USER GUIDE

ICM*compact*

Partial discharge detector

Megger

Register → megger.com/register

Application notes →

Support → megger.com/support

EN ENGLISH

This manual supersedes all previous issues of this manual.

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Destroy any copies that are of an older issue.

Declaration of Conformity

Hereby, Megger declares that equipment manufactured by Power Diagnostix Instruments GmbH described in this user guide is in compliance with Directives 2014/30/EU, 2014/35/EU, and 2011/65/EU. Other equipment manufactured by Power Diagnostix Instruments GmbH described in this user guide is in compliance with Directive 2014/53/EU where it applies.

Contents

1. General

1.1 About this manual

This manual describes the hardware, software, and usage of the standard ICM*compact* and ICM*compact* pro in its current version. Hereinafter, both instruments are referred to as ICM*compact.* A distinction of the two instruments is only made if necessary 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. Contact Megger for details.

Software updates are available from the Megger support team. Contact Megger via the contact form on the Megger web site www.megger.com.

This manual describes the ICM*compact* including its miscellaneous functions. For the standard ICM*compact*, these functions have to be ordered separately if they are marked as optional functions. The ICM*compact* pro comes with a lot of these functions built-in. For information regarding the accessories and special applications of the instruments, contact Megger.

2. Instrument safety

These safety warnings must be read and understood before the instrument is used. Retain for future reference.

2.1 Warnings, Cautions, and Notes

Only qualified and trained operators should operate the ICM*observer*. Each operator must read and understand the following safety information and this user guide prior to operating the equipment. The safety precautions herein are not intended to replace the safety procedures of your company.

In particular, read and follow the information 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.

This user guide follows the internationally recognised definition. These instructions must be adhered to at all times.

Description
WARNING : Indicates a potentially dangerous situation which, if ignored, could lead to death, serious injury or health problems.
CAUTION : Indicates a situation which could lead to damage of the equipment or environment
NOTE : Indicates important instructions to be followed to perform the relevant process safely and efficiently.

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 the time constraints frequently encountered during on-line and off-line tests 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.**

2.2 Safety, Hazard, and Warning symbols on the instrument

This paragraph details the various safety and hazard icons on the instrument’s outer case.

Icon	Description
	Warning: High Voltage, risk of electric shock
	Caution: Refer to user guide.
	EU conformity. Equipment complies with current EU directives.
	Do not dispose of in the normal waste stream.

2.3 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 Megger 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.

3. Principle of operation

The ICM*compact* partial discharge (PD) detector is designed for quality assurance and quality control tests of high, medium, and low voltage insulation in a test laboratory environment. The instrument may be adapted to non-conventional testing tasks such as field testing and diagnostics by use of various pre-amplifier and couplers. The standard set (Figure 1, marked blue) of the ICM*compact* consists of a coupling unit (CIL4L), a pre-amplifier (RPA1) and the instrument.

The ICM*compact* partial discharge detector is an autonomous instrument. Taking screenshots and storing results can be done by means of the serial interface and a PC program. A precise evaluation of the measurements is possible using databases, specific knowledge bases, or getting in contact with Megger. For tasks requiring extended computer control, protocol functions, and data manipulation, we recommend the ICM*system*.

Test object:
- Bushing
- Cable
- Switchgear
- Capacitor
- Transformer
- Motor
- Generator
- …

Coupling unit:
- Capacitor + CIL4L
- CC20B
- CC25C/V
- CC100
- CT1
- CT100

…

PD instrument:
- ICM*compact*
- ICM*monitor*
- ICM*system*

Pre-amplifier/FCU:
- RPA1
- RPA2m RPA2B
- RPA3
- RPA4
- RPA5

Database
- Software evaluation
- Data files
- MS Excel
- …

Knowledge base
- Experts
- Meetings
- Papers
- Reports

Support
- Megger Aachen PD
- Agents worldwide
- Megger sales offices

Figure 1: *Principle of PD measurement*

The ICM*compact* is easy to use. The operator can choose between several display modes of the integrated LCD screen, e.g., meter display, scope display, or partial discharge pattern display. All instrument settings including calibration are done via the on-screen menus by pushing the five buttons on the right side of the instrument. These settings are automatically stored in a non-volatile memory when the system is shut down. The following section describes the use of the ICM*compact* PD detector.

3.1 Features and built-in functions

3.1.1 Standard ICM*compact*

- PD detection according to IEC 60270
- TTL gating
- Backlit liquid crystal display (LCD), b/w
- Two display modes

3.1.2 ICM*compact* pro

- PD detection according to IEC 60270
- PD spectrum analysis
- PD fault location for cables with digital storage oscilloscope (DSO)
- Radio influence voltage (RIV) measurement
- High voltage measurement (HVM)
- Four-channel multiplexer
- TTL gating
- Analogue gating
- High speed coloured touch display
- Five display modes

NOTE : Most of the built-in functions of the ICM*compact* pro are described in the sections for optional features of the standard ICM*compact*. Please refer to "4.2 Options" on page 17 to find a description of these functions.

4. Hardware

4.1 Acquisition unit

The standard ICM*compact* package includes the partial discharge detector, the remote-controlled pre-amplifier and the standard coupling unit CIL4L. All PD detectors of Megger are built on a modular concept. Therefore, it is possible to vary all external accessory parts such as coupling units, pre-amplifiers, or calibration impulse generators. For more details about all accessories, contact Megger. It depends on each application as to what kind of combination of coupling unit and pre-amplifier will give the best results.

Figure 2 shows the instrument as rack mountable version, while a photo of the instrument in a half 19-inch rack (desktop version) is shown in Figure 3. The layout of an ICM*compact* in a robust outdoor case is shown in Figure 4. Figure 5 and Figure 6 show two available models of the ICM*compact* pro.

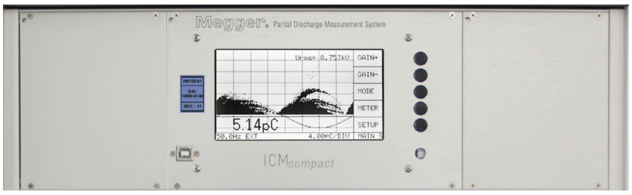


Figure 2: *Standard ICMcompact as rack mountable version*

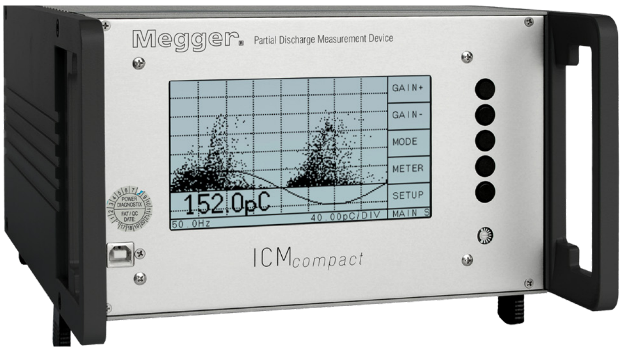


Figure 3: *Standard ICMcompact in a 19" housing*

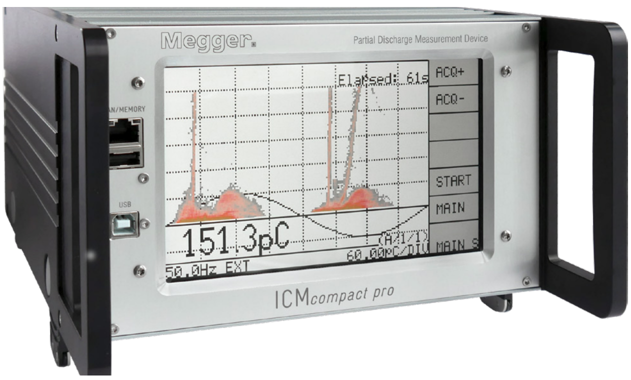


Figure 5: *ICMcompact pro in a half 19" housing*

Figure 4: *Standard ICMcompact in a rugged case*

Figure 6: *ICMcompact pro in a rugged case*

The backlit liquid crystal display (LCD) of the standard ICM*compact* models has a resolution of 240 x 128 pixels, while the coloured touch display of the ICM*compact* pro has a resolution of 800 x 480 pixels.

The control buttons of the standard ICM*compact* are arranged at the right-hand side of the LCD panel. 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.

On the rear panel of the half 19-inch and the rack-mountable (19 inch wide) instrument is the BNC connectors for signal input "AMP IN", the strip chart recorder output "REC OUT", the input for external synchronisation "SYNC IN", and the input for TTL and gating as well as the output for several different signals (SIG OUT), among others a signal for testing purposes according to IEC 60270. Further connectors for optional functions, such as a fibre optic serial connector "COM (TTL)", the input for analogue gating ("GATE IN"), or the input for a reference signal for RIV measurements (REF IN) can also be found here.

The instrument operates with mains supply in the range from 85 V AC up to 264 V AC at 47 to 440 Hz. The standard pre-amplifier RPA1 is connected to the AMP IN terminal with a normal 50 Ω coax cable, i.e., RG58. The amplified partial discharge signals as well as supply voltage and remote-control signals to the pre-amplifier are carried via this cable. The RPA1 acts as a 50 Ω line driver and thus significantly increases overall sensitivity when working with longer cables (up to 200 m). Furthermore, the RPA1 enhances the sensitivity of the coupling unit, essentially acting to match it to connecting cable impedance. This requires that the RPA1 be connected as close as possible to the coupling unit.

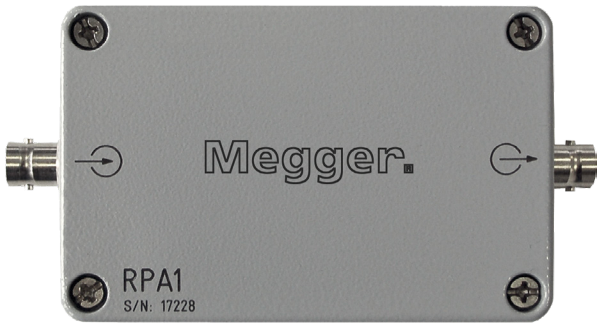


Figure 7: *Pre-amplifier RPA1*

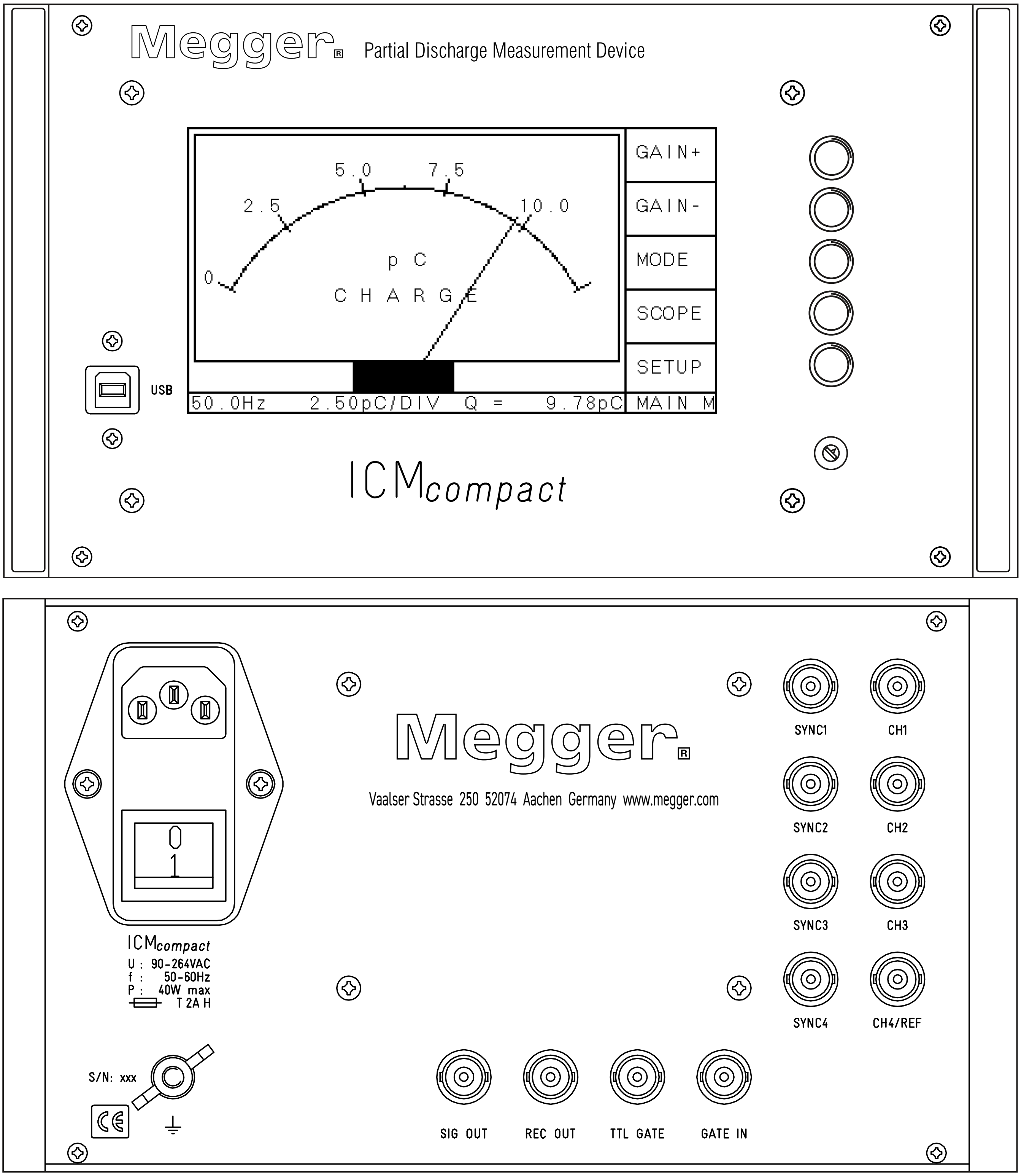


Figure 8: *Front panel (top) and rear panel (bottom) of the ICMcompact's standard desktop version with COM (TTL) connector*

