ICM*monitor*

Partial Discharge Monitor

User Manual

Rev. e3.41

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Contents

I General

I.1 About this manual

This manual describes the hardware, software, and usage of the ICM*monitor* in its current version. Some of the hardware features of the most recent versions are not available with earlier versions of the instrument. It is possible to upgrade most of the previous instruments to the features of the current instruments. Please contact Power Diagnostix for details.

Software updates are available through Power Diagnostix's web site (www.pdix.com). The access to the download area of that web site is password protected and requires a valid software maintenance contract. Contact Power Diagnostix for details. Current brochures and revisions of this manual are available for download (PDF format) on that web site as well.

This manual describes the ICM*monitor* including its miscellaneous functions. Some of these functions have to be ordered separately and are marked as optional functions. For information regarding the accessories and special applications of the ICM*monitor* please contact Power Diagnostix.

I.2 Instrument safety

Before using the ICM*monitor*, read the following safety information and this manual carefully. In particular, read and follow the information, which is marked with the words 'Warning' and 'Caution'. The word 'Warning' is reserved for conditions and actions that pose hazards to the user, while the word 'Caution' is reserved for conditions and actions that may damage the instrument or its accessories, or that may lead to malfunction.

Always obey the safety rules given with the warnings and in this section. Make sure to take care of the safety issues while performing field measurements. Never disregard safety considerations even under time constraints found often with on-line and off-line test on site.

Warning:

- Always provide solid grounding of the instrument and the coupling units. Never operate the instrument without protective grounding.
- Use isolation techniques, such as isolation transformers or fibre optic isolation to avoid hazard and injury. With applications bearing a high risk of electrical shock or breakdown use fibre optic isolation in general.
- Avoid working alone.
- Do not allow the instrument to be used if it is damaged or its safety is impaired.
- Inspect the ground leads and signal cables for continuity.
- Select the proper coupling circuit and connection for your application.
- Do not use the instrument in an environment that is at risk of explosion.

I.3 Battery module warnings

- This instrument may be provided with a battery module.
- Do not pierce, damage, disassemble, or modify the battery module. The battery module contains safety and protection devices which, if tampered with, may cause the battery to generate heat, to rupture, or to ignite.
- If a battery is suspected to be faulty, replace it with a Power Diagnostix approved battery module.
- If an instrument is suspected to contain a faulty battery module, the module must be removed before the instrument is shipped.
- Do not ship a faulty battery module, either separately or connected to an instrument.

II Introduction

The ICM*monitor* is a partial discharge analyser comprising a spectrum analyser, an acoustic detector, and a conventional partial discharge (PD) monitor in one instrument. This combination enables PD measurements even with a large background noise, e.g., on power transformer within substations or power plants.

The ICM*monitor* is an autonomous instrument, which can be used as stand-alone monitoring device. However, it is equipped with a serial computer interface for the download of trending data and remote access, e.g., by UMTS or LAN network (TCP/IP). The system can be adapted to utilise all commonly used types of couplers and sensors. It offers a relay output to give a warning if a pre-set threshold level is exceeded.

The ICM*monitor* is easy to use, where the user can choose between several display-modes of the integrated LCD screen. All instrument settings including calibration are done via the optional functions on-screen menus or via software. These settings are automatically stored in a non-volatile memory when the system is shut down.

III Hardware

III.1 Models

III.1.1 Rack mountable versions

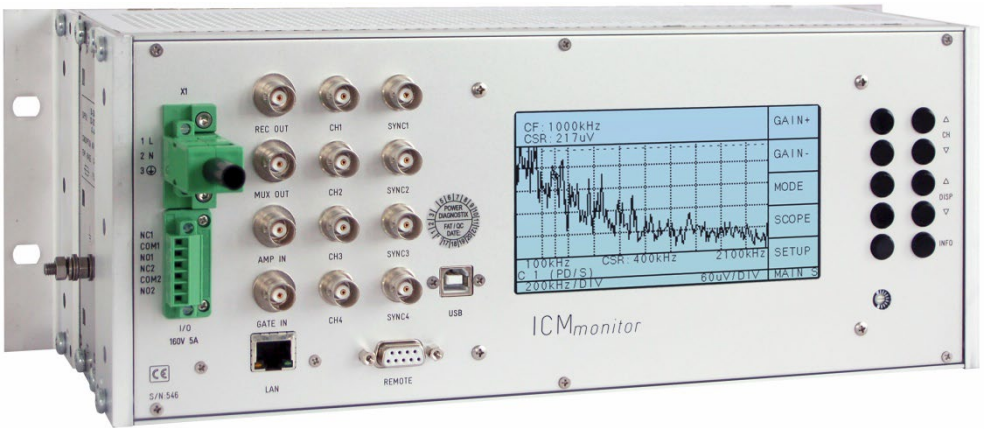


Figure III.1: ⅔ 19-inch rack

Figure III.2: Half 19-inch rack

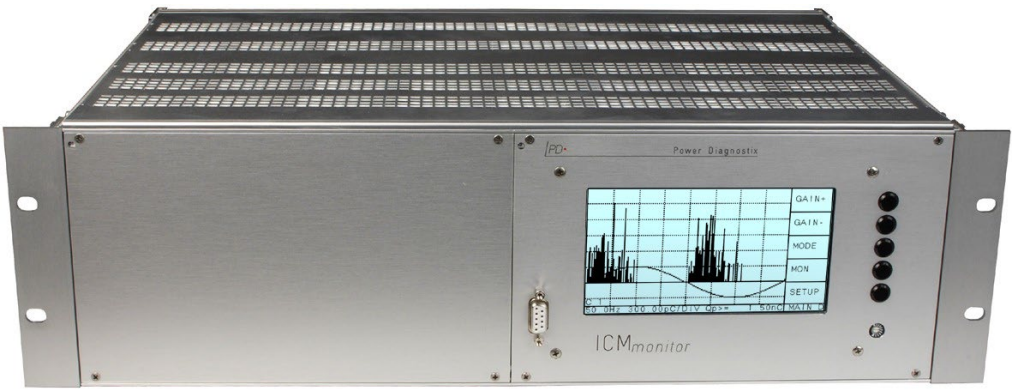


Figure III.3: Full 19-inch rack

III.1.1.1 Front panel and external connections

Figure III.5 shows the front panel of the instrument as ⅔ 19-inch rack. The backlit liquid crystal display (LCD) has a resolution of 240 x 128 pixels; the ten control buttons are arranged along the right-hand edge. The brightness adjustment of the LCD is accessed using a small screwdriver, immediately beneath the control buttons. A temperature deviation of the environment will be compensated by the device itself. For remote control purposes a computer system can be connected via USB.

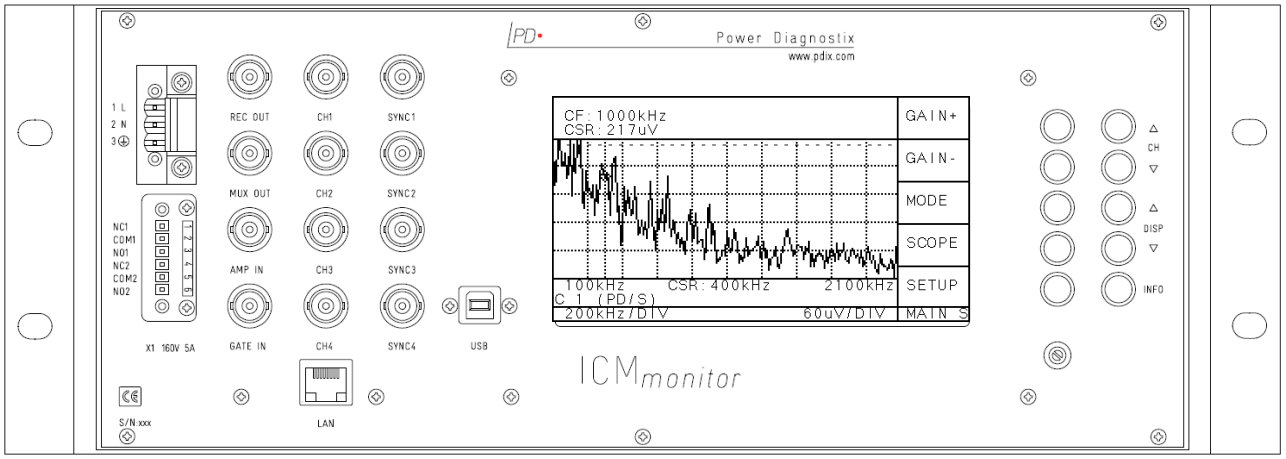


Figure III.5: Front panel of the ICM*monitor* in a ⅔ 19-inch rack

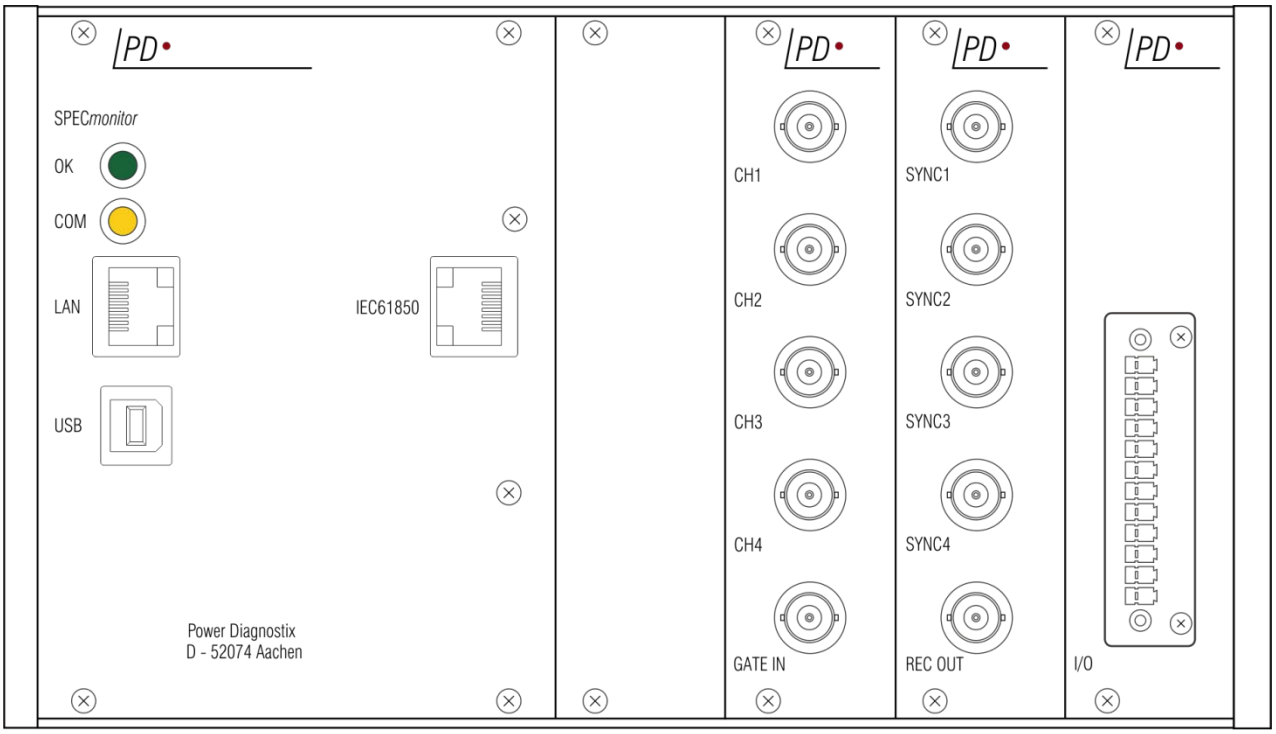


Figure III.4: Front panel of the ICM*monitor* with IEC61850 option in a half 19-inch rack

LAN: LAN Ethernet connector, RJ45, for connecting the ICM*monitor* with external controlling systems.

USB: The USB terminal provides the connection to a PC for remote communications.

CH1 ... CH4: The input connectors of the 4-channel MUX can be connected to different PD sensors or coupling units. The settings are changed in the menu SETUP3 / MUX.

SYNC1 ... SYNC4: The SYNC connections are used for external synchronisation of each channel to the frequency of the applied high voltage. This signal is usually derived from the coupling unit but can also be taken from an extra voltage divider. The terminals can take voltages up to ~100 V_{RMS} or ~200 V_{peak}. If the SYNC is not connected or the signal is too low, the ICM*monitor* will synchronise on the mains supply frequency (usually 50 or 60 Hz).

REC OUT: The REC OUT terminal of the ICM*monitor* may optionally be connected to a paper recorder or other device to provide a graph of the NQS value. The output gives 0 to 10 V with a R_0 = 100 Ω.

MUX OUT: When using the multiplexer the MUX OUT must be connected to the AMP IN either by a preamplifier or directly via a short BNC cable (see section X.1 "Connection of MUX OUT and AMP IN" on page 149).

AMP IN: The AMP IN connector takes the PD signal either from the MUX OUT (former AMP OUT) or directly from a PD source. Its input impedance is about 50 Ω and has a sensitivity of <2 mV. When using a preamplifier, the direction of the arrows engraved on the RPA's must point toward AMP IN connector.

GATE IN: The GATE IN terminal can be used for noise rejection during measurements. An additional RPA (usually RPA6G) is only necessary with older versions of the ICM*monitor*. The current versions come with an onboard integrated preamplifier. The unwanted noise signal must be connected with the GATE IN.

REMOTE: The REMOTE terminal provides a direct serial connection to a PC for remote communications, using the serial cable provided by Power Diagnostix. Alternatively, a TCP/IP interface box can be connected.

IEC61850: Optional terminal for communication with the ICM*monitor* according to IEC 61850. See page 12.

X1: Power supply and alarm relay output

Caution: Make sure you know for what kind of voltage your device is designed before connecting it to the power supply. The X1 connector of the ICM*monitor* DC version is only suitable for 12 to 26 V DC. Higher voltages can damage the instrument.

X2: Alarm relay output

: The case of the ICM*monitor* must be connected to ground.

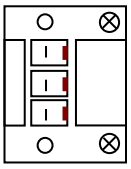


Figure III.6: X1 connector for AC power supply

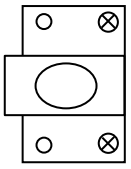


Figure III.7: X1 connector for DC power supply

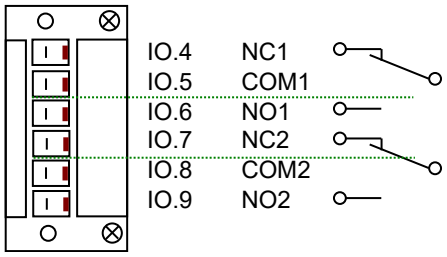


Figure III.8: X2 connector for alarm relay output

Caution: Preferably, the AMP IN is connected to the preamplifier. The supply voltage for the preamplifier may damage the output circuit of the signal source. Be sure not to connect anything but the RPA to this terminal or turn OFF the supply voltage. Only the SYNC IN terminal can take voltages up to ~200 V_{peak}. Do not apply any voltage to the REC OUT terminal (min. 100 Ω input impedance).

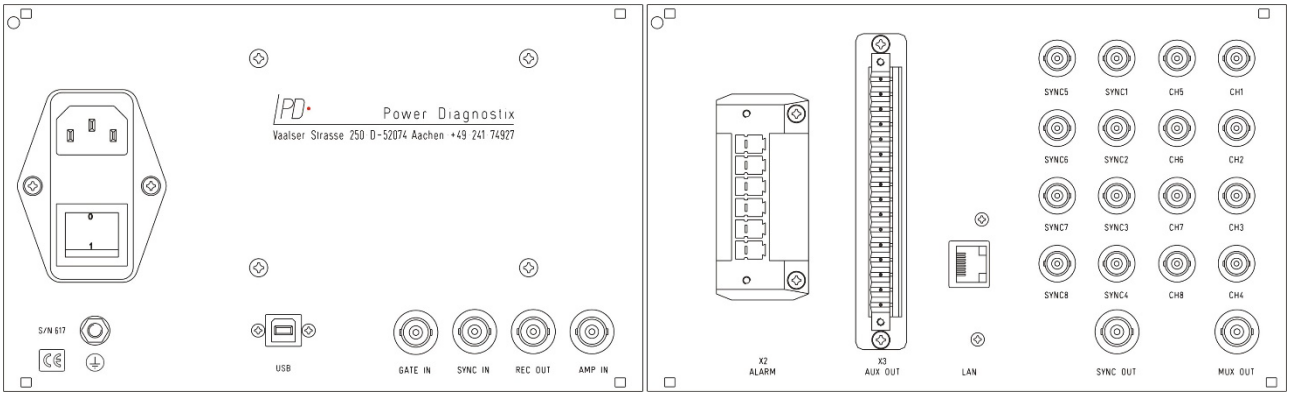


Figure III.9: Rear panel of ICM*monitor*'s 19-inch version with MUX8/8 and AUXOUT8 option

For a description and explanation of the left part of the rear panel, see above.

The panel's right part additionally provides:

MUX OUT: When using the multiplexer the MUX OUT must be connected to the AMP IN either by a preamplifier or directly via a short BNC cable (see section X.1 "Connection of MUX OUT and AMP IN" on page 149).

X1: Alarm relay output

X2 (optional): Up to eight additional output signals of 4–20 mA or 0–10 V DC can be provided for external monitoring purposes.

WLAN: Alternative to the LAN terminal for connecting controlling systems or a PC to the ICM*monitor*.

: The case of the ICM*monitor* must be connected to ground.

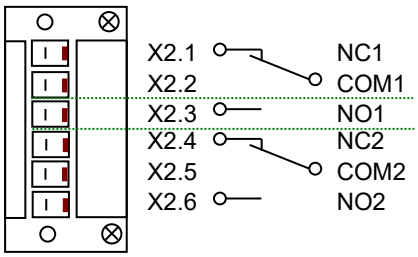


Figure III.10: Connection block X2

III.1.2 Enclosure for DIN rail mounting

For an explanation of the display and the push buttons, see page 3.

III.1.2.1 External connections

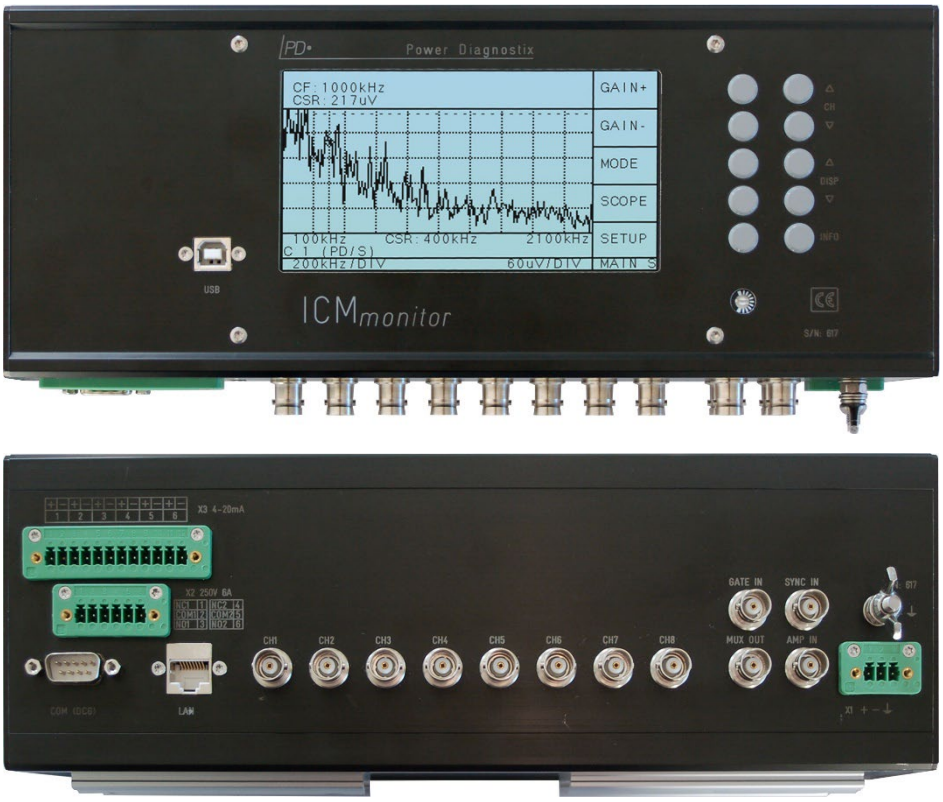


Figure III.11: DIN rail version of the ICM*monitor*

USB: The USB terminal provides the connection to a PC for remote communications.

X3 (optional): Up to six additional input signals of 4–20 mA can be measured and recorded.

X2: Alarm relay output (see Figure III.14 on page 8)

COM (DCG): Connector for a serial connection to a device communication gateway DCG61850 for communication with the ICM*monitor* according to IEC 61850. See also page 12.

Figure III.12: DCG61850

LAN: LAN Ethernet connector, RJ45, for connecting the ICM*monitor* with external controlling systems.

CH1 ... CH8: The input connectors of the 8-channel MUX can be connected to different PD sensors or coupling units. The settings are changed in the menu SETUP3 / MUX.

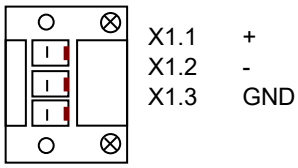
GATE IN: The GATE IN terminal can be used for noise rejection during measurements. An additional RPA (usually RPA6G) is only necessary with older versions of the ICM*monitor*. The current versions come with an onboard integrated preamplifier. The unwanted noise signal must be connected with the GATE IN.

SYNC IN: The SYNC IN can be used for external synchronisation of the ICM*monitor* to the frequency of the applied high voltage. This signal is usually derived from the coupling unit but can also be taken from an extra voltage divider. The terminal can take voltages up to ~100 V_{RMS} or ~200 V_{peak}. If the SYNC IN is not connected or the signal is too low, the ICM*monitor* will synchronise on the mains supply frequency (usually 50 or 60 Hz).

MUX OUT: When using the multiplexer the MUX OUT must be connected to the AMP IN either by a preamplifier or directly via a short BNC cable (see section X.1 "Connection of MUX OUT and AMP IN" on page 149).

AMP IN: The AMP IN connector takes the PD signal either from the MUX OUT (former AMP OUT) or directly from a PD source. Its input impedance is about 50 Ω and has a sensitivity of <2 mV. When using a preamplifier, the direction of the arrows engraved on the RPA's must point toward AMP IN connector.

X1: Power supply



Caution: The I/O is connector only suitable for 12–26 V DC. Higher voltages can damage the instrument.

Figure III.13: I/O connector X1

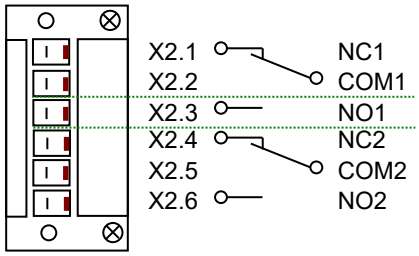


Figure III.14: Connection block X2

: The case of the ICM*monitor* must be connected to ground.

III.1.3 Explorer case

For a description and an explanation of this model's panel, see page 3 and 5.

Additionally, this panel provides a speaker in the upper corner on the right-hand side.

Figure III.16: Portable ICM*monitor* in a robust Explorer case

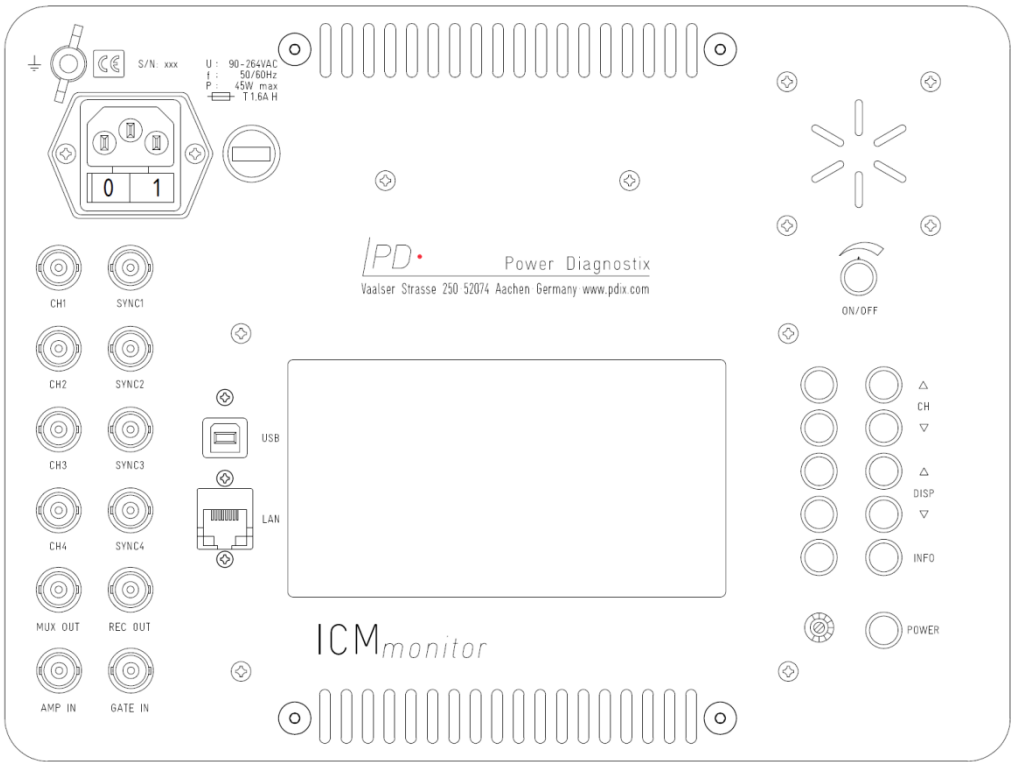


Figure III.15: Panel of the ICM*monitor* in an Explorer case

III.2 Cabinet

Power Diagnostix offers the ICM*monitor* fitted in a stainless steel cabinet with following parameters:

Protection class:	IP65
	Corrosion proved
	Screening grid
	Pivoting centre section
Options:	Heating installation or cooling system

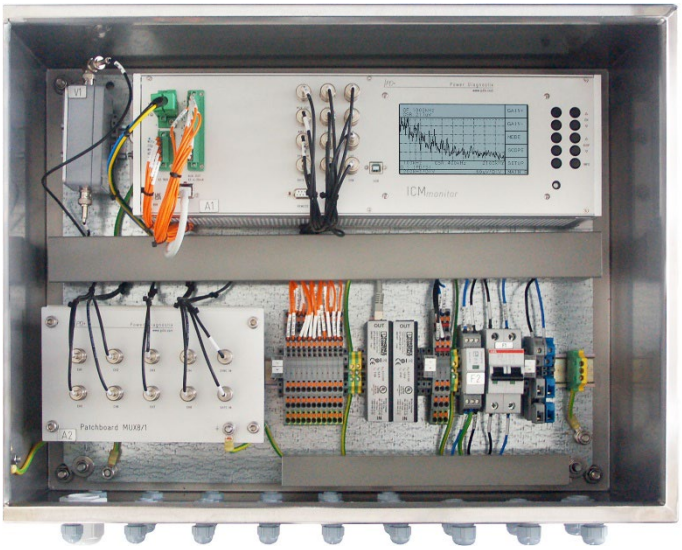


Figure III.17: ICM*monitor* with retrofitted MWS module in a stainless steel enclosure (PDMAR500)

III.3 Options

The ICM*monitor* can be equipped with several optional features to adapt the instrument for special acquisition tasks.

- MWS

  Monitoring web server providing an Ethernet gateway for platform independent remote access to an ICM*monitor* instrument. The module is available for DIN rail mounting or as built-in plug-in card.

- MCI2

  Additional module providing a mobile communication interface for remote access via UMTS.

- AUXOUT4/AUXOUT8
  Up to eight additional output signals of 4–20 mA or 0–10 V DC (to be specified on order) can be provided for external monitoring purposes.

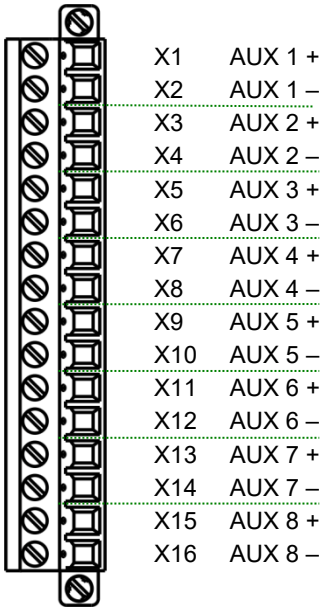


Figure III.18: AUXOUT connector for eight channels

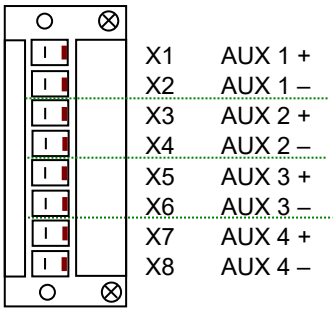


Figure III.19: AUXOUT connector for four channels

- AUXIN4/AUXIN6/AUXIN8
  Up to eight additional sensor signals of 4–20 mA or 0–10 V DC can be measured and recorded. These AUX data are only accessible by the ICM*monitor* software.

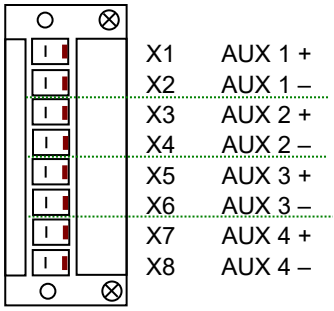


Figure III.20: AUXIN connector

Caution: The AUX inputs may be solely connected with their designed signal magnitude. Over-voltage (e.g., from the signal for the SYNC input) might harm your instrument.

Only with the ICM*monitor* software it is possible to label and scale the AUX inputs. Figure III.21 shows the setup window where the number of channels and the sort of input (4–20 mA or 0–10 V) have to be set according to the ordered instrument. Within the main panel of the software the loaded AUX values are displayed together with the PD trending data. An export of these data is easily done to standard data file formats.

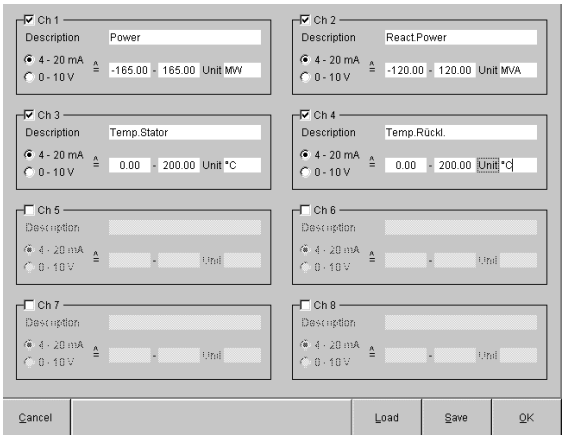


Figure III.21: Screenshot of the AUX input board

- MUX8/MUX12
  Eight or twelve input channels for PD and synchronisation signals.

- IEC61850
  Hardware based protocol converter for IEC 61850 compliant communication, built-in or as additional module (DCG61850). Instruments equipped with this option have an additional terminal for communication via LAN which can be used to transfer the following data:

  NQS: Average discharge current; the unit depends on the unit setting for the charge value.

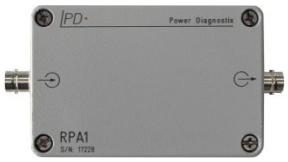
  AppPaDsch: Apparent charge of partial discharge, peak level; this value is only available, if the measuring mode of the corresponding channel is set to 'PD'.

  PaDschAlm: Partial discharge alarm; this value is set if a pre-set limit of the Qp value is exceeded.

  NQSAlm: NQS alarm; this value is set if a pre-set limit of the NQS value is exceeded.

III.4 Accessories

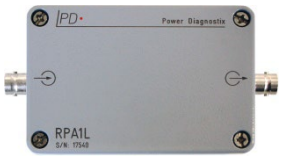
RPA1



Range: 40 kHz–800 kHz

The RPA1 is the standard preamplifier for measurements in the low frequency range according to standards such as the IEC 60270.

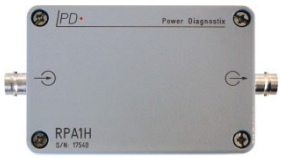
RPA1L



Range: 40 kHz–20 MHz

The RPA1L is the standard preamplifier for measurements in higher frequency ranges.

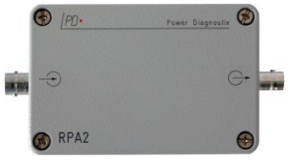
RPA1H



Range: 40 kHz–20 MHz

The RPA1H covers the same frequency ranges as the RPA1L but with lower input sensitivity.

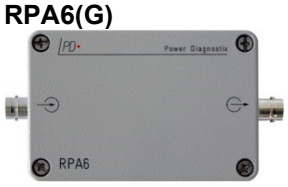
RPA2



Range: 2 MHz–20 MHz

The RPA2 is a signal-conditioning amplifier that is designed to measure PD in a frequency range higher than the range provided by the ICM*monitor* itself. Its basic function is to transfer the envelope of the high frequency signal found in the range of 2–20M Hz into a frequency range that can be acquired by the ICM*monitor* in the AMP mode.

RPA6(G)



MODE 1: 40 kHz–800 kHz (10 kΩ input impedance)
MODE 2: 2 MHz–20 MHz (50 Ω input impedance)
MODE 3: 200 MHz–600 MHz (50 Ω input impedance)

The RPA6(G) is a signal-conditioning preamplifier with a demodulating logarithmic transfer function covering 4.5 decades in one range. The remote control used with other preamplifiers to control the gain setting is here used to control three different frequency ranges. It is to be used for gating **only**. Please see also section IV.6.3.

Remark: With current versions of the ICM*monitor* the pre-amplifier RPA6 is no longer built in. The onboard integrated RPA6G is used instead. It offers a range of 100 kHz–10 MHz (1 kΩ input impedance).

FCU2

Range: 100 MHz–1800 MHz

The FCU2 is an ultra-wide band frequency converter unit. It is mainly used for GIS monitoring. It is designed to withstand high voltage transients for most applications, however in some cases it might be necessary to increase the input protection by an IPU2

IPU2

The protection unit IPU2 is designed to avoid damage of the FCU2 input stage under the presence of very strong transient signals.

AS75I

Range: 30–120 kHz acoustic sensor

The AS 75I is an active sensor with very high sensitivity for measurements on GIS, transformer tanks, or cable joints. They come with a built-in 40 dB pre-amplifier and can be connected to the RPA1D or directly to the ICM*monitor*.

RPA: The output arrow engraved on the RPA (preamplifier) must be connected towards the AMP IN connection. The input arrow of the RPA must be connected to the signal source via the MUX. It is also possible to place the RPA external, before the MUX for e.g., feeding long signal cables.

III.5 Connections

Warning: The installation of couplers for PD monitoring requires high voltage connections. Such installations require special knowledge. Leave the installation of couplers to qualified maintenance personal in general. Obey the relevant standards concerning phase-to-phase and phase-to-ground distance as well as concerning the creepage distance. Obey all safety regulations when working with high voltage equipment.

Only authorised persons should provide the coupler installation up to the CTB1. In order to prepare a measurement, provide a connection from each output of the termination box CTB1 to the corresponding input BNC connectors of the ICM*monitor* starting with channel 1 on the left side. The total cable length from a coupler to the input terminal of the ICM*monitor* should not exceed 20 m. Please refer to the "coupler installation guide" for further instructions.

Warning: Always provide solid grounding of the coupler termination box (CTB)! Never use the instrument without protective grounding on the mains side! Do not disconnect the cable between coupler and CTB1! This cable may carry up to 2000 V if not terminated adequate!

Depending on the instrument model, different principal connection methods are possible. They are shown in the figures below.

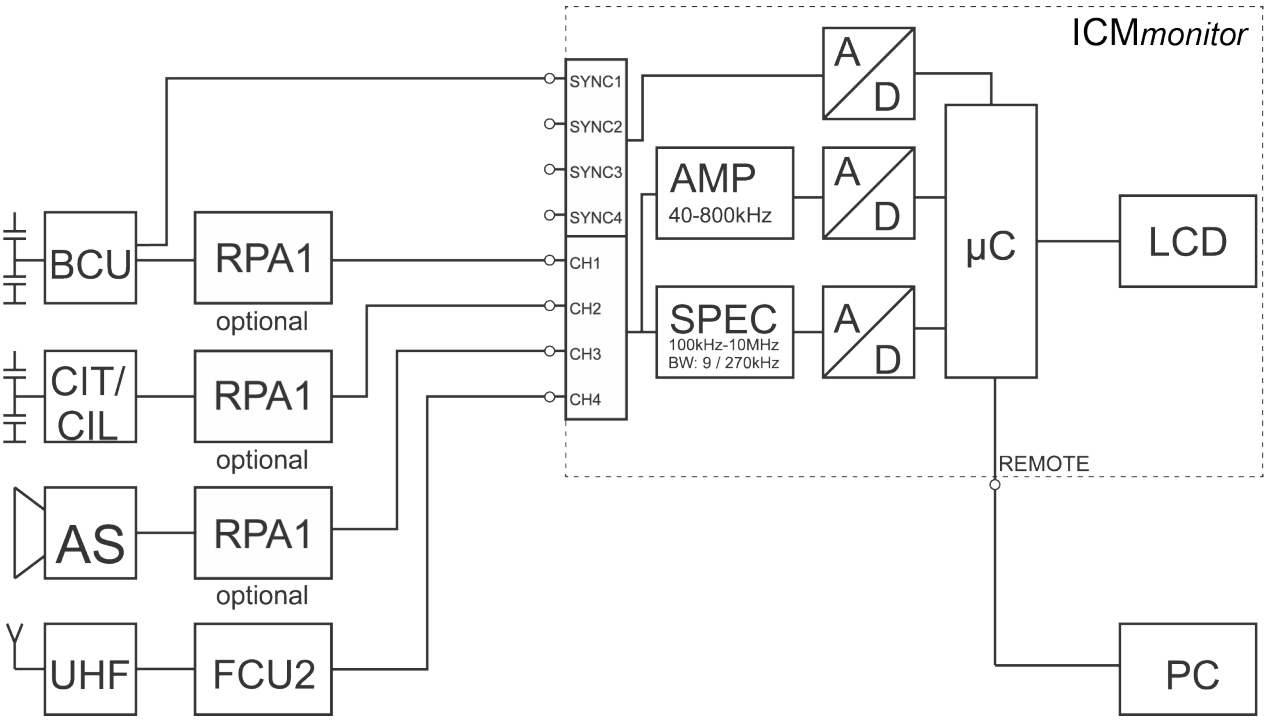


Figure III.22: Principal internal and external connections of the ICMmonitor with multiplexer

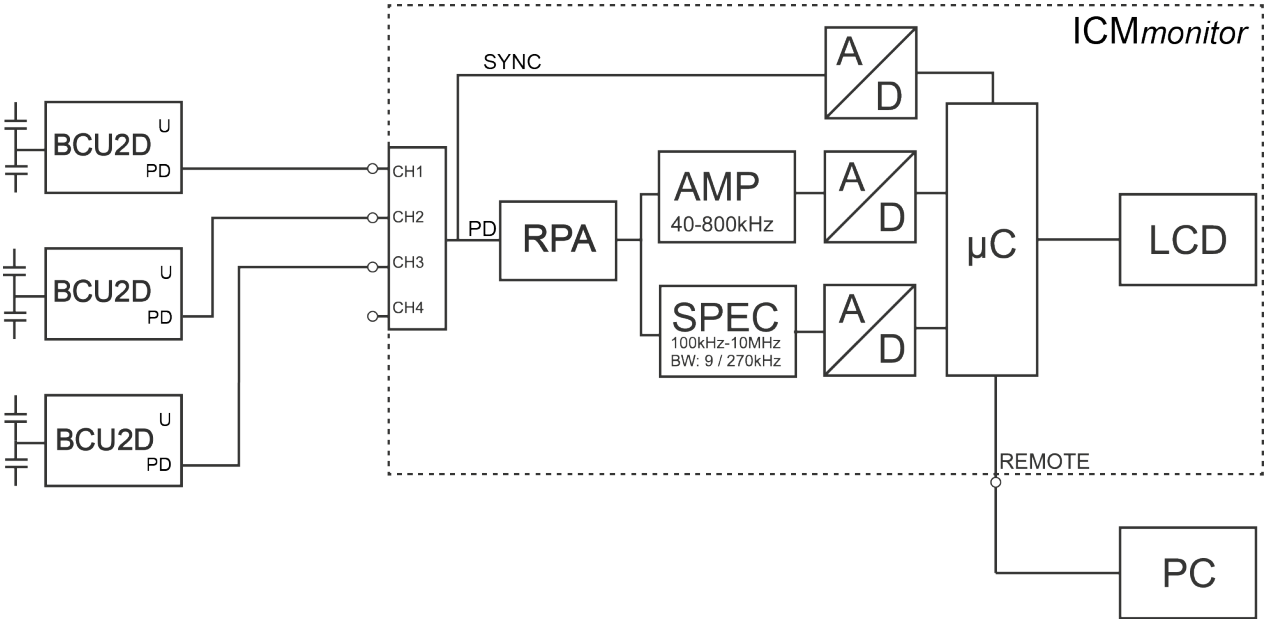


Figure III.23: Principal internal and external connections of the ICMmonitor with integrated RPA for superimposed PD and voltage signal

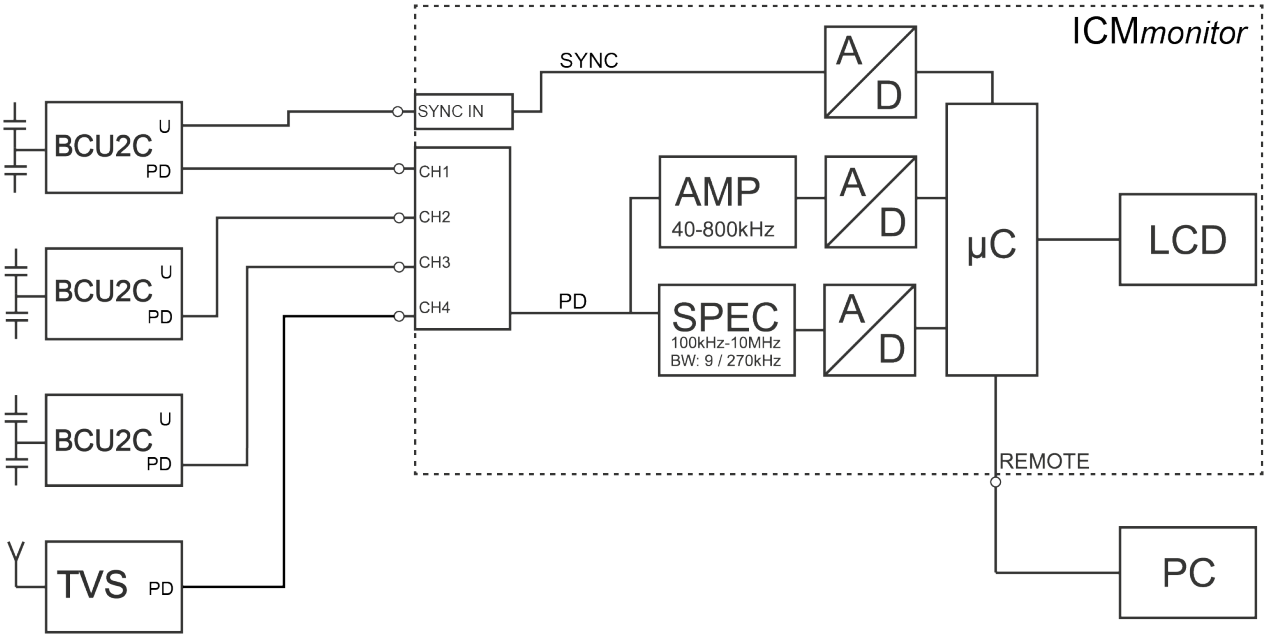


Figure III.24: Principal internal and external connections of the ICMmonitor for separate PD and voltage signal

With the setup shown in Figure III.24 the synchronisation signal can be derived from a voltage output of one BCU, the voltage signals from the other BCUs are shifted by 120° or 240°.

Caution: Don't use the superimposed PD and voltage signals for the inputs CH1 to CH4 as the ICM*monitor* does not have a preamplifier built in (input protection for the analogue PD path).

IV Operation

IV.1 General

After powering up the ICM*monitor*, the LC screen displays the logo and software version for about two seconds. Three short beeps indicate the initialisation of the instrument. One long beep later indicates a connected external modem device. This is also shown by a temporary 'REM' in the lower left corner. The instrument is controlled by the five pushbuttons on the front panel. In case of a remote control via PC software, these pushbuttons are disabled. The individual functions are assigned to each button by the menu fields on the right side of the display. There are several display modes and submenus available. The instrument automatically selects the display mode and submenu, which was active when the instrument was last switched off.

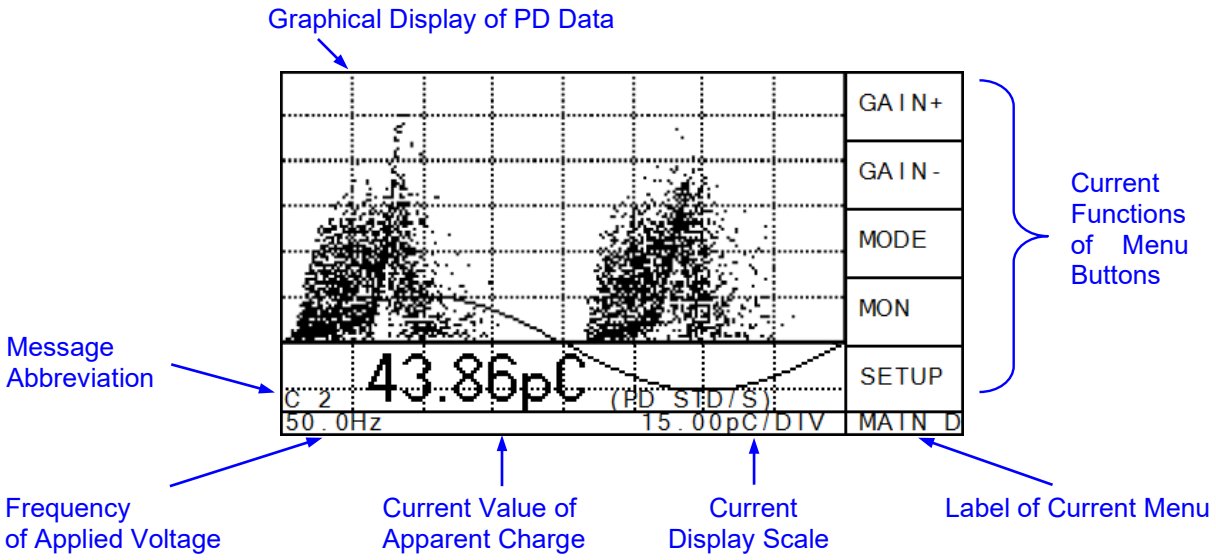


Figure IV.1: Parts of the ICM*monitor* display

The display consists of graphic elements such as the grid, the voltage curve, and the PD pattern. And it contains additional text elements such as the menu description, the values at the lower border and settings. Some conditions are displayed as abbreviations at the lower left side. The following table shows these abbreviations and its meaning.

Abbreviation Meaning

PD STD.....Standard PD measurement with or without RPA,
used with e.g., capacitive coupling units or quadrupoles.

AS+RPA.....Acoustic PD measurement with or without RPA1D (only),
if the RPA is turned off, the 'AMP IN' offers 12 V DC for the supply of the acoustic sensor,
if the RPA is turned on, an RPA1D should be used between the ICM*monitor* and the acoustic sensor (the RPA1D supports three gain steps and offers 15 or 28 V DC on its input).

PD UHF.....PD measurement in the ultrahigh frequency (UHF) band,
only sensible with the FCU2 and in the '/A' mode,
the display will change to a logarithmic grid.

/A.....Using the standard measuring path (AMP) with a frequency band of 40 to 800 kHz (max.).

/S.....Using the spectrum measuring path (SPEC D or SPEC N) with a tuneable frequency band of 0 to 10 MHz and a selectable bandwidth of 9 kHz or 270 kHz.

RPA?.....Missing preamplifier or damaged cable between preamplifier (i.e., RPA2) and input.

EXT .....External synchronisation; the device selects automatically the synchronisation source, means, that the line voltage will be used if there is no external voltage connected to the SYNC IN at the rear panel. For this, the ESYNC must be enabled.

RPA OFF .....Within the submenu MISC the control voltage for the preamplifier can be turned off.

G .....Analogue gating is turned on, selected channel number. See section IV.6.3.

C 4 .....Channel 4 of the multiplexer (MUX) is selected.

PC / NQ Alx .....Alarm level for the charge (PC) or NQS value is exceeded at channel x.

REM.....The software ICM*monitor* controls the instrument (during start up shown to indicate a modem).

In order to activate the MAIN menu, it may be necessary to press the EXIT button several times. This MAIN menu offers to toggle between five different display modes:

SCOPE, **MON**itoring, **PROJ**ection, **TIME** (trending), **SPEC**trum analyser

All MAIN menus offer the regular items:

GAIN+	GAIN+ and
GAIN-	GAIN- to adjust the preamplifier and internal gain to the actual signal magnitude.
MODE	MODE to call the specific configuration setup of that display mode.
SPEC	MON / PROJ / TIME / SPEC / SCOPE to change to the next display mode.
SETUP	SETUP to change the general instrument settings.
MAIN	

IV.2 Main display modes

The descriptions in this section refer to those kinds of models of the ICM*monitor*, that are furnished with a built-in display.

IV.2.1 Scope display

The display refresh rate of the ICM*monitor* is about 2 s^{-1}, thus every picture shows the discharge pulses accumulated over the last 25 cycles of the test voltage (at 50 Hz). The displayed sine wave helps to identify the phase position of the discharge impulses; it does not show the measured waveform. The line beneath the scope displays the synchronisation frequency, the scaling of the grid and the actual peak value of the apparent charge Q_p.

The buttons GAIN+ and GAIN- increases or decreases gain, i.e., the amplification factor, respectively. The grid scaling automatically tracks to the actual calibration and gain factor. The button AUTO activates the auto-range mode in which the gain is automatically adjusted. It is reduced, if the display reading continuously exceeds 90% full-range, and increased, if the reading remains under 20% of the selected scale. Every time the gain is changed automatically, a short beep from the built-in speaker is sound. [1]

Within the Scope mode there are two modes to display the PD pattern: NORM and HOLD.

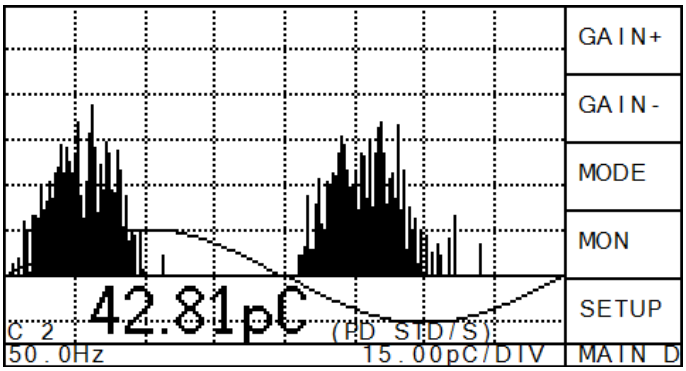


Figure IV.2: PD pattern in NORM mode

In the **NORM** mode every partial discharge (PD) pulse is displayed as a vertical line at the phase angle where it occurs. The length of the line is proportional to the apparent charge amplitude.

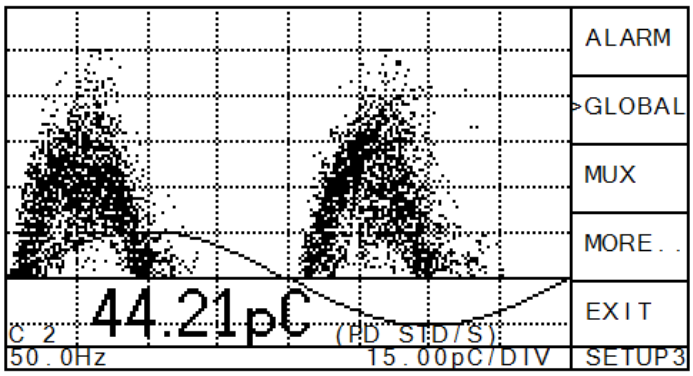


Figure IV.3: PD pattern in HOLD mode

In the **HOLD** mode every PD impulse activates a display pixel at the location according to the pulse magnitude and the phase angle of occurrence. The display is refreshed about every 400 ms which allows a visualisation of the build-up dynamics of a PD pattern (also called PD map or phase-amplitude distribution). Changing the gain or display mode will reset the PD pattern. Even though the ICM*monitor* can only 'count' up to 1 (pixel on/off) and other technical differences exist between the ICM*monitor* and the ICM*system,* the PD maps can be easily recognised and compared to the results obtained by the ICM*system*. The resolution of the ICM*system* is +/-128 x 256 x 65536 (16 Bit) versus 80 x 196 x 1 for the ICM*monitor* (amplitude x phase x count depth).

[1] Note: Using sensitive coupling with high charge levels, the system can be over-ranged. In this case, we can provide input attenuators.

IV.2.2 Monitoring display

The monitoring display mode offers two bar graph displays. On top the so-called NQS value, where N = number, Q = charge and S = per second. The NQS value shows the absolute discharge current and is derived by integrating the discharge values e.g., summing up the total charge flow, divided by the time interval (Q/t = [As]/[s]). The NQS value is displayed in a logarithmic scale e.g., 10^5 pA to 10^{11} pA = 100 nA to 100 mA. If an alarm threshold has been set within that range, a small arrow on top of the bar graph indicates the position. The lower bar graph shows the peak value of the apparent charge Q_P. This bar display has also a logarithmic scaling and the option to set an alarm level.

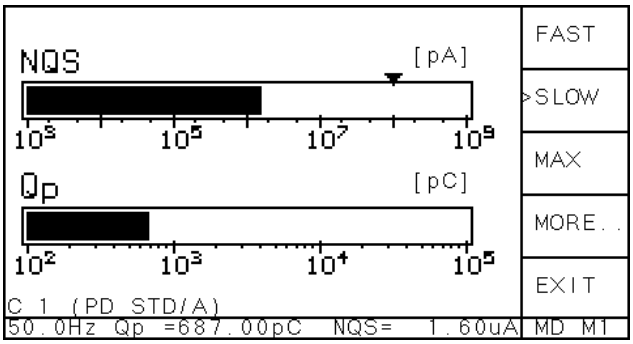


Figure IV.4: Monitoring display mode

The bar movement and speed is controlled in the menu **MD M1**. The chosen option is marked by an arrow ahead. However, the SLOW mode has turned out to be best suited for most applications.

When FAST mode is selected, the actual peak charge value of an acquisition cycle is displayed. This mode may lead to unstable readings (i.e., jerky movement of the peak charge bar).

When SLOW mode is selected, as well the peak value is displayed, but stabilised: Each time a new pulse occurs, the pointer shows the peak value practically immediately, and then slowly falls back until a new pulse occurs. When MAX mode is selected, the pointing edge remains on the peak value for one second, then slowly falls back.

The scaling is controlled in the menu **MD M2**. When LOW is selected, the bar graph for the QP value displays the range 10^0 to 10^3. The REC OUT range (0 to 10 V) for the NQS value equals 10^3 to 10^7.

When HIGH is selected, the bar graph for the QP value displays the range 10^2 to 10^5. The REC OUT range for the NQS value equals 10^5 to 10^9. If 'dBµV' is selected in the UHF mode, the scaling stays at 40-100 in both modes (HIGH and LOW).

The item AUTO calls the same auto-range function described in the previous chapter. The line underneath the bar display area shows the actual values of the synchronisation frequency, charge peak value and NQS value. The active input channel is indicated in the left lower corner.

IV.2.3 Projection display

The projection display mode PROJ shows the amplitude distribution graph of the measured PD pulses. This distribution graph reveals the contribution of each charge amplitude to the overall discharge current (NQS).

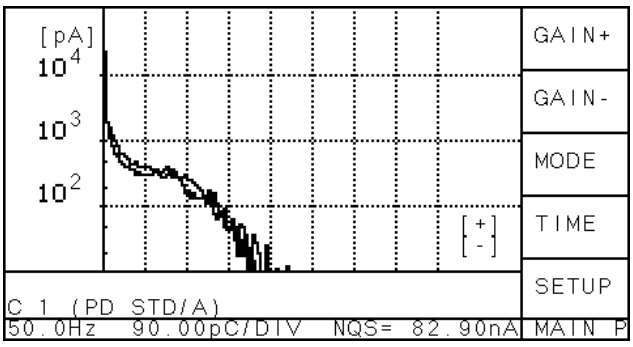


Figure IV.5: Projection display mode

The impulses are assorted to the positive and negative graph with respect to their occurrence related to the phase of the synchronisation signal derived from the coupler, since the original polarity of the pulses gets lost (!) during the frequency conversion procedure. Pulses occurring in the phase window from -11° to +169° are contributing to the positive graph, while the others are building up the negative graph.

The first item of the MODE menu toggles through the flashing modes of the graph (note: the button label shows the *next* option). The available options are flashing of the positive graph (+BLK), flashing of the negative graph (-BLK) or flashing disabled (NO BLK). The symbol [+] or [-] flashes together with the chosen graph. The second button switches between bipolar display (>BIPOL, i.e., positive and negative graph) and unipolar amplitude distribution (BIPOL). The latter to be used e.g., in case of line synchronisation and other applications, where the assorting into positive and negative pulses by looking to the phase position makes no sense. RESET restarts the calculation of the distribution graphs. The calculation procedure stacks several sets of measurements to achieve a stable reading and to smooth the distribution curves. This procedure ensures that also rarely occurring pulses will cause a stable contribution to the results. The button AUTO calls auto-range function as described in IV.1 Scope Display.

IV.2.4 Trending display

The trending display shows the evolution of the calculated discharge current – the NQS value – versus time. The trending data, projection graphs and further data can be downloaded to a PC via a serial link cable (RS232), UMTS, fibre optic link or LAN (TCP/IP). The time axis can be set to cover different time periods from some days to weeks, depending on the available memory. This selection is made in the SETUP 4 menu.

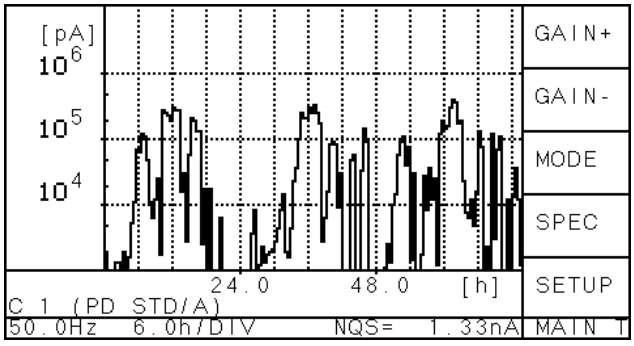


Figure IV.6: Trending display mode

Within the menu MODE the item MUX allows selecting one of the active channels (see SETUP3, item MUX) for the display. The RESET button clears all graphs – changing the time axis resolution in the SETUP4 menu (item MEM) clears the graphs too. EXIT returns to the MAIN menu.

With the multiplexer activated, the instrument will scan through the selected channels (SETUP3, item MUX) staying one minute at each channel. This time period can only be changed within the software ICM*monitor*. The trending display reveals the largest NQS value found during a scan cycle. The NQS alarm level is displayed together with the trending data as a horizontal line, if activated and not out of range. The actual reading of the NQS value can be found at the lower right-hand edge of the display area.

IV.2.5 Spectrum display

The SPEC mode shows the frequency spectrum of the input signal up to 10 MHz. Three traces for the current input channel allow to store, compare and process this spectrum. The figure below shows an example of a SPEC display with two traces. The cursor is placed on the lower trace at 570 kHz and has a magnitude of 13.77 mV.

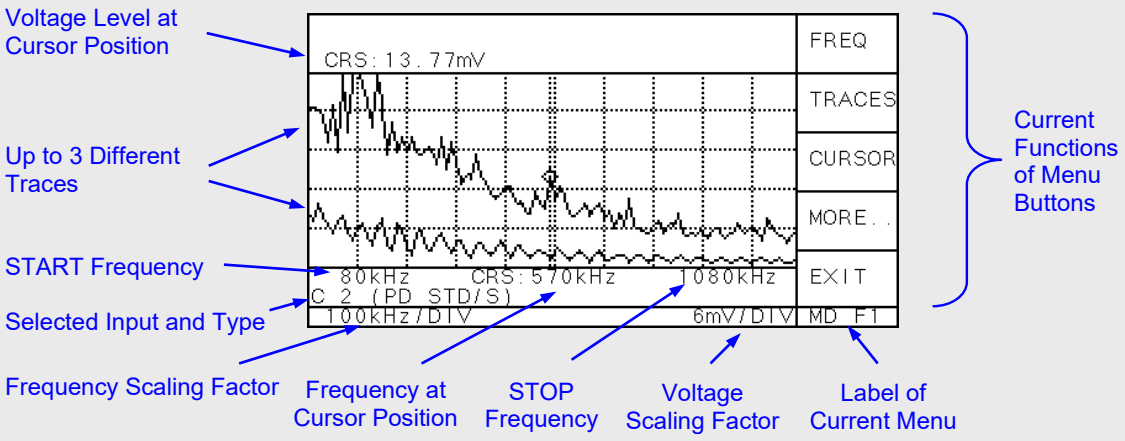


Figure IV.7: SPEC display mode

There are two MODE menus for adjusting the spectrum scan. 'MORE..' toggles between 'MD F1' and 'MD F2'. These menus are explained as followed; a description of all menus can be found in section IV.3.

FREQ

The **start** frequency can be set in steps of 10 kHz whereas the **span** (start frequency – stop frequency) has a variable step-size. The steps are set to get an even scaling factor (kHz/DIV). Therefore, the maximum frequency of 10 MHz can only be reached if e.g., the start frequency is 0 kHz, 2000 kHz...

TRACES

Accesses the trace softkeys that allow storing and manipulating trace information. The ICM*monitor* updates the information for any active trace with each sweep. The three traces (A, B and C) can be defined separately in 5 different modes:

- OFF Turns off the trace; graph is not visible.
- C/W Clears and writes the trace with every sweep.
- MHD The maximum values of all sweeps are updated and hold.
- VW Freezes the current view of trace.
- AVG The average of the last 1 to 10 values is shown. The number of values taken is set in the menu MD F2 / AVG.

CURSOR

The cursor can be shifted along the set frequency ('>>' and '<<') whereas the actual frequency is shown in the lower part next to 'CRS: '. With '->CF', this frequency is taken as 'centre frequency' (or measuring frequency) for the display modes SCOPE and METER, since these modes have only one fixed measuring frequency. This will not change the frequency spectrum of the SPEC mode. The current value at the cursor position is shown in the top line and taken from the selected trace. To change the trace, press the softkey 'TR_x', this will toggle through all three traces.

SWEEP
STEP
AVG
MORE...
EXIT
MD F2

SWEEP

Dwell-time (DWT) is the pause on one frequency during which demodulation takes place. The sweep-time (SWP) is calculated from the dwell-time, the span and the step-frequency. Sweep-time is the required time for one sweep i.e., scanning through the whole span of frequencies. If the sweep-time exceeds 1 second, the progress is indicated by an expanding line in the top of the display. To get the whole frequency spectrum of a pulse during on cycle (50 Hz or 60 Hz) in one sweep, the dwell-time should be set to 20 ms (16 ms). I.e., for measuring the frequency spectrum of the calibration pulse of a CAL1A, the dwell time should be at least 20 ms. The dwell time can be set in steps of 1 ms from 2 ms to 25 ms.

STEP

The STEP size defines the frequency steps between each demodulation within one sweep. It can be adjusted between 10 kHz and 1 MHz, however the minimum number of demodulation's is limited to 10 steps (frequencies) per sweep. Together with the dwell-time and the span, the sweep-time is calculated by:

$$SWP = (DWT + 0.5ms) \cdot \frac{SPAN}{STEP}$$

AVG

A trace can be smoothed with the average function (TRACES / A_AVG). The degree of smoothing can be adjusted from 1 (fast) to 10 (slow) in the menu MD F2 / AVG. This setting is valid for all three traces (A,B,C).

