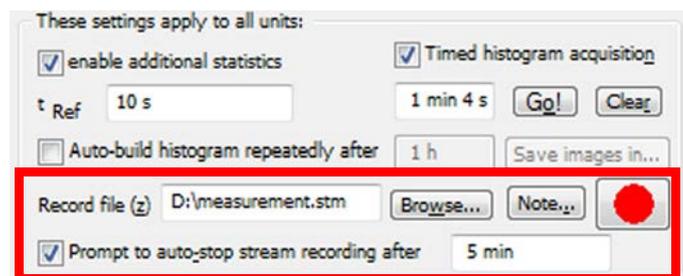


Figure 5-52 Record file (z) setting

**Note:** When streaming is actually started, the file name will be modified to contain the date and time (GMT/UTC) of the moment at which the stream file was created.

Clicking on the  button will start the streaming process. Clicking **Browse...** allows to navigate to a folder and enter a name for the stream file. To enter a note that should be included in the stream, click the **Note...** button. This will pop up the window shown below, which allows to enter text. This text is written to the stream as soon as you press , and can be viewed on replay.

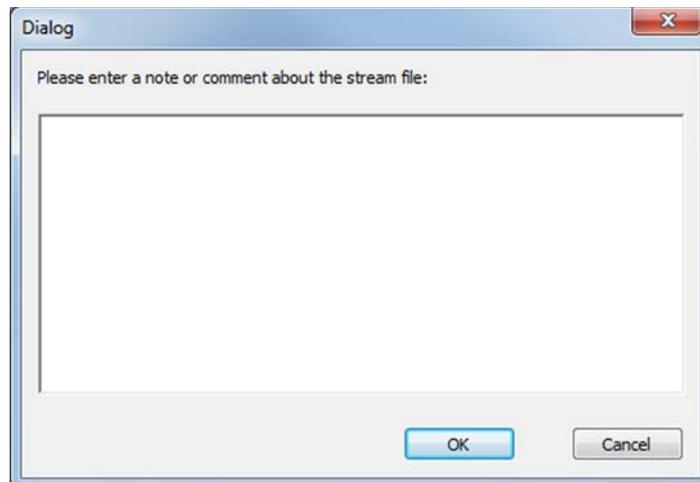
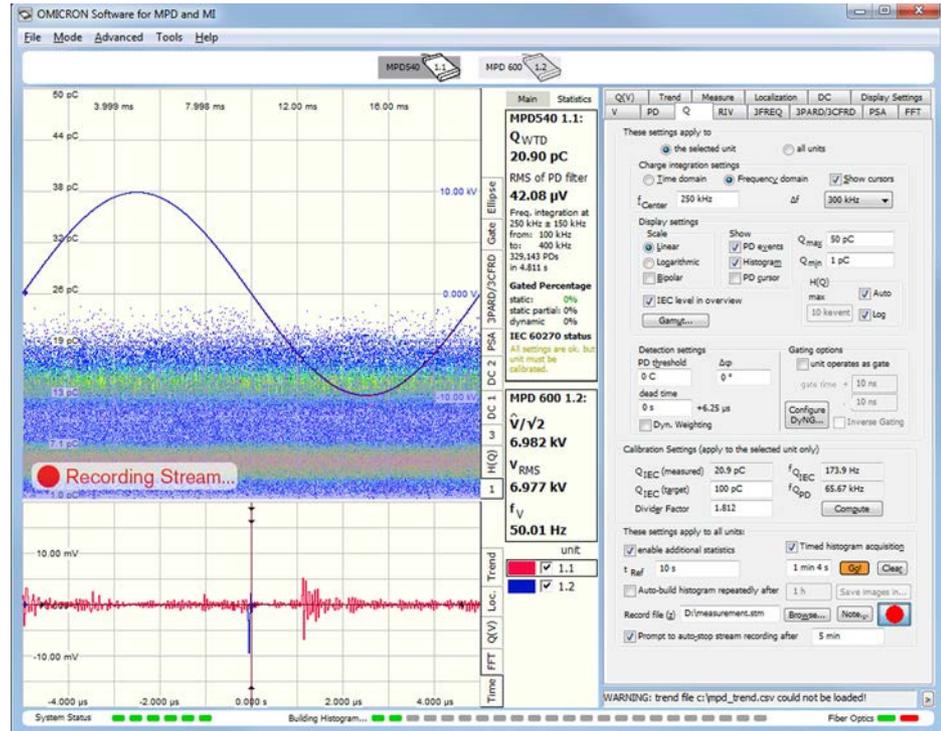


Figure 5-53 Note window

While a stream is being recorded, an indication is shown in the large scope view, as shown below.



When the **Prompt to auto-stop stream recording after** option is enabled and the chosen time has elapsed, a window pops up (see Figure 5-54).



Figure 5-54 End recording session window

Clicking on **Continue** will close the window and continue recording the stream. The window will then reappear after another interval of the chosen time has elapsed.

Clicking on **End Recording Session** will end the recording session and close the stream file. If no action is taken within 20 s of the window appearing, the stream recording session will be automatically ended.

**Note:** Changing the text of the stream note after streaming has begun has no effect.

**Note:** The software will automatically add the software version number to the stream note.

## 5.10 The 3PAR/3CFRD Tab

The **3PAR/3CFRD** tab controls the Three-Phase Amplitude Relation and Three-Channel Frequency Relation diagrams, which is shown on the 3PAR/3CFRD display of the large scope view.

To use the 3PAR or 3CFRD, 3 or more units have to be connected (although only 3 units can be used at a time to build a 3PAR/3CFRD). Alternatively, when the multi-band feature is licensed, you can select each of the 3 PD filters, for every connected unit, as well as the 3-band filter as the source for each axis. To plot a 3PAR or 3CFRD, the software computes the amplitude ratios of individual PD events detected on 3 units (or frequencies, when using the multi-band feature) within a small amount of time; these ratios become the coordinates of each of the 3PAR axes of the “star”. For every PD event seen on the 3 sources, these coordinates are computed and a histogram tracks the number of events that have the same coordinates. Because each MPD unit will always detect PD activity from a single PD source with a similar amplitude, each PD source will form a cluster in the diagram.

Different PD sources, however, will produce different amplitude ratios on the 3 units/frequencies and will therefore produce different clusters in the diagram. The 3PARD therefore allows us to distinguish different PD sources. For more information see the next two pages.

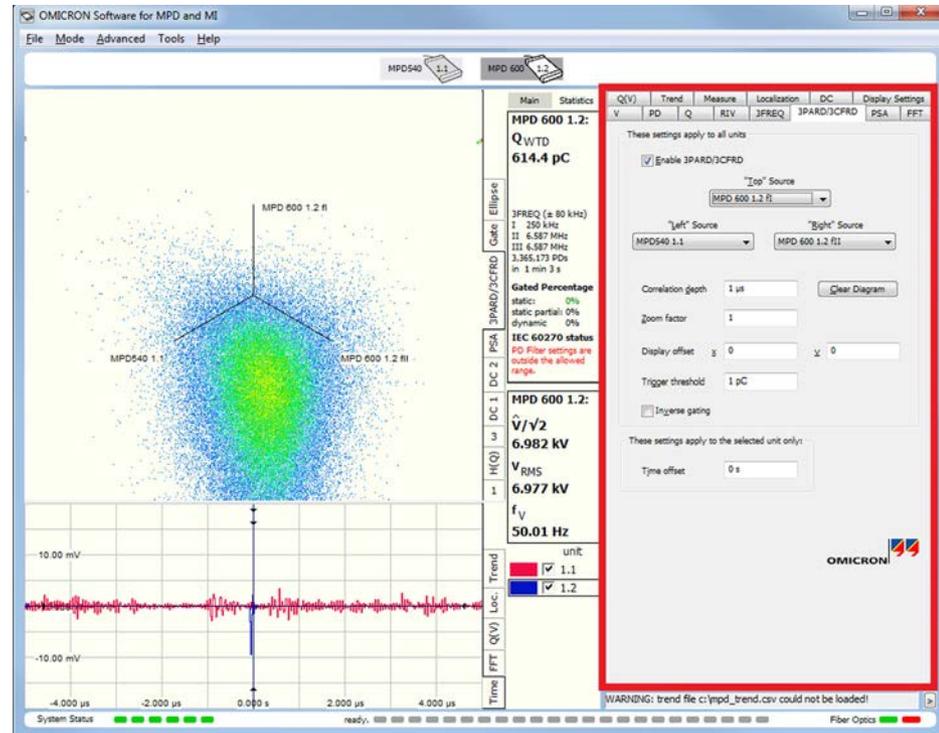


Figure 5-55 The 3PARD/3CFRD tab

### 5.10.1 3PARD/3CFRD for Gating

Once you have built a 3PARD, you can use the mouse to draw a rectangle or a polygon (a closed figure with an arbitrary number of points) in the 3PARD window. This will tell the software to continue processing only those PD events that contribute to the 3PARD area you selected. Thus, this will consider only PD events from a single source, and will disregard any noise or other sources. To consider all PD events again, click anywhere in the 3PARD to clear the rectangle.

To select the cluster using a rectangle, click in the diagram and, while keeping the mouse button pressed, drag to the desired size. To select the cluster using a polygon, click in the diagram and release the mouse button. Then move the mouse to the next point and click again. Continue until the desired shape is selected, then double-click on the last point to finish the polygon. Note that the

polygon will automatically be closed by drawing a line from the last point to the first point. If you want to abort drawing the polygon at any time, click anywhere using the right mouse button.

Note that if you draw a polygon that intersects itself, then notion of what is "inside" the polygon becomes fuzzy. The MPD/MI software uses the even-odd rule to determine whether a point lies inside the polygon.

To remove a cluster selection, double-click anywhere on the diagram.

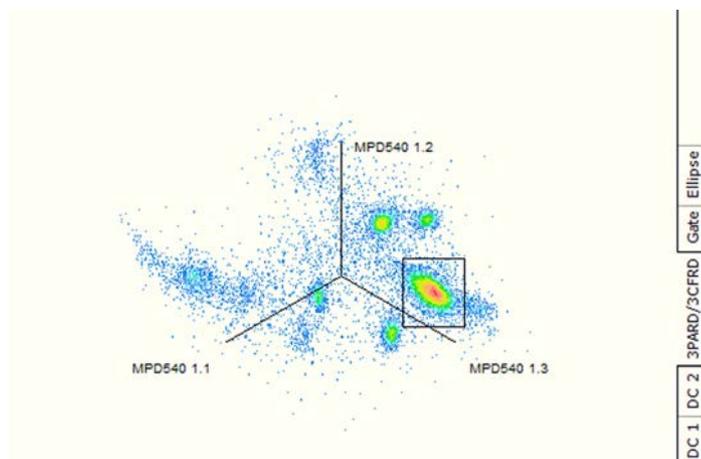


Figure 5-56 3PARD/3CFRD for gating (using a rectangle)

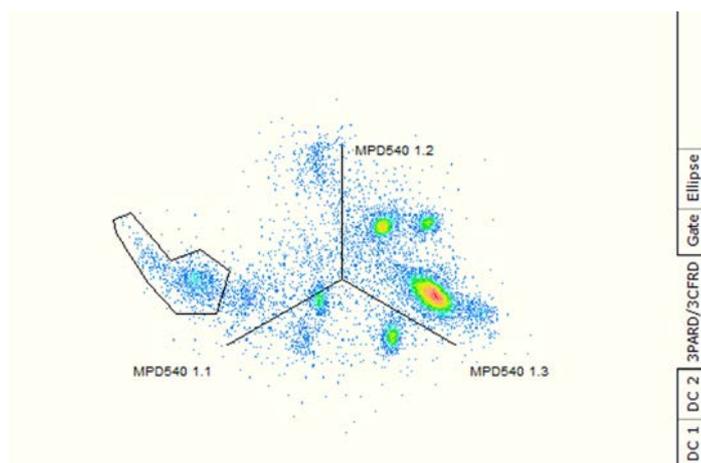
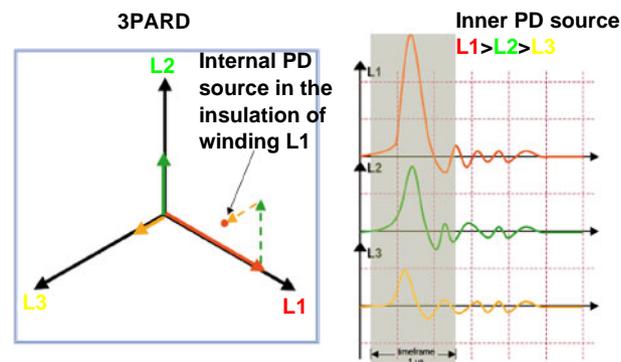
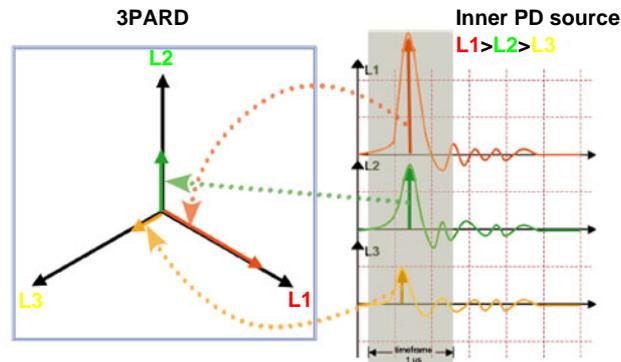


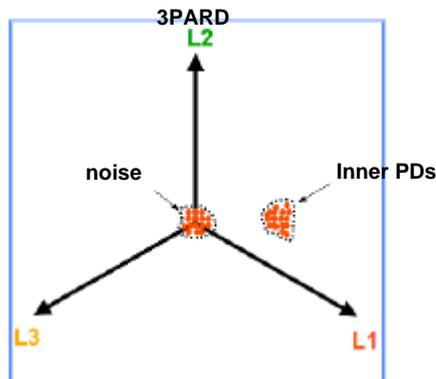
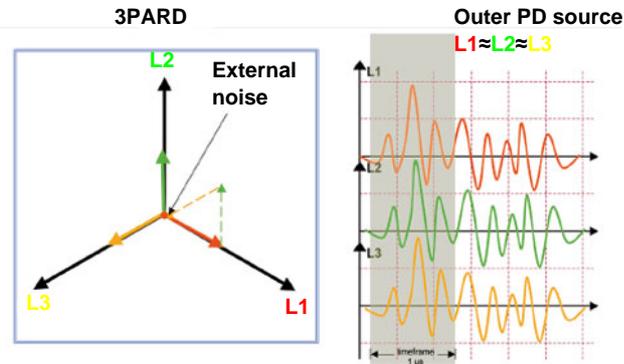
Figure 5-57 3PARD/3CFRD for gating (using a polygon)

## 5.10.2 Step-by-step example: 3PARD in rotating machines

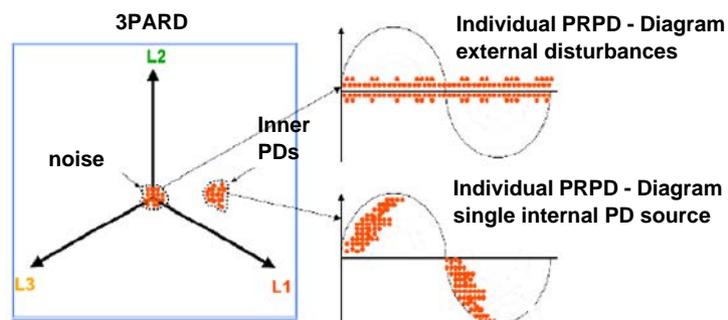
Every PD source within the machine appears as a clearly distinguishable concentration of vector sum points (a cluster) in a 3PARD.



Electrical interferences, which occur with almost the same amplitude on all three phases of the machine ( $L1 \approx L2 \approx L3$ ), show up at or near the origin of the 3PARD. Therefore, each cluster can be separated for further investigation without superposition.



A single PD triplet is represented by one point. Each cluster of points represents a single source of PD. Each cluster can subsequently be separated and, without superposition effects, be transformed into a classical PRPD.



### 5.10.3 Setting up 3PARD/3CFRD

Select a different unit for each **Source (Top, Left, Right)**; each “source” corresponds to the appropriate axis of the 3PARD/3CFRD “star”. The diagram will be created as long as the **Enable 3PARD/3CFRD** setting is checked. The **Correlation depth** setting determines the maximum time difference between PD events detected on each unit or PD filter to still be considered to have happened simultaneously. The **Zoom factor** allows you to change the size of the diagram. You can zoom in and out of the central point of the diagram. The **Trigger threshold** is an additional threshold; a PD event must be larger than this threshold on at least one of the sources to be eligible for the 3PARD/3CFRD. Setting this to higher values can prevent noise signals from being plotted in the diagram. Clicking on **Clear Diagram** will clear the diagram. When **Inverse Gating** is selected, only PD events that are not contained inside the cluster selection (but contribute to a triplet in the diagram) are used when plotting a PRPD.

**Note:** Only PD events that contribute to the 3PARD/3CFRD diagram are considered. Any PD event that does not form a point in the 3PARD/3CFRD diagram (because it is not detected by all three sources in the given correlation depth interval) will still be suppressed even if **Inverse Gating** is enabled.

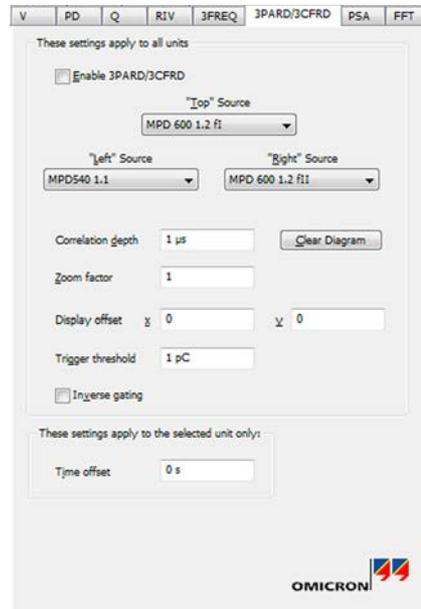


Figure 5-58 Setting up 3PARD3/CFRD

#### 5.10.4 Display Offset

The **Display offset** function allows to move the diagram along its x- and y-axis.



Figure 5-59 Display offset

#### 5.10.5 Time Offset

The 3PARD/3CFRD diagram works by considering the charge level of PD events that are detected simultaneously on 3 sources as explained above. It is then assumed that the PD events detected on the 3 sources are the same PD event. In some situations it is possible that the signal from a single PD event takes a longer time to reach some units. This is referred to as the signal's propagation delay.

With the **Time offset** function it is possible to compensate for the propagation delay. To do this, select the units one after another and enter the appropriate time difference ( $\Delta t$ ) for each unit in the field behind **Time offset** (see Figure 5-60).



Figure 5-60 Time offset

### 5.10.6 Time Offset Diagram

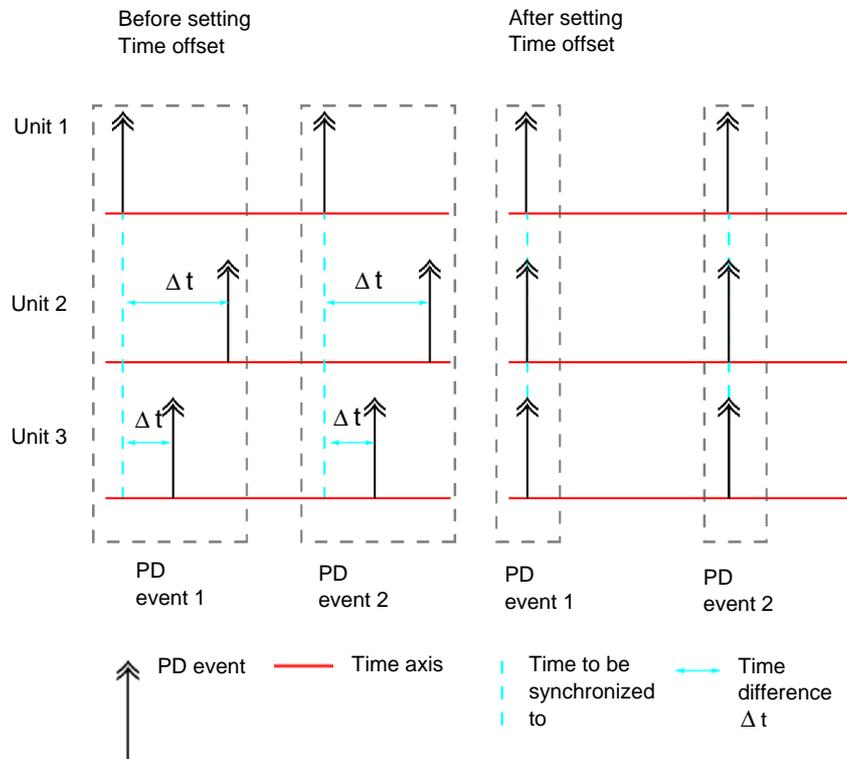


Figure 5-61 Time offset diagram

## 5.11 3FREQ Tab

The **3FREQ** tab controls multi-band measurements on a single MPD unit. One use of multi-band measurements is to provide sources for the 3PARD/3CFRD diagram (which in this case becomes a "3FREQ" diagram).

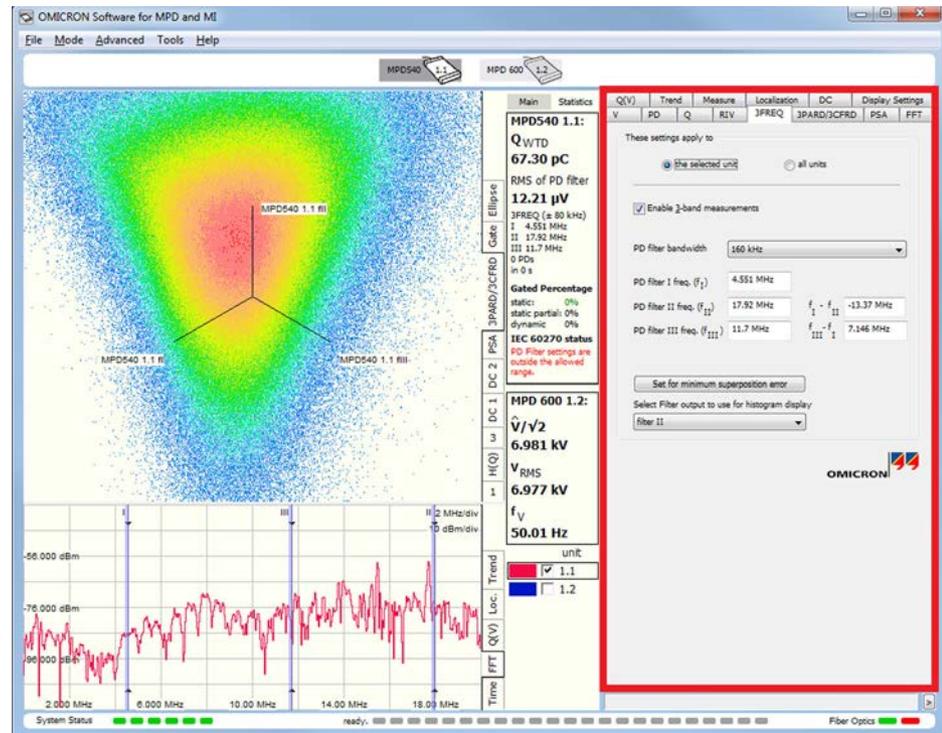


Figure 5-62 The 3FREQ tab

### 5.11.1 3-Band Measurements

The **3FREQ** feature enables a single MPD unit to simultaneously measure PD at three independently settable center frequencies. Each of these PD filters can be used as a source for a 3PARD diagram, and can also be set as the source for the histogram view and for the computation of derived quantities, such as the  $Q_{IEC}$  value. It is also possible to combine all three filters into a "3-band" filter which has an effective bandwidth covering the combined bandwidth of the 3 filters.

While the center frequencies can be set individually, all three PD filters will have the same bandwidth.

With a suitable spacing between the 3 center frequencies, the 3-band filter has the advantageous property that double pulses cannot cause a negative superposition.

**Note:** The 3FREQ feature is only available if the **Use high-bandwidth filters** setting from the **Advanced** menu is disabled.

### 5.11.2 Filter Adjustments

Set the center frequencies for each of the 3 filters directly in the **3 frequency fields** or change the values for the frequency differences behind  $f_I - f_{II}$  and  $f_{III} - f_I$ .