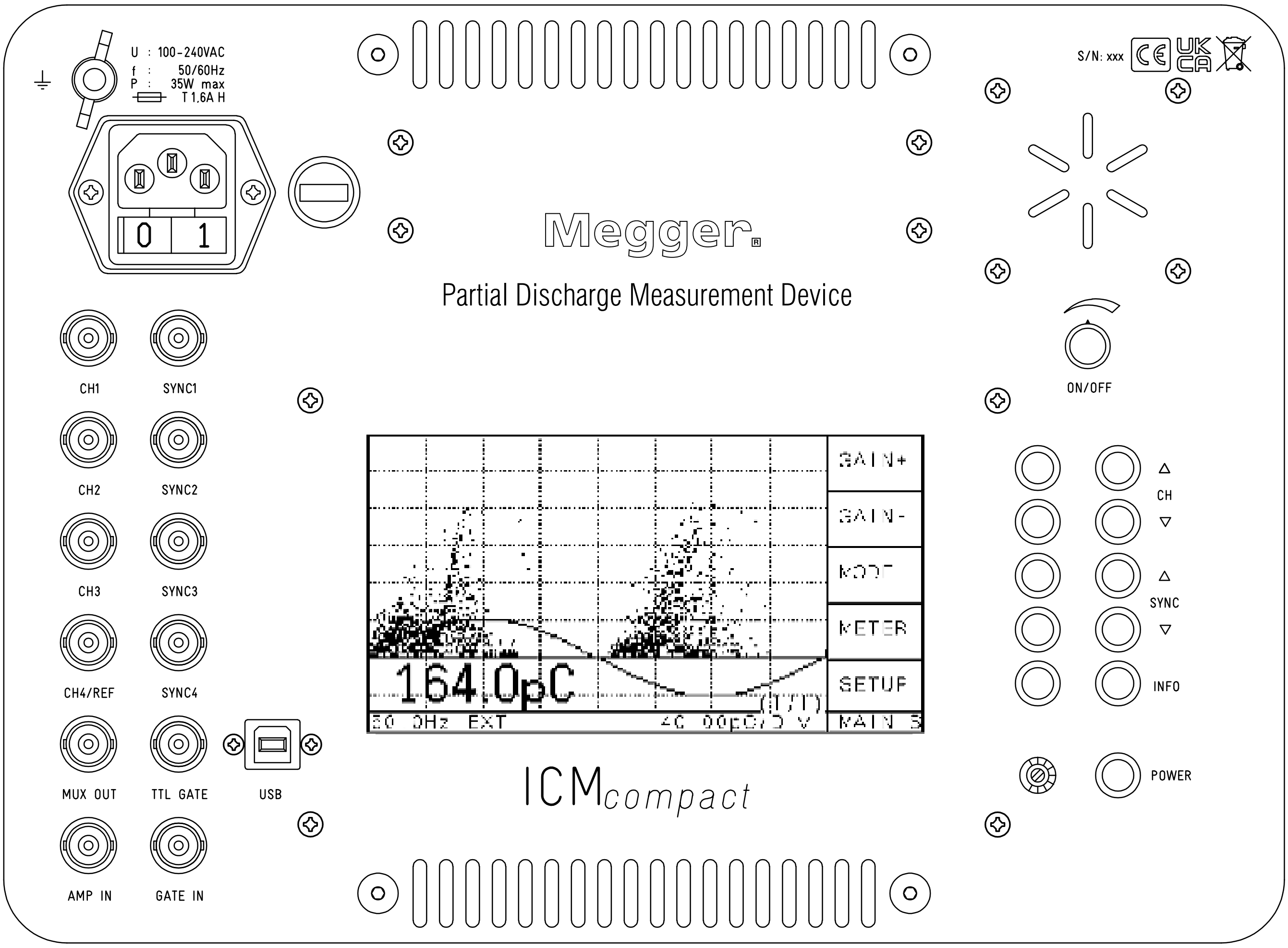


Figure 9: *All-in-one panel of an ICMcompact in an outdoor case with MUX4 option*

The CIL4L standard coupling unit is a so-called RL coupling unit (inductance-resistance), which is tuned to coupling capacitors in the range of 600 pF to 2500 pF. Its permissible maximum charging current is 50 mA. Other coupling units can be supplied by Megger on request.

Figure 10 shows the standard coupling unit for the ICM*compact*.

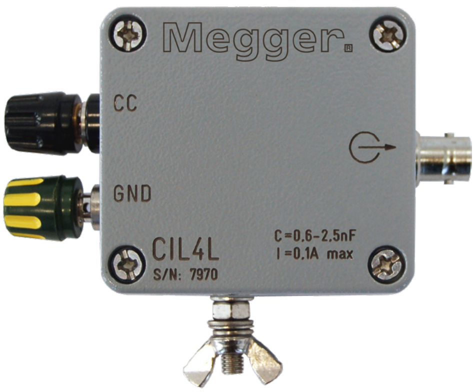


Figure 10: *Quadrupole CIL4L*

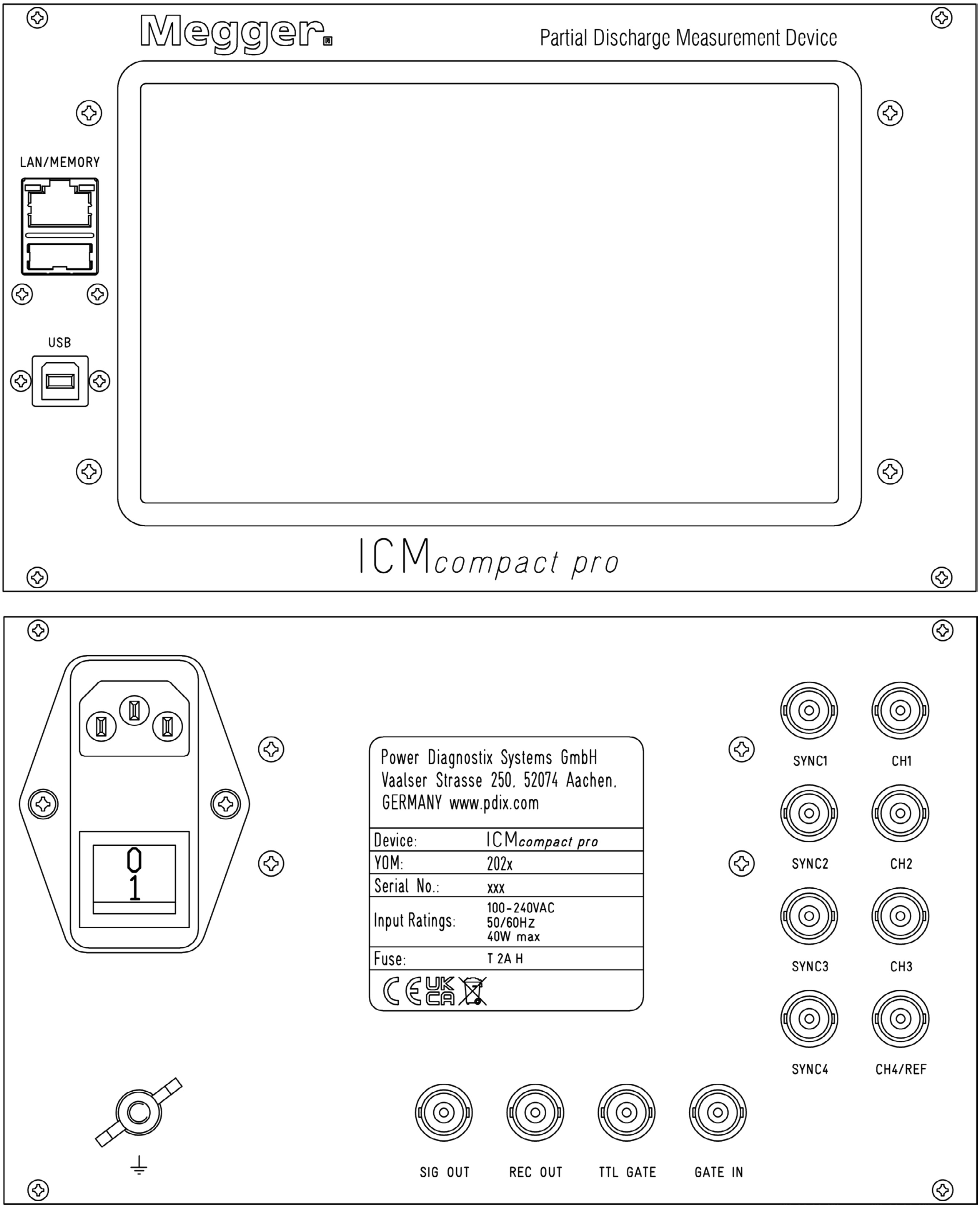


Figure 11: *Front and back of the half 19-inch ICMcompact pro with touch display*

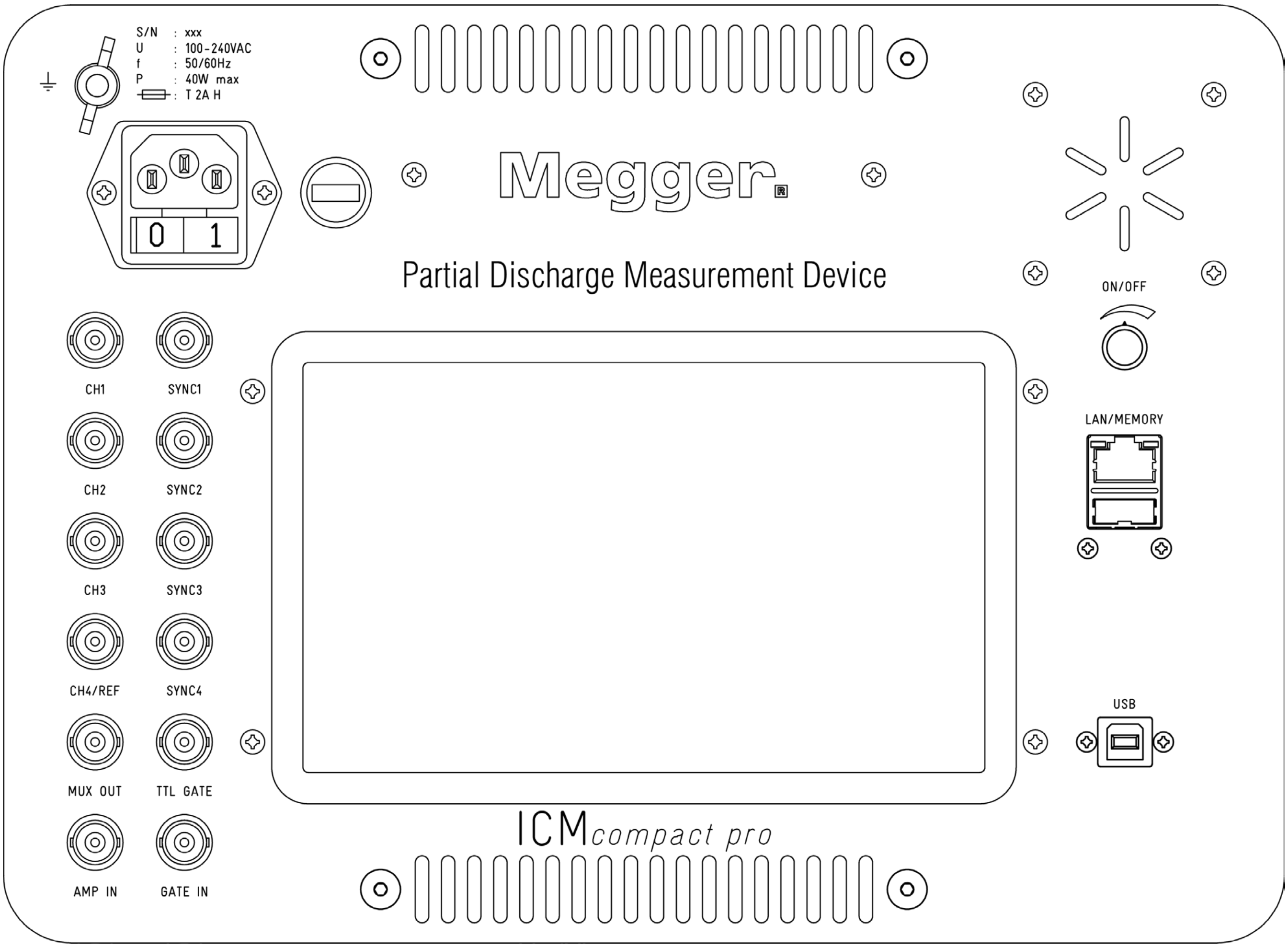


Figure 12: *Panel of the ICMcompact pro with touch display in an Explorer case*

4.2 Options

4.2.1 Standard ICM*compact*

The instrument can be equipped with several optional features:

- SPEC board offers an additional frequency spectrum display for PD spectrum analysis.
- DSO board for cable fault location. Single PD pulses and their echoes are captured with a high sampling rate to localise faults in long cables. The extended software version stores and analyses the data (see also section 6.3.4 and section 7.2).
- Additional voltage measurement and display: HVM display (see also section 6.3.2) and VLF (very low frequency) functionality that allows measurements with 0.1 Hz, 0.05 Hz, and 0.02 Hz (see also section 6.3.3).
- MUX4 or MUX12: The channel multiplexer allows manual switching between 4 or 12 different PD sources.
- AUX4: The auxiliary inputs record further data like power, temperature, speed (see also section 6.3.7).
- STP12: A quick change of twelve different setups including the calibration data (see also section 6.3.8).
- Software driver: If the ICM*compact* should be controlled by anything other than the original software, a driver for ‘C’ is available. This driver is only useful for software programming.
- Fibre optic link (COM TTL): Offers a safe insulation and an extended distance between ICM*compact* and the PC/laptop.
- Analogue gating input (GATE IN): Allows capturing disturbance signals via an onboard pre-amplifier RPA6G, which is used to blind out the noise signal (see also section 6.4.4).
- FO TTL gating input: Via an FO connector at the rear panel, a TTL signal allows to blind out disturbance signals (see also section 6.4.3. If the instrument is equipped with an analogue gating option, the signal is converted into an analogue TTL signal that is logically OR-connected with the internal gate trigger signal of the analogue circuit.
- RIV measurement: Adds a radio influence voltage measurement function to the instrument (needs the SPEC option and includes the MUX4 option).
- Software to record PD measurements and create report documents via a PC is available (see also section 7). Optional version for the cable fault location, only to be used with the DSO option.
- LAN: The instrument is equipped with an additional RJ45 LAN connector.

4.2.2 ICM*compact* pro

- Fibre optic link (COM TTL): Offers a safe insulation and an extended distance between ICM*compact* and the PC/laptop.
- Software to record PD measurements and create report documents via a PC is available (see also section 7). Optional version for the cable fault location, only to be used with the DSO option.

5. Installation

5.1 Connections

There are various circuits to take measurements of partial discharge (PD) with the ICM*compact.* The diagram below (Figure 13) illustrates the basic connections among the elements of the PD measuring setup with the ICM*compact*. Here, the coupling device (CIL4L) is put in series with the high voltage (HV) capacitor. So, the test object can be connected in parallel to the HV capacitor and the voltage supply.