IV.3 Key menus

IV.3.1 Overview

All functions described in this section are based on the current firmware version 15.2. The firmware version of an instrument can be seen at the start-up info-screen or in the menu INFO. Older releases are not necessarily compatible to the new one. Please contact Power Diagnostix to get update possibilities and price.

Each menu consists of five entries (one for each button) and a name for the menu at the lower right-hand side. The background of the menu names in Figure IV.8 are coloured in the respective level-colour. Each arrow shows the menu, the user enters when pushing that button. The EXIT button jumps back to the previous menu (one or two upper level). These ways are not visualised.

Figure IV.8 gives an overview of the standard menus being accessible with all ICM*monitor* instruments.

- Optional menus such as the external gating option are displayed in grey characters.
- Functions which are disabled by the key-lock (SETUP2 / MISC / KEYB / LOCK) are marked with: 🔒
- The SPEC menus are only available if one channel is in the SPEC mode (SETUP3 / MUX / AMP→SPEC D→SPEC N). These menus have a grey shadow.

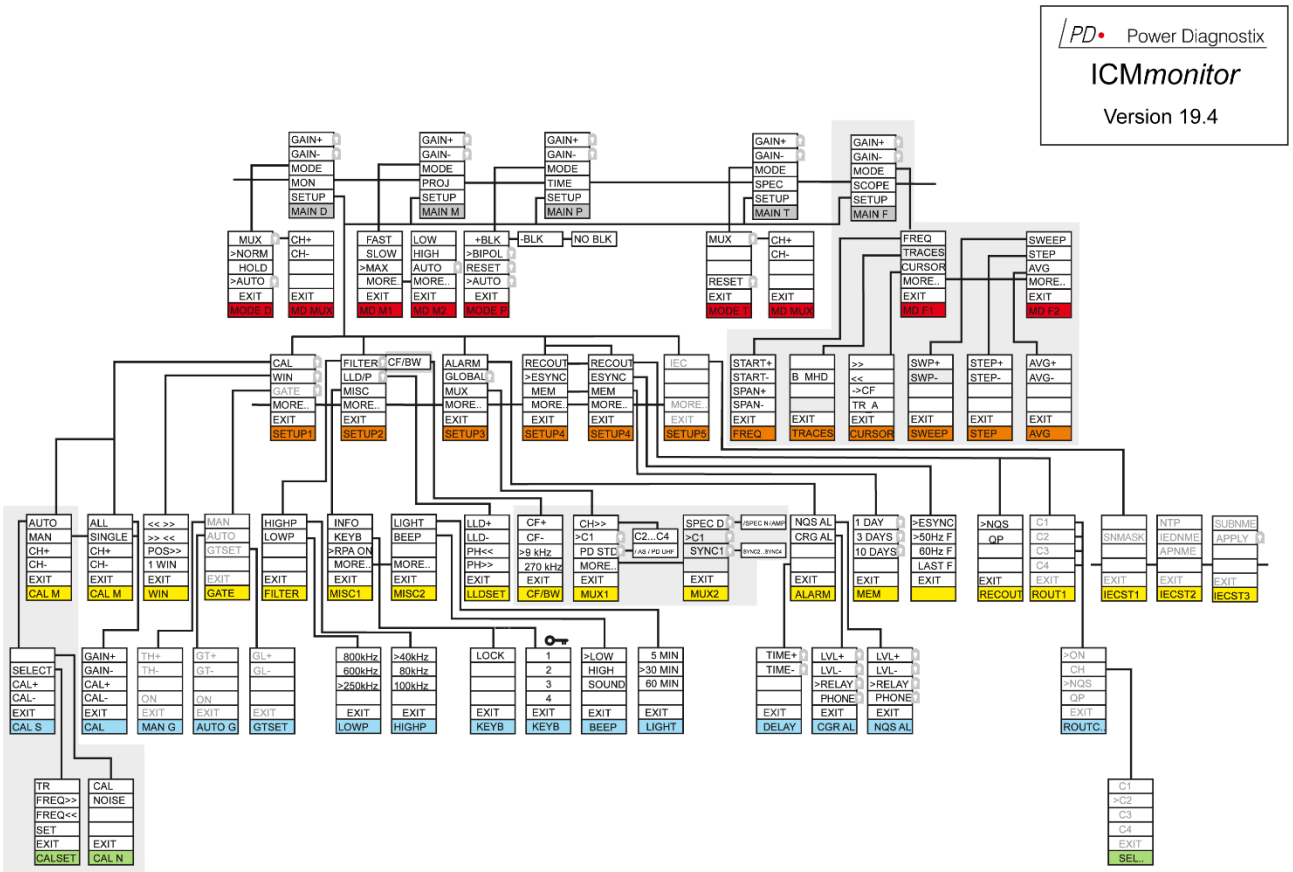


Figure IV.8: Menus of the ICM*monitor*

Key menus description

The following list explains all menus coming with the ICM*monitor*. Some settings are crucial for the PD measurement and can therefore be locked (see also LOCK). Such menus are signed with , this is not to confuse with the general key-lock during an access via the ICM*monitor* software.

GAIN+
GAIN-
MODE
MON
SETUP
MAIN D

GAIN+ / GAIN-

Sets up or down the amplification of the signal path. The total amplification is a combination of pre-amplification (external preamplifier, i.e., RPA1L) and main amplification (internal amplifier). By selecting the automatic mode (see MODE), the gain will be adjusted automatically to the current maximum discharge level. When setting the gain manually, it should be ensured that the PD peaks should be visible at 50% to 90% of the total display range. With very high gain settings, the noise becomes visible on the screen. If there is no phase dependency of the signal (no discharges), set the noise level to 5% of the total range of the display. This ensures that all new discharges will be recognised if their level is higher (see also LLD).

MODE

Push this button to change to the menu MODE D. Here settings relevant for the SCOPE display are done.

MON

Push this button to change to the next display mode, the monitoring mode.

SETUP

Push this button to change to the setup menu. Here general settings relevant for all display modes are done (see SETUP).

GAIN+
GAIN-
MODE
PROJ
SETUP
MAIN M

GAIN+ / GAIN-

(See MAIN D)

MODE

Push this button to change to the menu MODE M for the monitoring display. Here the bar movement and speed can be controlled.

PROJ

Push this button to change to the next display mode, the projection mode.

SETUP

(See MAIN D)

GAIN+
GAIN-
MODE
TIME
SETUP
MAIN P

GAIN+ / GAIN-

(See MAIN D)

MODE

Push this button to change to the menu MODE P. Here settings relevant for the projection display are done.

TIME

Push this button to change to the next display mode, the trending mode (versus time).

SETUP

(See MAIN D)

GAIN+
GAIN-
MODE
SPEC
SETUP
MAIN T

GAIN+ / GAIN-

(See MAIN D)

MODE

Push this button to change to the menu MODE T. Here settings relevant for the trending display are done.

SPEC (SCOPE)

Push this button to change to the next display mode, the SPEC mode. If no channel has the SPEC input activated (SETUP3 / MUX / AMP→SPEC), the next display mode will be the SCOPE mode.

SETUP

(See MAIN D)

GAIN+
GAIN-
MODE
SCOPE
SETUP
MAIN F

GAIN+ / GAIN-

(See MAIN D)

MODE

Push this button to change to the menu MD F1. Here settings relevant for the spectrum display are done.

SCOPE

Push this button to change to the next display mode, the SCOPE mode.

SETUP

(See MAIN D)

This menu is only available, if one channel is in SPEC mode
(SETUP3 / MUX / AMP→SPEC D→SPEC N).

MUX
>NORM
HOLD
>AUTO
EXIT
MODE D

MUX

The selected channel can be changed within this submenu. See also next MD MUX.
This MUX mode is not to confuse with the MUX setting within SETUP3 / MUX, where the settings for the single channels are done.

NORM

Setting this option (>) enables the normalised visualisation for the phase resolved PD display. The difference between NORM and HOLD is described in section IV.2.1 Scope Display.

HOLD

Setting this option (>) enabled the 'hold' visualisation for the phase resolved PD pattern.

AUTO

Setting this option (>) enables an automatic change of the gain.

EXIT

Push this button to change to the MAIN D menu.

CH+
CH-
EXIT
MD MUX

CH+ / CH-

These buttons allow a manual change of the current channel which is measured. The channel number is displayed in the lower left corner after the 'C'. The automatic change of the channels is active when this menu is left and after the set time (usually 60 Seconds). Only active channels can be selected. To activate a channel, go to SETUP3 / MUX / Cx.

EXIT

Push this button to change to the MAIN D menu.

FAST
>SLOW
MAX
MORE..
EXIT
MD M1

FAST

Either the FAST, SLOW or MAX option can be set (>). When FAST is selected, the actual peak charge value is displayed. See also section IV.2.2 Monitoring Display.

SLOW

When SLOW is selected, also the peak charge value is displayed, but the movement is stabilised. See section IV.2.2 Monitoring Display.

MAX

When MAX is selected, the pointer edge remains on the peak value for one second, then slowly falls back.

MORE..

Changes to the second mode menu 'MD M2'.

EXIT

Push this button to change to the MAIN M menu.

LOW
>HIGH
AUTO
MORE..
EXIT
MD M2

LOW

When LOW is selected, the bar graph for the QP value displays the range 10^0 to 10^3 pC. The REC OUT range (0 to 10 V) for the NQS value equals 10^3 to 10^7 pA. See also section IV.2.2 Monitoring Display.

HIGH

When HIGH is selected, the bar graph for the QP value displays the range 10^2 to 10^5 pC. The REC OUT range (0 to 10 V) for the NQS value equals 10^5 to 10^9 pA. If the instrument is in the UHF mode and 'dBµV' is selected, the scaling stays at 40–100 in both modes (LOW and HIGH).

AUTO

Setting this option (>) enables an automatic change of the gain. The gain of the preamplifier and the internal amplifier is adjusted automatically to the signal magnitude. See also section IV.2.1 Scope Display.

MORE..

Changes to the second mode menu 'MD M1'.

EXIT

Push this button to change to the MAIN menu.

+BKL
>BIPOL
RESET
>AUTO
EXIT
MODE P

+BLK, -BLK, NO BLK

Pushing this button toggles[2] through the flashing mode of the projection graph. Either the positive graph (-11° to 169°), the negative (-BLK) or no graph flashes. The option >BIPOL has to be selected (>) for this function. See also section IV.2.3 Projection Display.

BIPOL

Setting this option (>) enables the bipolar display of the projection graph. In unipolar mode, both graphs (pos. and neg.) are added up to one graph.

RESET

Pushing this button restarts the calculation of the distribution graphs. See also section IV.2.3 Projection Display.

AUTO

Setting this option (>) enables an automatic change of the gain. See section IV.2.1 Scope Display

EXIT

Push this button to change to the MAIN menu.

[2] The button label always shows the next option, not the current setting.

MUX
RESET
EXIT
MODE T

MUX

The selected channel can be changed within this submenu.

RESET

The RESET button clears the graph – changing the time axis resolution in the SETUP4 (item MEM) clears the graph too.

EXIT

Push this button to change to the menu MAIN T.

FREQ
TRACES
CURSOR
MORE..
EXIT
MD F1

FREQ

Push this button to change to the submenu FREQ. Here, the start frequency and the span (range) of frequencies can be set. See also section IV.2.5 Spectrum Display.

TRACES

Push this button to change to the submenu TRACE. Here the information of the three traces can be changed.

CURSOR

Push this button to change to the submenu CURSOR. Here the cursors can be shifted and the centre frequency set.

MORE..

Push this button to change to the next menu MD F2.

EXIT

Push this button to change to the MAIN F menu

SWEEP
STEP
AVG
MORE..
EXIT
MD F2

SWEEP

Push this button to change to the submenu SWEEP. Here the sweep-time can be changed via the dwell-time. See also section IV.2.5 Spectrum Display.

STEP

Push this button to change to the submenu STEP. Here the step size of frequency steps can be set. See also section IV.2.5 Spectrum Display.

AVG

Push this button to change to the submenu AVG. Here the average function can be adjusted. See also section IV.2.5 Spectrum Display.

MORE..

Push this button to change to the next menu MD F1.

EXIT

Push this button to change to the MAIN F menu.

The **SETUP menus** are accessible from all MAIN menus. However, some functions require a special display menu e.g., the phase shift LLD/P must be activated from the SCOPE display, since this is the only display mode where the influence of the modification can be estimated. Five setup pages are available. The number of the last activated setup page is stored – next pressing of the SETUP button recalls this page.

CAL
WIN
GATE
MORE..
EXIT
SETUP1

CAL

Push this button to change to the calibration menu CAL (see page 33). This menu is only available from the SCOPE and MON display.

WIN

Push this button to change to the menu WIN. In this menu, pulses can be blind out with respect to their phase position (see section IV.6.2).

GATE (optional function)

This function requires a special hardware and is only accessible from the SCOPE mode. It will change to the menu GATE. More details are in section IV.6.3.

MORE..

Push this button to change to the next setup menu 2.

EXIT

Push this button to change to the menu MAIN.

FILTER
LLD/P
MISC
MORE..
EXIT
SETUP2

FILTER CF/BW

Push this button to change to the menu FILTER to set the high- and low pass filter.

If the current channel is in SPEC mode, this button is labelled CF/BW. Within this submenu the centre frequency (or measuring frequency) and the bandwidth can be changed.

LLD/P

Push this button to change to the menu LLD/P to adjust the low level discriminator.

MISC

Push this button to change to the menu for miscellaneous settings, see page 37.

MORE..

Push this button to change to the next setup menu 3.

EXIT

Push this button to change to the menu MAIN.

ALARM
GLOBAL
MUX
MORE..
EXIT
SETUP3

ALARM

Push this button to change to the alarm menu for setting the NQS and charge alarm level.

GLOBAL

Selecting this option (>) will copy the current setup (from the active channel) to all other channels. With this option deselected it is possible to have a different setting for each channel. This refers to the settings of: GAIN, LLD/P, FILTER, GATE (window & external). Attention: There is no undo function to regain changed settings.

MUX

Push this button to change to the MUX menu. Here the single channels can be activated and defined (SPEC or AMP; PD, acoustic or UHF, phase shift).

MORE..

Push this button to change to the next setup menu 4.

EXIT

Push this button to change to the menu MAIN.

RECOUT
>ESYNC
MEM
MORE..
EXIT
SETUP4

RECOUT

Push this button to change to the RECOUT menu. Here the value for the REC OUT terminal can be set.

ESYNC

If this button is selected (>) the synchronisation signal is taken from the SYNC IN input, if possible. To manually turn to the line (mains) synchronisation, deselect the button.

MEM

The MEM menu controls the sampling rate of the NQS trending.

MORE..

Push this button to change to the setup menu 5.

EXIT

Push this button to change to the menu MAIN.

If the ICMmonitor is equipped with a battery (Explorer case model), the SETUP4 menu shows the following entries:

RECOUT
ESYNC
MEM
MORE..
EXIT
SETUP4

RECOUT

Push this button to change to the RECOUT menu. Here the value for the REC OUT terminal can be set.

ESYNC

Push this button to change to the ESYNC menu.

MEM

The MEM menu controls the sampling rate of the NQS trending.

MORE..

Push this button to change to the setup menu 5.

EXIT

Push this button to change to the menu MAIN.

The following menus are only available if one channel is in SPEC mode (SETUP3 / MUX / SPEC N(/D)) and if the SPEC display is active. To indicate these menus, a grey shadow is placed behind the text.

START+
START-
SPAN+
SPAN-
EXIT
FREQ

START+ / START-

Push this button to increment/decrement the start frequency in steps of 10 kHz. See also section IV.2.5 Spectrum Display.

SPAN+ / SPAN-

Push this button to increment/decrement the span of measured frequencies. The step size is set automatically, so that an even scaling factor (kHz/DIV) is given.

EXIT

Push this button to change to the menu MD F1.

A_AVG
B_MHD
C_C/W
EXIT
TRACES

A_, B_, C_,
OFF, C/W, MHD, VW, AVG

There are three traces (A_, B_ and C_) to display different curves. Pushing one of the three buttons will alter through the 5 different modes. Please see section IV.2.5 Spectrum Display.

OFF	Turns off the trace; graph is not visible.
C/W	Clears and writes the trace with every sweep.
MHD	The maximum values of all sweeps are updated and hold.
VW	Freezes the current view of trace.
AVG	The average of the last 1 to 10 values is shown. The number of values taken is set in the menu MD F2 / AVG

>>
<<
-> CF
TR_A
EXIT
CURSOR

>> <<

Pushing this button will shift the cursor along the frequency axis.

-> CF

Pushing this button takes the current cursor frequency as centre frequency (or measuring frequency) for the current active channel.

TR_A, _B, _C

Push this button to change the current trace. The measured value of the current trace is shown in the upper left corner (CRS:). The cursor position is indicated by ◇.

EXIT

Push this button to change to the menu MD F1.

SWP+
SWP-
EXIT
SWEEP

SWP+ / SWP-

Pushing this button will directly increase / decrease the dwell-time (DWT). It will also change the sweep-time (SWP). More details are in section IV.2.5 Spectrum Display.

EXIT

Push this button to change to the menu MD F2.

STEP+
STEP-
EXIT
STEP

STEP+ / STEP-

Pushing this button will increase / decrease the frequency step size between each demodulation. It can be set from 10 kHz to 1 MHz. More details are in section IV.2.5 Spectrum Display.

EXIT

Push this button to change to the menu MD F2.

AVG+
AVG-
EXIT
AVG

AVG+ / AVG-

Pushing this button will increase / decrease the number of values taken for the smoothing function (average). More details are in section IV.2.5 Spectrum Display.

EXIT

Push this button to change to the menu MD F2.

ALL
SINGLE
CH+
CH-
EXIT
CAL M

ALL

Push this button to change to the calibration menu (see next item). Here all channels are calibrated at once with the same calibration factor. The calibration factor is taken from the active channel.

SINGLE

Push this button to change to the calibration menu. Here only the active channel is calibrated.

CH+ / CH-

To change the active channel, press the corresponding button.

EXIT

Push this button to change to the menu SETUP 1.

GAIN+
GAIN-
CAL+
CAL-
EXIT
CAL

GAIN+ / GAIN-

Pushing this button increments/decrements the total gain by one step. The calibration signal should be 50% to 90% of the total y-axis range. Having a logarithmic scaling, the modulation range is displayed in the top row. Changing the gain **does not calibrate** the system. CAL+ / CAL- will recalibrate.

CAL+ / CAL-

These buttons can be used to enter the calibration value. Together with the measured peak charge level, the calibration factor is calculated and stored. There is no possibility to make it undo! The value should be set equal to the value shown on the connected pulse generator (e.g., CAL1A). For detailed information about calibration procedure see section IV.5.

EXIT

Push this button to change to the menu SETUP1.

If the current channel is in the SPEC mode, the CAL M menu has the following entries:

AUTO
MAN
CH+
CH-
EXIT
CAL M

AUTO

Push this button to change to the automatic frequency spectrum calibration mode (see section IV.5.2.2)

MAN

Push this button to change to the calibration menu. Here the active channel is calibrated.

CH+ / CH-

To change the active channel, press the corresponding button.

EXIT

Push this button to change to the menu SETUP 1.

CAL
SELECT
CAL+
CAL-
EXIT
CAL S

CAL

Starts the automatic frequency spectrum calibration mode and changes to the CAL N menu.

SELECT

Pushing this button switches to the menu for selecting a measurement frequency and setting the corresponding calibration.

CAL+ / CAL-

These buttons can be used to enter the calibration value. The value should be set equal to the value shown on the connected pulse generator (e.g., CAL1A). For detailed information about calibration procedure see section IV.5.

EXIT

Push this button to change to the menu CAL M

CAL
NOISE
EXIT
CAL N

CAL

Starts the automatic frequency spectrum calibration mode

NOISE

Starts a frequency spectrum scan after the calibration frequency spectrum scan without a calibration signal to measure the noise signal.

EXIT

Push this button to change to the menu CAL S

TR
FREQ>>
FREQ<<
SET
EXIT
CALSET

TR / RM / CUST

Select the predefined frequency set.

FREQ>>

Select the next frequency of the selected predefined frequency set. Used to select the measurement frequency and its calibration

FREQ<<

Select the next frequency of the selected predefined frequency set. Used to select the measurement frequency and its calibration

SET

Sets the selected frequency as new measurement frequency and the corresponding calibration.

EXIT

Push this button to change to the menu CAL S

<<>>
>><<
POS>>
1 WIN
EXIT
WIN

<<>>

Pushing this button widens the window(s) for blinding out the pulses on the display. The width of the windows is displayed at the upper right side of the screen, if at least one window is active.

>><<

Pushing this button scales down the window(s) for blinding out the pulses on the display.

POS >>

Push this button to change the position of each window. The phase position value is shown at upper left side of the display.

1 WIN (2 WIN, 3 WIN, OFF)

Selects the number of windows for the software gating. The phase distance using two windows is 180° and 120° for three windows. If one window should be used, the button '1 WIN' has to be pressed, so that '2 WIN' is displayed. The key always indicates the **next** option.

EXIT

Push this button to change to the menu SETUP1.

MAN
AUTO
GTSET
EXIT
GATE

GATE

A detailed description of the GATE menu can be found in section IV.6.3 Gating With External Sensor (Analogue Gating).

FILTER options are not available if the current channel is in SPEC mode (... /S).

HIGHP
LOWP
EXIT
FILTER

HIGHP

Push this button to change to the menu HIGHP for setting up the lower cut-off frequency.

LOWP

Push this button to change to the menu LOWP for setting up the upper cut-off frequency.

EXIT

Push this button to change to the setup menu SETUP2.

800kHz
600kHz
>250kHz
EXIT
LOWP

800kHz

Pushing this button sets the upper cut-off frequency to 800 kHz.

600kHz

Pushing this button sets the upper cut-off frequency to 600 kHz.

250kHz

Pushing this button sets the upper cut-off frequency to 250 kHz.

EXIT

Push this button to change to the setup menu FILTER.

>40kHz
80kHz
100kHz
EXIT
HIGHP

40kHz

Pushing this button sets the lower cut-off frequency to 40 kHz.

80kHz

Pushing this button sets the lower cut-off frequency to 80 kHz.

100kHz

Pushing this button sets the lower cut-off frequency to 100 kHz.

EXIT

Push this button to change to the setup menu FILTER.

If the instrument is used together with the preamplifier **RPA1**, it is recommended to use the maximum bandwidth of 40 to 800 kHz, in order to achieve a maximum sensitivity. Strong medium-wave radio-interference (typically between 526 and 1606 kHz) may require a reduction of the upper cut-off frequency (e.g., to 250 kHz) if the laboratory is insufficiently screened. Mains interference may require a selection of, e.g., 100 kHz as the lower frequency limit.

Using the preamplifier **RPA2**, the standard filter setting is HIGHP: 100 kHz and LOWP: 800 kHz since the limitation of the bandwidth is already done in the RPA2.

If the current channel is in the SPEC mode, the button 'FILTER' changes to 'CF/BW'.

CF+
CF-
>9 kHz
270 kHz
EXIT
CF/BW

CF+ / CF-

Pushing these buttons increments/decrements the centre frequency (measuring frequency). This value can be set between 100 kHz and 10 MHz.

9 kHz / 270 kHz

Pushing one of these buttons will set the bandwidth to 9 kHz or 270 kHz. The actual bandwidth is marked by '>'.

EXIT

Push this button to change to the setup menu SETUP3.

LLD+
LLD-
PH<<
PH>>
EXIT
LLDSET

LLD+ / LLD-

Pushing these buttons increases or decreases the level of the low-level discriminator. This value is displayed at the upper right side of the screen in percent (please see also section IV.6.1 LLD Noise Ground (Low-Level Discriminator)).

PH<< / PH>>

Pushing these buttons increases or decreases the position of the PD in relation to the zero point of the voltage synchronisation line. This value is displayed at the upper left side of the screen in degree (please see also section IV.6.1 LLD Noise Ground (Low-Level Discriminator))).

EXIT

Push this button to change to the setup menu SETUP2.

INFO
KEYB
>RPA ON
MORE..
EXIT
MISC1

INFO

Push this button to change to the INFO display. This display gives information about the current firmware version, hardware release and the mailing address of Power Diagnostix.

KEYB

Push this button to change to the menu KEYB. In here crucial menus, which will directly affect the PD measurement settings, can be locked and unlocked. To unlock the keyboard, a sequence of the numbers: **3 4 3 1** must be entered. Disabled functions are marked with the sign.

RPA ON

If this button is selected (>) the power supply for the preamplifier (e.g., RPA1) is turned on. To enable the use of the AMP IN terminal directly without preamplifier (e.g., via spectrum analyser) the checkmark has to be turned off.

MORE..

Push this button to change to the setup menu MISC2.

EXIT

Push this button to change to the setup menu SETUP2.

LOCK
EXIT
KEYB

LOCK

This button allows locking the keyboard, leaving only the functions available, which will not affect the parameters of the PD measurement. The locked functions are labelled in the menu structure (Figure IV.8) and in this description by .

EXIT

Push this button to change to the menu MISC1.

1
2
3
4
EXIT
KEYB

1, 2, 3, 4

Entering the KEYB menu while being locked, the buttons are labelled 1, 2, 3, 4, EXIT. To unlock the keyboard a sequence of the numbers: **3 4 3 1** must be pressed. If a wrong number has been pressed, the KEYB menu must be exit and re-entered to clear the internal code memory.

EXIT

Push this button to change to the menu MISC1

LIGHT
BEEP
MORE..
EXIT
MISC2

LIGHT

Push this button to change to the LIGHT menu for setting up the timer of the screen saver.

BEEP

The sound when pressing one of the five keys can be modified here. See also menu BEEP.

MORE..

Push this button to change to the setup menu MISC1.

EXIT

Push this button to change to the setup menu 2.

5 MIN
>30 MIN
60 MIN
EXIT
LIGHT

5 MIN, 30 MIN, 60 MIN

Pushing these buttons sets the automatic screen saver. If for about 5, 30 or 60 minutes no button has been pressed, the background lighting of the display will be turned off. The light will be turned on by pressing any button.

EXIT

Push this button to change to the setup menu MISC.

>LOW
HIGH
SOUND
EXIT
BEEP

LOW / HIGH

Pushing these buttons switches between a higher or lower sound for the buttons.

SOUND

Pushing this button enables (>) or disables the audible indicator for the partial discharge signal. When >SOUND is selected, each PD signal will result in a short sound.

EXIT

Push this button to change to the setup menu MISC.

NQS AL
CRG AL
DELAY
EXIT
ALARM

NQS AL

Push this button to change to the menu NQS AL. There the alarm configuration of the discharge current alarm can be done.

CRG AL

Push this button to change to the menu CRG AL. There the alarm configuration of the peak discharge alarm can be done.

After setting the alarm level the related value (NQS and/or QP) has to exceed the alarm threshold for four seconds in a row to activate an alarm.

DELAY

Push this button to change to the menu DELAY.

EXIT

Push this button to change to the setup menu 3.

LVL+
LVL-
>RELAY
PHONE
EXIT
NQS AL

LVL+ / LVL-

Pushing these buttons increases or decreases the threshold for the discharge current alarm.

RELAY

If this button is selected (>) an active alarm will switch the implemented relay output. For the connections of the relay, see Figure III.8, Figure III.10, or Figure III.14.

PHONE

If this button is selected (>) a triggered alarm will start a phone call via the connected modem. The phone number can only be set in the ICM*monitor* software.

EXIT

Push this button to change to the menu ALARM.

LVL+
LVL-
>RELAY
PHONE
EXIT
CRG AL

LVL+ / LVL-

Pushing these buttons increases or decreases the threshold for the peak discharge alarm.

RELAY

If this button is selected (>) an active alarm will switch the implemented relay output. For the connections of the relay, see Figure III.8, Figure III.10, or Figure III.14.

PHONE

If this button is selected (>) a triggered alarm will start a phone call via the connected modem. The phone number can only be set in the ICM*monitor* software.

EXIT

Push this button to change to the menu ALARM.

Within the monitoring-display (MON), both alarm thresholds are indicated by small triangles ▼ above the display. The charge alarm threshold is also shown in the scope-display as a horizontal line. Whereas the NQS alarm threshold is also shown in the trending-display (TIME) as horizontal line. Both alarm conditions will activate the same output relay or phone call. The alarm-causing source will be displayed in the alarm status line above the cannel display (left, lower corner). E. g. for peak charge alarm on channel two the display reads PC AL2. The NQS AL will be dominant in case of both thresholds being exceeded. There is no alarm level setting, which is universally valid for all machines. As a rule of thumb with an NQS value higher than ten µA and a peak charge value continuously above ten nC more detailed measurement should be done. The software ICM*monitor* offers some further functions to handle the alarm data.

TIME+
TIME-
EXIT
DELAY

TIME+ / TIME-

Pushing these buttons increases or decreases the delay for the peak discharge alarm. Values from 0 to 60 minutes are available in 1-minute-steps.

EXIT

Push this button to change to the menu ALARM.

The function of each channel can be set separately. This must be done according to the connected sensor. The MUX menu controls the activity of the build-in multiplexer. Every channel marked with an arrow (>C1) will be scanned by the instrument, staying approx. one minute at each activated channel. This scanning time can only be changed with the ICM*monitor* software. The multiplexer will remain at channel 1 with none of the channels marked. The channel number, from which the actual displayed data is derived, is shown in the lower left corner on the LCD. Behind the channel number (e.g., 'C1') the acquisition mode is shown (e.g., 'PD STD/A').

This MUX mode shall not be confused with the MUX selection within 'MAIN D / MODE D / MUX' or 'MAIN T / MODE T / MUX', where the active channel can be set manually.

CH>>
>C1 120
PD STD
MORE..
EXIT
MUX1

CH >>

Pushing this button toggles through all channels (4, 8, or 12 depending on the mux version). The selected channel is shown at the second menu button (e.g., >C1 120).

C1; >C1; >C1 120; >C1 240

Pushing this button toggles through the phase shift menu and enables to turn off the channel (no mark '>'). The phase shift is shown behind the channel number. There are three steps possible: 0°, 120° and 240° (for the phase shift in a 3-phase system if only one synchronisation signal is available).[3] This phase shift is not to confuse with the phase shift in the menu LLDSET.

PD STD; AS; PD UHF

Pushing this button toggles through the sensor selection.

PD STD for standard partial discharge (PD) measurements with or without preamplifier used with e.g., capacitive coupling (CC) units or quadrupoles (CIL / CIT)

AS for acoustic PD measurement with or without RPA1D (only)
if the RPA is turned off, the 'AMP IN' offers 12 V DC for the sensor supply
if the RPA is turned on, the RPA1D supplies the acoustic sensor with 15/29 V_{DC}

PD UHF for PD measurement in the ultrahigh frequency band,
only sensible with the FCU2 and in the '/A' mode (not spectrum path), the display will change to a logarithmic grid.

MORE..

Push this button to change to the menu MUX2.

EXIT

Push this button to change to the setup menu 3.

[3] With the usual direction of rotation and synchronisation to phase 1, the shift for phase 2 is -120° (i. e., +240°) and for phase 3 -240° (i. e. +120°). In other words, with synchronisation to U the graph of V is shifted by 120° to the left, i. e. -120° and corresponds to +240°. Ditto for phase W by 240° to the left corresponding to -240° or +120°.

AMP
>C1 120
SYNC1
MORE..
EXIT
MUX2

AMP; SPEC D, SPEC N;

Pushing this button toggles between the spectrum path and the standard analogue path. With the AMP path, a frequency band of 40 to 800 kHz (max.) is used.

With the SPEC path, a tuneable frequency band of 100 kHz to 10 MHz can be used with a bandwidth of 9 or 270 kHz. Two different settings are selectable: SPEC D is dynamic optimised, while SPEC N is noise optimised, which means that the combination of pre-gain and spec-gain is optimised according to this selection.

SYNC1; SYNC2; SYNC3 …

This menu is for setting the synchronisation channel for the chosen acquisition channel. Pushing this button toggles through all sync channels (4, 8, or 12 depending on the mux version).

MORE..

Push this button to change to the menu MUX1.

EXIT

Push this button to change to the setup menu 3.

>NQS
Qp
EXIT
RECOUT

NQS

If this option is activated (>), the REC OUT terminal of the ICM*monitor* provides NQS values.

Qp

If this option is activated (>), the REC OUT terminal of the ICM*monitor* provides Qp values.

EXIT

Push this button to change to the setup menu 4.

If the ICM*monitor* is equipped with auxiliary outputs, please refer to section IV.4.1.1 for the entries of the ROUT1 menu of instruments with AUXOUT option.

(Only available for Explorer case models with battery)

>ESYNC
>50Hz F
60Hz F
LAST F
EXIT
ESYNC

ESYNC

If this button is selected (>), the synchronisation signal is taken from the SYNC IN input, if possible. To manually turn to the line (mains) synchronisation, deselect the button.

50Hz F

If this button is selected (>) and there is no synchronisation signal available, the synchronisation frequency (fallback) is set to 50 Hz. There is no synchronisation signal, if the device is running on battery and there is no external synchronisation signal connected.

60Hz F

If this button is selected (>) and there is no synchronisation signal available, the synchronisation frequency (fallback) is set to 60 Hz. There is no synchronisation signal, if the device is running on battery and there is no external synchronisation signal connected.

LAST F

If this button is selected (>) and there is no synchronisation signal available, the synchronisation frequency (fallback) is set to the last valid frequency. There is no synchronisation sig-

nal, if the device is running on battery and there is no external synchronisation signal connected.

EXIT

Push this button to change to the setup menu 4.

1 DAY
3 DAYS
10 DAYS
EXIT
MEM

1 DAY; 3 DAYS; 10 DAYS

The MEM menu controls the sampling rate of the trending data. The data of NQS and QP (peak charge value) are continuously stored in the ICM*monitor*. The table beneath shows the total memory duration depending on the sampling interval and the ICM*monitor* type.

Sampling Interval	Memory Duration
6 min	1 day
18 min	3 days
60 min	10 days

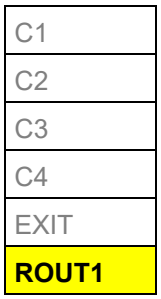
EXIT

Push this button to change to the setup menu 4.

IV.4 Optional key menus

IV.4.1.1 AUXOUT option

If the ICMmonitor is equipped with four auxiliary outputs the ROUT1 menu shows the following entries:



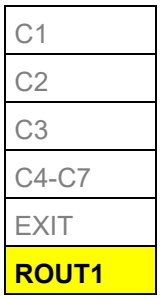
C1 … C4

Pushing one of these buttons changes to the configuration menu of the corresponding output channel (ROUTC1 … ROUTC4).

EXIT

Push this button to change to the setup menu 4.

If the ICMmonitor is equipped with eight auxiliary outputs the ROUT1 menu shows the following entries:



C1 … C3

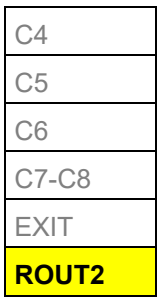
Pushing one of these buttons changes to the configuration menu of the corresponding output channel (ROUTC1 … ROUTC3).

C4-C7

This button changes to the ROUT2 menu.

EXIT

Push this button to change to the setup menu 4.



C4 … C6

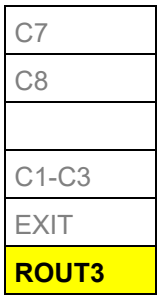
Pushing one of these buttons changes to the configuration menu of the corresponding output channel (ROUTC4 … ROUTC6).

C7-C8

This button changes to the ROUT3 menu.

EXIT

Push this button to change to the setup menu 4.



C7, C8

Pushing one of these buttons changes to the configuration menu of the corresponding output channel (ROUTC7 or ROUTC8).

C1-C3

This button changes to the ROUT1 menu.

EXIT

Push this button to change to the setup menu 4.

As the ROUTC menu for every auxiliary output channel is identical, the entries of ROUTC1 menu (for auxiliary output 1) and its sub menus are given here as an example.

ON
CH
>NQS
QP
EXIT
ROUTC1

ON

Pushing this button will activate (>) or deactivate the output.

CH

This entry changes to the SEL1 menu

NQS

If this option is activated (>), the auxiliary output terminal provides NQS values.

Qp

If this option is activated (>), the auxiliary output terminal provides Qp values.

EXIT

Push this button to change to the ROUT1 menu.

C1
C2
C3
C4
EXIT
SEL1

C1 ... C4

If these entries are activated (>), the signals of the corresponding PD input channels are used to derive the output signal for auxiliary output 1.

EXIT

Push this button to change to the ROUTC1 menu.

IV.4.1.2 IEC 61850 option

IEC
MORE..
EXIT
SETUP5

IEC

Push this button to change to the menu IECSTD1, where all relevant values for a IEC 61850 compliant communication with an external IEC 61850 client can be set.

MORE..

Push this button to change to the setup menu 1.

EXIT

Push this button to change to the menu MAIN.

IP
SNMASK
GATEW
MORE..
EXIT
IECST1

IP

Within this submenu the IP address of the ICM*monitor*'s IEC module can be set.

SNMASK

Submenu for setting the IEC module's subnet mask.

GATEW

Submenu for setting the IEC module's gateway.

MORE..

Push this button to change to the menu IECST2.

EXIT

Push this button to change to the setup menu 5.

NTP
IEDNME
APNME
MORE..
EXIT
IECST2

NTP

Within this submenu the IP address of the network time protocol server can be set.

IEDNME

Submenu for setting the name of the IED (Intelligent Electronic Device)

APNME

Submenu for setting the name of the access point.

MORE..

Push this button to change to the menu IECST3.

EXIT

Push this button to change to the setup menu 5.

SUBMNE
APPLY
MORE..
EXIT
IECST3

SUBNME

Within this submenu the name of the substation can be set.

APPLY

Pushing this button saves the settings of IEC menus to the memory of the IEC module. A sound indicates whether the storage was successful (low-high beep) or not (high-low beep).

MORE..

Push this button to change to the menu IECST1.

EXIT

Push this button to change to the setup menu 5.

IV.5 Calibration

PD measurements refer to the apparent charge and are relative measurements. Therefore, each new installation, changes of relevant quantity (e.g., bandwidth, coupling capacitance etc.) requires a new calibration. This is done by injecting a known PD pulse close to the origin of the real PD source (specimen) and from this calculating the scale factor for the measurement. The injected PD pulse should be in the range of 50% to 200% of the expected PD magnitude.

IV.5.1 Calibration impulse generator

There is a broad range of impulse generators offered by Power Diagnostix for different purposes. Table IV.1 gives an overview of these calibrators.

Calibration Impulse Generator	Range	Injection Capacitor (C_i)	50Hz or 60Hz light sync.	IEC 60270 compliant	2 pulses / cycle option	BNC connection	Remarks
CAL1A	1, 2, 5, 10, 20, 50, 100 pC	<1 pF	✓	✓	✓	✓	standard, laboratory use
CAL1B	100, 200, 500 pC, 1, 2, 5, 10 nC	<100 pF	✓	✓	✓	✓	high level application, e.g., rotating machines, cable field tests
CAL1C	1, 2, 5, 10, 20, 50, 100 pC* at 100 pF	V (50 Ω)	✓	✓	✓	✓	incl. ext. capacitor 100 pF; transformer tests
CAL1D	10, 20, 50, 100, 200, 500, 1000 pC	<10 pF	✓	✓	✓	✓	standard, laboratory use, transformer tests
CAL1E	0.5, 1, 2, 5, 10, 20, 50 nC	<500 pF	✓	✓	✓	✓	see CAL1B
CAL1F	0.2, 0.5, 1, 2, 5, 10, 20 nC	<200 pF	✓	✓	✓	✓	
CAL1G	0.02, 0.05, 0.1, 0.2, 0.5, 1, 2 nC	<20 pF	✓	✓	✓	✓	transformer tests
CAL1H	0.5, 1, 2, 5, 10, 20, 50 pC* at **pF	V (50 Ω)	✓	✓	✓	✓	GIS, live injection via stray cap.
CAL1J	10, 20, 50, 100, 200, 500, 1000 pC* at 100 pF 100, 200, 500, 1000, 2000, 5000, 10000 pC* at 1 nF	V (50 Ω)	✓	✓	✓	✓	incl. ext. capacitor 100 pF/1 nF, switchable; transformer tests
CAL2B	2, 5, 10, 20, 30, 40, 50 V (into 50 Ω)	V (50 Ω)	✓	-	-	N	GIS & UHF
CAL2C	1, 2, 5, 7, 10, 12, 15, 17, 20 V (into 5 Ω)	V (50 Ω)	✓	-	-	N	
CAL2D	5, 7.5, 10, 15, 20, 30, 40 V (into 50 Ω)	V (50 Ω)	✓	-	-	N	
CAL3A	600 kHz to 1.35 MHz, 10 µV to 10 mV	V (50 Ω)	✓			✓	
CAL3B	400 kHz to 1.9M Hz, 10 µV to 10 mV	V (50 Ω)	✓			✓	RIV calibration, NEMA compliant
CAL3C	600 kHz to 1.35 MHz, 20 µV to 2 mV	V (20 KΩ)	✓			✓	RIV calibration, NEMA compliant
							RIV calibration, CISPRE 18-2 compliant

*with external high voltage capacitor, ** value to be specified by customer

Table IV.1:Output ranges of PD calibrators

All calibrators are switched on with the pushbutton On/Off. Both amplitude (Range) and polarity (Pos/Neg) of the single charge pulse per cycle are displayed and can be adjusted by pressing the corresponding button. The instrument is synchronised to line frequency by a photo diode. In case of insufficient pick-up of power frequency light, it will automatically select the internal quartz oscillator (50 Hz and 60 Hz versions available). The button On/Off must be pressed for more than 1 second to switch the pulse generator off, while automatic switch-off occurs after approximately 15 min.

Operation time of up to 200 hours are obtainable with the 9 V lithium battery due to an average supply current of approx. 5 mA (quiescent current is negligible). An alkaline battery resulting in approx. 90 hours of continuous operation may replace the lithium battery. A weak battery is indicated by the LO BAT sign of the LC display.

Warning: While changing battery, be aware of internal parts carrying up to 125 V of DC potential!

Figure IV.9: Calibrator

The entire signal path from the discharging source to the instrument, as well as some instrument properties as filters, for instance, are introducing an overall attenuation which is not precisely known. Thus, the calibrator (CAL1A or equivalent) has to be connected to the actual PD source as close as possible.

To calibrate a test setup where a current transformer (as CT1 or CT100) is used, place the positive clip of the calibrator on the high voltage side of the test object, and the negative clip of the calibrator on the low voltage side of the test object. This will ensure that the calibration pulse will take the same signal path as the actual PD pulse.

IV.5.2 Calibration menu

IV.5.2.1 PD calibration

The ICM*monitor* offers a calibration menu (CAL M) which can be found as first item in the menu SETUP1. The calibration should be done in the SCOPE display, as all relevant information is available here. However, the menu CAL is not available, when the optional display PROJ (projections), TIME (trending) or SPEC are visible. Figure IV.10 shows the calibration in the SCOPE menu.

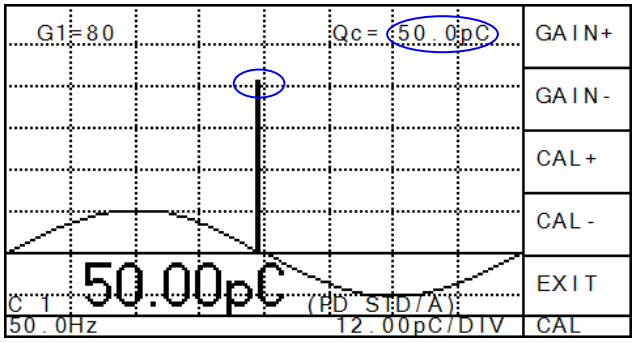


Figure IV.10: Scope display during calibration

Once the calibration pulse is displayed on the screen, GAIN+ and GAIN- should be used to place the calibration signal reading between 50% and 90% of full scale (i.e., four divisions, since maximum is at five divisions). The CAL+ and CAL- buttons then adjust the calibration value (shown in the upper part of the display). This value corresponds to the one on the calibration impulse generator. It is not possible to undo a calibration!

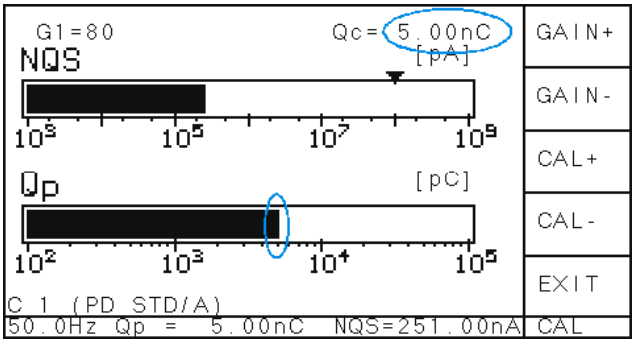


Figure IV.11: Monitoring display during calibration

The calibration factor and all other parameters remain stored when the system is switched off and are automatically recalled when the system is switched on again. Be sure, that the calibration is only changed in case of setup modifications to keep the integrity of the monitoring results.

If the calibration factor is saved from previous calibrations or from an identical test setup, it is also possible to download them via the ICM*monitor* software.

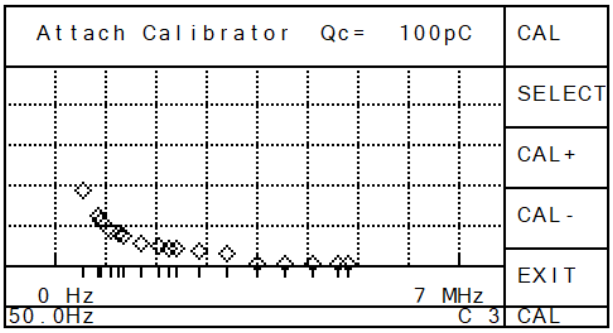
The software ICM*monitor* offers to save the whole data and instrument settings (as *.mon) and thus enables to repeat a measurement with the same settings and calibration. For using a stored calibration, it has to be ensured, that the measurement circuit is the same. For saving and loading the instrument settings, see sections VI.2.4 and VI.2.5.

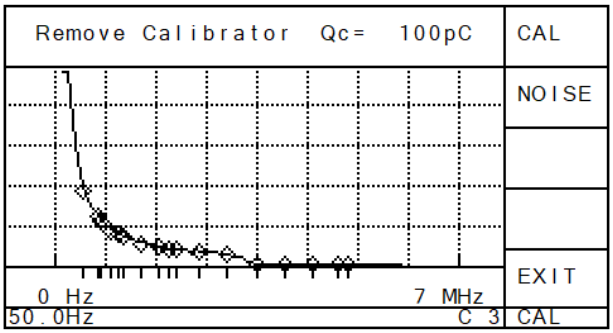
Caution: For calibration, the system has to be de-energised!

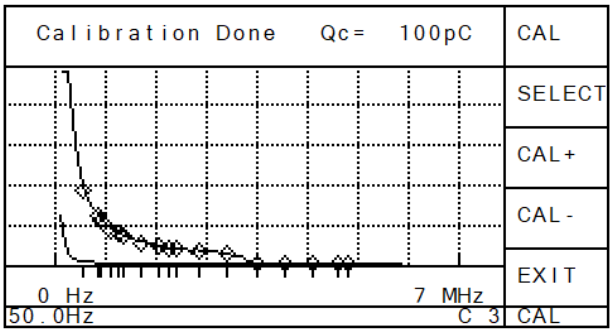
While being in the CAL menu, the channel is fixed to the current channel number. There is no automatic change. When leaving the CAL menu, the instrument continues to toggle through the active channels. If the user leaves the instrument by mistake in the CAL menu, the instrument will leave this menu as soon, as the light of the LCD turns off automatically. Thus, the instrument continues the automatic shift between the channels.

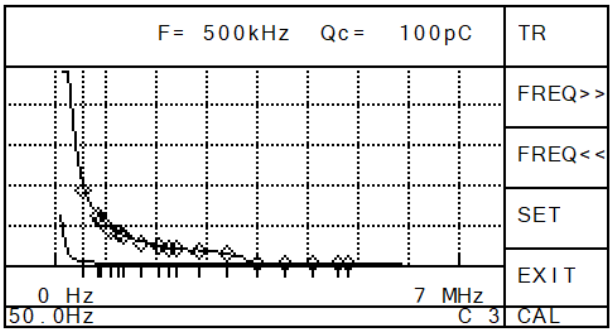
IV.5.2.2 Automatic frequency spectrum calibration

If the active acquisition channel is in SPEC mode, the CAL M menu offers the AUTO menu item. Selecting this item will switch to the automatic frequency spectrum calibration mode. If the SPEC mode is selected for an acquisition channel, the calibration is only valid for the measurement frequency on which the calibration was performed. The automatic frequency spectrum calibration mode offers the possibility to store and load the calibration for up to 20 measurement frequencies. The device offers three different predefined sets of measurement frequencies for calibration. The first set is intended for measurements at transformers (TR) and offers the following frequencies: 500, 750, 800, 1000, 1100, 1200, 1500, 1800, 2000, 2100, 2500, 3000, 3500, 4000, 4500, 4900, 5100 kHz. The second set is intended for measurements at rotating machines (RM) and offers the following frequencies: 500, 700, 900, 1100, 1200, 1300, 1500, 1800, 2000, 2100, 2200, 2500, 2800, 3000, 3500, 4000, 4500 kHz. The third set is customizable (CUST) by the ICM*monitor* software and offers the following predefined frequencies: 500, 750, 800, 1000, 1100, 1200, 1500, 1800, 2000, 2100, 2500, 3000, 3500, 4000, 4500, 4900, 5100, 5500, 6000, 6500 kHz. It is not possible to define different customised sets for different acquisition channels. There is only one customised set. The predefined set must be selected before starting the calibration.









The device uses an automatic gain adjustment function during the calibration. If the calibrator is connected to the test object, the calibration value (shown in the upper part of the display) must be adjusted by the CAL+ and CAL- buttons. The automatic calibration function can then be started by pressing the CAL button. Starting the calibration, will erase a previous calibration and cannot be undone. During the calibration a frequency scan in 10 kHz steps will be performed. The display shows the measured values versus frequency. The values for the frequencies of the selected set are marked by diamonds. After the calibration, a frequency scan with the noise signal can be performed. Therefore, the calibrator must be switched off and the NOISE button must be pressed. The noise trace together with the calibration trace allows to select a measurement frequency with a good signal-to-noise ratio. To select a measurement frequency press the SELECT button. The first button in this menu allows to select the predefined set of frequencies. The selected set is shown. Pressing the button switches through the possible sets. With the FREQ>> and FREQ<< buttons the measurment frequency can be selected. Pressing the buttons toggles forward resp. backward through the frequencies of the selected set. The currently selected frequency is displayed in the top area of the screen. Pressing the SET button sets the selected frequency as the new measurement frequency and also sets the corresponding calibration.

IV.6 Noise reduction

IV.6.1 LLD noise ground (low-level discriminator)

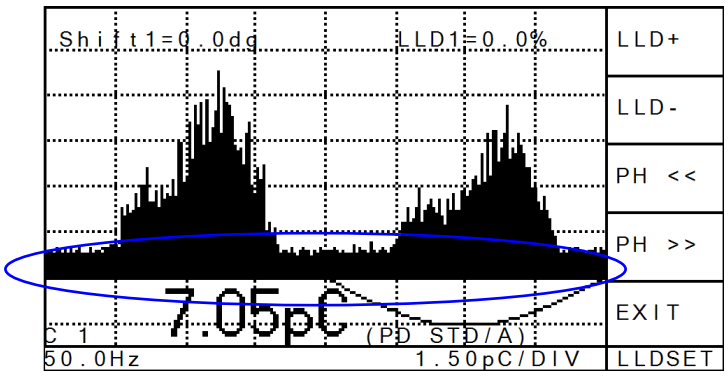


Figure IV.12: PD pattern including noise level (LLD=0%)

Depending on the environment and the measurement circuit, different levels of background noise are visible (see Figure IV.12). Since this noise level is usually stable for the whole period (360°), it can be removed by the LLD function (low level discriminator). All PD pulses falling beneath the LLD-threshold are deleted. This will remove the broad black band in the HOLD and NORM mode of the SCOPE display.

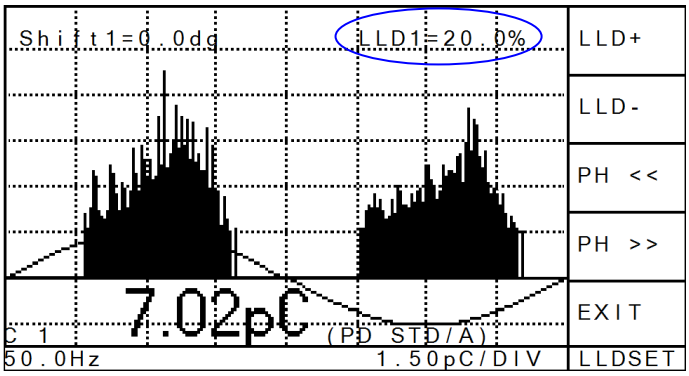


Figure IV.13: PD pattern without background noise

The LLD can be set in the menu SETUP2 \ LLDSET by the buttons LLD+ and LLD-. The standard range of the LLD is 5 % to 10 %.

PH>>: Usually the ICM*monitor* is synchronised with the voltage signal derived from the line side couplers fed into the 'SYNC' inputs. Because of the resistive loading of the coupling capacitor, the residual voltage used for synchronisation has a phase shift to the related high voltage. With an insufficient AC component of this signal, the instrument automatically synchronises to the supplying line voltage (mains). Even with line synchronisation of the same phase, it may be necessary to correct the phase position.

IV.6.2 Window mask (software)

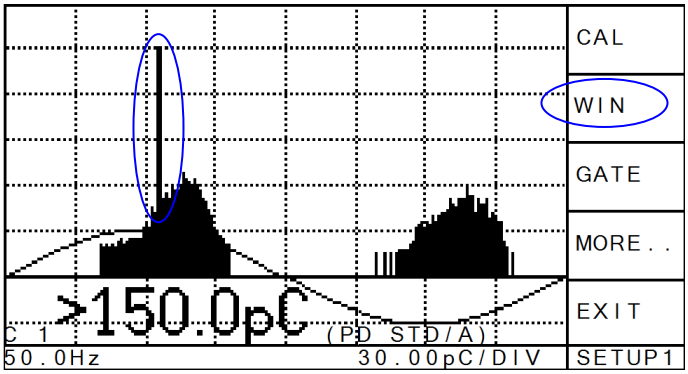


Figure IV.14: PD pattern with one phase stable disturbance

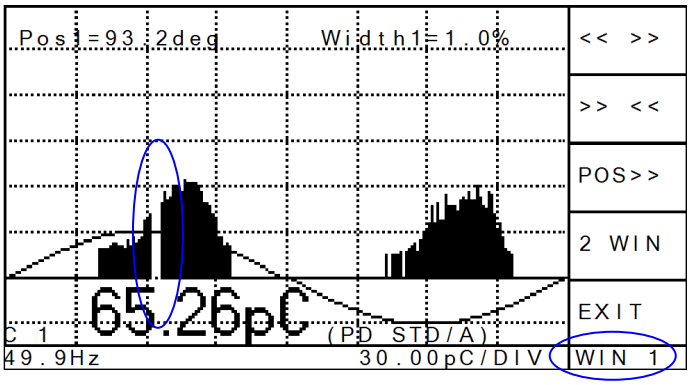


Figure IV.15: PD pattern with one window at 93.2°

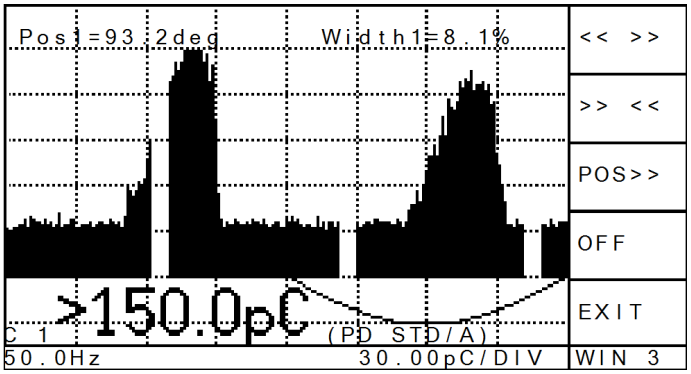


Figure IV.16: Three windows of 120° distance, LLD=0%

Some disturbances such as thyristor firing are phase stable. They can be removed by the software function WIN. This function allows selecting up to 3 windows which blank out pulses occurring in these windows. Pulses occurring within these windows will neither contribute to the displayed charge peak value of the SCOPE display, nor will they affect the later processing e.g., for the PROJ and TIME data.

Figure IV.14 and Figure IV.15 show the same measurement, whereby in Figure IV.15 one window is set to blind the respective phase position.

The menu SETUP1 \ WIN offers to set 0 to 3 windows. The number of windows can be changed by ‘OFF’, ‘1 WIN’, ‘2 WIN’, ‘3 WIN’ and is displayed at the bottom line. E. g. if one window should be set, the button ‘1 WIN’ has to be pressed. The key always indicates the next option. The width of each window is identical and can be increased by ‘<<>>’ or decreased by ‘>><<’. The phase position is changed by ‘POS>>’.

If a second window is selected the distance to the first will be 180°, for three windows the distances are 120°.

As in the previous menu, the window parameters remain stored after deactivating the window function or when the instrument is switched off.

IV.6.3 Gating with external sensor (analogue gating)

An effective noise reduction is required in case the ICM*monitor* is used for PD measurements in an environment with high frequency (HF) disturbance. HF disturbances, which hamper PD detection, and which can be handled by the gating function, are, for instance, radar signals, corona discharge, or thyristor firing. Using the analogue gating function blinds out such impulse noise. The ICM*monitor* has an external BNC connector to connect the noise sensor signal. With former versions of the ICMmonitor, the 8-channel version uses one of the eight input channels as gate signal source. This channel can be selected by the menu 'MUX G' (GATE / CH+/-), then.

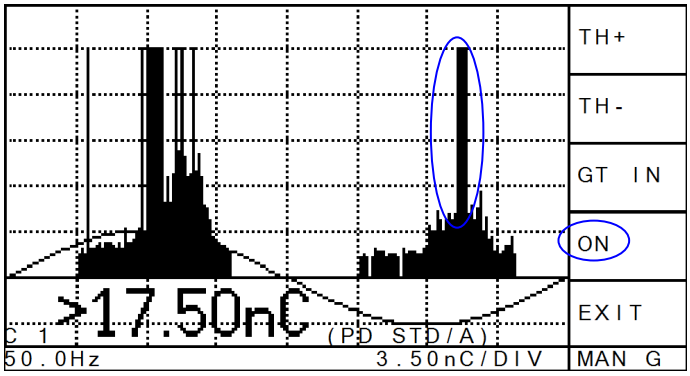


Figure IV.17: PD pattern including disturbances

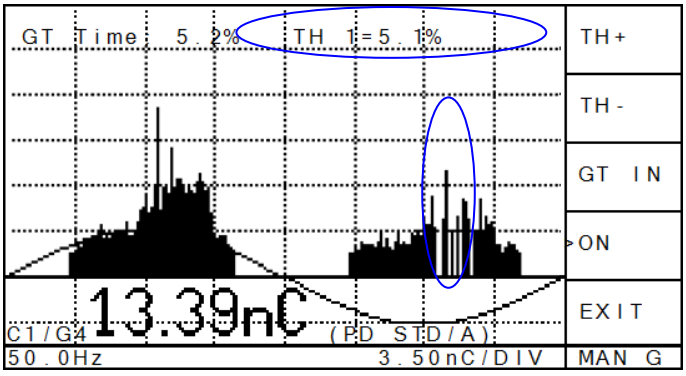


Figure IV.18: PD pattern after manual gating

The latest versions of the ICM*monitor* come with an onboard integrated preamplifier (RPA6G with a frequency range of 100 kHz to 10 MHz) and a 'GATE IN' terminal (BNC) on the rear panel. An antenna or another sensor that picks up the disturbance signal is connected to this 'GATE IN' terminal. With some applications a CT1 (current transformer) is used to acquire the disturbance signal from a ground conductor or from the screen of a signal cable (see Figure V.2).

The gating function is activated in the menu MAN G or AUTO G. '**>**ON' indicates activated gating. If the (disturbance) signal at 'GATE IN' terminal exceeds the set threshold level, the processing of the analogue signal is blocked for 10 µs (default) at 50 Hz. Thus, the signals falling in this period do not contribute to the instrument's display and derived quantities. The gating time (T_g) per noise event depends on the synchronisation frequency and is calculated by:

$$T_g = \frac{1}{f_{sync} \cdot 197}$$

(Where f_{sync} is the sync frequency displayed in the left bottom corner of the display.)

Two different modes of setting the trigger can be selected from the menu 'GATE':

MAN G - The manual mode offers to set the trigger from 1 to 100 % of the peak disturbance level. This threshold is displayed in the upper right corner of the display (MAN G) once this mode is active. Press 'TH+' and 'TH-' to change the trigger level. This option is used to remove a known disturbance source in a stable environment.

AUTO G - The automatic mode calculates a gating time as a fixed portion of the measured time. E. g., setting the gating time to 10 %, results in a total blind-out time of 2 ms for 20 ms @ 50 Hz. The trigger level will be set accordingly to this time. The total gating time, when activated, is displayed in the upper right corner of the menu 'AUTO G'. Pushing 'GT+' and 'GT-' allows changing the gating from 1% to 50%. This option is used when the noise situation is likely to change over time.

Depending on the hardware configuration, older versions of the ICM*monitor* come with a preamplifier (RPA6) built-into the instrument's housing. The preamplifier has a logarithmic amplification and can be set to three different frequency ranges, which are selected in the submenu 'BANDW'. The active bandwidth mode is marked by '>'. Table V.1 lists the frequency bands for the three modes.

Bandwidth Mode	Frequency Range
MODE1	40 kHz to 800 kHz
MODE2	2 MHz to 20 MHz
MODE3	200 MHz to 600 MHz

Table IV.2: PD pattern after manual gating

An ICM*monitor* offers the following menus for the analogue gating function. They can be accessed only in the ‘SCOPE’ display ‘SETUP1’/’GATE’ menu. While being in the GATE menu, the ‘autogain’ function as well as the automatic change of the active channel is disabled.

MAN

Push this button to change to the submenu for manual gating (see below).

AUTO

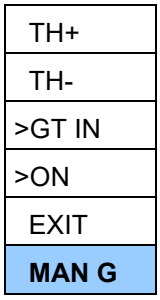
Push this button to change to the submenu for automatic gating (see below).

GTSET

Push this button to change to the submenu, where the gate level can be set.

EXIT

Push this button to change one level up to the menu SETUP1.



TH+ / TH-

Pushing these buttons increments or decrements the gating threshold level. If the function is ‘>ON’, this value is displayed at the upper right side of the screen in percent.

GT IN (>GT IN)

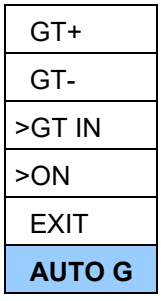
If this item is activated (>GT IN), the instrument's display shows the gating signal instead of the PD signal. This function is automatically deactivated, when leaving the MAN G menu.

ON (>ON)

This button turns the gating function on (>ON) or off (ON). The gating function remains off if no preamplifier is connected to the gating input. Usually, the preamplifier is built in.

EXIT

Push this button to change one level up to the menu GATE.



GT+ / GT-

Pushing these buttons increments or decrements the total gating time. If the function is ‘>ON’, this value is displayed at the upper right side of the screen in percent. The instrument automatically adjusts the threshold level to the set gating time.

Fehler! Textmarke nicht definiert.Fehler! Textmarke nicht definiert. GT IN (>GT IN)

If this item is activated (>GT IN), the instrument's display shows the gating signal instead of the PD signal. This function is automatically deactivated, when leaving the AUTO G menu.

ON (>ON)

This button turns the gating function on (>ON) or off (ON). The gating function remains off if no preamplifier is connected to the gating input. Usually, the preamplifier is built in.

EXIT

Push this button to change one level up to the menu GATE.

GL+ / GL-

Pushing this button increments or decrements the time period, during which the measured signal is blocked, if the threshold level is exceeded. Values from 5 to 255 µs are available by steps of 1 µs. The default value is 10 µs.

EXIT

Push this button to change one level up to the menu GATE.

V Application examples

V.1 Rotating machine monitoring

Different modes of installation of the couplers apply, depending on mainly the type, design, and size of the device under test. Followed example shows one standard use of the ICM*monitor*, the permanent monitoring of a large motor.