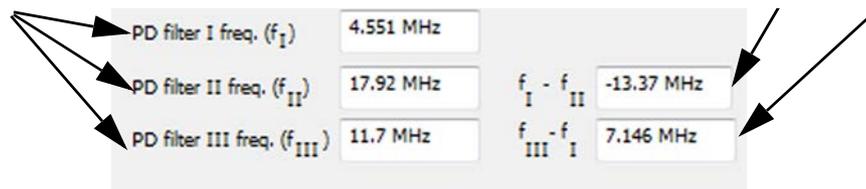


Figure 5-63 Filter Adjustment

As a result, the cursors appear in the FFT display of the small scope view as shown below. It is also possible to drag the cursors to the desired position. The coordinates of the dragged cursor is shown in an information box. Each PD filter is represented by a cursor at the selected frequency and a bar around it showing the bandwidth. A label shows the filter that corresponds to each cursor and bar.



Figure 5-64 FFT Display - filter adjustment

### 5.11.3 Selection of Filter Bandwidth

**Filter bandwidth** determines the bandwidth of the three PD filters.

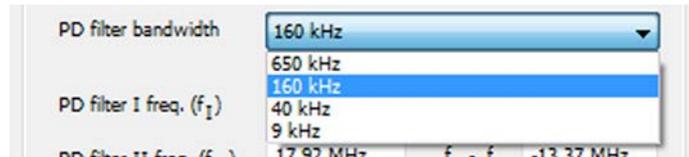


Figure 5-65 Filter bandwidth

To select which PD filter's output is used for creating the histogram and for computing derived quantities, choose the appropriate setting from the **Select filter output to use for histogram display** drop-down box. When the 3FREQ feature is enabled, only the following bandwidths are available: 650 kHz, 160 kHz, 40 kHz, and 9 kHz.

If a UHF 620 down-converter is connected, the option **650 kHz/70 MHz/1.9 GHz** becomes available as an additional bandwidth setting.

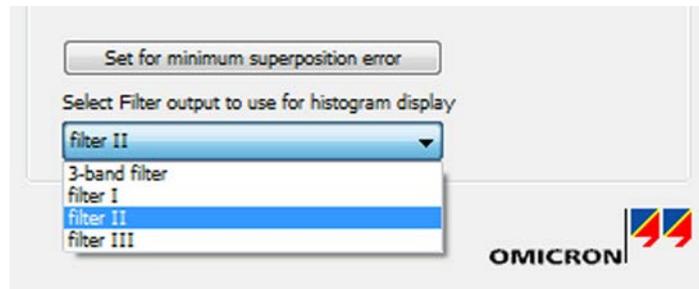


Figure 5-66 PD Filter Output Selection

Clicking the **Set for minimum superposition error** button will set the center frequencies of all three filters to predetermined values which guarantee that the 3-band filter is not subject to negative superposition. The values to which the center frequencies are set depend on the bandwidth setting.

**Note:** Only the 3-band filter is immune to the effects of negative superposition when the button is pressed. Each individual filter may still exhibit negative superposition.

## 5.12 The PSA Tab

The **PSA** tab controls the display settings and computation options to form a PSA (**P**ulse **S**equence **A**nalysis) histogram of the PD events applied at the PD input of the selected acquisition unit(s). The histogram is shown on the PSA display of the large scope view.

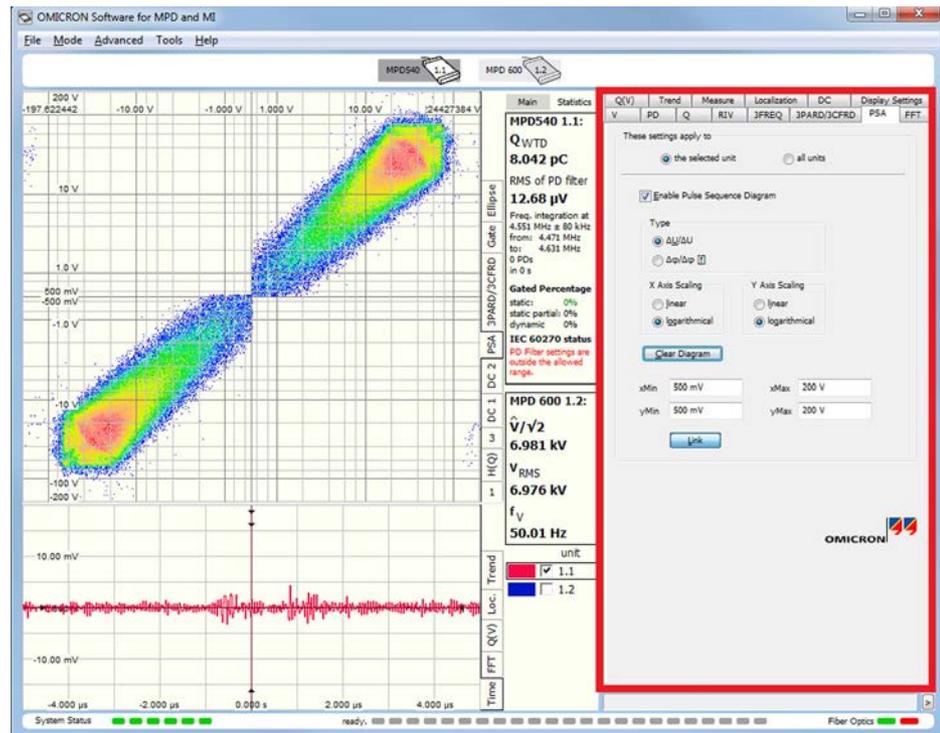


Figure 5-67 The PSA tab

### 5.12.1 Pulse Sequence Analysis

Pulse Sequence Analysis is based on the idea that a PD pulse changes the ignition conditions of the PD pulse that follows. For a PSA, three consecutive pulses are considered and shown in a graph where the x-axis plots the difference between the first two pulses and the y-axis plots the difference

between the second two pulses. Depending on the PSA setting, the difference used is in either the instantaneous voltage at the time of the PD event ( $\Delta U$ ) or in the phase of the PD event ( $\Delta\phi$ ). The illustration below shows an example.

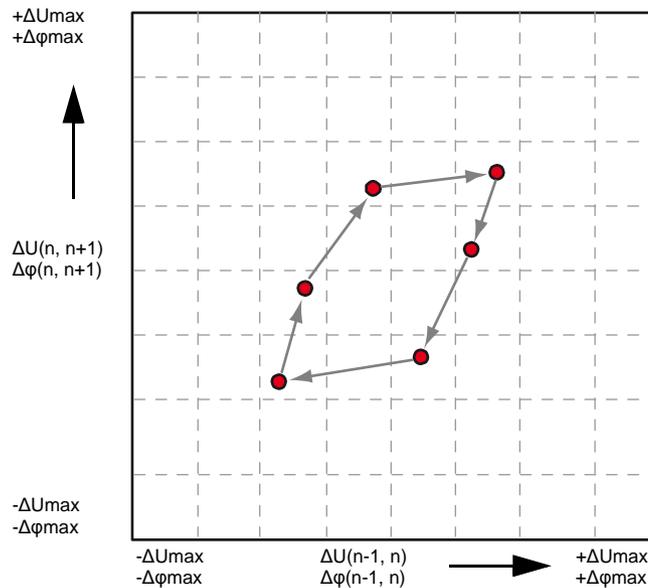


Figure 5-68 Visualization of pulse sequence analysis

## 5.12.2 Enabling the Pulse Sequence Diagram

**Note:** The creation of the pulse sequence diagram has to be enabled separately by selecting **Enable Pulse Sequence Diagram**. Select the type of correlation in the area **Type** of the PSA tab of the MPD/MI software.



Figure 5-69 PSA type settings

The results are shown on the PSA display of the large scope view.

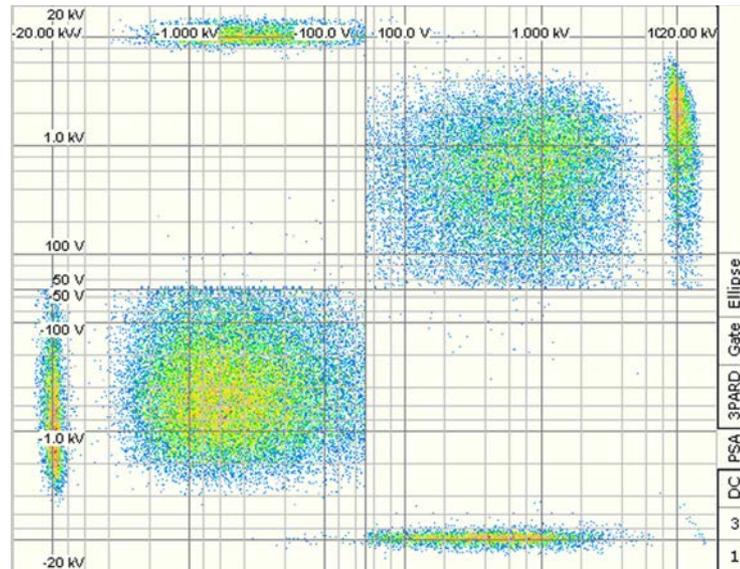


Figure 5-70 PSA display with histogram for  $\Delta U/\Delta U$  measurement

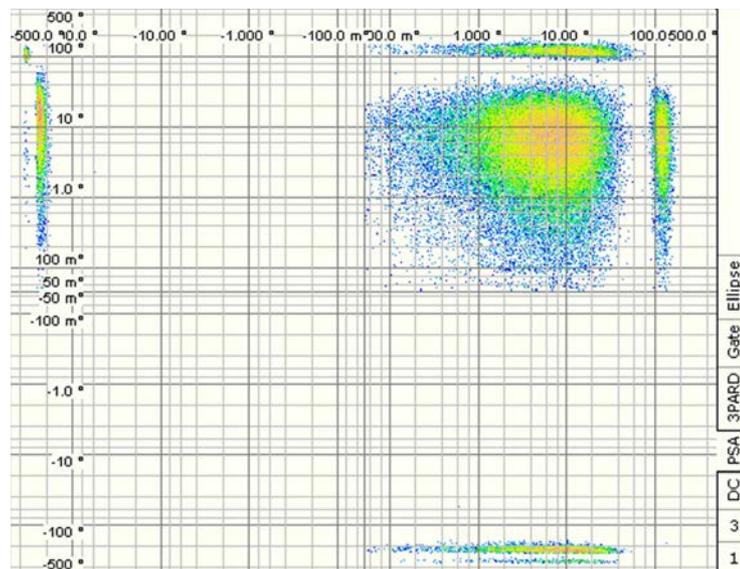
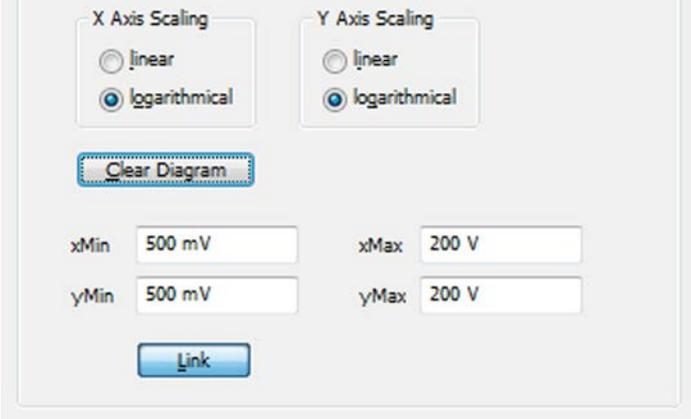


Figure 5-71 PSA display with histogram for  $\Delta\phi/\Delta\phi$  measurement

**Clear Diagram** will delete the histogram and begin to plot a new one. The **xMin** and **xMax** and **yMin** and **yMax** fields describe, respectively, the x and y dimensions of the PSA diagram. They are given in ° (degrees) when doing  $\Delta\phi/\Delta\phi$  measurements and in V (Volts) when doing  $\Delta U/\Delta U$  measurements.

When the **Link** option is enabled, the values of the **xMin** and **yMin** options are linked together, as are the values of the **xMax** and **yMax** options. Changing one will automatically update the other to the same value.



The image shows a software interface for PSA display settings. It features two sections for axis scaling: 'X Axis Scaling' and 'Y Axis Scaling'. Each section has two radio buttons: 'linear' and 'logarithmical'. The 'logarithmical' option is selected in both sections. Below these sections is a 'Clear Diagram' button. Further down are four input fields: 'xMin' (500 mV), 'xMax' (200 V), 'yMin' (500 mV), and 'yMax' (200 V). At the bottom is a 'Link' button.

Figure 5-72 PSA display settings

## 5.13 The FFT Tab

The **FFT** tab controls the display settings and computation options for the frequency spectrum of the voltage applied at the PD input. The spectrum is shown on the **FFT** display of the small scope view.

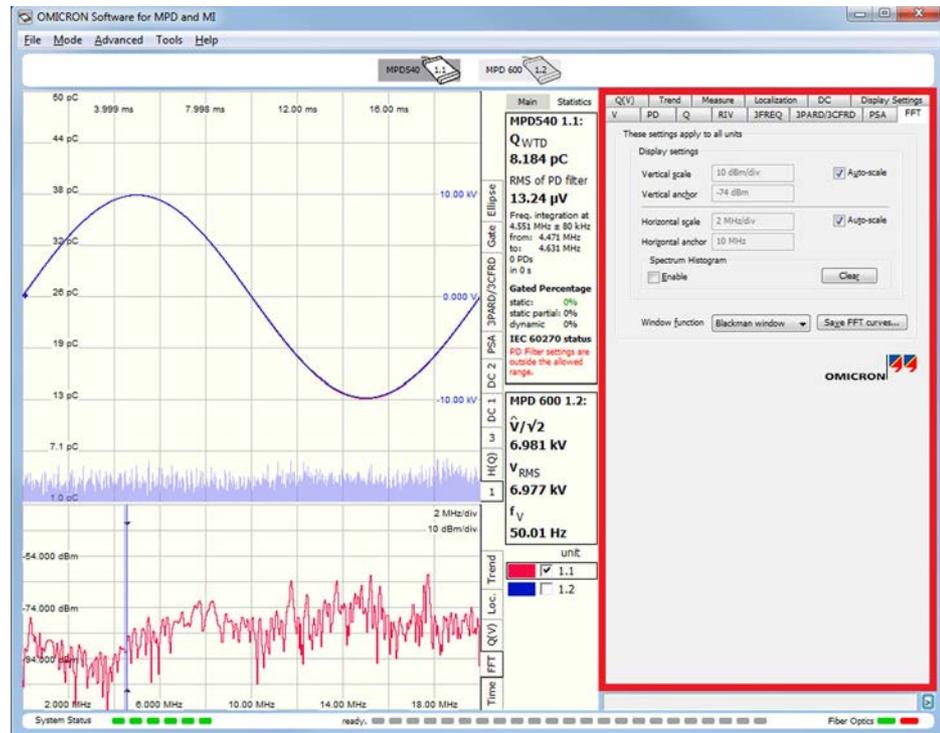


Figure 5-73 The FFT tab

The **Vertical scale** and **Horizontal scale** settings work like an oscilloscope; they correspond to the scale of the curve being shown in the respective dimension. The **Vertical anchor** setting defines the value of the middle of the vertical axis; similarly, the **Horizontal anchor** setting corresponds to the value of the middle of the horizontal axis.

Enabling **Auto-scale** for the vertical direction will automatically adjust the display in such a way that the entire height of the curve is shown. Enabling **Auto-scale** for the horizontal direction will automatically adjust the display in such a way that the curve is plotted from 0 Hz through 20 MHz. If auto-scale is enabled, the corresponding scale and anchor settings are not available. When a UHF 608 or 620 down-converter is connected, the horizontal auto-scale behavior changes to show all selected FFT curves. For example, if two units are connected and one has a UHF 608 converter connected that is set to 500 MHz

center frequency, the horizontal scale will be set to 50.13 MHz/div and the anchor will be set to 250.6 MHz to accommodate both the unit with the UHF down-converter and the one without it.

If the only visible FFT curve belongs to a unit with a UHF converter connected, then the horizontal scale is set to 250 Hz/div.

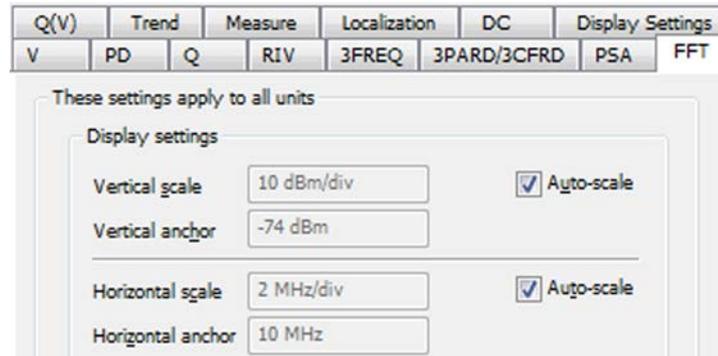


Figure 5-74 Display settings

### 5.13.1 Additional Settings

The **Window function** selects the windowing function that is applied to the data from the PD input before it is transformed into the frequency domain using the FFT. In most situations, the rectangular window is the proper choice. Other options are Blackman Window, Hamming Window, and Hann Window.

Clicking on the **Save FFT curves...** button produces a text file with 1024 lines, each of which contains the magnitude of the FFT coefficient of the corresponding frequency. The first line corresponds to the DC coefficient; the last line corresponds to 32 MHz. Each line in between is spaced 31.25 kHz from the previous one.

The file contains one column for each unit whose FFT was enabled at the time the file was generated.

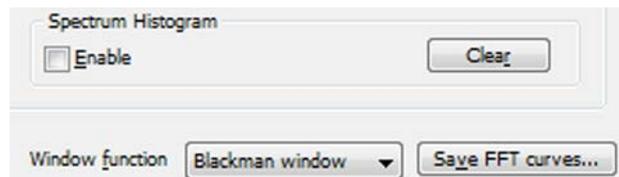


Figure 5-75 Additional settings

### 5.13.2 FFT Display Histogram View

The FFT display can be set to show a histogram of the spectrum; each point in the histogram corresponds to an FFT coefficient. Each point is assigned a color based on the number of times the corresponding FFT coefficient was a certain value. The class coloring is always automatically computed with logarithmic distribution. The histogram view is enabled by checking the **Enable** option in the **Spectrum Histogram** box. Clicking **Clear** will clear the histogram view.

**Note:** When auto-scaling is enabled, the software can automatically change the horizontal and vertical scale of the FFT. This will also affect the FFT histogram, which in this case will be cleared and restarted. In order to avoid that, disable auto-scaling when the FFT histogram is in use.

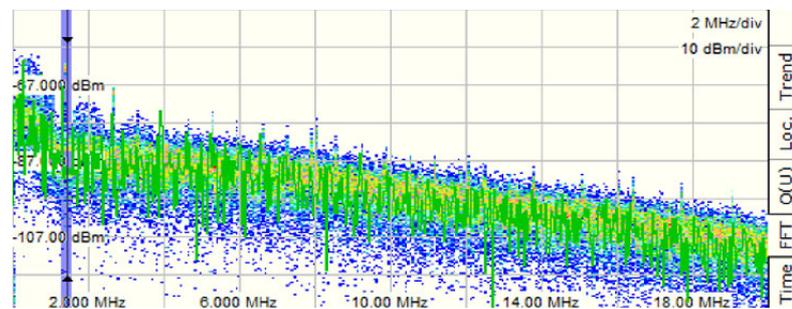


Figure 5-76 The FFT display histogram view

## 5.14 UHF Tab

The **UHF** tab shows the serial number of the attached UHF 608 or UHF 620 down-converters and allows the user to configure it.

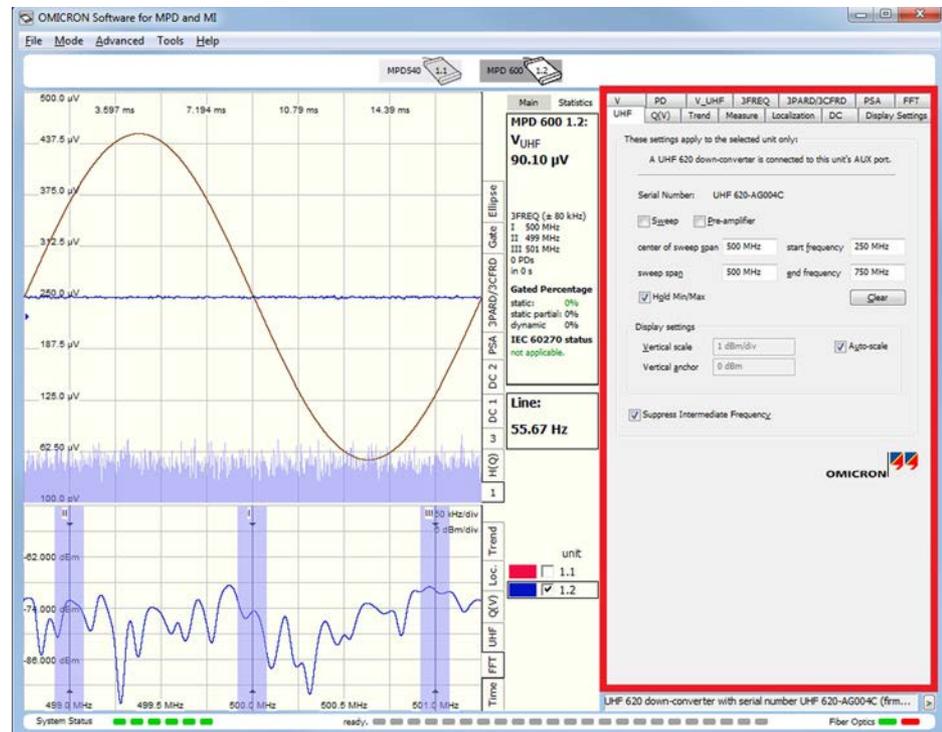


Figure 5-77 UHF tab

The UHF 608 and UHF 620 down-converters extend the usable frequency range of the *MPD 600* system to the UHF range. Specifically, they allow measurements between 220 and 850 MHz (with the UHF 608) and between 100 MHz and 1.9 GHz (with the UHF 620). The UHF converter performs frequency translation between a 10-MHz window around its configured center frequency. The MPD/MI software makes this frequency translation transparent, and allows the center frequency to be set directly to anywhere in the frequency range supported by the UHF down-converter.

The UHF 608 and UHF 620 down-converters can also perform a frequency sweep, during which it will sweep across the configured sweep span in 300 kHz steps. At each sweep step, the UHF 608/620 down-converter measures the

noise level and the maximum signal level. The resulting curves are shown in the UHF tab of the small scope view. Sweeping is enabled by checking the **Sweep** option on the **UHF** tab (see Figure 5-78).

The image shows a control panel for sweep options. At the top, there are two unchecked checkboxes: 'Sweep' and 'Pre-amplifier'. Below these are four input fields: 'center of sweep span' set to '500 MHz', 'start frequency' set to '250 MHz', 'sweep span' set to '500 MHz', and 'end frequency' set to '750 MHz'. At the bottom left, there is a checked checkbox labeled 'Hold Min/Max'. At the bottom right, there is a 'Clear' button.

Figure 5-78 Sweep options

The **center of sweep span** and **sweep span** options establish the range of the sweep. Alternatively, the **start frequency** and **end frequency** can be used; both settings are kept in sync by the software, i.e. when one setting is changed, the other is automatically updated to reflect the change.

The **Hold Min/Max** option determines what happens when the sweep completes and starts again. If the option is enabled, the minimum (for the noise curve) and maximum (of the maximum curve) of the curve and the value from the current sweep are used to determine the new value of the curve; if the option is disabled, the current sweep alone determines the curves.

Clicking on **Clear** clears both the noise and the maximum curve from the **UHF** tab. During the sweep no PD measurements can be performed.

The **Pre-amplifier** option determines the state of the pre-amplifier built into the UHF 608 and UHF 620. With the pre-amplifier enabled, the input signal is amplified by approx. 15 dB (UHF 608) or 22 dB (UHF 620) before being measured by the MPD unit.

The display settings work analogous to the FFT settings.

The image shows a control panel for display settings. It has a title 'Display settings' at the top. Below the title are two input fields: 'Vertical scale' set to '1 dBm/div' and 'Vertical anchor' set to '0 dBm'. To the right of these fields is a checked checkbox labeled 'Auto-scale'.

Figure 5-79 Display settings

The **Suppress Intermediate Frequency** option eliminates most aliasing artifacts caused by the down conversion within the UHF 608/UHF 620 during sweeping. When enabled, signal components that stem from aliasing are suppressed and not shown in the sweep diagram.