Caution: The AMP IN may only be connected to a preamplifier or a spectrum analyser. The supply voltage for the preamplifier may damage the output circuit of the signal source. Be sure not to connect anything but an RPA to this terminal or to turn OFF the supply voltage. Only the SYNC IN terminal can take voltages up to ~200 Vpeak. Do not apply any voltage to the REC OUT terminal (min. 100 Ω input impedance).

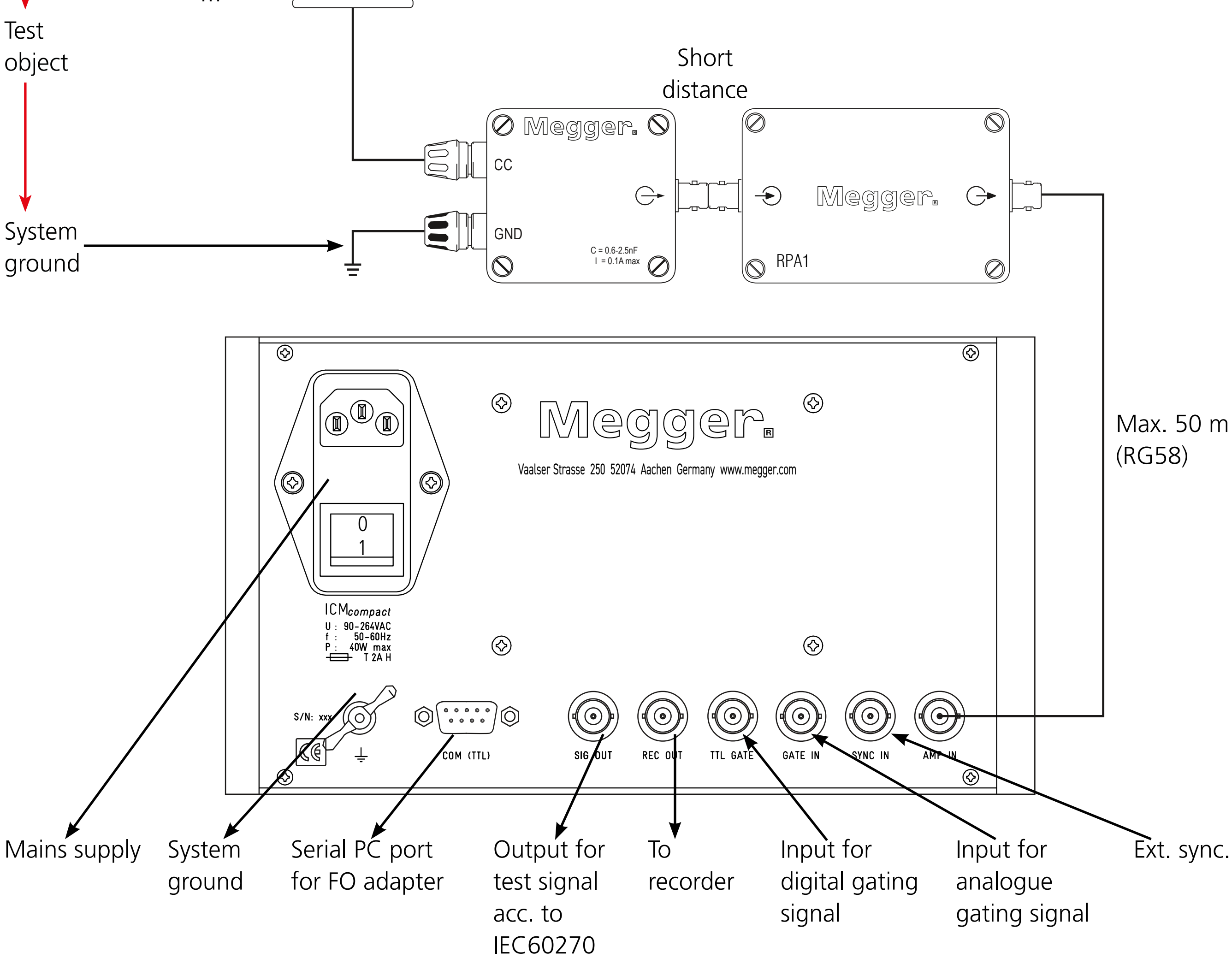


Figure 13: *Basic connections for PD measurement on a test setup (not drawn to scale)*

To prepare a measurement, connect the input (CC) of the coupling unit CIL4L to the low side terminal of the HV capacitor and the ground (earth) input (GND) of the coupling unit to ground. The output of the coupling impedance is directly connected to the RPA1 pre-amplifier preferably using a BNC/BNC adapter or a BNC cable of short length. This minimises the capacitive loading of the coupling unit and exploits the relatively high input impedance (10 kΩ//50 pF) of the RPA1. The quality of the connecting cable between the RPA1 output and the ICM*compact* display unit (AMP IN) is fairly uncritical. Up to lengths of 50 m, we recommend normal RG58 BNC cable. The RG213 cable (having a lower attenuation) is recommended for lengths up to 200 m.

Figure 14 shows an example of a test setup for measurements on a distribution transformer with an ICM*compact* with MUX option. Here, a coupling capacitor with built-in quadrupole (e.g., CC35B/V) acts as decoupling unit and provides a voltage signal for synchronisation. If only one channel is used for testing, the MUX output (“MUX OUT”) must be connected to the “AMP IN” terminal.

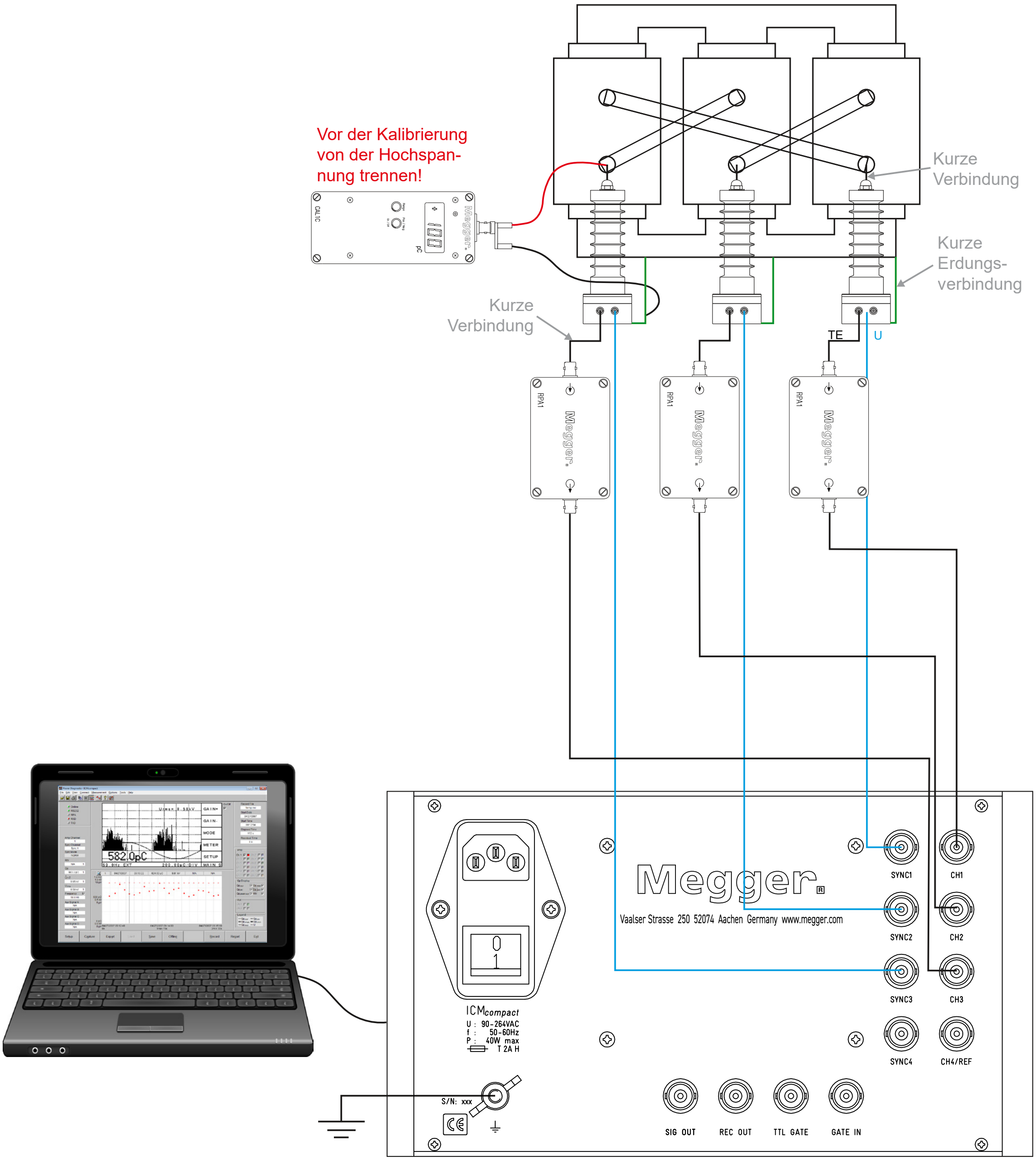


Figure 14: *Connections of the setup for measurements on distribution transformers with an ICMcompact with MUX option (not drawn to scale)*

Figure 15 shows a test setup on a power transformer using an ICM*compact* with MUX option. If only one pre-amplifier is connected to the instrument, the MUX output ("MUX OUT") must be connected to the "AMP IN" terminal.

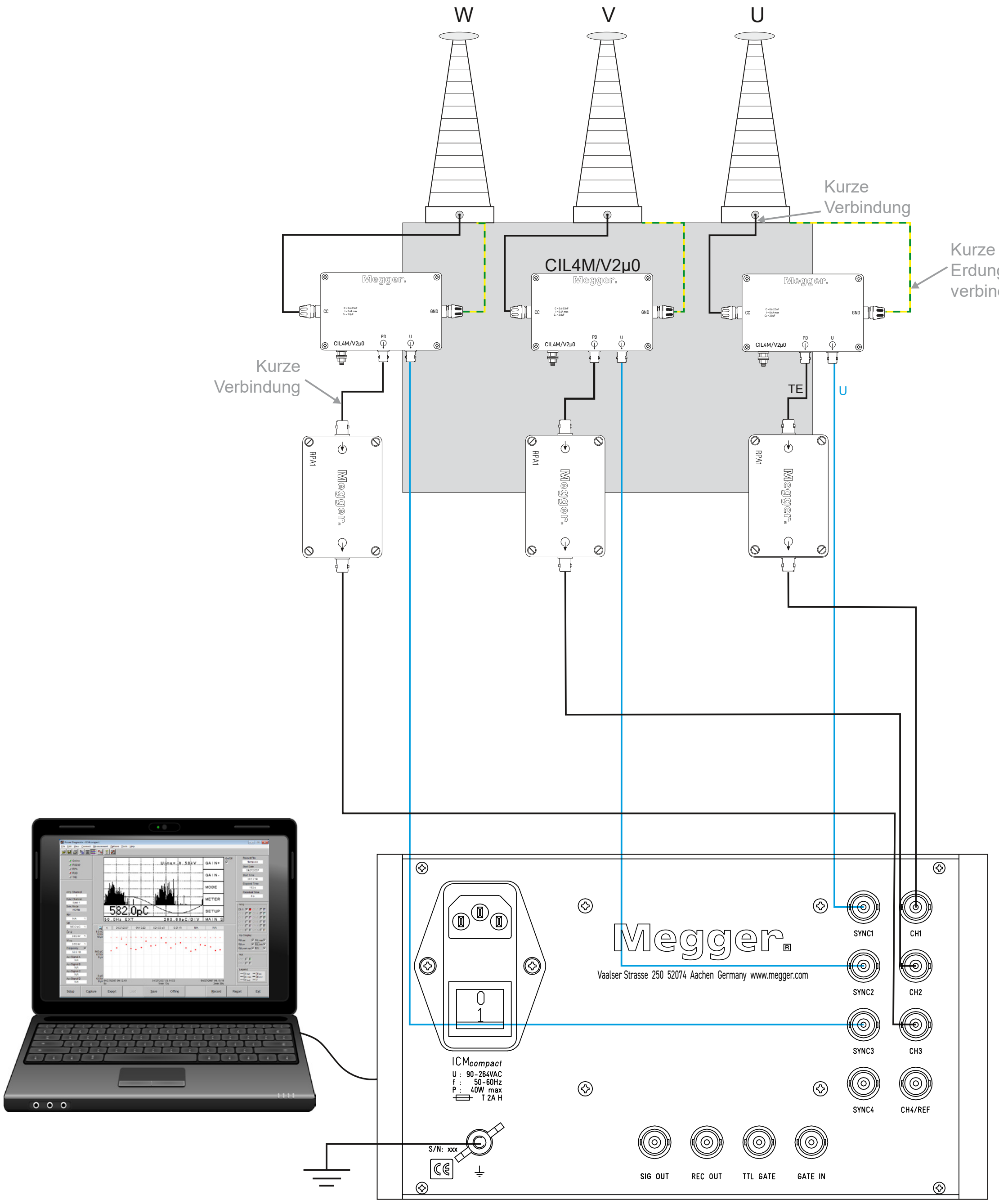


Figure 15: *Connections of the setup for measurements on power transformers with an ICMcompact with MUX option (not drawn to scale)*

The connections to the standard ICM*compact* are made by several BNC connectors, one wing nut screw, and one serial connector. The functions of the connectors are as follows:

AMP IN: The AMP IN input is connecting the PD signal with the ICM*compact*. The AMP IN connector must be connected to a remote pre-amplifier (RPA). Notice the direction of the arrows engraved on the RPA; the arrows must point toward the ICM*compact*.

REC OUT: The REC OUT terminal of the ICM*compact* may optionally be connected to a paper recorder or other device to provide a graph of the average charge magnitude. For the output level see Table 1 on page 40.

SYNC IN: The SYNC IN can optionally be used for external synchronisation of the ICM*compact* to the frequency of the applied high voltage. This can be the output of a voltage divider (such as the voltage divider included with some Megger quadrupoles) or of some other customised circuit. If the SYNC IN is not connected, the ICM*compact* will synchronise on the mains supply frequency (usually 50 or 60 Hz).

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

TTL GATE: Input connector for triggered noise cancellation (TTL). The TTL gating signal can be used to blind out disturbance signals provided by a resonant test set, for instance, during switching.

GATE IN (optional): The GATE IN terminal, which is not included in all models of the ICM*compact*, can be used for noise rejection during measurements. To do so, connect the output of an additional RPA, carrying the unwanted noise signal, to the GATE IN.