A coupling capacitor of the CCxxB series is connected to each phase bus in the connection box. The couplers have a high voltage connection, a ground lead, and a BNC signal connector. Each BNC connector is linked to the coupler termination box (CTB1) by a coaxial cable. This CTB1 provides the protective ground for the BNC signal cable. Therefore, the CTB1 is tied to the protective ground potential as well.

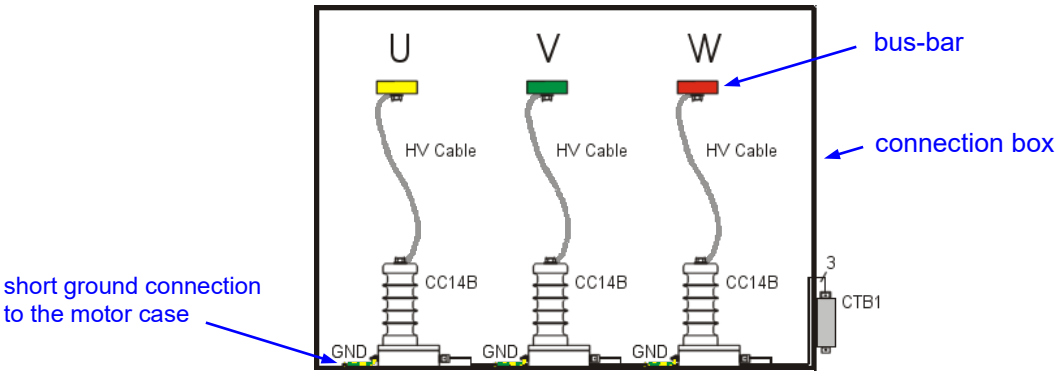


Figure V.1: Coupler connection on a motor

Usually, large motors are fed using medium voltage cables. Those cables have a very low high frequency impedance, which reduces the high frequency amplitude of the PD signal. Thus, the coupler shall be mounted in general as close as possible to the machine terminal. The high voltage as well as the ground connection of the coupler needs to be connected close to the machine and away from the supply line.

The noise signal for the analogue gating is picked up from a coupling capacitor by a current transformer CT1. The output of the CT1 is connected to GATE IN, the input of the logarithmic preamplifier RPA6G that is integrated with the ICM*monitor* unit.

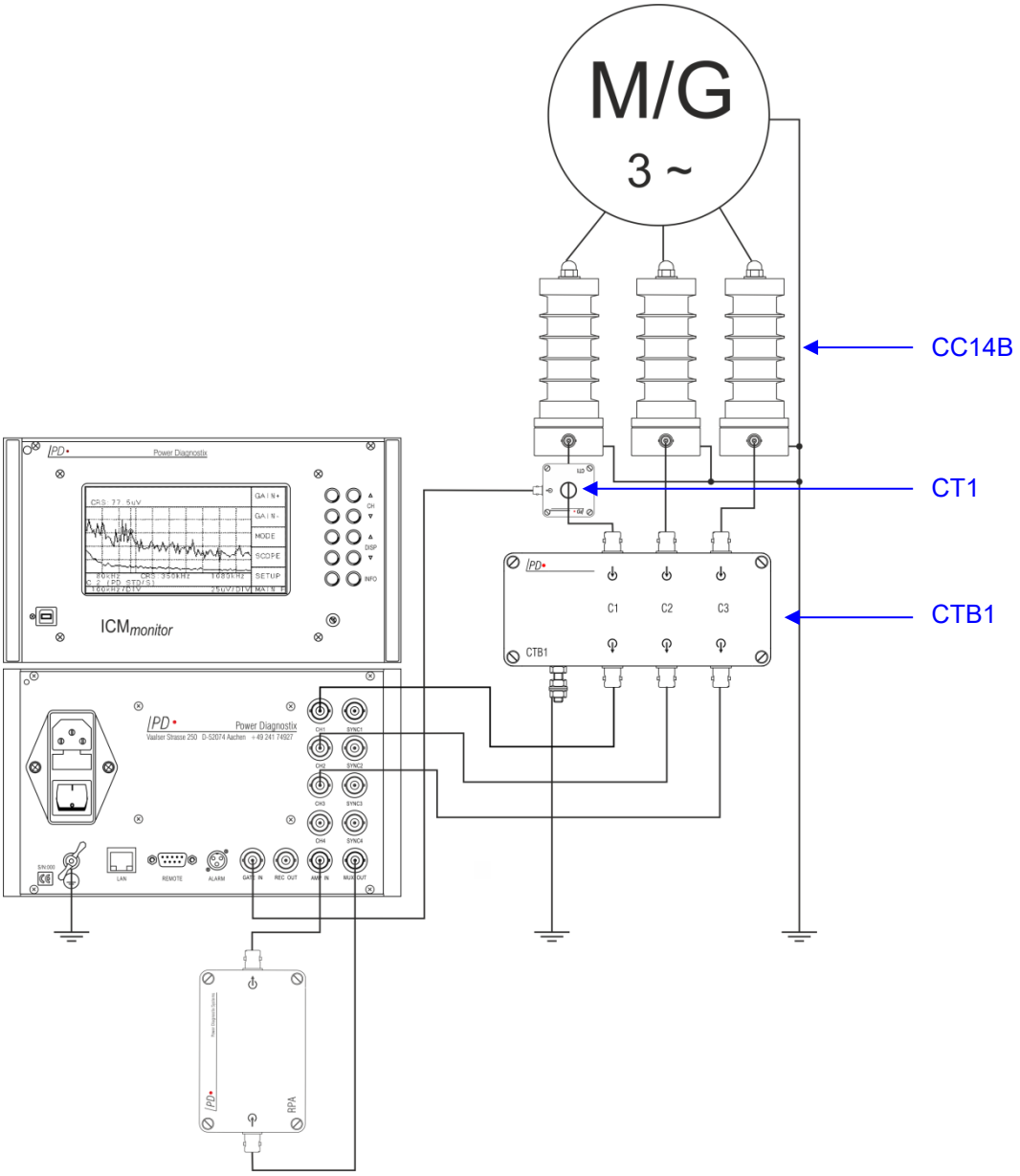


Figure V.2: Example connections of a standard ICM*monitor* to a rotating machine

V.2 Transformer monitoring

V.2.1 Typical setup

The following sketch shows an overview of one transformer PD monitoring system, which is a typical configuration. Installations, e.g., such as on three single phase transformers, transformers with oil/SF6, or oil/oil bushings may vary a little bit.

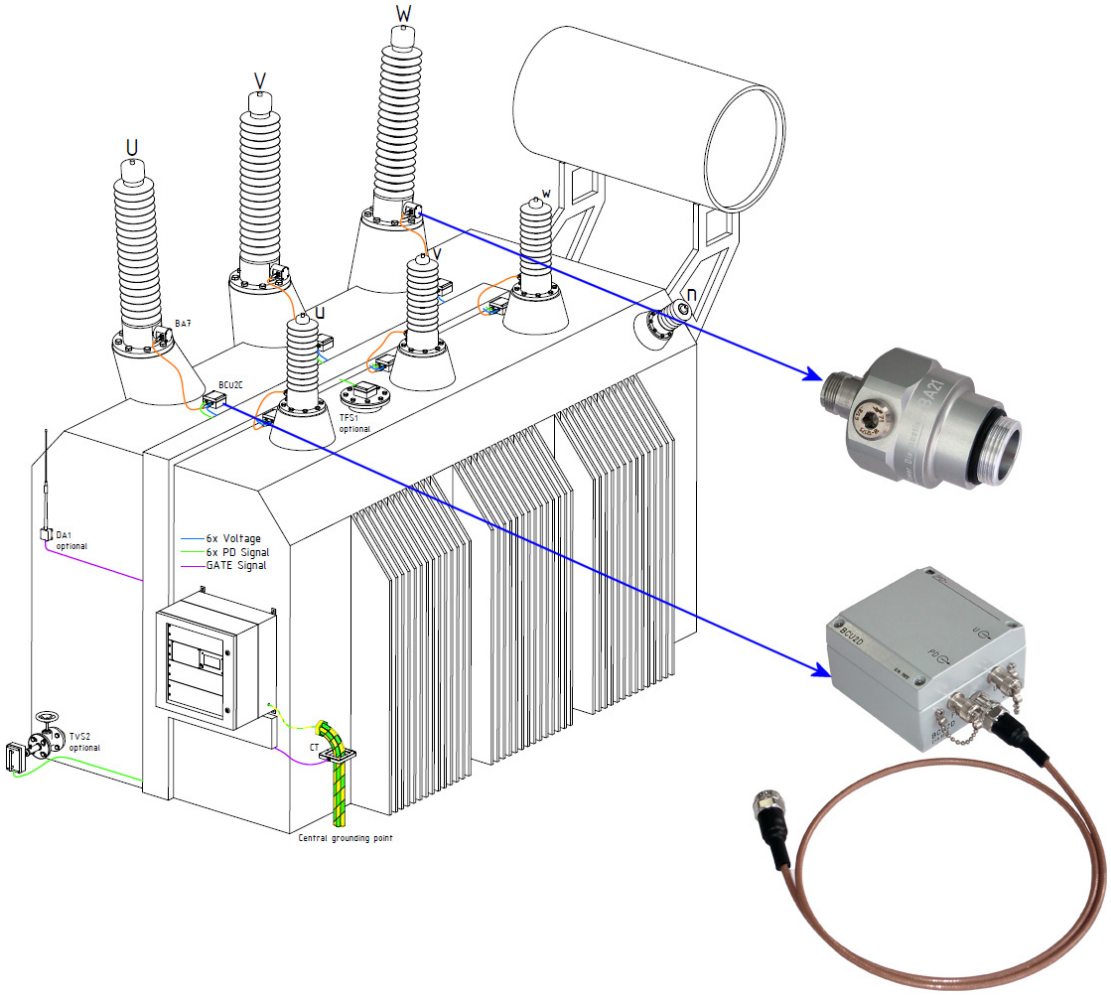


Figure V.3: Transformer with an ICM*monitor* permanently installed for monitoring purposes

If the PD signal is taken from the test taps of the bushings it is typically not necessary to install UHF sensors in addition. However, UHF sensors are available for the oil drain valve (TVS2) and for spare flanges (TFS1) as well. External disturbance signals can be detected by an antenna, such as the DA1 as shown on the picture, or by clamp on HF current transformer (CT1, CT100, CT120R, or similar) provided for different cable thicknesses. The instruments cabinet can be placed on the transformer tank wall or alternatively on a concrete wall or on a metal supporter close by. The instrument needs and provides the following external interface connections:

- Power supply cable, 220 V AC
- Network cable (optional)
- Telephone line (optional)
- 4–20 mA or 0–10 V input signals for measurement of temperatures or others
- 4–20 mA or 0–10 V output signals for NQS/Qp trend analysis
- Alarm output signals of potential free relay contacts

With some special bushings the test tap connector is under oil and not accessible from outside. In such cases it is possible to mount an oil tight N-N feed through connector into the outer metal enclosure. The following picture shows such a special configuration. It is important to keep the interconnection cable between test tap connector and wall connector as short as possible.

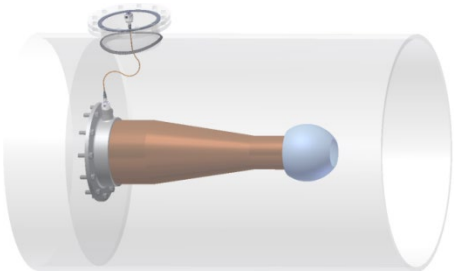


Figure V.4: Test tap under oil with installed oil-tight N-N feed through connector

The high frequency PD signal is taken from the capacitive tap of the transformer bushing. Special bushing adapters (BA type) are available for most of the commonly used bushings available in the market. This adapter is designed to ground the tap connector in case of failures, such as broken layers or overvoltage. A grounding of the test tap is guaranteed by integrated spark gaps switching at a peak voltage of 350 V. From the N output connector of the bushing adapter a short coaxial lead (typical RG142, 50 Ohm) connects to the bushing coupling unit (BCU2 series). This box provides the HF PD signal on a TNC connector and additionally the synchronisation voltage. The TNC protection caps should be left connected in case that no signal cable is attached to the TNC outputs.

The typical voltage at this "U" output can be calculated as follows:

$$U_{sync,out} = \frac{Ur}{\sqrt{3}} \times \frac{C1}{Cd}$$

Usync,out : AC RMS output voltage on the TNC output connector U of the BCU

Ur : Rated RMS voltage of the transformer bushing (phase to phase)

Cd : Divider capacity as written on the BCU

C1 : Capacity C1 of the bushing between HV terminal and test tap connector

The value of Cd is usually calculated by the supplier of the PD monitoring system. A typical range for the maximum voltage Usync is in a range of 60 V to 100 V_{RMS} AC. This voltage signal can be used for PD synchronisation, voltage monitoring, or tan delta calculations for instance.

The PD output of the BCU provides a high frequency signal in a range of 2 MHz to 20 MHz, or 40 kHz to 10 MHz alternatively. The specific range can be modified by setting a jumper under the cover of the BCU box (for BCU2 type only).

Jumper settings:

On: 2 MHz–20 MHz range (default setting)

Off: 40 kHz–10 MHz range

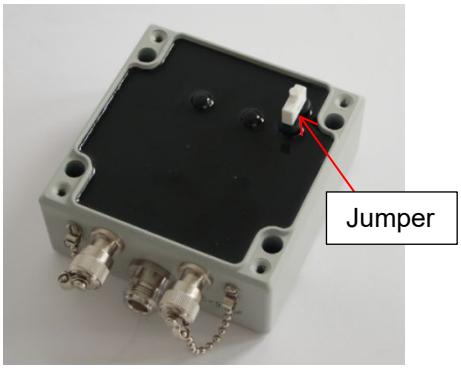


Figure V.5: BCU2D box view from top (cover removed)

Temperature stable coaxial cables such as RG142 can be used to connect all signal cables from the BCU to the instrument's cabinet. The monitoring device within the cabinet acquires all data, generates trending strip charts and alarm events and provides all interfaces for remote control and remote monitoring.

Instruments with built-in display can be operated in standalone mode without interoperation by software. Further protocol converter such as IEC 61850, DNP3, or others can be integrated to connect the system directly with substation or power plant monitoring control systems.

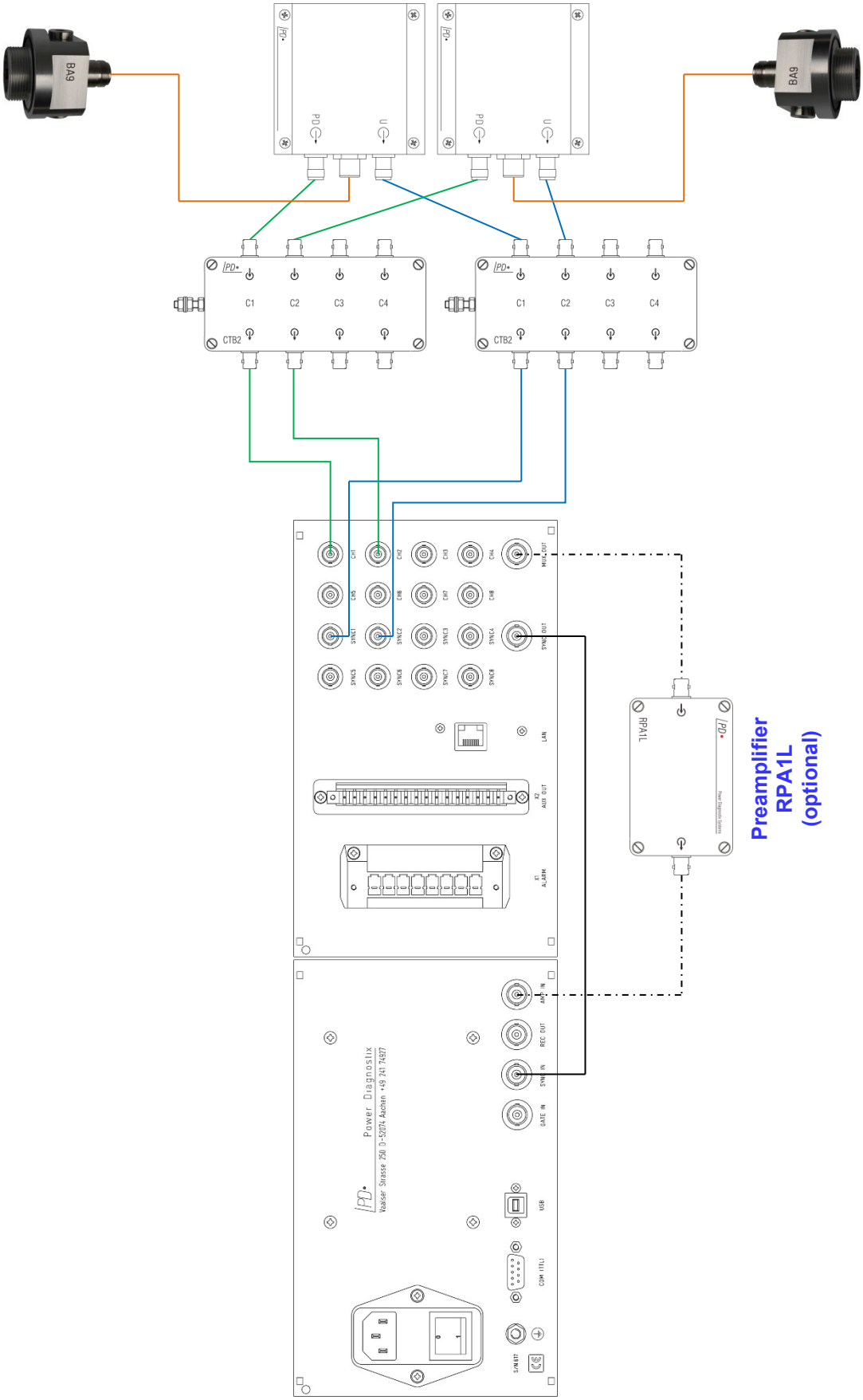


Figure V.6: Example connections of an ICM*monitor* with multiplexer to a transformer via bushing adapter (BA) and bushing coupling unit (BCU)

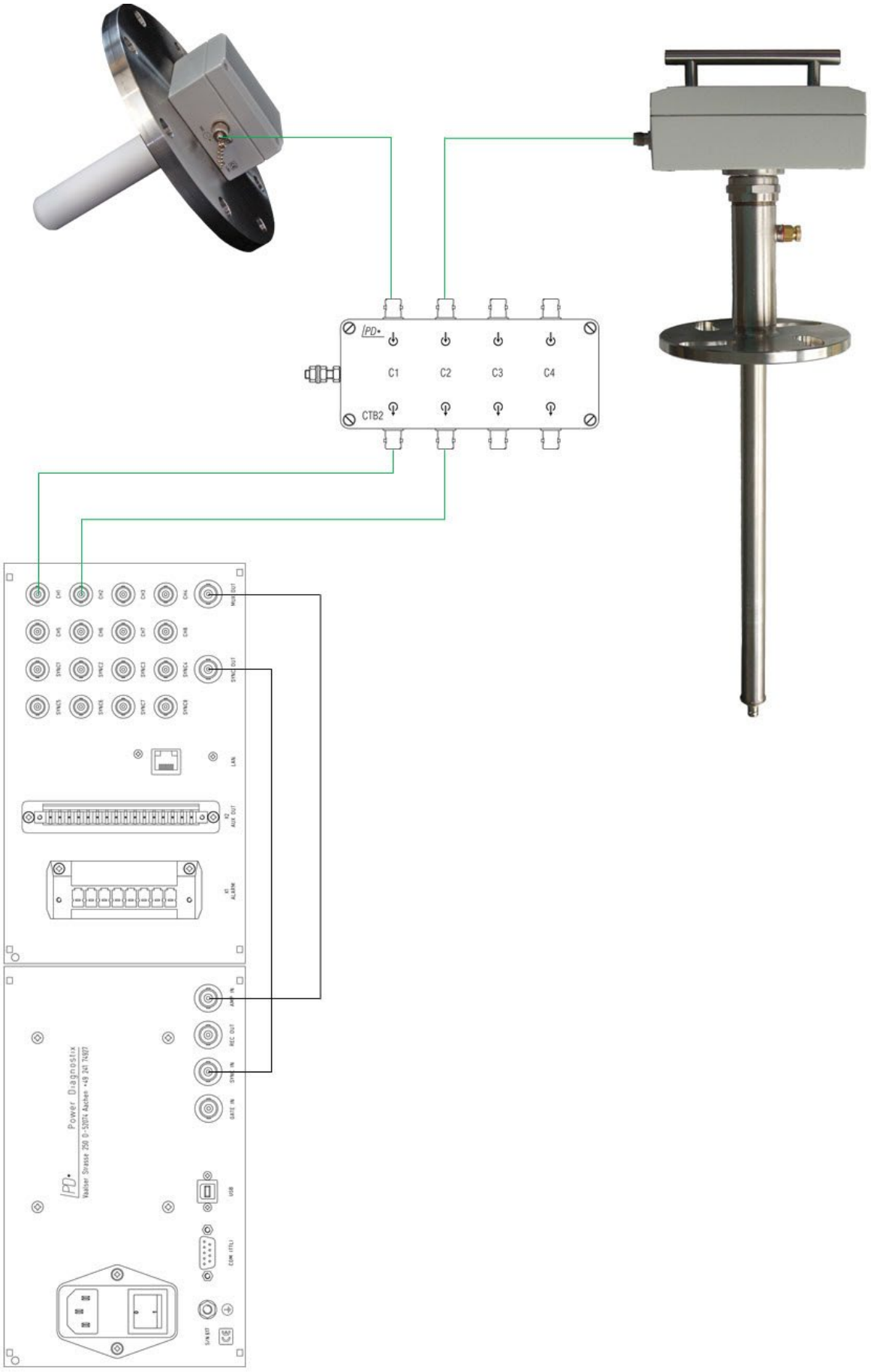


Figure V.7: Example connection of an ICM*monitor* to a transformer via transformer valve sensor (TVS2) and transformer flange sensor (TFS1)

V.2.2 Commissioning

The commissioning starts with the erection of the transformer on site. The bushing adapters and coupling units can be connected after assembling of the bushings. After that all signal cables are feed to a central point in close distance to the transformer. Here, the PD monitoring rack can be mounted on a metal supporter for instance. All cables are feed from the bottom of the cabinet inside. Coupler termination boxes can be used to connect all coaxial cables. The internal cabling to the ICM*monitor* should have been prepared at the PD or OEM manufacturer's site in advance.

After powering the ICM*monitor* the setup and calibration of the system needs to be prepared. Please refer to section IV.3.2 to setup the instrument correctly. Measurement mode, frequency bandwidth, centre frequency, LLD, and Gain are the most relevant settings for the calibration procedure. A typical calibration charge for onsite calibration is 1 nC, 2 nC, or 5 nC. A background noise floor of less than 500 pC on power transformers and less than 200 pC on cast resin distribution transformer is considered to be sufficient for a sensitive PD monitoring installation. It is advisable to perform multiple calibrations on different centre frequencies and to store them individually on the computer. The best signal to noise ratio can be found after energizing of the transformer earliest.

The following figure shows a simplified circuit diagram of the calibration setup. The standard procedure can be compared with the shop floor testing methods. On site the situation will be different as the bushing connects to a GIS, a cable box, or to the HV overhead lines directly. The additional impedance of this attached equipment of the HV grid will influence the calibration depending on its properties.

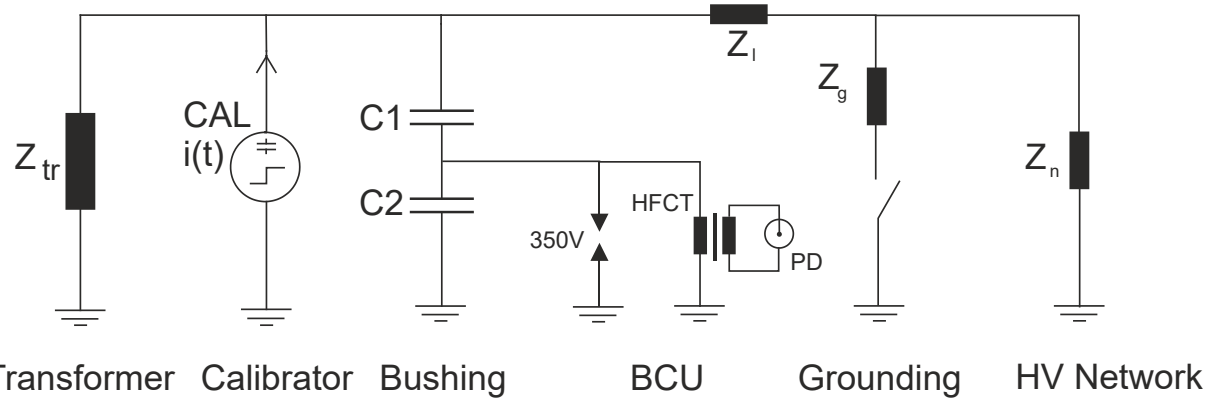


Figure V.8: Calibration setup diagram

Ztr	Impedance of the transformer
CAL	Impulse calibrator
C1	Capacitance HV to test tap of the bushing
C2	Capacitance test tap to ground of the bushing
350V	Spark gap of the bushing adapter (2x)
HFCT	High frequency current transformer (alternatively CIL circuit/not shown)
PD	Partial discharge measurement output of BCU
Zl	Impedance of the HV link connected to the bushing
Zg	Impedance of the grounding cable during commissioning (if connected)
Zn	Impedance of the HV network (GIS, GIL, HV cable, overhead line, ...)

Please consider the following important points while calibrating:

- Keep all connections leads from the calibrator to the bushing terminal and to ground as short as possible to minimise stray capacitances
- Remove the ground connection from the HV terminal, or
- keep a minimum distance of the ground connection to the HV terminal of several meters to increase the impedance (L_g) between calibration point and grounding point
- Do not connect the calibrator clamps to painted parts. A proper connection of the clamps to metal is mandatory for all calibrations

Alternative Methods

In some special cases it might be impossible to perform a calibration according to the standard definition due to the following reasons:

- The access to the HV terminals is prohibited due to safety issues
- The oil/oil bushing is already filled with oil and the access to the HV terminal is not given or prohibited
- A cable box is already installed

Here, it will be necessary to estimate the sensitivity and the background noise level by injecting the calibrator pulse into the test tap directly. Please note: This method is not a valid calibration according to IEC 60270.

Figure V.9 shows the principle of this method. The calibrator signal is connected to the test tap and in parallel to the BCU input connector. The right part of the picture shows the simplified equivalent circuit diagram, supposing that the inductance of the ground connection Lg and the inductance of the network Ln is comparably high and therefore the influence of these connections and the network is negligible.

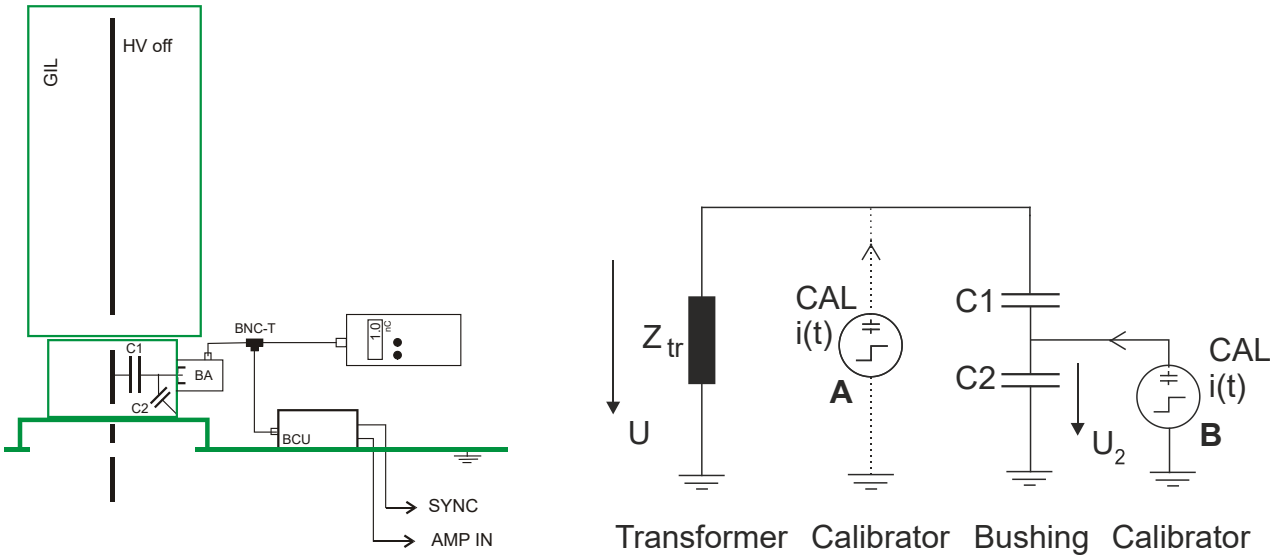


Figure V.9: Alternative calibration method

Position A shows the correct way of calibration according to the IEC 60270. Position B shows the injection of the calibrator pulse from the test tap connector. The injected discharge value translates into a short pulse current.

$$Qc = \int i(t)dt$$

Qc = Qca : Calibration value if injected on position A

Qb : Calibration value shown on the calibrator if injected from position B

i(t) : Impulse current provided by the calibrator

k : Correction factor

The correction factor can be calculated as follows:

$$U = k * U2$$

$$U = k * \left(U * \frac{\frac{1}{jwC2}}{\frac{1}{jwC1} + \frac{1}{jwC2}} \right)$$

$$k = \frac{C2 + C1}{C1}$$

$$Qc = k * Qb$$

Here, the operator needs to use the Qc value as calibration value to be set on the instrument instead of using the real Qb value as shown on the calibrator.

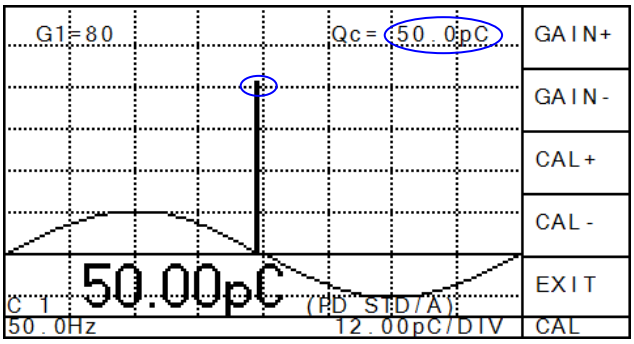


Figure V.10: CAL menu

After energizing the transformer, it is important to check the AC voltage on the synchronisation connector by a standard multi-meter with high input impedance. It is possible to T-connect a BNC connector on the "SYNC IN" input of the ICM*monitor* directly. The input impedance of the ICM*monitor* is 1 MΩ.

Problems that might occur are:

- No voltage on the 'Sync In' input:
  → Shortcut on the cable
  Check the crimping of the connectors
  → PD and voltage signal cables mixed up
- Higher voltages on the 'Sync In' input than expected
  → BCUs of LV and HV mixed up
  → Wrong Cd value for this type of bushing

V.2.3 Operation

After commissioning of the PD monitoring system, it can be helpful to consider some general rules for the operation of the instrument. The following list shall give a brief overview.

Alarm settings:

The most prominent question is the one regarding the correct settings of alarm levels. The instrument provides two general alarms that are independent on the active channel, means if an alarm condition is met on one of the eight or four channels the instrument will trigger the relays or will generate a software alarm event.

Alarm condition 1 (Qp alarm):

$$Qp[i, Tcycle] \geq Qalarm$$

i :	Channel number
Tcycle:	Refresh cycle of the instrument without LC display: typ. 50 ms–100 ms with LC display: typ. 150 ms–200 ms
Qalarm:	Pre-set alarm level at the instrument
Qp:	Highest PD value within one internal refresh cycle; value is shown in pC or nC.

Alarm Condition 2 (NQS alarm):

$$NQS[i, t] \geq NQSalarm$$

i :	Channel number
t:	Time stamp
NQSalarm:	Pre-set alarm level at the instrument
NQS:	Number of PD quantities per second; value is shown in pA or nA

The NQS value is calculated continuously. After one scan period the highest value during one scan on the selected channel is stored temporarily. The highest value of multiple scans is captured and stored permanently into the strip chart according to the MEM setting on the equipment (see user manual). Following, the internal calculation of the NQS value:

$$NQS(t) = \frac{\sum_{i,t=T0}^{t} Q[i, t]}{t - T0}$$

NQS : NQS value on one channel at time t

T0 : Time stamp of start of calculation period

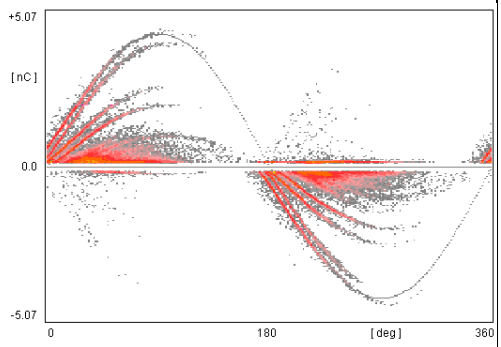
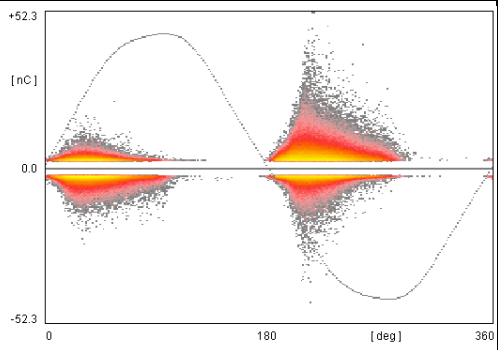
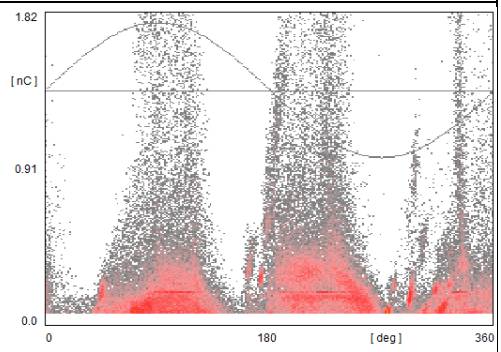
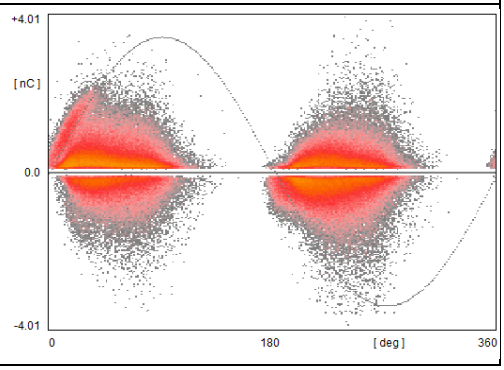
t : Current time stamp

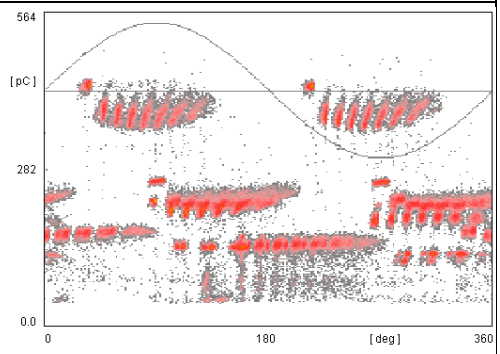
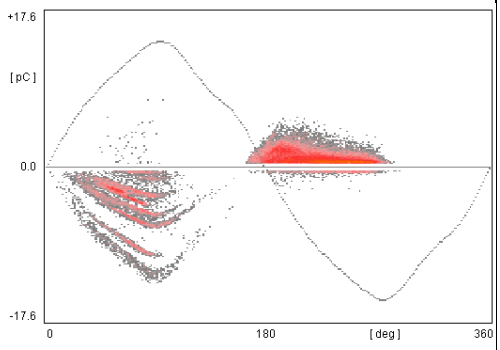
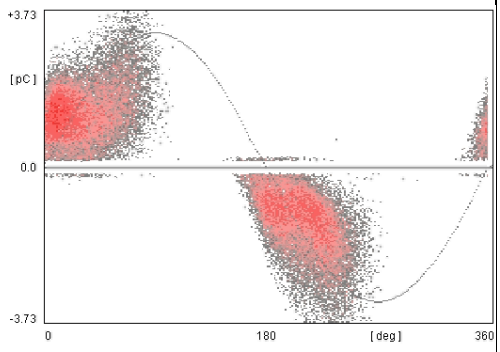
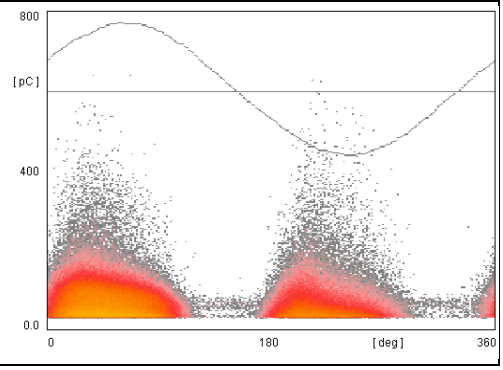
i : Index of sampled Q value

Due to the integration over time the NQS current value is a more stable value compared to the Qp value. Therefore, it is recommended to use the NQS for alarm detection instead of the Qp value. The Qp alarm can be easily triggered by switching pulses, short disturbance pulses, or other intermediate noise. The NQS will cross the trigger level only if an ongoing PD activity is present. After commissioning it is advisable to record the Qp and NQS trending for a while. After having found a constant level for both values it is common to set the alarm levels about 30–50% higher than this standard value. The NQS trending should be crosschecked from time to time to find deviations from the standard level. If the NQS alarm triggers frequently it can be caused due to the standard deviation.

V.2.4 PD pattern examples

Distribution and power transformers are tested in the factory according to common IEC standards. The guarantee level for new transformers is typically less than 20 pC on cast resin transformers and 200 pC on oil filled power transformers. Therefore, all PD detected on transformers under applied voltage up to 1.2 rated voltage should be considered as a problem. Further analysis should clarify the cause of such internal PD activity.

PD phenomena or external noise	**Typical range**	**Further analysis recommended**	**PD pattern example**
Void discharge with low availability of starting electrons	< 100 pC	> 200 pC	
Surface discharge	< 2 pC	> 20 pC	
Corona discharge on a 400 kV air bushing; cross coupling from all phases	nC	-	
Surface discharge on a damaged insulator part of an oil bushing			

PD phenomena or external noise	Typical range	Further analysis recommended	PD pattern example
Floating potentials			
Void discharges on a semiconductive layer			
Treeing			
Sharp point on a bad crimp connection			

VI The ICM*monitor* software

The standard software is called ICM*monitor* and shows an image of the LCD (display). The software has to be ordered separately and is delivered on a CD ROM. Updates can be downloaded from Power Diagnostix' web site (www.pdix.com) using a valid login and password.

VI.1 Starting the program

The ICM*monitor* software can be started via the Windows Explorer or the Windows Start / Programs menu. Subsequently the main panel appears as shown in Figure VI.1. At the beginning the last set of parameters and measuring data are loaded and displayed. The following search function checks if an ICM*monitor* is connected and ready-to-operate or if a modem is available. The configured serial ports are scanned successively, and the identified connections are displayed. If an ICM*monitor*, which is connected via a direct serial link, is selected, a connection to this monitor will be established immediately. If a modem is selected, the dial in number can be set via a special dialogue box and the connection to this monitor can be established.

Remark: If the application window appears very small when started on a PC with Windows 10, please refer to "The ICM*monitor* application widow appears very small on high resolution monitors with Windows 10" on page 141.

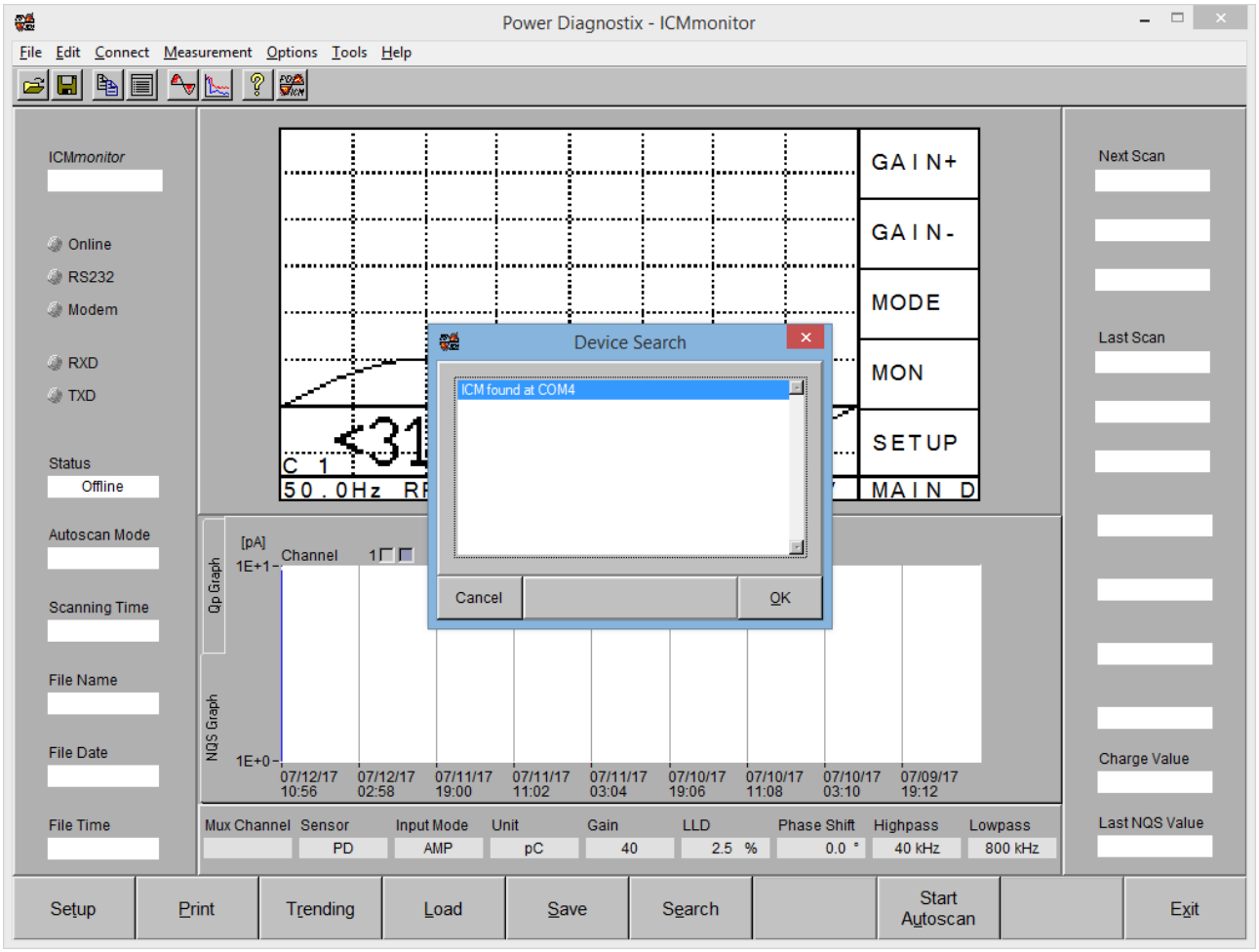


Figure VI.1: Startup of the ICM*monitor* software

The upper panel of Figure VI.1 shows the display and the five function buttons of the ICM*monitor*. After the instrument is initialised successfully, the setup is loaded, and the actual state is displayed. The monitor can be controlled via the five function buttons on the right-hand side of the display. The display is refreshed periodically with the data received from the instrument. Underneath the main display, the actual trending graph of the instrument connected is shown.

With the bar below the trending graph, the most important setup settings can be changed directly.

The most important functions of the program can be selected directly via the function buttons (F1 to F10) at the bottom of the screen. Additionally, these and additional functions are available via the menu bar at the top of the screen.

The LEDs on the left-hand side of the display indicate the status of a connected ICM*monitor*. The LEDs *Online*, *RS232* and *Modem* indicate if an instrument is connected and if it is connected via a direct serial link or a modem. The LEDs *RXD* and *TXD* show if there is a data transmission between the instrument and the software.

On the left side, there are further indicators. The box labelled ICM*monitor* shows the version of the firmware if an instrument is connected. The box underneath the LEDs shows the status of the connection. There are three conditions: *Online*, *Offline* and *Scanning*. The next box shows whether the auto-scan mode is enabled (Active / Not Active). If an instrument is connected, the next box displays the scanning time of the monitor. This is the time the instrument stays on one channel to collect and display the PD activity of this channel. After that period, the instrument changes to the next active channel. The name of a loaded file is shown in the *File Name* box. Beneath, the date and time of this file are displayed.

If the auto-scan mode is enabled, the boxes *Next Scan* and *Last Scan* display when a monitor will be scanned next or when a monitor was scanned last, respectively. Besides the actual values of the PD activity, the NQS and the frequency are displayed on the right side.

VI.2 Main functions

Figure VI.2: Offline (no instrument connected)

Figure VI.3: Offline, modem selected

Figure VI.4: Online, direct serial link

Figure VI.5: Online, linked via modem

Figure VI.6: Online, direct serial link, scan mode started

Figure VI.7: Online, direct serial link, scan mode started

VI.2.1 Setup (F1, Ctrl+T)

VI.2.1.1 Setup (new ICM*monitor* version >= 4.56)

The setup settings of the instrument can be displayed and set via the ICM*monitor* software. Figure VI.8 shows the setup dialogue box of a 4-channel ICM*monitor*. The setup of the active channel is marked in dark grey. The setup for each channel can be set separately. If the *Global* button is pressed, the settings of the active channel are set for all channels and only the settings of the active channel can be changed. With one exception: The *Q Cal* value remains unchanged. This value is independent of the *Global* setting.

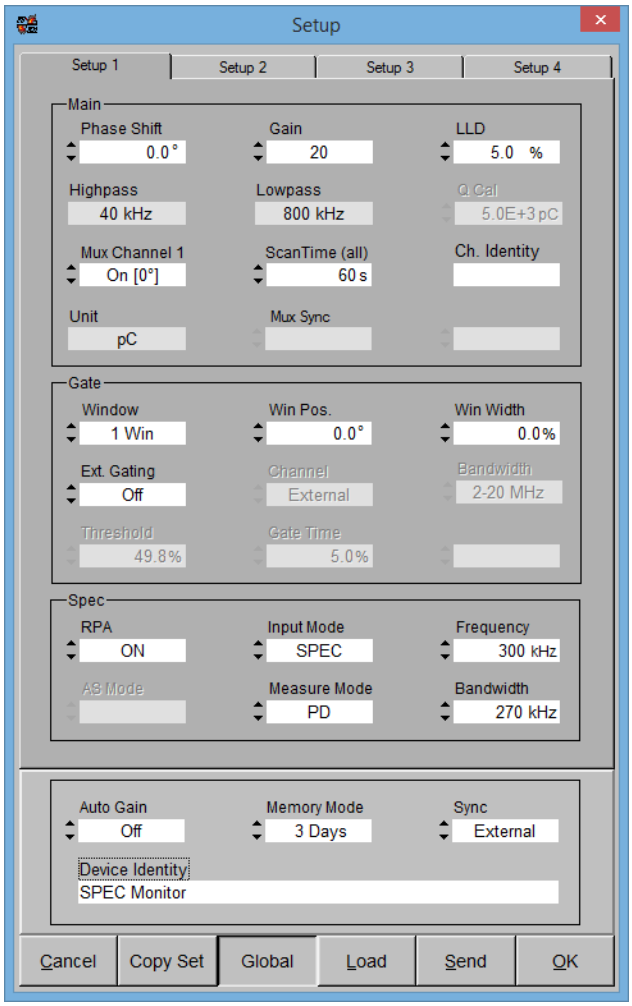


Figure VI.8: Setup window

The phase shift of the displayed pattern referring to the synchronisation voltage and the LLD can be set. In addition, the lower and upper cut-off frequencies of the filter can be defined, if the input mode is set to 'AMP'. The gain can be specified. An additional constant phase shift of 120° or 240° of the channel can be set (see footnote 3 on page 40). The scanning time, which can be adjusted, is identical for all channels.

The *Gate* settings are used to define windows for suppressing phase stable disturbances and to setup an external gating. It is possible to define up to three windows. The phase shift using two windows is 180° and 120° for three windows. The window position defines the position of the first window in relation to the zero point. The window width sets up one width for each window.

There are two possible settings for the external gating: Manual mode and automatic mode. The manual mode offers the possibility to set the trigger from 1 to 100% of the peak disturbance level. This option is used to remove a known disturbance source in a stable environment. The automatic mode calculates a gating time as a fixed portion of the measured time. E. g., setting the gating time to 10% results in a total blind-out time of 2 ms for 20 ms @ 50Hz. The trigger level will be set accordingly to this time. The input channel for the gating signal can be selected for an eight-channel ICM*monitor*, only. The four-channel version has a separate external BNC connector. For older versions of the ICM*monitor*, the frequency range for the preamplifier RPA6 at the gating input can be set via the *Bandwidth* selection box.

The '*Input Mode*' is used to switch between the standard measurement path (AMP) and the spectrum analyser path (SPEC). In SPEC mode the centre frequency (measuring frequency) can be set from 100 kHz to 10 MHz in steps of 10 kHz and the bandwidth can be set to 9 kHz or 270 kHz. If an RPA is connected the frequency range of this preamplifier has to be considered.

The value of "Memory Mode" controls the sampling rate of the trending data (see page 42 "1 DAY; 3 DAYS; 10 DAYS " for detailed information). Additionally, an identity can be defined for the instrument.

A previously stored setup file can be loaded via the *File* button. The setups are stored in a common .MON file. Older file versions (software < 4.36) or files, which contain setup information of older ICM*monitor* versions (< 3.8), include only one setup. If such a file is loaded, the setup is transferred to the active setup otherwise each setup is transferred. The *Send* and *OK* buttons send the current settings to the connected ICM*monitor*.

VI.2.2 Print (F2, Ctrl+P)

This function prints the actual display. A report, which is described in section 0, is printed as well. This report can be completed before printing.

VI.2.3 NQS Trending (F3, Ctrl+N)

This function changes to the NQS trending panel in which NQS trending files can be loaded and displayed. The panel shows a long-term trending of the NQS values and displays the stored PD pattern at certain points of time. More information is found in section VI.5.

VI.2.4 Load (F4, Ctrl+L)

The saved MON files can be loaded and displayed. This is only possible if no ICM*monitor* is connected. The files contain the display data, the setup of the instrument as well as the trending and projection data. By pressing the PgUp and PgDn keys, the next resp. previous file in the same directory is loaded.

VI.2.5 Save (F5, Ctrl+S)

This function opens a dialogue box to select a directory and filename. After that, the actual display, the setup of the instrument as well as the trending and projection data is saved in the selected MON file.

VI.2.6 Search / Offline (F6, Ctrl+E)

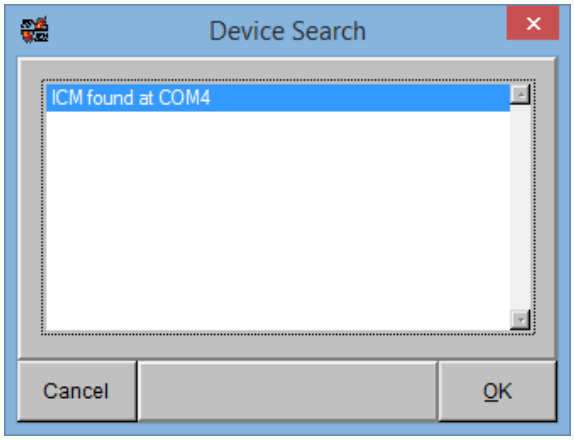


Figure VI.9: Device search dialogue

This function searches for an ICM*monitor* or a modem on the serial ports and shows the results in a list. If a connection to an instrument or a modem shall be established, one entry of the list must be selected. If a modem is selected, then a telephone number of an ICM*monitor* can be set by pressing the *Dial* button.

The function *Offline* cancels a direct serial link to a monitor and switches back into the *Offline* mode.

VI.2.7 Dial / Disconnect (F7, Ctrl+D)

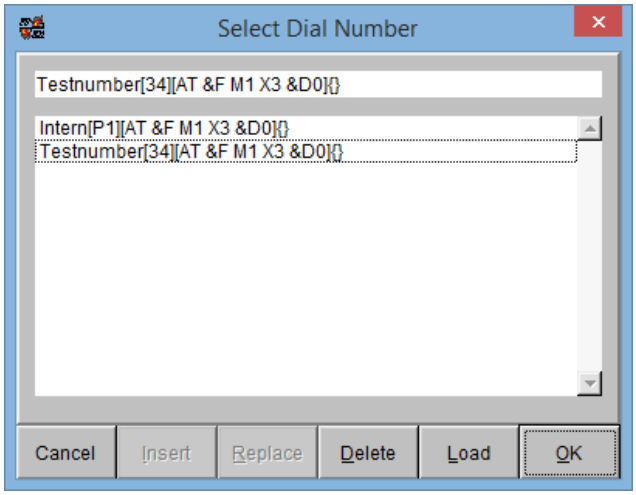


Figure VI.10: Select telephone number dialogue box

The function *Dial* shows a dialogue box to select a number. This number is used to establish a connection to a ICM*monitor*. If a modem was selected in the *Device Search* dialogue box, the function *Dial* becomes available. In here, telephone numbers can be selected to establish a connection to a ICM*monitor* via the modem. The selected entry is also displayed in the text box on top of the window and can be edited there. If an entry was changed, it must be enlisted first. This is done by pressing the *Insert* button to add the entry or by *Replace* to replace the selected entry with the edited entry. By pressing the *Load* button, a file can be selected and loaded which contains additional telephone numbers of instruments. With the *Delete* button, selected entries can be removed from the list. The following table shows how an entry is build up.

<entry name>[number][initialisation string]

Section	Description
entry name	name for this telephone number, instrument, or station
number	telephone number inclusive all characters (e.g., 0 to access an external line or ',' for delay)
initialisation string	initialsation string for the modem AT: indicates that AT commands are following; has to be used at the beginning &F: loads the standard configuration of the modem M0: loudspeaker always off M1: loudspeaker on during dial-up X3: Modem doesn't wait for dial tone (necessary for some telephone systems) … see manual of the modem

Tab. VI.1: Description of a telephone entry

If the connection via the modem shall be disconnected, the *Disconnect* button has to be pressed. This will also return to the *Offline* mode.

VI.2.8 Start / Stop Auto-scan (F8, Ctrl+A)

This function starts or stops the auto-scan mode. If the auto-scan mode is started, the label of the button changes to *Stop Auto-scan* and the background colour switches to red. More about the auto-scan mode can be found in section 0.

VI.2.9 Scan / Stop (F9, Ctrl+C)

The function starts the scan mode. In this mode the instrument switches to the *Hold* mode and starts scanning the first activated channel. This will be done for a settable time (standard 60 s). During that time, every

partial discharge impulse activates a display pixel in the scope display at the location according to the pulse magnitude and the phase angle of occurrence. Afterwards, the scope display is stored in a MON file. Subsequently, the other activated channels are scanned. If the scan mode is enabled, all other functions of the software are disabled. The scan mode can be cancelled by pressing the *Stop* button. The settings for the scan mode can be defined via the *Edit / Scan Settings* menu.

VI.2.10 Exit (F10, Ctrl+X)

The function disconnects an ICM*monitor* and terminates the program.

VI.3 Main menu

Besides the functions of the button bar on the bottom, the main menu offers some additional functions. In the following, only those functions are described which are accessible via the pull-down menu and which are not mentioned previously.

VI.3.1 File menu

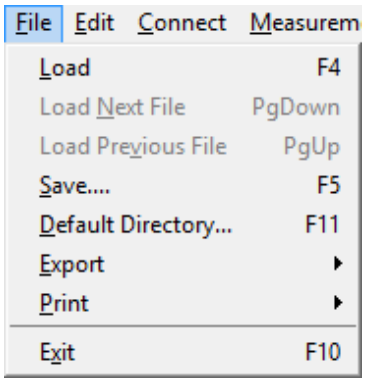


Figure VI.11: File menu

The menu item *Default Directory* opens a dialogue box to select a directory. This is used as the default directory for the *Load* and *Save* functions. Besides, the files, created during the *scan mode*, are stored in that directory. With the *PgDn* and *PgUp* keys the next resp. the previous file in the directory is opened if a file was loaded before. The menu item *Export* has the subitems *Current Display*, *Scope Data*, *NQS Projections* and *NQS Trending*. The *Current Display* function saves the current display as a BMP file. The *Scope*, *NQS Projection* and *NQS Trending* data are saved as a text file. Those files contain the report, the setup and the raw data. The data is arranged in columns separated by tabulators. By this data format, the data can be copied to e.g., Excel and can be processed further. The function *Export / NQS Trending* writes each data set provided with the date and time to a file.

If an existing file is selected, the new data sets can be appended to the existing file. Time overlaps and gaps are taken into account. If time gaps are recognised, the data sets are filled with zeros.

For older ICM*monitor,* which are not equipped with an internal clock, the data sets, transmitted by the instrument, are interpreted as follows: The first data set is assigned to the current time; the following data sets are in backward time order. The instrument has a limited memory for the measured data. Depending on the number of channels and the set timeline of the instrument, the recording period can vary between one and 20 days. If new data shall be appended to an existing file, the new data is searched for the first data set with new data. This is appended to the file. Since the instrument itself has no clock, it is not possible to recognise if it was switched off for a certain period. Thus, this off time is not interpreted as a time gap.

The current display, the NQS projections view and the NQS trending view can be printed via the *Print* menu command.

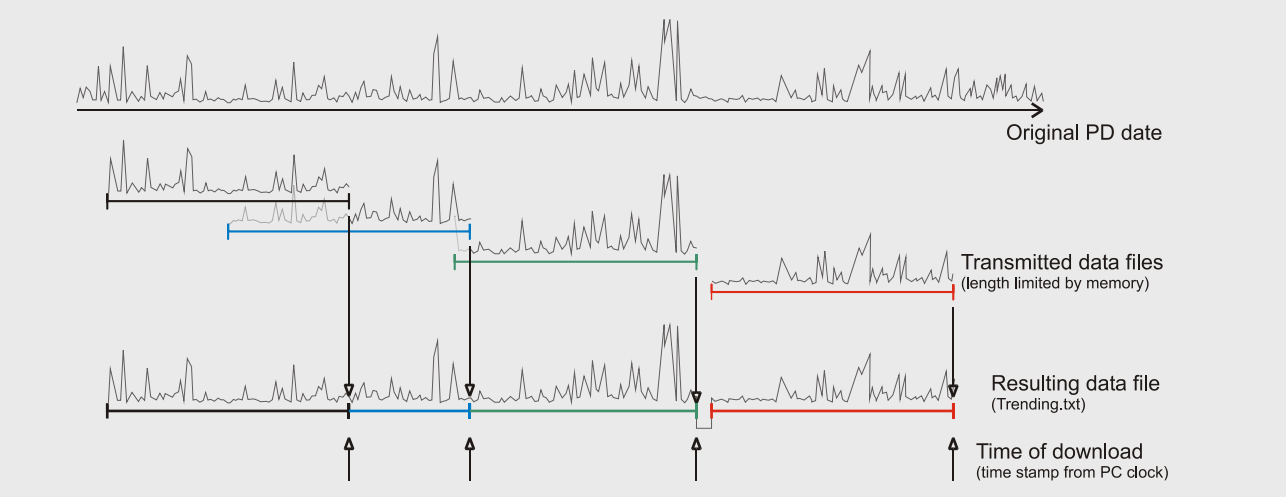


Figure VI.12: Build-up of a trending file

VI.3.2 Edit menu

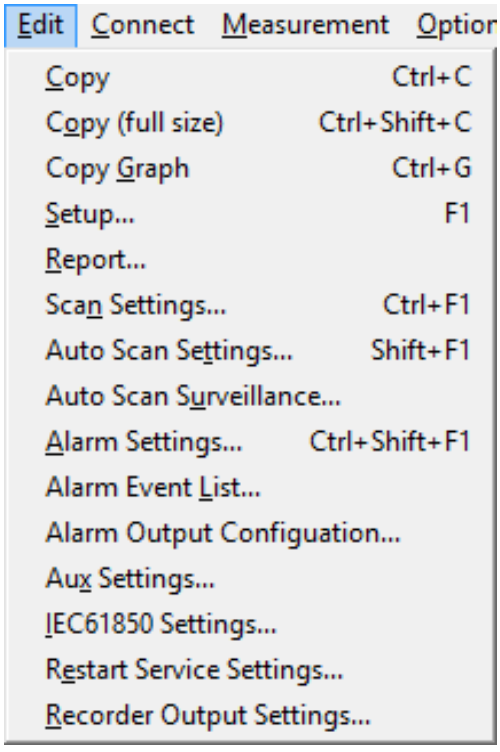


Figure VI.13: Edit menu

If the *Copy* menu item is selected, the current display without the button area on the right side is copied to the clipboard. To copy the whole display, use the *Copy (full size)* menu item.

VI.3.2.1 Report

The report is stored in every MON file and every export file. Comments to the measurement can be put in the dialogue box, which can be loaded and printed out.

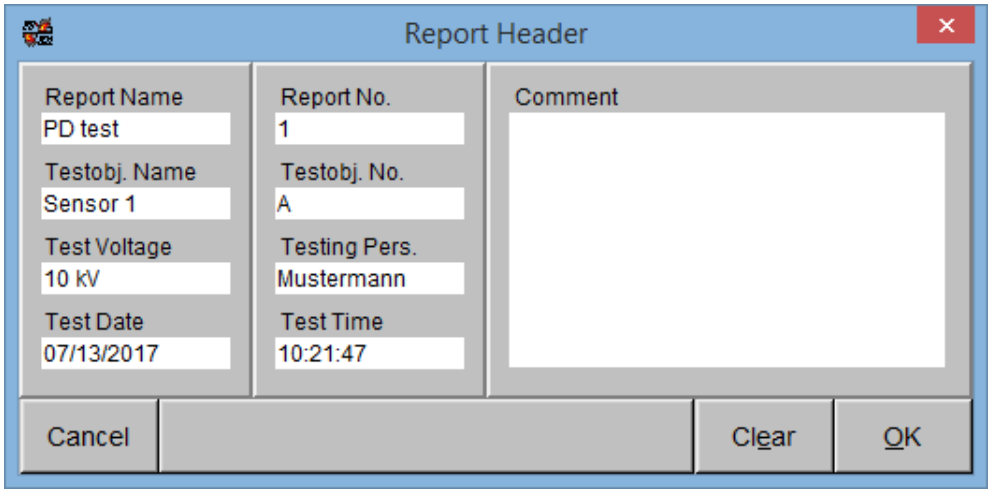


Figure VI.14: Report dialogue box

VI.3.2.2 Scan settings

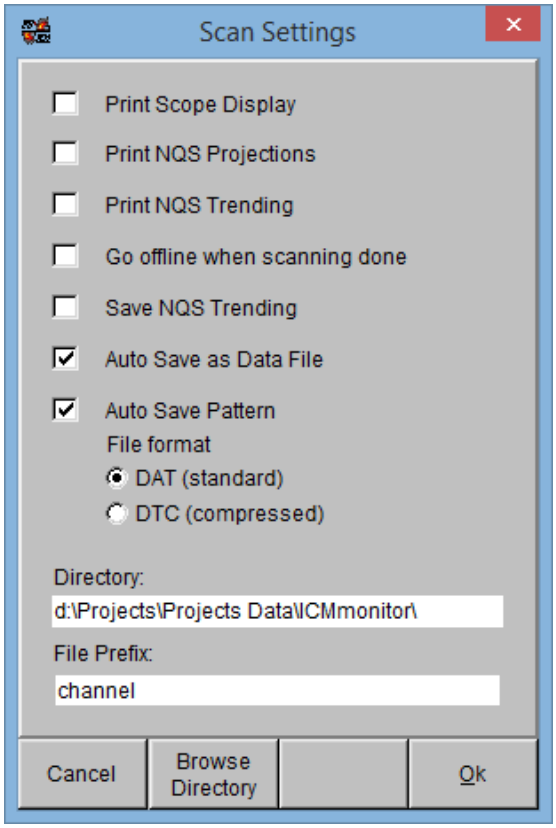


Figure VI.15: Scan settings dialogue box

The scan settings define the parameters for one scan cycle. The check boxes *Print Scope Display*, *Print NQS Projections* and *Print NQS Trending* define which of these views are to be printed at the end of a scanning process. The monitor is disconnected after the scanning process, if the check box *Go Offline when scanning is done* is marked. The NQS trending data is stored to a file, if the *Save NQS Trending* check box is activated. The name of this file is *Trend.txt* and the file is stored in the default directory. If there is already a file with that name, the data will be appended to this file. By activating the *Auto Save as Data File* check box, the scanning data of each channel is stored to a file. This option should be activated always. The *Directory* box shows the directory for storing the files. This can be changed by pressing the *Browse Directory* button and selecting another. The name of a scanning file consists of the file prefix as shown in the corresponding box, the number of the scanned channel, and the file extension .mon (e.g., channel1.mon). Which channels are to be scanned and the scanning time is defined in the *Mux Settings* of the setup dialogue box which can be opened via the *Edit / Setup* menu item.