Suppress Intermediate Frequency

Figure 5-80 Suppress options

## 5.15 The Q(V) Tab

The **Q(V)** tab contains the controls that allow you to plot the  $Q_{IEC}$  value over the voltage. This diagram is available on the Q(V) display of the small scope view. The diagram is useful for PD inception/extinction voltage tests. As the voltage changes, the PD level is recorded and plotted in this diagram.

The diagram shows the Q(V) curve of all units for which the PD scope and FFT is enabled (via the check box next to the unit designator below the statistics panel). Increasing voltage is shown by a lighter shade of the MPD unit's color; decreasing voltage is shown by a darker shade of the MPD unit's color. This diagram allows to see the inception and the extinction voltage at a glance. The diagram's vertical axis (plotting the charge) is always scaled logarithmically; the horizontal axis (plotting the voltage) is scaled linearly.

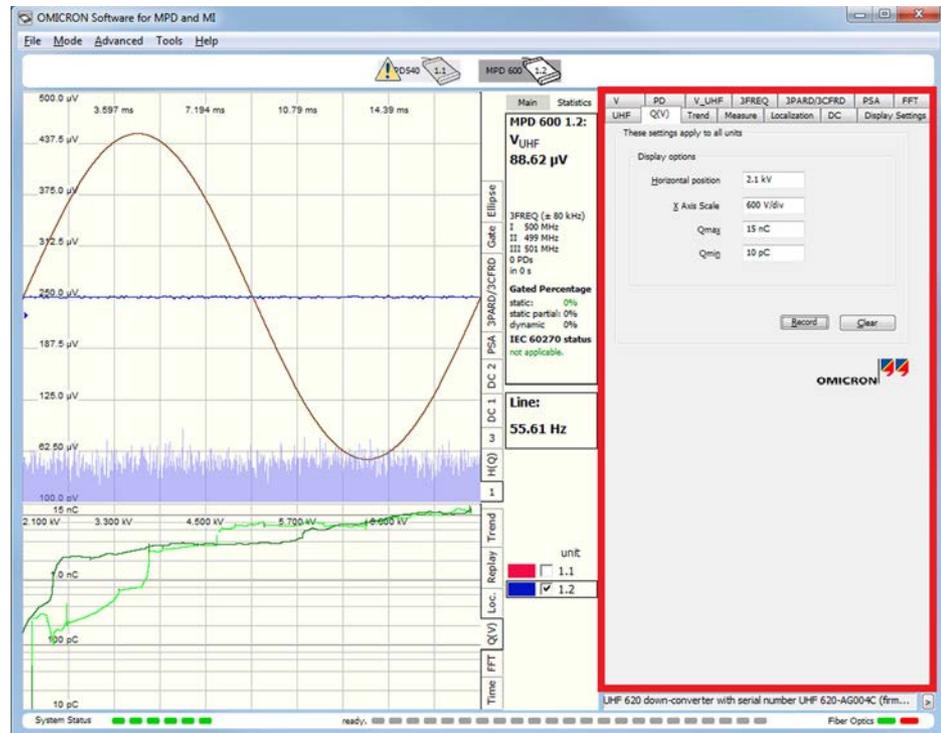


Figure 5-81 The Q(V) tab

## 5.15.1 Display Options

The display options on the **Q(V)** tab work like an oscilloscope; **Horizontal position** and **X Axis Scale** define the viewport on the horizontal axis. **Qmax** and **Qmin** define the top and bottom margin of the diagram, respectively. Pushing the **Record** button will start recording the Q(V) diagram, releasing it will stop recording. To clear the diagram, click on **Clear**.

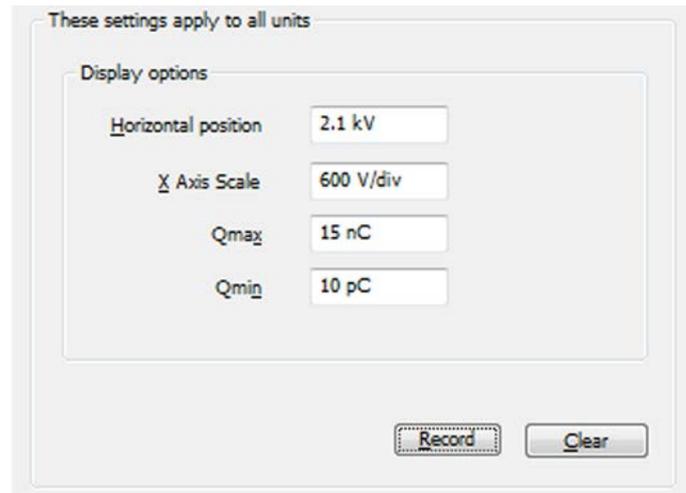


Figure 5-82 Display options

## 5.16 The Trend Tab

The **Trend** tab contains the controls that govern trending. Trending consists of recording one or more measured quantities in regular intervals and optionally saving them to a file. The trended values are shown in the trending diagram on the Trend display on the small scope view.

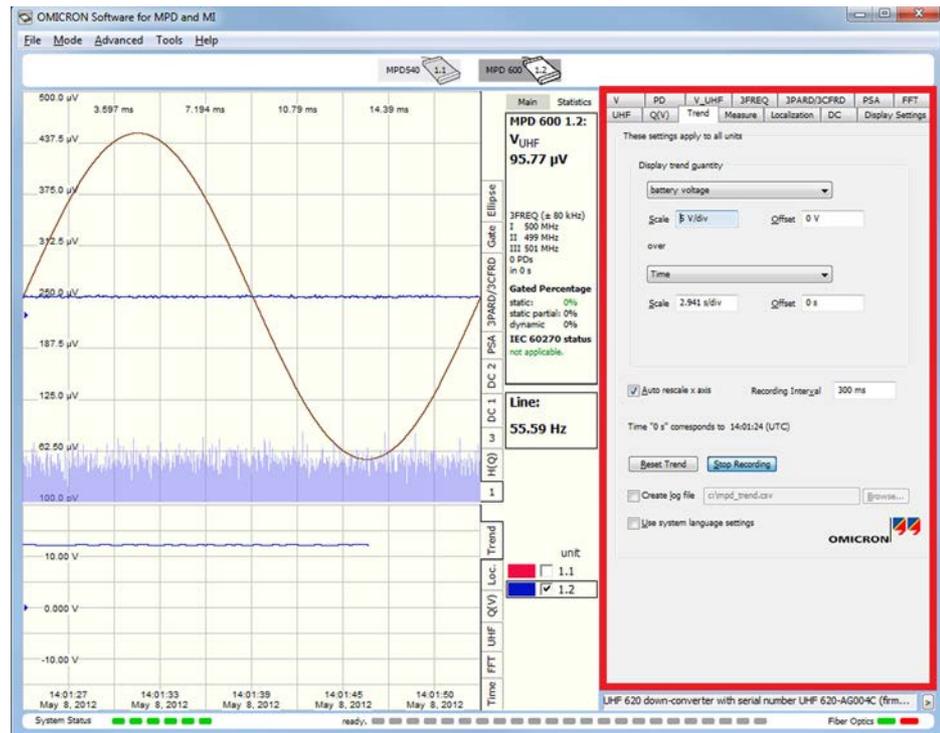


Figure 5-83 The Trend tab

### 5.16.1 Quantities for Trending

The following measured quantities are available for trending:

- The voltage of the unit's power supply
- The RMS voltage of the **V** input
- The PD level ( $Q_{IEC}$ )
- The peak voltage of the **V** input divided by  $\sqrt{2}$
- The number of PD events per second that contribute to the  $Q_{IEC}$  value
- The number of PD events detected per second

**Note:** Any settings on the **Trend** tab apply to all connected MPD units, regardless of which unit is selected.

## 5.16.2 Display Settings

The **Display trend quantity** selection box allows to select which of the above measurement quantities shall be displayed. **Scale** and **Offset** work like an oscilloscope and operate on the vertical scale of the display. These values can be changed independently for the various measurement quantities. The top fields select the measurement quantity to plot on the y-axis, the bottom fields determine the quantity to be plotted on the x-axis.

Setting the top quantity to **disabled** disables the trend diagram.

The trend diagram saves the actual time (GMT/UTC) of day as well as the date of the trended quantities. The offset refers to the time that the trend diagram was first started. The actual time and date of the offset value "0" are shown for reference.

**Note:** The **Time** quantity is only available for the x-axis.

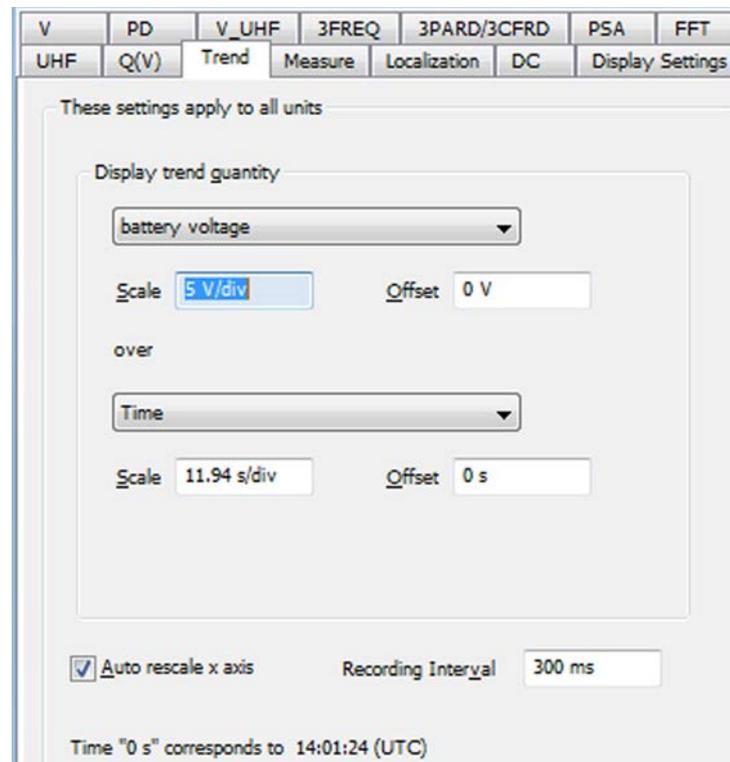


Figure 5-84 Display settings

If the **Auto rescale x axis** option is enabled, the display will automatically be rescaled when the trending display hits the right margin of the diagram. The rescaling will set the horizontal position to 0 and double the value in the x-axis scale setting so that every time the display hits the right margin, the display is rescaled so that the curve ends in the middle of the diagram. Clicking on **Reset Trend** will reset the trend diagram.

**Note:** If the check box **Create log file** is set clicking on reset trend will also clear the file. Toggling **Start Recording** enabled will start trending, toggling it off will stop trending.

### 5.16.3 Trend Files

Enabling **Create log file** and entering a file path into the text field next to it will cause all trended values to be saved to the file represented by the file path. If the file exists, it will be loaded into memory, and the trend quantities saved therein will be shown in the trending diagram. Any new trend values will then be appended to the file. When the **Use system language settings** option is enabled, the MPD/MI software will use the decimal point and list separator settings as configured in the system control panel when writing trend files. When that option is disabled, the software will always use the English settings, so a decimal point is always a point (.) and the list separator is always a semicolon (;).

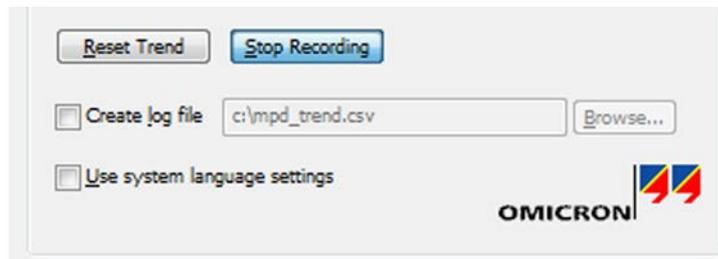


Figure 5-85 Trend files

## 5.17 The Measure Tab

The **Measure** tab offers the measure cursor functionality built into many oscilloscopes. It operates on the data from the PD input as displayed in the Time display of the small scope view. The tab contains the controls for two measurement cursors.

**Note:** When the **Measure** tab is selected, the Time display is modified so that it shows only these two cursors. All other cursors (including trigger threshold, trigger time, and integration domain cursors) are hidden.

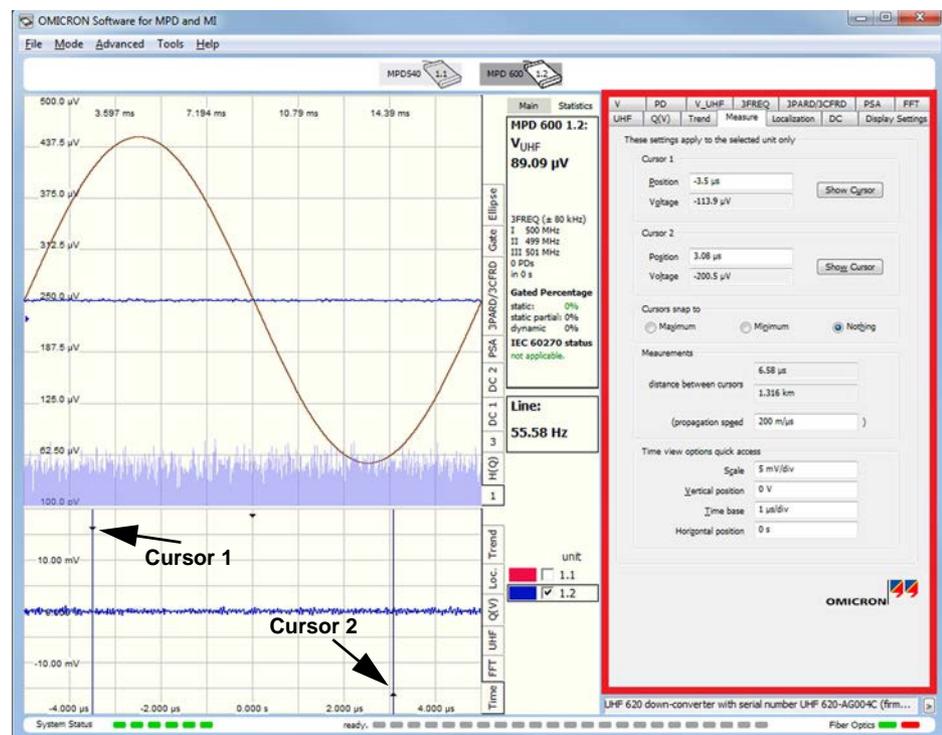


Figure 5-86 The Measure tab

### 5.17.1 Display Settings

For every cursor, the following controls are available:

The **Position** setting, which corresponds to the horizontal position of the cursor in the display. To adjust the position, just type into the field a value that fits the needs or move the cursor by dragging its handle across the diagram. Both cursors have only one handle. The position is given with respect to the PD scope's trigger time.

Cursor 1's handle (arrow) is near the top of the display, cursor 2's near the bottom. This allows to decide which cursor to move with the mouse if both are on the same location. Cursors that are outside of the diagram's current viewport are shown at the left or right margin of the diagram, depending on whether they are located to the left or to the right of the viewport. This allows you to grab the cursors with the mouse and pull them into the view even if they are far outside the currently visible part of the curve.

The **Voltage** display will be continuously updated to reflect the voltage of the selected unit's curve under the associated cursor (i.e. the y dimension of the point at the intersection of cursor and curve).

The **Show Cursor** button, if pressed, will move the diagram's viewport such that the cursor is shown in the center of the diagram.

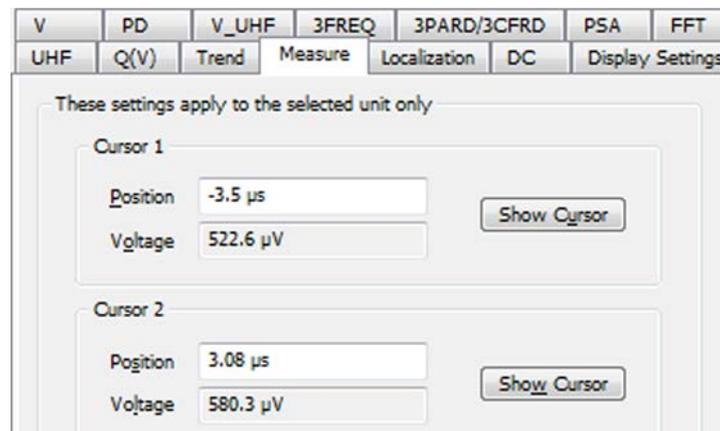


Figure 5-87 Display settings

### 5.17.2 Cursor Snap Settings

With the options in the **Cursors snap to** box, cursors can optionally be set to automatically snap to a local maximum or minimum in the vicinity (i.e. approx. 10 pixels around the cursor location) of the cursor position when moved by dragging. This allows to move a cursor towards a maximum/minimum of the curve. The cursor will then automatically snap to the exact position of the peak and will give the exact maximum or minimum voltage at the peak with subpixel resolution. Selecting **Nothing** in the **Cursors snap to** box will disable cursor snapping. The cursors will stay exactly where they have been dropped.

**Note:** Snap to always applies to selected unit's curve.



Figure 5-88 Cursor snap settings

### 5.17.3 Measurement Display

The **Measurements** box shows the distance between the two cursors. The top value shows the distance expressed as a time difference, the bottom value shows it as a spatial distance. The software actually measures the time difference, so in order to arrive at a spatial distance, the **propagation speed** must be known. Enter its value in the propagation speed field.

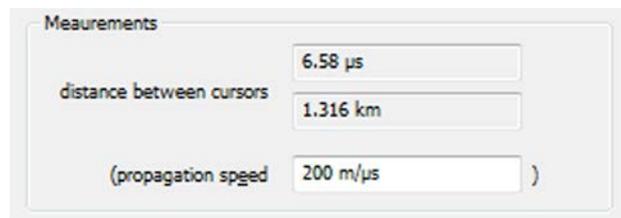


Figure 5-89 Measurement display

### 5.17.4 Time Display Options

The options in the **Time view options quick access** box duplicate the display controls from the **PD** tab for convenience (see 5.8 on page 118). The **Scale**, **Vertical position**, **Time base**, and **Horizontal position** settings control the viewport and scaling of the PD data curve. Showing these options here again makes it possible to adjust the display settings of the PD data curve without switching back and forth between the **Measure** tab and the **PD** tab.

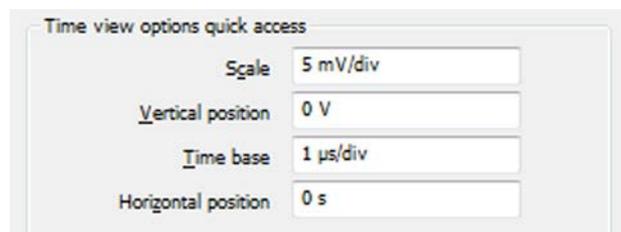


Figure 5-90 Time display options

## 5.18 The Localization Tab

The **Localization** tab contains the controls and displays necessary for performing fault localization using a Statistical TDR approach. Statistical TDR works by correlating the impulse amplitude and time difference between consecutive PD impulses. Start by selecting a range of PD impulses in the large scope view (see rectangle on the left-hand side in Figure 5-91) that correspond to the fault you want to localize; these impulses act as a trigger for the correlation process. That trigger range is expressed in terms of a charge-by-phase window, i.e. a rectangle selecting impulses within a certain phase range and a certain charge range. Any impulse within this range will be correlated with every subsequent impulse, whether it is in the trigger window or not, up to a selectable maximum correlation depth. Each subsequent impulse is plotted into the localization histogram (available in the **Loc. Display** of the small scope view). Its time difference to the triggering impulse becomes the x position and the amplitude ratio between the triggering impulse and itself becomes the y position in the histogram. Each point in the histogram thus corresponds to a number of PD event pairs with a certain time difference and a certain amplitude ratio.

Fault Localization using the histogram correlation diagram comes in two flavors: **Statistical TDR (Time Domain Reflectometry)** works with a single unit and exploits the fact that high-frequency PD signals are reflected on any open HV connections. The reflected impulses are correlated with the direct impulses; the time difference between the two can be used to derive the length of the signal path, and, ultimately, the position of any faults. In contrast, **Time-Difference Measurement** (also called **Dual-End Measurement**) uses two units that are located at different positions in the test circuit (in a cable, they are connected to both ends). Because they are located at different positions in the test circuit, both units will detect the signal emanating from a PD source at a different time. But because they operate fully synchronously, this time difference can be used to determine the position of the PD source. Dual-end measurements are more precise than statistical TDR measurements because they require no minimum detection distance.

The idea behind statistical TDR is that impulse pairs that correspond to a fault and its reflections (or to two independent detections of the same pulse by two units in dual-end measurements) will have a fixed time difference and amplitude ratio, and will thus be represented in the localization histogram as a cluster of points with a maximum number of occurrences. The localization histogram consequently automatically selects the histogram point that most likely corresponds to the fault position<sup>2</sup>) and will consider the reflection/detection distance to be the x position of that histogram point.

---

2. Every correlation in the histogram is scored according to its number of occurrences, the maximum charge level of the triggering impulse, and the amplitude ratio.

Remember: The x position corresponds to the time difference between the trigger impulse and the correlated impulse that follows it, so it represents the time difference between the primary fault impulse and its first reflection (or between the detection of the primary pulse by two different units in dual-end measurements). It is possible to override the software's default selection by drawing a rectangle in the localization histogram; in this case, the software will select the point with the maximum number of occurrences inside that rectangle. This point is called the **Reflection point**, and is shown in the corresponding display inside the **Localization** tab.

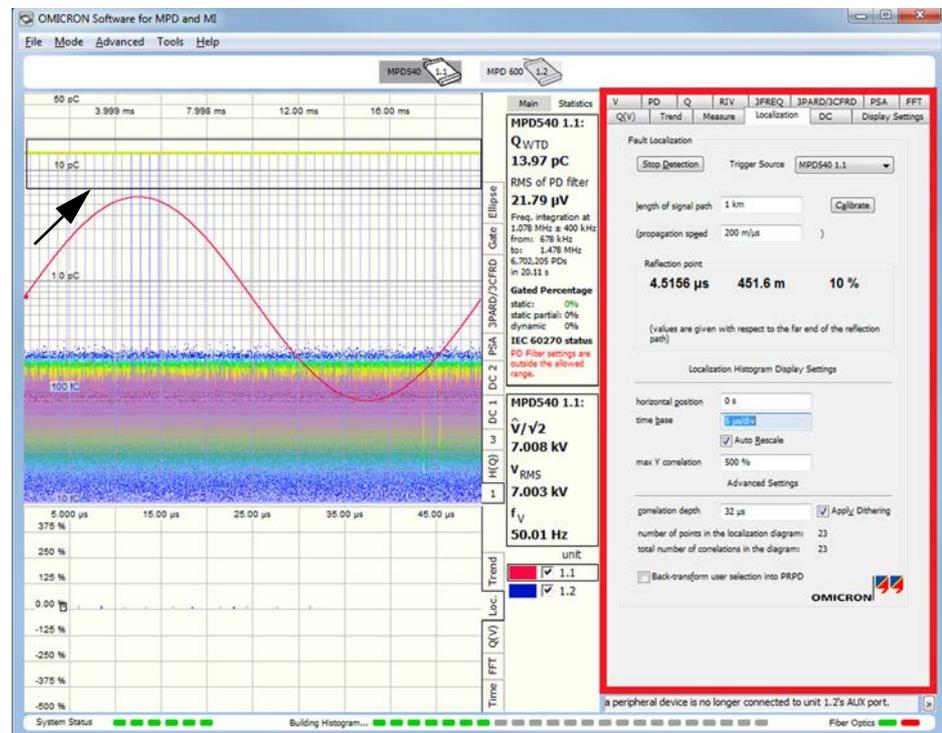


Figure 5-91 The Localization tab

The user experience during a dual-end measurement is essentially identical to that of the statistical TDR; the only difference being that one unit acts as the trigger with which the other unit correlates its data. In statistical TDR, the triggering unit always correlates with itself. As a generalization of the dual-end measurement, it is possible to do this with more than two units. In this case, the triggering unit is in turn correlated with all other units, giving a correlation histogram for each pair of units. This is handy for transformer measurements or measurements on rotating machines.

So keep in mind that when the following pages refer to reflections or the reflection point, the term is strictly only correct when using statistical TDR. With dual-end measurements, the more appropriate term would be “detection distance”. However, for the sake of brevity, reflection point is used throughout.