SIG OUT: The SIG OUT BNC connector provides a test signal according to IEC 60270. Refer to the IEC 60270 specification for detailed information. In SPEC mode SIG OUT provides the demodulated test signal, while it provides a TTL gating signal when "GT OUT" is activated within the menu GT SET.

Mains supply: The mains (power supply) plug must be connected to a power outlet providing power in the voltage range 85 V AC up to 264 V AC, frequency 47 to 440 Hz. The on/off switch for the unit is located beneath the mains plug. A power supply fuse is located between the on/off switch and the mains power inlet.

GND: The wing nut must be connected to ground.

RPA: The output arrow engraved on the RPA (pre-amplifier) must be connected to the AMP IN of the ICM*compact*. The input arrow of the RPA must be connected to the output of a quadrupole (measuring impedance) or other PD signal sources (such as a current transformer).

The connection between the output of the coupling impedance and the RPA1 pre-amplifier should be with a BNC/BNC adapter or a short length of BNC cable, in order to minimise the capacitive loading of the coupling unit and fully benefit from the relatively high input impedance (10 kΩ||50 pF) of the RPA1. The quality of the connecting cable between the RPA1 output and the ICM*compact* display unit (AMP IN) is fairly uncritical. The normal RG58 BNC cable is recommended for lengths up to 50 m, while the RG213 cable (which has a lower attenuation) is recommended for lengths up to 200 m.

Quadrupole: The quadrupole captures the PD signal from the coupling capacitor or, alternatively, from the test object itself. Megger offers quadrupoles as separate modules or as built-in components of coupling capacitor units. The output of the quadrupole must be connected to the input of a pre-amplifier. The input marked "CC" must be connected to the low side of the coupling capacitor (or alternatively to the low side, or neutral, of the test object). The terminal marked "GND" must be connected to the system ground.

If the quadrupole has an optional voltage divider, the output marked "U" is a low voltage copy of the high voltage applied to the test object and coupling capacitor. This output can be used for external synchronisation when connected to the "SYNC IN" terminal of the ICM*compact*.

The minimum connections that must be made in order to use the ICM*compact* are the mains power supply, the AMP IN, and the system ground.

5.1.1 Connections for devices with built-in multiplexer

SYNC1... SYNC4: Instead of a SYNC IN connection, devices with a built-in multiplexer have four SYNC connections. These connections are used for the external synchronisation of each channel to the frequency of the applied high voltage. This signal can be the output of a voltage divider (e.g., the voltage divider included in some Megger quadrupoles) or other customised circuitry. If the SYNC IN is not connected, the ICM*compact* synchronises to the mains frequency (normally 50 or 60 Hz).

CH1...CH4/REF: The input sockets of the 4-channel multiplexer must be connected to remote pre-amplifiers (RPA). Note the direction of the arrows engraved on the RPA; the arrows must point towards the ICM*compact*. CH4/REF is also used as an input for a reference signal for RIV measurements.

5.1.2 Synchronising the ICM*compact*

In the absence of an external synchronisation signal, the ICM*compact* will automatically synchronise to the sine wave of the line voltage of the supplying power for the ICM*compact*. Often, the high voltage applied to the test setup is not in phase with the line voltage and may not even be the same frequency as the line voltage. In such cases, it is best to synchronise the ICM*compact* with an external signal.

To synchronise the ICM*compact* with the high voltage applied to the test setup, a voltage divider is needed to create a copy of the voltage wave. The SYNC IN input is designed for a voltage in the range of 1 V to 100 V RMS (max. 200 V_{peak}). Note that the input impedance of the SYNC IN input is about Z_{in} = 1 MΩ||200 pF. With the optional VLF function switched on, it’s about 10 MΩ.

If you use a coupling unit from Megger, either quadrupole or capacitor with a built in quadrupole, the once with the extension .../V (like CC25C/V or CIL4M/V) will have an extra output labelled “U”. Connect this low voltage copy of the applied voltage to the SYNC IN connection on the rear of the ICM*compact*. Additionally, a TTL type trigger signal can be supplied to the SYNC IN connection to force synchronisation.

6. Operation

6.1 Main functions

After switching on the ICM*compact*, the LCD screen shows the ICM*compact* logo and software version for about two seconds. The instrument is controlled by the five buttons on the front panel. 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.

After the instrument is powered up and displaying the ICM*compact* logo, it automatically selects the display mode and submenu that were active when the instrument was last switched off. In order to activate the main menu, you may need to press the "EXIT" button several times. In this main menu, you can select either the "METER (MAIN M)" or the "SCOPE (MAIN S)" display mode. If implemented, the HVM (high voltage meter) becomes available. Devices with an additional acquisition board (DSO board) for cable fault location have an additional display called "DSO". Figure 16 shows the ICM*compact* in the menu "MAIN S". An overview of the key menus can be found in section 6.2.1.

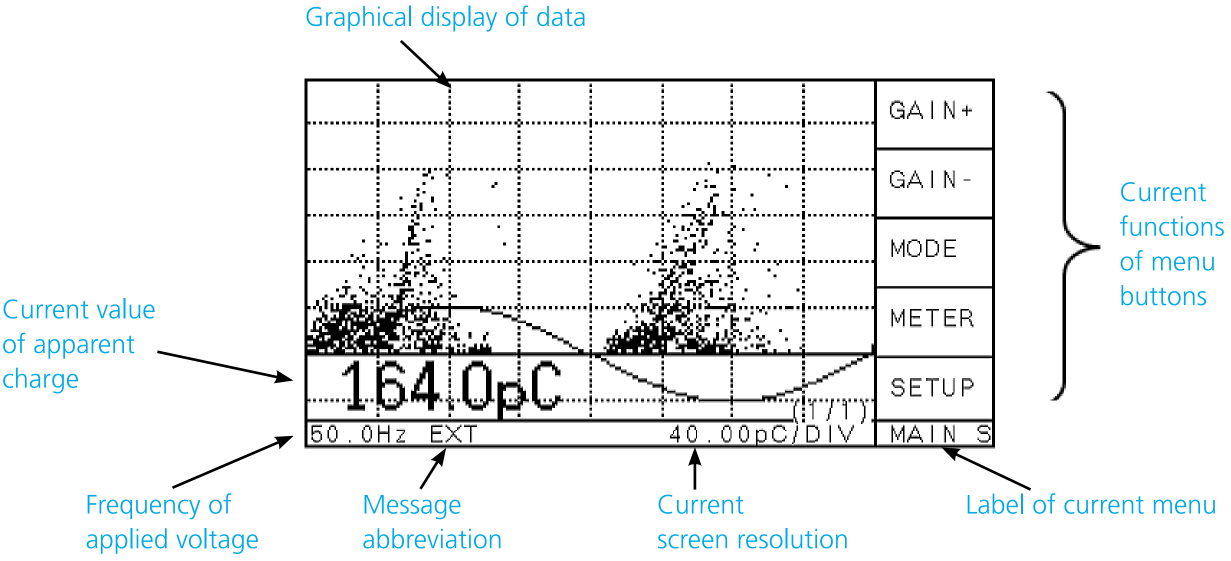


Figure 16: *Parts of the ICMcompact display*

The display of the ICM*compact* consists of graphic elements like the grid, the voltage curve, and the PD pattern and additional text elements, like the menu description, the values shown at the lower border, and settings written at the upper border. Some conditions are displayed as abbreviations at the lower left side. The following table shows these abbreviations and their meanings.

Abbreviation	Meaning
RPA?	Missing pre-amplifier or damaged cable between pre-amplifier (i.e., RPA1) and input of the ICM*compact* (AMP IN).
EXT	External synchronisation; the device automatically selects the synchronisation source, meaning 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 pre-amplifier can be turned off.
G	External gating is turned on (see section 6.4.4).
B	The instrument is battery-operated. A flashing "B" indicates that the battery needs to be recharged.
C	The battery is currently being charged.

There are two displays to indicate the captured PD activity. In the "Scope" display, every PD signal is shown on a phase-resolved graph. In the "Meter" display, the peak value is shown on an analogue meter.

6.1.1 Scope

Within the "Scope" mode there are four ways to display the PD pattern. These types can be selected in the menu "MODE / DISPL" and will be explained now.

Figure 17 shows the "Scope" display with "NORM" mode activated (see menu description for menu "MAIN S"): Every partial discharge 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. The display refresh rate of the ICM*compact* is about 0.1 s, thus every picture shows the discharge pulses accumulated over the last five cycles of the test voltage (at 50 Hz!). The displayed sine wave helps to identify the phase position of the discharge impulses.

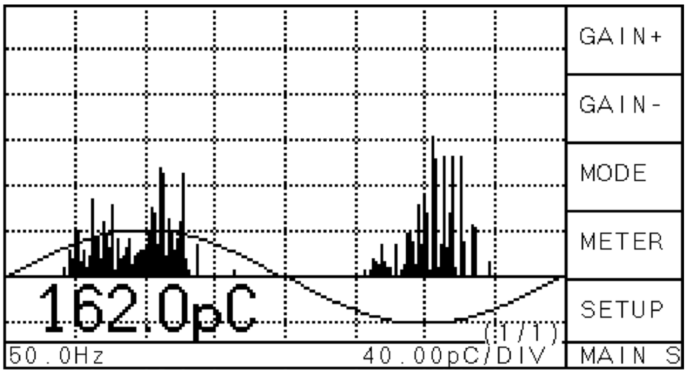


Figure 17: *Scope display (NORM mode)*

Figure 18 shows the scope display with "SINE" mode active. The only difference between "NORM" mode and "SINE" mode is that in the "SINE" mode, the impulses are superimposed onto the sine wave.

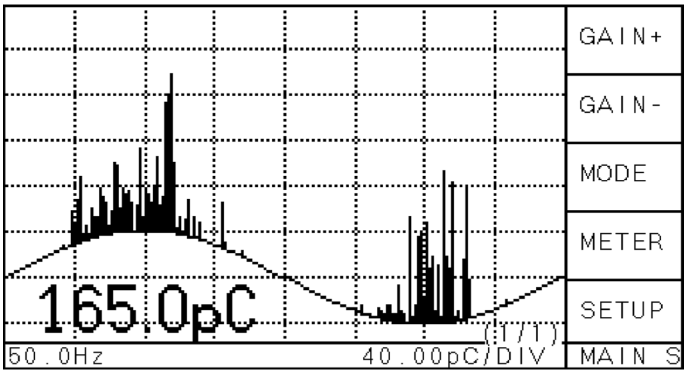


Figure 18: *Scope display (SINE mode)*

Figure 19 shows the scope display with "LISSA" mode active. In this mode, the phase positions from 0 ° to 360 ° are divided into two parts represented by two half sine waves. The upper part displays the phase positions from 0 ° to 180 ° (left to right). The lower part represents the positions from 180 ° to 360 ° (right to left). As the resolution of the instrument has not changed, every impulse is displayed as a double vertical line.

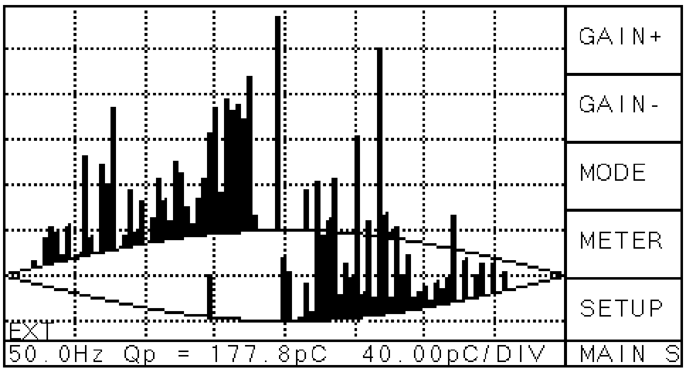


Figure 19: *Scope display ("LISSA" mode)*

In the “HOLD” mode, every partial discharge impulse activates a display pixel at the location according to the pulse magnitude and the phase angle of occurrence. Note that in this case, the display is refreshed every 100 ms which allows a visualisation of the build-up dynamics of a partial discharge pattern (also called ‘PD map’ or ‘phase-amplitude distribution’). Changing the gain will reset this display mode. Even though the ICM*compact* can only ‘count’ up to 1 (pixel on/off) and that other technical differences exist between the ICM*compact* 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 bits) whereby the ICM*compact* is unipolar and has a resolution of 80 x 196 x 1 (amplitude x phase x count depth).

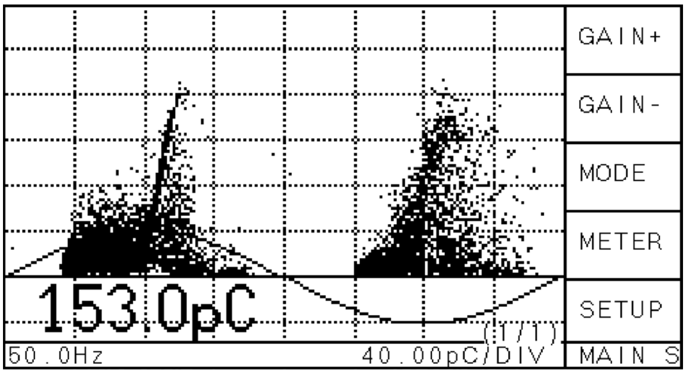


Figure 20: *Scope display (HOLD mode)*

At the bottom of the display, the synchronisation frequency (left), the scaling of the y-axis in coulomb per division (right) and the current maximum value of discharge (large letters) is shown. This maximum is calculated from voltage periods during the last refresh cycle. For best results the gain should be set so that this maximum appears in the range of 50 to 90 % of the y-axis total range. In case the PD values are out of this range no valid Qp can be shown. This happens if the gain is either too high or too low. In the first case “>” (max. value) and in the second case “<” (min. value) is displayed. The setting of the gain can be adapted manually or automatically by turning on or off the “AUTO” mode. This option is accessible at the “MODE S” or “MODE M” menu.

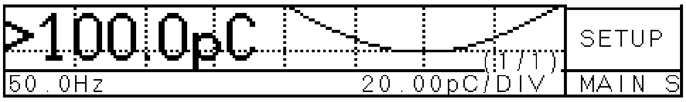


Figure 21: *MAIN menu; charge level out of range*

The evaluation of the PD pattern, measured in “HOLD” mode, enables you to determine the kind of fault within the test object. Most PD faults like e.g., isolation damages, voids, surface discharges, or floating points will have completely different PD pattern. Typical criteria to classify these patterns are:

- phase position of the maximum partial discharge
- phase position of the starting electron
- the gradient of discharges
- the shape of discharges in the positive and negative half-cycle
- the absolute value of discharge in pC or nC
- short-time or continuous discharges

Some installations make it necessary to correct the phase position of the pattern. For example, measuring on a three-phase system without using the external synchronisation, where the line synchronisation comes from one of the two other phases. In that case a correction of 120 ° would be necessary. This phase shift can be set at the menu “SETUP2 \ LLDSET”. Note that the correct phase position is very important for proper evaluations of the PD pattern. To avoid the need for applying a phase shift, coupling units that include a voltage divider circuit should be used to provide a signal for external synchronisation (e.g., CC20B).