VI.3.2.3 Alarm settings

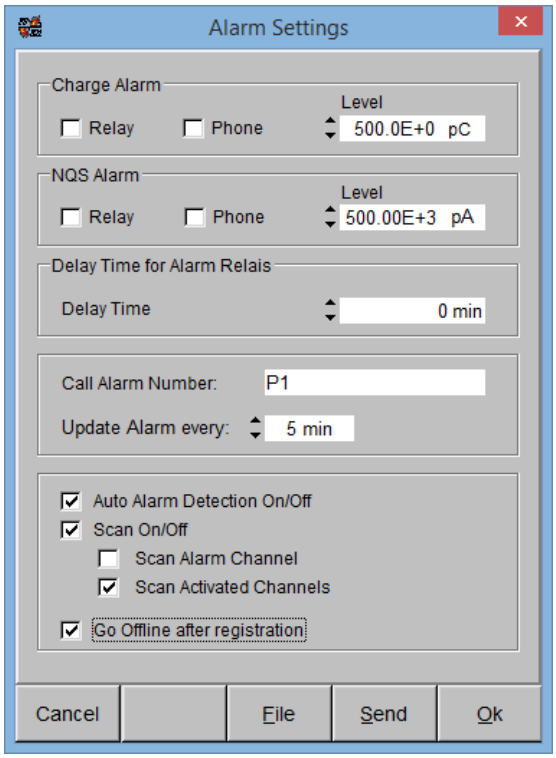


Figure VI.16: Alarm settings dialogue box

The alarm settings in the monitor can be defined using this dialogue box. A level of the Qp value can be defined which will trigger an alarm if this value is exceeded. This alarm can trigger the built-in relay and/or link to a PC via the modem. The corresponding check boxes must be activated. The same parameters can be defined if an NQS value is exceeded. The dial up number of a modem, which shall be dialled in case of an alarm, can be defined in the *Call Alarm Number* box. To avoid permanent alarm calls, the minimum time between two alarm calls can be adjusted in the *Update Alarm every* box. To register these alarm calls, the ICM*monitor* software has to run on the PC, which is called. The data of the alarm is stored in a file. This data is displayed by selecting the *Edit / Alarm Event List* menu item. If alarm calls shall be registered, the *Auto Alarm Detection On/Off* check box has to be activated. The following settings in the dialogue box define the behaviour of the program in the case of a registered alarm call: An automatic scanning process can be defined. Either only the alarm channel or all channels can be scanned. If the monitor shall be disconnected after an alarm was registered and the scanning process is finished, the last check box must be activated.

Alarm settings, which were stored previously in a **.mon* file, can be loaded by pressing the *File* button. The alarm settings must be transmitted to the instrument via the button *Send* or *OK*.

For the auto-scan and auto-scan surveillance settings see section VI.4.

VI.3.2.4 Alarm event list

The alarm event list displays the registered alarms. There are two types of alarms. If the maximum charge level is exceeded (PC AL) or if the maximum NQS level is exceeded (NQ AL), the alarm is triggered. The time of the registered alarm, the alarm type (PC AL / NQ AL), the channel which triggered the alarm, and the measured Qp and NQS values are shown. The identity of the monitor is displayed as well. The maximum number of alarms displayed is 100. If a further alarm appears, the oldest event is deleted from the list and the new one is appended. The entire alarm-event list is deleted by pressing the *Clear* button. The list can be stored as a text file (*Save*) and can be printed (*Print*).

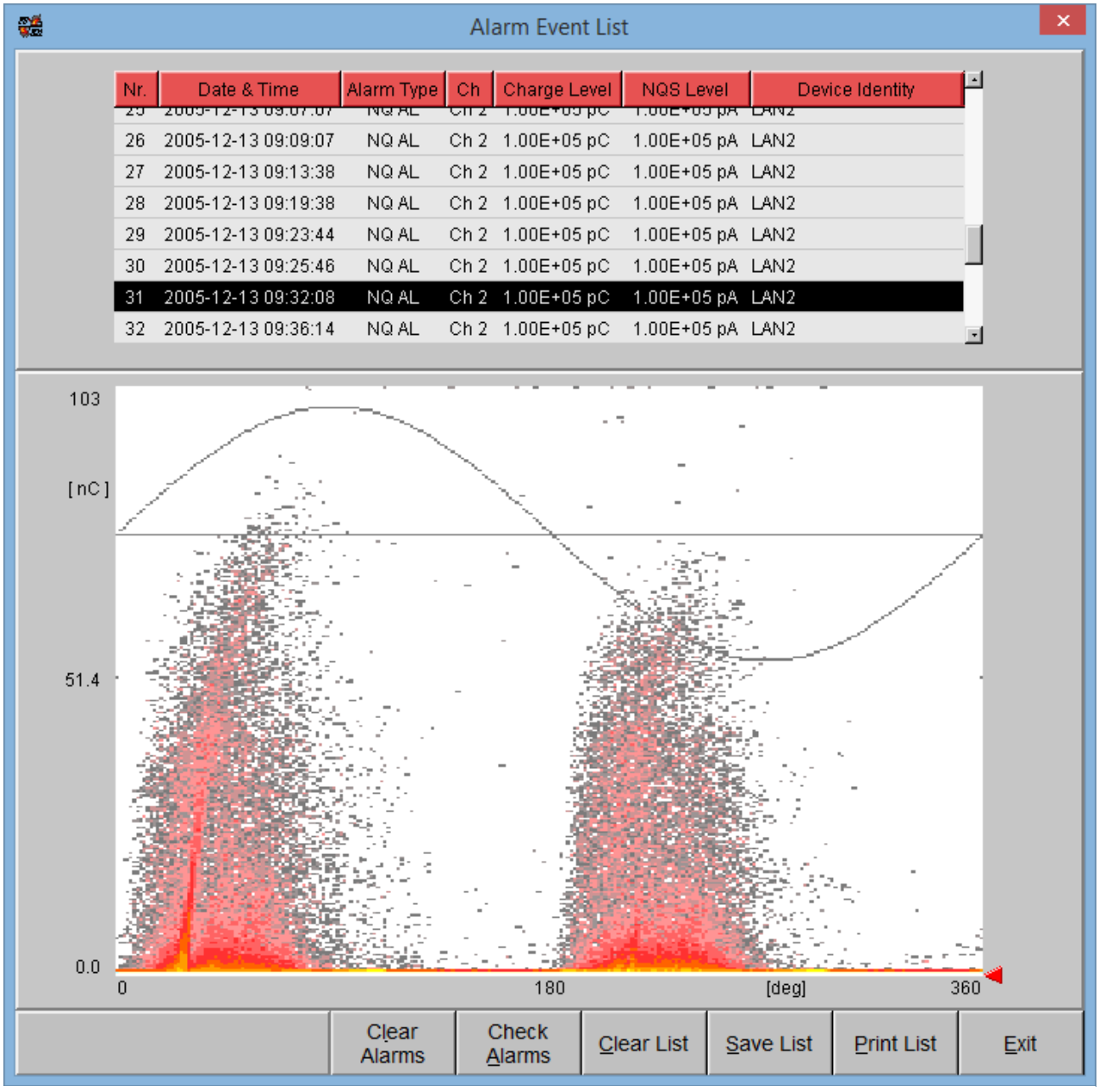


Figure VI.17: Alarm event list

VI.3.2.5 Alarm output configuration (optional)

This menu item is only available if the computer running the ICM*monitor* software is equipped with a National Instruments I/O card.

If the check box 'Activate Warning Output' is activated, the settings of this group define a warning level for the outputs of the I/O card. The card's output channel to be triggered, if a warning occurs, and the contact configuration of the channel can be defined. A level of the Qp and NQS values can be defined which will trigger a warning if this value is exceeded.

If 'Activate FCU Alarm Output' is checked and the ICM*monitor* is in UHF mode, the software will trigger an alarm if no frequency converter unit (FCU) is connected to the instrument. The card's output channel to be triggered if this alarm occurs and the contact configuration of the channel can be defined.

The settings for alarms are similar to these of warnings. It's possible to use the levels defined in the *Alarm Settings* dialogue box (see page 75) by activating the radio button 'Use ICMmonitor Levels' or to define separate NQS and Qp levels. As with warnings, the card's output channel to be triggered if this alarm occurs and the contact configuration of the channel must be defined.

If the I/O card reset mode is set to 'Manually', channels that were triggered by an alarm or warning are reset by pressing the corresponding 'Reset..' button at the bottom of the dialogue box. If the reset mode is set to 'Auto', the channels are rest after the defined reset time.

By pressing the 'Test' button the defined channels to be triggered in case of a warning or alarm can be checked for functionality.

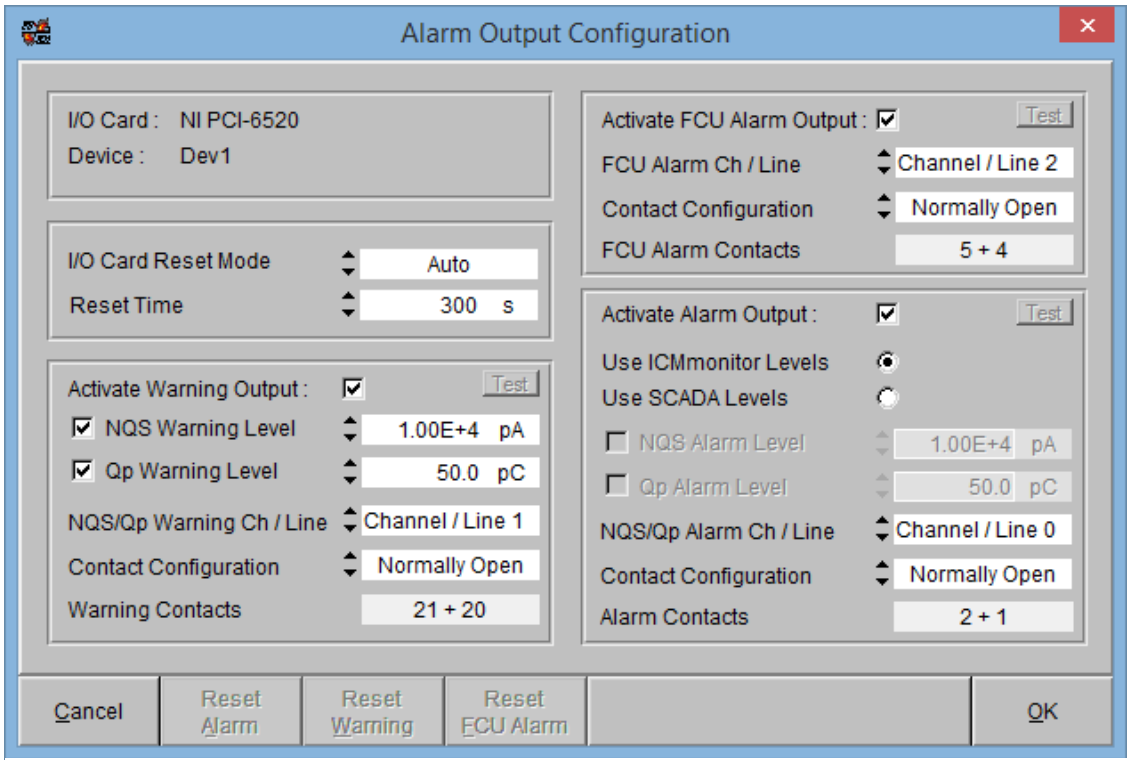


Figure VI.18: Alarm output configuration dialog box

VI.3.2.6 Auxiliary input board AUXIN (optional)

The *AUXIN settings* define the channels of the optional AUX input board. The measurement category can be labelled, and the output quantity of the connected sensor must be specified. The following quantities are supported: 4–20 mA and 0–10 V. Additionally, the equivalent to the 4–20 mA resp. 0–10 V can be defined. Up to eight channels can be set. The user is responsible for these settings. A verification of the settings by the software is not possible.

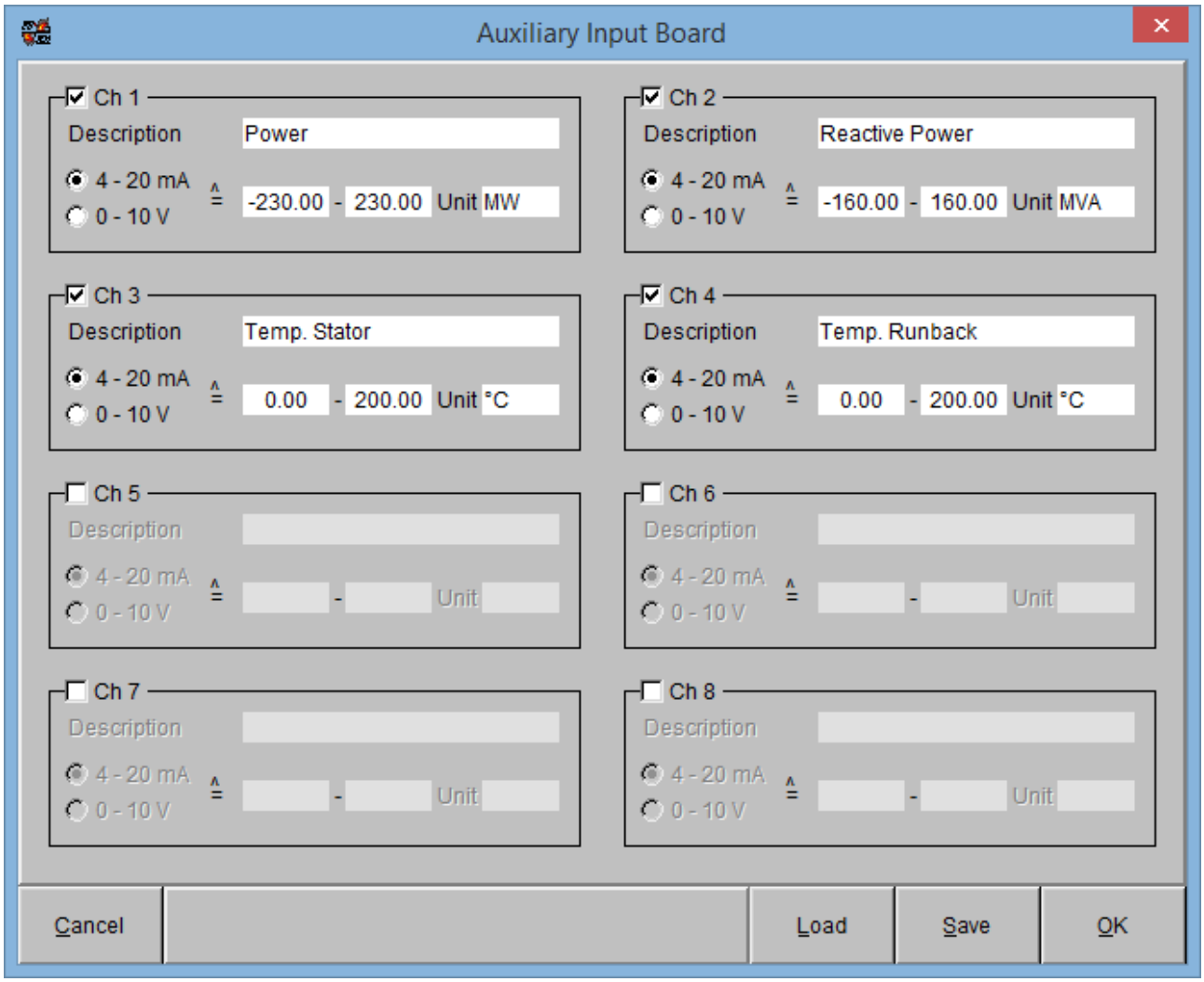


Figure VI.19: AUXIN settings dialogue box

VI.3.2.7 IEC 61850 settings (optional)

This menu item is only available if the ICM*monitor* is equipped with an optional IEC 61850 hardware interface.

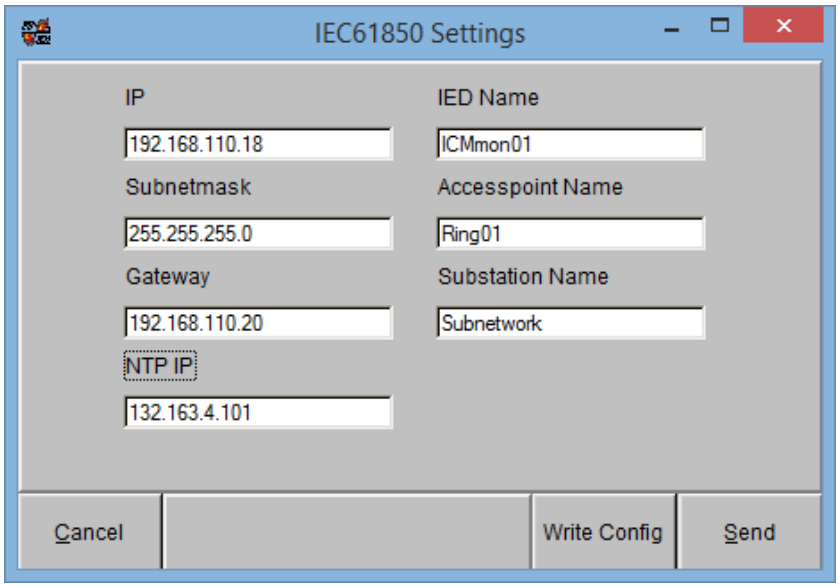


Figure VI.20: Dialog box for IEC 61850 settings

The IP address of the IEC 61850 interface must be entered. This address must match with the settings of the corresponding LAN interface of the device. Additionally, other IEC 61850 relevant LAN settings must be configured, such as subnet mask, IPs of the gateway and NTP server (Network Time Protocol server) as well as names of the IED (Intelligent Electronic Device), access point, and substation.

With the 'Write Config' button the settings can be stored in two configuration files for future reuse.

By pressing the 'Send' button the current settings are sent to the ICM*monitor* and stored within the instrument.

VI.3.2.8 Restart service settings (optional)

Please refer to section VI.9.1 for more information on ICM*Serve*r and relevant settings.

VI.3.2.9 Recorder output board AUXOUT (optional)

Figure VI.21 shows the setup window for configuring the optional AUX outputs with the ICM*monitor* software. To each activated output channel must be assigned at least on PD input channel. The outputs can provide signals related to the derived NQS or Qp values of these assigned input channels.

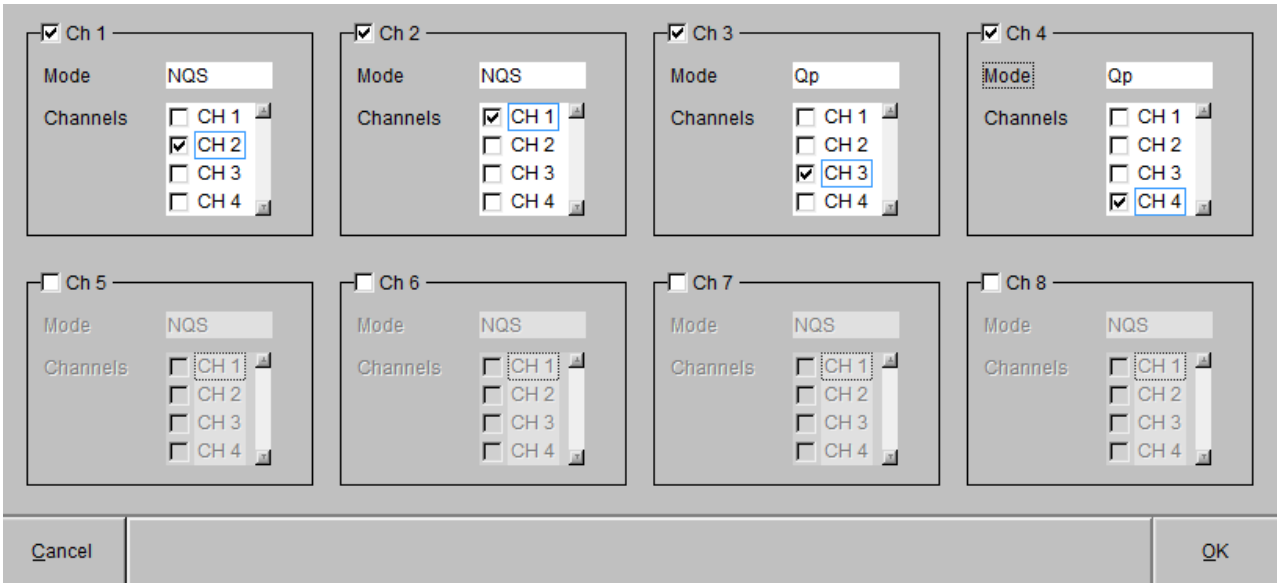


Figure VI.21: AUX output panel of the ICM*monitor* software

The following table shows the output values depending on the current NQS or Qp values and the chosen scaling value (see section IV.2.2).

		Scaling level	
		LOW	**HIGH**
Output mode	**NQS**	<= 10^3 pA: 4 mA	
		> 10^3 pA: $I[mA] = (\log(NQS[pA]) - 3) * \frac{8}{3} + 4$	
	Qp	<= 1 pC: 4 mA	<= 100 pC: 4 mA
		> 1 pC: $I[mA] = \frac{Qp[pC]}{1000} * 16 + 4$	> 100 pC: $I[mA] = \frac{Qp[pC]}{100000} * 16 + 4$

Table VI.1: Tab. VI.1: Output values of auxiliary outputs

Remark: If the instrument is equipped with auxiliary outputs, the standard REC OUT output is automatically deactivated.

VI.3.3 Measurement menu

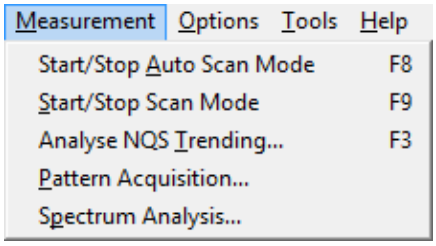


Figure VI.22: Measurement menu

Via the measurement menu, the auto-scan mode can be enabled or disabled, and the normal scan mode can be started or stopped if a monitor is connected. By selecting the *Analyse NQS Trending* menu item, the stored NQS trending curves can be displayed. For a description of this function, see section VI.2.3

VI.3.4 Options Menu

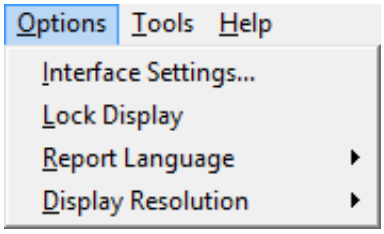


Figure VI.23: Options menu

Some settings for the monitor software can be adjusted via the *Options* menu. With the *Interface Settings* menu item, the ports can be selected, which shall be checked while searching for a ICM*monitor*.

The operation of the ICM*monitor* software can be locked by selecting the *Lock Display* menu item. A password is required for activating and deactivating this function. If this function is used for the first time, the password must be set. After activating this function, all functions of the software require the input of this password.

The language of the report can be set via the *Report Language* submenu. *English*, *French* and *German* can be selected. The report dialogue box appears in that language and the printing is also done using this language.

The submenu *Display Resolution* sets the size of the main panel. Available resolutions are *SVGA* (800 x 600) and *XGA* (1024 x 768). The menu item *Auto* loads the main panel as large as possible for the screen resolution. This is the default setting. If another resolution is selected, the panel appears in this resolution. The maximum size of the main panel is limited by the screen resolution, of course.

VI.3.4.1 Interface settings

With the *Interface Settings* dialogue box the search options can be defined. The ICM*monitor* software offers the possibility to scan the COM ports and to scan the network for connected ICM*monitors*. Additionally, a remote connection to an ICM*monitor*, equipped with an MCI2, is possible. The MCI2 provides a mobile telephone network connection and a UMTS gateway for remote access. To use this connection an internet connection of the PC, running the ICM*monitor* software, is mandatory.

In Figure VI.24 the settings for the RS 232 interface are shown. Normally the settings of this dialogue box need not to be changed. But in case of problems with the serial communication, changes can be done. If the PC uses others than the first three COM ports to connect to the instruments, these can be enabled by setting the corresponding check boxes. The search timeout is the time the PC waits on an answer on a COM port while searching for devices. If the PC often cannot find a device on a COM port even though there is a device connected, this time can be increased. The run timeout sets the time the PC waits on requests over the COM ports. If the device often is disconnected because of communication errors this time can be increased. By pressing the *Standard* button, the settings are reset to those values shown in Figure VI.24.

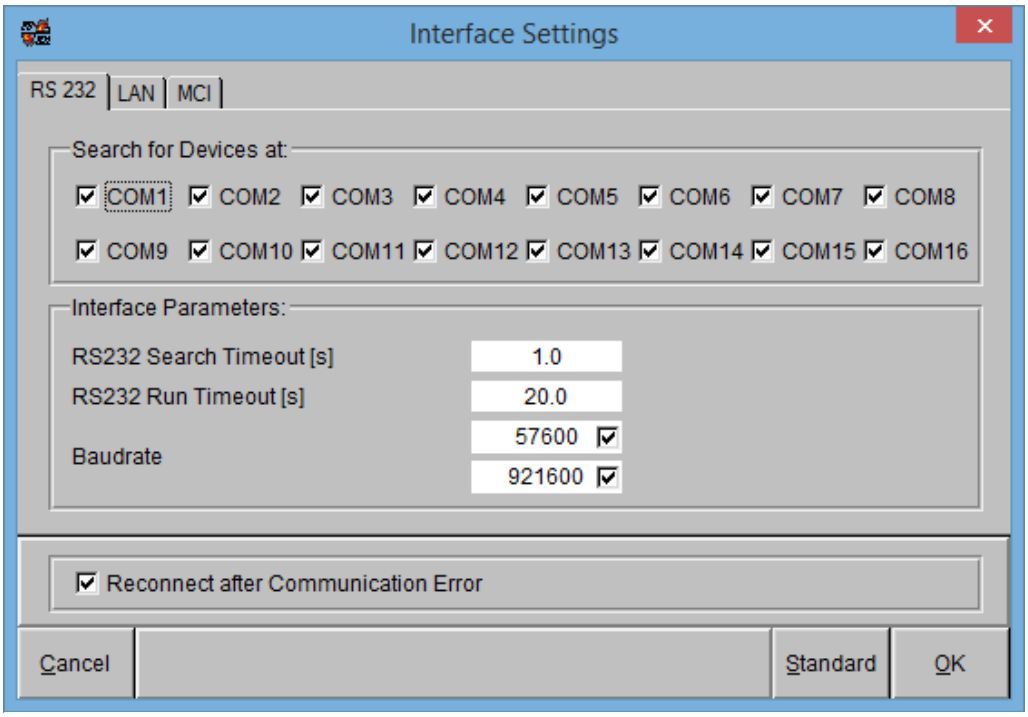


Figure VI.25: Interface settings (RS 232)

In Figure VI.25 the settings for network connections are shown. If the first check box *Search for Devices at LAN* is enabled, the software searches the defined IP addresses for a connected ICM*monitor*. The IP addresses and the port numbers must be set, first. These settings must correspond to the settings of the ICM*monitor*'s serial-to-Ethernet converter. Up to 16 IP addresses can be predefined. The software checks the marked IP addresses, only.

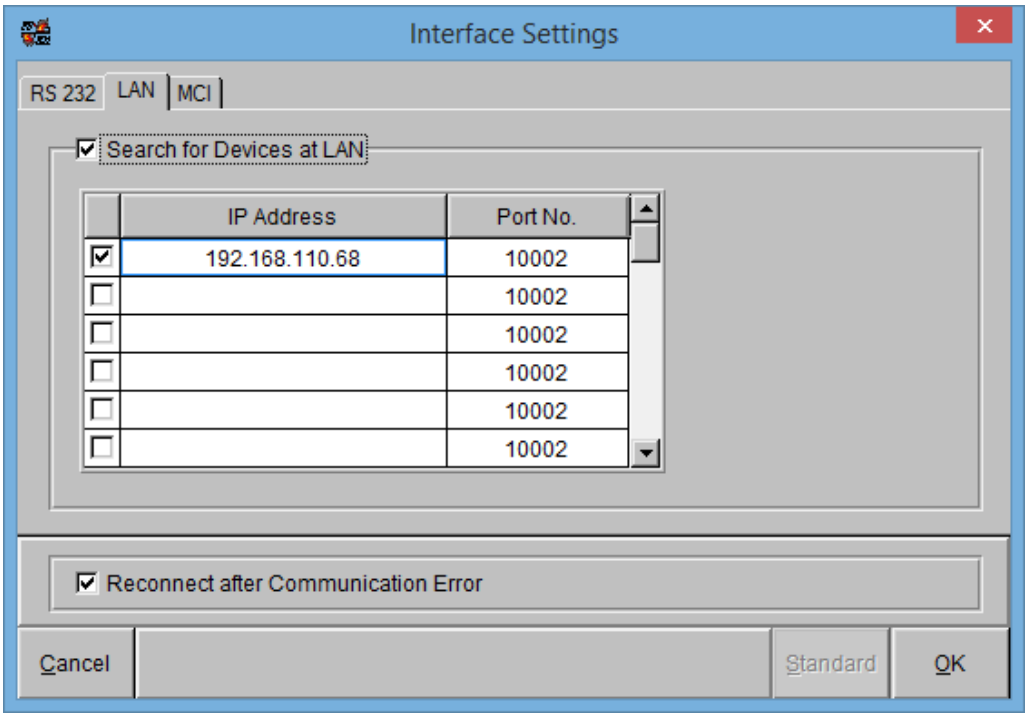


Figure VI.24: Interface settings (LAN)

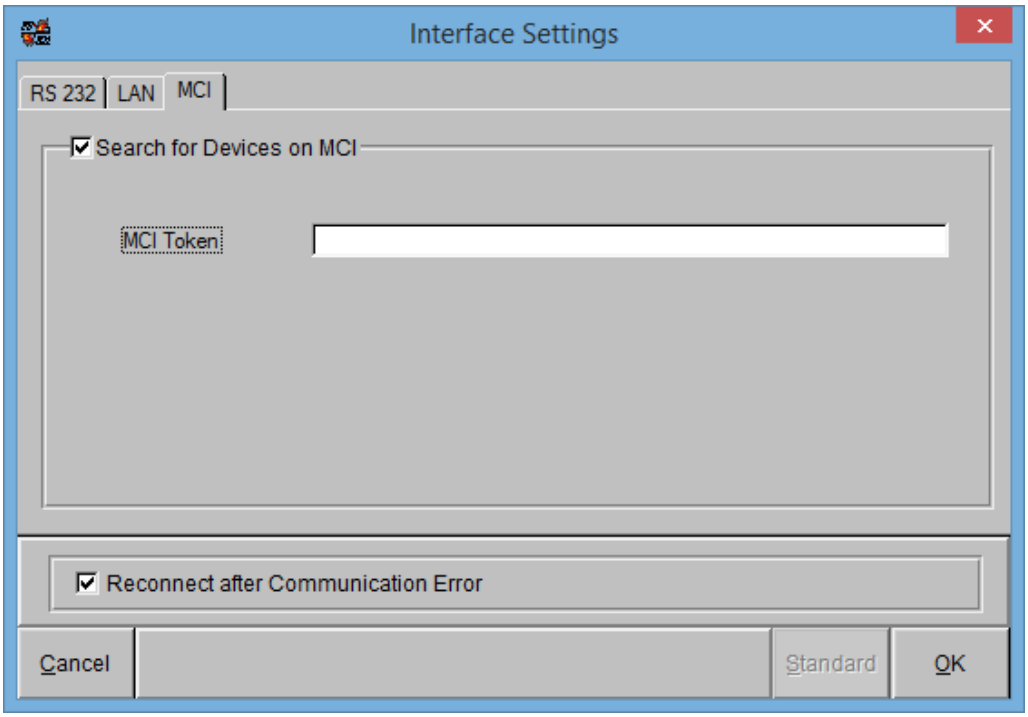


Figure VI.26: Interface settings (MCI); optional

To establish a remote connection to an ICM*monitor*, equipped with a MCI2, the check box *Search for Devices on MCI* must be enabled. To ensure a secured and valid connection to the ICM*monitor*, a *Token* must be selected. This *Token* is provided by Power Diagnostix. A double-click on the *MCI Token* field, opens a window to select the provided *Token*.

VI.3.5 Help menu

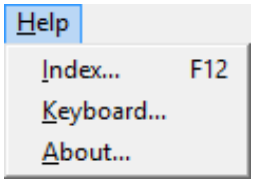


Figure VI.27: Help menu

The menu item *Index* shows a keyword list. By selecting a keyword, the help text is displayed. The menu item *Keyboard* shows the list of short-cut keystrokes for the program. Details of the program are shown by selecting the menu item *About*.

VI.4 Auto-scan mode

With the auto-scan mode enabled, it is possible to scan one or several monitors at predefined time intervals automatically. For this purpose, the monitor software has to run permanently. The settings for the auto-scan mode can be defined in the *Auto Scan Settings* dialogue box.

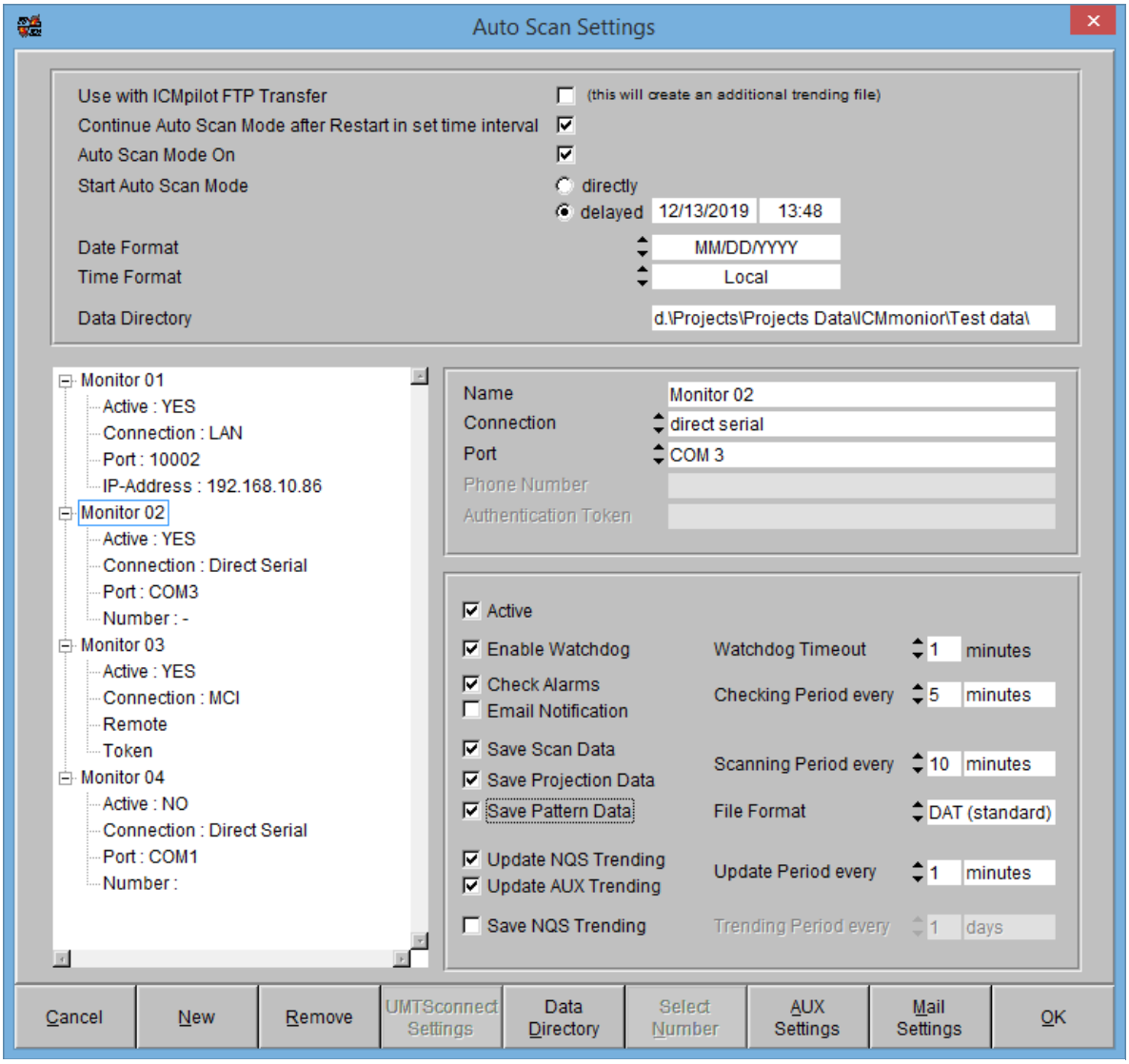


Figure VI.28: Auto-scan settings

Auto Scan Mode Date Format Time Format	To enable the auto-scan mode, the check box *Auto Scan Mode On* of the *Auto Scan Settings* dialogue must be selected. In this dialogue box, it is possible to choose whether the auto-scan mode should start *directly* or *delayed*. If *delayed* is selected, the starting date and time can be set. The date format for the trending files can be chosen in the next box. The formats are *MM/DD/YYYY*, *DD.MM.YYYY*, *DD-MM-YYYY*, *YYYY-MM-DD*, *YYYY/MM/DD*. The time format for the trending files can be defined in the next box. *Local* time means the actual settings of the time zone of the PC running the ICM*monitor* software. If this is selected, all dates in the files refer to the local time. This includes daylight-saving time (DST) dates. So, during the change to DST the dates in the file will change also. E. g. during normal time the dates when the data is saved are: 0:00, 6:00, 12:00 and 18:00. This will change to: 1:00, 7:00, 13:00 and 19:00 during DST. The time difference remains the same. To avoid this and to get always the same dates, the time format can be changed to *UTC* (coordinated universal time), which means all dates refer to UTC. But then the difference between the local time and UTC must be considered.

Date Directory	The text box *Data Directory* shows the parent directory of the auto-scan directory structure. It is possible to type in a directory name directly or to choose one via the *Browse Directory* button. The monitors to be scanned can be defined in the following table. Firstly, a name must be defined for each monitor. This can be done by double clicking on one cell in the *Name of ICMmonitor* column to activate it and then by putting in a name with a maximum of 29 characters. Subsequently, the connection to that monitor must be defined. By double clicking the cell in the *Connection* column, a list appears which shows the possible connection types. A modem, a direct serial link and a LAN connection can be selected. If a Modem or a direct serial link is chosen, double-clicking the cell in the *Port* column opens a list with the COM Ports 1–16 to select the COM port for this specific monitor. If a modem is selected, the dial in number for the monitor can be put in the next cell. The telephone number can also be selected from a list by clicking the *Select Number* button. It's the same list as shown when the *Dial* button is pressed in the main panel. If a LAN connection is selected, the port number for the TCP/IP connection can be put in the *Port* column. The standard port for the ICM*monitor* is 10002. In the next cell the IP-Address of the ICM*monitor* can be set. The Port and IP-Address settings for a LAN connection must be put in, according to the settings of the ICM*monitor*'s serial-to-Ethernet converter. If a remote connection via an MCI is selected, the *Authentication Token* must be chosen.
Name of Connection	
Modem	
LAN	
MCI	
☑	By activating the check box in the first column, the auto-scan mode for that monitor is enabled. Otherwise, this monitor will not be scanned automatically. The area below the table shows the auto-scan settings of the selected monitor. By activating the corresponding check boxes, the monitor can be scanned normally, the projections and the NQS trending as well as the AUX trending data can be stored. The time interval for storing the data can be put in the boxes on the right-hand side of the corresponding check boxes. Saving of the projections is processed during a normal scan. *Update NQS Trending* and *Update AUX Trending* means updating the Trending.txt file with the newest data sets, whereas *Save NQS Trending* means saving the current complete NQS Trending data sets in a separate file. If the time intervals are chosen too short, the execution times may overlap and thus, conflict. E.g., if a monitor with eight channels shall be scanned and the scanning time of each channel is 60 seconds, then the time interval should be at least 10 minutes. Therefore, when several monitors should be scanned, the scanning times of all monitors must be added first and then the time intervals can be specified.
Settings of Scanning Period	
Enable Watchdog	Use this option to enable a communication watchdog in the ICM*monitor*. If the communication during the auto-scan mode is lost and could not be re-established, the ICM*monitor* resets itself after there was no communication for longer than the set *Watchdog Timeout*.
Check Alarms	If this option is enabled, the alarm status of the ICMmonitor will be read periodically and, if available, an alarm pattern will be read and stored to disk. After this check, the alarm status of the ICM*monitor* will be reset.
Auto Scan	If the auto-scan mode is enabled and a connection to a monitor can't be established at the pre-set time, reconnecting this monitor will be tried after a certain delay. As a standard setting, reconnecting is attempted for three times with a delay time of 90 seconds. These settings can be changed manually in the *Autoscan.ini* file, which can be found in the installation folder. The section *Main* defines the tags *Connection Period* and *Number of Connection Trials*. The first tag defines the period between two retries in seconds. The second tag defines the number of attempts. The file *Autoscan.ini* can be edited with a common text editor.

The files that are created by the auto-scan mode will be stored in a certain directory structure. The *Data Directory* is used as the parent directory for all files and independently from the *Standard Directory*. For each monitor in the table, a new subdirectory will be created with the name of that monitor. This subdirectory contains the NQS trending file t*rending.txt*. The new data of every scan will be appended to this file. Another subdirectory for each day will be created if a scan was processed. The name of that subdirectory contains the date in the YYYY*_MM_DD* format. All files, which are created at this day, will be stored in this directory. The prefix of these file names contains the time they are created, in the format hhmm_. The file names are built up as follows:

Scan file	Structure of the file names
Normal scan file	hhmm_C< number of the channel >.mon
Pattern file	hhmm_C< number of the channel >.dat/dtc
Projections file	hhmm_projC< number of the channel >.txt
Trending file	hhmm_trend.txt

The trending data will not only be appended to the main trending file but can also be stored in a separate file. Figure VI.29 shows the file structure as described:

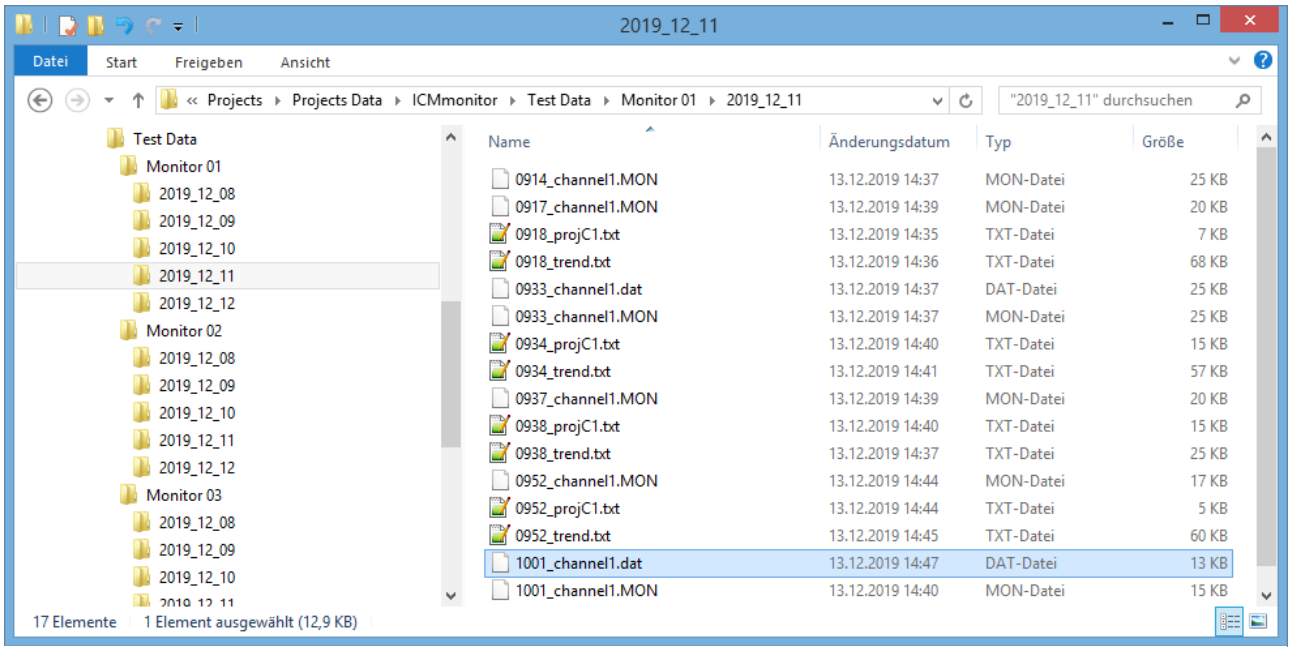


Figure VI.29: Auto-scan file structure

The parent directory in this example is named *D:\Projects\Software\Monitor\Daten*. The subdirectories *Monitor 1*, *Monitor 2* and *Monitor 3* are the names of three scanned monitors. Each monitor directory has a subdirectory for each day. The right window shows the files, which were created at the 2001-03-15. The file names contain the scanning time.

The ICM*monitor* software can send an email to a predefined email address if no auto-scan connection can be established. Necessary information, e.g., SMTP server as well as sender and recipient address, can be set in the *Auto Scan Surveillance* dialogue box shown with Figure VI.30.

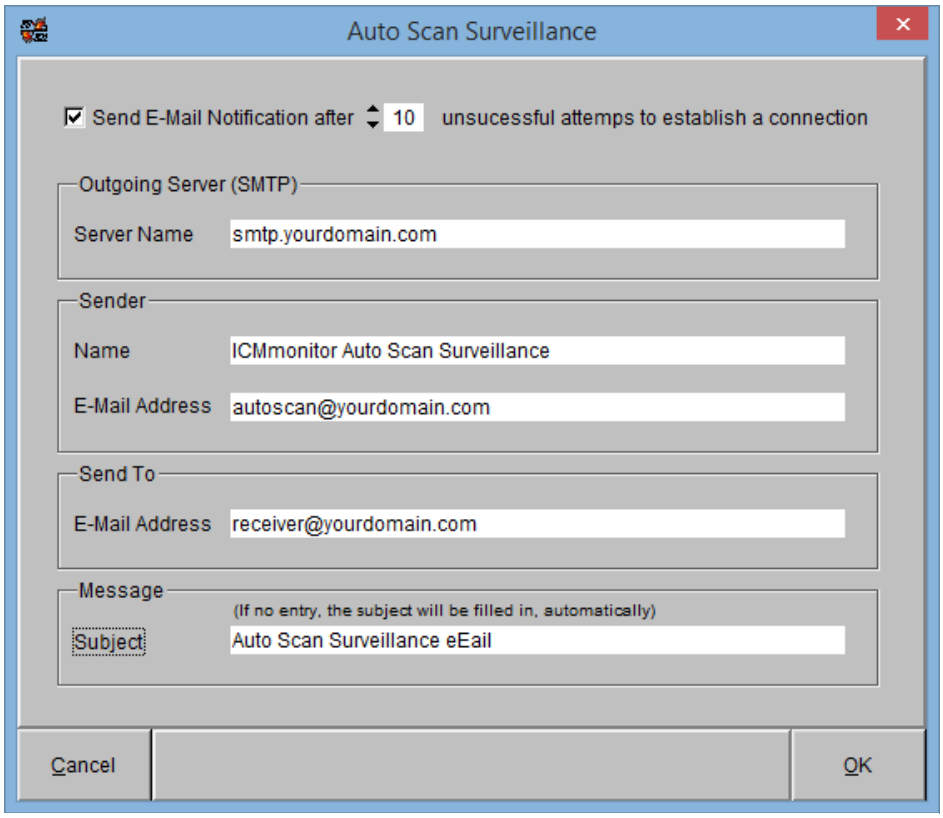


Figure VI.30: Auto-scan surveillance dialogue box

VI.5 NQS trending analysis

The analysis of NQS trending data can be accessed via the *Measurement / NQS Trending* menu item and is only available if no ICM*monitor* is connected. A panel appears which shows the last loaded trending data. New data can be loaded by using the *Load* button. With newer ICM*monitor* firmware versions (>= 3.8) the panel shows the NQS and Qp trending data. Additionally, the AUX trending is shown, if the ICM*monitor* is equipped with the AUXIN option. Underneath, the patterns of the scanned channels are displayed. The display of the channels 1–4, channels 5–8 and the channels 9-12 can be toggled by the corresponding tabs. By moving the cursor of the NQS graph, the point in time can be selected at which the corresponding patterns are to be displayed. In addition, the corresponding NQS values, the Qp values and the AUX values of each channel are shown on the right-hand side. If the Qp values or the AUX values are to be displayed, the corresponding tab on the top right-hand side must be selected. In order to display the right pattern, the files have to be stored in the auto-scan directory and file structure. Additionally, the *Trending.txt* file, which is stored in the monitor directory, must be opened (see page **Fehler! Textmarke nicht definiert.** for the autos-can directory structure). The corresponding pattern-files are searched automatically. Pattern files whose creation date is closest to the selected point of time are displayed. The creation date and time of the files are shown at the top of the pattern.

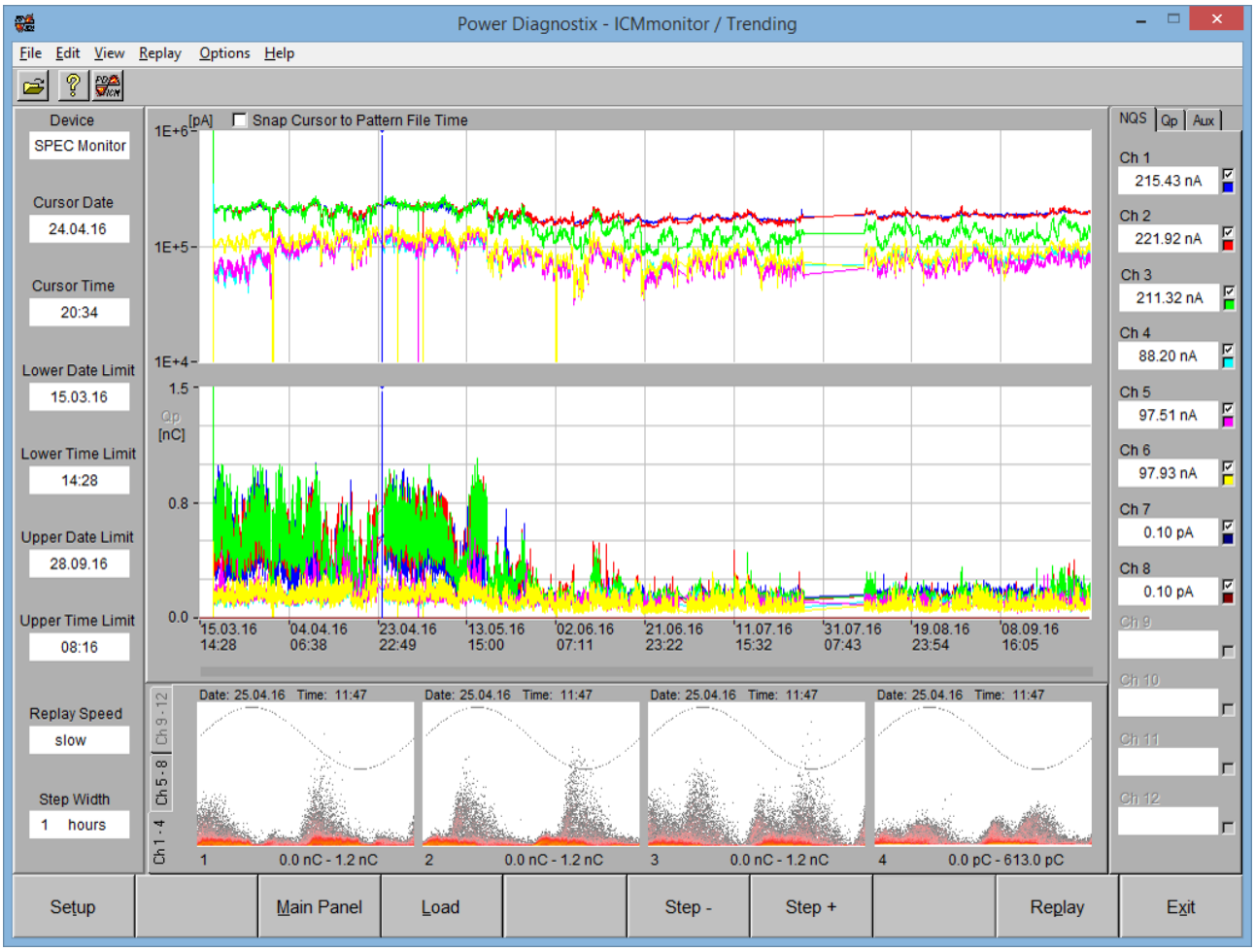


Figure VI.31: Trending analysis

Normal trending files, which were created by the *Export* function, can be loaded as well, but it is not possible to display pattern files then. In addition, there is the *Replay Mode*, which allows to move through the trending curve automatically and to display the corresponding pattern.

The boxes on the left-hand side of the screen display the name of the monitor whose trending file is loaded, the actual cursor position, the lower and upper time limit of the displayed section of the trending curve, as well as the settings of the replay mode. The right-hand side boxes show the NQS values, the Qp values, or the AUX values, depending on the selection, of each channel at the cursor position. By activating or deactivating the check boxes besides the values, the graphs of each channel can be enabled or disabled, and the colour can be selected.

Zooming and shifting of the graph

Zooming and shifting of the graph in x direction is done using the zoom bar underneath the graph. By moving the mouse over the ends of the bar, the cursor changes to a left and right double arrow. By pressing the left mouse button and dragging the cursor at the same time, the bar size and position can be modified. The relation of the modified bar size to its maximum size determines range of trending information shown with the main display. Moving the mouse to the middle of the bar changes the cursor to a hand pointer. Pressing the left mouse button and dragging the cursor at the same time, the bar is moved which subsequently adjusts the displayed period. The data of the trending file determines the maximum time displayed. The minimum possible time shown is ten times the time interval between two data sets in the file.

The resolution of the y-axis is adjusted by double clicking in the area of the y-axis scaling or via the *Options / Scaling of Y-Axis* menu item. The maximum and minimum value of the axis can be set in the corresponding dialogue box. For details see section VI.5.4.5.

VI.5.1 Button bar

Figure VI.32: Button bar, loaded NQS trending file

Figure VI.33: Button bar, replay mode

Figure VI.34: Button bar, paused replay mode

The button *Setup* opens a dialogue box, which shows the settings stored in a displayed pattern file. For details see Figure VI.8. By pressing the *Main Panel* button, the display returns to the main panel. Another trending file can be selected and displayed by pressing the *Load* button. The buttons *Step-* and *Step+* move the cursor backward or forward, respectively. This is also done using the left and right arrow keys. The step width can be adjusted by the corresponding box on the left-hand side of the panel. Selecting the *Exit* button terminates the program.

VI.5.2 Replay mode

In the *Replay Mode*, the cursor moves through the trending curve automatically and the corresponding pattern and NQS values, Qp values or AUX values at the cursor position are displayed continuously. The *Replay Mode* is started via the *Replay* button. The button bar changes according to Figure VI.34. The *Replay Mode* can be terminated by the *Stop* button and the display of the trending curve changes to the initial state. By selecting the *Break* button, the *Replay Mode* is paused, and the cursor stops at the current position. The *Replay Mode* can be resumed by the *Continue* button.

If the graph of the trending curve is not zoomed, the cursor moves through the curve from the beginning to the end. If just a certain area of the curve is selected, the cursor starts at the beginning of the area and moves until the end of the curve. The displayed time interval remains the same. The speed of the cursor can be adjusted by the *Replay Speed* box, which offers the selections *slow*, *medium*, and *fast*. The step width of the cursor can be set in the corresponding box. If all stored patterns are to be displayed, the time between two stored pattern-files should be set in the *Step Width* box.

VI.5.3 Loading via FTP

It is possible to load trending files via an FTP connection. This requires an internet connection, or, if the FTP server is within a local intranet, a network connection. The *File* menu offers the *Load via FTP* menu item.

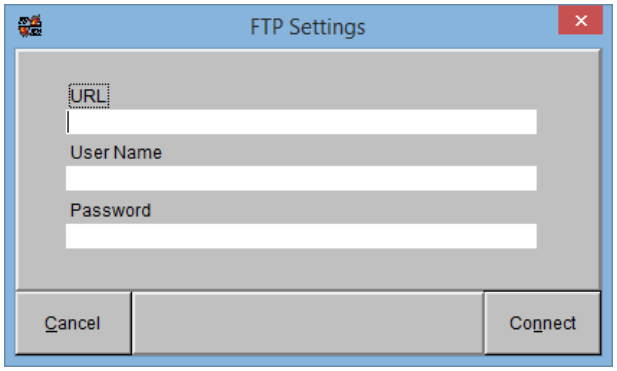


Figure VI.35: Settings dialogue box

After selecting this item, a dialogue box is opened, to define the FTP connection parameters. Figure VI.35 shows this dialogue box. The URL, the username and the password of the FTP server must be set. By pressing the *Connect* button, a connection to the specified FTP server will be established. If the connection is built up, the next dialogue box (Figure VI.36) shows the file structure of the FTP server. In this dialogue box a trending file can be selected which is loaded as a normal trending file, then. By pressing the *OK* button, the selected file is loaded. If the connection is not established or a connection to another FTP server shall be build up, the *Connect* button can be pressed and the *FTP Settings* dialogue box appears again.

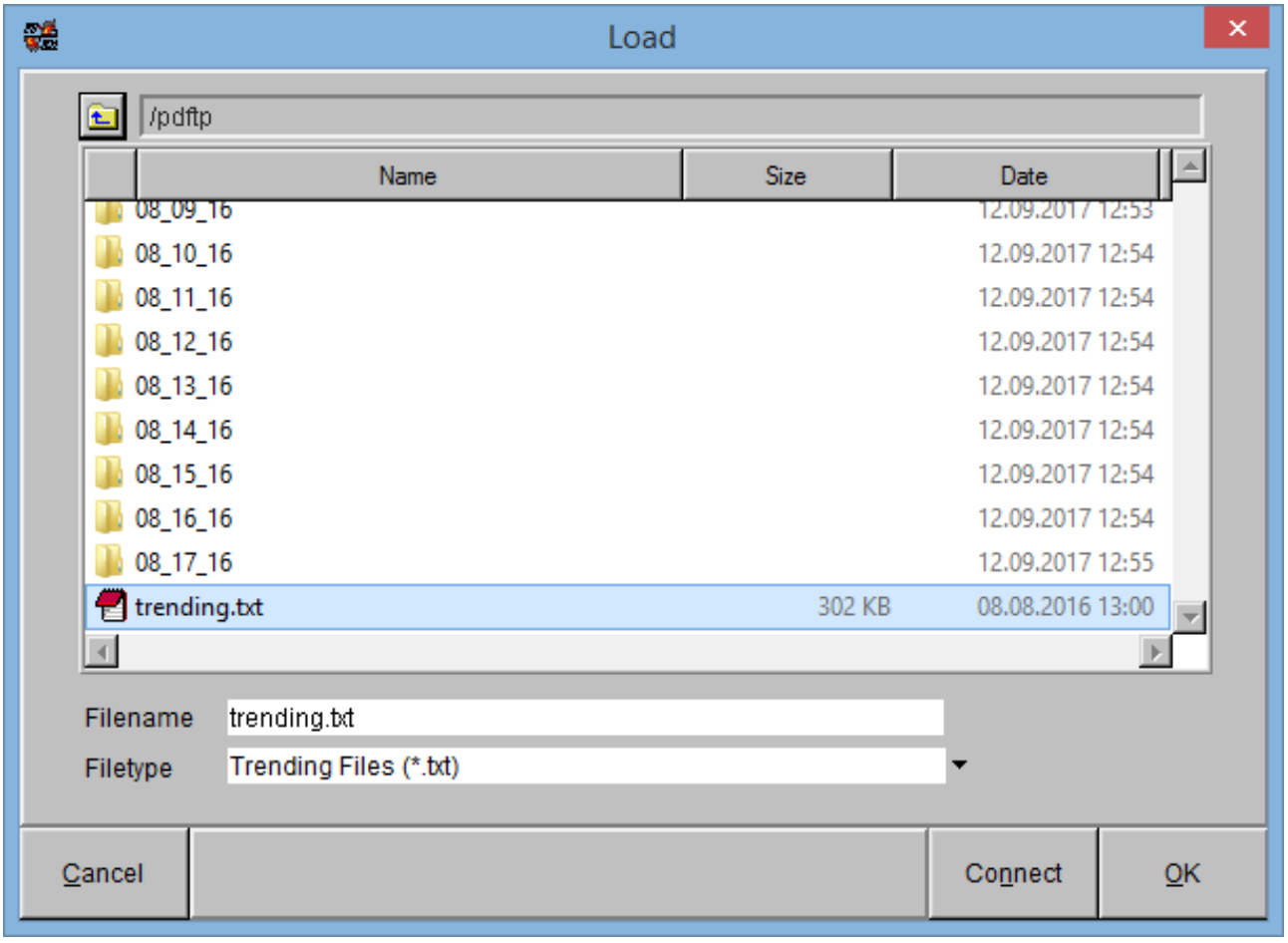


Figure VI.36: Load dialogue box (file structure of an FTP server)

VI.5.4 Menu options

VI.5.4.1 File menu

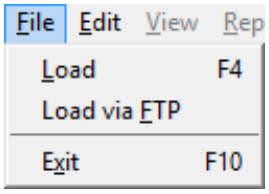


Figure VI.37: File menu of the trending analysis

A trending file can be selected and displayed using the *Load* menu command. Additionally, a trending file can be loaded via an FTP connection. By selecting the *Exit* menu item, the program is terminated.

VI.5.4.2 Edit menu

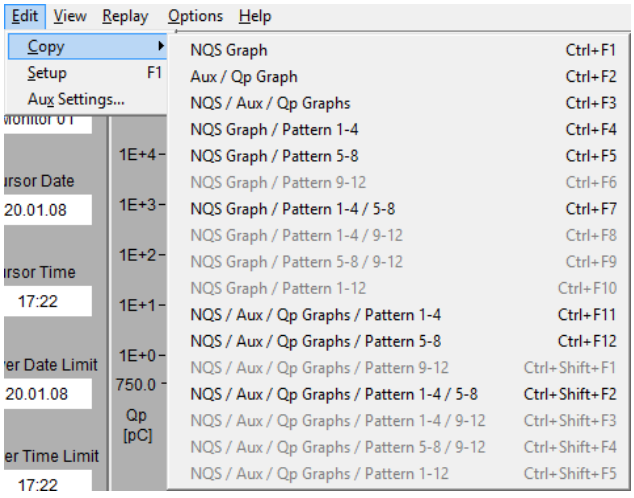


Figure VI.38: Edit menu of the trending analysis

All graphs can be copied to the clipboard by the *Copy* function and can be pasted in other applications subsequently. The combinations of graphs, which will be copied to the clip board, can be selected by *Copy* submenu. By selecting the *Setup* function the setup of the monitor stored in a pattern file is displayed. The AUX settings of the displayed AUX values can be changed by the *Aux Settings* menu item. The opened dialogue box is the same as described in section VI.3.2.5 Alarm Output Configuration (Optional). Changes in these settings might affect the scaling of the AUX graphs.