### 5.18.1 Fault Localization Settings

Select one of the units as the **Trigger Source**. The **Start/Stop Detection** button in the **Fault Localization** box starts the process; once clicked, you must draw a rectangle in the large scope view containing all PD impulses you want to trigger on (see Figure 5-91 on page 173). Note that the rectangle applies only to the unit selected under **Trigger Source**! The text of the **Start Detection** button will change into **Stop Detection**. For calibration purposes, it is possible to enter a value into the **length of signal path** setting; the detected **Reflection point** will then be considered to correspond to that length. This is used to compute the **propagation speed** of the impulse ( $v$ , not  $v/2$ ) through the test object (typically a cable).

To use this, disconnect the high voltage, connect a charge calibrator to your test object, then start the localization process by triggering on the calibrator impulses. The reflection point will correspond to the reflection of the calibrator impulse at the open end of the test object. If the length of the cable/signal path is known, it can be entered into the **length of signal path** setting, and the **Calibrate** button can be pressed. This will compute the propagation speed and place it into the **propagation speed** setting.

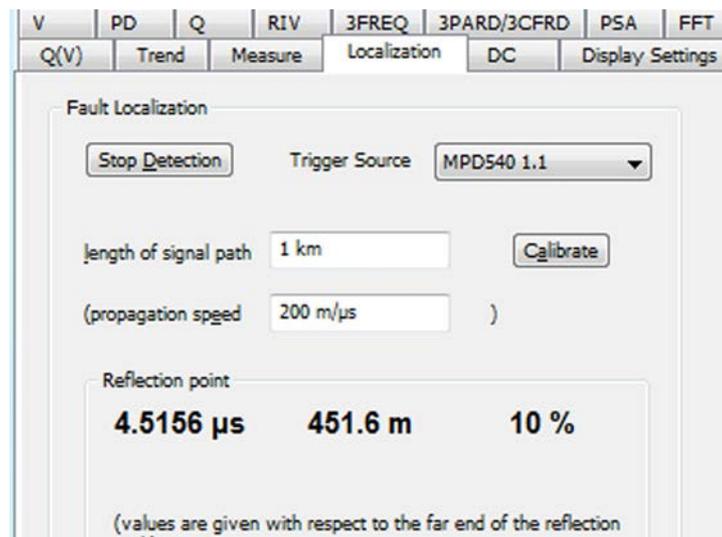


Figure 5-92 Fault localization settings

Alternatively enter the propagation speed directly ( $v$  not  $v/2$ ). With the correct propagation speed, the spatial value (the center value) shown in the **Reflection point** display should match the actual length of the signal path<sup>3</sup>).

Clicking on **Stop Detection** will stop the correlation process. The localization histogram will no longer be updated, the button text will change back to **Start Detection** and the trigger rectangle will disappear.

## 5.18.2 Display Settings

Set the **time base** and **horizontal position** offset value for the localization histogram; these settings work just like those from an oscilloscope. If the **Auto Rescale** option is enabled, clicking on the **Calibrate** button sets the horizontal position to 0 and the time base value will be scaled so that the right border of the diagram corresponds to the reflection point of the calibration. When used with a cable, this means that the width of the diagram corresponds to twice the length of the cable, and the fault position can be visualized as a percentage of the cable length at a glance.

The **max Y correlation** field determines the maximum amplitude ratio that can be shown in the localization histogram. Larger values will fall outside of the histogram and will not be considered. The default value is 500%, which means that pulse pairs where the trigger pulse is up to 5 times higher than the correlated pulse (or vice versa) are contained in the diagram.

Localization Histogram Display Settings	
horizontal position	0 s
time base	5 μs/div
	<input checked="" type="checkbox"/> Auto Rescale
max Y correlation	500 %
Advanced Settings	
correlation depth	32 μs <input checked="" type="checkbox"/> Apply Dithering
number of points in the localization diagram:	23
total number of correlations in the diagram:	23

Figure 5-93 Display settings

- On a cable, the signal path is twice the length of the cable, because the calibrator impulse passes through the entire cable, gets reflected at the open end, and travels back again along the entire length of the cable.

### 5.18.3 Advanced Settings

**Advanced Settings** contains the **correlation depth** parameters and the **Apply Dithering** option. The former value determines how many impulses will be correlated with a trigger impulse during fault localization. Correlation will stop when the time difference between the trigger impulse and the impulse currently being considered is greater than this value. The fault localization process then continues with the next trigger impulse. The latter option, when enabled, causes the localization histogram to be dithered, i.e. each correlation produces not only a single point in the histogram but a "smear" of points around its actual position. This will produce results faster, but with less accuracy than if this option is disabled.

The **Advanced Settings** section also shows the number of correlations that appear in the diagram: The first value, **number of points in the localization diagram** show how many points in the diagram have received at least one correlation (i.e. has a color different than the background color). The second value, **total number of correlations in the diagram** tracks all correlations made by the diagram, including those that occur at the same points in the diagram (and thus change the color of the point).

The option **Back-transform user selection into PRPD** takes effect only if the user drew a rectangle around the area of interest in the localization diagram. In that case, if the option is enabled, the PRPD will only show pulses that produce correlation pairs in the selected area of the localization diagram. Both the triggering pulse and the correlated pulse are shown. Pulses that produce a correlation outside of the selected area or do not produce a correlation at all are suppressed in the PRPD.

This option can help with determining which correlation in the diagram is caused by the PD fault and can remove noise from the PRPD, producing a "purer" fingerprint pattern of the actual PD fault.

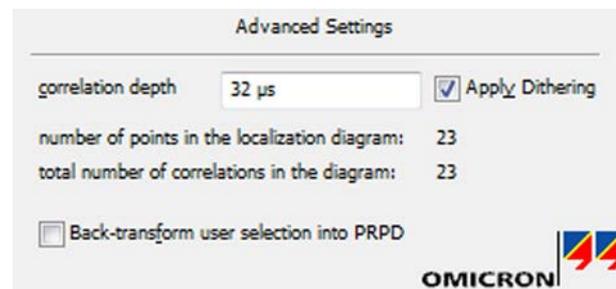


Figure 5-94 Advanced settings

## 5.19 The DC Tab

The **DC** tab controls DC measurements, and contains the display settings for the various diagrams that are shown in the **DC 1** and **DC 2** displays of the large scope view.

Starting a DC measurement by clicking on the **Go** button on this tab actually switches the software into DC mode. DC mode ends when the **Go** button is released.

There are five diagrams that are relevant for DC measurements; three (the **Q(t)** diagram, the Pulse Count diagram, and the Accumulated Charge diagram) are available on the **DC 1** display of the large scope view, and two more (the Charge Count Bar graph and Accumulated Charge Count Bar graph) are available from the **DC 2** display.

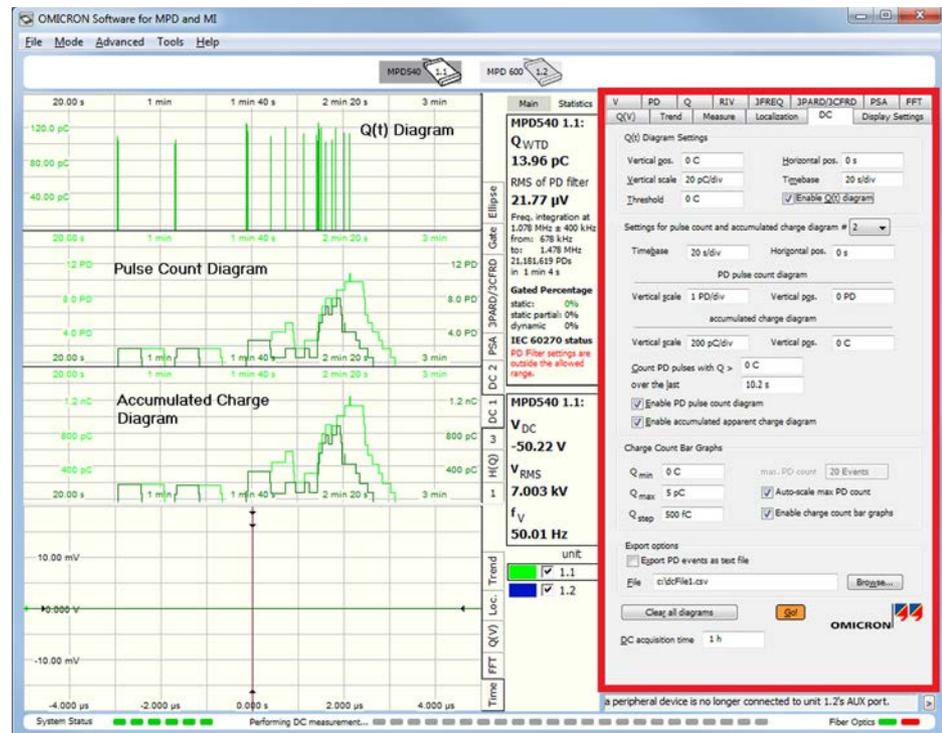


Figure 5-95 The DC tab with DC 1 display

The **Q(t)** diagram plots the charge level of all PD events above a certain threshold over time. The Accumulated Charge Count diagram displays the accumulated charge of all PD events seen within the selected period of time. The **Pulse Count** diagram displays the number of PD events above a selectable

charge level inside a selectable period of time, also plotted over time. Both the Charge Count diagram and the Accumulated Charge diagram actually contain two individually configurable graphs plotted inside the same diagram window.

### 5.19.1 Q(t) Diagram Settings

The **Vertical position**, **horizontal position**, **Vertical scale** and **Time base** settings correspond to the well-known oscilloscope settings. The **Threshold** setting contains the minimum charge level that events need to have in order to be included in the Q(t) diagram.

The diagram itself plots every event as a "spike", i.e. it draws a line from 0 to the charge corresponding to the PD event. Be sure to set the threshold above the noise level; PD event noise will occur very frequently and can easily bog down the computer, if every single one is included in the Q(t) diagram. The Q(t) diagram is only built if the **Enable Q(t) diagram** check box is enabled.

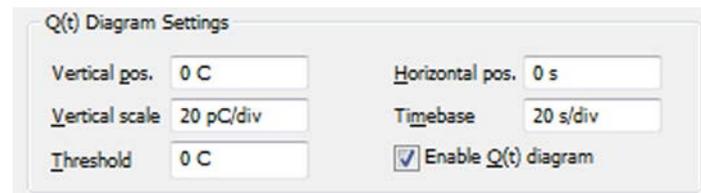


Figure 5-96 Q(t) diagram settings

### 5.19.2 PD Pulse Count and Accumulated Charge Diagram Settings

Remember: There are two PD pulse diagrams and two accumulated charge diagrams. Select either **1** or **2** in the selection box in the title area of the **Settings for** box.

**Note:** All settings for both diagrams are completely independent, including the **Time base**.

The **Vertical position**, **horizontal position**, **Vertical Scale** and **Time base** settings are similar to an oscilloscope's display settings.

The **Count PD pulses with Q >** setting determines which events will cause the count to be increased in the PD pulse count diagram and the charge to be added in the accumulated charge diagram. The **over the last** setting determines the time period for which the diagram should be maintained. Every event detected with a charge level above the **Count PD pulses with Q >** threshold is "remembered" and both increments the count in the PD pulse count diagram and its charge is added to the accumulated charge diagram. When the time of the measurement exceeds, the time specified in the **over the last** setting, the former "remembered" event is "forgotten" and the count is decremented and the

associated charge is subtracted from the accumulated charge diagram. Thus, the count acts as a rolling window over the history of counted PD events. The **Enable PD pulse count diagram** determines whether or not the corresponding PD pulse count diagram is built. This means the software can be set to show one, both, or no PD pulse count diagram.

Likewise, the **Enable accumulated apparent charge diagram** setting determines which accumulated charge diagram is enabled.

Settings for pulse count and accumulated charge diagram # 2

Timebase 20 s/div Horizontal pos. 0 s

PD pulse count diagram

Vertical scale 1 PD/div Vertical pos. 0 PD

accumulated charge diagram

Vertical scale 200 pC/div Vertical pos. 0 C

Count PD pulses with  $Q >$  0 C  
over the last 10.2 s

Enable PD pulse count diagram

Enable accumulated apparent charge diagram

Figure 5-97 Pulse Count and Accumulated Charge diagram settings

**Note:** The vertical scale corresponds to the number of events within the selected time period. This value is updated every 300 ms.

Clicking on the **Clear all diagrams** button will clear all diagrams manually. It is possible to limit the acquisition time automatically by entering a value into the field behind **DC acquisition time**. DC mode will then automatically be exited when the entered time elapses.

Clear all diagrams Go!

DC acquisition time 1 h

Figure 5-98

### 5.19.3 Charge Count Bar Graph Settings

The **DC 2** display contains two bar diagrams: the top diagram shows a bar graph of charge classes: Each bar represents the number of PD events whose charge level is equal or above the value on the x-axis (this is the so-called accumulated charge count).

The bottom diagram shows the number of PD events that fall within the charge range given by the x-axis.

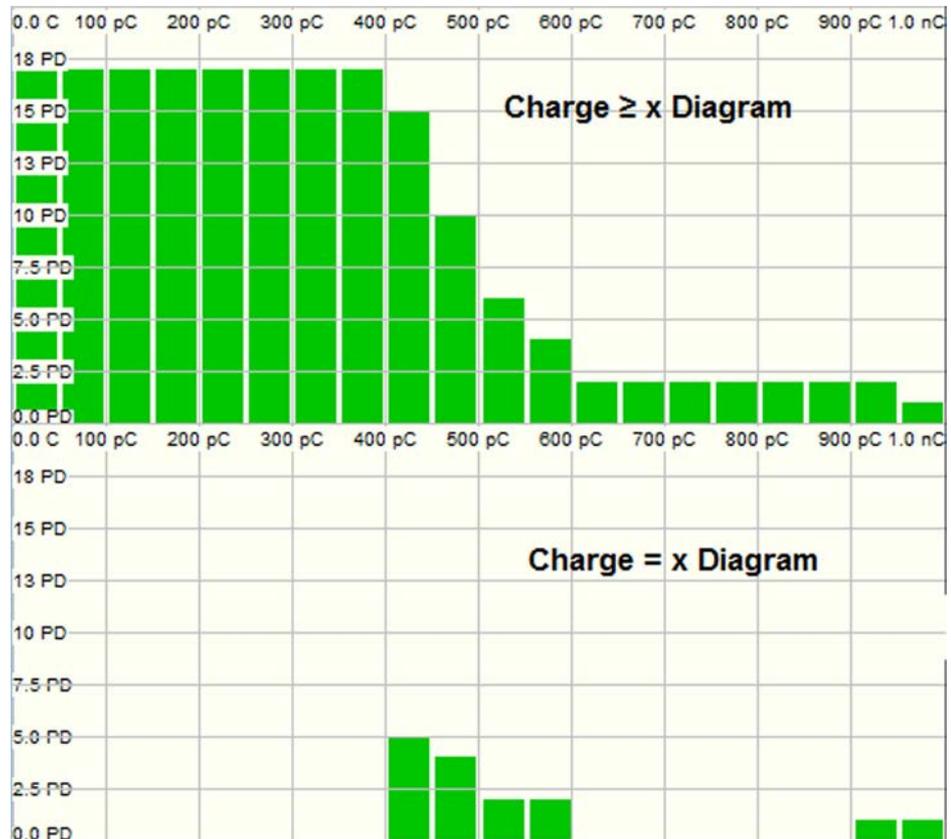


Figure 5-99 The DC 2 display

These diagrams are configured in the **Charge Count Bar Graphs** section of the DC control panel.

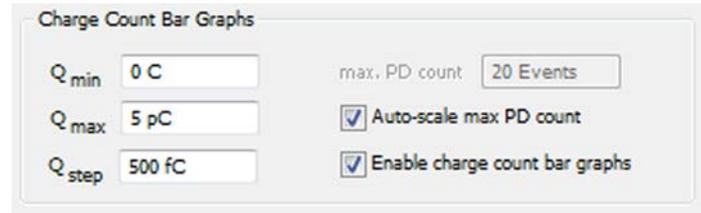


Figure 5-100 Charge Count Bar Graphs settings

$Q_{min}$  determines the leftmost value of the x-axis for both diagrams, and thus corresponds to the minimum charge level being tracked by these diagrams.  $Q_{max}$  establishes the right-most value of the x-axis, and corresponds to the maximum charge being tracked.

The  $Q_{step}$  control determines the range that each bar covers: The leftmost bar spans  $Q_{min}$  to  $Q_{min} + Q_{step}$ , the next bar spans  $Q_{min} + Q_{step}$  to  $Q_{min} + 2 * Q_{step}$ , and so on.

Enabling **Auto-scale max PD count** will cause the y-axis of the bar graphs to be scaled automatically so that all bars are completely visible. When this setting is disabled, the **max. PD count** field takes the number of PD events that correspond to the top margin of the bar graph diagrams.

The bar graph diagrams are only generated when the **Enable charge count bar graphs** option is checked. This setting applies to both diagrams; there is no way to enable one but not the other diagram.

## 5.19.4 Export Options

In addition to forming diagrams inside the software every detected PD event can be written to a text file. Enter the full path of the file in the **File** text field or **Browse...** for a folder and create a file name and save the file. As soon as the **Export PD events in text file** is activated, all detected events will be saved to this file. Every PD event will be written to a separate line, and every line will contain the time of the PD event, followed by the charge of the event and the DC voltage at the time of the PD event.

**Note:** The file exported using this function will always be written as a CSV-file using English-language settings, i.e. fields are separated by commas (,) and the decimal point will always be a point (.).

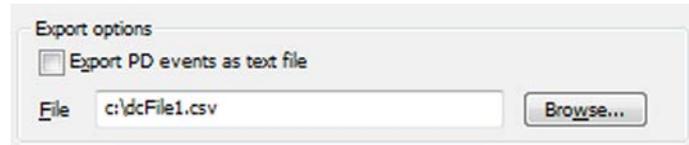


Figure 5-101 Export options

**Note:** Before selecting this option, make sure that the PD detection threshold on the **Q** tab is set above the noise level. If the threshold is below the noise level, noise events will also be saved to the file. Since there can be a large number of noise events, this can easily bog down the computer and the software may not respond any longer.



## 5.20.1 Grid Color Settings

These settings allow the color of the window **Background**, the **Grid lines**, **Labels**, and the semitransparent **PD events** to be changed. Change the color by clicking on the color button and selecting a new color.

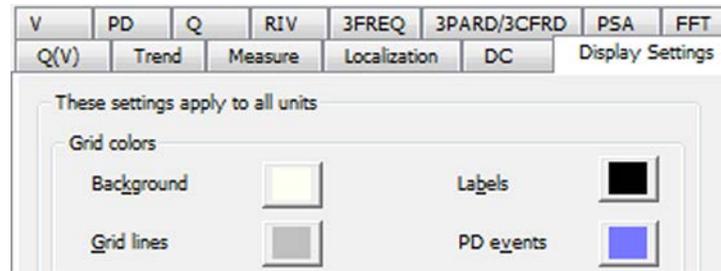


Figure 5-103 Grid color settings

## 5.20.2 Grid Options

This section allows to select which common part of a diagram is visible. Enable or disable **Grid** lines and Grid **Labels**, and choose the preferred location for grid labels. To do the latter, select **left** or **right** in the **Q Label positions** box.

**Note:** Some diagrams show labels on both sides of the diagram. In this case, the settings in the label position box have no influence.

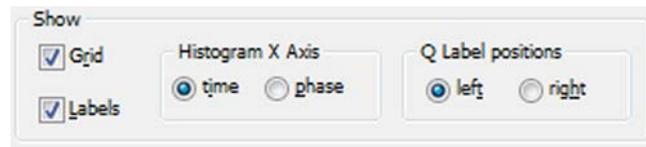


Figure 5-104 Grid options

## 5.20.3 Histogram Colors

This section allows to define the number of histogram classes and the colors associated with them. The number of classes and colors assigned here apply to all histogram diagrams in the software (phase-resolved PD pattern histogram, localization histogram, FFT histogram, 3PARD).

To change a color, double-click on the colored rectangle and select a new color from the color chooser window. To remove a class, select a colored rectangle by clicking on it once (the selected class will have a dashed selection frame drawn around it), then click on **Remove class**. To add a class, click the **Add class** button. When the **Add class** button is pressed without having a class

selected, the class will be added as the bottom-most class; if a class was selected before the button has been pressed, the new class will be added immediately after the selected class.

It is possible to restore the set of histogram classes to the default, which consists of 12 classes that progress from dark blue (few occurrences) to red (many occurrences) by clicking on the **Set to Default** button.

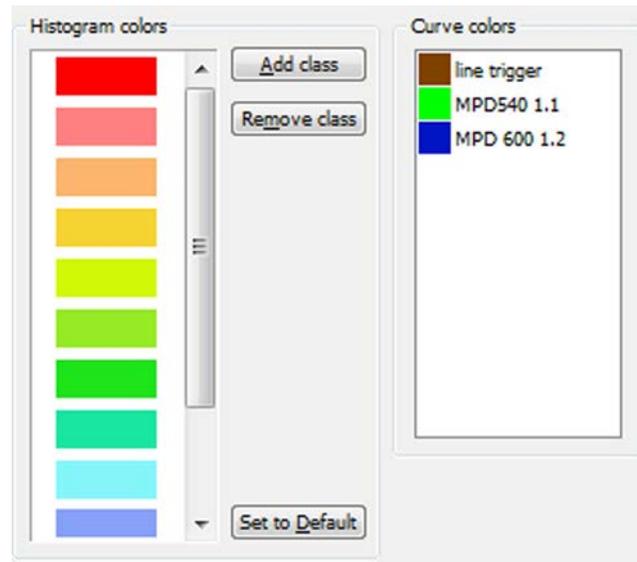


Figure 5-105 Histogram colors

## 5.20.4 Assigning Curve Colors

The **Curve colors** box will list every connected MPD unit along with its color. Additionally, it contains an entry for the line trigger, which is the curve that is shown if **Line Trigger 50 Hz** or **Line Trigger 60 Hz** is selected as the trigger source on the **V** tab. To change the color of the unit (or the line trigger curve) double-click on the colored rectangle to the left of the unit identifier. The color selected here applies to the AC voltage curve, the PD data curve, the FFT curve, the Q(V) diagram, and any trend diagrams.

There is also an alternative way to change a unit's representation color. Each unit appears along with its color in the measured quantities display in the middle of the software window (see 5.4 on page 101). The color of the unit can be changed by clicking on the colored rectangle next to the name of the unit and choosing a new color. The same approach also works for the line trigger curve if one of the Line trigger sources is selected. In this case, the line color is shown in the middle pane. To change its color click on the colored rectangle.

## 5.21 Replay Tab

The **Replay** tab controls playback of recorded measurement streams. A stream contains all data that was acquired during the actual measurement for all acquisition units that were connected during the measurement, including PD event data, status information, and program settings. Additionally, if at the time that the stream was recorded the voltage curve of a measurement unit was visible or was being used as a trigger source, voltage curve data is also available. Similarly, any time oscilloscope curves that were visible during recording are also contained within the stream and are available upon replay.

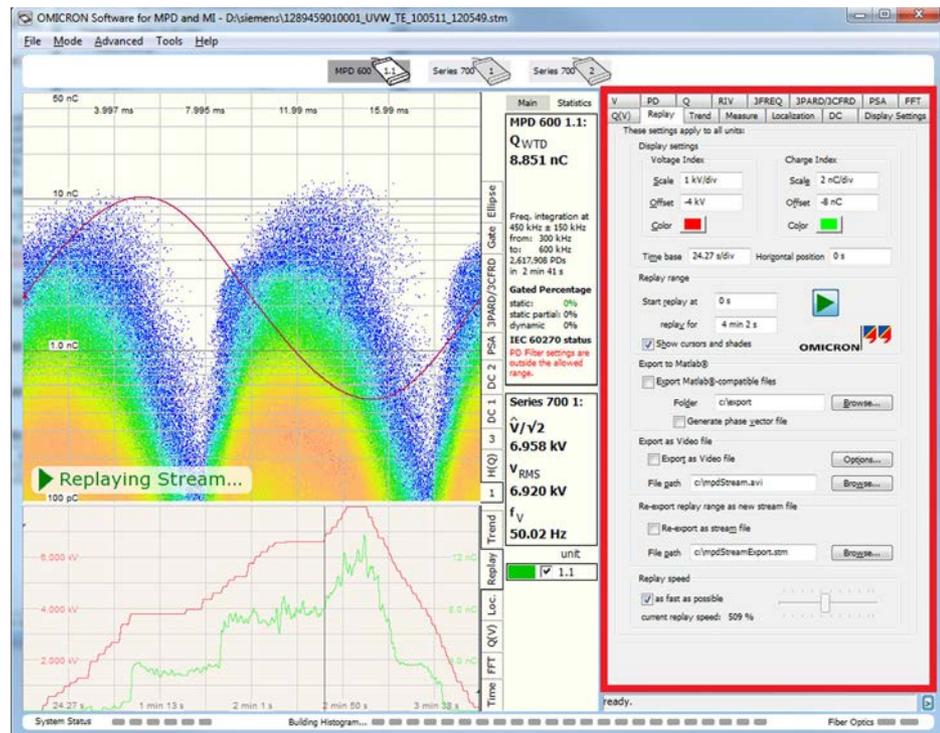


Figure 5-106 Replay tab

Most software options can be set during replay in the same way as during an online measurement. However, settings that must be executed by the acquisition unit (as opposed to the software) cannot be made during replay.