For successful interpretation, it is also necessary to get as much information as possible about the test object and its environment. Such information can be, for example, temperature, installation condition, age of the test object, previous faults, or weather conditions. It is useful to store typical PD patterns of known faults in an archive. This can be done by using the PC software (see section 7.1 “Standard software”). This customer specific database will be helpful for later evaluation on other test objects.

6.1.2 Meter

Figure 22 shows the instrument's display in the "MAIN" menu and "METER" mode. The buttons "GAIN+" and "GAIN-" increase or decrease the gain resp. amplification factor. Meter scaling automatically tracks the current calibration and gain factor. The button "SCOPE", "DSO", or "HVM" activates the next display mode, and the button "SETUP" calls the configuration menus. The line beneath the meter displays the synchronisation signal frequency (line voltage or the external signal at the SYNC IN terminal), the scaling of the meter, and the current peak value of the apparent charge "QP". "MODE" calls a submenu for controlling the pointer movement and speed (see Figure 23) and the "Auto Gain Mode".

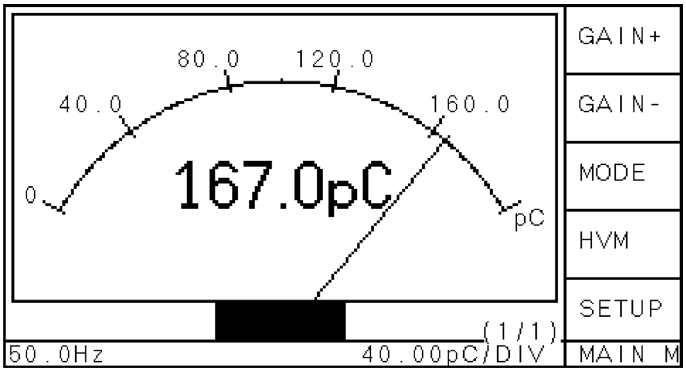


Figure 22: *Meter display ("MAIN" menu)*

Within the menu "DISP M", three different speeds for the pointer can be selected. The chosen option is marked with an arrow ahead. In ">FAST", the current peak charge value of an acquisition cycle is displayed; this may lead to unstable readings (i.e., jerky movement of the pointer) when the pulse repetition rate is slower than about 5 s^{-1}. The current peak value is also displayed in ">NORM" mode, but here the pointer is stabilised; new pulse values are shown immediately yet the pointer falls back slowly until a bigger pulse occurs.

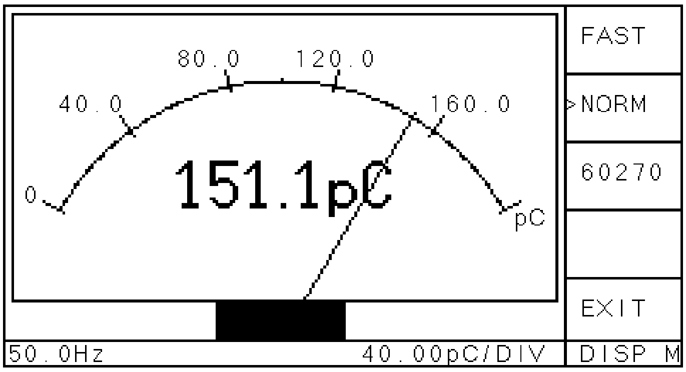


Figure 23: *Meter display ("MODE" menu)*

The option ">IEC620270" treats the pulses with a weighting curve as mentioned in the IEC 60270. This weighting, which displays rarely occurring pulses only with a fraction of their real amplitude (≥40 %), leads to a strong stabilisation of the pointer and a reduced reading.

The buttons "AUTO" and "AUTO F" of the "Mode M" menu activate 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 when the reading remains under 20 % of the selected scale. The fast "Auto Gain Mode" ("AUTO F") adjusts the gain immediately to the optimum, whereas in normal "Auto Gain Mode", the gain is changed step by step after each display refresh. Each change in gain is indicated by a short beep from the built-in loudspeaker. From 1000 pC upwards, the displayed unit changes from [pC] to [nC].

Note: Using sensitive coupling with high charge levels, the system can be over-ranged. In this case Megger can provide input attenuators (1:10 and 1:100).

The "EXIT" button moves back to the "MAIN" menu.

6.2 Key menus

All functions described in this section is based on the firmware version 4.28. You can find the firmware number either by start up at the info screen or by selecting the "INFO" submenu while the instrument is running. Older releases are not completely compatible to the newer ones. Contact Megger to get update possibilities and prices.

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 is coloured in the respective level colour. Each arrow shows the menu that you enter when pushing that button. The "EXIT" button jumps back to the previous menu on the upper level.

6.2.1 Overview

Figure 24 gives an overview of the whole menus being accessible with the ICM*compact* instruments. The dimmed menus are optional and explained separately in the following figures. Menus with a grey shadow are optional menus (e.g., HVM, VLF, DSO, and gating). They are only accessible if the respective function is included.

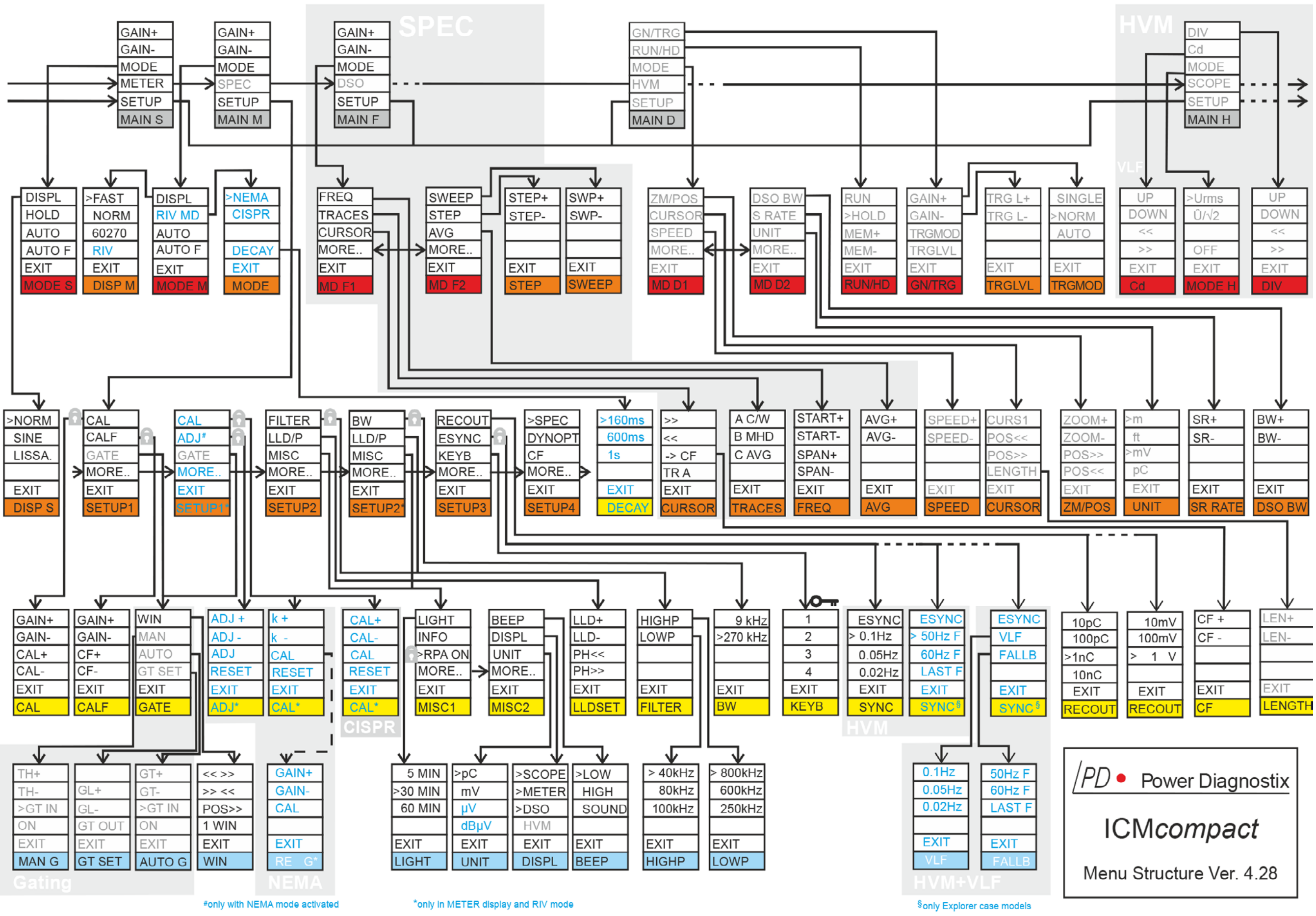


Figure 24: *Menu overview*

Some text entries can vary, depending on the several setup settings and of the state of the device. All exit buttons will bring you back to the menu one level higher. This path is not shown in the overview. The arrows are showing the way from menu to menu if pushing the appropriate button. At the bottom of each menu its name is written (with level-wise coloured background).

6.2.2 Optional key menus

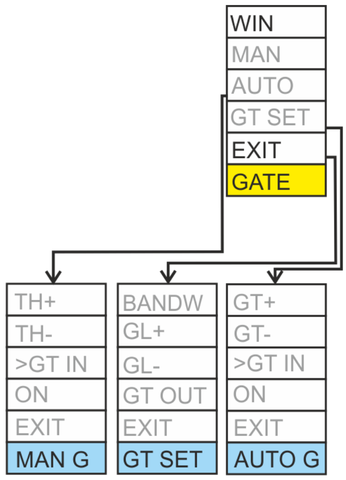


Figure 25: *Optional menus for gating (GATE)*

Figure 25 shows the optional gating menus. These menus become visible if the device has an activated external "GATE IN" input channel. In this case, the ICM*compact* is equipped with an onboard logarithmic pre-amplifier, RPA6G. The noise signal can directly be connected to the "GATE IN" channel.