VI.5.4.3 View menu

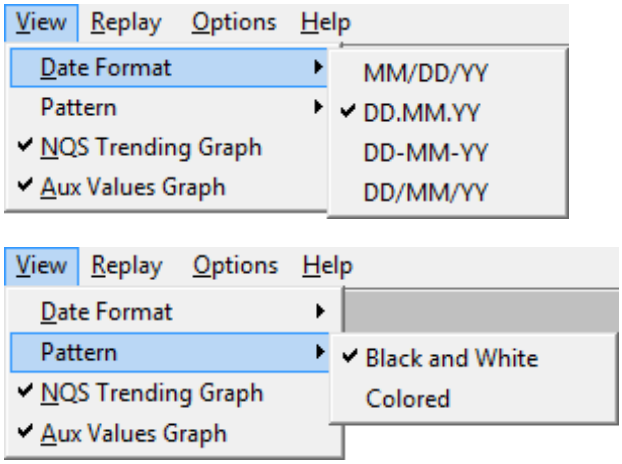


Figure VI.39: View menu of the trending analysis

The menu item *Date Format* defines the format of the labels of the X-axis scaling. Several different formats can be selected. The item *Pattern* defines whether the PD pattern is displayed in black and white or as a coloured pattern. The next two items define which graphs are displayed on the panel. If only one is selected, the corresponding graph is enlarged.

VI.5.4.4 Replay menu

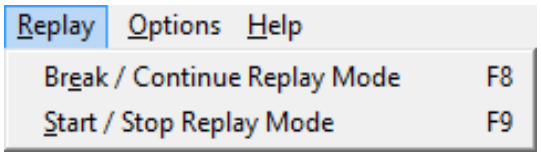


Figure VI.40: Replay menu of the trending analysis

The menu entry *Start / Stop Replay Mode* starts resp. stops the replay mode. The menu command *Break / Continue Replay Mode* is available only if the *Replay Mode* has been started. The *Replay Mode* is paused resp. resumed then.

VI.5.4.5 Options menu

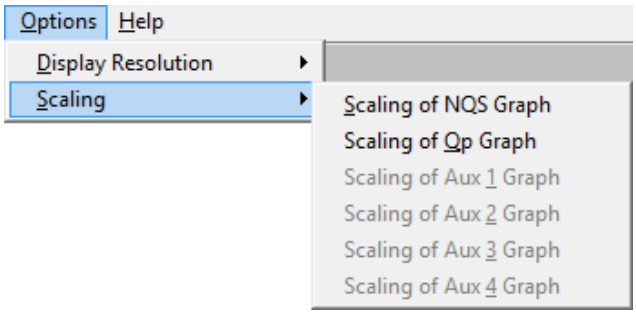


Figure VI.41: Options menu of the trending analysis

The submenu *Display Resolution* sets the size of the trending panel. Available resolutions are *SVGA* (800 x 600) and *XGA* (1024 x 768). The menu item *Auto* loads the trending panel as large as possible for the screen resolution. This is the default setting. If another resolution is selected, the panel appears in this resolution. The maximum size of the trending panel is limited by the screen resolution.

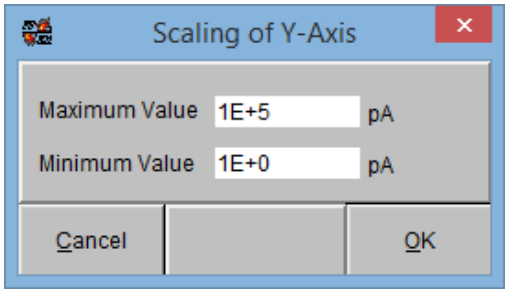


Figure VI.42: Scaling of the Y-axis

The submenu *Scaling* sets the scaling of the Y-axis of the different graphs. The maximum and minimum value of the Y-axis of the respective unit can be adjusted. The values for the NQS graph are logarithmic and are rounded up resp. down to the next decade. The values of the other graphs are linear. These values can also be set by double-clicking the Y-axis of the corresponding graph.

VI.6 Pattern acquisition

The pattern acquisition panel shows the pulse-amplitude-phase-height-distribution, whereas every single grey dot stands for an acquired pulse at this specific phase position (x-axis) with respect to the synchronisation source used and this specific amplitude position (y-axis). In case more than one pulse occurs at the same coordinates, the dot changes its colour to visualise the frequency of occurrence. Figure VI.43 shows an example of such a partial discharge pattern.

The display block at the left-hand side of the pattern contains mainly status information regarding the current file or measurement and the communication channel used. The status of the communication interface used is shown with the five 'LED'-like indicators. The first indicates an active connection (Online). In case of such an active connection, the upper red LED indicates ongoing transmission of data (commands and setup strings) to the instrument (TXD), while the lower red LED refers to a transmission of data (measurements) from the instrument (RXD). The RS232 indicator shows that an ICM*monitor* is connected to the software via USB or RS232. The Modem LED indicates a connection via modem. The lower part of this display block shows the file name of the current data set. The date and time shown with the two remaining displays is referring to the moment when the acquisition of the current data set was started.

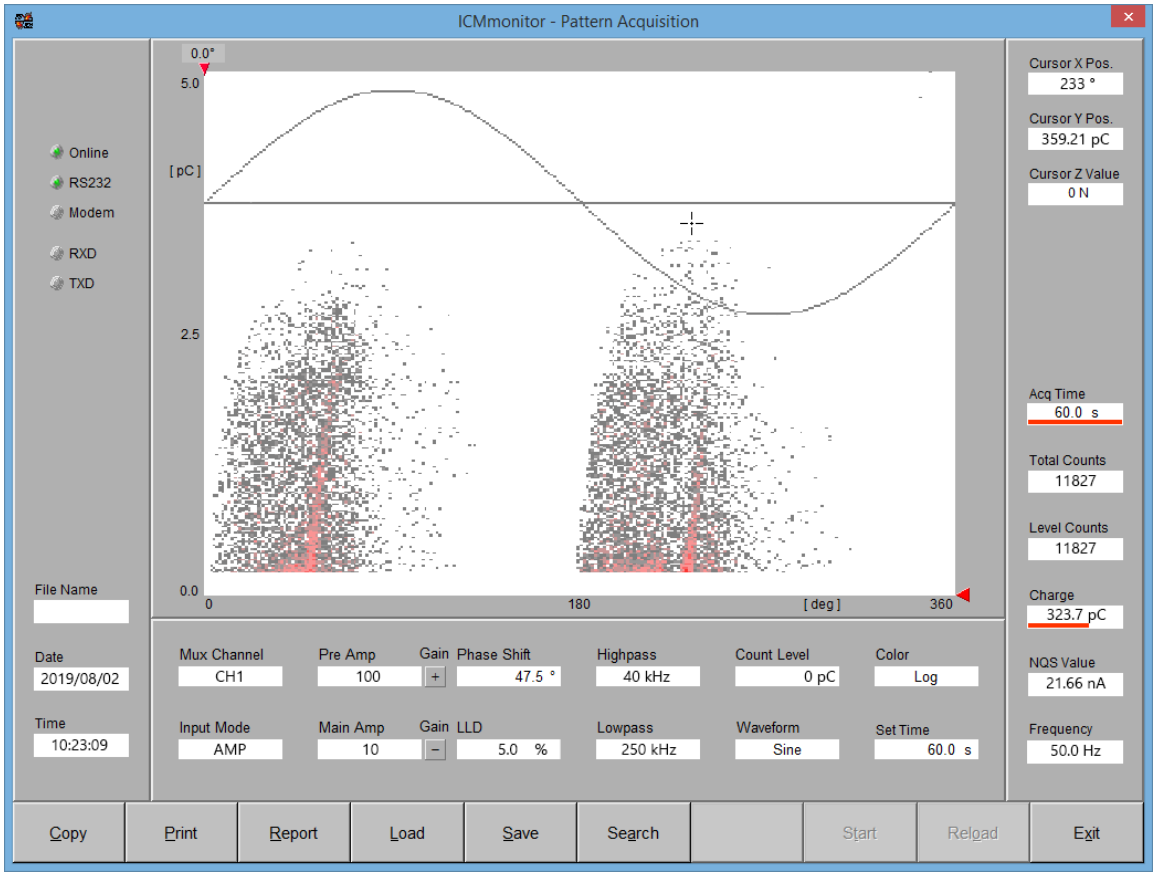


Figure VI.43: Pattern acquisition panel

The right-hand block bears nine items. The first three fields display the current cursor position. The fourth item shows the acquisition time. It is a combined indicator, where the red bar graph shows the relation between pre-set acquisition time and the amount of time already passed. The following two entries are to display the number of counts of the current acquisition. 'Level Counts' displays the counts raising the level set. The seventh item indicates the current peak charge measured. The NQS value is a derived quantity. It is the average discharge current, calculated by dividing the sum of the charge of all discharge pulses acquired by the acquisition time. The last item of this block shows the frequency of the connected synchronisation voltage.

Below the pattern display some settings of the ICM*monitor* and for the pattern acquisition are shown. The entries show the current settings of the connected ICM*monitor* or the setup, stored in the loaded file. The following settings are displayed:

Mux Channel	Current Measurement Channel
Input Mode	Select between AMP and SPEC path for pattern acquisition. While a pattern acquisition using the AMP path is limited to fixed cut-off frequencies, pattern acquisition using the spectrum path offers selection of a centre frequency up to 10 MHz with a bandwidth of 9 kHz or 270 kHz
Pre Amp	Amplification of the preamplifier
Main Amp / Spec Amp	Amplification of the instrument's measurement path. Depending on the selected *Input Mode* different values are selectable.
Gain +	Increases the current Gain setting to the next valid combination of Pre- and Main / Spec gain
Gain -	Decreases the current Gain setting to the next valid combination of Pre- and Main / Spec gain
Phase Shift	In case the sync source used is not of the same phase as the high voltage causing the current discharge pattern, this entry serves to adjust the phase position by filling in a phase shift.
LLD	Entry to set the low level discriminator. A minimum level of 2% should be set to eliminate small noise pulses. The level refers to the 100% full scale of the y-axis of the pattern graphs
Highpass / Center Frequency	Setting for the lower cut-off frequency of the PD bandpass filter in *AMP Mode*. In *SPEC Mode* the *Center Frequency* of the spectrum path.
Lowpass / Bandwidth	Setting for the upper cut-off frequency of the PD bandpass filter in *Amp Mode*. In *Spec Mode* the *Bandwidth* (9 kHz or 270 kHz) of the spectrum path.
Count Level	With some applications it is wanted to know the number of pulses exceeding a certain level. This entry serves to enter such level. The level counts and the total counts are displayed in the right-hand display block
Waveform	The shape of a sine wave and a base line can be displayed along with the partial discharge pattern.
Color	The z-axis (i.e., the distribution of the colour) may be coded linear ('Norm') or logarithmic ('Log').
Set Time	Entry to pre-set the acquisition time. An acquisition may be stopped earlier by pressing the 'Stop' button.

There is a row of function buttons at the bottom of the panel. The following buttons are available:

Copy	Copies the current displayed partial discharge pattern to the clipboard
Print	Prints out the current displayed partial discharge pattern together with the settings and additional report information
Report	Opens a window to enter additional report information
Load	Loads a previously stored pattern file.

Save	Saves the current displayed partial discharge pattern to the hard disk. The format of the file is a .DAT or DTC file
Search / Offline	If no ICM*monitor* is connected, the software searches for available ICM*monitor* on the COM ports or LAN interfaces. If an ICM*monitor* is already connected, the software disconnects.
Start / Stop	Start or stop a pattern acquisition. The software stops the acquisition automatically after the *Set Time*.
Reload	Reloads the last stored pattern of the connected ICM*monitor*.
Exit	Closes the pattern acquisition panel.

VI.7 Spectrum analyser

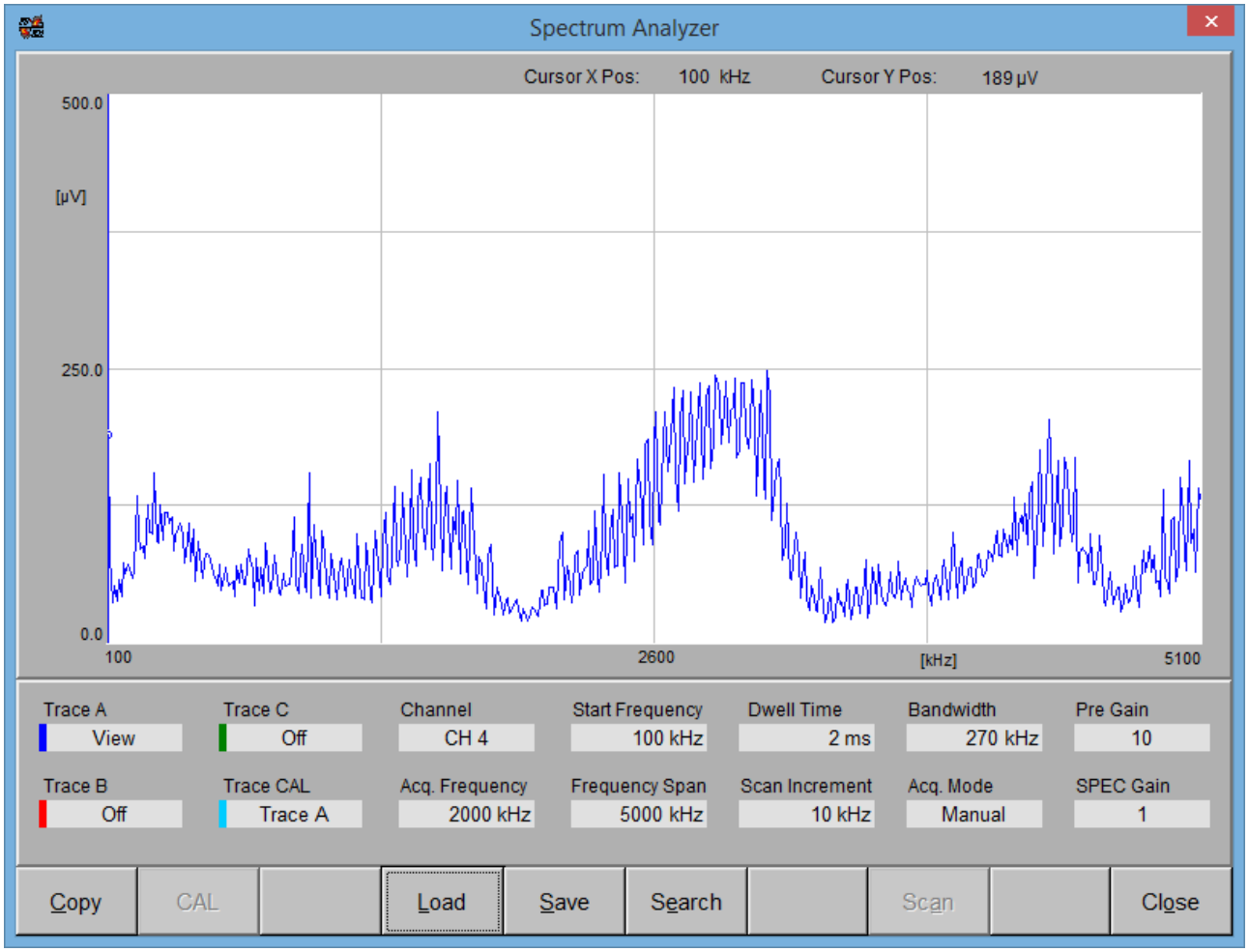


Figure VI.44: Spectrum analysis panel

The spectrum analysis panel shows the frequency spectrum of the input signal up to 10 MHz. This spectrum scan can be used to select the measurement frequency of the input channel for the monitoring. The *input mode* of the selected channel must be set to *SPEC* to start a spectrum scan. The *Start Frequency* of the scan can be set to an arbitrary value between 0 kHz and 9900 kHz. The *Frequency Span* can be selected of fixed values between 100 kHz and 10000 kHz. The sum of *Start Frequency* and *Frequency Span* should not exceed 10000 kHz. There are three traces available, which can be used independently. A frequency scan can be started by pressing the *Scan* button in *Manual* mode and by the *Start* button in *Continuous* mode. In *Manual* mode only one sweep (from *Start Frequency* until Stop Frequency) is acquired, whereas in *Continuous* mode the acquisition will be performed continuously until the *Stop* button is pressed. Below the display of the frequency spectrum the settings for the spectrum scan are shown. The entries show the current settings of the connected ICM*monitor* or those, which are stored in the loaded file. The following settings are displayed:

Trace A Trace B Trace C	Up to 3 traces can be displayed independently. The following modes are available: Clear Write: A new sweep replaces the old one. View: The trace will not be changed any more. Maxhold: The maximum amplitude at each frequency is stored and displayed. Average: The average amplitude at each frequency is calculated and displayed. Off: The trace is hidden.
Channel	Current measurement channel

Acq. Frequency	Measurement frequency of the selected channel
Start Frequency	Start frequency of the spectrum scan
Frequency Span	Width of the spectrum scan
Dwell Time	The time the acquisition unit measures on each frequency point
Scan Increment	The distance between two frequency points, which are used for the spectrum scan
Bandwidth	The bandwidth of the measurement: 270 kHz or 9 kHz
Acq. Mode	The acquisition mode of the spectrum scan: Manual or continuous
Pre Gain	Amplification of the preamplifier
SPEC Gain	Amplification of the spectrum path of the instrument

There is a row of function buttons at the bottom of the panel. The following buttons are available:

Copy	Copies the spectrum scan graph to the clipboard
Load	Loads a spectrum scan file
Save	Stores a spectrum scan file
Search / Offline	If no ICM*monitor* is connected, the software searches for available ICM*monitor* on the COM ports or LAN interfaces. If an ICM*monitor* is already connected, the software disconnects.
Scan / Start / Stop	In *Manual* mode one sweep is acquired; in *Continuous* mode the acquisition of several sweeps is started / stopped
Close	Closes the *Spectrum Analysis* panel

VI.8 Frequency spectrum calibration

The frequency spectrum calibration panel can be opened by selecting the *Measurement – Spectrum Calibration* menu item or the corresponding toolbar icon. After opening the window, only the calibration values of the selected channel are shown. These values are stored in the instrument.

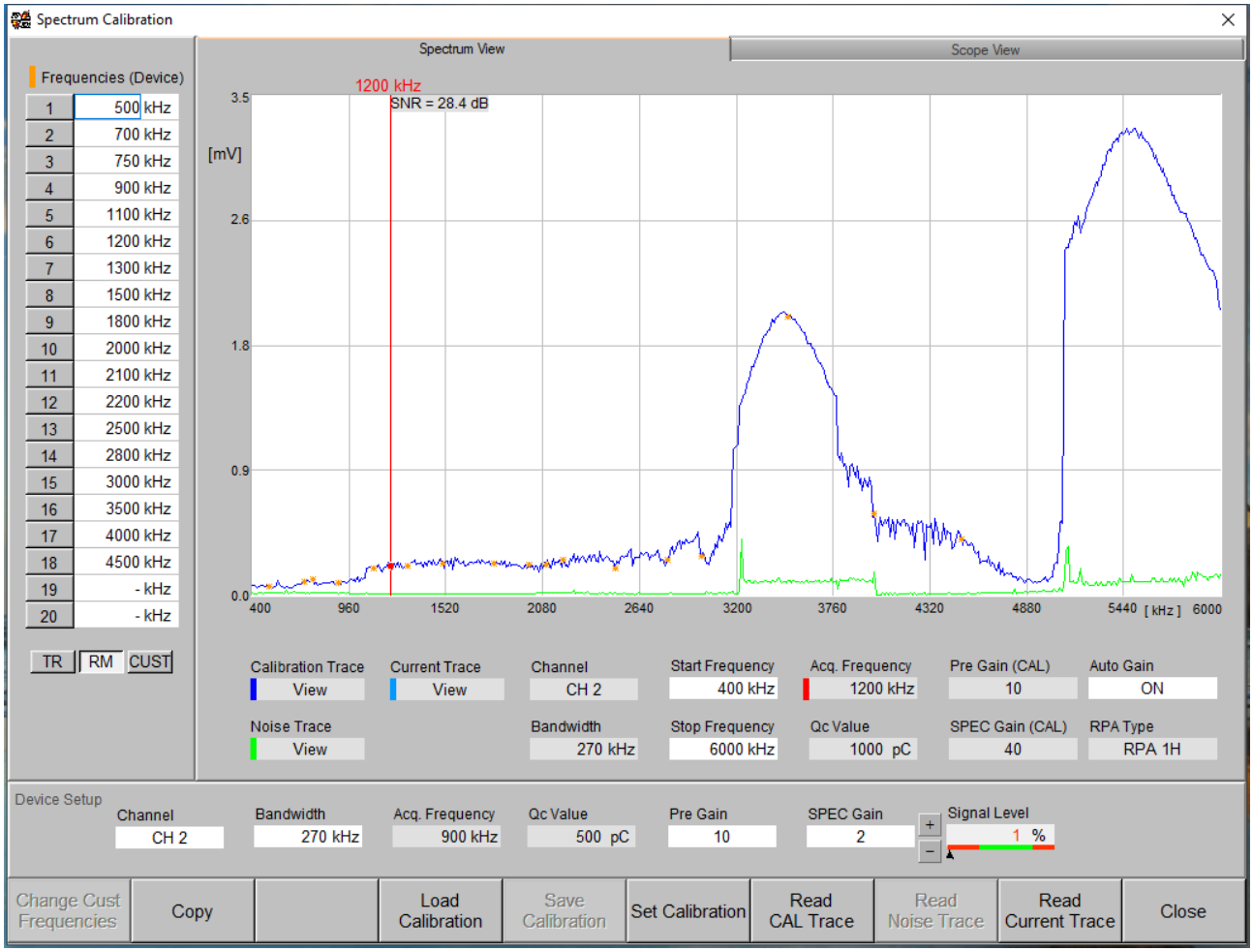


Figure VI.45: Frequency spectrum calibration panel

In spectrum acquisition mode, the calibration is only valid for the measurement frequency on which the calibration was performed. This always requires a re-calibration if the measurement frequency is changed. During commission the frequency that is used later during operation is not known, so multiple calibrations on different frequencies must be performed. The frequency spectrum calibration function simplifies this task and offers the possibility to store and load the calibration for a selected frequency range in 10 kHz steps.

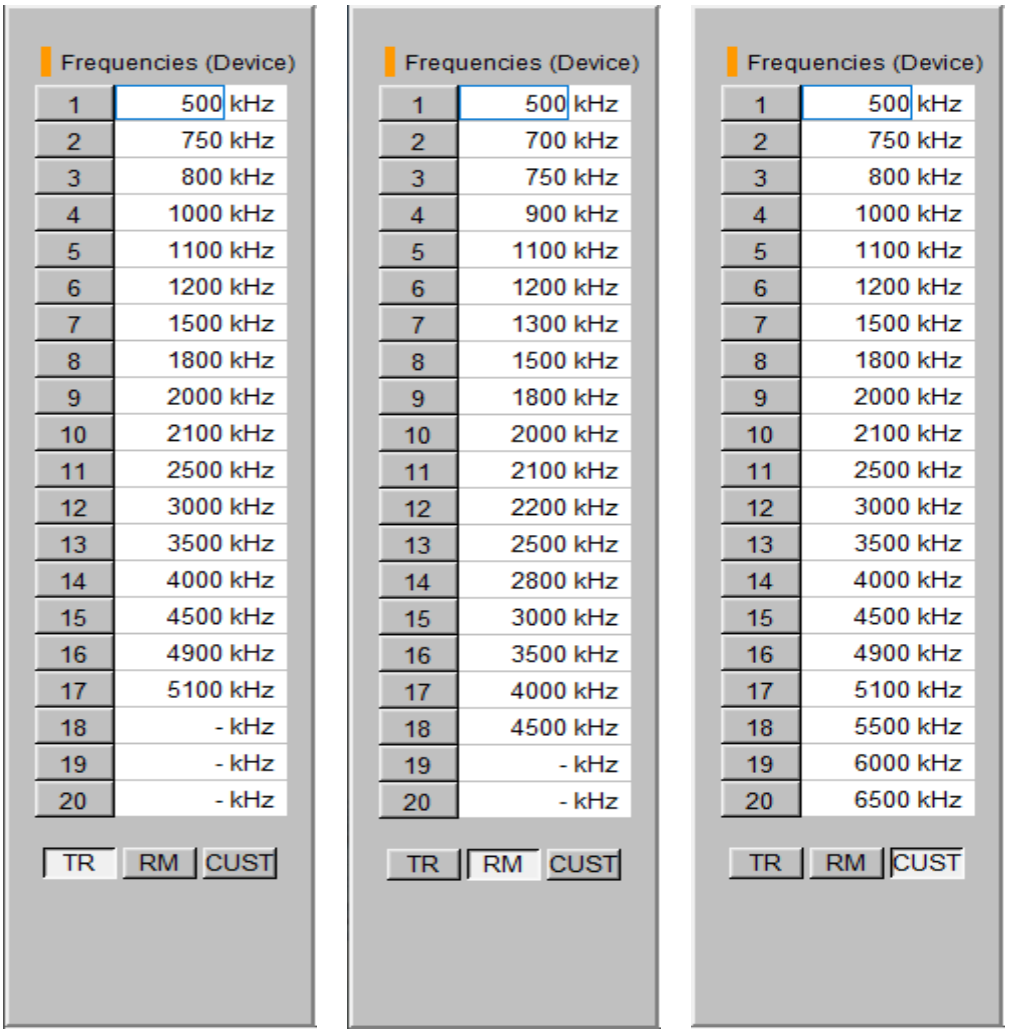


Figure VI.46: Predefined frequency sets

In the device itself the calibration for up to 20 frequencies per channel can be stored. Here, one of three predefined frequency sets can be selected. These predefined sets are valid for all measurement channels; there is no individual configurable set for each channel. The first set is intended for measurements at transformers (TR) and offers the following frequencies: 500, 750, 800, 1000, 1100, 1200, 1500, 1800, 2000, 2100, 2500, 3000, 3500, 4000, 4500, 4900, 5100 kHz. The second set is intended for measurements at rotating machines (RM) and offers the following frequencies: 500, 700, 900, 1100, 1200, 1300, 1500, 1800, 2000, 2100, 2200, 2500, 2800, 3000, 3500, 4000, 4500 kHz. The third set is customizable (CUST) by the ICM*monitor* software and offers the following predefined frequencies: 500, 750, 800, 1000, 1100, 1200, 1500, 1800, 2000, 2100, 2500, 3000, 3500, 4000, 4500, 4900, 5100, 5500, 6000, 6500 kHz. These predefined sets are shown in the table on the left-hand side of the panel and can be selected individually for each channel by the buttons below the table. These frequencies are marked by orange asterisks in the graph. The colour can be changed by a left click on the colour field on top of the table. The custom frequencies set can be changed by pressing the *Change Cust. Frequencies* button. Additionally, the values can be changed by selecting one of the asterisks in the graph with a left mouse click and moving it while pressing down the left mouse button. The current value will be displayed in the table. Pressing the *Change Cust. Frequencies* button again will send the changes to the instrument. If a value of the custom frequencies set is changed, the calibrations of the channels, which are correlated with the custom frequencies set and stored in the instrument, will be deleted and are not valid anymore.

The setup values at the bottom of the panel show the current settings of the connected device. Here, the *Channel* for the calibration and the corresponding *Bandwidth* can be selected. The next two fields show the currently selected measurement frequency and the corresponding calibration value. The gain of the selected channel can be changed by the *Pre Gain* and *Spec Gain* controls or by pressing the plus or minus buttons.

The current signal level of the input is shown by the last indicator. The green area indicates the best range for the calibration.

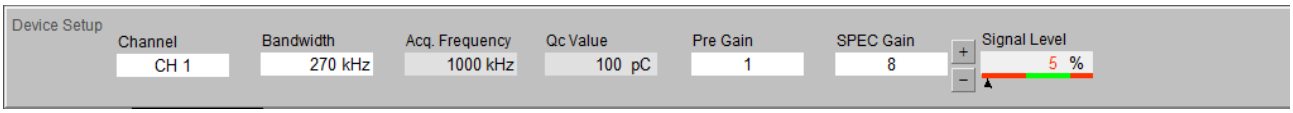


Figure VI.47: Device setup

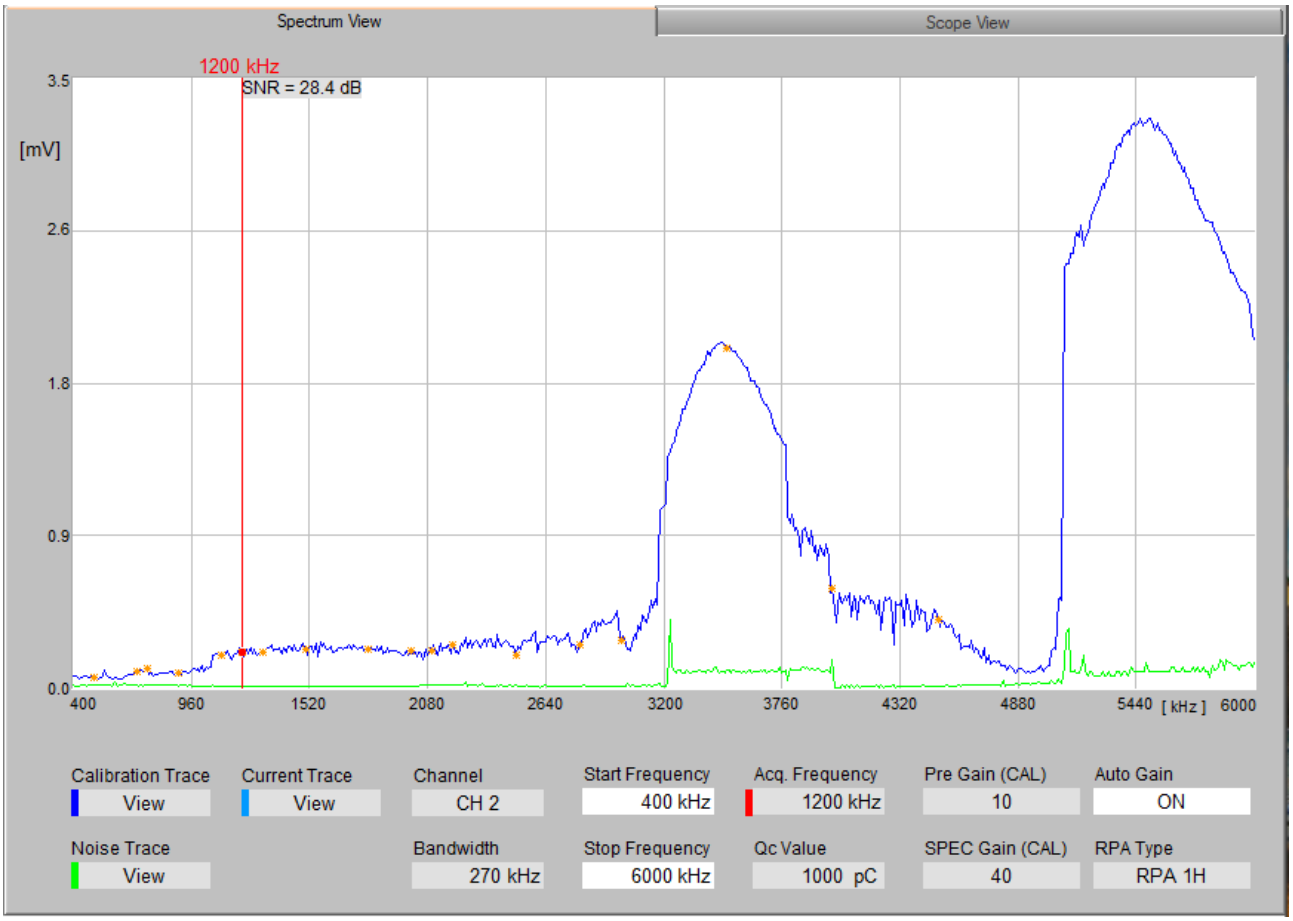


Figure VI.48: Spectrum view

The settings below the graph refer to the displayed traces, only. The displayed graph can show the recorded traces of the connected device or from a loaded file. Up to four traces can be displayed in the graph. The *Calibration Trace* shows the spectrum scan that has been recorded during the calibration. The *Noise Trace* is also recorded during the calibration process, but without a calibrator signal. The *Current Trace* is usually recorded under online conditions after the calibration. The fourth *Trace* shows the calibration values at the predefined frequencies of the selected frequency set, which are stored in the device. These are marked by asterisks. The colours of the traces can be changed by clicking on the colour bars on the left of the corresponding controls. The cursor shows on top the selected frequency and the signal-to-noise ratio and snaps to the next 10 kHz step. The frequency range for the spectrum scan can be set by the *Start Frequency* and *Stop Frequency* fields. The range must at least include the range of the selected frequency set. The range will be adapted automatically, if necessary. To adapt the signal amplitude to the ideal range during the calibration process, an automatic gain adjustment can be selected. Three different modes are available for *Auto Gain*: *OFF* means no automatic gain adjustment, *ON (fixed pregain)* means automatic gain adjustment, but the pre-gain will not be changed, *ON* means automatic gain adjustment.

VI.8.1 Frequency spectrum calibration process

Before starting the calibration process, the channel, the bandwidth, and the predefined frequency set must be selected. Furthermore, the automatic gain adjustment mode must be selected. If not set to *ON*, the gain must be set manually. The calibrator must be connected to the test object. Pressing the *Read CAL Trace* button will start the calibration process.

A window will pop up to set the injection value of the calibrator and to select the type of pre-amplifier. Pressing the *OK* button will start the frequency spectrum scan. In the graph the progress of the scan is displayed. When reaching the *Stop Frequency,* the spectrum scan will stop automatically. Additionally, the frequency spectrum of the noise signal can be recorded by pressing the *Read Noise Trace* button. Therefore, the calibrator must be turned off. During this frequency scan, the gain is set equally to the gain of the calibration scan. Both frequency spectrum scans can be stored by pressing the *Save Calibration* button (The noise signal spectrum scan is not a must). This process can be repeated for different injection values and the other measurement channels.

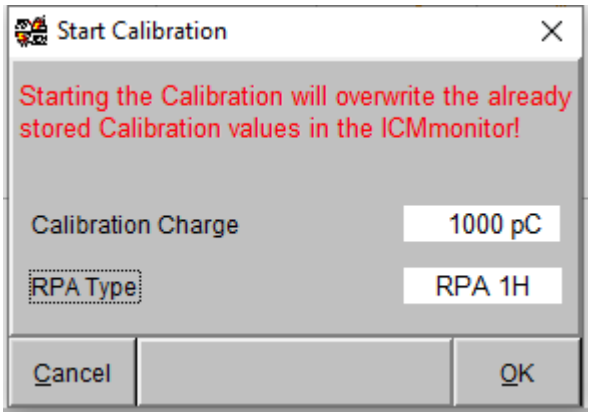


Figure VI.49: Setup of calibration charge and pre-amplifier

After the calibration is done and the machine or transformer is energised, the measurement frequency must be selected, and the corresponding calibration must be uploaded to the instrument. This can also be done in the *Spectrum Calibration Panel*. First, a frequency spectrum scan of the current conditions must be performed by pressing the *Read Current Trace* button. Then one of the calibration files can be loaded by pressing the *Load Calibration* button. By comparing the amplitudes of the current frequency scan with the amplitudes of calibration files with different injection values, the correct calibration file can be found. Then, the measurement frequency must be selected, and the calibration values must be uploaded to the instrument.

Pressing the *Set Calibration* button opens a window to select the measurement frequency. This can be done directly by entering the value into the *Measurement Frequency* field or by moving the cursor. Additionally, the injection value, the gain settings, and the bandwidth are displayed. These values correspond to the selected measurement frequency and have been recorded during the calibration process. Pressing the *OK* button will send the selected measurement frequency and the corresponding calibration values as well as the bandwidth to the instrument. The selected channel is now calibrated. This process can be repeated for the other measurement channels.

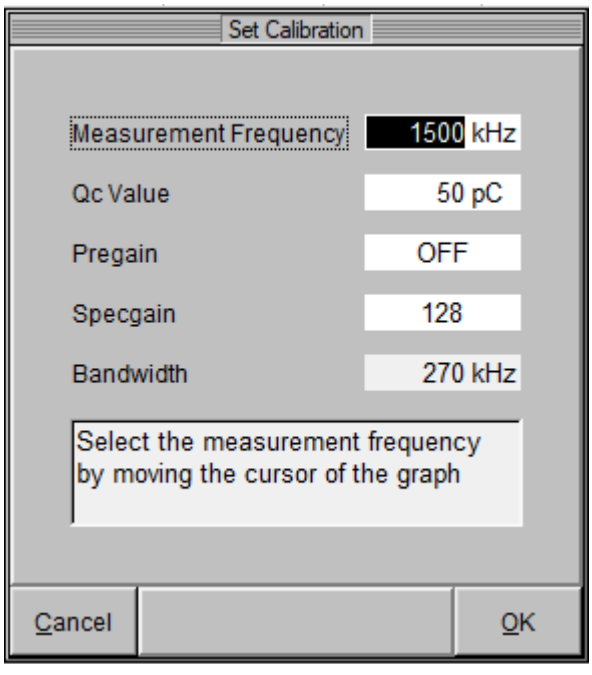


Figure VI.50: *Set Calibration* window

VI.9 Optional software functions

VI.9.1 ICM*Server*

If the auto-scan mode is activated, it should be ensured that the ICM*monitor* software is running permanently. ICM*Server* is additional software that can restart the ICM*monitor* software, if necessary. For that purpose, the ICM*monitor* software sends notifications to the ICM*Server* in predefined intervals. If these notifications are missing, the ICM*Server* restarts the ICM*monitor* software automatically.

In the *Restart Service Settings* dialogue box, the data for establishing a communication with the ICM*Server* are defined if 'Activate Restart Service' is checked. The ICM*monitor* software needs the IP address and the communication port of the ICM*Server*. This communication port is defined in the ICM*Server* software. Additionally, the notification interval and, optionally, a short string as notification message can be defined.

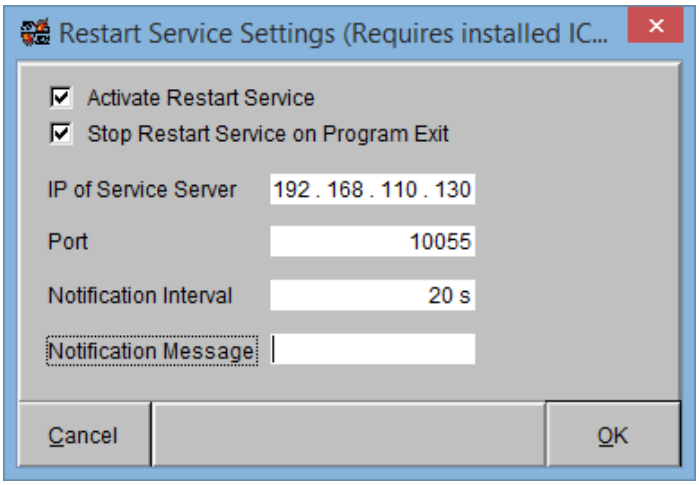


Figure VI.51: Dialogue box for ICM*server* settings

VII MWS – Monitoring web server (optional)

VII.1 Overview

The MWS is a monitoring web server providing an Ethernet gateway for platform independent remote access to monitoring data recorded with a PD instrument such as the ICM*monitor*. To access the PD instrument by remote a modern web browser is required.

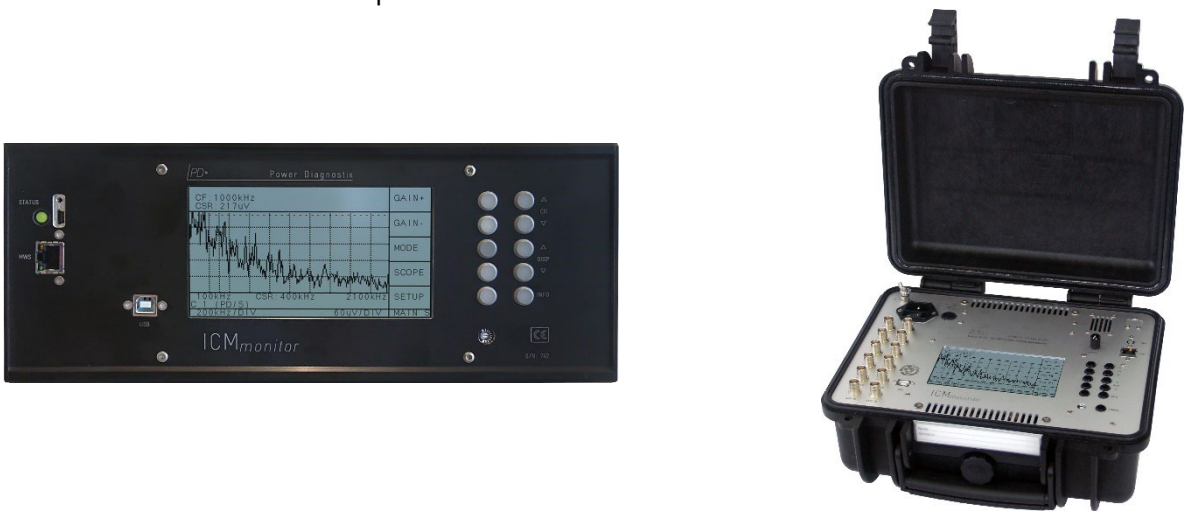


Figure VII.1: Two models of ICM*monitor* with built-in MWS: DIN rail mountable (left) and Explorer case model (right)

VII.2 Signal flow

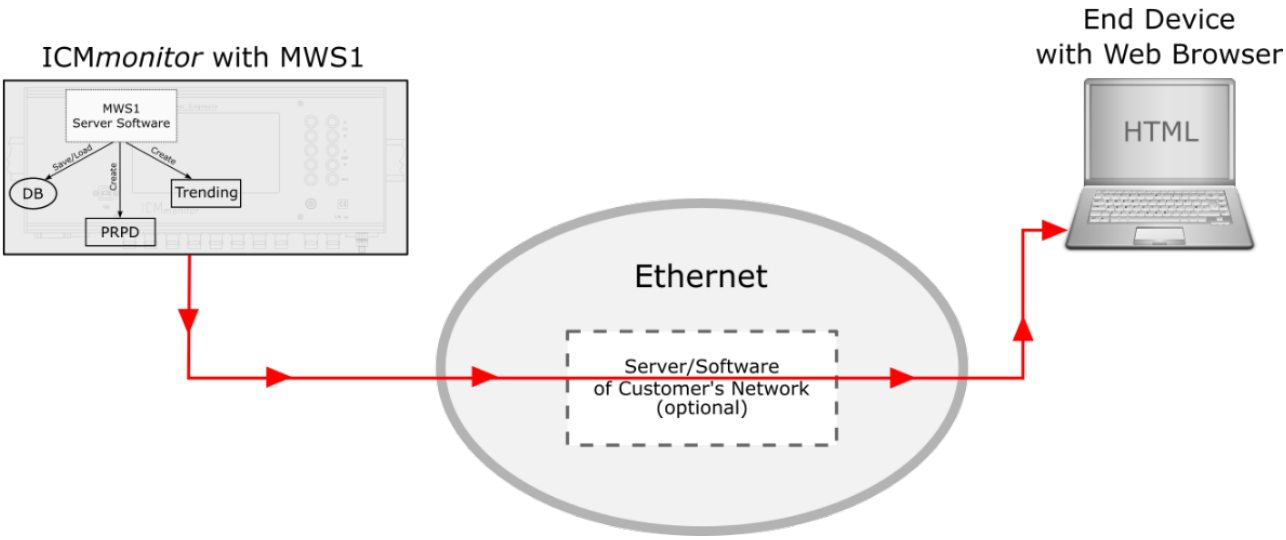


Figure VII.2: Signal flow

VII.3 Web interface

The MWS application is integrated in the hardware and can be accessed with any modern web browser that supports HTML5 (Firefox version 68.0, Chrome version 75.0, Opera version 62.0, Edge version 44.0, or later). There is no installation required.

VII.3.1 Login und overview page

The MWS application is loaded via an address such as https://mws[serial number].yourdomain.tld. Please remark: To be able to establish a connection, the client computer must be in the same IP range as the mobile web server, whose standard IP is 192.168.122.1xx with xx being the last two digits of the *ICMmonitor*'s serial number.

On start-up, the application shows a login page for entering your user credentials. At delivery there are three pre-configured accounts:

User	Password
Admin	admin
User	user
Viewer	viewer

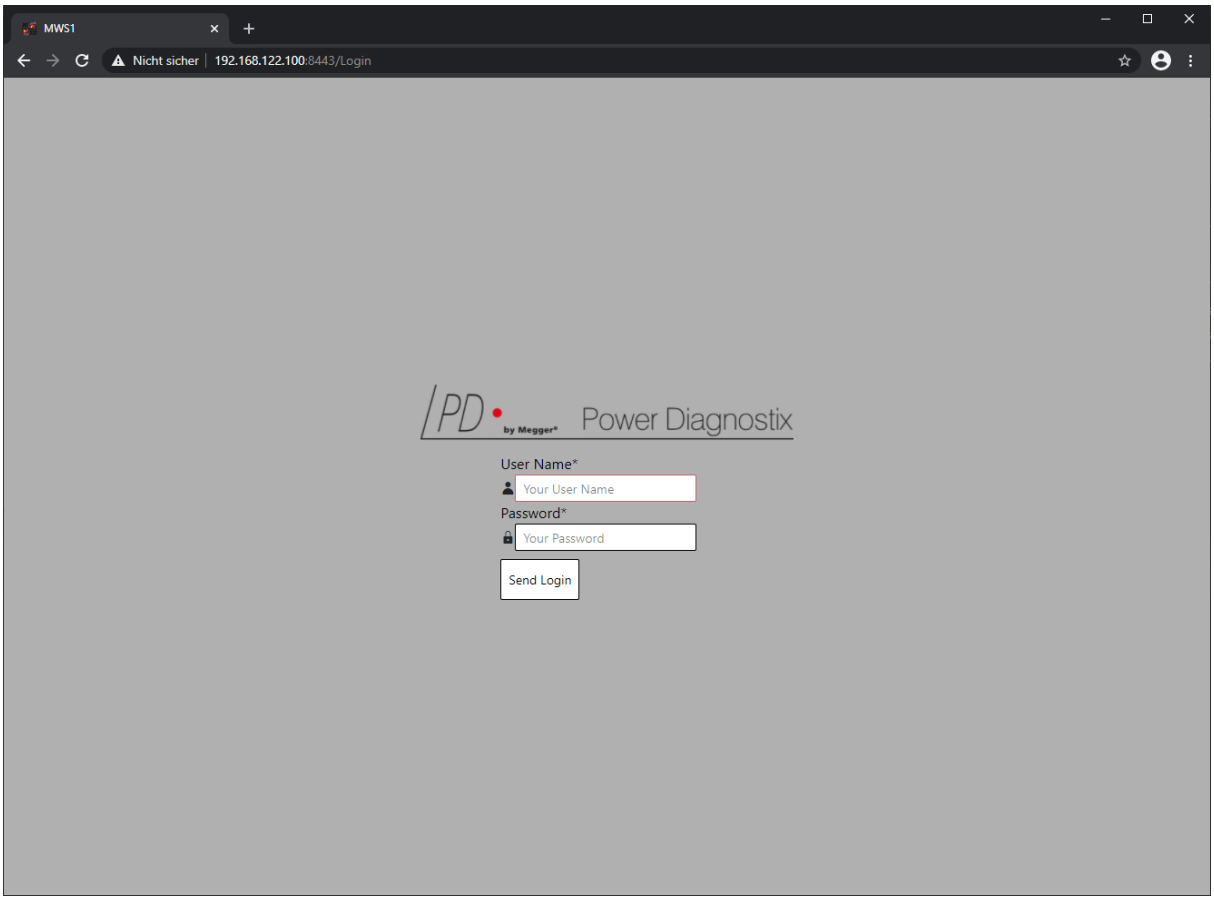


Figure VII.3: Login screen

After successful authentication (for detailed information on user administration see section VII.3.5) the overview page shows up.

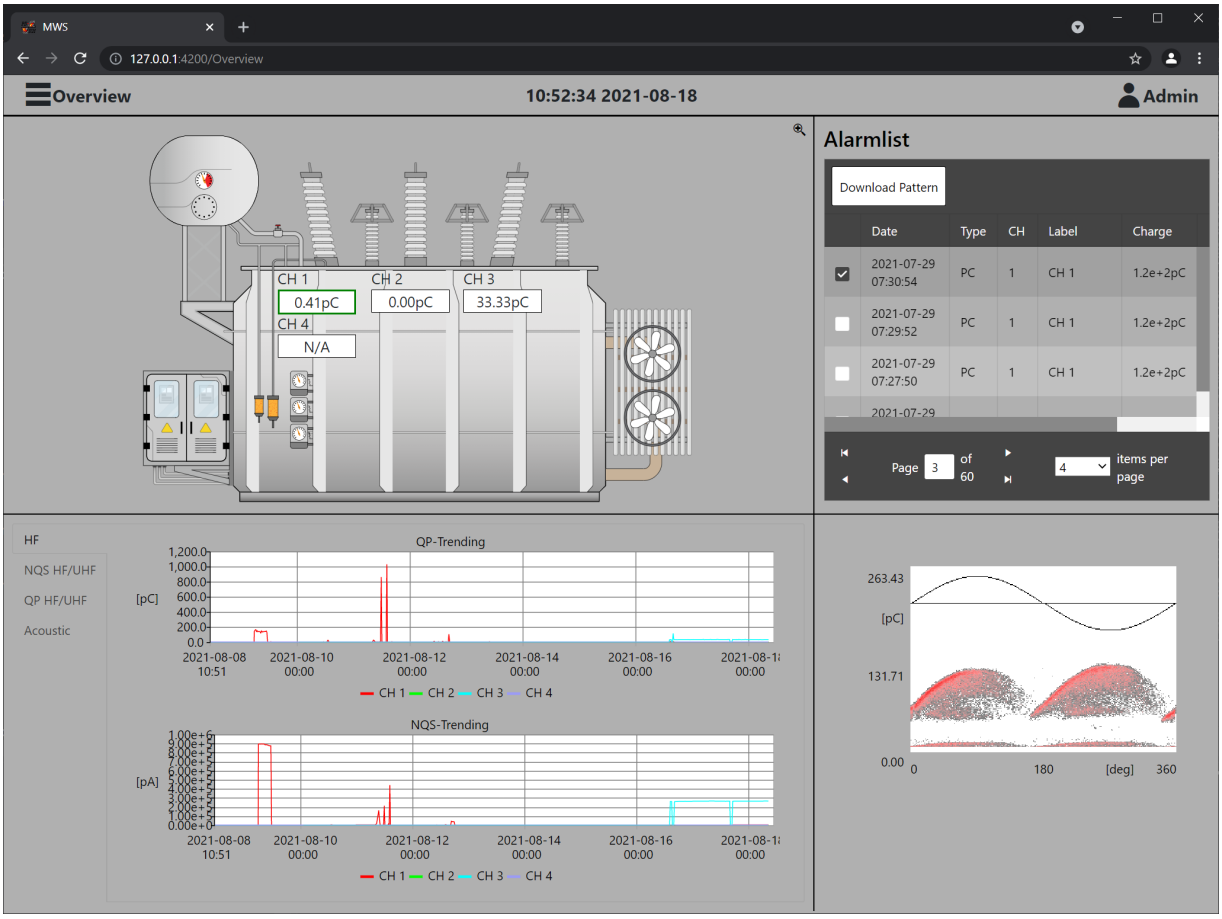


Figure VII.4: Overview page of the web interface

The four sections show general information concerning the monitored asset, alarm events, and trending information of the last ten days. Additionally, it offers logout by clicking on the username in the upper right-hand corner of the page.

The overview image of the monitored asset provides the latest values for all measuring channels. A green frame indicates the currently active channel. A click on the magnifier icon in the upper right-hand corner of the overview image enlarges it and hides all other areas of the page.

The information shown with the trending panel in the lower left-hand corner depends on the currently chosen display mode, which is selectable by the tabs on the left-hand side of the panel. If the display mode is set to "HF", the panel shows a graph with QP values on the top and NQS values at the bottom. The "NQS HF/UHF" display mode offers two NQS graphs, one with values of HF measurement at the top and a second one with values of UHF measurement at the bottom. The graphs of the "QP HF/UHF" display mode are similar to the NQS display mode, they offer HF measurement values at the top and UHF measurement values at the bottom. The "Acoustic" display mode is for acoustic measurements only. In this mode the trending panel shows a graph with QP values on the top and NQS values at the bottom. A click onto any point of a graph will show the corresponding PD pattern in the lower right-hand corner of the overview page.

The alarm list in the upper right-hand corner shows the registered alarms for all measurement channels. If an entry is marked with an active check box, the corresponding PD pattern will be shown below the list in the lower right-hand corner of the overview page. This pattern can be downloaded with the "Download Pattern" button above the alarm list.

A click on the menu item in the upper left-hand corner of the window opens a menu bar, which allows switching to different displays and lists. At the bottom of this menu, administrator users can find the button to reboot the ICM*monitor* and MWS.

VII.3.2 Display

"Display" shows the current state of the ICM*monitor*'s display, after the instrument was successfully initialised.

The monitor can be controlled via the function buttons on the right-hand side of the instrument's display. The display is refreshed periodically with the data received from the instrument. For detailed information on the individual parts of the display, see the separate ICM*monitor* user manual.

The fields to the right of the display show the current NQS value and the elapsed time of the last or currently running auto scan cycle for the active channel. If the ICM*monitor* is equipped with an optional board for auxiliary inputs, the values of these AUX inputs are also shown there.

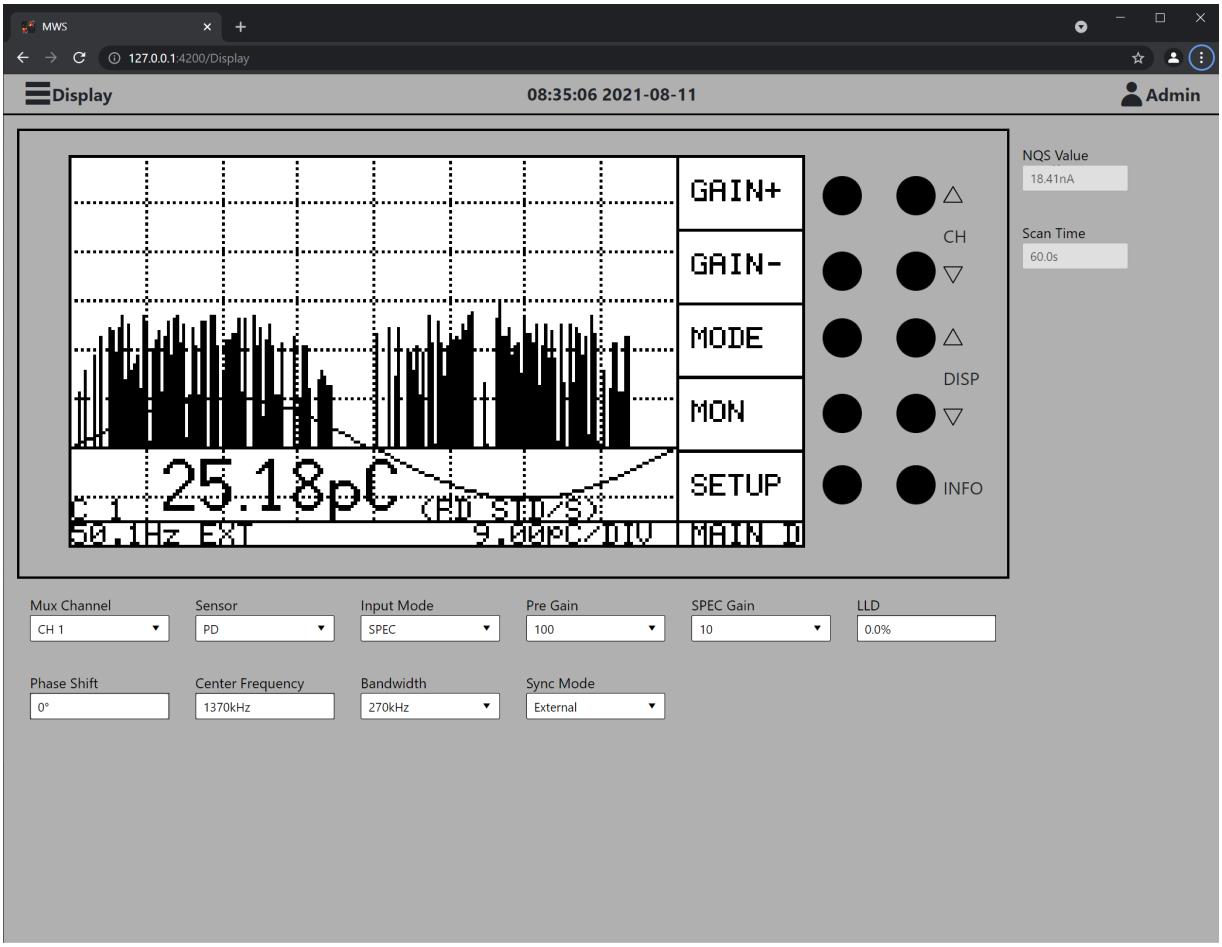


Figure VII.5: Overview page of the web interface

With the fields below the display, the most important device settings can be changed directly. Depending on the instrument 4, 8, or 12 channels can be selected. The respective channel of the multiplexer (MUX) is chosen with the "Mux Channel" drop down list. The "Sensor" field specifies what kind of sensor is used. Available sensors are PD, UHF, and Acoustic. The "Input Mode" is used to switch between the standard measurement path (AMP) and the spectrum analyser path (SPEC).

"Pre Gain" sets the gain of the connected preamplifier. With the "Spec" settings (see page 119) set to "RPA On" the following values are available: 0, 1, 10, and 100. "SPEC Gain"/"AMP Gain" (depending on selected input mode) shows a list of possible main amplification factors (4, 8, 10, 20, 40, 80, 100, 200, 400, 800). The

LLD entry sets the low-level discriminator for the selected channel. Use the individual gain setting only, in case you do not want to have the pre-set table of pre- and main amplification offered by the [GAIN+] and [GAIN-] buttons of the display. "Phase shift" sets the phase shift of the displayed pattern referring to the synchronisation voltage.

"Sync Mode" determines whether the device is synchronised to an external synchronisation source or to the line voltage.

When the input mode of the measuring channel is set to SPEC, the measuring frequency is set with "Center Frequency", while the dropdown list of "Bandwidth" offers 270 kHz and 9 kHz. When the input mode of the measuring channel is set to AMP, "Highpass" and "Lowpass" specify the lower and upper cut-off frequencies of filters used in the measurement setup.

VII.3.3 Pattern

The pattern panel is for PD pattern recording. The fields below the pattern display are for setup of the next pattern to be recorded.

The respective channel is chosen with the "Mux Channel" drop down list. "Pre Gain" sets the gain of the connected preamplifier. With the "Spec" settings (see page 119) set to RPA "On" the following values are available: 0, 1, 10, and 100. "AMP Gain"/"SPEC Gain" (depending on current input mode for the selected channel) shows a list of possible main amplification factors (4, 8, 10, 20, 40, 80, 100, 200, 400, 800). Use the individual gain setting only in case you do not want to have the pre-set table of pre- and main amplification offered by the [GAIN+] and [GAIN-] buttons of the instrument's display. The LLD entry sets the low-level discriminator for the selected channel. The red triangle marker at the bottom right of the pattern has the same function. It can be moved by dragging it up and down.

"Count Level" sets the charge limit pulses must exceed to be recorded, while "Set Time" sets the period of recording. "Waveform" determines if a sine wave is displayed with the pattern or not.

The "Color" entry affects the coding of the pattern's Z-axis, i.e., the colour axis. "Norm" normalises the distribution to a colour palette: The highest count of the current memory content is taken and assigned to the 'highest' colour number, with all the other counts of the pattern being normalised to this largest one. The benefit of this setting is that the pattern derived does not change that much during the acquisition, it gets smoother only. The main drawback of this normalisation is the loss of low count rate pules as they drop under the colour #1 threshold. On the other hand, it may be wanted to have spurious noise pulses automatically removed by this effect. "Log" assigns the counts to the next colour with every step of the power of two. Thus, the entire dynamic range of the 16-bit-memory depth is maintained. The drawback of this setting is that the pattern changes its colour with the progress of the acquisition.

With "Start Pattern" the current channel setup is transmitted to the ICM*monitor*, and a new pattern recording is started. While recording, the button shows the label "Stop Pattern" and its colour is red (see Figure VII.7). The pattern values are updated regularly until the recording is stopped.

The recorded pattern data can be saved and downloaded as .png and .dat files via the "Download" button. A previously saved pattern can be loaded with the "Load" button to display the pattern and the corresponding values, such as acquisition time, NQS value, measuring frequency, and current peak charge (see Figure VII.6).

"Total counts" shows the total amount of PD pulses in the pattern, while the number of counts above the preset count level is displayed with "Level Counts".

The red triangle marker at the top of the pattern display is for virtual phase shifting.

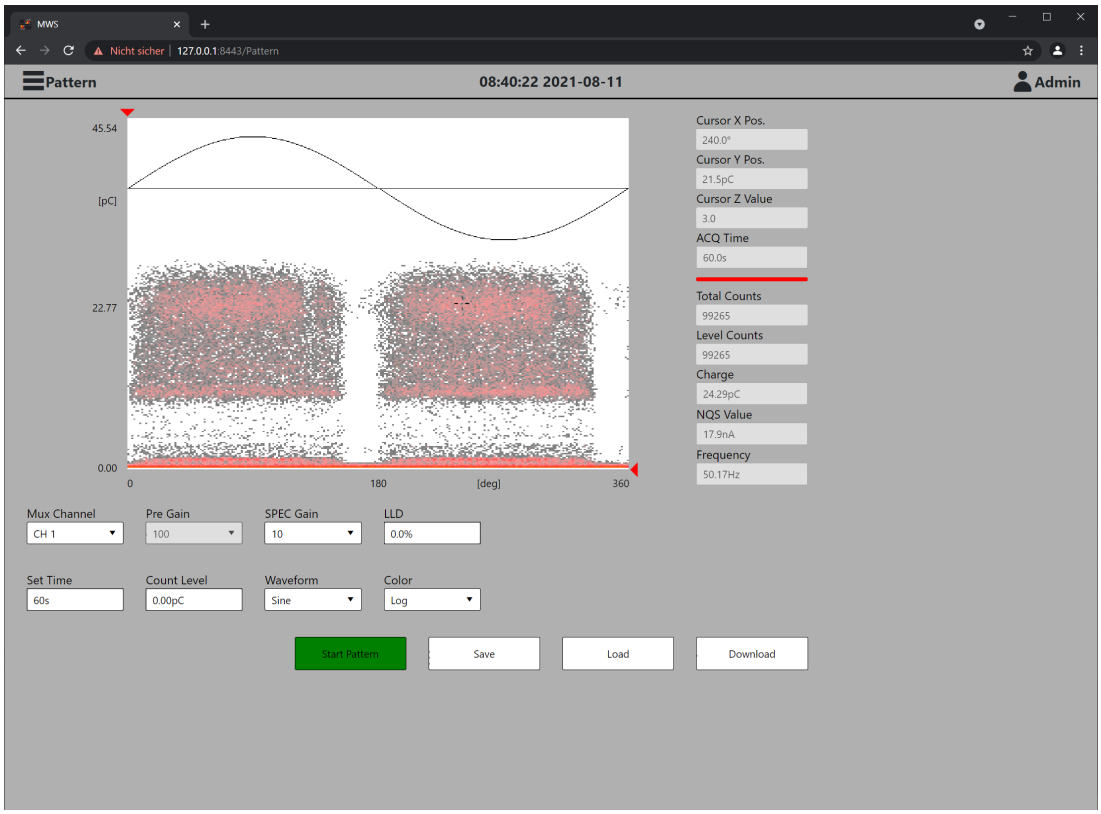


Figure VII.6: Pattern panel with loaded pattern and corresponding values

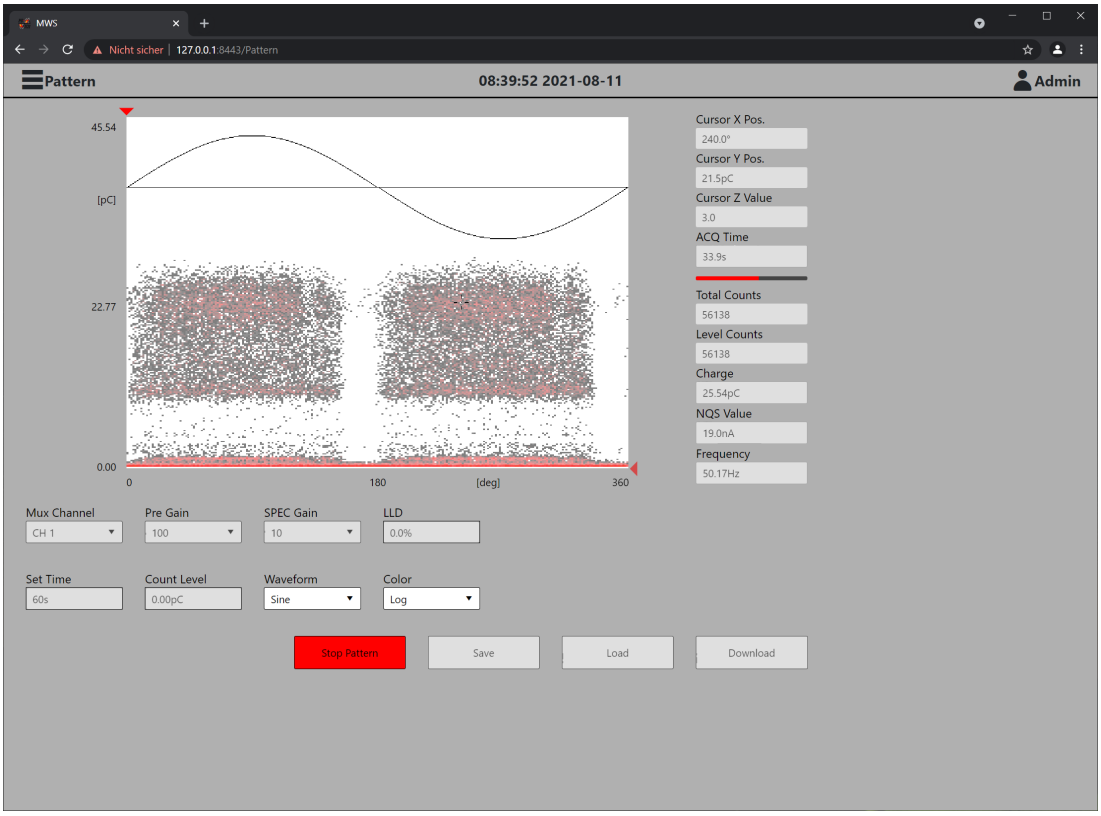


Figure VII.7: Pattern panel during pattern recording

VII.3.4 Spectrum

By switching to the spectrum panel, the ICM*monitor* will automatically change to SPEC mode if auto scan is inactive, and no pattern is currently recorded. Subsequently, the spectrum display shows the frequency spectrum of the input signal up to 10 MHz. If auto scan is active or a pattern is currently recorded, the user will be notified by a message that the ICM*monitor* is not in SPEC mode and, hence, spectrum scan is currently not available (see figure below). For further information about the instrument's different display modes see separate ICM*monitor* manual.