These include:

- charge integration settings (time domain vs. frequency domain, center frequencies, bandwidth, t1 and t2), 3-band mode, use of high-bandwidth filters
- the PD detection threshold,
- time oscilloscope trigger settings (including pretrigger delay),
- the PD input gain (including the Auto Gain and High-Sensitivity settings),
- test generator settings (on vs. off, and frequency),
- PD input filtering and averaging,
- quadripole setting (internal vs. external),
- enabling display of time oscilloscope curves that were not visible during recording,
- enabling display and selection as trigger source of V curves that were not visible or being used as a trigger source during recording

Additionally, the **Reset settings to default menu** item is not available in replay mode.

## 5.21.1 Display Settings

These settings allow to change the color of the **Voltage** and **Charge** curves on the **Replay** tab of the small scope view. Just click on the color buttons below the value fields for **Scale** and **Offset**. **Scale** and **Offset** work like an oscilloscope and operate on the vertical scale of the display.

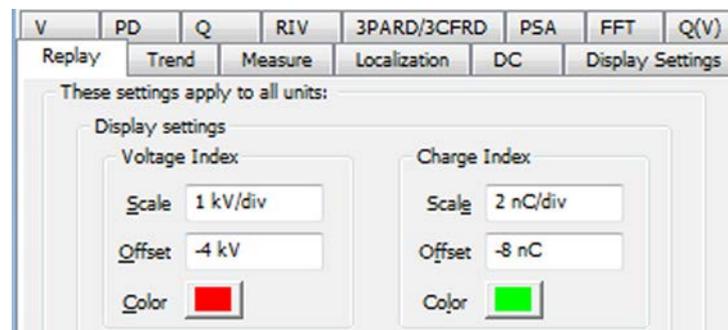


Figure 5-107 Display settings

The **Time base** option determines the horizontal scaling of the display. The **Horizontal position** setting determines the offset on the horizontal axis, given as a time value.

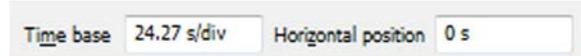


Figure 5-108 Time base option

## 5.21.2 Replay Range

With **Replay range** you set the “In” and “Out” point of the part of the stream you are interested in watching.

Pressing or releasing of  will start or stop playback of the loaded stream.

With **Show cursors and shades** checked, the replayed range of the stream is marked in the Replay tab of the small scope view as shown below.

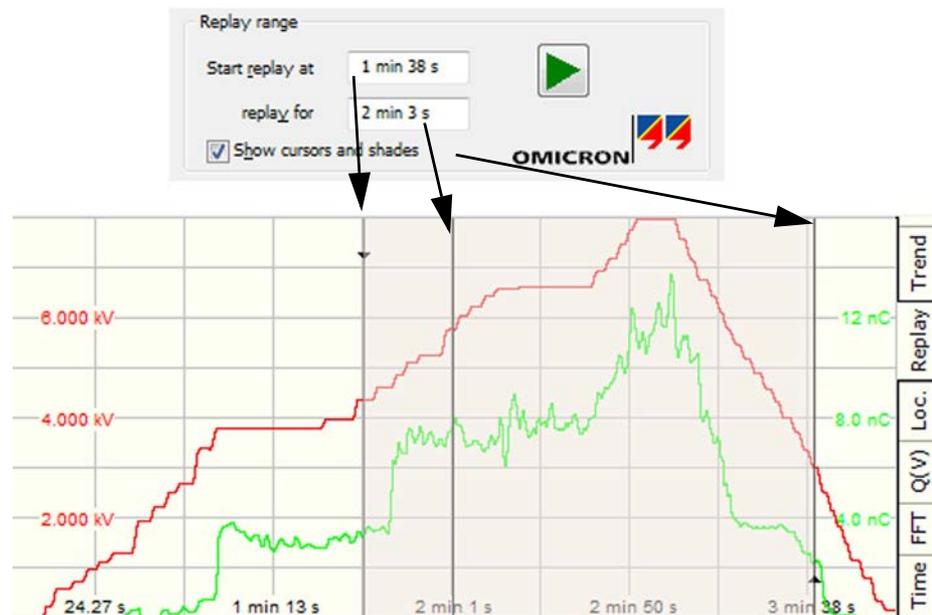


Figure 5-109 Replay range

## 5.21.3 Export Options

During replay, the software can export all data into a format that can be processed by third-party applications, including Matlab®. This option is enabled by checking the **Export Matlab®-compatible files** option. When checked, the

software creates a new subfolder in the specified folder every time the **Replay** button is toggled on. The name of that subfolder will be the smallest number not yet present (for instance '0001' if no subfolder exists, '0015' if everything up to '0014' already exists). It then creates a number of files in that subfolder. The format of these files is explained in 9.4 on page 246.

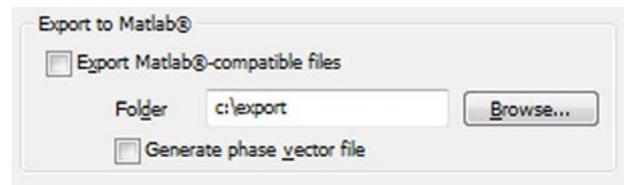


Figure 5-110 Export options

It is also possible to create a video of the stream being replayed.

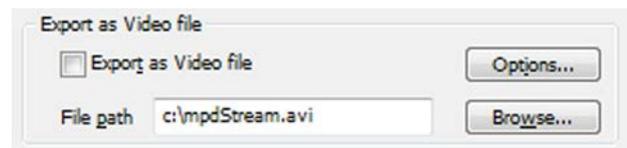


Figure 5-111 Export as video file option

To enable video export, check the **Export as Video file** option. The file name of the video file can be set in the **File path** field. By pressing the **Browse...** button you can select a folder into which the file should be placed. When the **Export as Video file** option is enabled and replay is started (by pressing the **Play** button), the file name given in **File path** is modified to include the date and time of the moment the replay process was started, similar to what happens when a stream is recorded initially.

Clicking on **Options** opens a dialog that allows the video compression, quality and size to be configured.

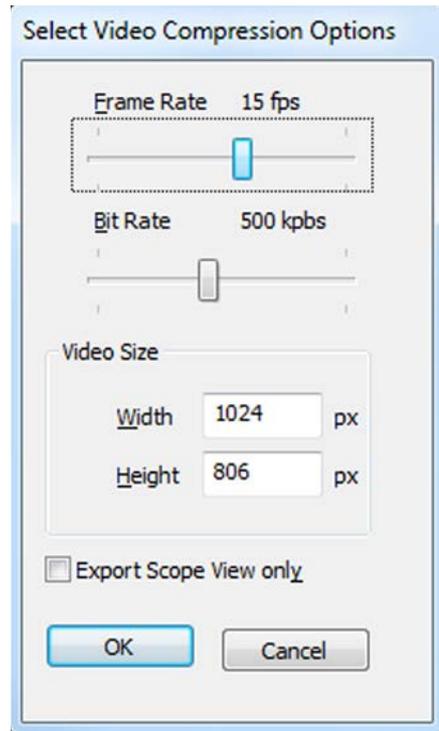


Figure 5-112 Replay video export options

The **Frame Rate** sets the rate at which images (frames) are saved in the video. This value is given in frames per second (fps). Reasonable values range from 5 through 15. Smaller values mean choppy video but smaller file size. Larger values mean smoother videos and larger file sizes.

The **Bit Rate** sets the quality of the images stored in the video. This value is given in kilobits per second (kbps). Smaller values lead to "mushier" videos (where the images are more blurred and less clearly defined). Larger values lead to crisper, clearer images at the expense of file size. Good values are between 400 kbps and 1000 kbps.

The **Video Size** section contains the size that each frame in the exported video should have. The video will contain the entire application window, scaled to the size given here, unless the **Export Scope View only** option is enabled, in which case only the left-hand side of the application window will be exported, including the large scope, the small scope and the measured values display, but not the control panel or the acquisition unit display.

When replay is started and the **Export as Video file** option is enabled, the software attempts to create a video file with the given settings. If for some reason the selected CODEC cannot produce a suitable output, the video export will be aborted and the **Export as Video file** option will be disabled at this point, but the stream will continue to be replayed.

By checking the **Re-export as stream file** option, it is possible to generate a new stream file that only contains the range that is being replayed. The file name of the new stream file can be set in the **File path** field. By pressing the **Browse...** button you can select a folder into which the file should be placed. When the **Re-export as stream file** option is enabled and replay is started (by pressing the **Play** button), the file name given in **File path** is modified to include the date and time of the moment the replay process was started, similar to what happens when a stream is recorded initially.

**Note:** When re-exporting a stream to a new file, the values used to plot the replay overview diagram are also regenerated. For the  $Q_{IEC}$  ( $Q_{WTD}$ ) this means that for a very short time at the start of the re-exported stream the value will be unknown by the software, and will be set to 0 until the value can be computed from the data that is available in the re-exported stream file.

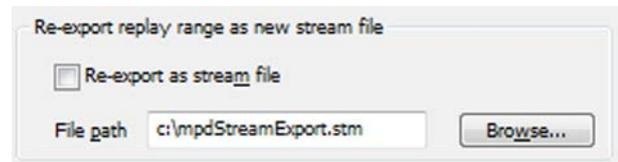


Figure 5-113 Re-export replay range as new stream file option

The speed of the replay process can be controlled via the fields from the **Replay speed** section. Enabling **as fast as possible** will replay the stream as quickly as the computer is capable of doing. Disabling that option makes the slider next to it available, which controls the replay speed. The middle position corresponds to 100% speed, i.e. the stream is played back about as fast as it was recorded. Moving the slider to the left slows down the replay, moving it to the right speeds it up. The current replay speed is shown below the **as fast as possible** option, given as a percentage of the recording speed.

**Note:** Setting the speed is not very accurate because the actual processing speed can fluctuate quite dramatically during playback. The software will attempt to deliver the selected speed on average.

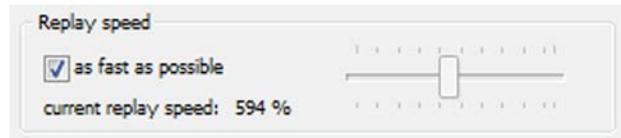


Figure 5-114 Replay speed option

## 6 Cable Mode

### 6.1 Introduction

A special user mode exists for use of the MPD system with PD routine testing in cable manufacturing plants, called Cable Mode. Cable Mode guides the user through the entire testing procedure with an intuitive user interface.

#### 6.1.1 Test Field Setup

To test a high-voltage cable, the test field must be set up as follows:

- The AC supply is connected to one end of the inner conductor of the cable.
- The outer conductor at the same end of the cable is connected to ground.
- The other end of the cable is left open.
- A coupling capacitor is connected in parallel to the cable.
- The CPL quadripole unit is wired between the base of the coupling capacitor and ground.
- The MPD unit is connected to the CPL quadripole unit.

#### 6.1.2 Starting Cable Mode

Start the software and select **Mode** from the main menu in the upper menu bar. Then choose **Cable**.

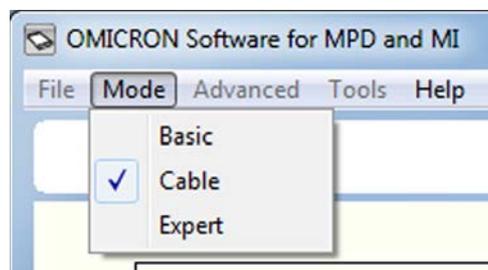


Figure 6-1 Cable Mode selection

**Note:** Cable Mode of the MPD/MI software is password-protected. It is possible to start the Cable Mode without a password, but for leaving Cable Mode the password has to be entered.



Figure 6-2 Enter password window

### 6.1.3 Password Setup

The factory default password is “OMICRON”. To change the password proceed as follows:

Shut down the MPD/MI software and look for the file `mpd.conf` in the folder `c:\OMICRON` if a default software installation has been done.

MDF300App.exe	5/21/2007 5:31 PM	Application	11,624 KB
mpd.conf	8/20/2007 3:08 PM	CONF File	46 KB
mtronix.exe	7/31/2007 1:34 PM	Application	30,352 KB

Open this file with a text editor program and use the search function to find **MPD540.cable.expert.lockedModePassword = OMICRON** and replace **OMICRON** with a new password. This password is necessary when changing from Cable Mode to Expert Mode.

```

PD540.station0.gamutClass31.maxForClass = 0.00000000e+00
PD540.station21.thresholdDiagram0.dcAccumulatedApparent
PD540.station6.dcEventBarQMin = 1.00000000e-009 C (, de
PD540.station5.PSAyMax = 1.00000000e+004 V (, default 1
PD540.cable.expert.lockedModePassword = OMICRON (, def
PD540.station16.gamutClass59.maxForClass = 0.00000000e+
PD540.station1026.exportDCFile = no (, default off, ra
PD540.station5.gamutClass15.maxForClass = 0.00000000e+0

```

With a second search run find **MPD540.cable.basic.lockedModePassword = OMICRON** and replace **OMICRON** with a new password. This password is necessary when changing from Cable Mode to Basic Mode. Save the file and start the MPD/MI software again. Using this method, it is also possible to disable the password request when switching from cable mode to another mode. To do so, replace the existing password ("OMICRON" by default) with "%00".

```
MPD540.station3.vCurveTriggerThreshold = 3.58936246e+0
MPD540.station24.uhfverticalAnchor = -8.00000000e+001
MPD540.station22.pdVoltsPerDivision = 1.00000000e-002
MPD540.cable.basic.lockedModePassword = OMICRON (, def
MPD540.station19.uhf608EnablePreamplifier = yes (, default
MPD540.station19.pdIntegrationEndTime = 2.42187500e-00
MPD540.station19.pdIntegrationCursors = yes (if enabl
```

**Note:** Keep the password in a safe place.

**Note:** Using this approach, it is also possible to set a password for any mode change. There is one password entry for every combination of modes that can be independently set. The notation in the configuration file is MPD540.<fromMode>.<toMode>.lockedModePassword, where <fromMode> and <toMode> must be one of "cable", "basic", or "expert", but cannot be the same.

## 6.2 Start Screen

Once inside Cable Mode, the application's user interface changes as shown below. Cable Mode is a guided mode and supports each phase of the cable test with a wizard interface that appears as soon as the corresponding button in the right-hand panel is clicked. It is also possible to create stream files from within

Cable Mode. Clicking on the button  will start the streaming process. Clicking the button again ends streaming. Clicking **Browse...** allows to navigate to a folder and enter a name for the stream file.

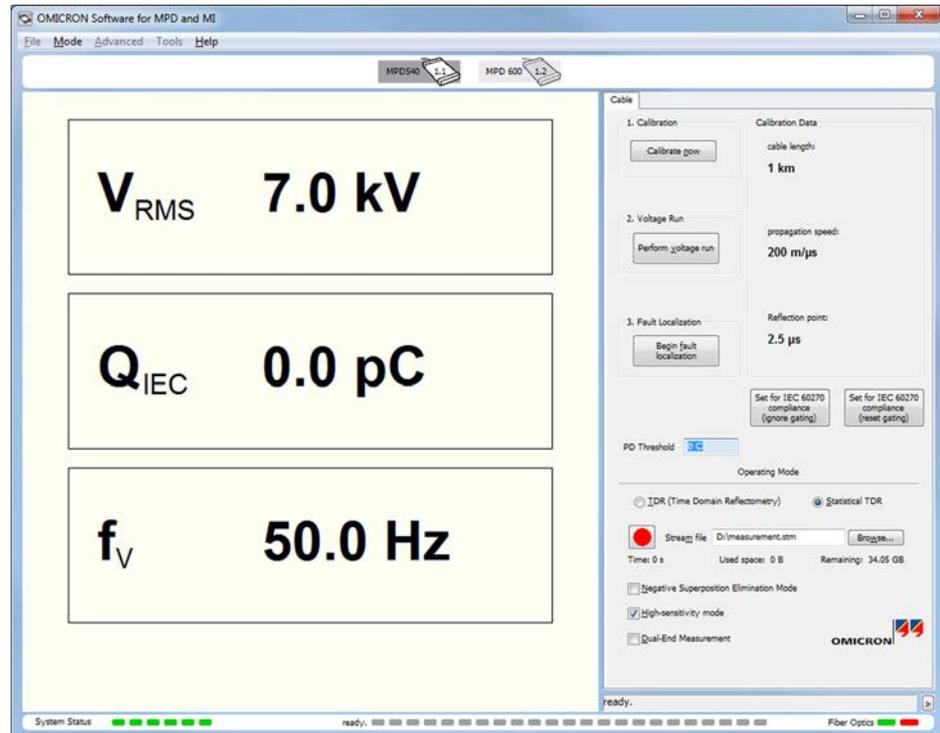


Figure 6-3 Cable Mode opening screen

## 6.2.1 Initial Setup

Before beginning testing of your cable, set the **Operating Mode**, as described in 6.2.3, and configure the options listed in the table below according to your test setup:

<b>Negative Superposition Elimination Mode</b>	<p>For short cables, the time difference between a PD impulse and its reflection on the open end can be very small. In some cases, this can lead to negative superposition, which means that the reflected pulse cancels the original pulse out, and no PD is detected. When enabling the <b>Negative Superposition Elimination Mode</b> option, the MPD system is configured such that no negative superposition is possible, and PD can always be detected.</p> <p><b>Note:</b> Enabling <b>Negative Superposition Elimination Mode</b> sets the center frequencies to predefined values that cannot be changed. <b>Negative Superposition Elimination Mode</b> works with bandwidths of 650 kHz, 160 kHz, and 40 kHz.</p> <p><b>Note 2:</b> <i>Positive</i> superposition is still possible. This means that 2 pulses within a very short time may be detected as a single pulse with twice the charge level.</p> <p><b>Note 3:</b> This option is only available if the multi-band feature has been purchased.</p>
<b>High-Sensitivity Mode</b>	Enables High-Sensitivity Mode.
<b>Dual End Measurement</b>	<p>When more than one <i>MPD 600</i> unit is available, you can perform a dual-end measurement, which uses the time difference of PD impulses detected on both ends of the cable to determine the location of a PD fault.</p> <p>This option only applies to Statistical TDR.</p>
<b>PD Threshold</b>	The PD Threshold can also be set from the main screen.

## 6.2.2 Process Phases

Testing high-voltage cables is a three-phase process.

Phase 1 - <b>Calibration:</b>	The length of the cable and the calibrator factor of the test setup are determined.
Phase 2 - <b>Voltage Run:</b>	<b>Voltage Run</b> is used to perform the high-voltage test on the cable. During the course of this test the cable may exhibit PD. In this case, the user performs phase 3.
Phase 3 - <b>Fault Localization:</b>	<b>Fault Localization</b> is used to determine the location of the fault causing PD.

## 6.2.3 Operating Modes

**Calibration** and **Fault Localization** operate in one of two different modes: These modes are **Time Domain Reflectometry (TDR)** or **Statistical TDR**.

Time Domain Reflectometry (TDR)	Statistical TDR
<ul style="list-style-type: none"> <li>works by detecting the time difference between a PD impulse and its first reflection on the open cable end</li> <li>operates on the unfiltered input signal of a single PD impulse and provides much better resolution than Statistical TDR</li> <li>is much more susceptible to external noise and signal filtering introduced by the test setup</li> <li>can be used for cable lengths of up to 2500 m</li> </ul>	<ul style="list-style-type: none"> <li>correlates the time differences between many successive PD impulses, some of which will be reflections of the original PD pulses on the open cable end</li> <li>is effective for cables of up to 30 km in length</li> </ul>

## 6.2.4 Mode Selection

The **Operating Mode** can be selected in the lower part of the control panel. When **Statistical TDR** is selected as the operating mode and more than one unit is connected, the **Dual-End Measurement** option at the bottom of the control

panel becomes available. When this is also enabled, a dual-end measurement is performed (see 5.18 on page 172 for more details on dual-end measurements).

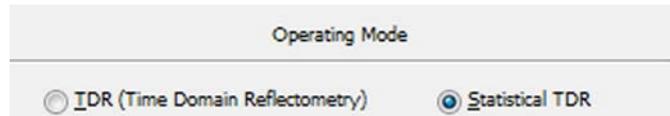


Figure 6-4 Mode selection

## 6.2.5 Starting the Operation

Click on the **Calibrate now** button of the control panel.

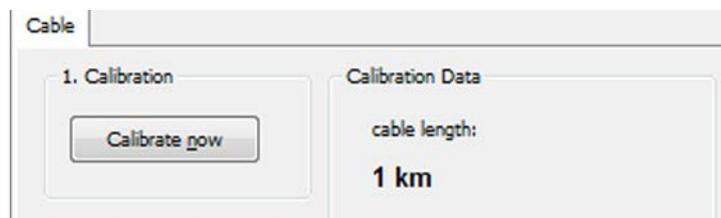
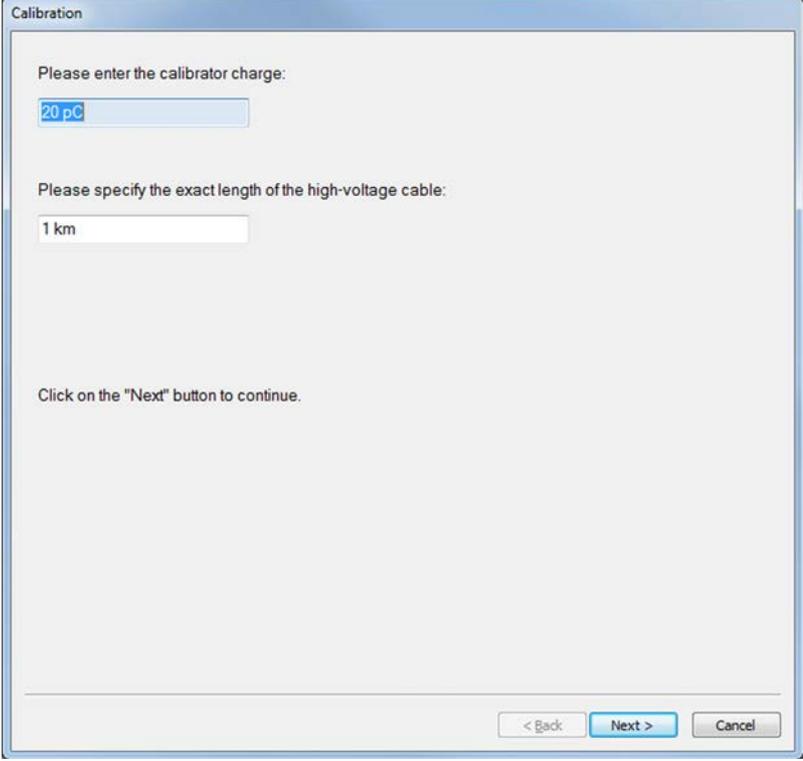


Figure 6-5 Starting the operation

## 6.3 Phase 1 Calibration

The Calibration wizard appears.



The screenshot shows a dialog box titled "Calibration". It contains two input fields. The first is labeled "Please enter the calibrator charge:" and contains the text "20 pC". The second is labeled "Please specify the exact length of the high-voltage cable:" and contains the text "1 km". Below the input fields, there is a line of text: "Click on the 'Next' button to continue." At the bottom right of the dialog box, there are three buttons: "< Back", "Next >", and "Cancel".

Figure 6-6 Calibration wizard

**Enter the calibrator charge** that is set on the calibrator unit as well as the **exact length of the high-voltage cable**. Doing so allows the software to automatically compute the PD divider factor and the propagation speed. Click **Next**.