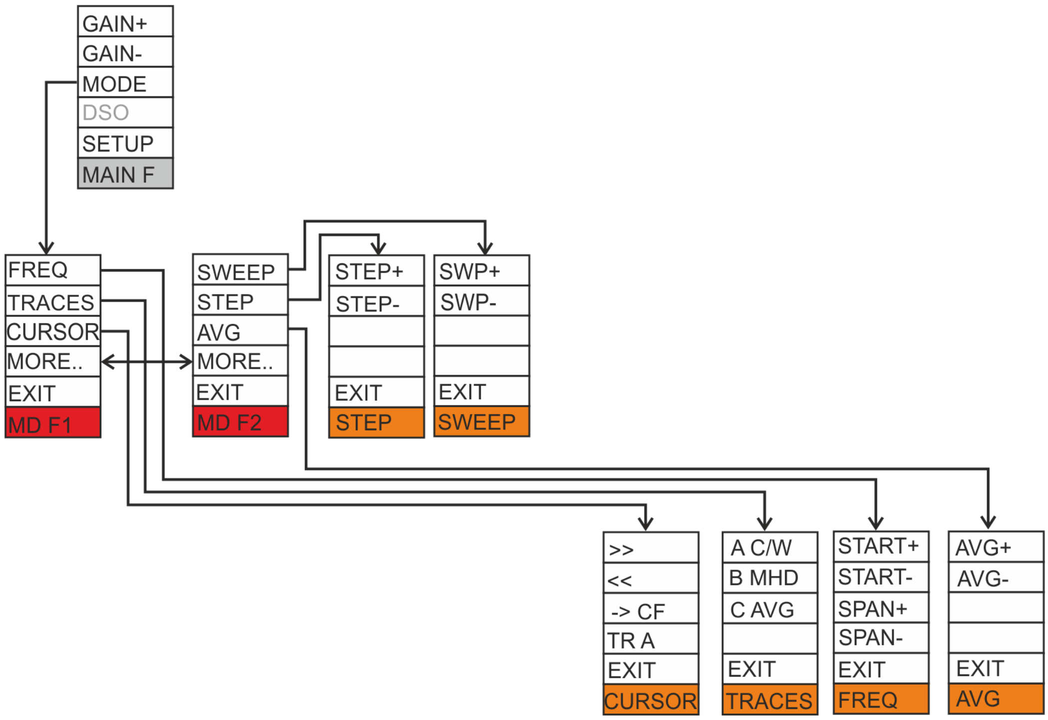


Figure 26: *Optional menu for the spectrum function (SPEC)*

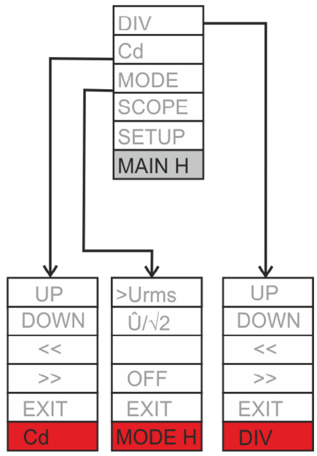


Figure 27: *Optional high voltage meter menus (HVM)*

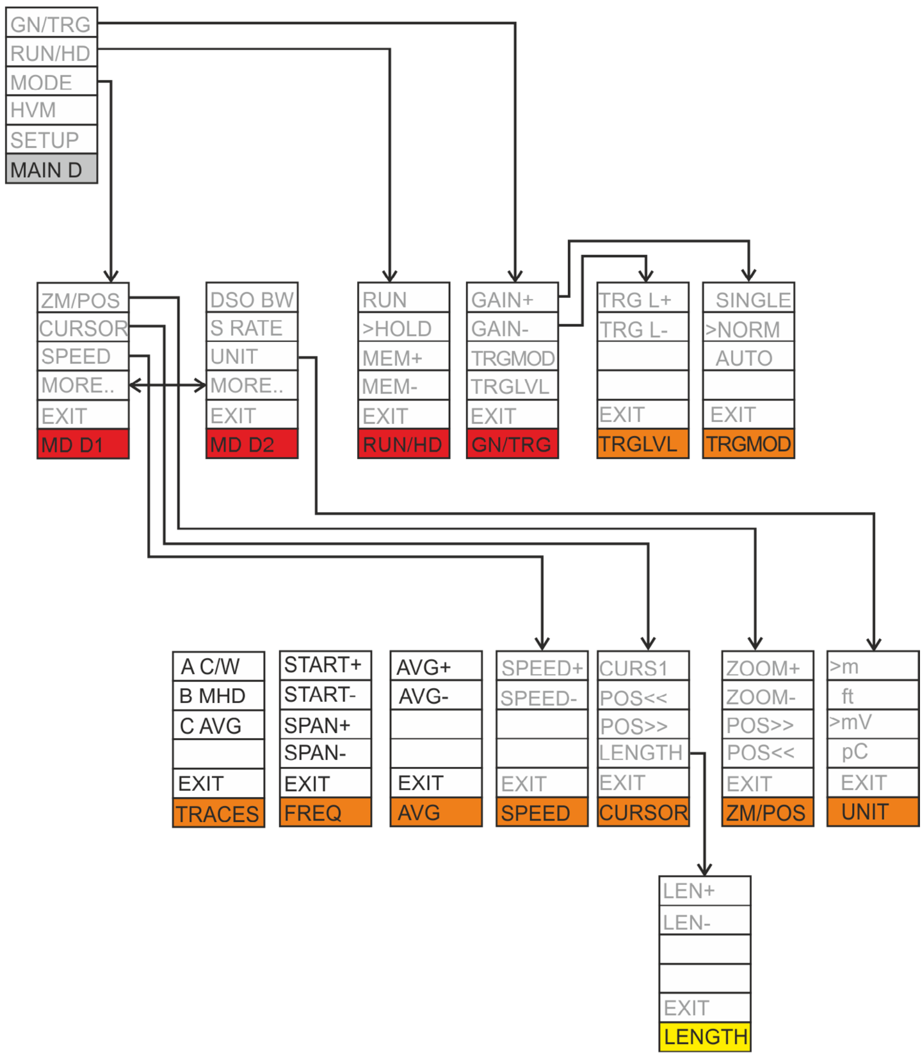


Figure 28: *Optional menus (DSO extension)*

Devices with a DSO acquisition board for cable fault location get the entry “UNIT” within the MD D2/UNIT menu. This option allows to select the display unit for cable fault positions. There will also be an additional menu “MAIN D” for working with the DSO board. This is shown in Figure 28.

6.2.3 Key menus description

The following list explains step by step all menus coming with the standard ICM*compact* firmware releases higher than version 4.00.

GAIN+
GAIN-
MODE
METER
SETUP
MAIN S

GAIN+/GAIN-
Sets the amplification of the ICM*compact* signal path up or down. The total amplification is a combination of the pre-amplification (external pre-amplifier, i.e., RPA1) and the (internal) main amplification. By selecting the automatic mode (see "MODE S"), the gain will be adjusted automatically to the current maximum discharge level. The peaks of discharges should be visible at 60 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 signals (no discharges), set the noise level to 5% of the total range of the display. This ensures that all newly appearing discharges will be recognised if their level is higher than the noise at the input.

MODE
Push this button to go to the "MODE S" menu.

METER, DSO or HVM
Depending on the optional DSO acquisition board and the switched-on displays (see menu "DISPL") this function switches to the next display type.

SETUP
Push this button to go to the setup menu. As there are several setup menus, this function enters the last setup you've been before.

GAIN+
GAIN-
MODE
METER
SETUP
MAIN M

GAIN+/GAIN-

See explanation above.

MODE

Push this button to go to the "MODE M" menu.

METER or SPEC

Depending on the optional "SPEC" function and the switched-on displays (see menu "DISPL") this function switches to the next display type.

SETUP

Push this button to go to the setup menu. As there are several setup menus, this function enters in the last setup you've been once before.

Depending on the optional functions three main menus and their submenus are added. For more information see:

MAIN F	Ssection 6.3.1 "SPEC – Spectrum function"
MAIN D	Ssection 6.3.4.6 "Key menus for the DSO"
MAIN H	Ssection 6.3.2 "HVM – High voltage meter display"

DISPL
HOLD
AUTO
AUTO F
EXIT
MODE S

DISPL
Push this button to go to the “DISP S” menu.

HOLD
Setting this option (>) enables the “HOLD” visualisation for the phase resolved PD display (SCOPE). Pushing this button again will freeze the current display. Pushing this button for the third time will clear the frozen hold display and will continue with the “HOLD” mode.

AUTO
Setting this mode (>) means that the gain will be adjusted automatically to the maximum level of the current PD pulses. In this mode the gain is adjusted slowly. This mode is useful if a PD level is quite constant, or if random spikes will disturb a continuous measurement.

AUTO F
Setting this mode (>) means that the gain will be adjusted very fast. The “FAST” mode is useful if rapid changes of the PD level should be captured, e.g., when measuring the inception voltage of a specimen. A single PD level which will over range the pre-amplifier stops the acquisition and the gain is adjusted instantly.

EXIT
Push this button to go to the “MAIN S” menu.

>NORM
SINE
LISSA.
EXIT
DISP S

NORM
Setting this option (>) enables the normalised visualisation for the phase resolved PD display (SCOPE). The differences between “NORM”, “SINE”, “HOLD”, and “LISSA” are described in section 6.1.1.

SINE
Setting this option (>) enables the “sine” visualisation for the phase resolved PD display (SCOPE).

LISSA.
Setting this option (>) enables the “Lissajous” visualisation for the phase resolved PD display (SCOPE).

EXIT
Push this button to go to the “MODE S” menu.

DISPL
RIV MD
AUTO
AUTO F
EXIT
MODE M

DISPL
Push this button to go to the “DISP M” menu.

RIV MD
Push this button to access the “MODE” menu for RIV measurements.

AUTO
Setting this mode (>) means that the gain will be adjusted automatically to the maximum level of the current PD pulses. In this mode, the gain is adjusted slowly. This mode is useful if a PD level is quite constant, or if random spikes will disturb a continuous measurement.

AUTO F
Setting this mode (>) means that the gain will be adjusted very fast. The “FAST” mode is useful if rapid changes of the PD level should be captured e.g., when measuring the inception voltage of a specimen. A single PD level which will over range the pre-amplifier stops the acquisition and the gain is adjusted instantly.

EXIT
Push this button to go to the “MAIN M” menu.

>FAST
NORM
60270
RIV
EXIT
DISP M

FAST
Setting this option enables the fast movement speed of the pointer in the "METER" display.

NORM
Setting this option enables the normal movement speed of the pointer in the "METER" display.

60270
Setting this option enables IEC60270 mode for updating the pointer in the "METER" display.

RIV
Setting this option enables RIV mode. In this mode the RIV level is shown in µV. For more information see section 6.3.5.

EXIT
Push this button to go to the "MODE M" menu.

NEMA
CISPR
DECAY
EXIT
MODE

NEMA
Sets the calibration mode according to NEMA 107 standard.

CISPR
Sets the calibration mode according to CISPR 18-2 standard.

DECAY
Push this button to go to the menu "DECAY" for setting the decay time.

EXIT
Pushing this Button returns you to the "MAIN" menu.

>160MS
600ms
1s
EXIT
DECAY

160ms
Sets the decay time to 160 ms.

600ms
Sets the decay time to 600 ms.

1s
Sets the decay time to one second.

EXIT
Push this button to go to the menu "MODE".

Depending on the optional functions, several mode menus and their submenus are added. For more information see:

MD F1/2	Ssection 6.3.1 "SPEC – Spectrum function"
MD D1/2	Ssection 6.3.4.6 "Key menus for the DSO"
MODE H	Ssection 6.3.2 "HVM – High voltage meter display"

CAL
CALF / ADJ
GATE
MORE..
EXIT
SETUP1

CAL
Push this button to go to the calibration menu “CAL”.

CALF
Push this button to go to the menu “CALF”. Here the calibration factor can be set directly.

ADJ *(only in METER/RIV mode with activated NEMA mode)*
If the display is in meter mode and RIV mode is enabled, the “CALF” button changes to “ADJ”. Push this button to go to the adjust menu for the RIV function. Further information can be found in section 6.3.5.

GATE
Push this button to go to the menu “GATE”. The gating function reduces noise coming from e.g., antennas and pre-processes the analogue disturbance signal. To use this option, the device needs to be equipped with an external gating input and the hardware of the device has to be greater than version 2.60. A special logarithmic pre-amplifier (RPA6G) is also needed to amplify the disturbance signal.

MORE..
Push this button to go to the setup menu “SETUP2”.

EXIT
Push this button to go to the main menu (“MAIN S”, “MAIN M”, “MAIN F”, or “MAIN D”).

FILTER/BW
LLD/P
MISC
MORE..
EXIT
SETUP2

FILTER
Push this button to go to the filter setting menu “FILTER”.

BW *(only with SPEC mode activated)*
Push this button to go to the bandwidth setting menu “BW”.

LLD/P
When “SCOPE” display is active, push this button to go to the menu “LLDSET” to adjust the low level discriminator.

MISC
Push this button to go to the menu “MISC” for miscellaneous settings.

MORE
Push this button to go to the setup menu “SETUP3”.

EXIT
Push this button to go to the main menu one level up.

RECOUT
ESYNC
KEYB
MORE..
EXIT
SETUP3

RECOUT
Push this button to go to the menu "RECOUT". Here the ratio of charge value to output voltage can be set.

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

With the optional 'HVM', this button changes to the menu "SYNC". See also section 6.3.2.

KEYB
Push this button to go 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 2 must be entered.

MORE
Push this button to go to the setup menu "SETUP4".

EXIT
Push this button to go to the main menu ("MAIN S", "MAIN M", "MAIN F", or "MAIN D").

>SPEC
DYNOPT
CF
MORE..
EXIT
SETUP4

SPEC
Activates the "SPEC" path for display. When not activated, the "AMP" path is displayed.

DYNOPT
This entry sets the gain strategy. If activated, the internal gain settings are optimised to accept PD signals with a strong dynamic. If not selected, the gain settings are focusing on overall low noise. Thus, choosing dynamic optimisation is recommended for PD signals with high signal amplitudes, while noise optimisation should be used if high sensitivity and low noise is needed.

CF
Push this button to go to menu "CF". Here the centre frequency for the "SCOPE" and "METER" mode can be set.

MORE..
Push this button to go to the set-up menu "SETUP1".

EXIT
Push this button to go to the main menu.

GAIN+
GAIN-
CAL+
CAL-
EXIT
CAL

GAIN+/GAIN-
Pushing this button increases/decreases the total gain by one step. The calibration signal should be 50 to 90 % of the total y-axis range. Changing the gain does not calibrate the system. Use the buttons "CAL+" or "CAL-" to 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. This cannot be undone! The value should be set equal to the value shown on the connected pulse generator (e.g., CAL1A). For detailed information's about the calibration procedure, see section 6.5.

EXIT
Push this button to go to the setup menu "SETUP1".

The following two menus are only available in the "METER" display when "RIV" mode is selected and "NEMA" mode is activated.

k+
k-
CAL
RESET
EXIT
CAL

(NEMA mode)

k+/k-
Pushing this button increases/decreases the calibration factor (k) of the RIV measurement directly. If known from a previous calibration, the factor can be set here to skip further calibration. The set value is immediately stored in a non-volatile memory.

CAL
Pushing this button will start one measurement on the reference input ("REF" input) for about 1 second. Thereafter one measurement is done on the selected input channel CHx. The calculated correction factor (k) can be seen in the bottom right-hand side of the display. This circuit RIV factor is defined as the ratio of the voltage at the input channel (CHx input) to the signal generator voltage (REF input) k = VCH / VREF.

If the signal of the "REF" input is too strong, the ICM*compact* changes automatically to the menu "REF G".

RESET
Pushing this button will undo the calibration and reset the factor to k=1 (see section 6.3.5.3).

EXIT
Push this button to go to the set-up menu "SETUP1".

GAIN+/GAIN-

GAIN+
GAIN-
CAL
EXIT
REF G

(NEMA mode)

Sets the amplification of the reference input "REF" up or down.

CAL
Pushing this button starts one measurement on the "REF" input for about 1 second. Thereafter, one measurement is done on the selected input channel "CHx". The calculated correction factor (k) is indicated at the bottom right-hand corner of the LC display. This circuit RIV factor is defined as the ratio of the voltage at the input channel ("CHx" input) versus the signal generator's voltage facing the load ("REF" input) $k = V_{CH} / V_{REF}$.

EXIT
Push this button to go to the menu "CAL".

(The following menu is only available in the "METER" display when "RIV" mode is selected and "CISPR" mode active).

CAL+
CAL-
CAL
RESET
EXIT
CAL

(CISPR mode)

CAL+/CAL-
These buttons allow setting the value for calibration. The value should be set according to the voltage set on the signal generator (CAL3D).

CAL
Pushing this button adjusts the instrument by comparing the measured voltage with the set voltage (e.g., CAL: 100 µV).

RESET
Pushing this button will undo the calibration and reset the factor to k=1 (see section 6.3.5.4).

EXIT
Push this button to go to the set-up menu "SETUP1".

- GAIN+
- GAIN-
- CF+
- CF-
- EXIT
- CALF

GAIN+/GAIN-
Pushing this button increases/decreases the total gain by one step. This will have no impact on the calibration factor.

CF+/CF-
These buttons can be used to set the calibration factor directly. This function can be used to copy a previously done calibration. For more detailed information about the calibration procedure, see section 6.5.

EXIT
Push this button to go to the setup menu "SETUP1".

The following menu is only available in the "METER" display when "RIV" mode is selected and "NEMA" mode is activated.

- ADJ+
- ADJ-
- ADJ
- RESET
- EXIT
- ADJ

(NEMA mode)

ADJ+/ADJ-
These buttons allow you to set the value for adjustment. The value should be set according to the voltage set on the signal generator (e.g., CAL3A).

ADJ
Pushing this button will adjust the instrument by comparing the measured voltage with the set voltage (e.g., ADJ: 100 µV), see section 6.3.5.2.

RESET
Pushing this button will undo the adjustment, see section 6.3.5.2.

EXIT
Push this button to go to the setup menu "SETUP1".

- WIN
- MAN
- AUTO
- BANDW
- EXIT
- GATE

WIN
Push this button to go to the menu "WIN". The 'window' function makes it possible to blind out pulses with respect to their phase position. With older devices (firmware <2.00) this function was called "GATE".

MAN, AUTO, BANDW
Gating with an external sensor (analogue gating) is an optional function. An ICM*compact* with this gating function will have an onboard pre-amplifier (RPA6G) and a "GATE IN" terminal (BNC).

EXIT
Push this button to go to the setup menu "SETUP1".

<< >>
>> <<
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 upper right side of the screen.