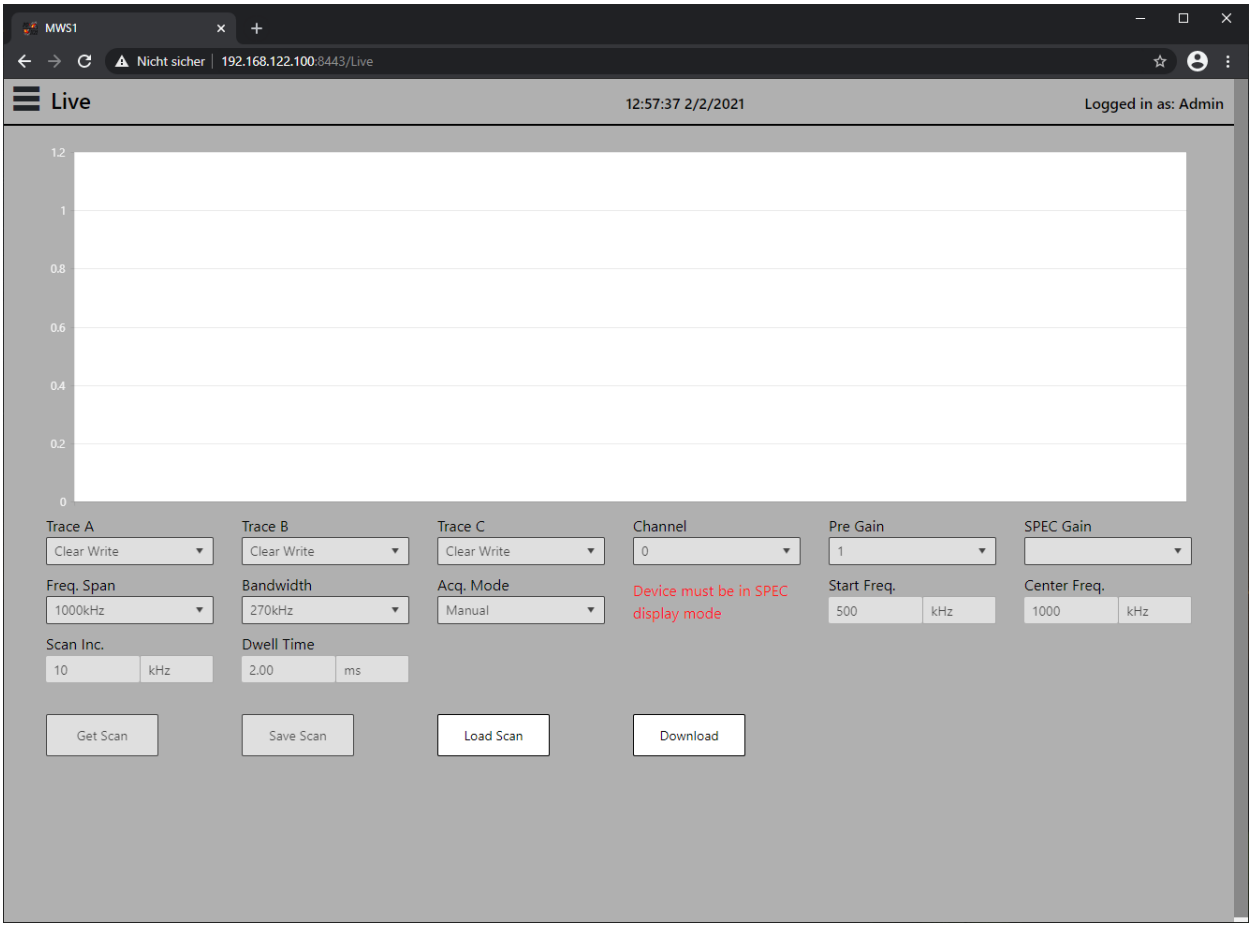


Figure VII.8: Spectrum panel, when instrument is not in SPEC display mode

Three traces for the current input channel allow to store, compare, and process this spectrum. The ICM*monitor* updates the information for any active trace with each sweep (Sweep time is the required time for one sweep, i.e., scanning through the whole span of frequencies). The three traces (A, B, and C) can be defined separately in five different modes:

Off	Turns off the trace; graph is not visible.
Clear Write	Clears and writes the trace with every sweep.
Maxhold	The maximum values of all sweeps are updated and hold.
View	Freezes the current view of trace.
Average	The average of the last 1 to 10 values is shown.

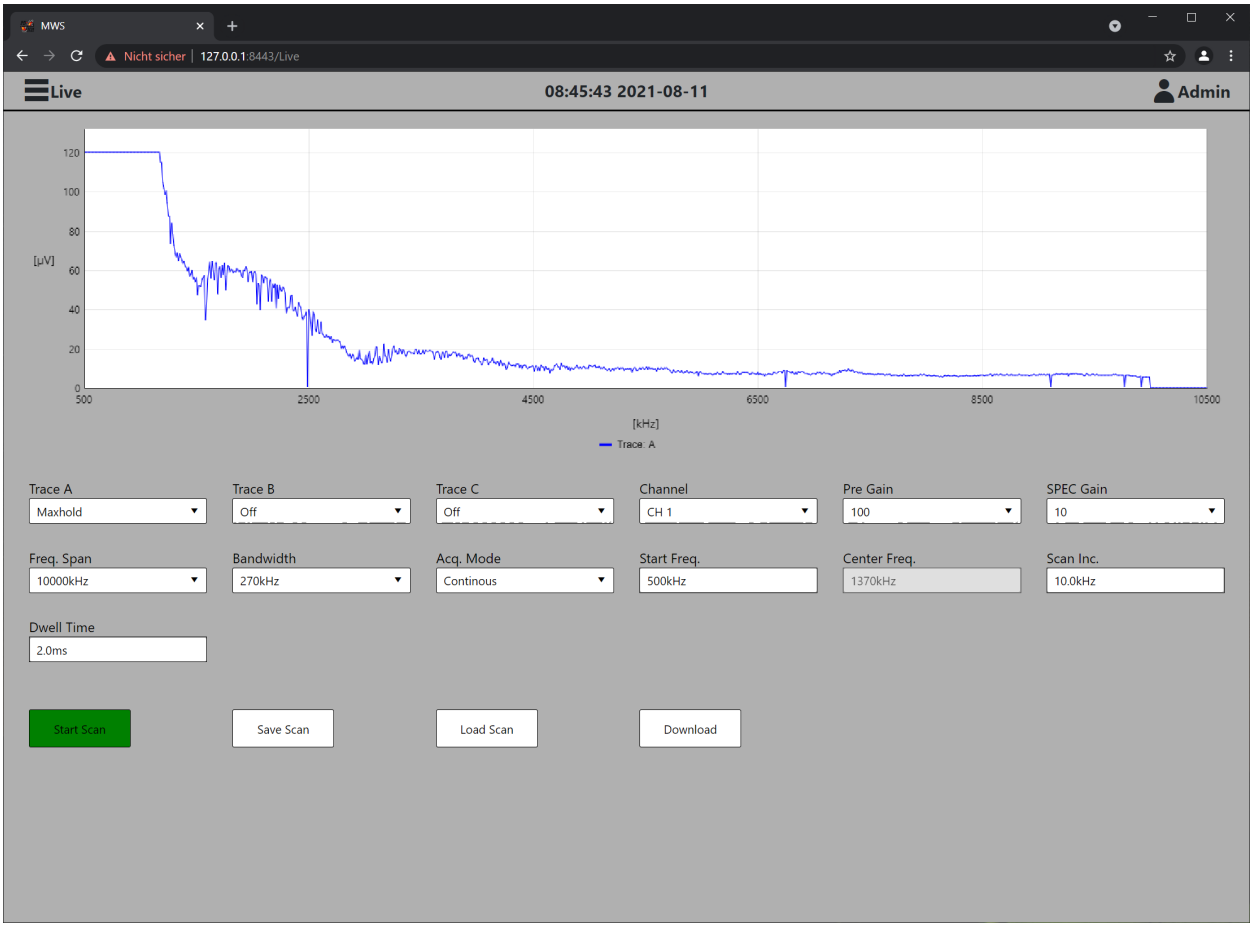


Figure VII.9: Spectrum panel during spectrum scan

The current input channel is chosen with the "Channel" drop down list. "Pre Gain" sets the gain of the connected preamplifier. With the "Spec" settings (see page 119) set to RPA "On" the following values are available: 0, 1, 10, and 100. "SPEC Gain" shows a list of possible main amplification factors (1,2, 4, 8, 10, 20, 40, 80).

The "Start frequency" can be set with variable step size, whereas the drop-down list for the "Frequency span", i.e., start frequency – stop frequency, offers 17 values in a range from 100 kHz to 10000 kHz. The "Bandwidth" can be switched between 9 and 270 kHz, while the "Acq. Mode" drop down list is for choosing the acquisition mode ("Manual" or "Continuous"). Manual mode means, that the acquisition covers one sweep, while the continuous mode means permanent acquisition.

"Center Frequency" sets the measuring frequency for the display mode SCOPE, since this mode has only one fixed measuring frequency.

"Scan Increment" defines the increment step size of the start frequency until the whole frequency span is scanned. The "Dwell Time" is the pause on one frequency during which demodulation takes place.

The acquisition is started with the "Get Scan" button (if acquisition mode is "Manual") or the "Start Scan" button, respectively (if acquisition mode is "Continuous").

"Download" saves the scan as an .spc file on the user's hard disk if that file was created before with "Save Scan". "Load scan" allows displaying a previously saved scan.

VII.3.5 AutoScan

With auto scan mode enabled, it is possible to scan a monitor at predefined time intervals automatically. For this purpose, the MWS has to run permanently.

The auto scan panel shows a list of all files that were created by the auto-scan mode so far. By selecting a list entry, the corresponding pattern will be shown at the right-hand side of the list.

Selected pattern can be saved and downloaded as .png and .dat files to the user's hard disk with the "Download Pattern" button.

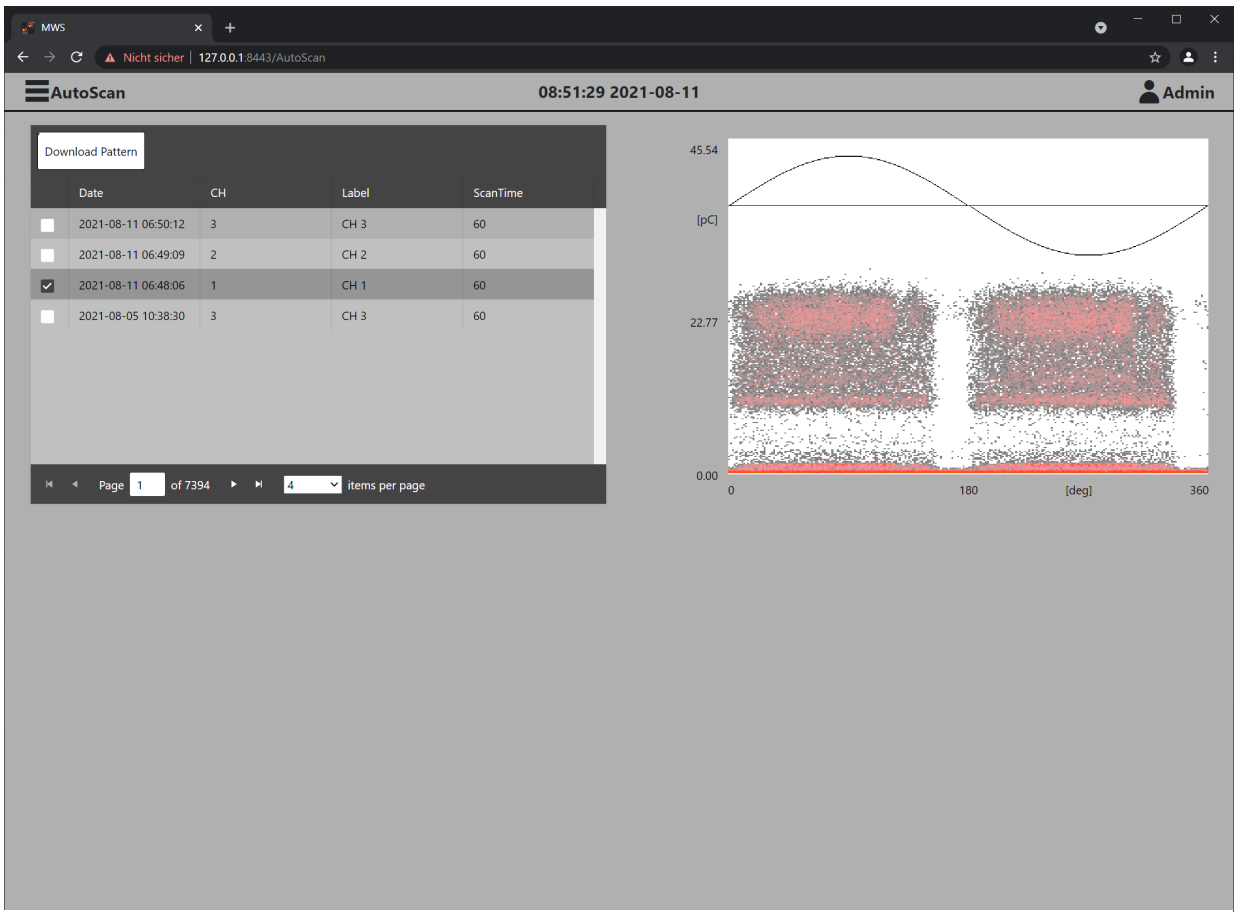


Figure VII.10: AutoScan panel

VII.3.6 Trending

The analysis of NQS and QP trending data can be accessed via the "Trending" menu entry. Initially the panel shows two graphs with trending data of the last ten days (see Figure VII.11). The displayed period can be changed with the "From" and "To" fields. By clicking onto a specific point of a graph, information about date, time, and the corresponding PD patterns (if existent) for every channel will be displayed on the right-hand side of the window. The click mark (black vertical line) will automatically jump to the time point that is nearest to the original click point and for that a PD pattern is available. If the checkbox "Cursor snap to pattern time" is checked, the application will show the nearest PD pattern within the set scan interval. To find this nearest pattern, the application considers half of the scan interval to the left and to the right of the click point.

The information shown with the trending graphs depends on the currently chosen display mode, which is selectable by the tabs on the left-hand side of the panel. If the display mode is set to "HF", the panel shows a graph with QP values on the top and NQS values at the bottom. The "NQS HF/UHF" display mode offers two NQS graphs, one with values of HF measurement at the top and a second with values of UHF measurement at the bottom. The graphs of the "QP HF/UHF" display mode are similar to the NQS display mode, they offer HF measurement values at the top and UHF measurement values at the bottom. The "Acoustic" display mode is for acoustic measurements, only. In this mode the trending panel shows a graph with QP values on the top and NQS values at the bottom.

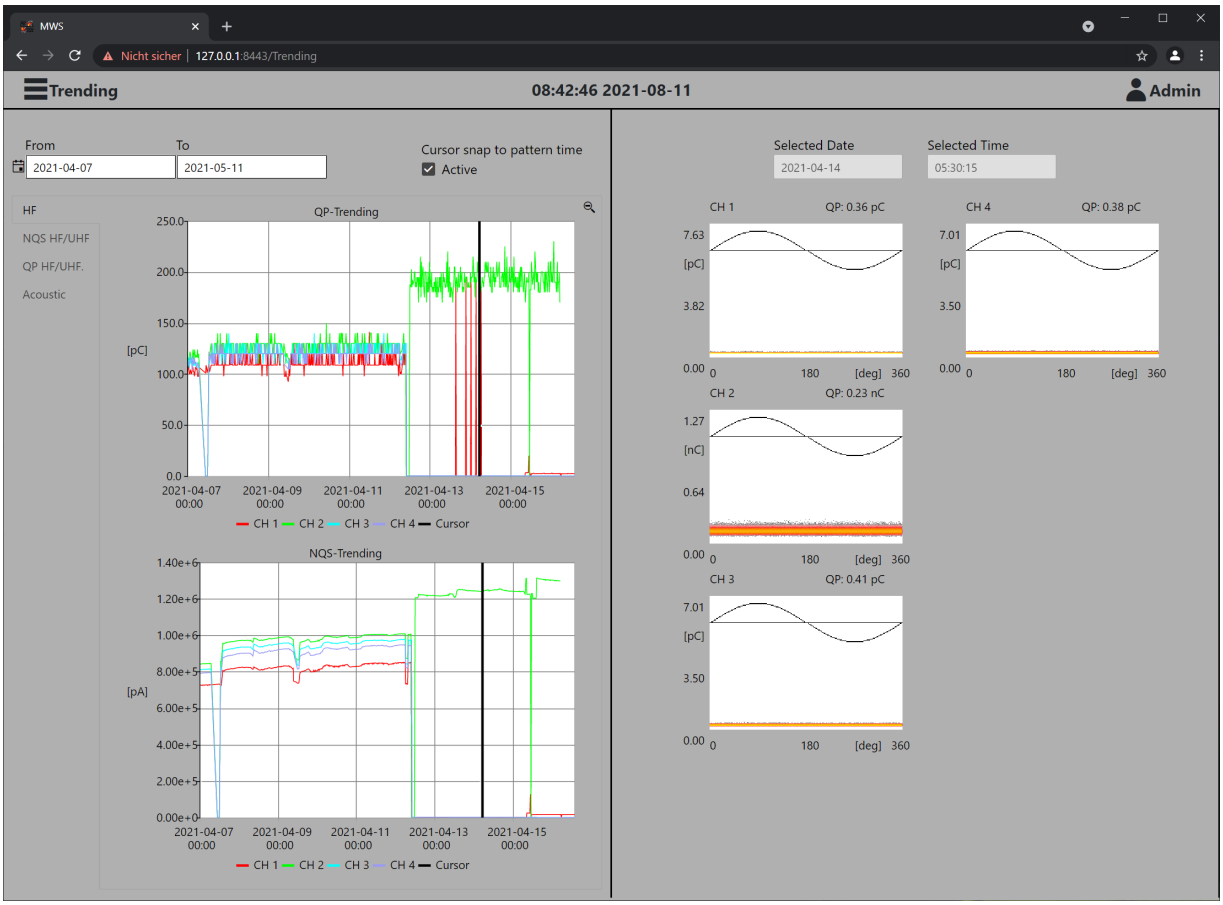


Figure VII.11: NQS and QP trending panel

Zooming of the graphs can be done by clicking and dragging (with 24 hours the minimum period). This highlights an area that is subsequently zoomed in. The magnifier icon on the upper right-hand corner of the graphs resets the zoom.

VII.3.7 Alarm

With a click on the "Alarm" menu entry the interface changes to the alarm event list, which displays the registered alarms. There are two types of alarms: If the maximum charge level is exceeded (PC) or if the maximum NQS level is exceeded (NQ), the alarm is triggered. The date and time of the registered alarm, the alarm type (PC/NQ), the channel which triggered the alarm, and the measured Qp and NQS values are shown.

For every alarm event the corresponding partial discharge pattern is stored and can be displayed by selecting an event entry. The pattern will be shown at the right-hand side of the alarm list.

Pattern of selected events can be saved to the user's hard disk with the "Download Pattern" button.

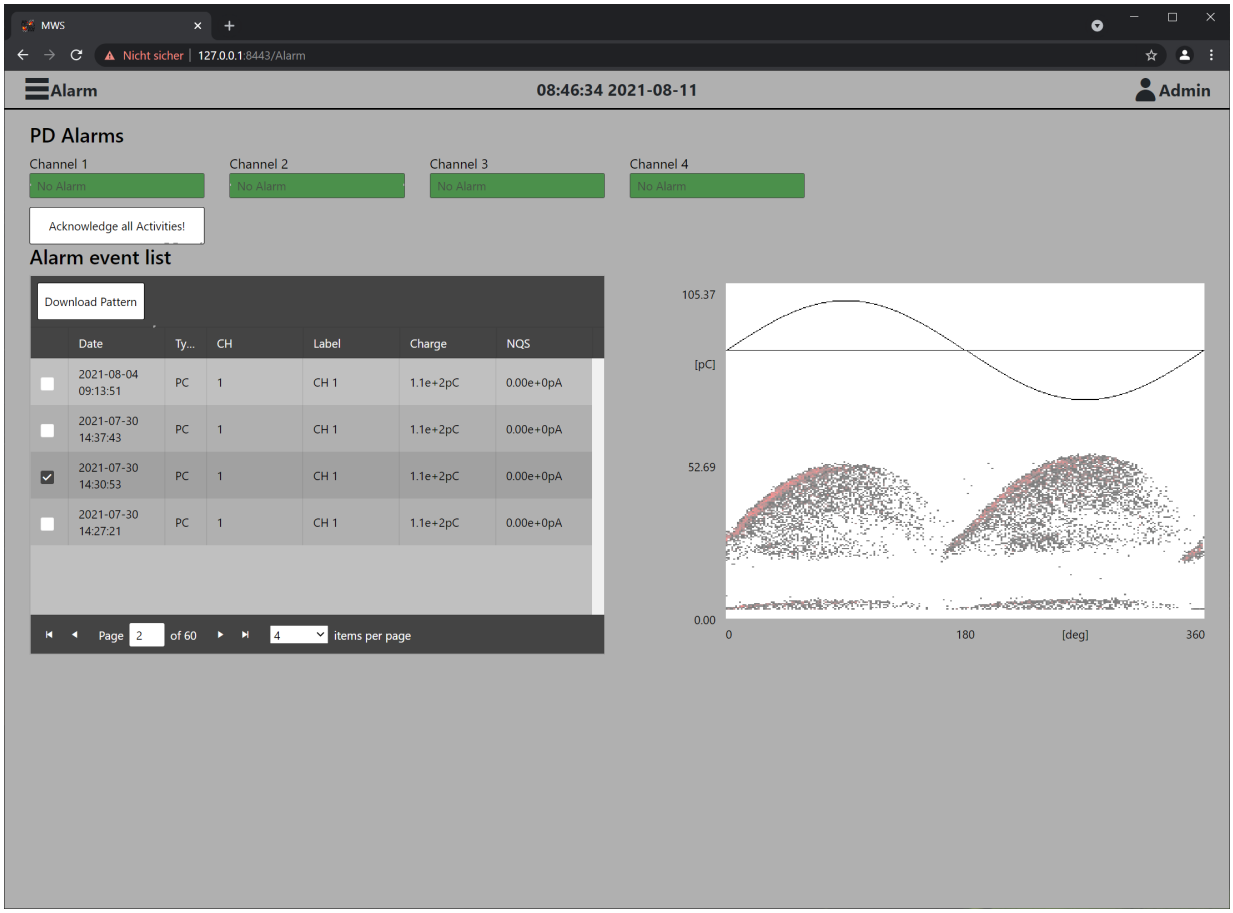


Figure VII.12: Alarm event list

VII.3.8 Export

The "Export" panel offers a comfortable export/download function for trending files, alarm lists, and reports.

Trending data and alarm lists will be stored in .csv files (with US standard as number format), which can be copied to e.g., Microsoft Excel and processed.

Two date fields allow limiting the export data to a specific period.

"Download Database" offers downloading the database in its current status to the user's hard disk.

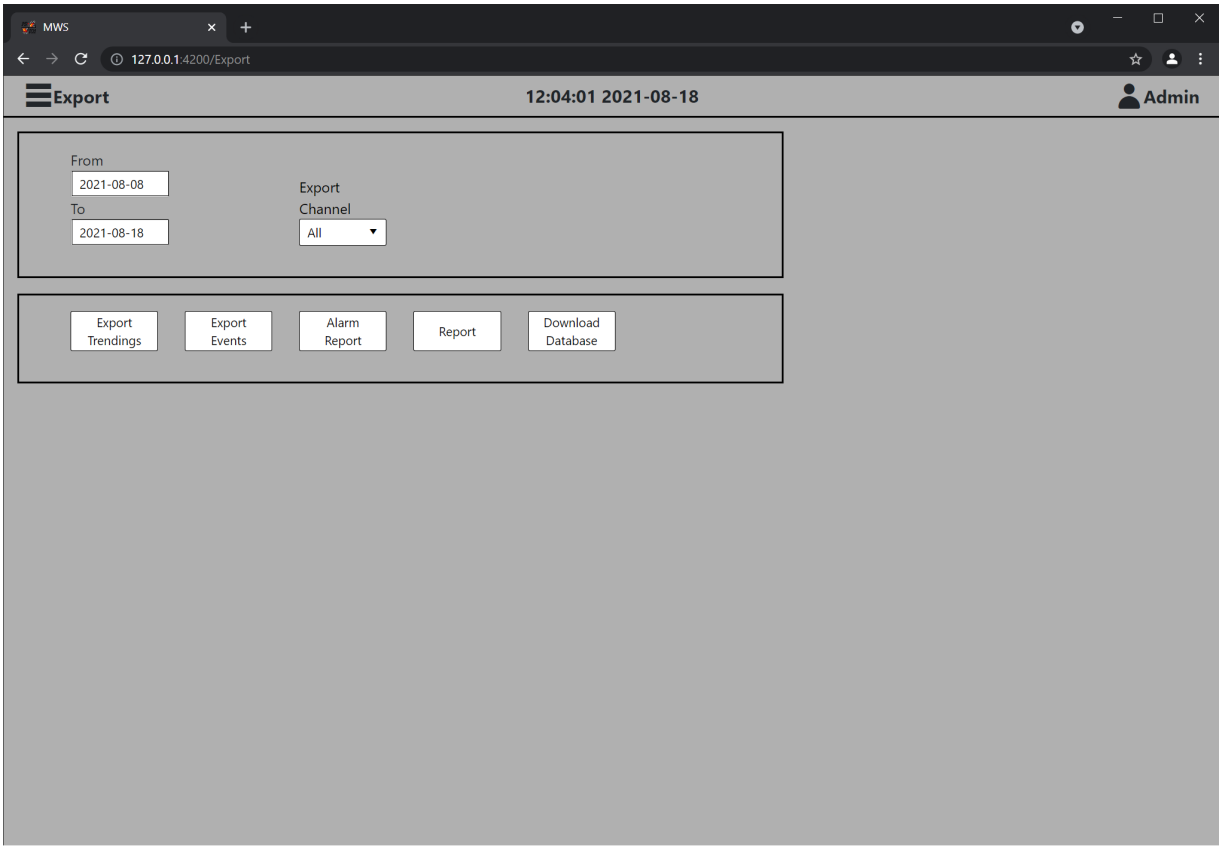


Figure VII.13: Export panel

The "Alarm Report" function allows generating a report with all alarms during the set period, including corresponding graphs and PD patterns. A click an on the ► button starts the generation of the report file as PDF, which can be downloaded with the 💾 button.

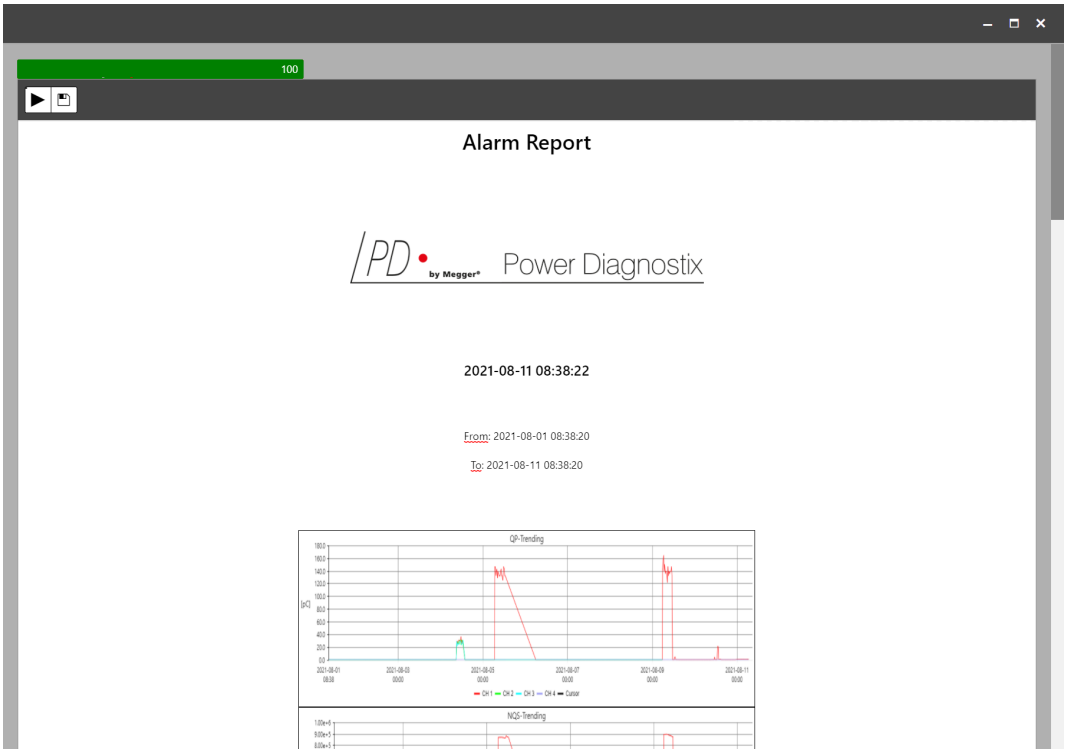


Figure VII.14: Alarm report window

The "Report" function allows printing the data that was recorded during the selected period. A report editor opens, which offers the input and formatting options known from common word processing systems (see Figure VII.15).

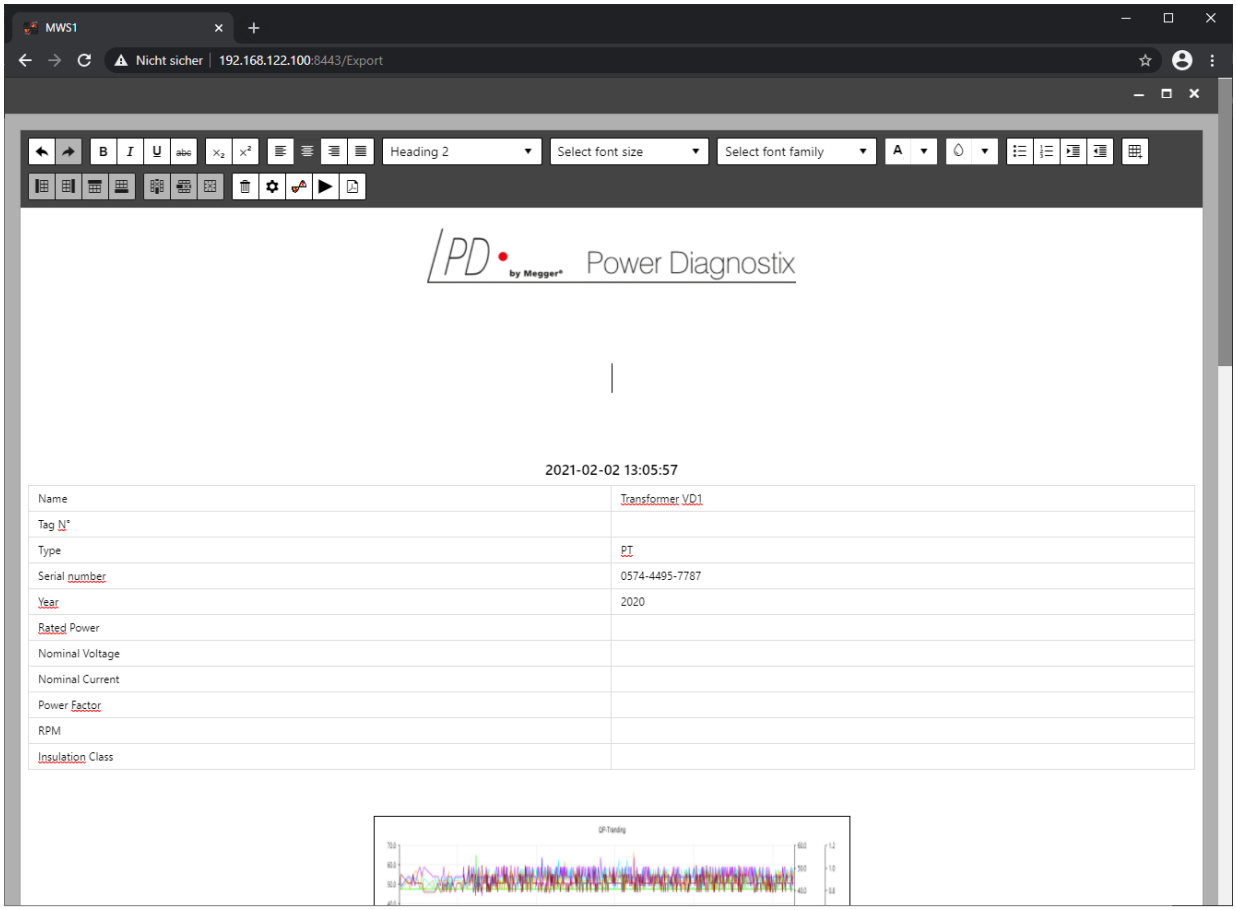


Figure VII.15: Report window

Contents of the report can be discarded with the trashcan button  .

A click on the  button opens a setup window for changing the report header settings, such as logo, title, or machine data (see Figure VII.16).

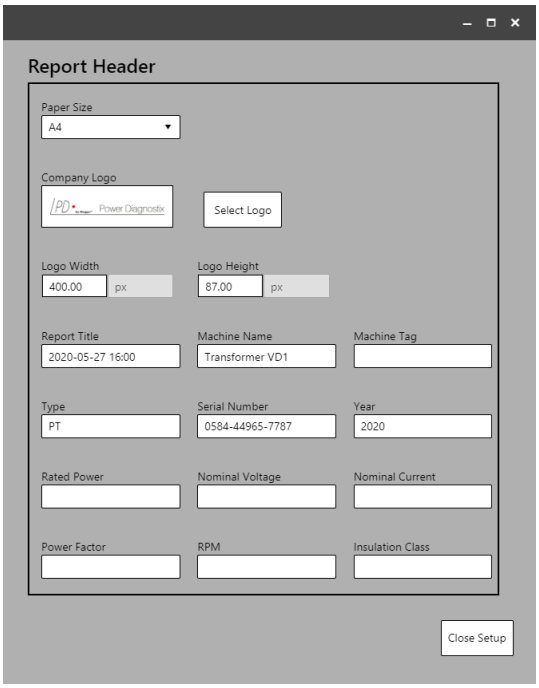


Figure VII.16: Report header configuration window

The  button opens a separate window showing the trending data from the previously defined period (see Figure VII.17). The period can be narrowed by the "From" and "To" fields.
Remark: The maximum period is limited by the selection previously made in the export panel.

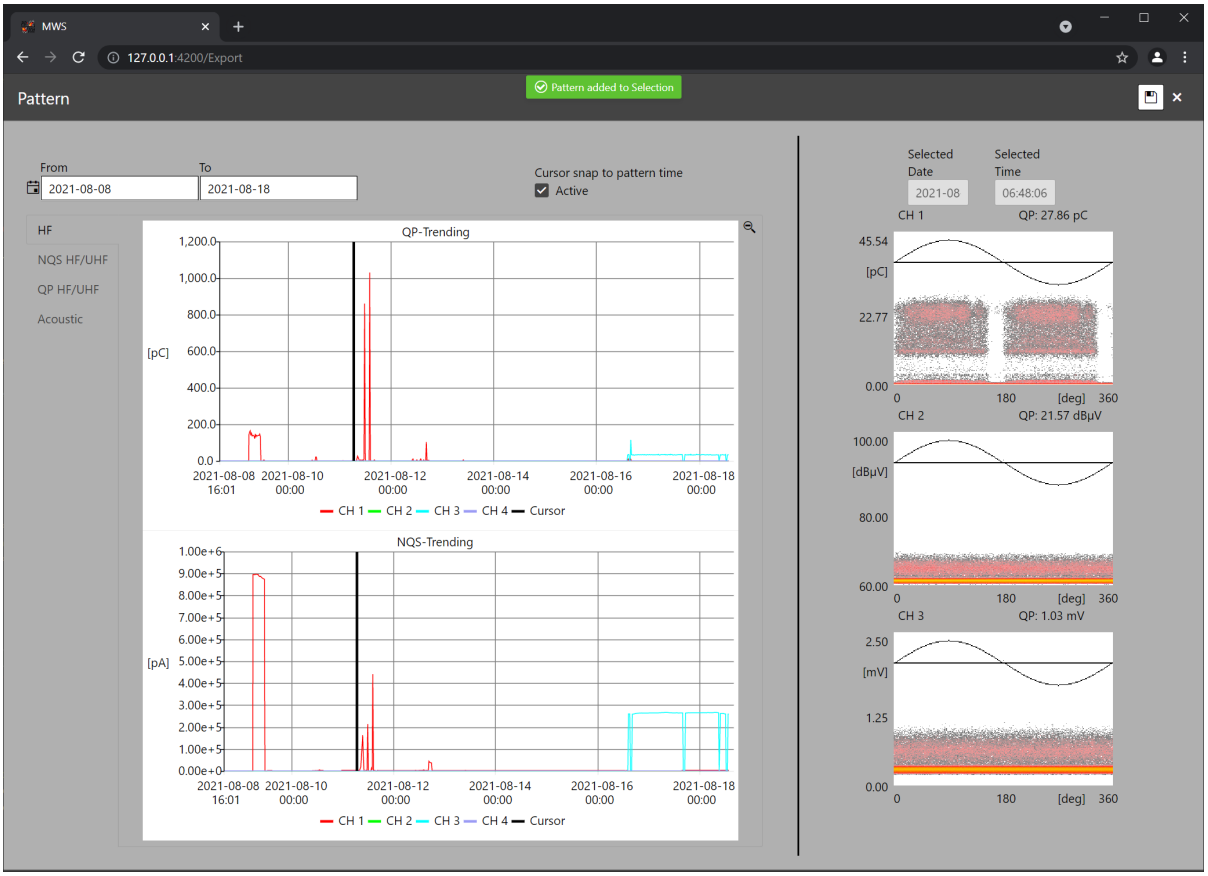


Figure VII.17: Selection of report data

By moving the cursor to a specific point of a graph, information about date, time, and NQS value as well as the corresponding PD pattern (if existent) for every channel will be displayed. These patterns are automatically flagged for transfer into the report. Every click into the trending graph flags more patterns for transfer. All flagged patterns can be stored to a virtual selection with the  symbol in the upper right-hand corner, which also closes the data selection window.

Closing the data selection window with the X symbol will unflag all patterns.

Stored pattern can be added to the report with  .

The  button allows saving the report as pdf file to hard disk.

VII.3.9 Setups

A click on the "Setups" entry shows sub entries for the settings of the connected instrument. If the ICM*monitor* is equipped with optional boards for auxiliary inputs and/or additional auxiliary outputs, the entry offers additional sub entries for AUXIN and AUXOUT settings.

VII.3.9.1 Acquisition

Depending on the instrument 4, 8, or 12 channels can be configured separately. The channel, which is to be configured, is chosen with the "Selected channel" drop down list.

In the "Main" section the "Pre Gain" dropdown list sets the gain of the connected preamplifier, while "AMP Gain"/"SPEC Gain" (depending on whether the input mode in the SPEC section is set to AMP or SPEC) shows a list of possible main amplification factors. Additionally, the phase shift of the displayed pattern referring to the synchronisation voltage and the LLD can be set. Moreover, the lower and upper cut-off frequencies of used filter can be defined ("Highpass" and "Lowpass"). An additional constant phase shift of 120° or 240° of the channel can be set with the "Scan Channel" drop down list. A phase shift of 0° is equivalent to 'On', which means that the channel is included with the auto scan.

The scan time, which can be adjusted, is identical for all channels. With the "Sync Mux" drop down list the synchronisation channel for the chosen acquisition channel is set. The charge that was applied during calibration is shown in the field Q Cal. "Channel Identity" offers a naming function for easy identification of the measuring channels. These names are used in many displays throughout the application.

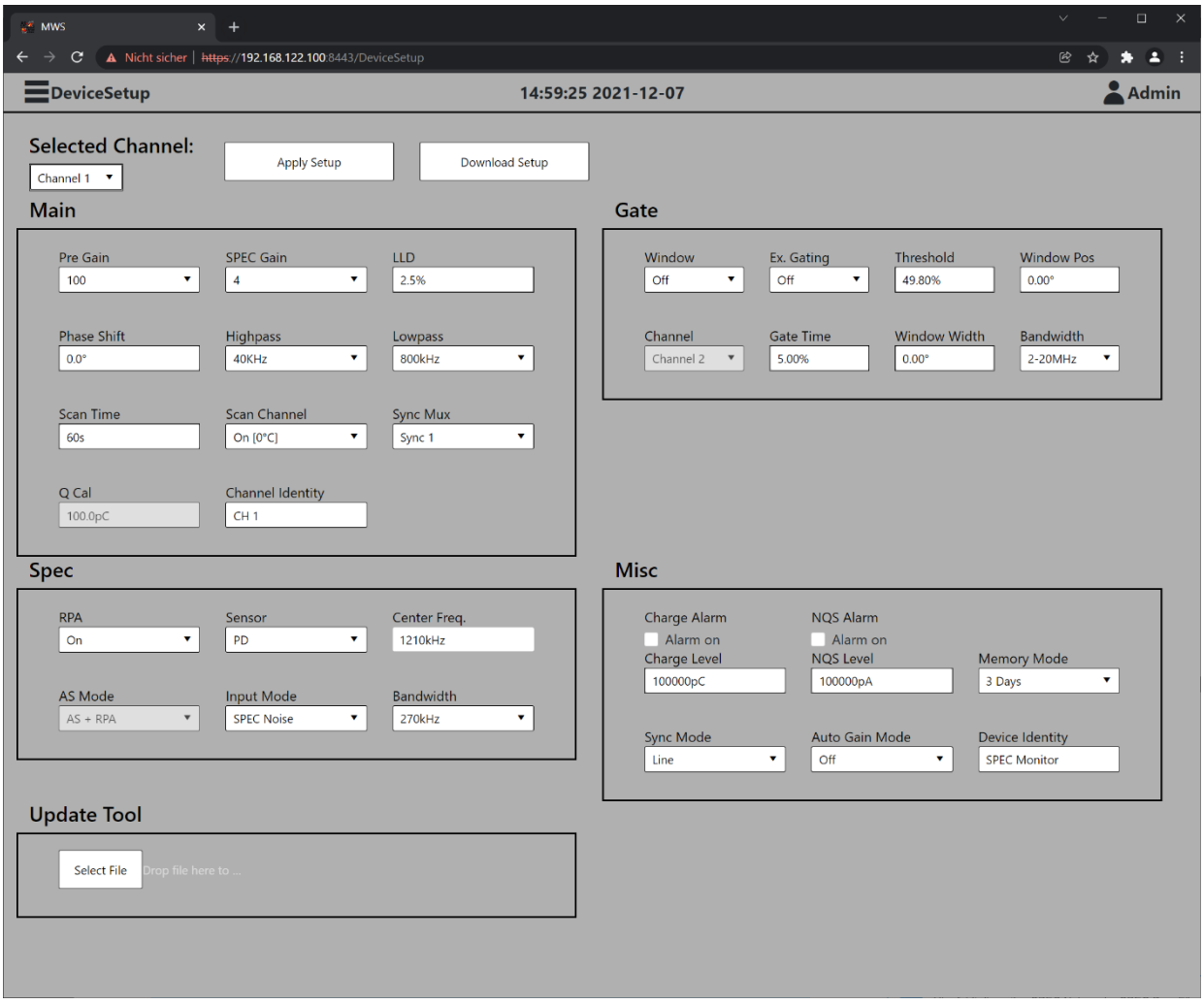


Figure VII.18: Selection of report data

The "Gate" settings are used to define windows for suppressing phase stable disturbances and to setup an external gating. It is possible to define up to three windows. The phase shift using two windows is 180° and 120° for three windows. The window position defines the position of the first window in relation to the zero point. The window width sets up one width for each window. There are two possible settings for the external gating: Manual mode and automatic mode. The manual mode offers the possibility to set the trigger from 1 to 100% of the peak disturbance level. This option is used to remove a known disturbance source in a stable environment. The automatic mode calculates a gating time as a fixed portion of the measured time. E. g. setting the gating time to 10% results in a total blind-out time of 2 ms for 20 ms @ 50Hz. The trigger level will be set accordingly to this time. The input channel for the gating signal can be selected for an 8-channel ICM*monitor*, only. The 4-channel version has a separate external BNC connector. The frequency range for the preamplifier RPA6 at the gating input can be set via the "Bandwidth" drop down list.

With the "Spec" settings the "Input Mode" is used to switch between the standard measurement path (AMP) and two versions of the spectrum analyser path (SPEC Noise and SPEC Dyn). Recommendation is to try "SPEC Noise" for optimisation first in order to deal with as little noise as possible. In case of linearity issues when using different gain values, try to use "SPEC Dyn".

If a preamplifier is used for the selected channel, "RPA" must be set to "On". The "Sensor" field specifies what kind of sensor is used. Available sensors are PD, UHF, and Acoustic. The "AS Mode" field determines whether an acoustic sensor is used with or without preamplifier, and the "Bandwidth" drop down list is for choosing between 9 and 270 kHz.

The "Misc" setup is for miscellaneous settings. The value of "Memory Mode" controls the sampling rate of the trending data. Setting "Auto Gain Mode" to 'On' enables an automatic change of the gain. The gain of the preamplifier and the internal amplifier are adjusted automatically to the signal magnitude. Besides that, in this setup charge and NQS alarms can be activated and configured. The "Sync Mode" field specifies if an external source or line is used to synchronise the ICM*monitor*. Additionally, an identity can be defined for the instrument.

A click onto "Apply Setup" at the top of the window transfers the settings for the channel to the instrument. "Download Setup" saves the settings as a .mon file on the user's hard disk.

Users with administrator rights have the possibility to update the instrument's firmware presented as "Update Tool" setting. Furthermore, it's possible to load saved configuration files. Allowed file formats are: cfg, mon, bin, and vme.

VII.3.9.2 AUXIN setup (optional)

These settings define the channels of an optional AUX input board. Each channel can be labelled, and the output quantity of the connected sensor must be specified. The following quantities are supported: 4–20 mA and 0–10 V. Additionally, the equivalent to the 4–20 mA resp. 0–10 V can be defined. Up to eight channels can be set by pressing the "Send Setup" button. The user is responsible for these settings. A verification of the settings by the application is not possible.

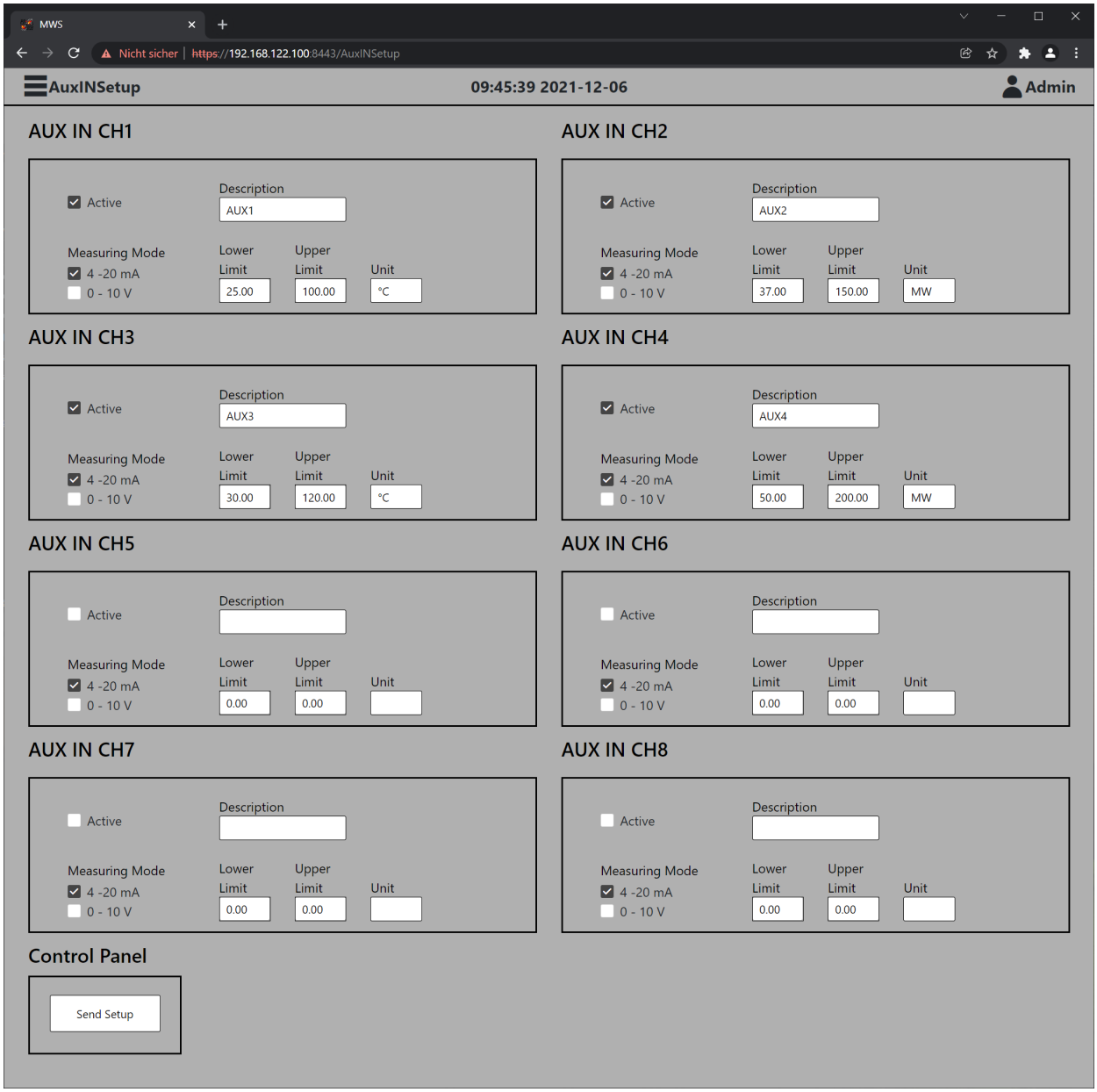


Figure VII.19: Setup panel for optional auxiliary inputs

VII.3.9.3 AUXOUT setup (optional)

Figure VII.20 shows the setup panel for configuring AUX outputs of an optional recorder output board. To each activated output channel must be assigned at least on PD input channel. The outputs can provide signals related to the derived NQS or Qp values of these assigned input channels.

Remark: The output values depend on the current NQS or Qp values and the chosen scaling value. Please refer to the detailed ICM*monitor* manual for further information.

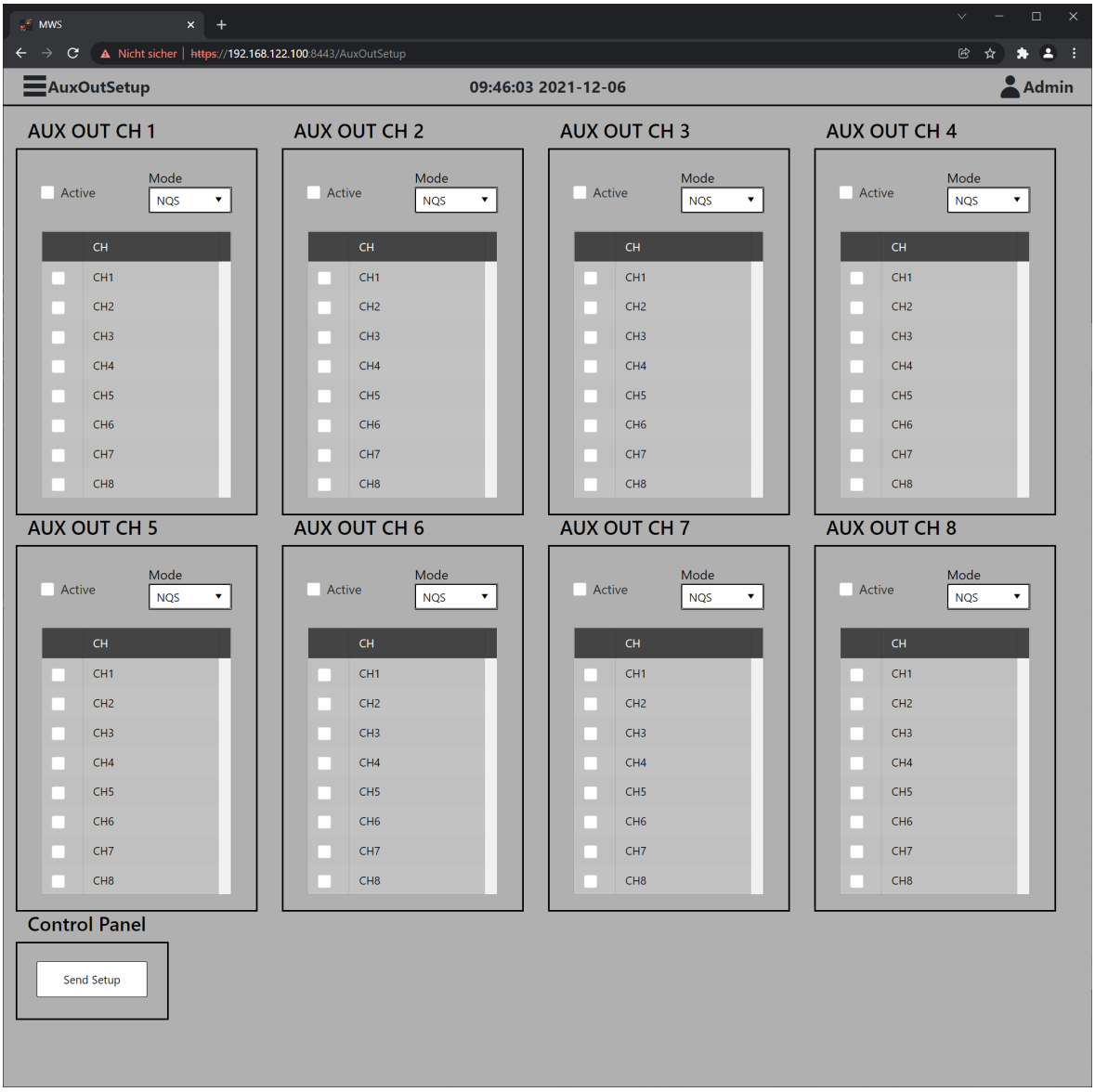


Figure VII.20: Setup panel for optional recorder outputs

VII.3.9.4 Web interface (administrators only)

The "Web interface" menu offers entries for setup of the web server.

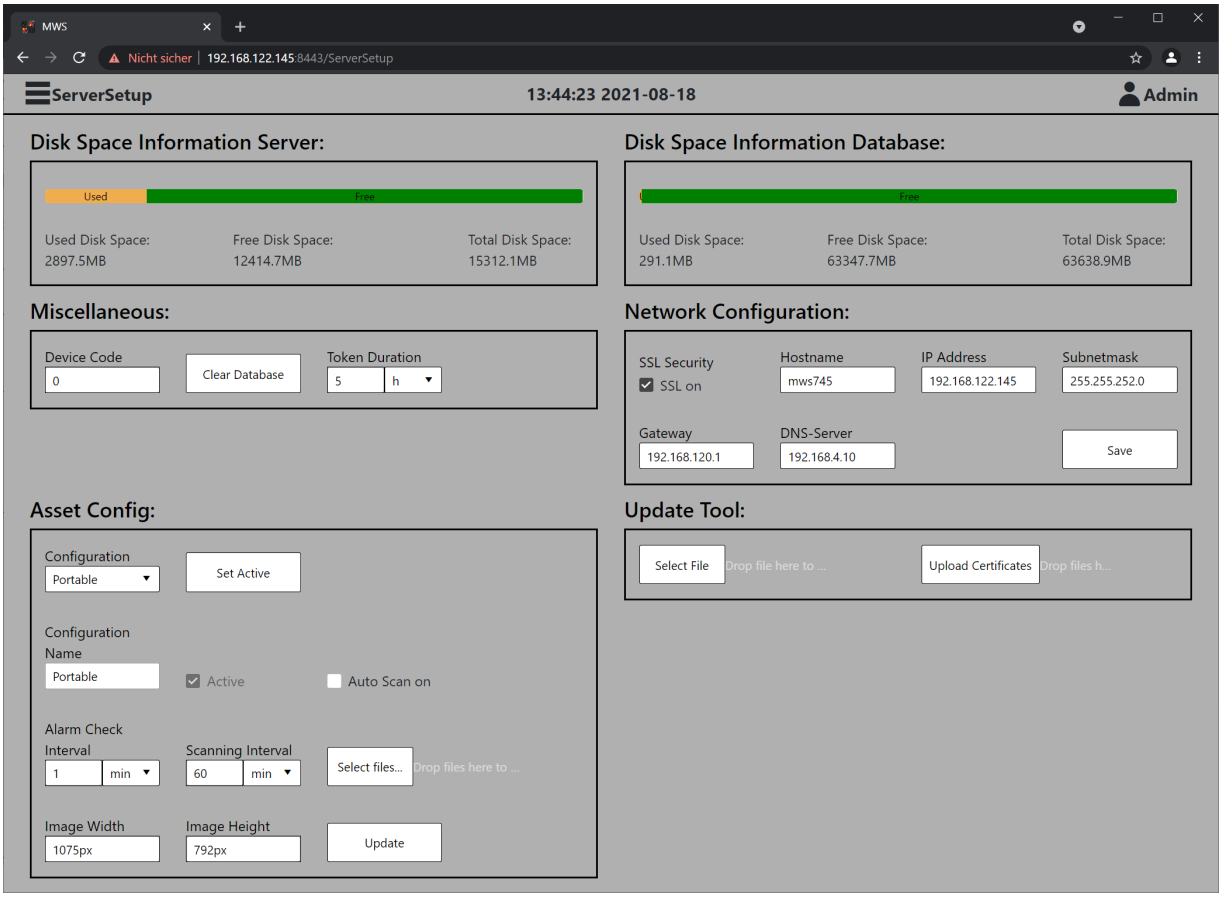


Figure VII.21: Server settings

An ICM*monitor* comes with two storage media: One for the database (gathered measuring data) and one for the server (application data). The two sections "Disk Space Information Server" and "Disk Space Information Database" show information concerning capacity and used disk space of the storage media.

To enable the web interface to connect to the ICM*monitor,* a valid device code must be set in the "Miscellaneous" settings. This code was delivered with the web server interface files. Please contact Power Diagnostix if you've lost this code. During the user login process a token is set, which is used for auto login of the user. The lifetime of this token is set with "Token Duration".

The "Network Configuration" section is for integration of the MWS into the customer's local intranet. The entered data is transmitted with "Save". Please be careful by changing these settings because misconfiguration will cause the MWS to be no longer accessible.

If the ICM*monitor* is not used exclusively for monitoring one single asset, but for several assets, the "Asset Config" section offers the possibility to create asset labels to be stored with measuring data and configure these assets. When an asset is selected from the drop-down list, all data recorded by the ICM*monitor* is assigned to the currently selected asset. When displaying trending information, the active asset is used for filtering the relevant trending data for this specific asset.

To create a new asset, select "New config" from the "Configuration" drop-down list. Set up a "Configuration Name" and choose an .svg file as asset image, which is displayed on the overview page, as well as a .json file containing information on sensor label positioning by use of the "Select files…" button. Please note:

These two files must be selected at once (Press the Ctrl key while selecting the files with a mouse click from the file list). Fill in height and width of the image file (see Figure VII.21) then press "Create".

To activate auto scan for this specific asset, check the corresponding checkbox "Auto Scan on". The "Alarm Check Interval" entry specifies how often the alarm list/file is checked, and the "Scanning Interval" determines how often the scan data are saved.

Any configuration change can be saved with the "Update" button.

The possibility to update the web server interface is presented as "Update Tool" setting. The file to be loaded must be of .bin format. "Update Certificate" allows an update of the server security certificates with a combination of .pem and .key files. At least a valid TLS certificate and corresponding key are necessary to communicate with the MWS.

VII.3.9.5 Mail setup (administrators only)

The MWS is able to send email notifications to a specific email address if an alarm is triggered. The "Mail Setup" is for setting the relevant e-mail data for the integrated mailing service, e.g., sender and recipient addresses or address of the SMTP server.