Now connect the calibrator to either end of the high-voltage cable. To use the CAL 543 online calibrator, select the **Use...** item from the **CAL 543** menu on the MPD/MI software main window, then select the appropriate charge level. Doing so will turn on the CAL 543.

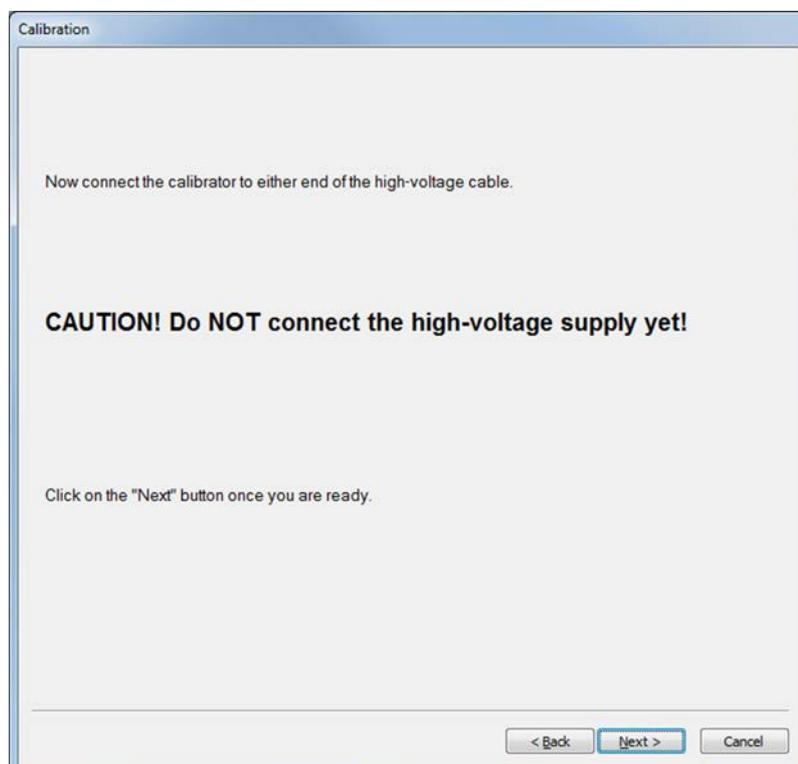


Figure 6-7 Caution window



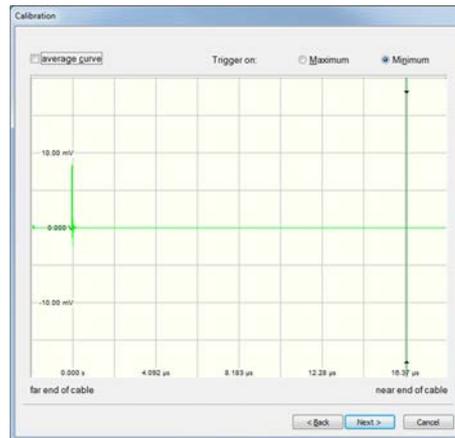
**Warning:** Do not connect the high-voltage supply yet.

**Note:** When using the CAL 543 online calibrator, it is ok to turn on the high-voltage supply.

Click **Next**.

Depending on the mode (TDR or Statistical TDR) selected before, the next steps are as follows:

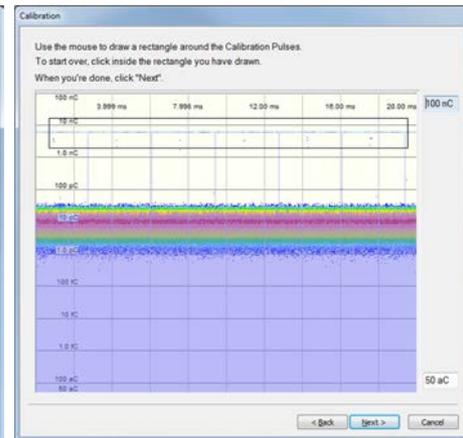
## TDR



In TDR mode the calibration impulse and its first reflection on the open cable end are shown and plotted over time. Using the supplied cursor, the user can now fine-tune the precise moment at which the reflection appears with respect to the calibration impulse. The software initially places the cursor at the maximum of the reflection impulse that follows the original calibrator impulse. Depending on the shape and polarity of the calibration impulse, the user can set the software so that it triggers the display on the minimum of the impulse, in which case the cursor should be moved to the minimum of the reflection. The cursor will automatically snap to the nearest maximum or minimum, depending on the setting. If there is much noise, and the calibrator impulses do not clearly stand out, averaging the curve may bring out the impulses more clearly.

Click **Next** to proceed.

## Statistical TDR



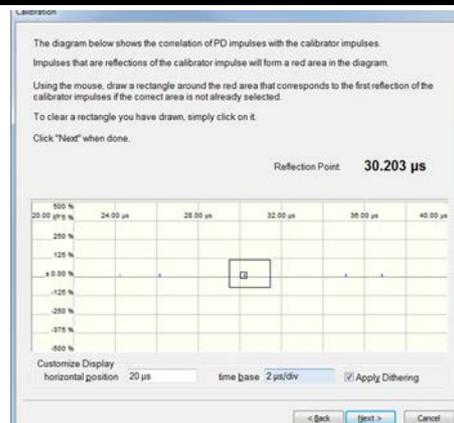
In Statistical TDR mode the phase-resolved PD pattern is shown. Using the mouse, the user draws a rectangle around the pattern formed by the calibrator pulses. This rectangle defines a trigger area; all impulses within the selected area will trigger the statistical correlation. During this process, all PD impulses following a triggering impulse have their charge normalized with respect to the triggering impulse (i.e. their charge is expressed in percentages of the triggering impulse's charge). The normalized charge is recorded in a histogram, using the time difference between the triggering impulse and the impulses following it as the X axis.

**Note:** When a dual-end measurement is being performed, the unit that is not currently selected is used as the trigger.

Click **Next** to proceed.

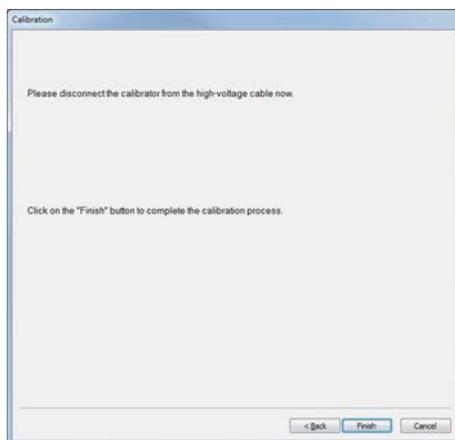
## TDR

## Statistical TDR



As the histogram is recorded, the software tracks the absolute maximum of the correlation (represented by a reddish tint in the diagram) and draws a small rectangle around it (see red circle above). The time corresponding to that maximum represents the propagation delay through the cable, and can be used to calibrate the propagation speed. If the software does not automatically select the correct correlation, the user can manually draw a rectangle around the correct area. The software will then find the maximum correlation inside the area selected by the user.

Click **Next** to proceed.



When the **Next** button is clicked, the propagation speed is computed and the user is instructed to **disconnect the calibrator from the high-voltage cable now**.

Click the **Finish** button to complete the calibration process.

### 6.3.1 Intermediate Screen

Now start a **Voltage Run** by clicking the button **Perform voltage run**.

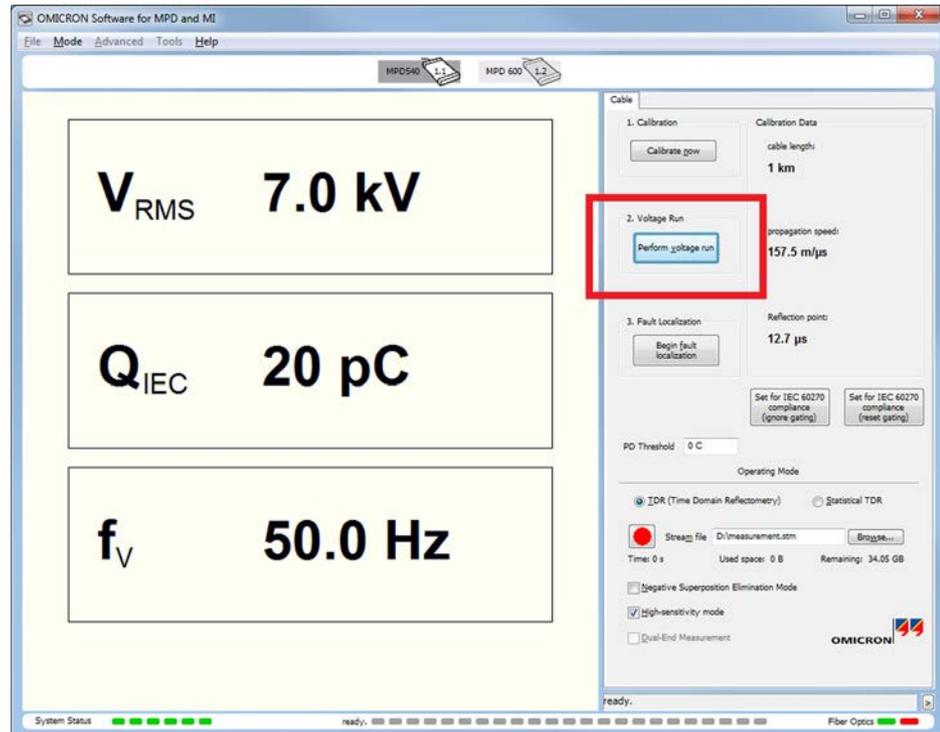


Figure 6-8 Intermediate Screen

## 6.4 Phase 2 Voltage Run

This will start the **Voltage Run** wizard. The wizard first instructs the user to switch on the high-voltage supply after removing the calibrator from the test setup.

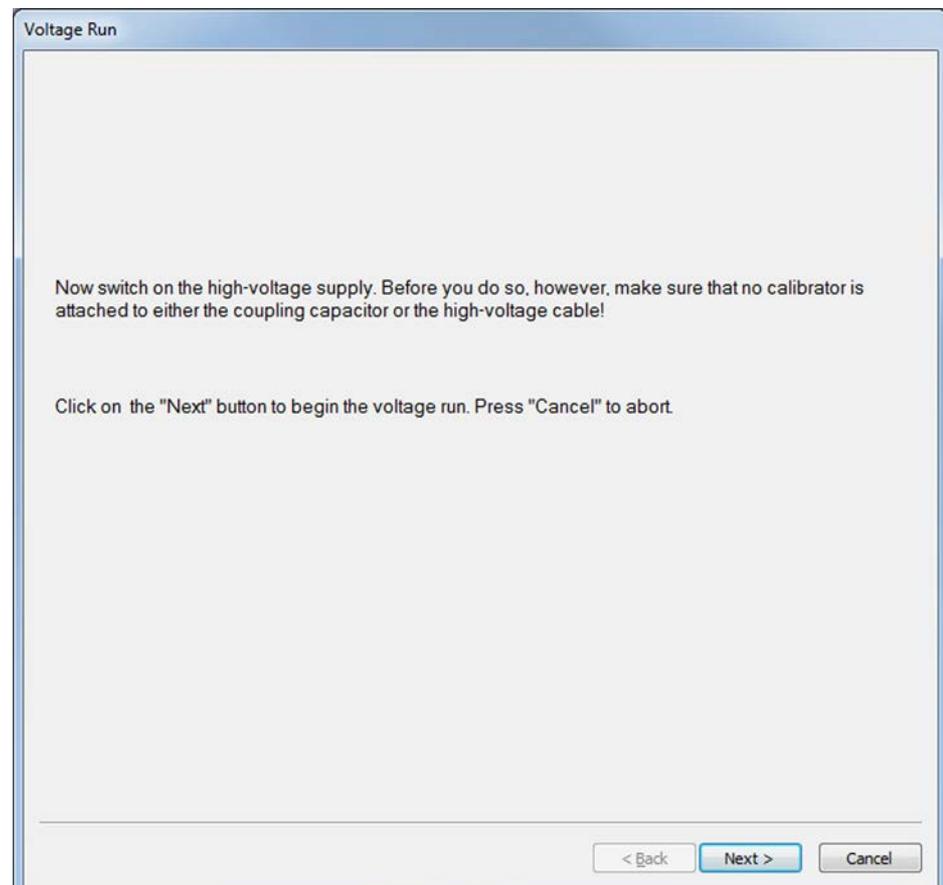


Figure 6-9 Voltage run

Click on **Next**.

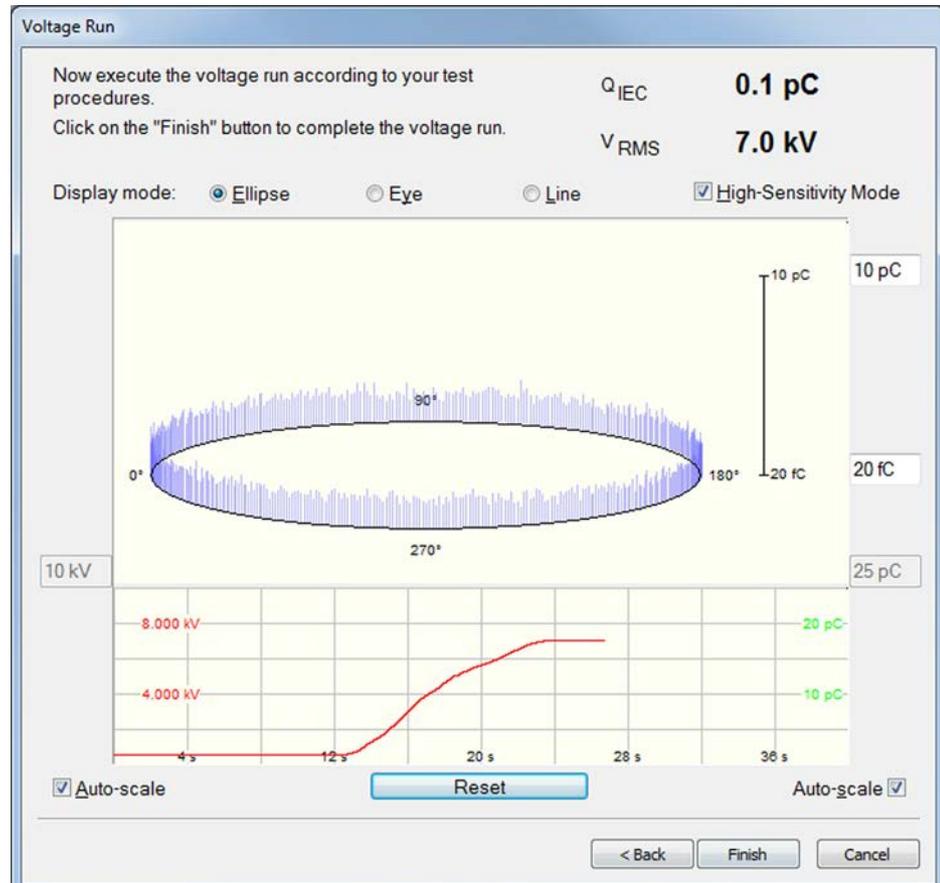


Figure 6-10 Ellipse view

The user now proceeds with the voltage run, gradually increasing the voltage until the test voltage has been reached. The test voltage is then left on for a certain amount of time (usually between 10 minutes and 1 hour), and then gradually decreased until it can be turned off. If at any point during the voltage run PD activity becomes excessive, a cable fault is possible and a localization phase may need to be performed. Note that it is normal for short bursts of PD

noise to appear while equipment is being operated nearby or while changing the voltage. Such noise does not indicate a cable fault. A cable fault typically manifests itself in sustained PD events, often with a clear phase correlation.

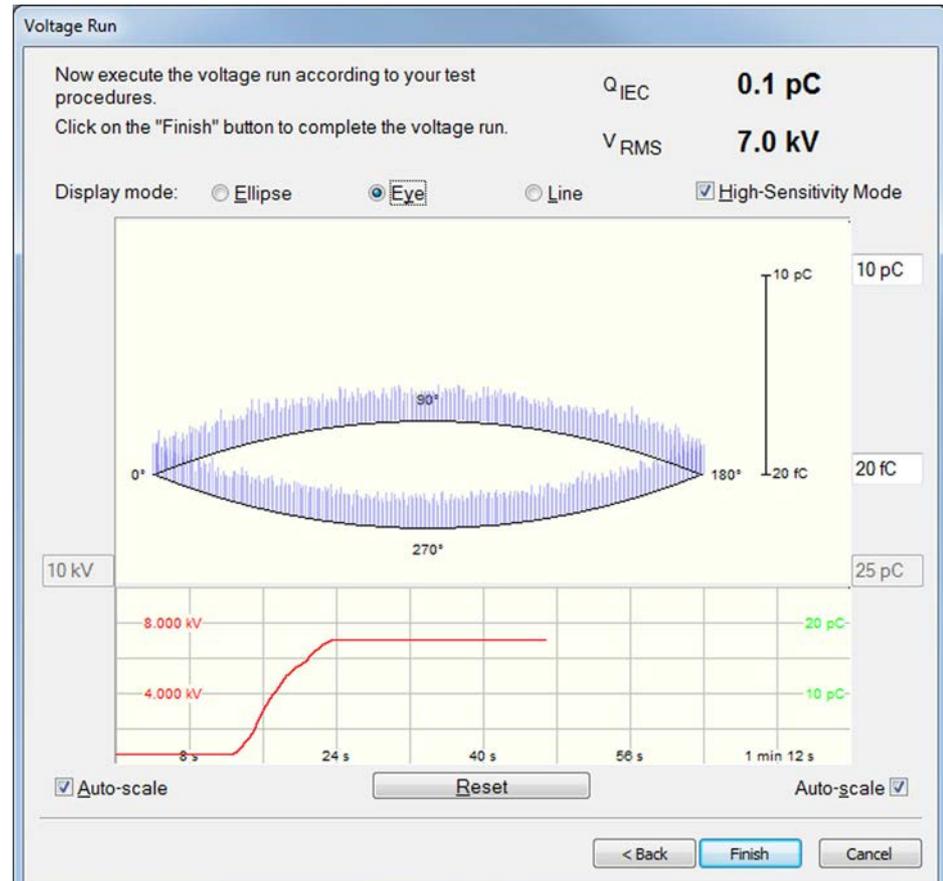


Figure 6-11 Eye view

The progress window shows all the information that is relevant during a voltage run. The actual voltage and PD level are shown in large letters on the top right, and the instantaneous PD event display below provides information about PD events as they occur.

This display can be switched between the **Ellipse**, **Eye**, and **Line** views. Additionally, the software records a trend of the voltage and PD levels, which is plotted at the bottom of the window. Clicking the **Reset** button will clear the trend display. Clicking **Finish** completes the voltage run wizard.

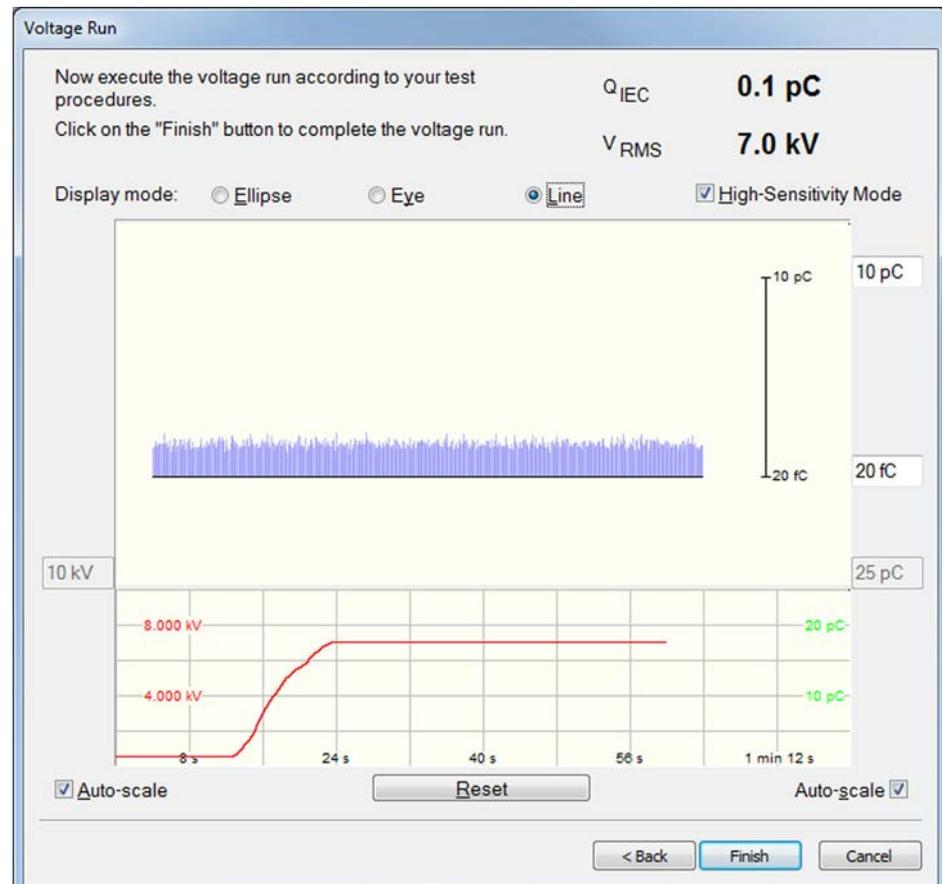


Figure 6-12 Line view

### 6.4.1 Intermediate Screen

If excessive PD activity was detected during the voltage run phase or a cable fault is suspected for other reasons, a fault localization phase can be performed. To start the localization phase, click on **Begin fault localization**.

The user experience during the localization process is very similar to the calibration procedure. Instead of calibrator impulses, however, the process now operates on actual PD events that are caused by the cable fault.

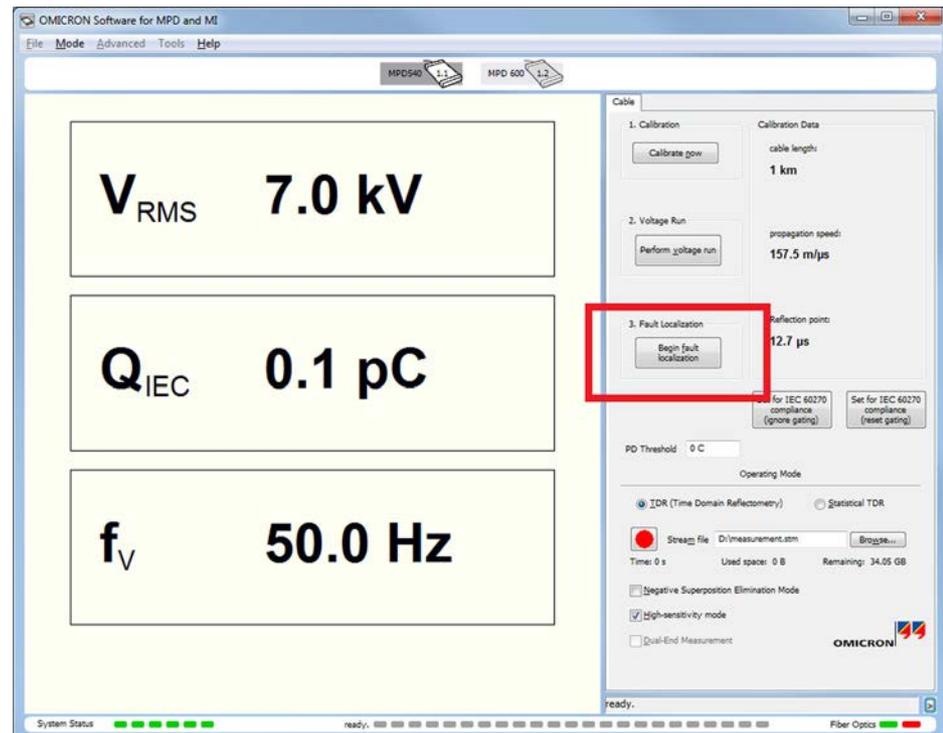
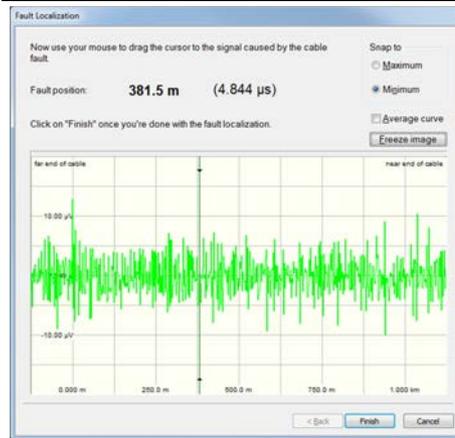


Figure 6-13 Intermediate screen

## 6.5 Phase 3 Fault Localization

Depending on the mode (TDR or Statistical TDR) selected before, the next steps are as follows:

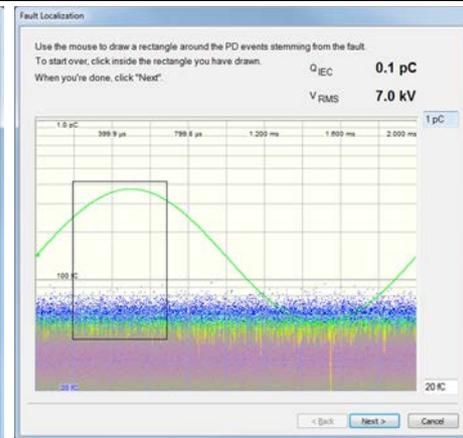
**TDR** **Statistical TDR**



In TDR mode, the fault localization wizard will show the largest PD impulse and its first reflection plotted over time, similar to the calibration wizard.