>> <<
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 software gating. The phase distance using two windows is 180 ° and 120 ° for three windows. Press "1 WIN" if you want to get one window for gating. The key always indicates the next option.

EXIT
Push this button to go to the setup menu "GATE".

HIGHP
LOWP
EXIT
FILTER

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

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

EXIT
Push this button to go to the setup menu "SETUP2".

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 go to the setup menu "FILTER".

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 go to the setup menu "FILTER".

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. All discharges below that level are deleted and not displayed on the screen.

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.

EXIT
Push this button to go to the setup menu “SETUP2”.

LIGHT
INFO
>RPA ON
MORE..
EXIT
MISC1

LIGHT
Push this button to go to the menu “LIGHT” for setting up the timer for the screensaver.

INFO
Push this button to go to the “INFO” display. This display gives information about the current firmware (SW version) and hardware version (HW version), release day (SW release), optional instrument functions, and contact details of Megger.

RPA ON
If this button is selected (>), the power supply for the pre-amplifier is turned on. Pushing this button until the check/tick (henceforth referred to as ‘check’) symbol switches off will turn off the supply to the pre-amplifier and enable you to use the “AMP IN” terminal directly without pre-amplifier.

MORE..
Pushing this button will take you to “MISC2”.

EXIT
Push this button to go to the setup menu “SETUP2”.

BEEP
DISPL
UNIT
MORE..
EXIT
MISC2

BEEP
Push this button to modify the sound that is played when you press a button.

DISPL
Display modes (“SCOPE”, “METER”, “DSO” and “HVM”) can be deselected in this menu.

UNIT
The unit for the “SCOPE” and “METER” displays can be selected here.

MORE..
Pushing this button will take you to “MISC1”.

EXIT
Push this button to go to the setup menu “SETUP2”.

5 MIN
>30 MIN
60 MIN
EXIT
LIGHT

5 MIN, 30 MIN, 60 MIN
Pushing these buttons sets the automatic screen saver to 5, 30, or 60 minutes. That means, if no button has been pressed for about 5, 30, or 60 minutes, the background lighting of the display will be turned off. Push any button to turn the light on.

EXIT
Push this button to go to the menu “MISC1”.

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 signals.

EXIT
Push this button to go to the menu “MISC2”.

>SCOPE
>METER
DSO
HVM
EXIT
DISPL

The display modes that are installed in the instrument can be deselected if they are not currently visible. Modes which are deselected in this menu cannot be selected in the “MAIN” menu and will be skipped. This will increase the handling, especially when the modes are changed frequently.

EXIT
Push this button to go to the menu “MISC2”.

>PC
mV
EXIT
UNIT

pC
Setting this mode (>) changes from the acoustic measurement mode (‘mV’) back to the charge measurement mode.

mV
Setting this option (>) changes the display unit to ‘mV’ for the acoustic measurement. For a correct calculation of the input voltage, it is mandatory to connect the RPA1D pre-amplifier or to disconnect the RPA supply in the menu “MISC1”. Within this mode, the “CAL” and “CALF” menus are blocked, and the “FILTER” setting is fixed to the frequency range 40 to 800 kHz. All these settings are stored before and will be recalled when changing back to the ‘pC’ display mode.

EXIT
Push this button to go to the menu “MISC2”.

The following menu is only available when “SPEC” mode is activated.

9 kHz
>270 kHz
EXIT
BW

9 kHz/270 kHz
Pushing this button sets the measuring bandwidth to 9 kHz or 270 kHz. The selected frequency is marked by “>”.

EXIT
Push this button to go to the setup menu “SETUP2”.

The following menu is only available if voltage output is set to coulomb.

10pC
>100pCz
1nC
10nC
EXIT
RECOUT

10pC, 100pC, 1nC, 10nC
Pushing these buttons sets the level of the analogue voltage output "RECOUT" in coulomb. The scaling is linear.

Record output	Button 10 pC	Button 100 pC	Button 1 nC	Button 10 nC
0 V	0 pC	0 pC	0 nC	0 nC
5 V	5 pC	50 pC	0.5 nC	5 nC
10 V	≥10 pC	≥100 pC	≥1 nC	≥10 nC

Table 1: *Coulomb ranges of the voltage output*

EXIT
Push this button to go to the setup menu "SETUP3".

The following menu is only available if voltage output is set to volt.

10mV
>100mV
1 V
EXIT
RECOUT

10mV, 100mV, 1V
Pushing these buttons sets the level of the analogue voltage output "RECOUT" in volt. The scaling is linear.

Record output	Button 10 mV	Button 100 mV	Button 1 V
0 V	0 mV	0 mV	0 V
5 V	5 mV	50 mV	0.5 V
10 V	≥10 mV	≥100 mV	≥1 V

Table 2: *Volt ranges of the voltage output*

EXIT
Push this button to go to the setup menu "SETUP3".

The following menu is only available with standard and rack-mountable instruments.

ESYNC
0.1Hz
0.05Hz
0.02Hz
EXIT
SYNC

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

0.1Hz, 0.05Hz, 0.02Hz
For the acquisition with the VLF (very low frequency) option, the external voltage signal from the "SYNC IN" is mandatory. Selecting one of the three VLF frequencies will deselect the external frequency measurement and set the sampling time according to the set VLF. The synchronisation is done automatically by the "SYNC IN" input.

EXIT
Push this button to go to the setup menu "SETUP3".

The following menu is only available with Explorer models without VLF option.

ESYNC
50Hz F
60 Hz F
LAST F
EXIT
SYNC

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

EXIT
Push this button to go to the setup menu "SETUP3".

The following three menus are only available with Explorer models with VLF option.

ESYNC
VLF
FALLB
EXIT
SYNC

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.

VLF
Push this button to go to the VLF menu where you can activate the VLF measurement mode and select one of the three VLF frequencies.

FALLB
Push this button to go to the menu "FALLB" where you can select the frequency (fallback) if there is no synchronisation signal available.

EXIT
Push this button to go to the setup menu "SETUP3".

0.1Hz
0.05Hz
0.02Hz
EXIT
VLF

0.1Hz, 0.05Hz, 0.02Hz
Select one of these buttons (>) to activate the VLF measurement mode. For the acquisition with this VLF option, an external voltage signal from the VLF system is recommended. Selecting one of the three VLF frequencies will deselect the external frequency measurement. The zero crossing of the voltage signal will be automatically determined by the internal software. The frequency must be chosen according to the settings at the VLF high voltage source.

EXIT
Push this button to go to the setup menu "SETUP3".

50Hz F
60 Hz F
LAST F
EXIT
FALLB

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

EXIT
Push this button to go to the setup menu “SETUP3”.

LOCK
EXIT
KEYB

LOCK
This button allows to lock the keyboard, leaving only the functions available, which will not affect the parameters of the instrument. The locked functions are labelled in the menu structure (section 6.2.1) by . If you got to the “KEYB” menu while the keyboard is locked, you will see buttons that are labelled 1, 2, 3, 4, EXIT. To unlock the keyboard, a sequence of the numbers: 3 4 3 2 must be pressed.

EXIT
Push this button to go to the setup menu “SETUP3”.

6.2.4 Reset to default settings

To restore the factory default settings of an ICM*compact*, press the top and bottom push buttons simultaneously when switching on the device. If the instrument is equipped with two lines of push buttons, use the buttons on the left-hand side for a reset.

6.3 Optional functions

6.3.1 SPEC – Spectrum function

The "SPEC" display 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.

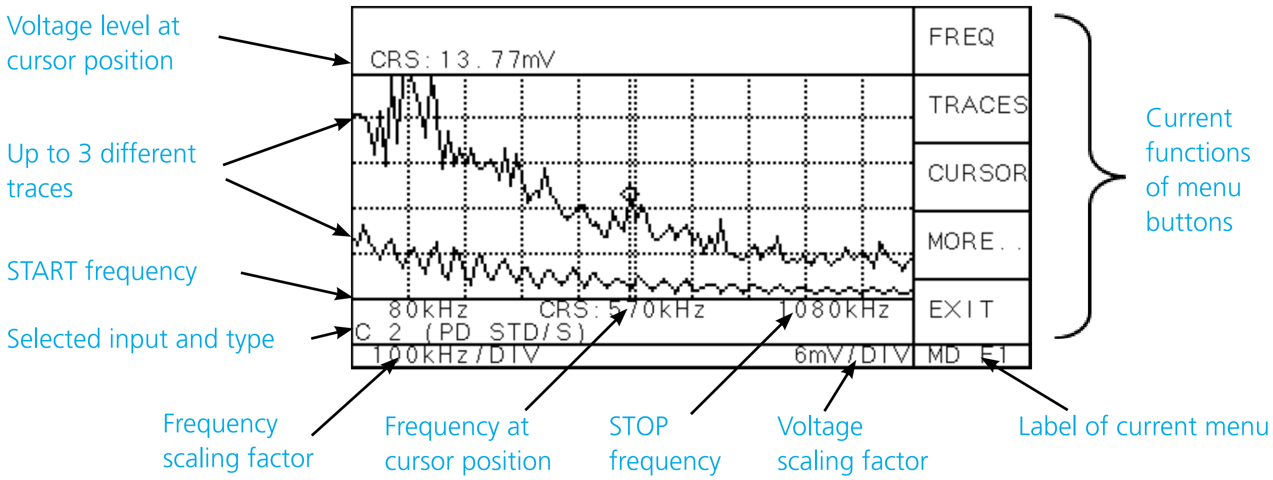


Figure 29: *"SPEC" display*

6.3.1.1 Key menus for the spectrum function

GAIN+
GAIN-
MODE
DSO
SETUP
MAIN F

GAIN+/GAIN-
Sets the amplification of the ICM*compact* signal path up or down. The total amplification is a combination of pre-amplification (external pre-amplifier, i.e., RPA1) and main amplification (internal).

MODE
Push this button to go to the "MD F1" menu.

DSO, HVM, or SCOPE
Depending on the optional DSO acquisition board and/or the optional HVM functionality as well as the switched-on displays (see menu "DISPL") this function switches to the next display type.

SETUP
Push this button to go to the setup menu. As there are several setup menus, this function enters the last setup you've been before.

There are two “MODE” menus for adjusting the spectrum scan. “MORE..” toggles between “MD F1” and “MD F2”. These menus are explained as follows:

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*compact* updates the information for any active trace with each sweep. The three traces (A, B, and C) can be defined separately in five 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 current 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
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 one 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 ten steps (frequencies) per sweep. Together with the dwell time and the span, the sweep time is calculated by: SWP = (DWT + 0.5 ms) * 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).

FREQ
TRACES
CURSOR
MORE..
EXIT
MD F1

FREQ
Push this button to go to the submenu "FREQ". Here, the start frequency and the span (range) of frequencies can be set.

TRACES
Push this button to go to the submenu "TRACE". Here, the information of the three traces can be changed.

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

MORE..
Push this button to go to the next menu "MD F2".

EXIT
Push this button to go to the "MAIN F" menu.

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.

START+
START-
SPAN+
SPAN-
EXIT
FREQ

START+/START-
Pushing this button increases/decreases the start frequency in steps of 10 kHz.

SPAN+/SPAN-
Pushing this button increases/decreases the span of measured frequencies. The step size is set automatically, so that an even scaling factor (kHz/DIV) is given.

EXIT
Pushing this button will go 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 available modes.

EXIT
Pushing this button will go to the menu "MD F1".

>>
<<
-> CF
TR_A
EXIT
CURSOR

>> <<
Pushing these buttons 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 other display modes ("SCOPE", "MON", "PROJ", "TIME").

TR_A, _B, _C
Push this button to go to 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
Pushing this button will take you to the menu "MD F1".

SWEEP
Push this button to go to the submenu “SWEEP”. There, the sweep time can be changed via the dwell time.

STEP
Push this button to go to the submenu “STEP”. There, the step size of frequency steps can be set.

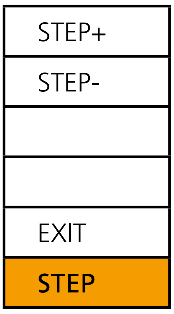
AVG
Push this button to go to the submenu “AVG”. There, the average function can be adjusted.

MORE..
Push this button to go to the next menu “MD F1”.

EXIT
Push this button to go to the “MAIN F” menu.

SWP+/SWP-
Pushing this button will directly increase/decrease the dwell time (DWT). It will also change the sweep time (SWP).

EXIT
Pushing this button will take you to the menu “MD F2”.



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.

EXIT
Pushing this button will take you to the menu “MD F2”.

AVG+/AVG-
Pushing this button will increase/decrease the number of values taken for the smoothing function (average).

EXIT
Pushing this button will take you to the menu “MD F2”.

6.3.2 HVM – High voltage meter display

Instruments with the option of a high voltage meter (HVM) display are able to calculate and display the voltage waveform connected to the SYNC IN terminal. The scaling of the amplitude and time base is done automatically so that one full waveform is displayed. The calculated values Urms and Û/√2 can also be shown in the other selected displays (“SCOPE”, “METER”, “DSO”). However, this will decrease their refreshing rate. The software ICM*compact* can record these values together with PD level and the date/time. Also refer to the software introduction in section 7 and the technical data in section 10.

The displayed waveform has no impact on the calculation of the values shown in the top two rows or other menus. The crest factor (Crest) is calculated by $\frac{peak\_voltage}{effective\_voltage} = \frac{\hat{U}}{U_{rms}}$ resulting in a factor of 1.41 for non-distorted sine waves.

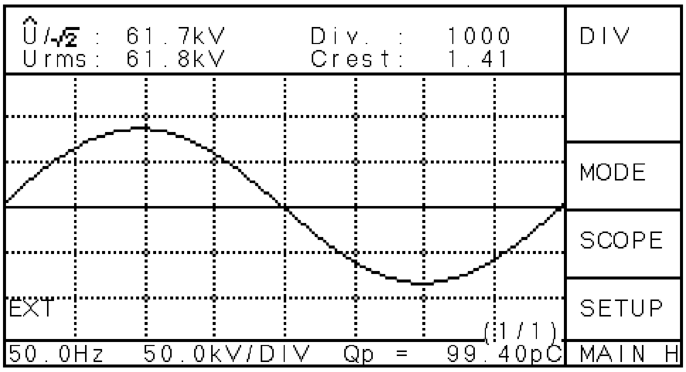


Figure 30: *HVM display showing voltage waveform*

To adjust the signal voltage entering (SYNC IN) to the measured voltage the divider factor (DIV.) can be changed by using the buttons DIV+ and DIV-. Holding these buttons will increase the step width.

The voltage frequency and the scaling factor for the displayed waveform are shown in the bottom row together with the peak PD value taken from the AMP IN terminal.