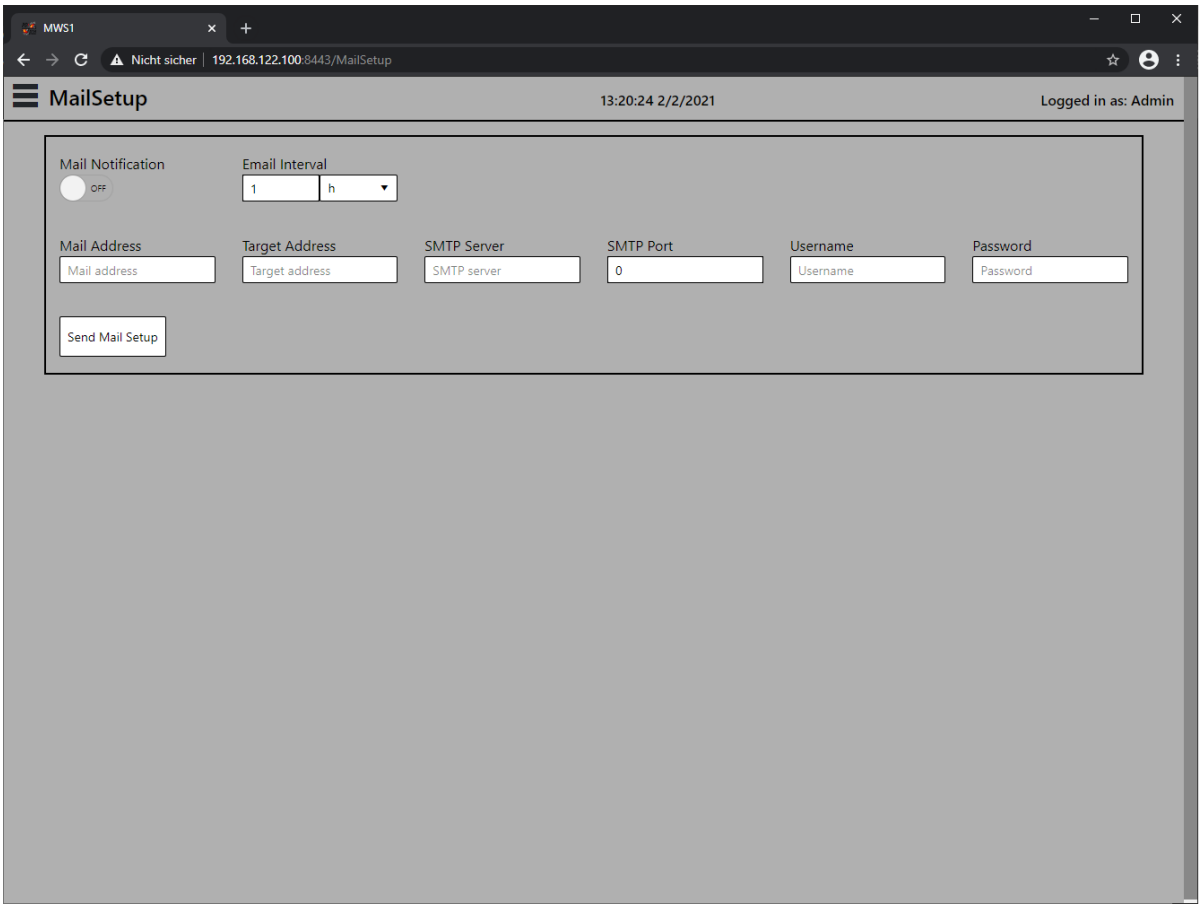


Figure VII.22: Mail settings

If "Mail Notification" is activated, an e-mail with information concerning alarm type, date, value, and affected channel is sent according to the interval set with "Email Interval".

VII.3.9.6 IEC setup (optional)

Instruments equipped with an optional protocol converter for IEC 61850 compliant communication have an additional terminal for communication via LAN. All relevant values for an IEC 61850 compliant communication with an external IEC61850 client can be set in the IEC setup panel.

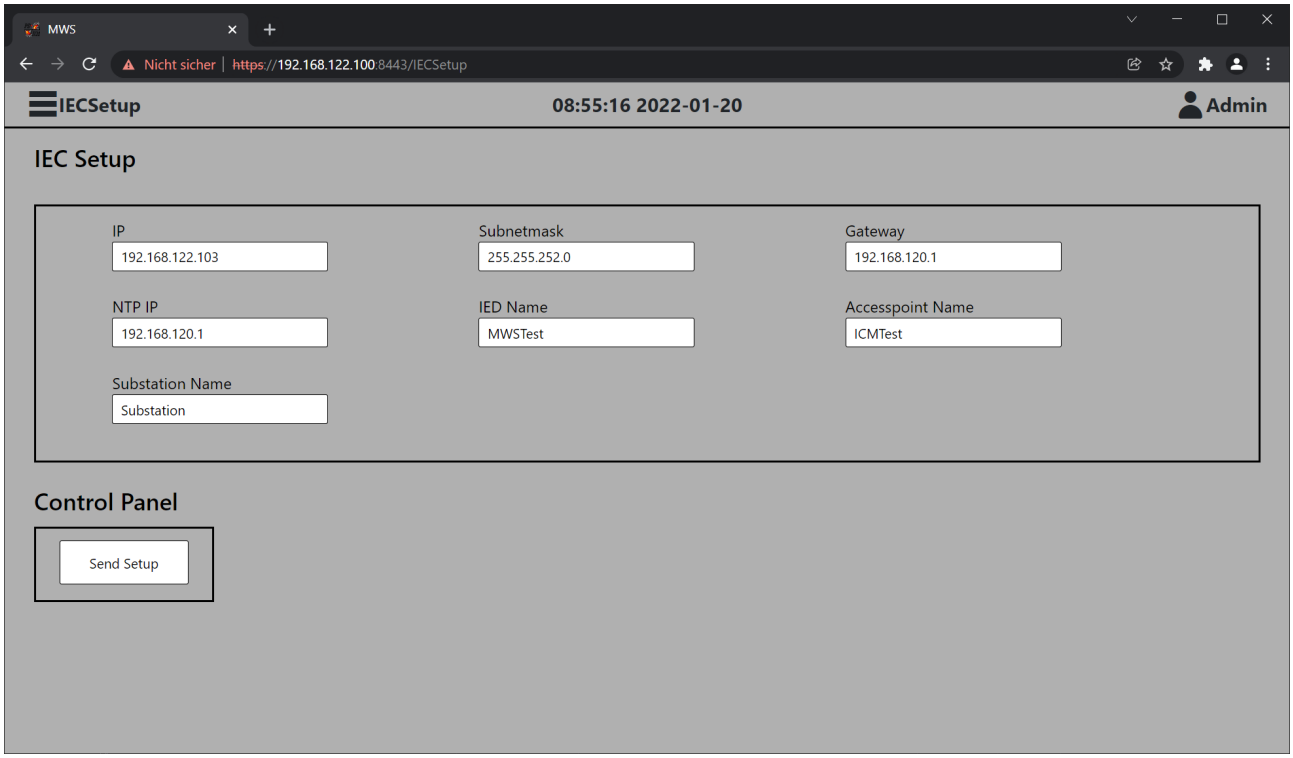


Figure VII.23: Setup for IEC 61850 compliant communication

The IP address of the IEC 61850 interface must be entered. This address must match with the settings of the corresponding LAN interface of the device. Additionally, other IEC 61850 relevant LAN settings must be configured, such as subnet mask, IPs of the gateway and NTP server (Network Time Protocol server) as well as names of the IED (Intelligent Electronic Device), access point, and substation.

With the 'Send Setup' button the settings are sent to the instrument and saved.

VII.3.10 Calibration

The "Calibration" panel allows the test setup to be calibrated or applying the data of an earlier calibration. For detailed information on the principle of calibration, please refer to section IV.5.

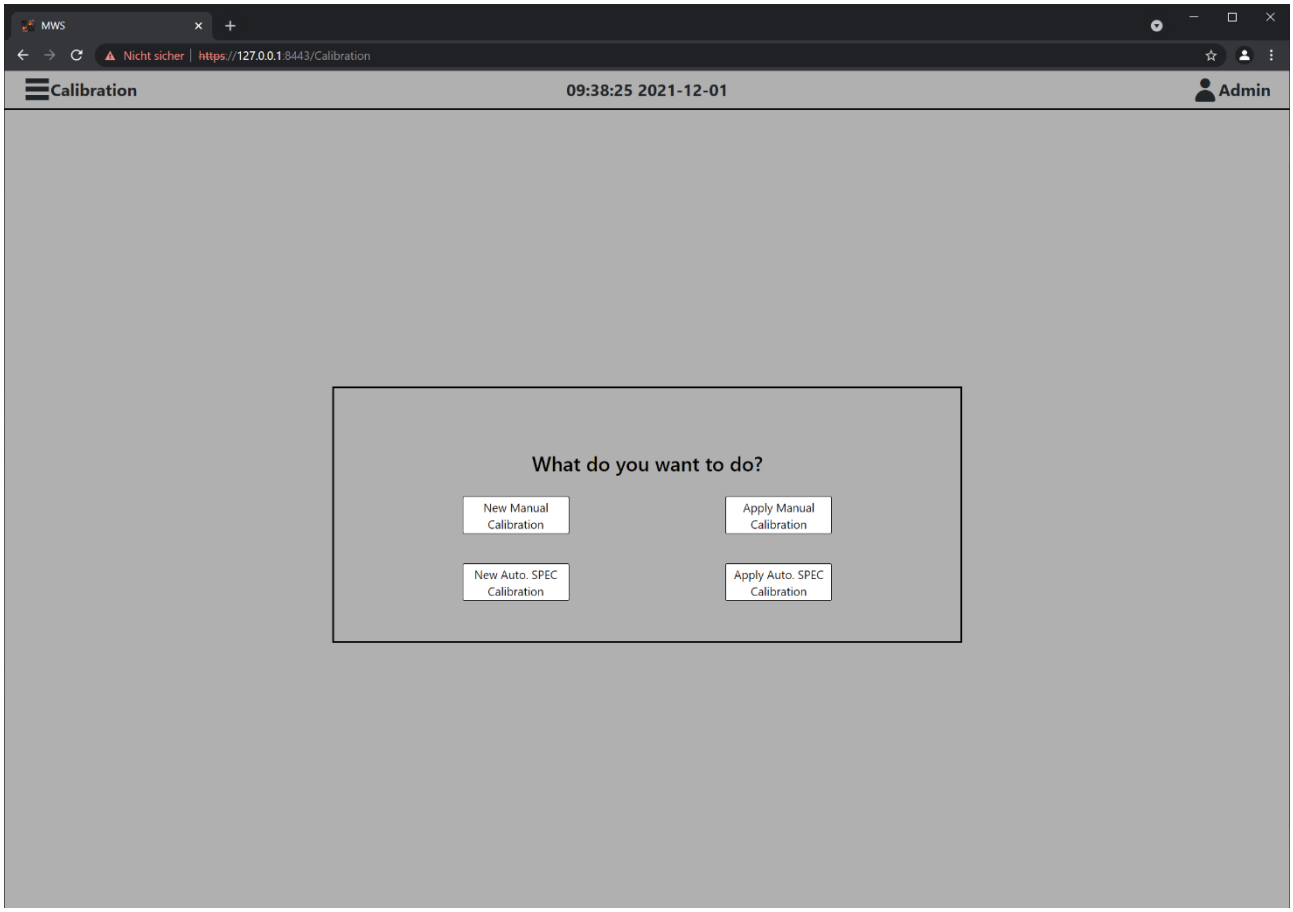


Figure VII.24: Calibration start panel

VII.3.11 Manual calibration

The user is guided step by step through the calibration process.

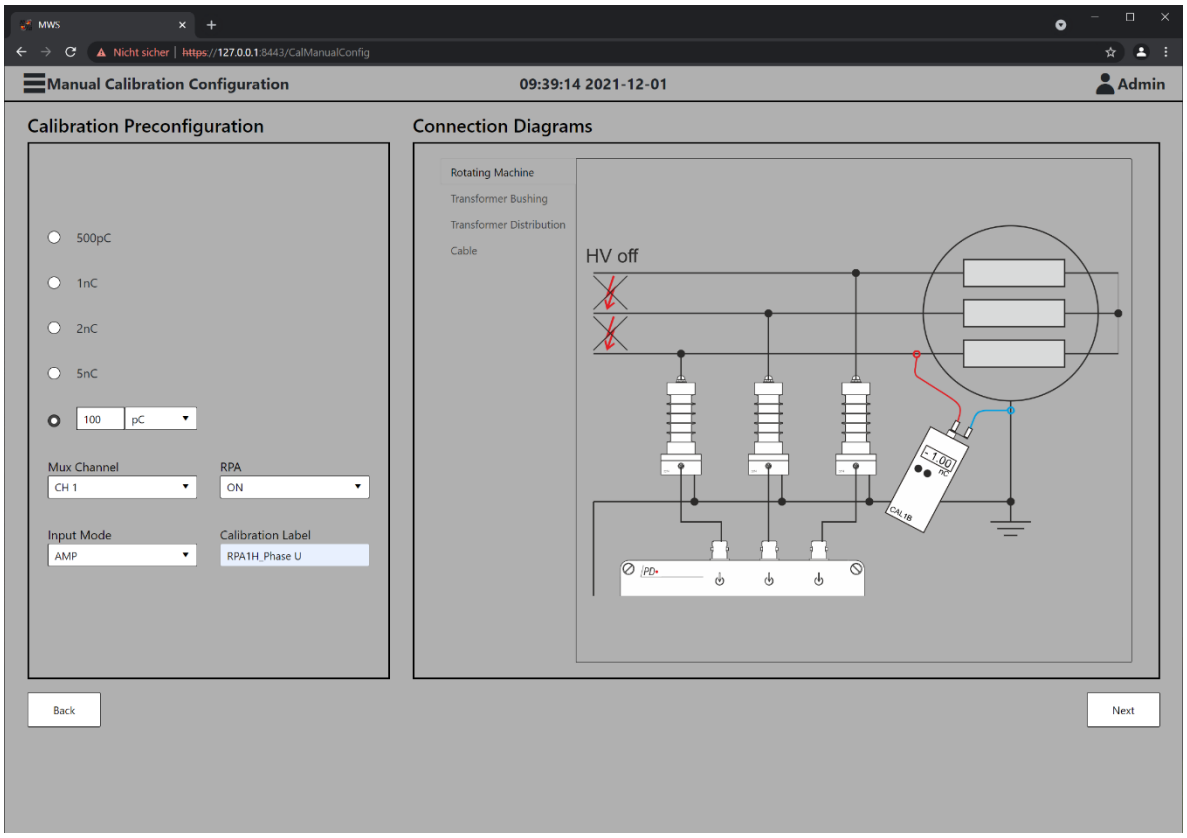


Figure VII.25: Calibration pre-configuration

Pre-configuration settings for the manual calibration are made on the left-hand side of the first step-by-step panel. Mandatory settings are calibration charge, channel, input mode, and whether a pre-amplifier is used or not. A calibration label is optional and helps identifying this specific calibration at a later date. Some example drawings of calibration setups for rotating machines, transformer, bushings, and cables can be found on the right-hand side.

Pushing the "Next" button changes to the calibration panel of the selected channel.

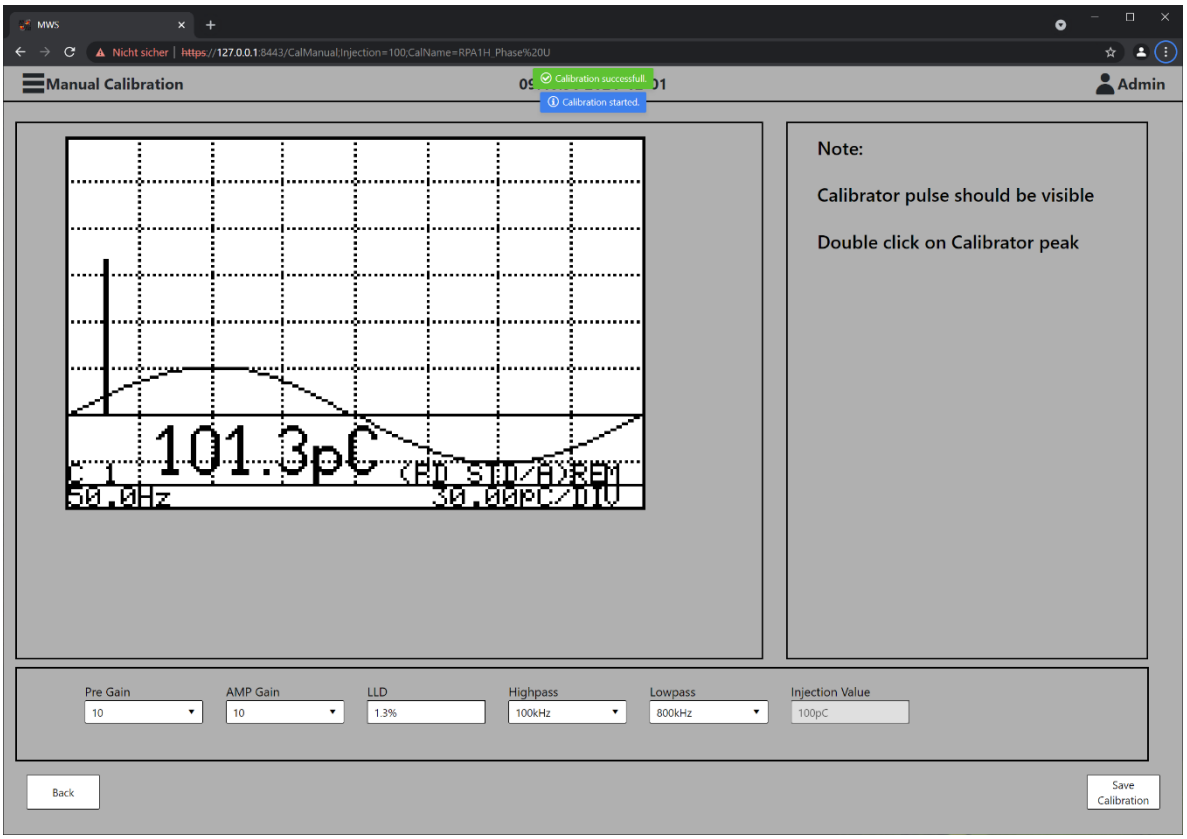


Figure VII.26: Panel for manual calibration

After the injection of a calibrator impulse double-click on the peak of the visible pulse in the display. Messages inform you that a calibration was started and when it was successful. Then save calibration data with the "Save Calibration" button.

Please go back to the pre-configuration panel and repeat the calibration process for the remaining channels of the ICM*monitor*.

VII.3.12 Automatic SPEC calibration

The web interface offers automatic calibration of an acquisition channel if this channel is in SPEC mode (see also section IV.5.2.2). The user is guided step by step through the calibration process.

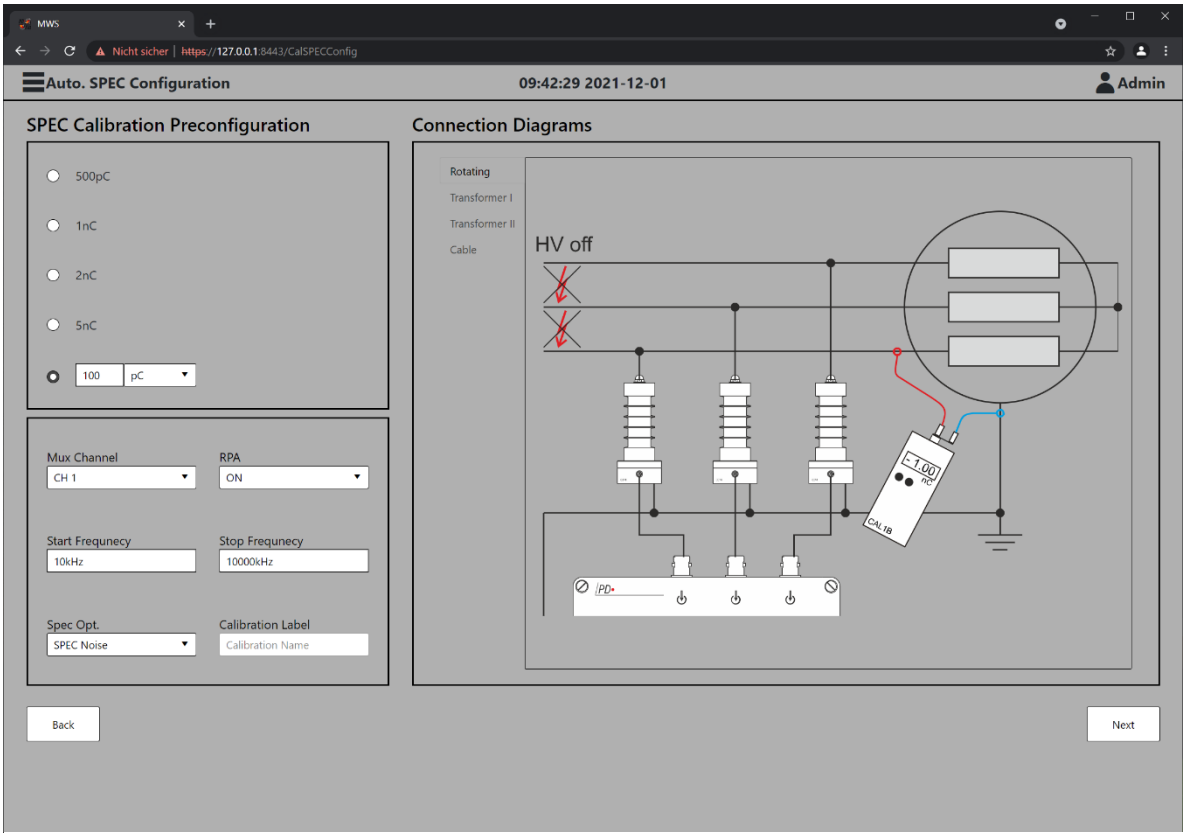


Figure VII.27: SPEC calibration pre-configuration

Pre-configuration settings for the automatic spectrum frequency calibration are made on the left-hand side of the first step-by-step panel. Mandatory settings are calibration charge, channel, whether a pre-amplifier is used or not, start and stop frequency, as well as optimisation mode.

A calibration label is optional and helps identifying this specific calibration at a later date. Some example drawings of calibration setups for rotating machines, transformer, bushings, and cables can be found on the right-hand side.

Clicking the "Next" button changes to the calibration panel of the selected channel.

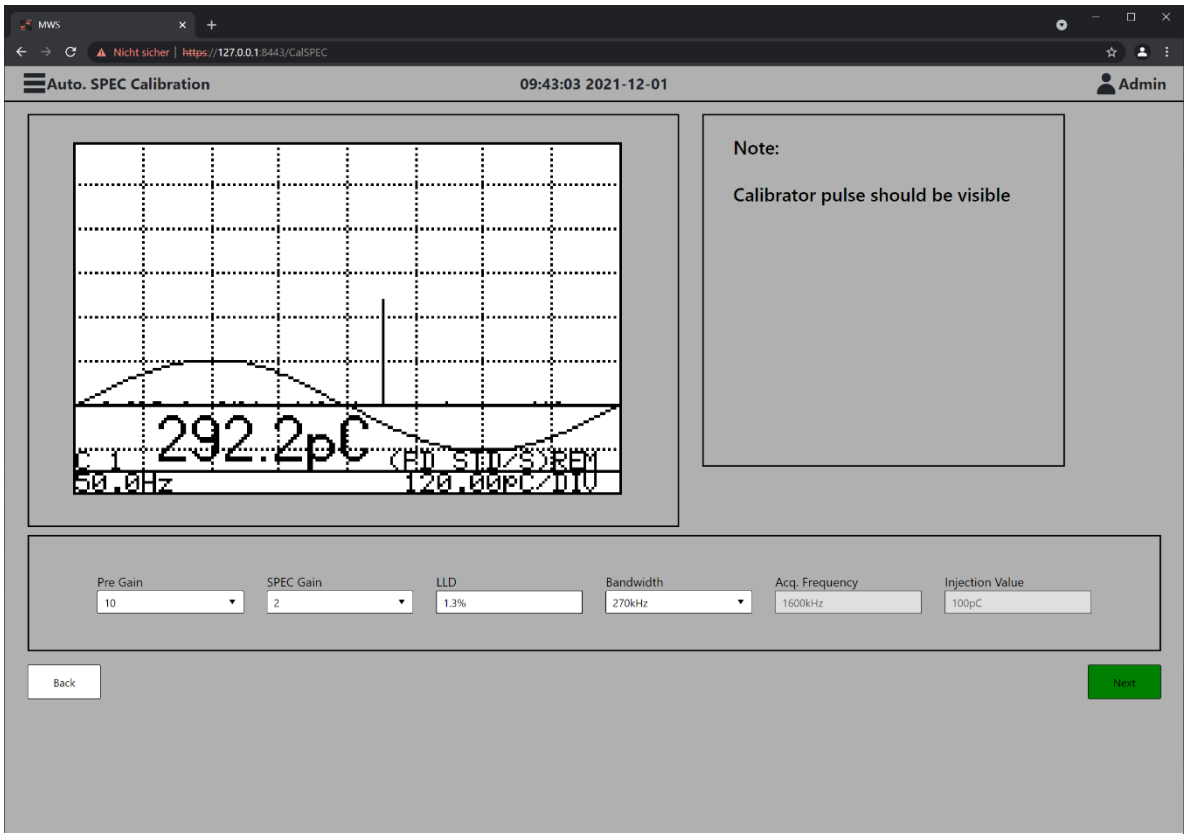


Figure VII.28: Panel for automatic spectrum frequency calibration

After the injection of a calibrator impulse this pulse should be visible in the display.

The "Next" button brings the user to the panel for automatic calibration.

Clicking the "Start Calibration" button starts the automatic SPEC calibration. A bar at the top shows the progress, while a blue graph gradually builds up in the diagram.

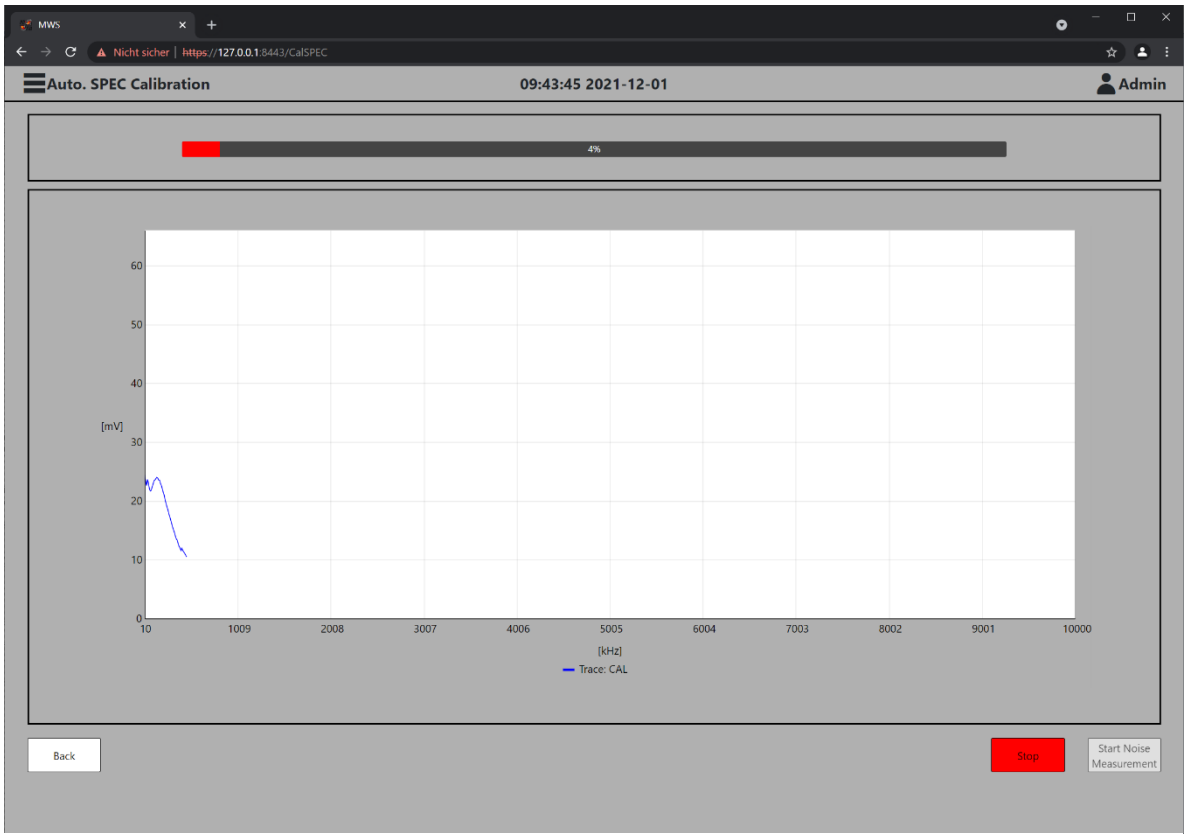


Figure VII.29: Automatic SPEC calibration in progress

After the automatic calibration has finished, please start a noise measurement to complete the process. A bar at the top shows the progress of the measurement, while an additional red graph gradually builds up in the diagram.

Calibration data can be saved with the "Save Calibration" button. Thereafter, the user is automatically brought back to the pre-configuration panel to repeat the calibration process for the remaining channels of the ICM*monitor*.

VII.3.13 Apply saved manual calibrations

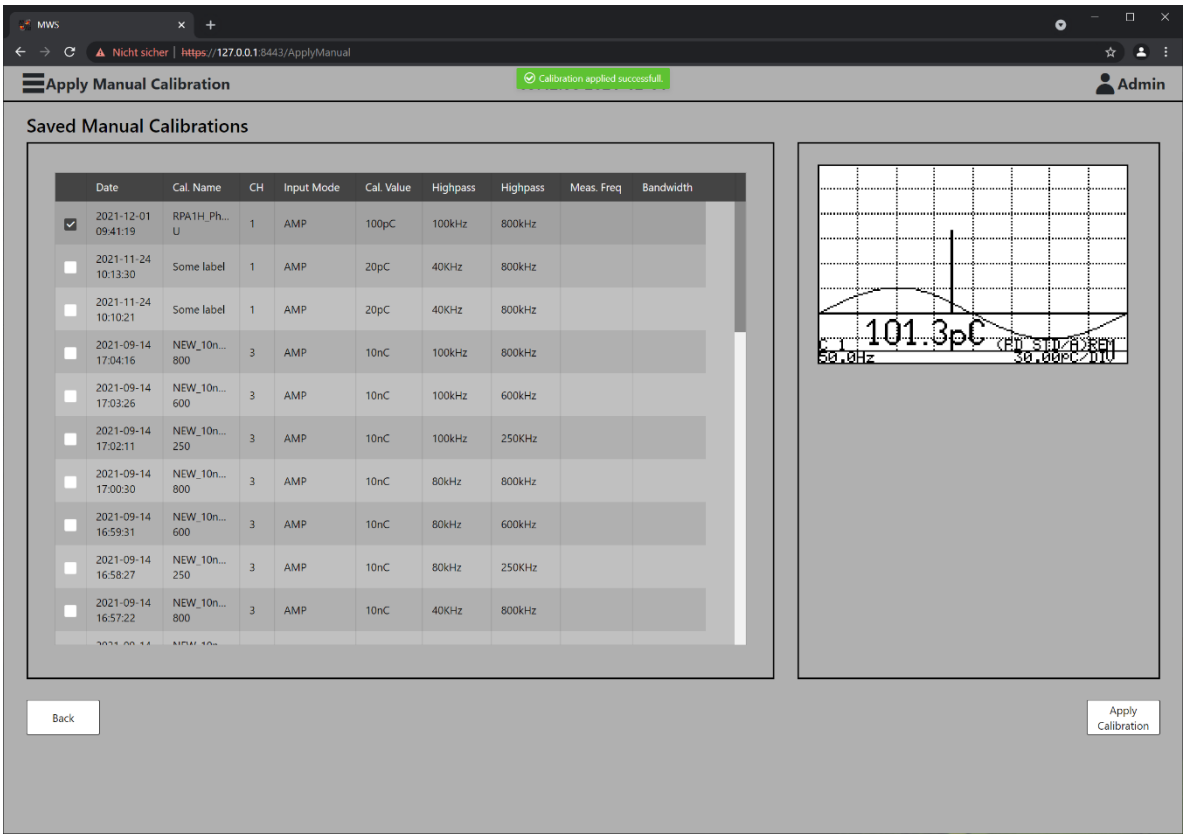


Figure VII.30: Selection list of saved manual calibrations

A detailed list offers selection of already saved manual calibration data sets by use of the corresponding check box. The data preview of a selected calibration is displayed at the right of the selection list.

A selected calibration is applied with the "Apply Calibration" button, and a message informs the user of a successful application.

VII.3.14 Apply saved automatic SPEC calibrations

A detailed list offers selection of already saved automatic spectrum frequency calibration data sets by use of the corresponding check box. The data preview of a selected calibration is displayed at the right of the selection list.

Clicking the "Next" button changes to the application panel that shows the calibration and noise graph as well as the pre-configured settings of the selected data set. The settings of the currently active measuring channel are displayed at the bottom of the panel. Clicking the "Start" button starts a noise measurement with a third green graph gradually building up in the diagram representing the current noise level.

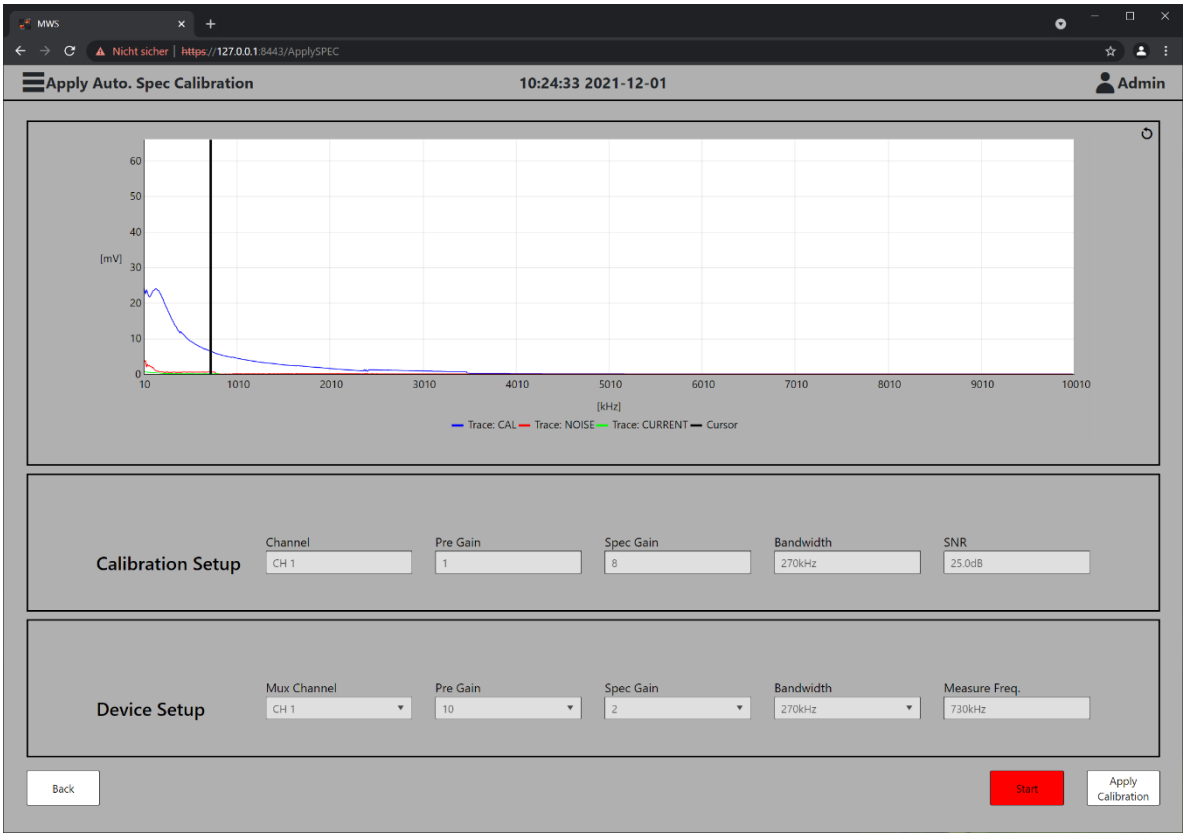


Figure VII.31: Running noise measurement with loaded automatic SPEC calibration data set

The measuring frequency is set by clicking onto the graph display at the corresponding x-axis position. Please remark, that the frequency is always rounded to the nearest full 10 kHz.

After the measurement is finished and the measuring frequency is selected, the calibration can be applied with the "Apply Calibration" button. The user is asked to confirm the current settings, and after confirmation a message informs the user of a successful application.

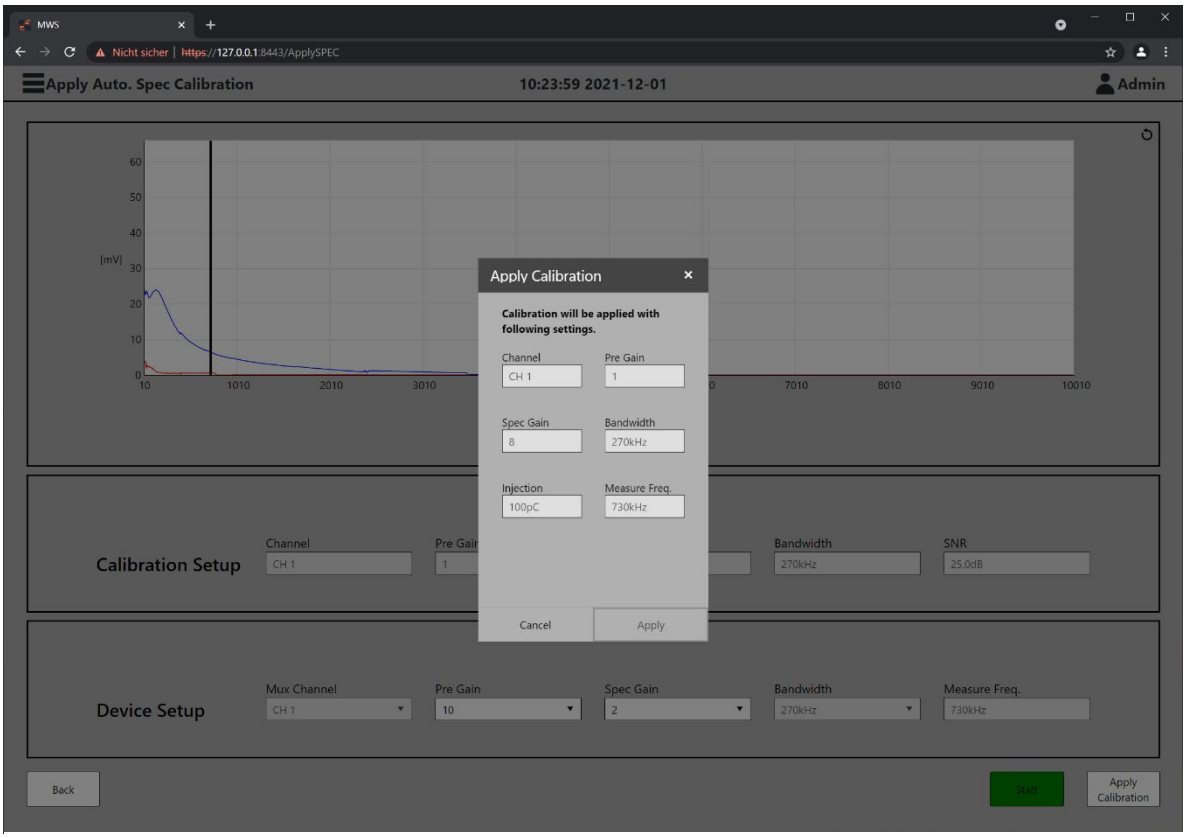


Figure VII.32: Apply saved automatic SPEC calibration

Please go back to the selection list and repeat this process for the other channels of the ICM*monitor*, if necessary.

VII.3.15 Status (administrators only)

The "Status" panel shows information on the connected instrument and a list of server events. The events can be removed individually with the "Remove" button or with the "Clear Server Log List" button at the top of the list.

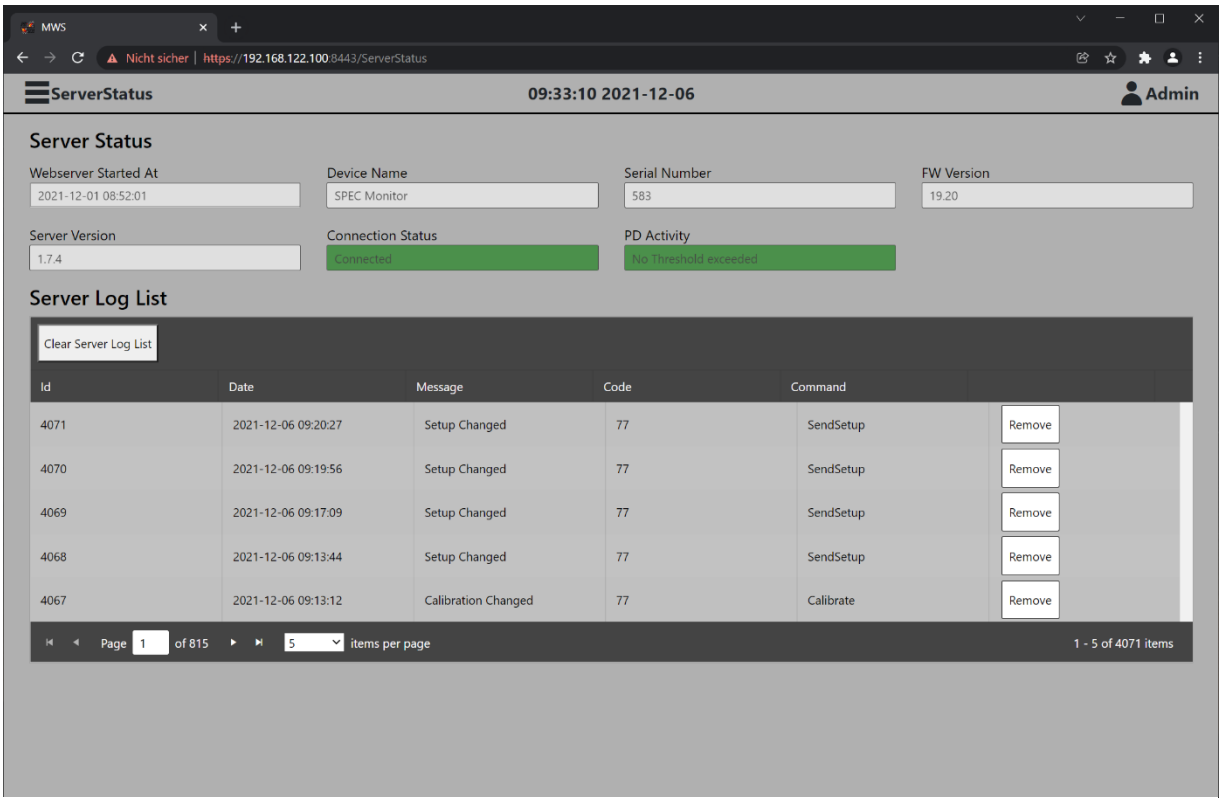


Figure VII.33: Status panel

VII.3.16 User (administrators only)

A click on the "User" entry brings up the user administration panel.

"Add new" offers the possibility to enter a username, password, and access mode for a new user. The entry is saved by pushing the "Add" button. The three different user access modes are:

- Viewer: Has only observation rights
- User: Has right to configure and control the MWS and the ICM*monitor*
- Admin: Has all rights for configuration, update, and control of the MWS and the ICM*monitor*

At delivery the default administrator user is “Admin” with password “admin”. Please setup another administrator user immediately after commissioning of the instrument and after this delete the default administrator account.

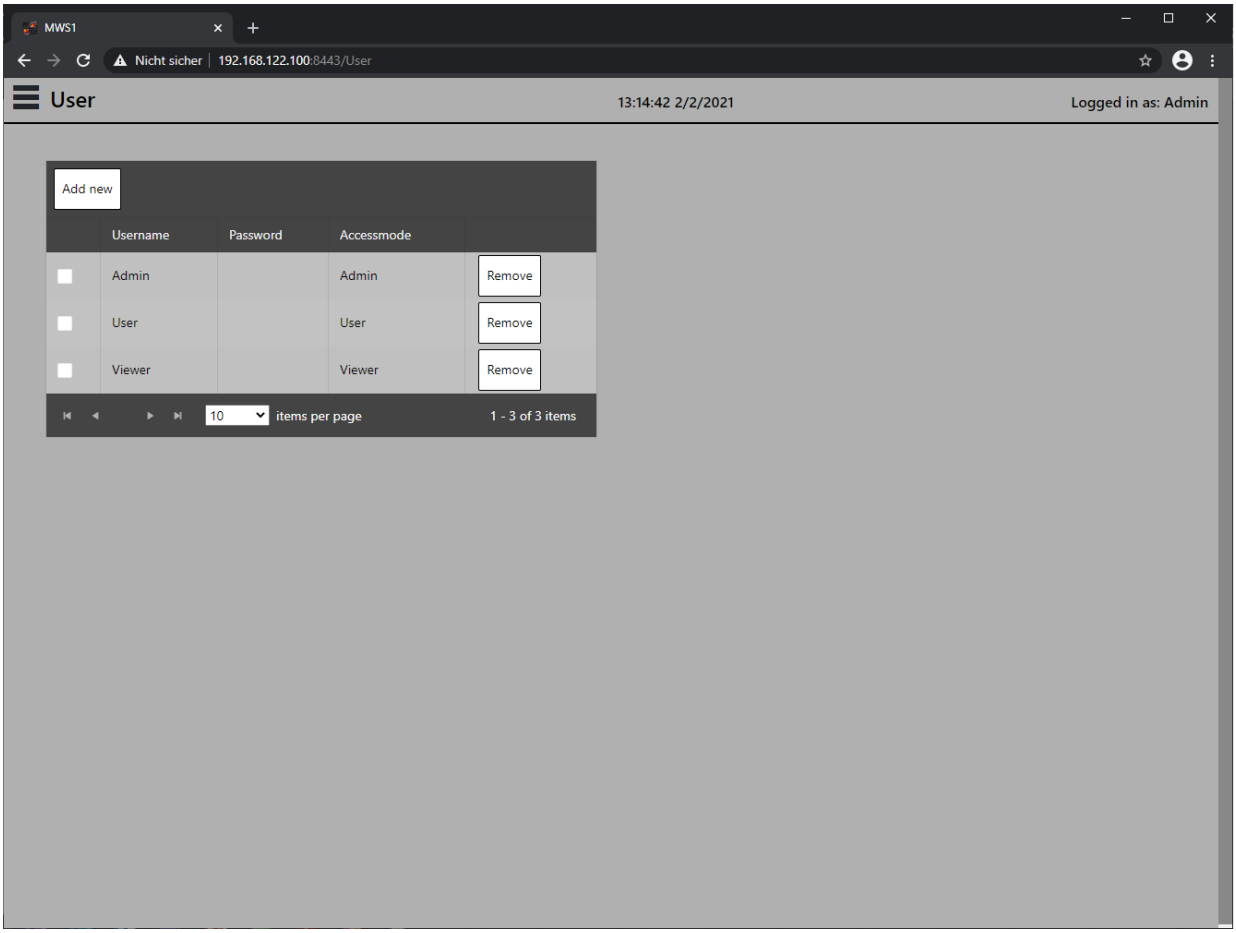


Figure VII.34: User administration panel

Existing user entries can be removed with the corresponding "Remove button".

Attention: Please be aware, that administrators can remove their own account. If there is only one user account with administrator rights and this account is deleted, it's no longer possible to manage user accounts for the MWS.

VII.4 Rest API

The following section gives a short overview on the REST-API commands that can be used for integration of the MWS into an existing monitoring system:

VII.4.1 Login

POST /api/v1/login

User credentials send in body as JSON in JSON.

```
{
    Data: {
            User: username,
            Password: password
        }
}
```

Response will be data object with the following keys:

```
{
    Authenticated: true/false,
    Message: message,
    Token: JSON web token,
    AccessMode: access mode
}
```

By using the MWS web application a JSON web token will be saved in local storage.

VII.4.2 Alarm

GET /api/v1/Alarm/alarmstatus

Response will be the last read alarm status as list of JSON.

Each element contains information about type, time, and channel the alarm occurred on.

```
{
    Date: date,
    Channel: channel no.,
    Type: alarm type
}
```

Type: 0 = no alarm

Type: 1 = NQS alarm

Type: 2 = PC alarm

Type: 3 = NQS/PC alarm

VII.4.3 Exports

GET /api/v1/Exports/events

Response will contain all events from database and will be a JSON with a csv file as base64 encoded string.

```
{
    File: csv file
}
```

GET /api/v1/Exports/trendings

Response will contain all trending values from database and will be a JSON with a csv file as base64 encoded string.

```
{
    File: csv file
}
```

VIII FAQ (Troubleshooting)

This section lists some problems that may be encountered in using the ICM*monitor* along with possible causes and remedies.

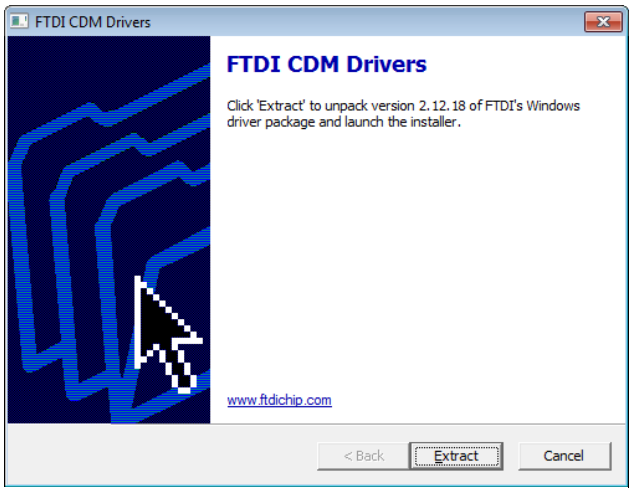
The personal computer cannot find the ICM*monitor*

A communications error with the serial connection to the ICM*monitor* might have occurred. Within the ICM*monitor* software, check to be sure that the serial com port selected in the menu 'Connect' is the com port to which the ICM*monitor* is connected. Try rebooting both the ICM*monitor* and the PC. Check within the Windows Device Manager if the USB driver is installed.

Installation of the USB Driver

For communication of the ICM*monitor* with a PC a USB driver has to be installed manually. To do so, take the following steps after the installation of the ICM*monitor*'s software.

Open the USB driver folder, which should be a subfolder of the installed ICM*monitor* software (e.g., C:\pdix\software\ICMmonitor\monp.499\USB Driver). Open the sub folder FTDI and start the installation process by double clicking the file CDM21218_Setup.exe. Follow the instruction of the installation process.



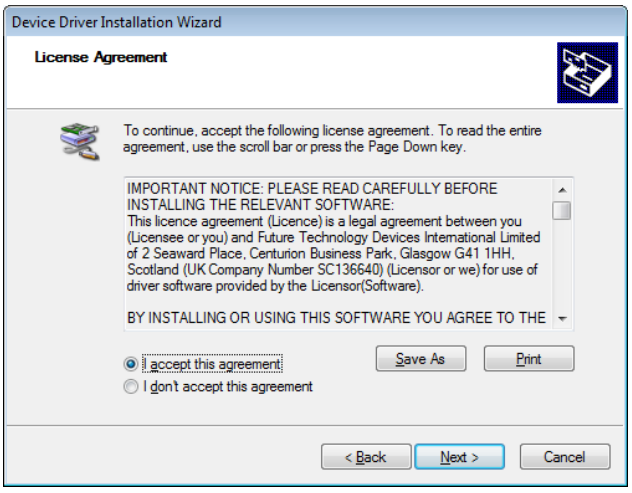


Figure VIII.2: FTDI USB driver installation

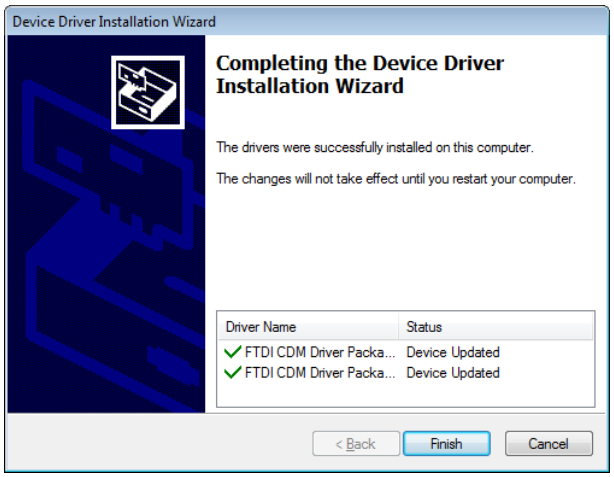


Figure VIII.1: Dialog box after successful USB driver installation

After the installation has finished a reboot of the PC is necessary.

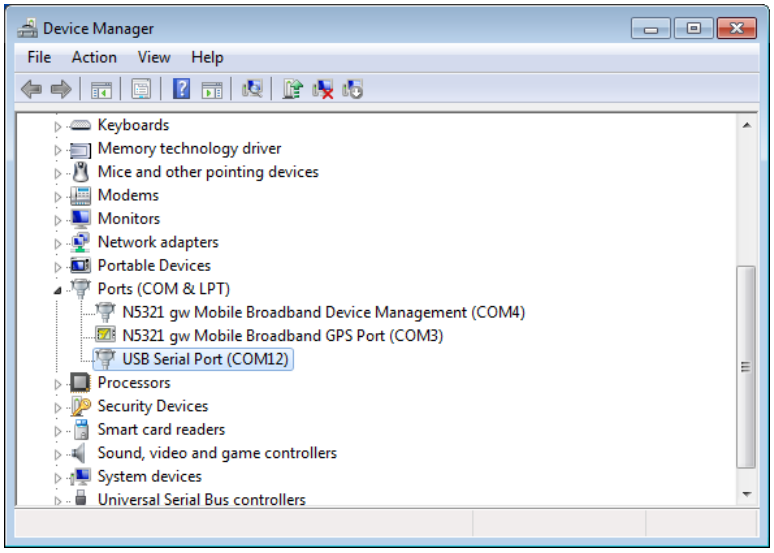


Figure VIII.3: Windows device manager items after a successful FTDI driver installation

The automatic installation of the USB driver fails <u>with earlier versions</u> of the ICM*monitor*.

If the automatic installation of the USB driver fails, it's possible to install the driver manually. Manual installation is divided in two steps due to the driver properties:

Step 1: Open the device manager. Select 'Silicon Labs CP210X USB to UART Bridge', which is listed as an item of 'Other devices'. Right-click on it and select 'Update Driver' from the context menu.

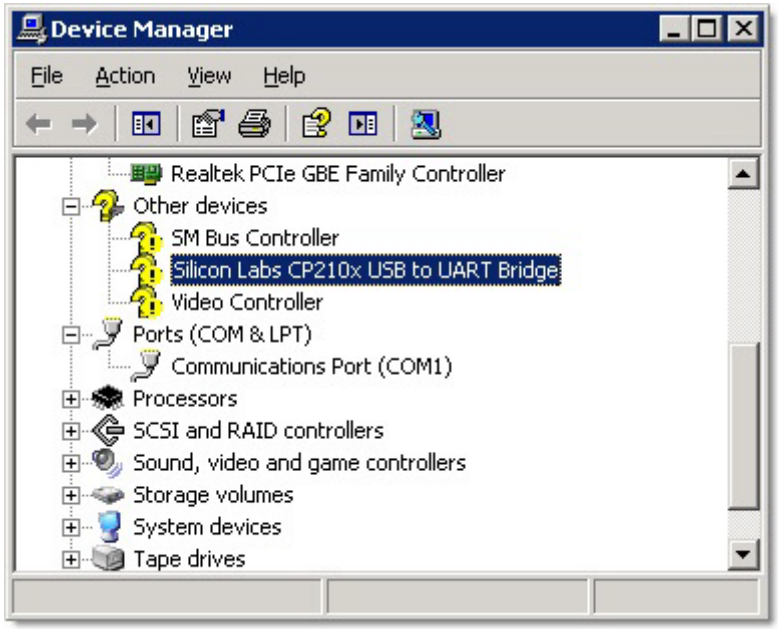


Figure VIII.4: Windows device manager

The hardware update wizard will open. Select 'Search for the best driver in these locations'. and specify the directory where the ICM*monitor* software has been installed, as shown with Figure VIII.5. Click 'Next' to proceed. Windows will now install the first part of the driver software, the USB controller driver. Usually, the installation will end with an error message, since the second part of the driver – the USB bridge driver – is still missing.

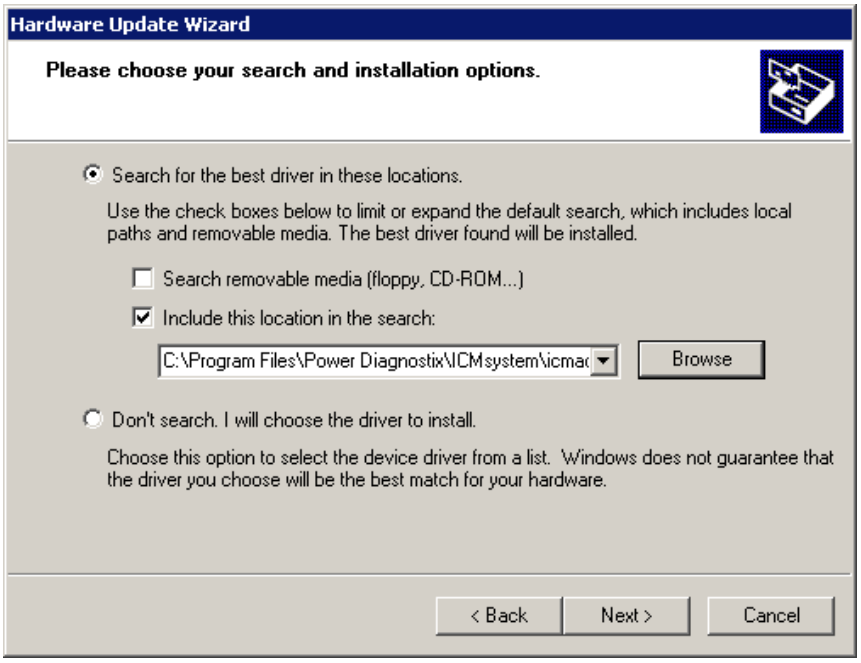


Figure VIII.5: Hardware update wizard

Repeat the steps above to install the second part of the CP210X bridge driver. If the installation is completed successfully, the CP210X device should appear in the device manager.

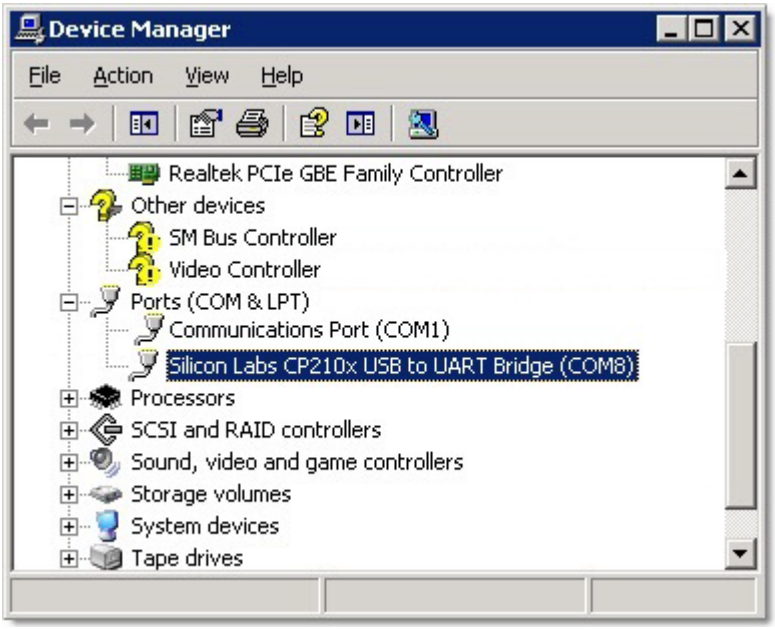


Figure VIII.6: Windows device manager items after a successful driver installation

The ICM*monitor* application widow appears very small on high resolution monitors with Windows 10

On PCs running Windows 10 with the Creator's Update of 2017 the ICM*monitor* application window may appear very small on high resolution monitors. To enlarge the display size of the software, please take the following steps:

1. Right-click on the application short cut on the desktop.
2. Choose "Properties" from the context menu, which will open the Properties window.
3. Enable "Override high DPI scaling behaviour" and set "Scaling performed by" to "System" on the "Compatibility" tab.
4. If you have administrator rights, you can change the settings for all users by clicking the corresponding button.
5. Approve the change by clicking "OK".

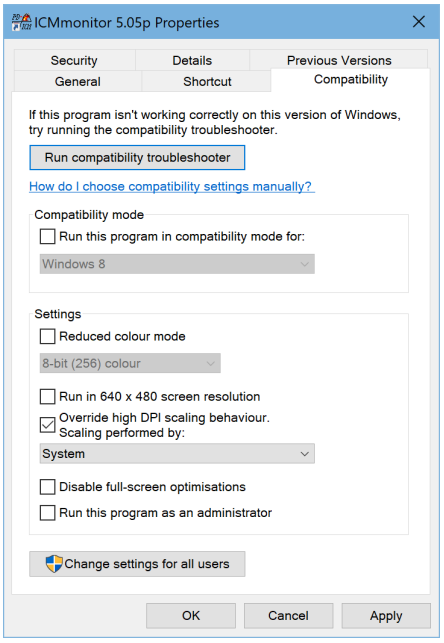


Figure VIII.7: Properties window

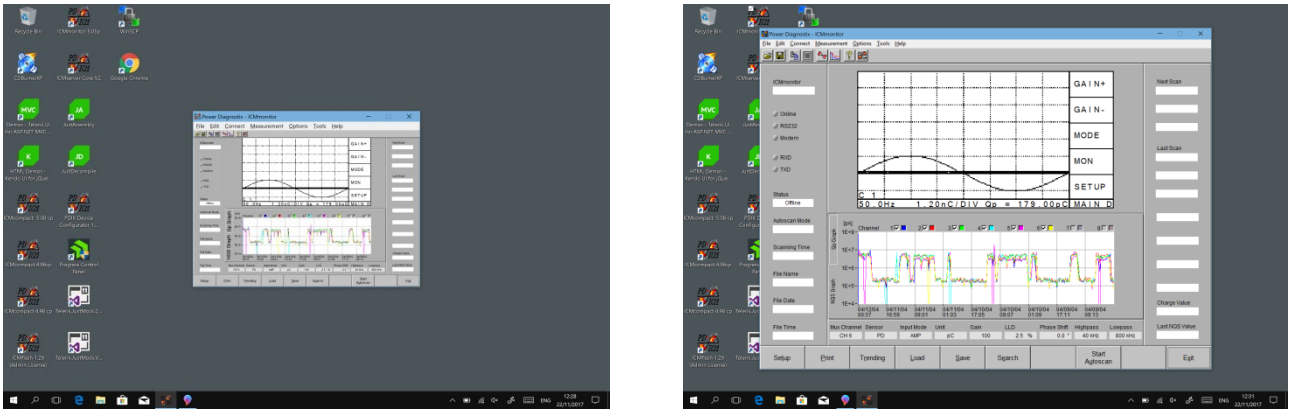


Figure VIII.8: Desktop before and after change of scaling behaviour

The 'RPA?' message appears in the lower left portion of the data display of the LCD panel, even though the RPA (preamplifier from Power Diagnostix) is connected.

The preamplifier must be enabled. Ensure the **>**RPA ON is marked (see page 37).

The calibration pulse is not visible on the LCD panel.

First check that the calibrator is still on. The calibrator will shut off automatically after about 15 minutes without having its buttons pushed. Check that the low battery indicator is not showing on the LCD panel of the calibrator.

The calibration pulse setting might be too weak for the test setup. Try increasing the magnitude of the calibration impulse applied to the test setup.

The calibration pulse on-screen might be present but too small to be easily visible. Try putting the ICM*monitor* into SCOPE / MODE / NORM. This will make the calibration pulse appear as a vertical bar, which makes it easier to see onscreen that it appears in the 'HOLD' mode.

Sometimes the calibration pulse is lost if the high-voltage power supply is connected to the test setup when the calibration is performed, even if the high-voltage supply is completely powered off. Ensure the power supply is not earthed during calibration. Try physically disconnecting the high-voltage supply from the test object during calibration. The calibrator will then be connected across only the test object quadrupole, and the coupling capacitor (if present).

Other problems

The troubleshooting section of the ICM*monitor* manual is evolving. If you encounter problems with your ICM*monitor* that you think would be helpful to add to this troubleshooting section, please submit them to Power Diagnostix. Thank you for your assistance.

IX Miscellaneous

IX.1 Maintenance

The ICM*monitor* does not require any maintenance on a regular basis. There is no fine adjustment on a regular basis required, as the partial discharge measurement is a relative measurement that is calibrated with a reference source prior to a measurement. The calibration impulse generator (e.g., CAL1B) as the reference source, however, must be calibrated on an annual basis to ensure that its output signal remains within the recommended boundaries.

IX.2 Product marks

This symbol indicates that the product, which is marked in this way, should not be disposed of as normal household waste. As it is a B2B product, it may also not be disposed of at civic disposal centres. If you wish to dispose of this product, please do so properly by taking it to an organisation specialising in the disposal of old electrical equipment near you.

As a responsible manufacturer, who is certified according to ISO 14001, Power Diagnostix offers customers to take back old instruments. Please contact Power Diagnostix to discuss the procedure for this.

IX.3 Shipment instructions

IX.3.1 Instrument

In case a unit needs to be returned to the factory, make sure the acquisition unit is packed safely. As the units are relatively small, shipment by couriers, such as DHL, FedEx, or equivalent is the recommended mode of transportation. If possible, declare the instrument as 'used instruments for evaluation' at a relative low value. Consult Power Diagnostix for further details. Additionally, Power Diagnostix may provide you with a temporary replacement unit, in case of urgent needs.