As in the calibration phase, the software attempts to automatically determine the reflection point of the PD impulse caused by the cable fault, and presets the cursor on that location. The user can override the software's selection by moving the cursor around. Depending on the polarity and shape of the PD impulse, the display can be triggered on minimum or maximum. **Averaging curve** may make the reflection stand out more clearly.

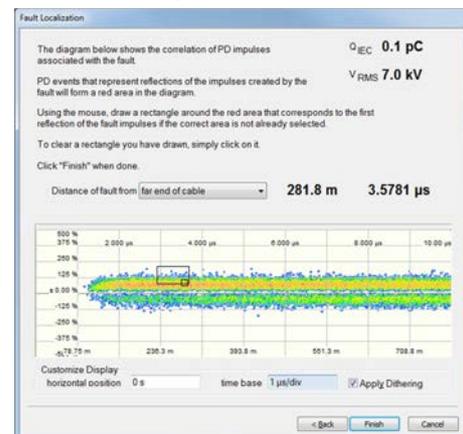
It is recommended to experiment with the **Minimum/Maximum** trigger in the **Snap to** box and **Average curve** settings to receive the clearest curve. As the cursor moves, the software updates the corresponding fault position in the cable, measured from the far end of the cable (i.e. the cable end left open).



In statistical TDR mode the phase-resolved histogram view is shown. As in the calibration phase, the user must now select that part of the PD pattern which results from the cable fault. The user does this by drawing a rectangle around the corresponding part of the pattern.

**Note:** When a dual-end measurement is being performed, the unit that is not currently selected is used as the trigger.

Click **Next** to proceed.



TDR	Statistical TDR
<p>If the curve changes quickly and the reflections disappear irregularly, users can freeze the curve by using the <b>Freeze image</b> button, i.e. take a snapshot of the curve at a certain point in time.</p> <p>A frozen curve will no longer change, and users can position the cursor on the correct reflection without having to hurry.</p> <p>The cursor position is shown both in terms of the time difference between the trigger impulse and the first reflection as well as in terms of the actual distance of the fault from the far end of the cable.</p> <p>Click <b>Finish</b> to complete the localization process.</p>	<p>The correlation process has been started, and the normalized charge/time difference correlation histogram is shown.</p> <p>As during calibration, reflections from the PD impulses originating in the cable fault will have similar time differences to the original impulses, and will thus form a red area in the histogram. The software will pre-select the absolute maximum in the histogram, but the user can override the software's choice by drawing a rectangle around the part of the histogram where the reflections should be found.</p> <p>The software will show both the time difference of the reflections to the originating impulses and the corresponding <b>Distance of fault</b>, measured from either the <b>near</b> or the <b>far end of the cable</b>.</p> <p><b>Note:</b> If a dual-end measurement is being performed, keep in mind that the correlation histogram extends to both the negative and the positive x axis. The maximum cluster can be located in the negative half of the histogram.</p> <p>Click <b>Finish</b> to complete the localization process.</p>

## 6.5.1 End of Fault Detection

The main screen appears, similar to the picture below.

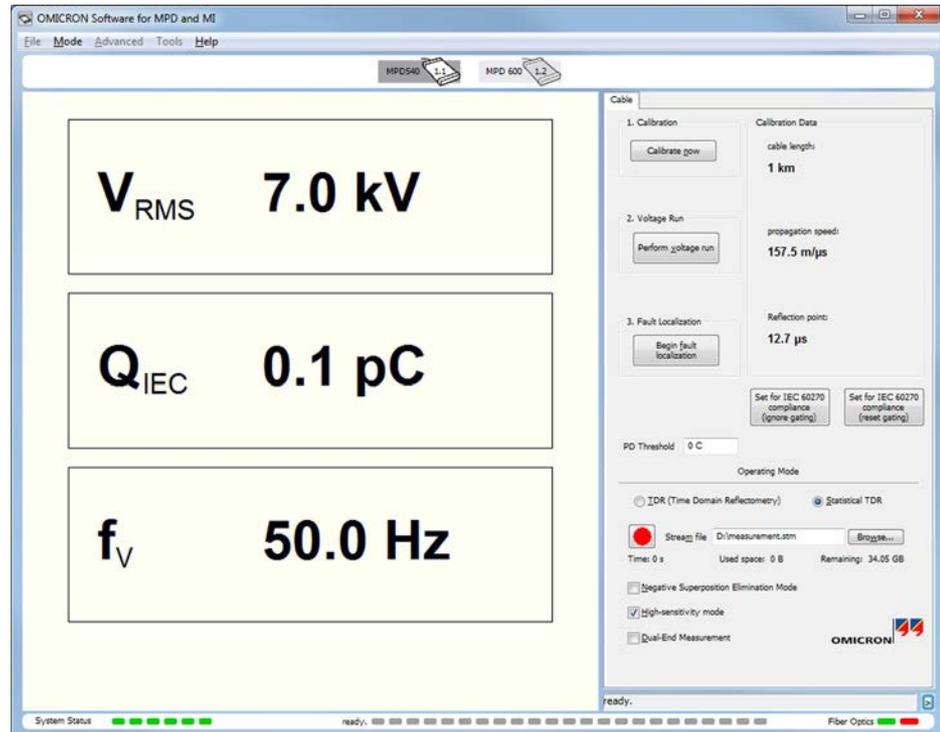


Figure 6-14 End of fault localization

## 7 Application

### 7.1 Safety Instructions for Connecting the *MPD 600* System to High-Voltage Systems



**Warning:** Working in the area of high-voltage systems is very dangerous! Make sure to observe dangerous areas. Always obey the internal safety instructions for working in areas with high voltage to avoid injury.

- Turn off and disconnect the high voltage from the test object.
- Protect yourself and your working environment against an accidental re-connection of high voltage by other persons and circumstances.



**Warning:** Carry out grounding and short-circuiting of the test object's terminals using a grounding set.

- Protect yourself and your working environment with a suitable protection against other (possible) life circuits.
- Protect others from accessing the dangerous area and accidentally touching life parts by setting up a suitable barrier.

### 7.2 Connection

Check your additional equipment (PC) for environmental conditions before use.

1. Install the MPD/MI software (if not already done) without connection between PC and MCU.
2. Use the fiber optic cables to provide a connection between the MCU and *MPD 600* units.

**Note:** Always use dry and clean fiber optic cables. Make sure that the cables have earth contact to avoid leakage current.



**Caution:** Use only original cables provided by OMICRON electronics!

3. Connect the *MPD 600* system as described in 1.2 "Hardware Setup" on page 22.

**Note:** Position the MPD/MPP units on insulating ground to ensure maximum sturdiness.



**Warning:** The *MPP 600* is a rechargeable lithium battery. Risk of fire and burns. Do not drop or crush, do not short circuit, do not open, do not expose the battery to high temperatures. Must be disposed of properly, may explode if damaged or disposed of in fire. Do not immerse in any liquids, read the User Manual before charging, do not charge in flammable environment, do not charge below 0 °C (32 °F) and above 35 °C (95 °F) or discharge below -20 °C (-4 °F) and above 60 °C (140 °F), use specified charger only. Please refer to the User Manual or follow local ordinances and/or regulations for usage of lithium batteries.

4. Optional: If you use an MCC 2x coupling capacitor, use the two BNC cables to provide a connection between the MCC and *MPD 600*, and ground the MCC unit using the grounding screw. Select **External** from the **Quadripole configuration** setting of the **Calibration** tab (Basic Mode).
5. Optional: If you use an MCC 1x coupling capacitor, provide a connection to the *MPD 600*'s **PD** input using a coax cable and an TNC/BNC adapter, and ground the MCC unit using the grounding screw. The **V** input of the *MPD 600* is not used. Instead, select **Internal** from the **Quadripole configuration** setting of the **Calibration** tab (Basic Mode) of the MPD/MI software.
6. Optional: If you use a UHF 608 or UHF 620 down-converter, provide a connection to the *MPD 600* using the BNC and AUX cables. Connect the **UHF** input of the UHF 608 or UHF 620 to the UHF coupler (for example, the UVS 610 sensor or any built-in UHF coupler in GIS) using an N-cable (50 Ω impedance). Select **external quadripole** in the **Coupling** setting of the **PD** tab (if a UHF 608 is used) or **Internal** from the **Quadripole configuration** setting of the **Calibration** tab (Basic Mode) if a UHF 620 is used and the **V** input of the *MPD 600* is left open.

**Note:** The UHF 620 requires an additional MPP connection to support all functions. For this purpose, provide an additional MPP battery pack. Alternatively, one MPP battery pack can be used by connecting the power from the MPP unit to the **Power In** input of the UHF 620 and the **Power Out** output to the **Power** input of the *MPD 600* unit.

**Note:** Grounding of the *MPD 600* and UHF 608 or UHF 620 units is provided by the shield of the N-cable.

## 7.3 Measurement

1. Start the MPD/MI software.



**Warning:** Switch off the high voltage, if it is necessary to enter the high-voltage area (for example, if you change the measurement setup), according to internal safety instructions.

2. If the Basic Mode is not automatically selected, select **Mode** from the main menu and choose **Basic**.
3. In the **Settings** tab, select **line** from the **Trigger source** drop-down box.  
**Note:** The system then uses a light-sensitive sensor to synchronize itself to fluorescent light sources. Do not forget to change the trigger source back to unit x.x before performing the actual measurement.
4. Choose 250 kHz in the **f<sub>Center</sub>** box (with UHF 400 MHz).
5. Choose 300 kHz in the **Bandwidth** box (with UHF 1.5 MHz).
6. The option **High Sensitivity Mode** must only be checked for very noiseless measurements (< 1 pC).
7. Check the **Quadripole configuration** in the **Calibration** tab depending on the coupling type.
8. Calibration: refer to 4.12 "Calibration Tab" on page 90. If UHF is used, use the UPG 620 for checking the performance (refer to 8.12 "UPG 620 - UHF Pulse Generator" on page 235).



**Warning:** Switch off the high voltage. Carry out grounding and secure against re-connection.

9. Conduct the measurement.

## 7.4 Disconnection



**Warning:** Switch off the high voltage. Carry out grounding and secure against re-connection.

1. Clean the fiber optic cables. In dusty regions, use protective caps.
2. Disconnect the cables.
3. Remove the *MPD 600* system from the power supply.

4. Recharge the battery pack for later use.



**Warning:** The *MPP 600* is a rechargeable lithium battery. Risk of fire and burns. Do not drop or crush, do not short circuit, do not open, do not expose the battery to high temperatures. Must be disposed of properly, may explode if damaged or disposed of in fire. Do not immerse in any liquids, read the User Manual before charging, do not charge in flammable environment, do not charge below 0 °C (32 °F) and above 35 °C (95 °F) or discharge below -20 °C (-4 °F) and above 60 °C (140 °F), use specified charger only. Please refer to the User Manual or follow local ordinances and/or regulations for usage of lithium batteries.

## 8 Technical Specifications

### 8.1 Complete *MPD 600* System



Figure 8-1 Complete *MPD 600* system

#### 8.1.1 PD Detection Features

- Continuous, uninterrupted acquisition of PD events
- Digital numerical real-time integration of PD currents
- Supports frequency domain and time domain integration
- Integration ranges freely selectable:
  - Time domain: 100 ns ... 8  $\mu$ s
  - Frequency Domain;  
center frequency: 0 Hz ... 32 MHz  
bandwidth: 9 kHz, 40 kHz, 100 kHz, 160 kHz, 300 kHz, 650 kHz,  
800 kHz, 1 MHz, 1.5 MHz (standard),  
9 kHz, 30 kHz, 100 kHz, 300 kHz, 1 MHz, 3 MHz (using high-bandwidth  
filters)
  - Charge evaluation fully compliant with IEC 60270

- System noise < 15 fC  
(frequency domain integration at maximum bandwidth)
- Maximum double pulse resolution < 200 ns  
(time domain integration, superposition error < 1%)
- Maximum pulse rate:  
1.5 • 10<sup>6</sup> pulses/second per fiber optical network
- PD event time resolution: < 2 ns
- Supports various gating options (optional):
  - An unlimited number of phase and phase-amplitude gates for gating noise with stable phase correlations
  - Unit gating for gating external noise (requires a separate acquisition unit)
  - OMICRON Dynamic Noise Gating technology for reliable suppression of external noise bursts
  - 3FREQ/3PARD gating (see below)

### 8.1.2 Visualization Features

- Highly responsive real-time oscilloscope view for V and PD inputs
- Real-time spectrum analyzer view for PD input, including spectral probability visualization  
Spectrum analyzer system noise < -120 dBm
- Persistent trend visualization of measured quantities for long-term on-line monitoring, including Q(V) Diagram
- Versatile phase-resolved PD pattern visualization:
  - Real-time view (“spikes”)
  - Fully configurable phase histogram view
  - H(Q) diagram plotting the number of PD events per charge level
  - Overview histogram view (multi-channel)
  - Legacy Lissajous (“ellipse”) view
- On-Line Three-Phase Amplitude Relation and Three-Frequency Amplitude Relation Diagrams (optional) (allows separation of PD sources; can be used as a gating option)
- Online Pulse-Sequence-Analysis Diagram

### 8.1.3 Fault Localization Features

- Supports PD event localization via 2 Time Domain Reflectometry (TDR) modes:
  - individual TDR (oscilloscope-based) for high accuracy and reflection distances up to 2.5 km
  - statistical TDR for noise-resistant operation and reflection distances up to 1000  $\mu$ s
- Supports PD event localization via synchronous dual-end measurements

### 8.1.4 Other System Features

- Fully synchronous acquisition of V and PD inputs synchronous to < 2 ns
- V input effective frequency: 0.1 Hz – 2.1 kHz
- Full real-time recording and play-back functionality for all measured quantities (PD events, PD input voltage, V input voltage)
- Supports averaging (16 x – 32768 x) for PD input view
- Various PD input trigger options:
  - edge (rising/falling slope)
  - peak (positive/negative)
  - auto-trigger (synchronous to internal test generator)
  - trigger on PD event (positive/negative polarity)
- V input edge trigger, rising/falling slope  
Available trigger sources: line trigger, single V input, triggers all units, each unit triggers on its own V input, internal (computed) trigger
- Integrated cable mode supporting each cable-testing step with a wizard-like user interface
- Support for DC measurements:
  - export PD all activity to text file
  - PD Event plot over time
  - PD pulse count plot (number of PD events per time above certain threshold)
  - accumulated charge plot (accumulated charge of all PD events per time)
  - bar graph showing the number of PD events with a certain charge range
  - bar graph showing the number of PD events equal to or higher than a certain charge

### 8.1.5 Software Integration Features (optional)

COM interface providing access to all measured quantities and configuration settings. Pipe interface providing access to every detected PD event and voltage sample

### 8.1.6 Reporting Features

- Integrated XML reporting functionality, including customizable report viewer utility (see 2.2.5 "The File Menu" on page 44).
- Customizable Report Generator Module (optional):
  - full support for Microsoft Excel
  - controls and integrates all measurement functions of the *MPD 600* System
  - supports direct printing from Reporting Module

### 8.1.7 Fiber Optical Network Features (600 series)

- Complete electrical insulation between acquisition units and control station, enabling ungrounded measurements in high-voltage setups
- Up to 480 acquisition units per network (up to 32 are fully synchronized)
- Network segments can be up to 2 km in length
- True Plug-and-Play functionality
- Uses duplex multi-mode ST fibers, 50/125  $\mu\text{m}$ , near-infrared (820 nm)
- Automatic fiber optics propagation delay compensation

### 8.1.8 Control PC Requirements

Intel Pentium 4 ( $\geq 2.5$  GHz), Pentium M ( $\geq 1.5$  GHz), Core, Core 2 processor; or AMD Athlon 64 or Turion 64 processor,  $\geq 1$  GB RAM, USB 2.0 compatible, Microsoft Windows XP, Microsoft Windows 2000 Professional, or Microsoft Windows 7 (64-bit and 32-bit), Windows VISTA

## 8.2 **MPD 600 Unit**



Figure 8-2 *MPD 600 unit*

### 8.2.1 **Device**

Material: Extruded aluminum  
 Dimensions: 110 mm (W) x 190 mm (D) x 44 mm (H)  
 Weight: 630 g

### 8.2.2 **Power Supply**

8 - 14 V DC  
 max. power dissipation: 4 W (standby < 10 mW)

Battery pack included in package:  
 Lithium-polymer battery 11.1 V / 8 Ah, battery lifetime 11 - 22 h (depends on temperature)

External plug-in power supply included in package:  
 input range 100 - 240 V, 50 - 60 Hz

### 8.2.3 **Indicators**

2 x LED  
 stand-by/power/operational status, fiber optics data integrity

### 8.2.4 **Connectors**

Fiber optic connectors: 2 x OMICRON fiber optical network (master/slave) (600 series)

Input connectors: 2 x BNC: low-frequency voltage input (V), high-frequency partial discharge detect input (PD)

Output connector:

1 x Lemo aux

1 x BNC (optional): 500 pC test signal (*MPD 600C*) or trigger signal

## 8.2.5 Environmental Conditions

Operating temperature: 0 °C ... 55 °C

Storage temperature: -10 °C ... 70 °C

Humidity: 5 % ~ 95 % non-condensing

## 8.2.6 Input

	PD input	V input
Frequency Range	0 kHz - 20 MHz	0.1 Hz - 2.1 kHz
Impedance	50 Ω	1 μF // 1 MΩ
Max. Voltage	10 V rms	60 V rms
Dynamic Range	132 dB (overall); 70 dB (per input range)	102 dB
Range Control	11 levels, 7.4 dB gain per level	

## 8.2.7 PD Input Protection

Robust, software-controlled protection circuitry protects PD acquisition unit from over-currents and surges

## 8.2.8 Measurement Uncertainty

voltage:	± 0.05%	after calibration
frequency:	± 1 ppm	
PD level:	± 2%	after calibration

## 8.2.9 Additional Hardware Features

Internal test generator, deployable under software control provides self-test of entire signal path

Built-in, independently deployable quadripole with  $C_{LV} = 1 \mu\text{F}$

## 8.3 MPP 600 Battery Pack and Battery Charger

For use with the supplied charger only. For charging, see the battery status on the battery charger. For discharging, see the status on the connected unit.



Figure 8-3 MPP 600

### 8.3.1 Safety Instruction to *MPP 600*

Lithium batteries are small, compact, and ideal for providing long-lasting power to measurement systems. However, they must be used and charged properly. Improper use can result in serious injury or fire.

Please read and understand the following warnings. If you have any question, please contact the OMICRON electronics technical support.



**Warning:** The *MPP 600* is a rechargeable lithium battery. Risk of fire and burns. Do not drop or crush, do not short circuit, do not open, do not expose the battery to high temperatures. Must be disposed of properly, may explode if damaged or disposed of in fire. Do not immerse in any liquids, read the User Manual before charging, do not charge in flammable environment, do not charge below 0 °C (32 °F) and above 35 °C (95 °F) or discharge below -20 °C (-4 °F) and above 60 °C (140 °F), use specified charger only. Please refer to the User Manual or follow local ordinances and/or regulations for usage of lithium batteries.

### 8.3.2 Battery Charging and Capacity Information

For use with the supplied charger only. For charging, see the battery status on the battery charger. For discharging, see the status on the connected unit (MPD/MI software).

Never charge the battery near the heat of flammable objects. The required charging time depends on the charging level of the battery and may vary from one to four hours for full charge. The required charging time will be increased at lower temperatures. Do not leave a battery on prolonged charge when not in use.

After extended periods of storage, it may be necessary to charge and discharge the cells or batteries several times to obtain maximum performance.

The battery life will be extended by the following:

1. Store the battery at a 40% (~11.5 V) charging level and at a low temperature 4 °C (40 °F). The refrigerator provides good storage as long as the temperature does not drop below 0 °C (32 °F).
2. Never discharge the battery fully (below 9.5 V). Avoid deep discharge at any time.
3. Charge early and often.
4. Always charge at least once per year to prevent overdischarge.

### 8.3.3 Device

Material: Extruded aluminum  
Dimensions: 110 mm (W) x 170 mm (D) x 28 mm (H)  
Total weight: 1050 g (option: Li-Po)  
Total weight: 810 g (option: Li-Ion)

### 8.3.4 Battery

Type Li-Po: 11.1 V nominal, 8 Ah, lithium-polymer, rechargeable  
Capacity: 90 Wh (Option: Li-Po)

Type Li-Ion: 11 V nominal, 4.8 Ah, lithium-ion, rechargeable  
Capacity: 53 Wh

### 8.3.5 Battery Life Cycle

Depending on which comes first:  
500 charging and discharging cycles or 3 years

### 8.3.6 Additional Hardware Battery Charger

In: 100 - 240 V AC, 50 - 60 Hz, 0.9 A  
Out: 12.3 V<sub>nom</sub>, ≤ 4 A

### 8.3.7 Battery DC In/Out

	Voltage	Current
Charging	12.6 V max.	4 A max.
Discharging	9 - 11.1 V	4 A max.