IX.3.2 Batteries

If an instrument is suspected to contain a faulty battery module, the module must be removed before the instrument is shipped. Never ship a faulty battery module, either separately or connected to an instrument.

IX.4 Declaration of Conformity

The manufacturer
Power Diagnostix Instruments GmbH
Vaalser Strasse 250
52074 Aachen
Germany

declares, that the product

ICM*monitor*
Partial discharge monitor for use in high voltage test areas

provided it is installed, maintained, and used for which it was made, in accordance with relevant installation standards and manufacturer's instruction, meets the requirements of the following directive(s):

Low Voltage Directive 2014/35/EU
EMC Directive 2004/108/EG
RoHS Directive 2011/65/EU

It complies with the following standards and/or normative documents:

EN 61010-1:2010,
EN 61326-1:2013
EN IEC 63000:2018

Aachen, 04.09.2023
Dr. Mihai Huzmezan
(CEO, Power Diagnostix Instruments GmbH)

Note: Since the measurement of partial discharge pulses is done in frequency bands partly occupied by radio transmission, and since further test leads may act as antennas, disturbance free measurements may require well shielded environments and/or additional filter techniques.

IX.5 UK Declaration of Conformity

The manufacturer
Power Diagnostix Instruments GmbH
Vaalser Strasse 250
52074 Aachen
Germany

declares, that the product

ICM*monitor*
Partial discharge monitor for use in high voltage test areas

provided it is installed, maintained, and used for which it was made, in accordance with relevant installation standards and manufacturer's instruction, meets the requirements of the following Statutory Instruments:

SI 2016 no. 1101	**The Electrical Equipment (Safety) Regulations 2016**
SI 2016 no. 1091	**The Electromagnetic Compatibility Regulations 2016**
SI 2012 no. 3032	**The Restriction of the Use of Certain Hazardous Substances in Electrical and Electronic Equipment Regulations 2012**

It complies with the following standards and/or normative documents:

EN 61010-1:2010,
EN 61326-1:2013
EN IEC 63000:2018

Aachen, 04.09.2023
Dr. Mihai Huzmezan
(CEO, Power Diagnostix Instruments GmbH)

Note: Since the measurement of partial discharge pulses is done in frequency bands partly occupied by radio transmission, and since further test leads may act as antennas, disturbance free measurements may require well shielded environments and/or additional filter techniques.

X Technical data

X.1 Main unit

Mains supply:	Portable version:	85–264 V AC, 47–440 Hz	(automatic)
	Acquisition box:	85–264 V AC, 47–440 Hz	(automatic)
	Acquisition box w. display:	90–264 V AC, 47–440 Hz	(automatic)
	Wall mounted version:	90–264 V AC, 47–440 Hz	(automatic)
	19-inch enclosure unit:	85–264 V AC, 47–440 Hz	(automatic)
	Explorer case version:	90–264 V AC, 47–440 Hz	(automatic)
	DIN rail versions:	12–26 V DC	(external supply)
Line fuse:	1.6 A time-lag	(85–264 V AC)	
Power requirements:	Approx. 40 VA		
Display:	Backlit LCD		
Display size:	120 mm x 64 mm		
Display resolution:	128 x 240 Pixel B/W		
Operation:	5 menu supported pushbuttons 5 fix function pushbuttons		
Recorder output (option):	0–10 V with R=100 Ohm		
Operation temperature:	10–40°C	(non-condensing)	
	0–55°C	(version without display; non-condensing)	
Input impedance (AMP IN):	50 Ohm||50 pF		
A/D converter (PD):	8 bits (unipolar) / ±7 bits (bipolar)		
Weight:	Approx. 1.6–5.6 kg	(depending on installed options and enclosure)	
Overall size (H x W x D): [4]	Portable version:	133 x 236 x 295 mm^3	(incl. connectors)
	Acquisition box:	133 x 270 x 260 mm^3	(incl. connectors)
	Acquisition box with display:	133 x 376 x 260 mm^3	(incl. connectors)
	Wall mounted version:	260 x 305 x 210 mm^3	(incl. connectors)
	19-inch enclosure unit:	133 x 482.6 x 345/310 mm^3	(depending on version)
	Explorer case version:	360 x 305 x 270 mm^3	(closed)
	DIN rail version 1:	116 x 220 x 102 mm^3	(incl. connectors)
	DIN rail version 2:	109 x 300(±1) x 137 mm^3	(incl. connectors)

Communication interfaces:

USB 2.0

Fibre optic serial link

LAN

RS232 (57.6 kBit/s), on request

Alarm relay:

Contact rating:	DIN rail versions:	6 A / 160 V AC
	Other models	5 A / 160 V AC, 5A / 30V DC
Min. contact load:	DIN rail versions:	100 mA / 12 V AC
	Other models	100 mA / 5 V DC

[4] Allow about additional 100 mm to connect the cables.

Standard PD mode:

Lower cut-off (-6 dB):	40, 80, or 100 kHz	(software controlled)
Upper cut-off (-6 dB):	250, 600, or 800 kHz	(software controlled)
Input sensitivity:	< 500 μV_{rms} / 5pC	(without preamplifier)
Gain range:	1, 2, 4, 8, 10, 20 …, 200, 400, 800	

Preamplifier:

Input impedance:	10 kOhm||50 pF	(RPA1 / RPA1D / RPA1G / RPA4)
	1 kOhm||50 pF	(RPA1L / RPA1H)
	50 Ohm||50 pF	(RPA2 / RPA3 / FCU2)
Input sensitivity:	< 50 μV_{rms}/0.03 pC	(RPA1 / RPA1D / RPA1G / RPA4)
	< 15 μV_{rms}/0.02 pC	(RPA1L)
	< 40 μV_{rms}/0.05 pC	(RPA1H)
	< 800 μV_{rms}	(RPA2)
	< 2 mV_{rms}	(RPA3)
	< 200 μV_{rms} (46 dBµV)	(FCU2)
Bandwidth:	40–800 kHz	(RPA1 / RPA1D / RPA1G / RPA4)
	40 kHz–20 MHz	(RPA1L / RPA1H)
	2–20 MHz	(RPA2)
	200–1000 MHz	(RPA3)
	100–1800 MHz	(FCU2)
Acquisition bandwidth:	2–20 MHz	(RPA2, optional)
	40–800 kHz	(RPA1, optional)
	100–1800 MHz	(external FCU2, optional)

Synchronisation:

Sync. Frequency:	Standard:	5–320 Hz (firmware version >= 19.8)
		10–510 Hz (firmware version < 19.8)
	UHF mode:	5–250 Hz (firmware version >= 19.8)
		10–350 Hz (firmware version < 19.8)
Maximum voltage:	200 V_{peak} (140 V_{rms}), 100 V_{rms} nom.	
Input impedance:	10 MOhm	

SPEC function:

Input sensitivity	< 5 μV_{rms}/0.5 pC	(270 kHz bandwidth)
	< 1 μV_{rms}/2 pC	(9 kHz bandwidth)
Maximum input voltage	120 mV_{rms}	(270 kHz bandwidth)
	5 mV_{rms}	(9 kHz bandwidth)
Frequency range	100 kHz–10 MHz (in steps of 10 kHz)	
Bandwidth	9 kHz or 270 kHz	
Precision:	< 5% (typical)	

X.2 Cabinet

Model 500

Material:	Stainless steel	
Ingress protection class:	IP65	
Heating	Optional	
Cooling	Optional	
Overall size (H x W x D):	450 x 600 x 250 mm^3	(excl. mounting brackets)

XI Annex

XI.1 Connection of MUX OUT and AMP IN

There are different ways to connect the MUX OUT to the AMP IN, depending on hardware version of the instrument.

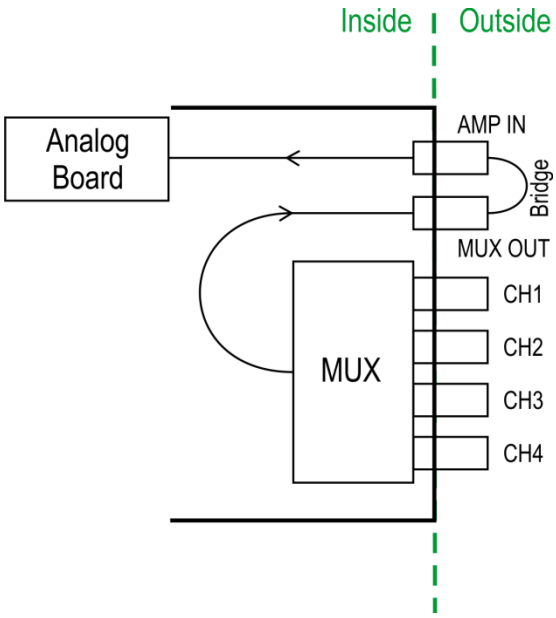


Figure XI.3: Alternative 1: Short BNC cable

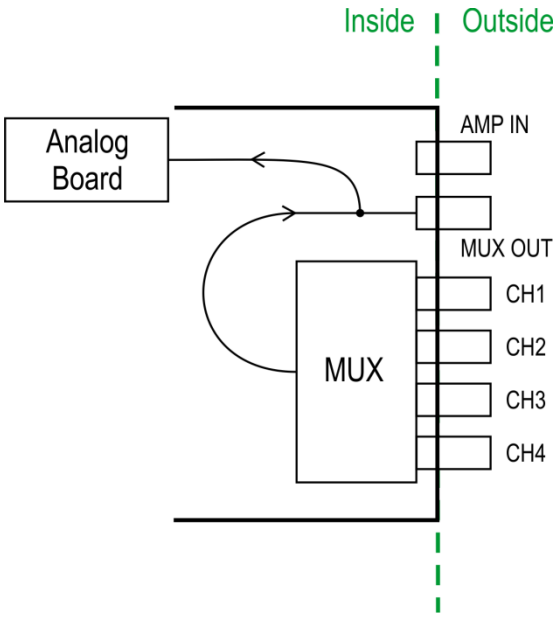


Figure XI.2: Alternative 2: No cable, built-in hardwire connection

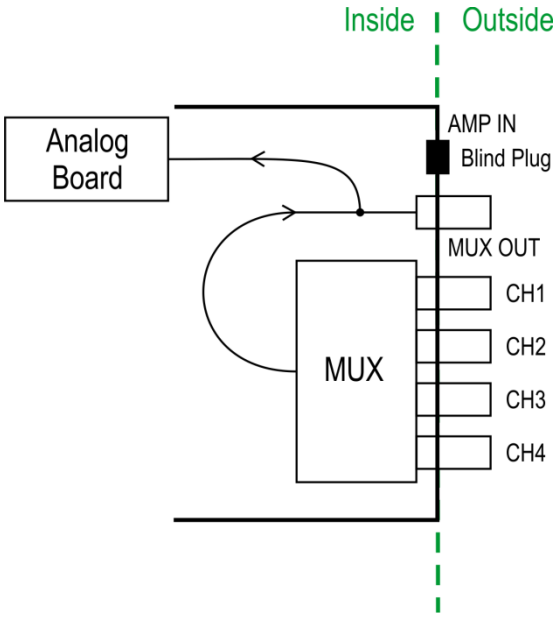


Figure XI.1: Alternative 2: No cable, built-in hardwire connection

XI.2 National Instruments hardening guide

XI.2.1 Introduction

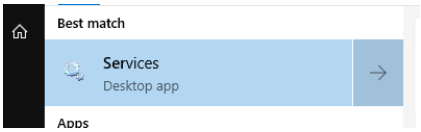
This manual will guide you through the Power Diagnostix proposed cyber security operation system hardening after the installation of a National Instruments based software product. The configuration refers to the Power Diagnostix software products, only. If any other third-party National Instruments based software products are installed or required, the proposed configuration should be adjusted with the configuration of the responsible manufacturer.

This configuration guide will close three unnecessary National Instruments services. Furthermore, the local Port 3848 UDP and TCP opened by these services will be closed.

nidmsrv.exe	3848	TCPV6	[0:0:0:0:0:0:0:1]	49672	[0:0:0:0:0:0:0:1]	49673	ESTABLISHED
nidmsrv.exe	3848	TCPV6	[0:0:0:0:0:0:0:1]	49673	[0:0:0:0:0:0:0:1]	49672	ESTABLISHED
nidmsrv.exe	3848	TCP	DESKTOP-Q5NEF6E	59111	DESKTOP-Q5NE...	0	LISTENING
nidmsrv.exe	3848	UDP	DESKTOP-Q5NEF6E	5000	*	*	
nidmsrv.exe	3848	UDP	DESKTOP-Q5NEF6E	6000	*	*	

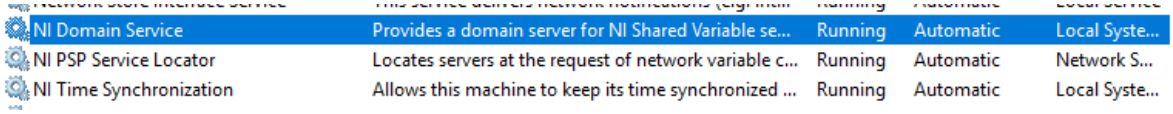
XI.2.2 Step-by-step guide

1.) Open the Windows start menu and type services.msc.



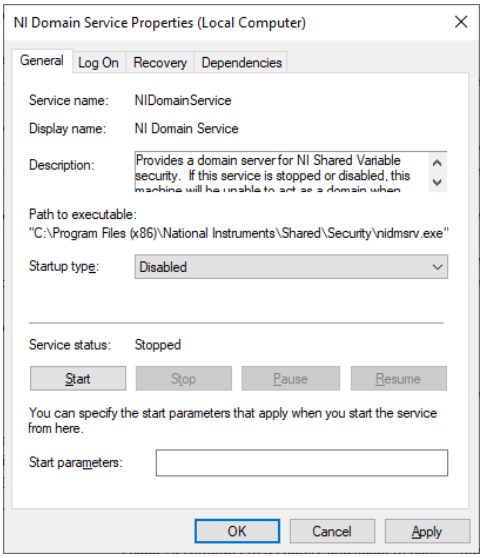
2.) Click onto the search result named Services. The Services window will open.

3.) Locate these services in the service list:
- NI Domain Service
- NI PSP Service Locator
- NI Time Synchronization



4.) Open the configuration popup by double clicking **each service** and changing the Startup type to Disabled.

5.) Save the changes by pressing the OK button.



XI.2.3 Service description

http://www.ni.com/product-documentation/14487/en/

NI Domain Service
Service: NIDomainService **Process**: nidmsrv.exe
Description: Provides a domain server for NI Shared Variable security. **If Disabled**: If this service is stopped or disabled, this machine will be unable to act as a domain when configuring shared variable security.

NI PSP Service Locator
Service: lkClassAds **Process**: lkads.exe
Description: Locates servers at the request of network variable clients and other proprietary NI network protocols. **If Disabled**: If this service is stopped or disabled, network variables and network streams will stop working.

NI Time Synchronization
Service: lkTimeSync **Process**: lktsrv.exe
Description: Allows this machine to keep its time synchronized with a master time server, or to act as a time server for other machines. This feature is configured with the Shared Variable Engine settings in LabVIEW. **If Disabled**: If this service is stopped or disabled, this form of time synchronization will not be available.

XI.3 Old enclosure models

XI.3.1 Wall mounted instrument

Figure XI.4: ICM*monitor* as a wall mounted device

XI.3.1.1 Front panel

For an explanation of the front panel, see page 3.

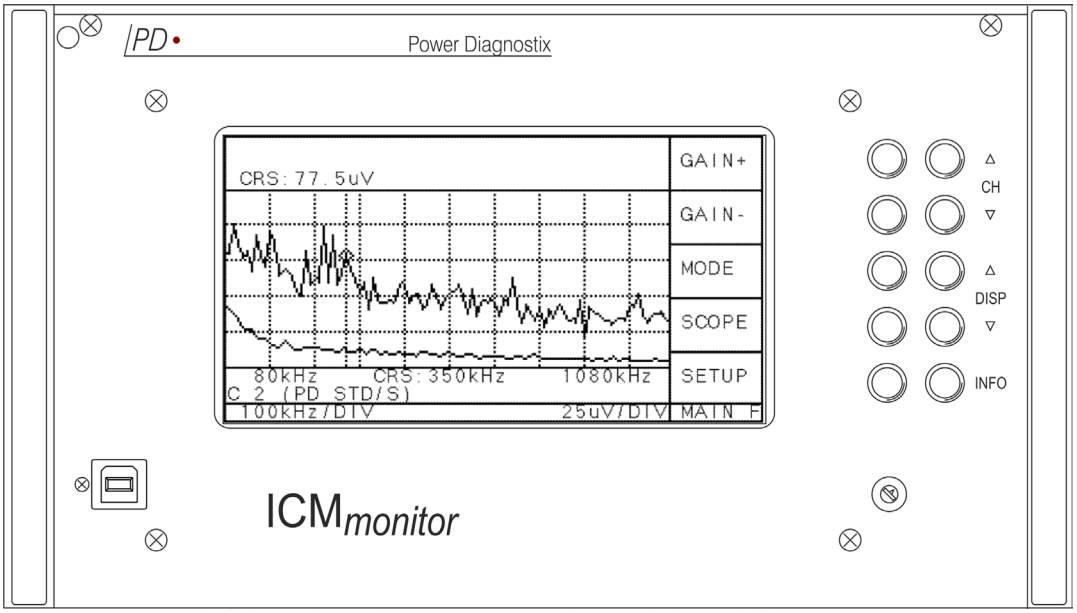


Figure XI.5: Front panel of the ICM*monitor*'s wall mounted version

XI.3.1.2 External connections

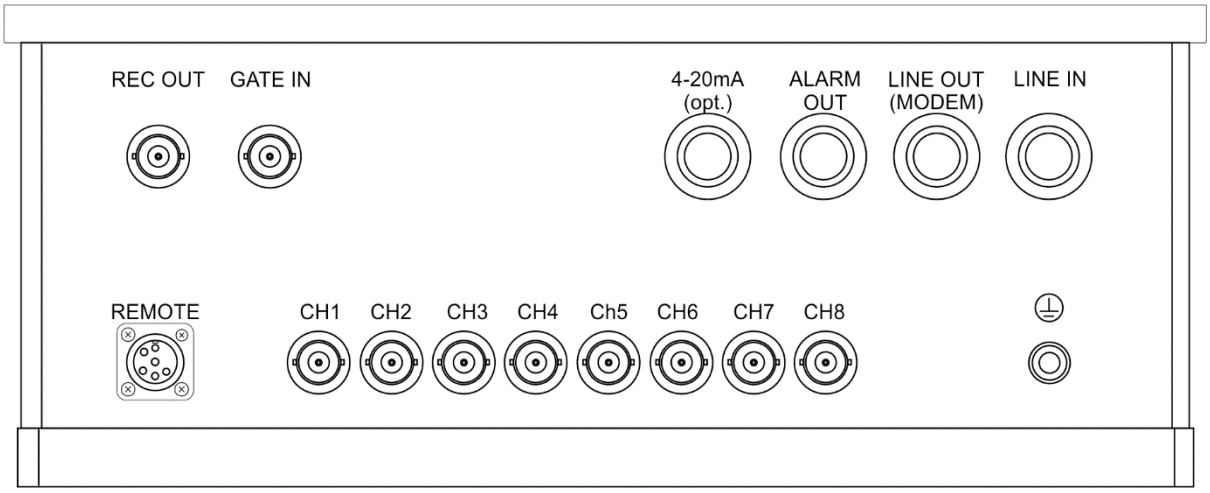


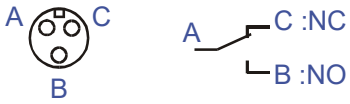
Figure XI.6: External connections of the ICM*monitor*'s wall mounted version

REC OUT: The REC OUT terminal of the ICM*monitor* can be connected to a paper recorder or other device to provide a graph of the NQS or Qp value. The output gives 0 to 10 V with a R_0 = 100 Ω.

GATE IN (optional): The GATE IN terminal, which is not included in all models of the ICM*monitor*, can be used for noise rejection during measurements. Using an 8-channel MUX, the second (internal) output is used for this signal. Within the setup MUX G, the corresponding channel has to be selected.

4–20 mA (optional): Alternative to the voltage output of the REC OUT signal, a current output of 4 to 20mA is available on request.

ALARM OUT: The alarm level, set in the menu ALARM, triggers a double-throw relay. The pin connection of the connector is shown on the right.



LINE OUT (MODEM): The power supply for an optional external modem can be taken from the ICM*monitor.*

LINE IN: The power supply for the ICM*monitor* must be in the voltage range of 85 V AC up to 264 V AC and a frequency range of 47 Hz to 440 Hz. The power supply fuse is 1.6 A time-lag.

REMOTE: The REMOTE terminal provides the direct serial connection to a PC for remote communications, using the serial cable provided by Power Diagnostix. Alternatively, a TCP/IP interface box can be connected.

SYNC1 … SYNC4 : The SYNC connections are used for external synchronisation of each channel to the frequency of the applied high voltage. This signal is usually derived from a coupling unit but can also be taken from an extra voltage divider. The terminals can take voltages up to ~100 V_{RMS} or ~200 V_{peak}. If the SYNC is not connected or the signal is too low, the ICM*monitor* will synchronise on the mains supply frequency (usually 50 or 60 Hz).

CH1 ... CH4: The input connectors of the 4-channel MUX can be connected to different sensors or preamplifiers. The settings are changed in the menu SETUP3 / MUX.

⏚ : The case of the ICM*monitor* must be connected to ground.

XI.3.2 Desktop enclosure

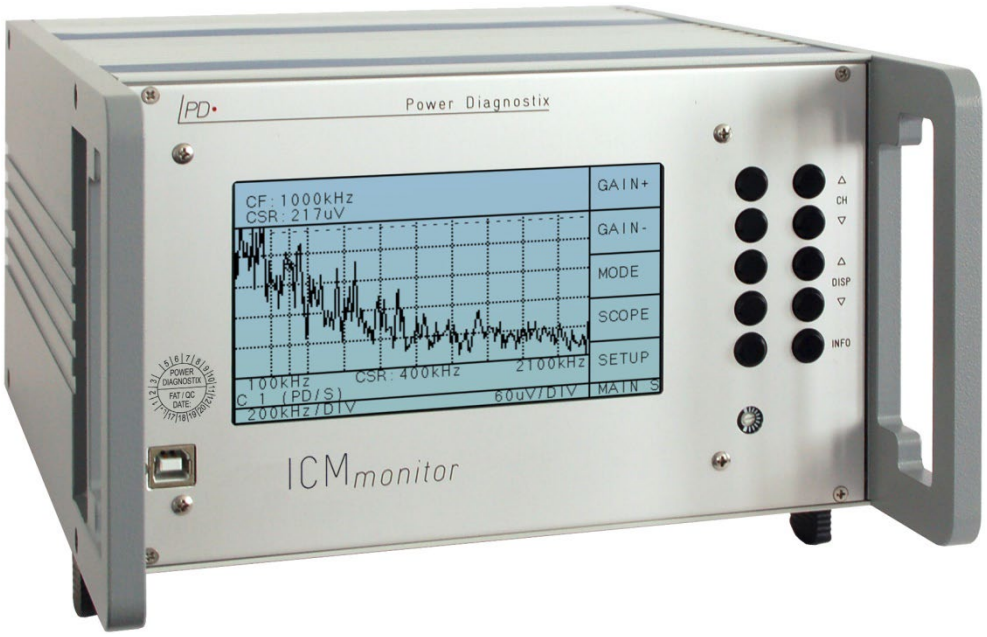


Figure XI.7: Portable half 19-inch ICM*monitor* in a desktop enclosure

XI.3.2.1 Front panel

For a description and explanation of the front panel of the portable device, see page 3.

XI.3.2.2 Rear panel

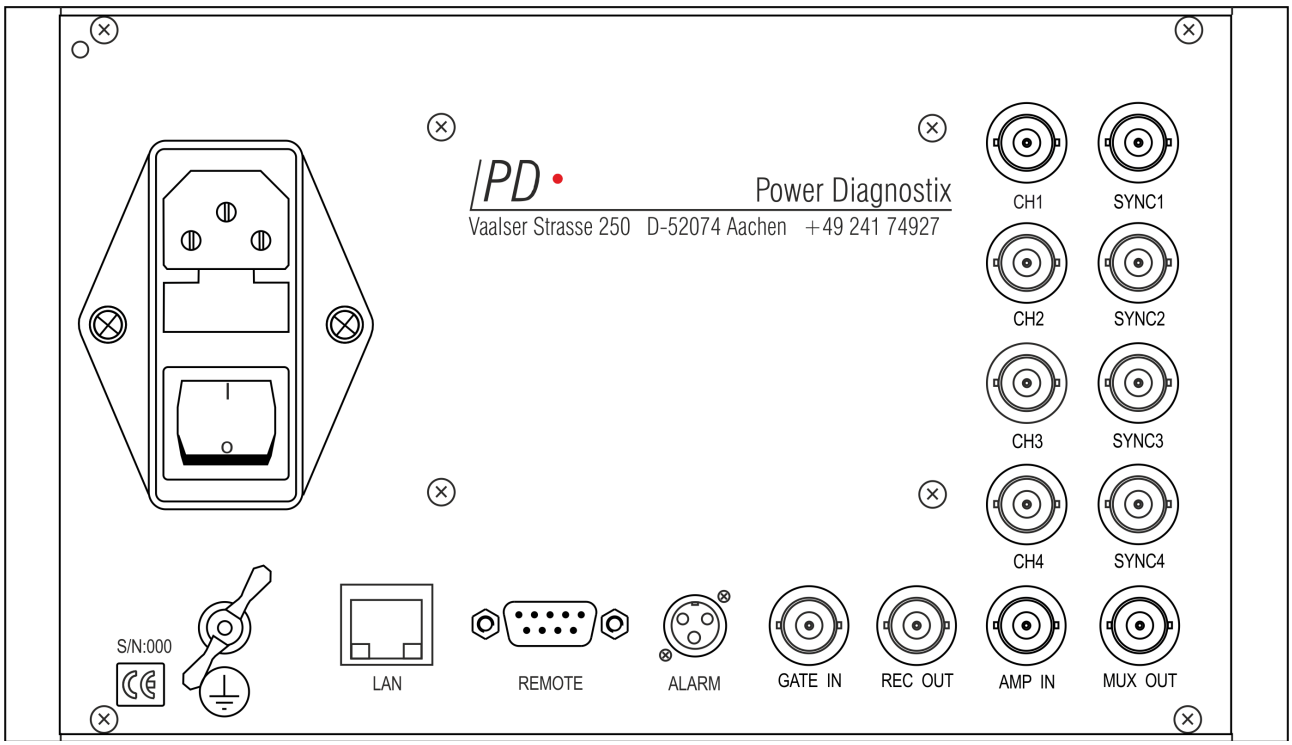


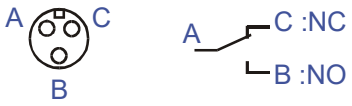
Figure XI.8: Rear panel of the portable half 19-inch version of the ICM*monitor*

Caution: Preferably, the AMP IN is connected to the preamplifier. The supply voltage for the preamplifier may damage the output circuit of the signal source. Be sure not to connect anything but the RPA to this terminal or turn OFF the supply voltage. Only the SYNC IN terminal can take voltages up to ~200 V_{peak}. Do not apply any voltage to the REC OUT terminal (min. 100 Ω input impedance).

LAN: LAN Ethernet connector, RJ45, for connecting the ICM*monitor* with external controlling systems.

REMOTE: The REMOTE terminal provides the direct serial connection to a PC for remote communications, using the serial cable provided by Power Diagnostix. Alternatively, a TCP/IP interface box can be connected.

ALARM: The alarm level, set in the menu ALARM, triggers a double-throw relay. The pin connection of the connector is shown on the right.



GATE IN: The GATE IN terminal can be used for noise rejection during measurements. For this, an additional RPA (usually RPA6G) connects the unwanted noise signal with the GATE IN.

REC OUT: The REC OUT terminal of the ICM*monitor* can be connected to a paper recorder or other device to provide a graph of the NQS or Qp value. The output gives 0 to 10 V with a R_0 = 100 Ω.

AMP IN: The AMP IN connector takes the PD signal either from the MUX OUT or directly from a PD source. Its input impedance is about 50 Ω and has a sensitivity of <2 mV. When using a pre-amplifier, the direction of the arrows engraved on the RPA's must point toward AMP IN connector.

MUX OUT: When using the multiplexer the MUX OUT must be connected to the AMP IN either by a preamplifier or directly via a short BNC cable.

SYNC1 … SYNC4 : The SYNC connections are used for external synchronisation of each channel to the frequency of the applied high voltage. This signal is usually derived from the coupling unit but can also be taken from an extra voltage divider. The terminals can take voltages up to ~100 V_{RMS} or ~200 V_{peak}. If the SYNC is not connected or the signal is too low, the ICM*monitor* will synchronise on the mains supply frequency (usually 50 or 60 Hz).

CH1 ... CH4: The input connectors of the 4 channel MUX can be connected to different sensors or preamplifier. The settings are changed in the menu SETUP3 / MUX.

: The case of the ICM*monitor* must be connected to ground.

XI.3.3 Outdoor cabinets

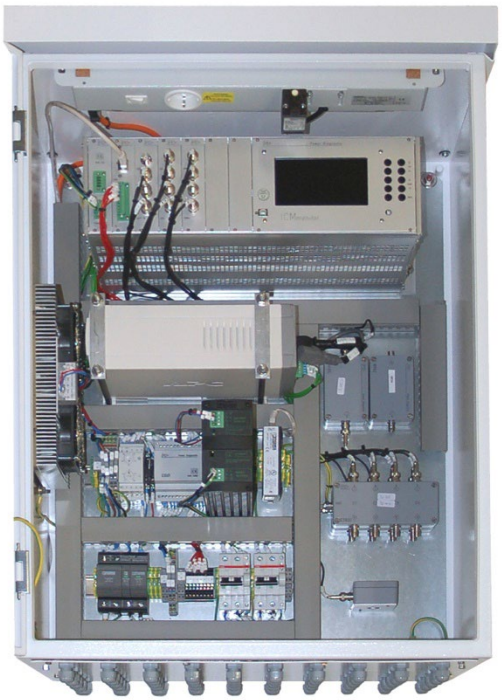


Figure XI.9: ICM*monitor* in a coated steel sheet enclosure (model B)

Model A

Material:	Stainless steel	
Overall size (H x W x D):	Cabinet IP52: 478 x 600 x 416/551 mm³ Cabinet IP65: 620 x 600 x 430 mm³	(depending on version) (excl. mounting brackets)

Model B

Material:	Coated steel sheet	
Colour:	Exterior: RAL9016 Interior: RAL9003	
Ingress protection class:	IP65	
Overall size (H x W x D):	800 x 600 x 350 mm³	

XI.4 Scale drawings

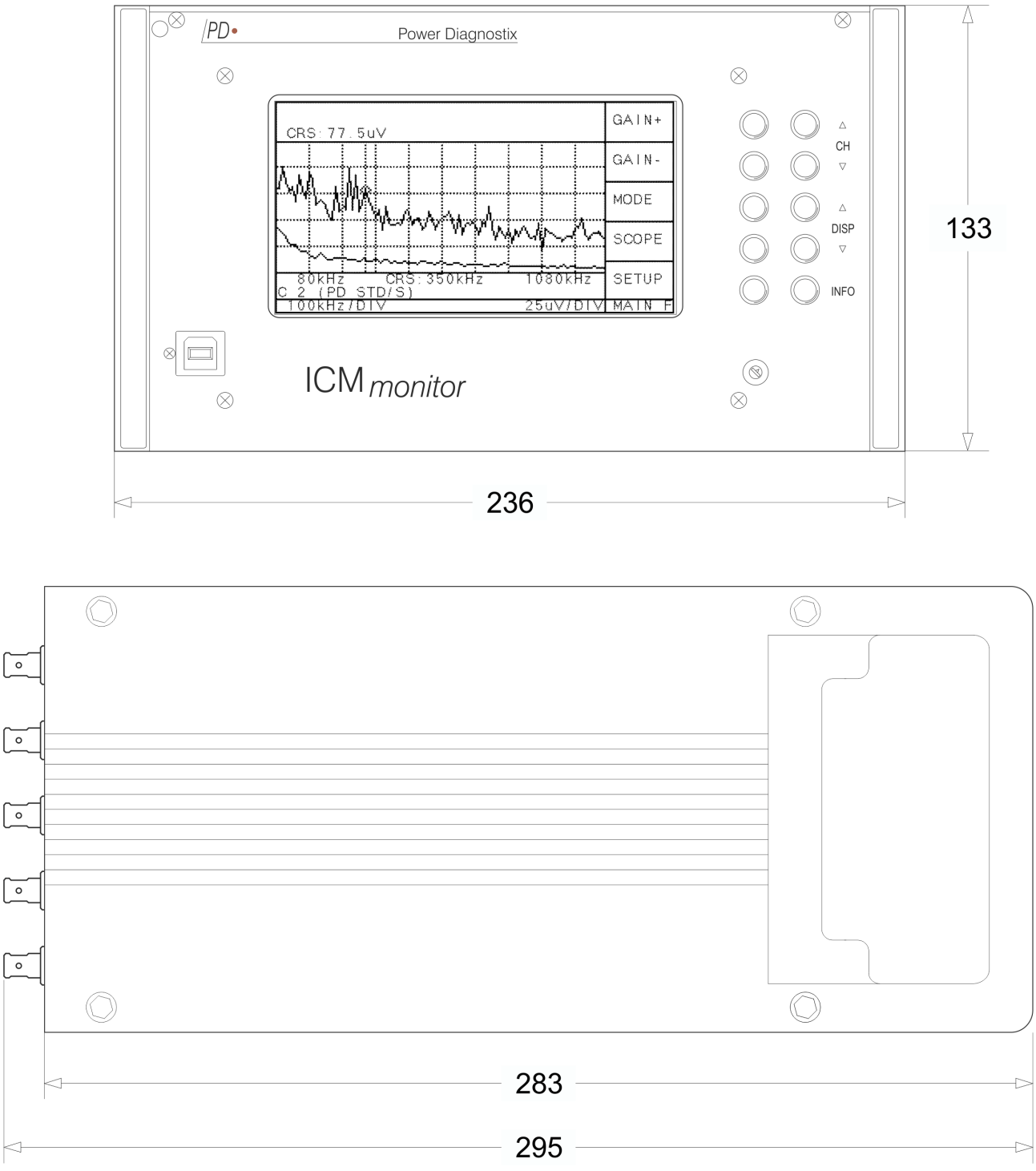


Figure XI.10: Dimensions of the desktop version

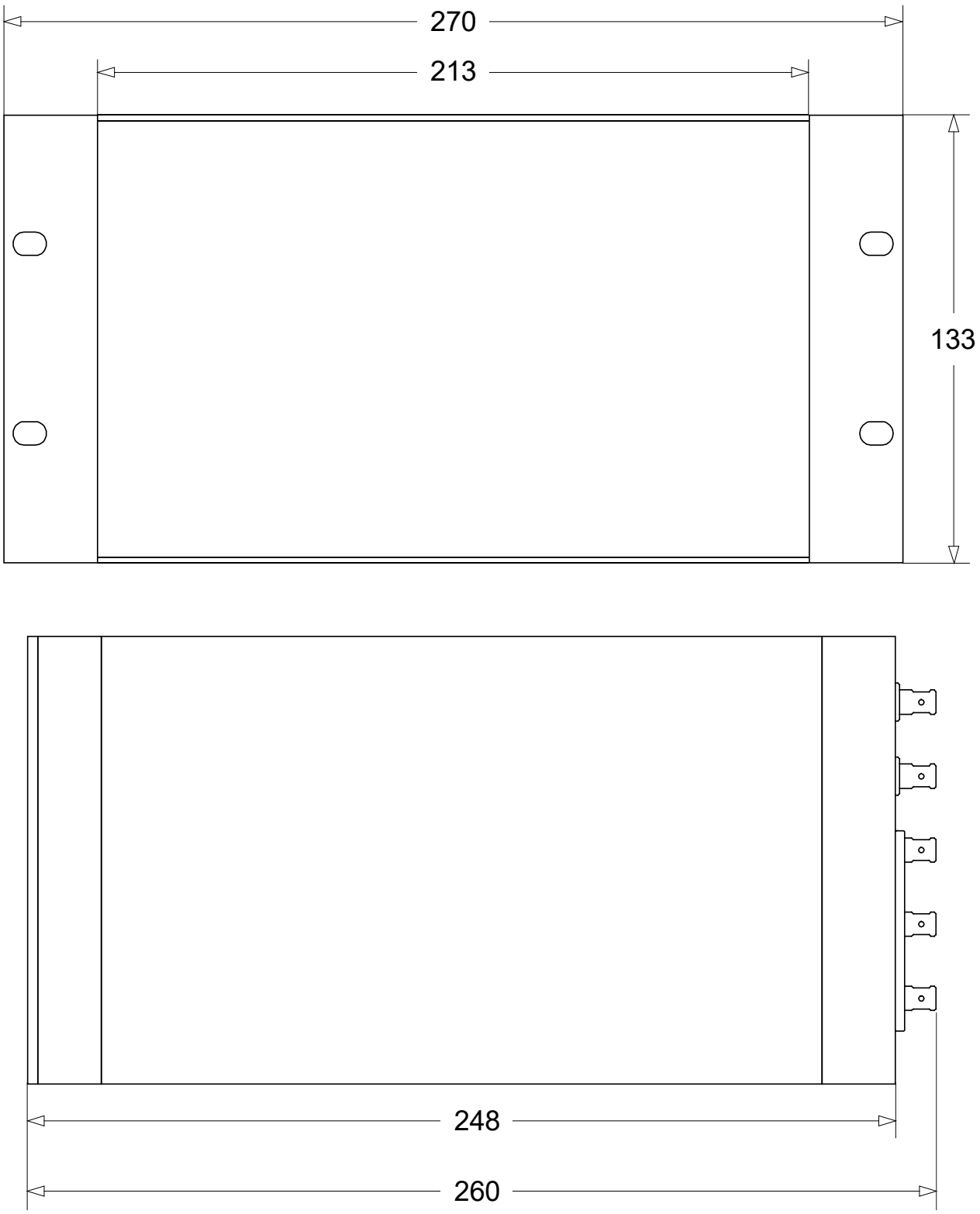


Figure XI.11: Dimensions of acquisition box

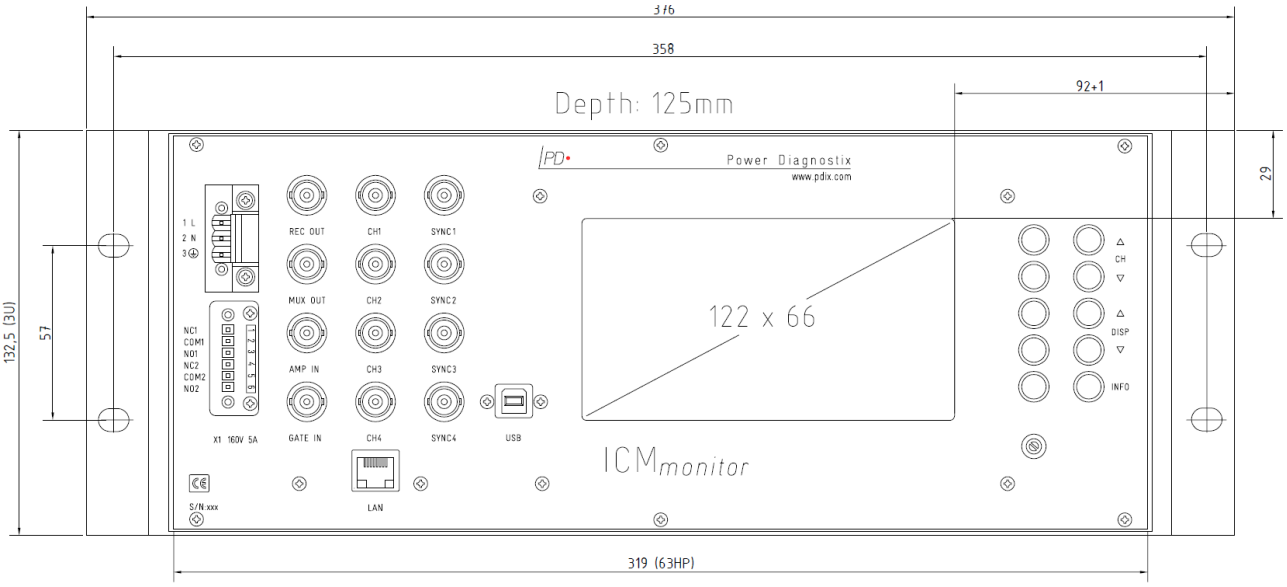


Figure XI.12: Dimensions of the acquisition box with display

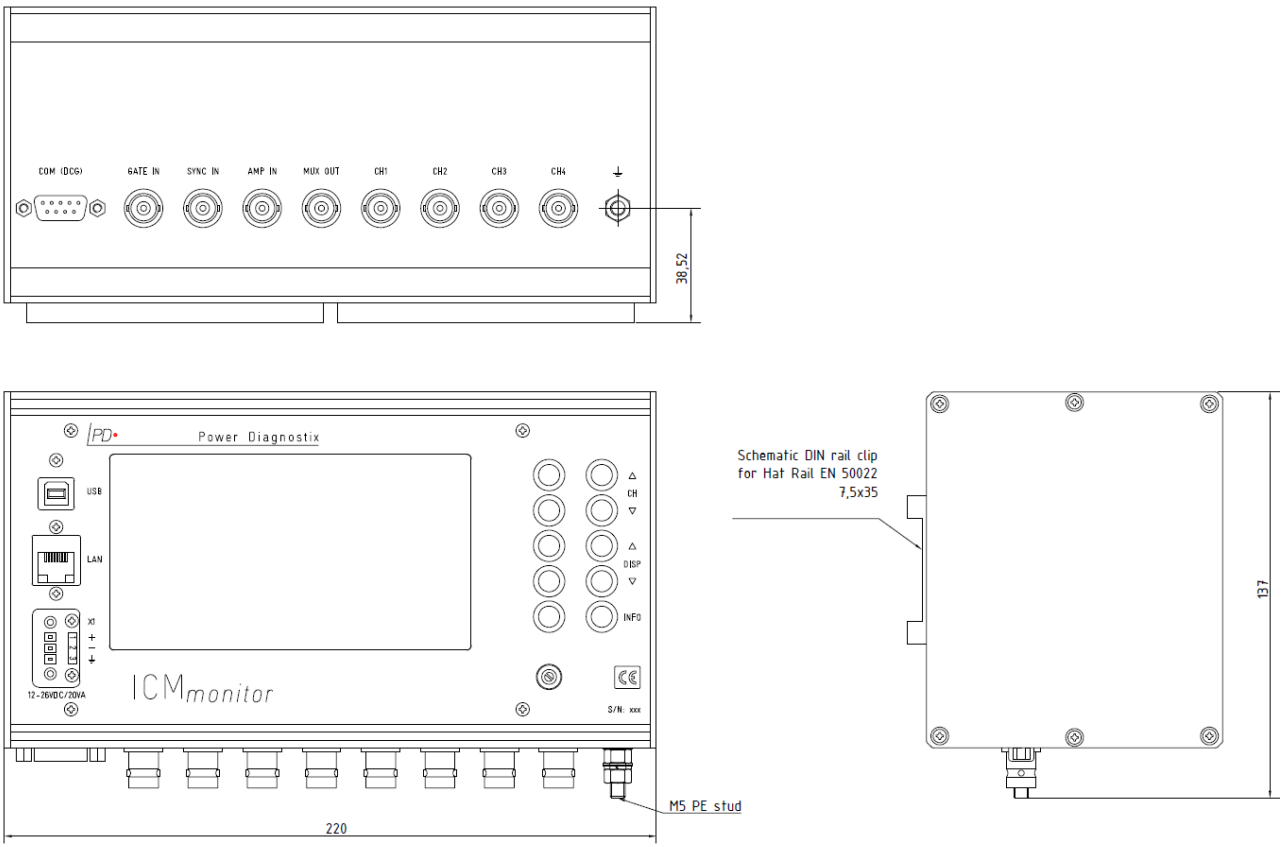


Figure XI.13: Dimensions of the DIN rail version 1

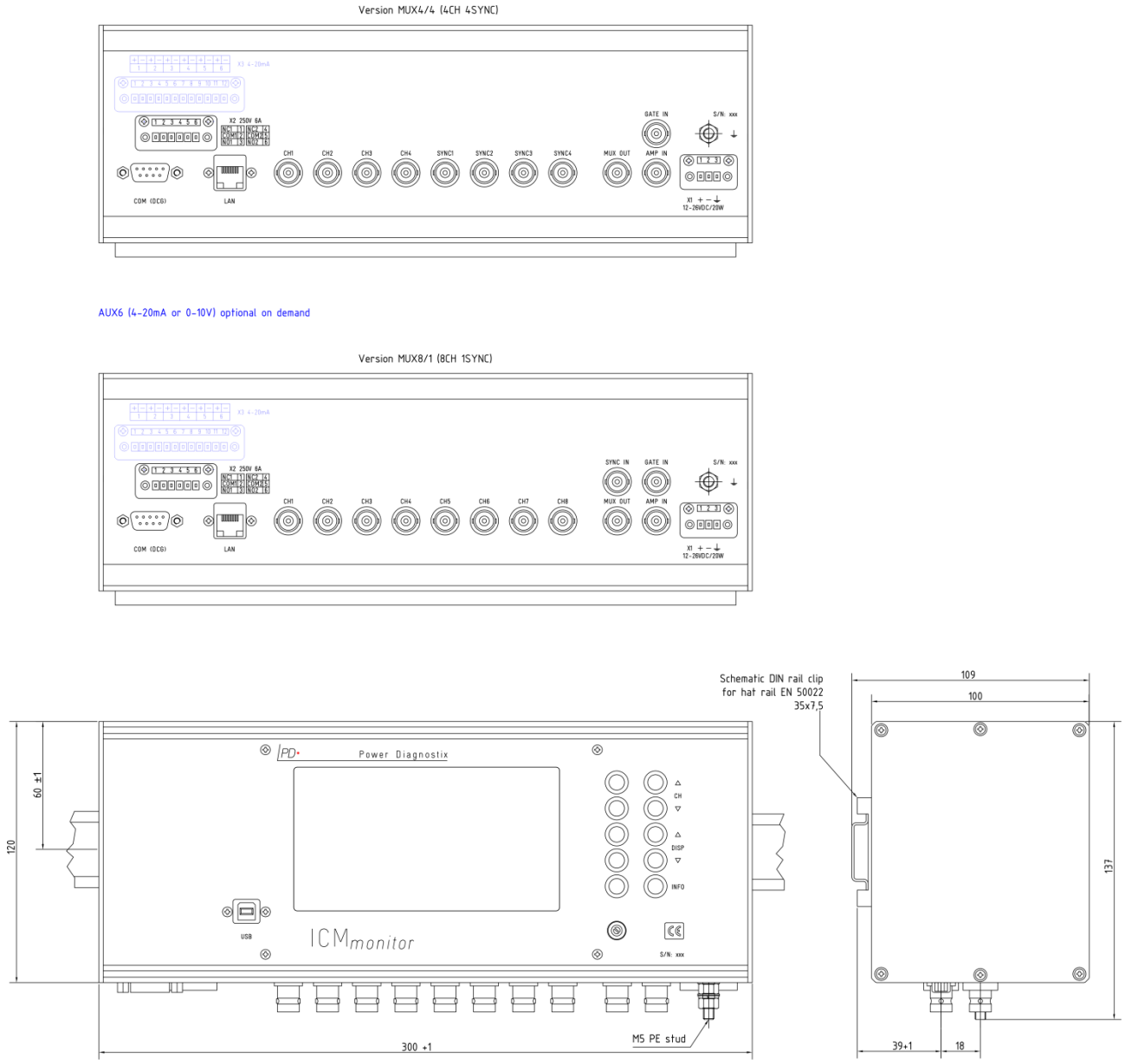
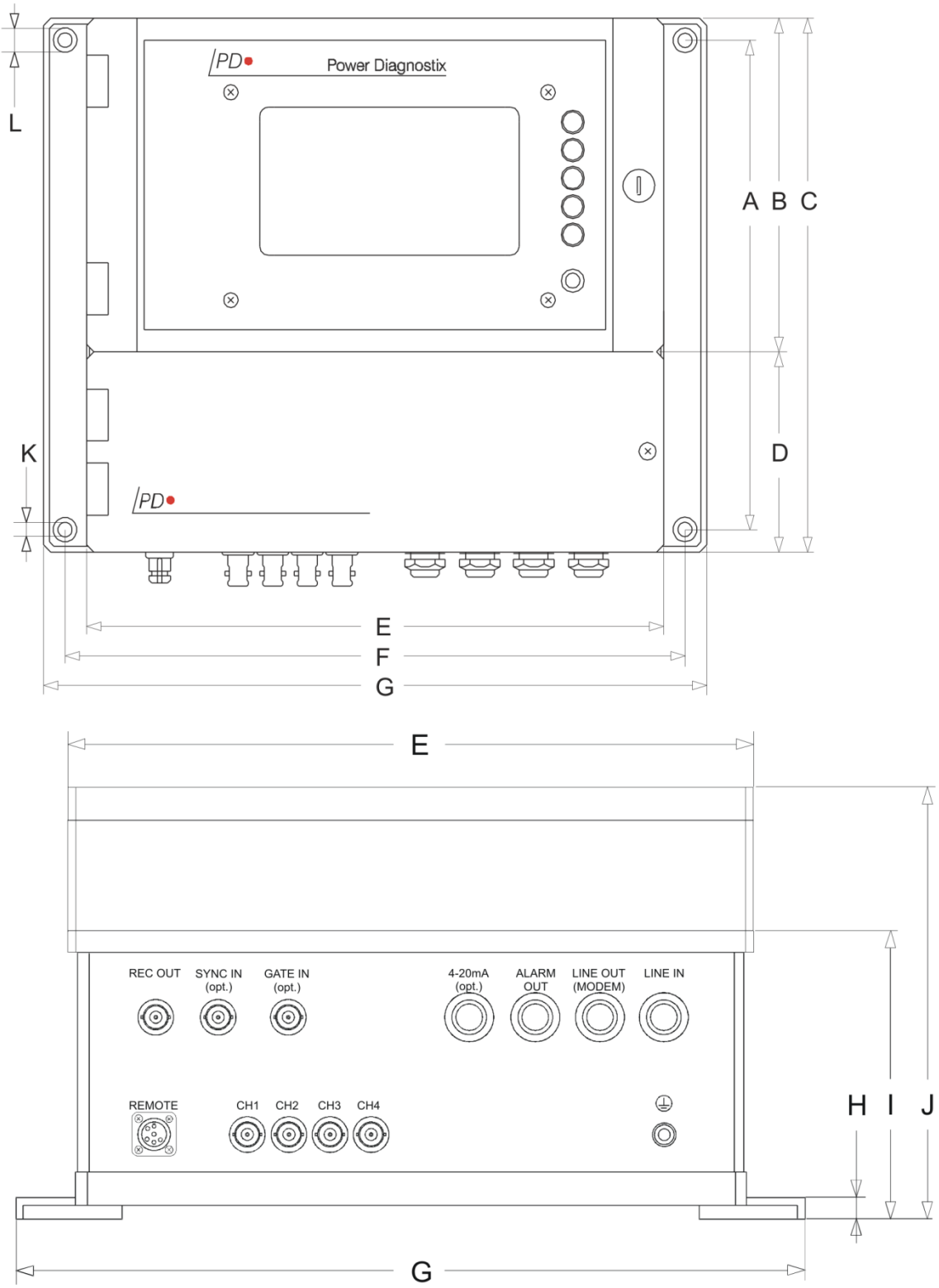


Figure XI.14: Dimensions of the DIN rail version 2



Item	A	B	C	D	E	F	G	H	I	J	K	L
[mm]	220	149	241	90	264	285	305	10	110	210	6.5	10.5

Figure XI.15: Dimensions of the version for wall mounting

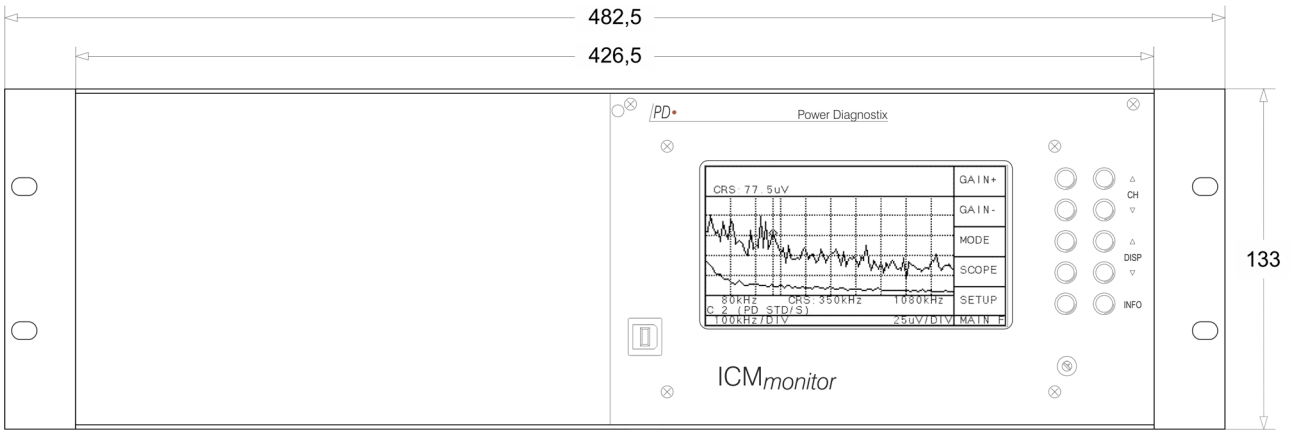


Figure XI.16: Dimensions of the 19-inch enclosure unit

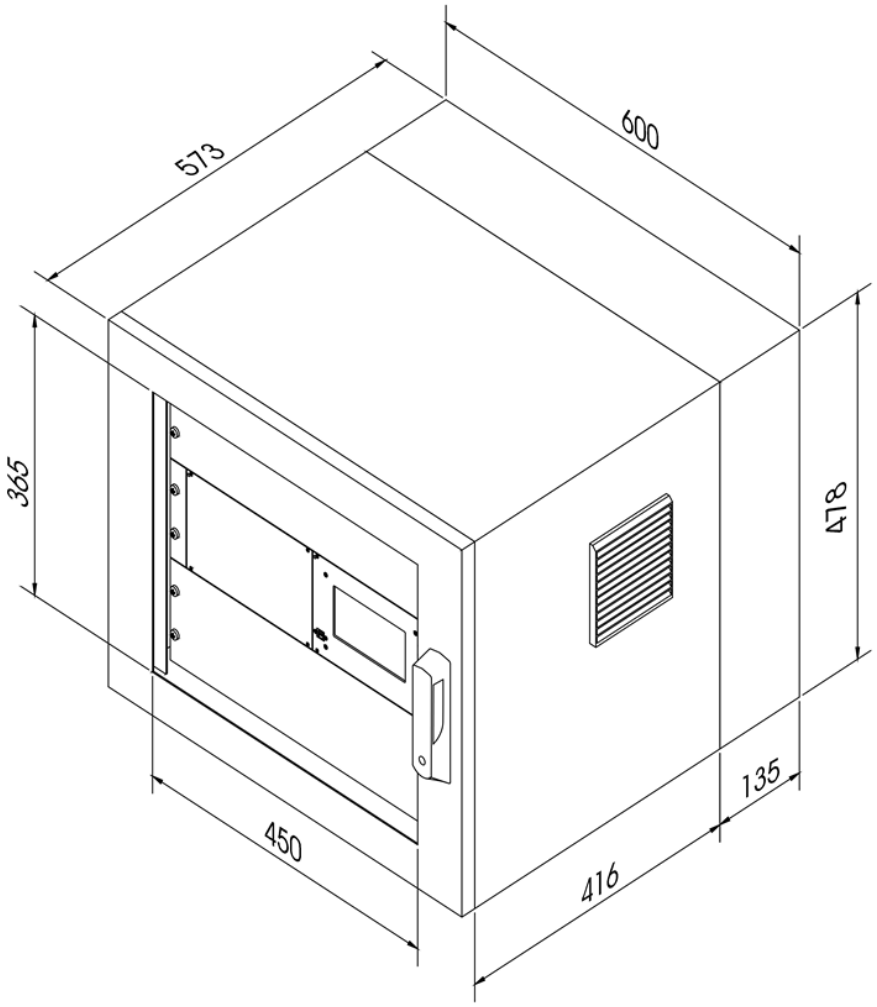


Figure XI.17: Dimensions of the 19-inch enclosure IP52, model A

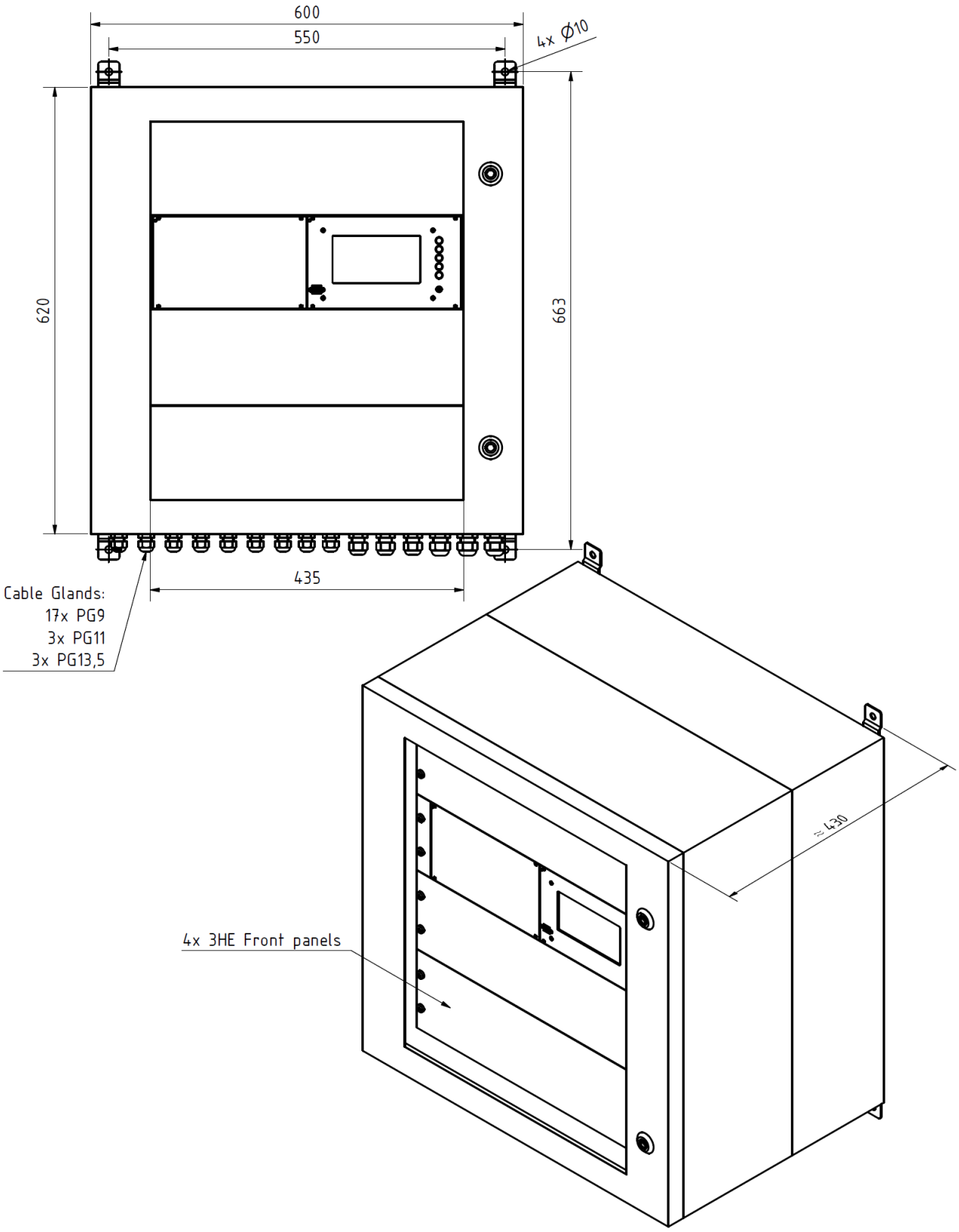


Figure XI.18: Dimensions of the 19-inch enclosure IP65, model A

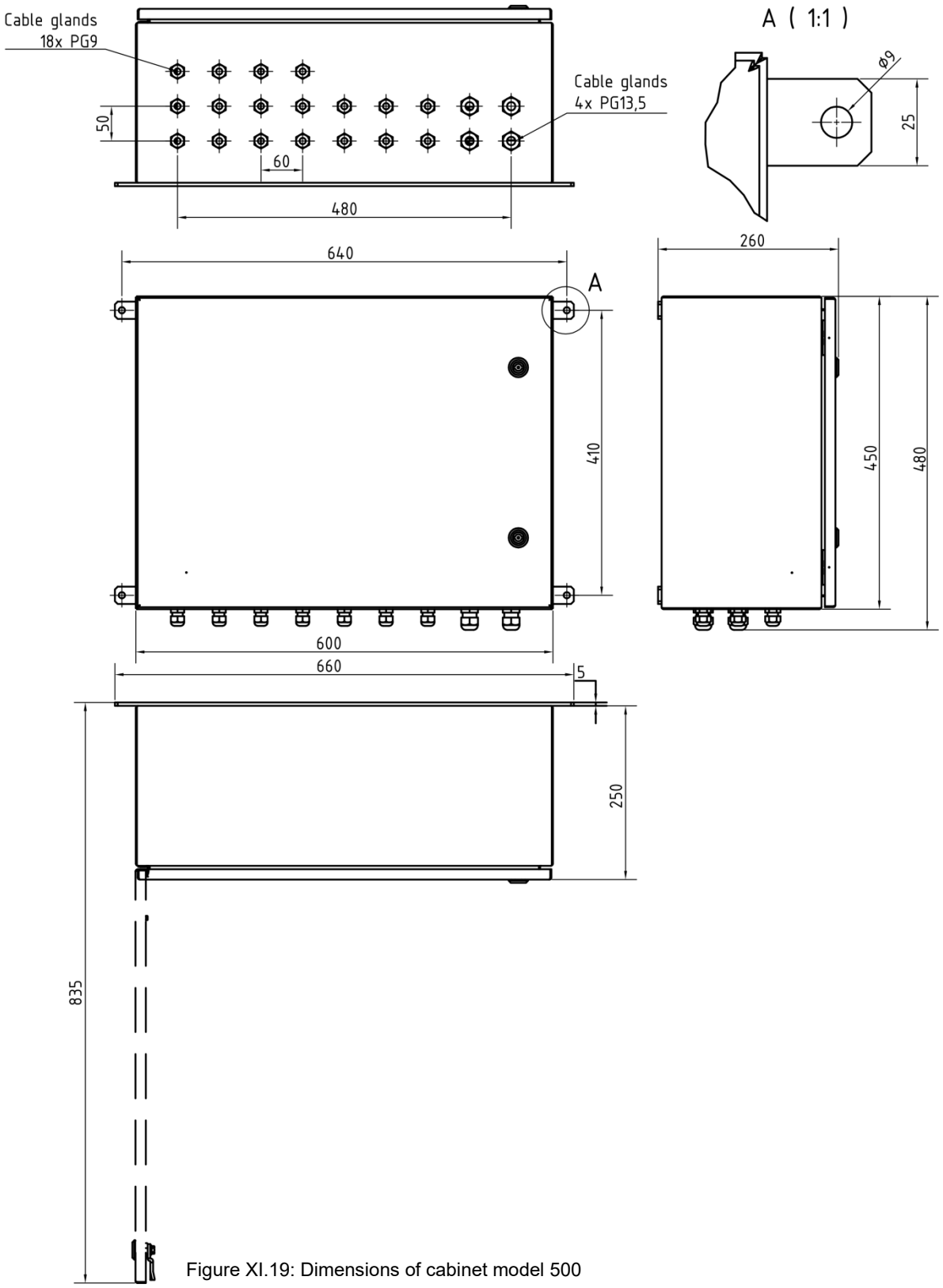


Figure XI.19: Dimensions of cabinet model 500

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