### 8.3.8 Environmental Conditions

Operating and storage temperature: -20 °C to +60 °C  
Charging temperature range: 0 °C to +35 °C

## 8.4 MCU Control Units



Figure 8-4 MCU 502, MCU 504, MCU 550

### 8.4.1 Device

Material: Extruded aluminum  
Dimensions: 110 mm (W) x 180 (190) mm (D) x 28 mm (H)  
Weight: 590 g

### 8.4.2 Power Supply

USB 2.0 bus-powered, no separate power supply needed

### 8.4.3 Connectors

**MCU 502:**  
1 x USB 2.0  
2 x OMICRON fiber optical network (600 series)

**MCU 504:**  
1 x USB 2.0  
2 x OMICRON fiber optical network (600 series)  
3 x OMICRON fiber optical network (200 series)

**MCU 550:**  
1 x USB 2.0  
1 x OMICRON fiber optical network (600 series)  
2 x OMICRON fiber optical network (300 series)

**Note:** Each fiber optical network consists of two ST connectors.

### 8.4.4 Indicators

1 x LED: USB connection/system error

### 8.4.5 Additional Hardware Features

1 x light-sensitive line trigger, 50 – 60 Hz

### 8.4.6 Environmental Conditions

Operating temperature: 0 °C ... 55 °C  
Storage temperature: -10 °C ... 70 °C

## 8.5 CPL 542 Quadripole/Measuring Impedance



Figure 8-5 CPL 542

### 8.5.1 Device

Material: Extruded aluminum  
 Dimensions: 145 mm (W) x 98 mm (D) x 58 mm (H)

### 8.5.2 Connectors

Input connectors:  
 2 x 4 mm terminals (for connecting coupling capacitor)  
 1 x GND

Output connectors:  
 2 x BNC (PD, V)

### 8.5.3 Operation

	CPL 542		CPL 543
	0.5 A version	2 A version	5 A version
Max. Current	0.5 A	2 A	5 A
Low-Arm Capacitance	30 $\mu$ F	120 $\mu$ F	272 $\mu$ F

### 8.5.4 Frequency Range

PD output: 20 kHz - 6 MHz

### 8.5.5 Additional Hardware Features

Arc detection output (TTL signal)

## 8.6 MCC Coupling Capacitors



Figure 8-6 MCC 124 and MCC 205

### 8.6.1 Devices

	MCC 112	MCC 124	MCC 205	MCC 210
Weight	3.0 kg	3.5 kg	8.2 kg	10.5 kg
Dimensions W x H x D	140 x 200 x 140 mm	150 x 250 x 150 mm	450 x 575 x 450 mm	450 x 755 x 450 mm
Fastening	Screw on	Screw on	On mobile base incl. CPL quadripole	On mobile base incl. CPL quadripole

## 8.6.2 Coupling Capacitors

	MCC 112	MCC 124	MCC 205	MCC 210
Max. voltage (RMS)	12 kV	24 kV	50 kV	100 kV
Capacity	1.1 nF	1.1 nF	1.0 nF	1.0 nF
PD level	< 2 pC	< 2 pC	< 1 pC	< 1 pC

## 8.7 MCT High-Frequency Current Transformer

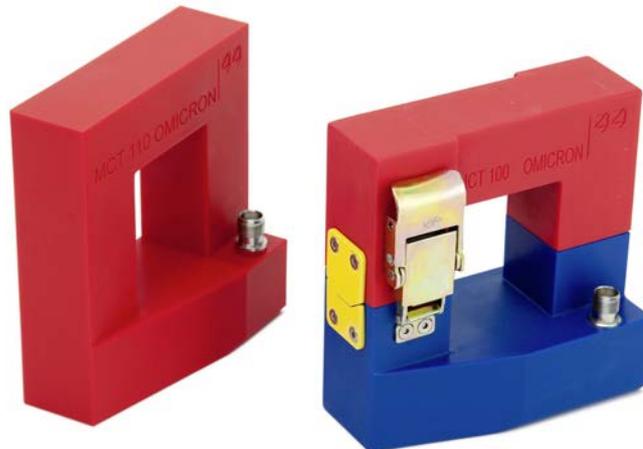


Figure 8-7 MCT 110 and MCT 100

### 8.7.1 Devices

	MCT 100	MCT 110
Inner hole dimensions	47 x 57 mm	47 x 57 mm
Outer dimensions	115 x 120 x 65 mm	115 x 120 x 55 mm

### 8.7.2 Connectors

TNC (BNC adapter included)

### 8.7.3 Frequency Range

MCT 100 and MCT 110: 80 kHz to 5 MHz

## 8.8 CAL 542 Charge Calibrator



Figure 8-8 CAL 542

### 8.8.1 Device

Material: Extruded aluminum  
Dimensions: 110 mm (W) x 185 mm (D) x 28 mm (H)  
Weight: 520 g

### 8.8.2 Output Connector

1 x BNC

### 8.8.3 Pulse Charge

Version A: 0.1 pC ... 10 pC  
Version B: 1 pC ... 100 pC  
Version C: 10 pC ... 1000 pC  
Version D: 0.1 nC ... 10 nC  
custom versions available on request

### 8.8.4 Pulse

Frequency: 300 Hz  
Rise time: < 10 ns

### 8.8.5 Power Supply

Lithium Battery 9 V, 1.2 Ah  
Lifetime > 10 years

### 8.8.6 Additional Hardware Features

1 x light-sensitive trigger, 50 – 60 Hz,  
for line synchronization  
auto-off 60 minutes after last keystroke

### 8.8.7 Environmental Conditions

Operating temperature: 0 °C ... 55 °C  
Storage temperature: -10 °C ... 70 °C

## 8.9 CAL 543 Online Calibrator



Figure 8-9 CAL 543

### 8.9.1 Device

Material: Aluminum  
Dimensions: 100 mm diameter

### 8.9.2 Input Connector

1 x OMICRON fiber optical network (200 series) simplex

### 8.9.3 Controls

None, all functions fully remote-controlled via software

### 8.9.4 Pulse Charge

10 pC for up to 400 kV<sub>eff</sub>  
1 nC for up to 30 kV<sub>eff</sub>  
custom versions available on request

### 8.9.5 Pulse

Frequency: 1200 Hz  
Rise time: < 5 ns

### 8.9.6 Power Supply

Lithium Battery 10,8 V, 2,4 Ah  
Lifetime > 10 years

### 8.9.7 Additional Hardware Features

auto-off after 60 minutes  
IP67 version available on request

## 8.10 UHF 608 Converter

The UHF 608 is a down-converter which extends the usable frequency range of the *MPD 600* system to the UHF range. The application field of the UHF 608 is unconventional PD measuring in the UHF/VHF domain at cable terminations and transformers. An *MPD 600* with AUX connector is necessary to use the UHF 608 converter. If your *MPD 600* does not have an AUX connector, please contact Technical Support.



Figure 8-10 UHF 608 Converter

### 8.10.1 Device

Material: Extruded aluminum  
 Dimensions: 110 mm (W) x 190 mm (D) x 44 mm (H)  
 Weight: < 700 g

### 8.10.2 Power Supply

Power consumption: < 1 W  
 No external power supply needed (powered by the *MPD 600* via AUX)

### 8.10.3 Connectors

UHF Input connector: 1 x Type N connector (return loss > 12 dB)  
 Output connector: 1 x BNC PD Output  
 Control connector: 1 x Lemo AUX

### 8.10.4 Environmental Conditions

Operating temperature: 0 °C ... 55 °C  
 Storage temperature: -10 °C ... 70 °C  
 Humidity: 5 % ~ 95 % non-condensing

## 8.10.5 Frequency Range and System Behavior

UHF Input: 220 ... 850 MHz  
 Frequency stability / accuracy: +/-50 ppm (typ. +/-20 ppm)  
 Measurement bandwidth: up to 1.5 MHz (narrow-band method)

## 8.10.6 Additional Hardware Features

Switchable built-in pre-amplifier

## 8.11 UHF 620 Converter

The UHF 620 is a down-converter which extends the usable frequency range of the *MPD 600* system to the UHF range. The application field of the UHF 620 is unconventional PD measuring in the UHF/VHF domain at various assets like GIS, transformer and cable terminations. An *MPD 600* with AUX connector is necessary to use the UHF 620 converter. If your *MPD 600* does not have an AUX connector, please contact Technical Support.



Figure 8-11 UHF 620 Converter

### 8.11.1 Device

Material: Extruded aluminum  
 Dimensions: 110 mm (W) x 190 mm (D) x 44 mm (H)  
 Weight: < 700 g

### 8.11.2 Power Supply

Power consumption: < 2 W  
 Powered by the *MPD 600* via AUX and by an additional connection to an MPP 600 (if medium- or narrow-band method is required)

### 8.11.3 Connectors

UHF Input connector: 1 x Type N connector (return loss > 12 dB)  
Output connector: 1 x BNC PD Output  
Control connector: 1 x Lemo AUX  
Power connector: 1x Power In (from MPP 600) / 1x Power Out (to *MPD 600*)

### 8.11.4 Environmental Conditions

Operating temperature: 0 °C ... 55 °C  
Storage temperature: -10 °C ... 70 °C  
Humidity: 5 % ~ 95 % non-condensing

### 8.11.5 Frequency Range and System Behavior

UHF Input: 100 ... 2000 MHz  
Frequency stability / accuracy: +/-50 ppm (typ. +/-20 ppm)  
Measurement bandwidth:

- up to 1.5 MHz (narrow-band method)
- 70 MHz (medium-band method)
- 1.9 GHz (broad-band method)

### 8.11.6 Additional Hardware Features

Switchable built-in pre-amplifier  
Test voltage synchronization (10 - 100 Hz) of the PD measurement via UHF sensor is possible

## 8.12 UPG 620 - UHF Pulse Generator

The UPG 620 pulse generator is used to test the UHF circuit with a very fast slope, reaching the set voltage in less than 200 picoseconds. With a frequency spectrum of up to 2 GHz, CIGRE's recommendation is achieved. The peak voltage of the output is adjustable from 0.5 V to 60 V either in 10 V steps or in 0.5 V steps for greater accuracy.

The UPG 620 is also used to quickly determine the appropriate measuring frequency of the UHF 608 or UHF 620.

The application field of the UPG 620 is mainly the sensitivity verification of PD measuring circuits operating in the UHF/VHF domain recommended by the CIGRE Task Force 15/33.03.05 "Partial Discharge Detection Systems for GIS

with the UHF Method and the Acoustic Method" (Electra No. 183, April 1999). When using the UPG 620, make sure to position the device either in a horizontal position or a vertical position with the connection facing upwards.

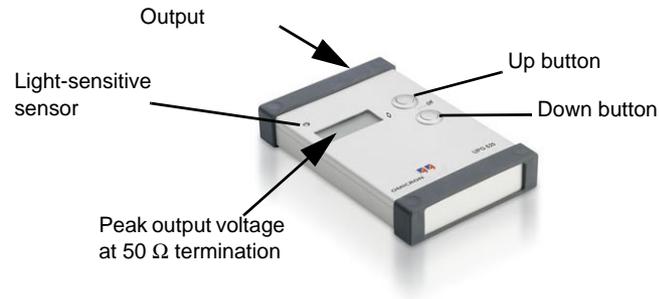


Figure 8-12 UPG 620

Press the Up or Down button to switch the UPG 620 on. Use the Up and Down buttons to set values between - 60 V and + 60 V. Press both buttons to turn the UPG 620 off.

The UPG 620 is used as signal source for test impulses in the UHF measurement. For this purpose, the UPG 620 output can be connected to a UHF sensor of the device under test (DUT) or the UVS 610, which should feature an impedance of 50  $\Omega$ . Otherwise, a corresponding termination has to be used. A second sensor connected to a measurement system (for example, UHF 620) can be set in such a way that a sensitive measurement frequency is used. Thus, it is possible to determine and use the resonance frequency of the DUT.

### 8.12.1 Device

Material: Extruded aluminum  
 Dimensions: 110 mm (W) x 185 mm (D) x 28 mm (H)  
 Weight: < 700 g  
 Output connector: 1 x N-Type

### 8.12.2 Output Pulse Voltage

Pulse peak voltage (at 50  $\Omega$ ): 0.5 ... 60 V  
 Output signal adjustable in steps of 0.5 V and 10 V

### 8.12.3 Output Pulse

Frequency (repetition rate): 100 Hz  
Rise time: < 200 ps  
Decay time: > 100 ns

### 8.12.4 Power Supply

2 x Lithium battery 9 V, 1.2 Ah  
Life time > 120 h  
Battery LOW display

### 8.12.5 Environmental Conditions

Operating temperature: 0 °C ... 55 °C  
Storage temperature: -10 °C ... 70 °C  
Humidity: 5 % ~ 95 % non-condensing

### 8.12.6 Additional Hardware Features

1 x light-sensitive trigger, 50 - 60 Hz, for line synchronization  
auto-off 5 minutes after last keystroke

## 8.13 UVS 610 - UHF PD Sensor

The UVS 610 is used for decoupling electromagnetic PD signals from the inner side of oil-paper-insulated transformers. Measuring in the high-frequency range enables PD detection of internal PD with simultaneous suppression of external noises, such as corona discharge on high-voltage lines. The measurement procedure can be used as trigger source for acoustic PD measurements or PD measurements according to IEC60270. In combination with the UHF 608 or UHF 620, this sensor enables measurements with the *MPD 600*.

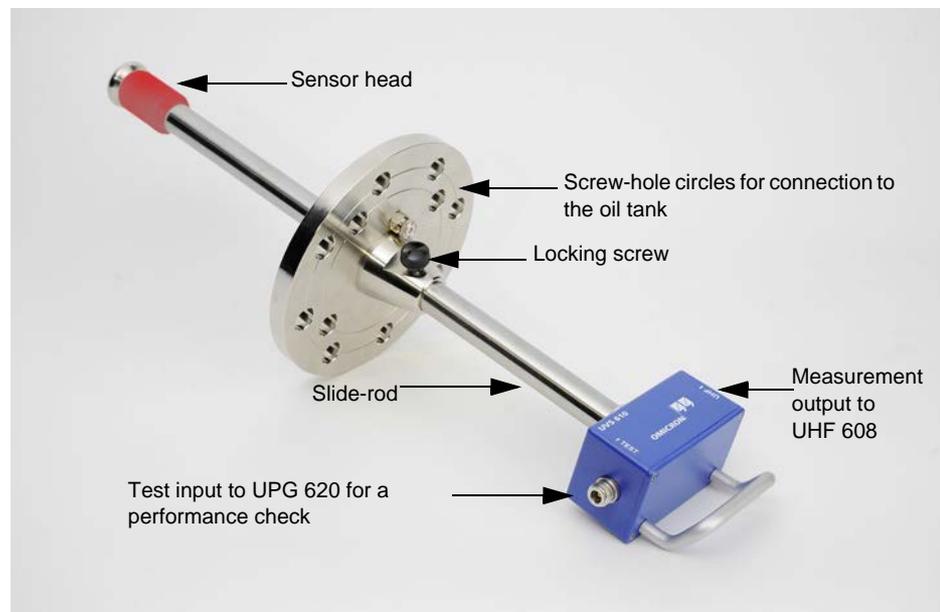


Figure 8-13 UVS 610

### 8.13.1 Frequency Range

Signal decoupling in the ultra-high-frequency range of 150 MHz - 1 GHz

### 8.13.2 Leak tightness

For oil temperatures of -15 °C to +120 °C at 5 bar pressure

### 8.13.3 Dimensions

Plate dimensions: 200 mm  
Standard design for DN 50 and DN 80 drain valves  
Insertion depth: 55 mm to 450 mm  
Weight: 3.1 kg

### 8.13.4 Environmental Conditions

Operating temperature: -15 °C ... 120 °C  
Storage temperature: -10 °C ... 70 °C  
Humidity: 5 % ~ 95 % non-condensing

## 8.14 Cleaning



**Warning:** Prior to cleaning, disconnect all devices.

To clean all devices mentioned in the manual, use a cloth dampened with isopropanol alcohol or water.



# 9 Appendix

## 9.1 Type Test Certificate



Independent, accredited testing station - Member laboratory of STI and LOVAG

## TYPE TEST REPORT

NO. 2254.2081086.1189

OMICRON electronics GmbH Oberes Ried 1 6833 Klaus	CLIENT
Lehter Str. 16-17 10557 Berlin	MANUFACTURER
Advanced Partial Discharge Measuring System	TEST OBJECT
MPD600	TYPE
MPD600-BE402B	SERIAL NO.

Time interval:	100 ns - 8 µs	RATED CHARACTERISTICS GIVEN BY THE CLIENT
Frequency range	0 Hz - 32 MHz	
Midband frequency	9 kHz, 30 kHz,	
Bandwidth	100 kHz, 300 kHz,	
	1 MHz, 3 MHz	
Resolution time of PD event:	2 ns	
Input frequency range:	0 Hz - 20 MHz	
PD input terminal	0.1 Hz - 2.5 kHz	
Voltage input terminal	10 Vrms	
Input voltage:	60 Vrms	
Voltage input terminal		

IEC 60270, 2000-12	NORMATIVE DOCUMENT
Determination of the scale factor Uncertainty test Determination of the bandwidth Determination of the pulse resolution time Determination of the pulse train response Measurement of the recorded number of pulses Determination of the transfer impedance Z0 Measurement of stochastic PD pulses	RANGE OF TESTS PERFORMED
14 July to 27 August 2008	DATE OF TEST
The type test has been PASSED.	TEST RESULT



R. SCHILLER  
Director Testing Operations  
Berlin, 19 October 2011



R. HOLLE  
Test engineer in charge

Independent test laboratory, accredited by Deutsche Akkreditierungsstelle Technik (DAK-AT) in the fields of fire, electrical and switching power cables and power cable accessories, for apparatus and outgases, installation equipment and switching and control equipment.

IPH BERLIN is a subsidiary of CER S.p.A. Milan.




DAT - P - 019/02

Figure 9-1

Type Test Certificate

## 9.2 Package Contents

- One fiber optics controller MCU 502, 504, or 550
- One (or more) acquisition unit(s) *MPD 600*
- One (or more) battery pack(s) MPP 600
- One (or more) quadripole(s)/measuring impedance unit(s) CPL 542
- *MPD 600* system software
- One charge calibrator CAL 542 with cables and clamps (optional)

Accessories:

- Fiber optic cable(s)
- BNC cables
- Battery cable(s)
- USB cable

## 9.3 List of Software Options

Feature	Package Availability				
	Basic	Ad- vanced	Multi- Band (3FREQ)	Cable	Reporting (Excel- based)
Support for cable fault localization using TDR		x		x	
Support for cable fault localization using statistical TDR		x		x	
Support for cable fault localization using dual-end measurements		x		x	
Light-sensitive line trigger can be used to trigger the histogram	x	x	x	x	x
Every <i>MPD 600</i> unit can trigger itself	x	x	x	x	x

Feature	Package Availability				
	Basic	Ad- vanced	Multi- Band (3FREQ)	Cable	Reporting (Excel- based)
Support for internal triggering if no external trigger source is available	x	x	x	x	x
Support for triggering on connected series 700 units when using an MCU 550 controller	x	x	x	x	x
Supports digital low-pass filters on the PD input		x			
Support for 3PARD diagrams		x			
Support for RIV measurements	x	x	x	x	x
Support for Dynamic Noise Gating		x			
Support for phase and phase-amplitude gating	x	x	x	x	x
Support for unit gating	x	x	x	x	x
Support for the Q(V) diagram in Expert mode		x			
Support for DC measurements		x			
Support for trending in Expert mode		x			
Support for creating and replaying measurement streams	x	x	x	x	x
Support for the spectrum analyzer visualization	x	x	x	x	x
Support for the oscilloscope visualization	x	x	x	x	x

Feature	Package Availability				
	Basic	Ad- vanced	Multi- Band (3FREQ)	Cable	Reporting (Excel- based)
Support for the phase-resolved PD pattern, individual PD events display, and voltage curve display	x	x	x	x	x
Support for the ellipse and "eye" visualizations	x	x	x	x	x
Support for generating MATLAB-compatible files during replay		x			
Automation support via COM interface					x
Support for batch features					x
Support for freely selecting measurement frequencies	x	x	x	x	x
Support for 3D histogram visualizations	x	x	x	x	x
Support for additional statistics values		x			
Support for using MPD540/MPD 600 units together with MI540 and MI 600 units	x	x	x	x	x
Support for using MPD540/MPD 600 units together with MPD402 units	x	x	x	x	x
Support for using MPD540/MPD 600 units together with series 700 units	x	x	x	x	x
Access to voltage and PD data for third-party applications					x

Feature	Package Availability				
	Basic	Ad- vanced	Multi- Band (3FREQ)	Cable	Reporting (Excel- based)
Support for multi-band measurement			x		
Support for pulse sequence analysis		x			
Support for exporting measurements to XML files for reporting purposes	x	x	x	x	x
Support for connecting an external peripheral device to the <i>MPD600</i> 's AUX port	x	x	x	x	x
Support for controlling CAL543 calibrators	x	x	x	x	x
Support for time-domain integration		x			
Support for Expert mode	x	x	x	x	x
Support for Cable mode				x	
Support for Basic mode	x	x	x	x	x
Report Generator Excel-based					x
Report Generator XML-based	x	x	x	x	x

## 9.4 Matlab Files and Format

The following files are placed into the folder created during replay with the **Export Matlab®-compatible files** option checked:

unitX.Y.Q (with X = [1,2] and Y = [1,1024], see below)

unitX.Y.V (only for units that act as a trigger source)

unitX.Y.PH (only if "Generate Phase Vector File" is checked)

lineTrigger.TM (only if any of the line trigger options was used as the trigger source)

Every unit that was recorded in the stream will have the corresponding unitX.Y.\* files created in the folder. These files are a binary representation of the data processed during replay.

In the file description above, "X" corresponds to the number of the 600 series bus to which the unit was connected. There are two 600 series buses on the MCU 502, MCU 504 and USB 502 controller and there is one 600 series bus on an MCU 550 controller. The Y value represents the unit's position on the bus. The unit that is directly connected to the controller has position 1, the next one position 2, etc.

The .Q files contain every PD event processed in the replay range. For each PD event, the file contains a 32-bit floating point value that represents the charge of the PD event (expressed in Coulomb), immediately followed by a 64-bit value representing the time at which the PD event happened (expressed in seconds). The time of the first PD event is 0. All PD events are stored in chronological order with no gaps.

The .V files contain every voltage curve sample processed during replay. Voltage curve samples are generated every 48  $\mu$ s and are stored as a 32-bit floating point value corresponding to the voltage present at the V input at the time the sample was taken. All samples are stored in chronological order with no gaps.

The .PH files contain a vector of phase positions for every PD event. .PH files are only generated if the "Generate Phase Vector File" option is checked. There is a one-to-one correspondence between items stored in a .PH file and the PD events stored in the corresponding .Q file. For each PD event in the replay range, a .PH file contains a 64-bit floating point value between 0 and 1 that represents the phase position of the PD event. The phase position is expressed in terms of the phase of the voltage. A value of 0 means the PD event occurred exactly at the beginning of a voltage cycle; a value of 0.9 means it happened at 90% of the voltage cycle.

The lineTrigger.TM file contains the time values at which the line trigger fired. This file is only generated if one of the line trigger options (50 Hz line trigger or 60 Hz line trigger) was selected as the trigger source during replay. The file

contains a vector of 64-bit floating point values that each represent the time at which the line trigger fired. The times in the file are given with reference to the time that the measurement was started.

**Note:** The data being exported is the same that is plotted in the histogram visualization and that is used to compute the  $Q_{IEC}$  value. That is, any phase-amplitude or phase gates, unit gates, DynG options, and 3PARD back transformations are applied before the export is made, and can exclude PD events from being exported.

## 9.5 Format of Data Files Generated by "Save histogram data to file..."

The `.dat` files generated by the MPD/MI software are a representation of the histogram diagram at the time that the file was saved. It is a binary file that follows the format described below:

Byte Offset	Length in Bytes	Name	Description Contents
0	8	QMin	64-bit floating point describing which charge level corresponds to the top bound of the diagram (in C)
8	8	QMax	64-bit floating point describing which charge level corresponds to the bottom bound of the diagram (in C)
16	4	LinLog	unsigned 32-bit integer set to 0 if the diagram is scaled linearly, 1 if it is scaled logarithmically
20	4	Bipolar	unsigned 32-bit integer set to 0 if the diagram is a unipolar display, 1 if it is a bipolar display
24	4	Width	unsigned 32-bit integer set to the width of the diagram, in pixels
28	4	Height	unsigned 32-bit integer set to the height of the diagram, in pixels
32-	Width * Height * 4	Data	an unsigned 32-bit integer for each point in the diagram giving the count of PD events at the $[x,y]$ position with $x$ being the phase of the voltage with the mapping $[0..2*\text{Pi}] \rightarrow [0..\text{width}]$ ; and $y$ being the charge level of the PD event as given by QMax and QMin. The data is stored as a sequence of rows, starting with the top-most row.

## 9.6 Format of Files Saved via "Save FFT curves..."

FFT curves are saved in a comma-separated text format, suitable for import in many third-party applications. The FFT (spectrum) curves for all connected units are saved into the same file, organized in columns. The first column contains the frequency component, given in Hz. Each subsequent column lists the FFT coefficients for a single unit. The first line of the file contains a textual description of each column.

The entire recorded spectrum is saved (between 0 Hz and 32 MHz), independent of the FFT visualization settings, with a frequency granularity of 31.25 kHz. Thus, each FFT file contains 1025 lines (1 header line plus 1024 data lines).

## 9.7 Format of Files Saved via "Save PD curves..."

Time oscilloscope curves are saved in a comma-separated text format, suitable for import in many third-party applications. The oscilloscope curves for all connected units are saved into the same file, organized in columns. Since each oscilloscope curve is triggered independently and can have a different pretrigger delay, each curve has its own time vector. Thus, each unit is represented by 2 columns in the file. The first column lists the time, with reference to the trigger time and given in seconds, whereas the second column lists the voltage sample and is given in V. The first line of the file contains a textual description of each column.

The entire 32  $\mu$ s oscilloscope buffer is saved to the file, independent of the Time display visualization settings, with a time granularity of 15.625 ns. Thus, a oscilloscope file contains 2049 lines (1 header line plus 2048 data lines).

## 9.8 Abbreviations

Abbreviation	Meaning
3PARD	3-Phase Amplitude Relation Diagram
3CFRD	3-Channel Frequency Relation Diagram
DyNG	Dynamic Noise Gating
FFT	Fast-Fourier Transformation, used to show the spectrum of the input signal
PD	Partial Discharge
FO	Fiber Optics
Q	International symbol for electric charge
Q(V)	A Q(V) diagram plots charge over voltage
RMS	Root Mean Square  When used with AC voltage signals, the rms value is equivalent to the effective voltages.

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