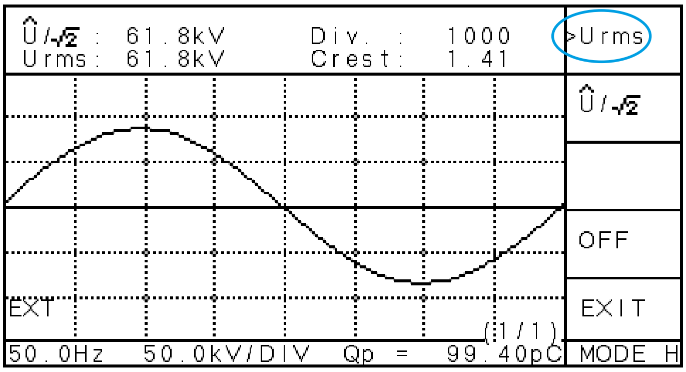


Figure 31: *“MODE” menu for the HVM mode*

To select a value (Urms, Û/√2) to be displayed in “SCOPE”, “METER”, or “DSO” mode, switch to “MODE H” and select the respective value.

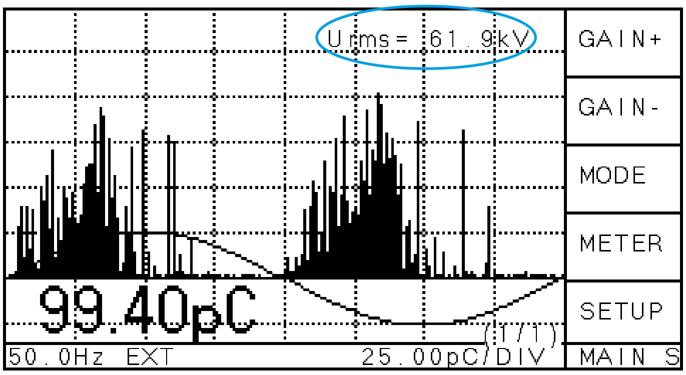


Figure 32: *“SCOPE” display with URMS value*

DIV
Cd
MODE
SCOPE
SETUP
MAIN H

DIV
Changes to the submenu DIV. There, the divider ratio of the high voltage divider can be set.

Cd
Changes to the submenu Cd. There the low voltage capacitance can be entered. This menu is only visible if one of the three VLF is selected in the menu "SYNC".

MODE
Push this button to go to the "MODE H" menu (see menu MODE H).

SCOPE, DSO, or METER
Depending on the optional DSO acquisition board, this function switches to the next display type.

SETUP
Push this button to go to the last selected "SETUP" menu.

UP
DOWN
<<
>>
EXIT
Cd

The following menu is only visible if one of the three VLF is selected in the menu "SYNC".

UP/DOWN
Sets the low voltage capacitance. The selected character (.) can be increased ("UP") or decreased ("DOWN") by pushing the button.

<</>>
To select the character that you want to change, the cursor (.) can be moved up ("<<") or down (">>") in range by these buttons.

EXIT
Push this button to go to the "MAIN H" menu.

UP
DOWN
<<
>>
EXIT
DIV

UP/DOWN
Sets the divider ratio of the high voltage divider. The selected character (.) can be increased ("UP") or decreased ("DOWN") by pushing the button. The ratio has to be inserted as a factor of 1/x, e.g., with a divider factor of DIV = 1000 a maximum measuring range of 140 kV RMS is possible, since the maximum input voltage is 140 V RMS or 200 V_{peak}.

<</>>
To select the character that needs to be changed, the cursor (.) can be moved up ("<<") or down (">>") in range using these buttons.

EXIT

Push this button to go to the "MAIN H" menu.

Urms
Û/√2
>OFF
EXIT
MODE H

Urms
Setting this option displays additionally the root-mean-square value of the voltage in the further selected displays (see Figure 31).

Û/√2
Setting this option displays the peak value divided by 1.414 in the further selected displays.

OFF
Turns off the additional display of the voltage value in the selected displays (see menu DISPL). This will increase the refreshing cycles in the other displays since the voltage value is not calculated.

EXIT

Push this button to go to the "MAIN H" menu.

6.3.3 VLF – Very low frequency

Instruments with the optional VLF acquisition can synchronise (trigger) at very low frequencies like 0.1 Hz. Since the synchronisation is done by the supplied high voltage, the instrument needs also to have the optional high voltage measurement HVM. An ICM*compact* with the VLF function has an additional submenu "SYNC" which is accessible in the "SETUP3" menu (see section 6.2.3). With an ICM*compact* without the VLF function, this key is labelled "ESYNC".

ESYNC
0.1Hz
0.05Hz
0.02Hz
EXIT
SYNC

ESYNC
If this button is selected (>), the frequency measurement and synchronisation with frequencies >10 Hz are taken from the SYNC IN input, if possible. To manually turn to the line (mains) synchronisation, deselect the button.

0.1Hz, 0.05Hz, 0.02Hz
Selecting one of these buttons (>) will activate the VLF measurement mode. For the acquisition with this option, an external voltage signal from the VLF system is recommended. Selecting one of the three VLF frequencies will deselect the external frequency measurement. The zero crossing of the voltage signal will be determined by the internal firmware automatically. The frequency has to be chosen according to the settings at the VLF high voltage source.

6.3.3.1 VLF – Installation, connection

For partial discharge measurement on a medium voltage cable, the core of the specimen must be connected to a coupling capacitor CC (e.g., 1 nF). The low voltage side of C_C is then connected to a quadrupole (e.g., CIT4L) suitable to stand the max. current determined by C_C, U_{max}, and frequency of the test voltage. A broad-band pre-amplifier should be connected with a short link (coax or BNC-adapter) to the quadrupole. Megger offers two pre-amplifiers suitable for this purpose. The RPA1L is designed for laboratory environment and production line, and the RPA1H is suitable for field test. Both pre-amplifiers have a frequency range of 40 kHz to 20 MHz. The test voltage (VLF high voltage source) is also connected to the specimen core. To minimise noise and unwanted oscillations of the PD signal, the coupling capacitor CC should be connected as close as possible to the cable under test. The earthing connections should be kept short as well. The specimen screen should be connected closely to the quadrupole.

The fault location on cable (TDR) requires a point of reflection; therefore, the cable specimen should not be terminated at the far end nor short circuit.

6.3.3.2 VLF – Calibration

Charge calibration
The calibration for a PD pattern acquisition in the VLF mode can be done in advance, while in the line sync mode (50/60 Hz). This is described in section 6.5.3. However, it is also possible to calibrate in the VLF mode (e.g., 0.1 Hz). Both modes will result in the same calibration factor (CF), but CF is more facile to get in the line sync mode since the calibration signal is easier to identify.

The calibration of the cable length for the TDR is described in section 6.3.4.3.

Divider factor adjustment

The HVM (high voltage meter) option is mandatory to get the correct phase synchronisation with the VLF mode. Therefore, the divider factor (DIV) should also be adjusted. The divider factor can either be read off the coupling unit directly (e.g., CC50/V with DIV=500) or calculated by:

$DIV = \frac{C_c + C_d}{C_c}$ whereas C_c relates to the HV coupling capacitor and C_d to the low voltage capacitor.

For $C_d >> C_c$ applies $DIV \approx C_d/C_c$.

Phase shift adjustment

The ICM*compact* will adjust the phase shift (PH) due to the lower frequency automatically. This calculation requires the nominal divider factor and the low voltage capacitor (C_d) of the coupling unit. These values can be set in the menu "MAIN H" while the synchronisation frequency is set to one of the three VLF's (e.g., "SETUP3"/"SYNC"/">0.1 Hz"). Usually, these values can be found on the coupling capacitor. Using the combined filter-coupler unit TCC, the following table shows the relevant values:

Coupler type	Cd	Divider factor at 50 Hz
TCC25	250 nF	250
TCC30	500 nF	500
TCC50	500 nF	500

Table 3: *Values of coupling capacitors*

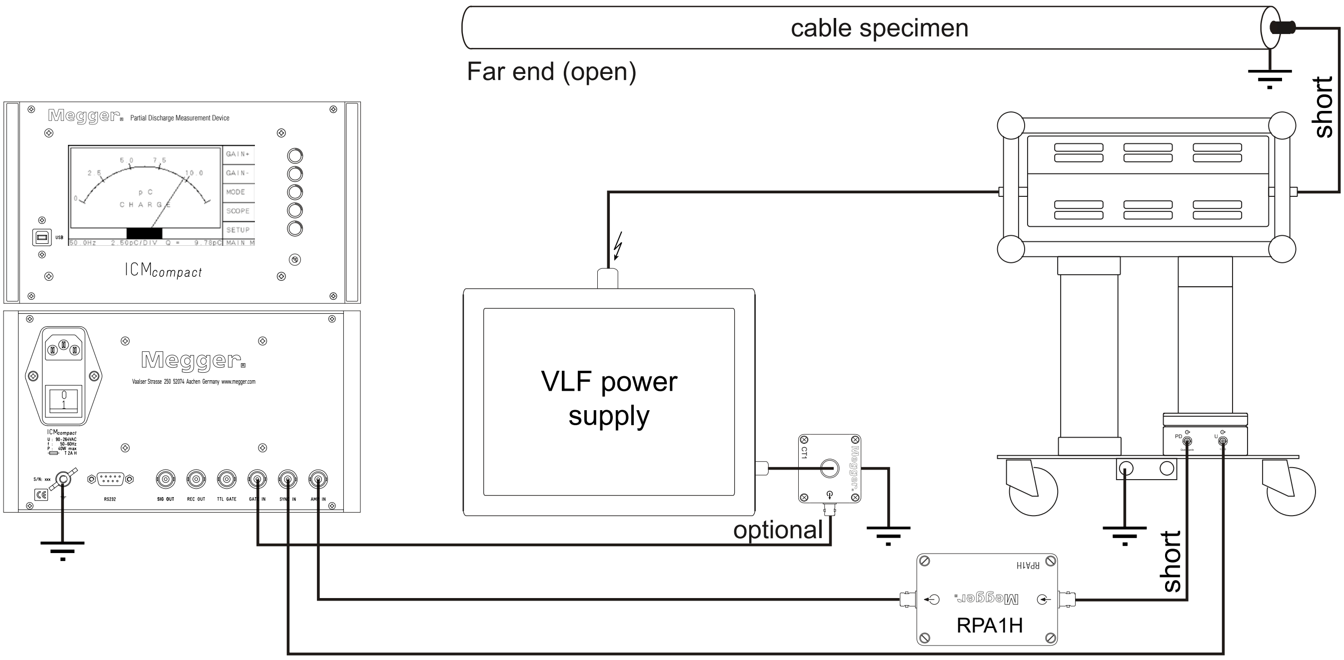


Figure 33: *Example test set-up for a VLF measurement on a HV cable with a TCC filter-coupler-unit*

6.3.4 DSO – Digital storage oscilloscope for time domain reflectometry (TDR) measurements

Instruments with an optional DSO acquisition board for cable fault location are able to process and display PD signals on a time-based curve. Single PD pattern can be triggered and recorded with a resolution of 10 ns (= 100 MSamples/s) and a maximum total display range of 80 µs (with firmware ≤2.16: 60 µs). This results in a maximum cable length of about 5 km (max. measuring time 80 µs and pulse velocity of vC=140 m/µs). Since the LCD resolution is limited to 200 pixels, the data display is compressed. Using the PC software whose name is extended by ‘c’, e.g., ICM*compact* 5.05c, offers full advantage of the high resolution. This software is specialised to locate faults in long cables using the TDR (time domain reflectometry) at the cable terminations.

NOTE : Due to high frequency effects (i.e., attenuation, dispersion) it is not possible to locate partial discharge faults after approximately 3 km. The cable length should be at least 10 m. Also refer to the software description in section 7.2.

6.3.4.1 Measurement principle of TDR with the DSO

The TDR uses the travel time of pulses. Long high voltage (HV) cables behave as a wave conductor. Therefore, a pulse which is generated e.g., by a discharge, travels to both cable ends. If these ends do not have the characteristic impedance of the cable (open ends), the pulse will be reflected to the opposite end. The distance from the fault (pulse source) to the end of the cable is calculated from the time difference (Δt) the two pulses occur at the measured end (coupling unit). Figure 34 shows an HV cable with a fault. The traveling ways of the first three pulses entering the coupling unit are displayed on top.

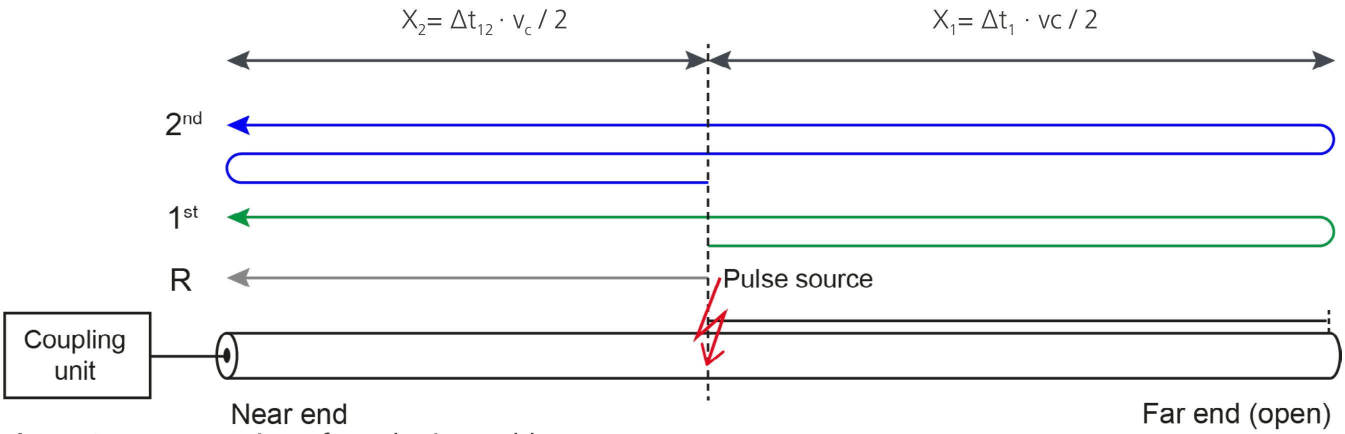


Figure 34: *Propagation of a pulse in a cable*

Figure 35 shows the time diagram of the three pulses entering the coupling unit. The reference pulse (R) travels the direct way to the coupling unit. The first reflection (1st) has travelled the opposite direction and is reflected at the open end of the cable; thus, resulting in a time delay Δt_1 which indicates the distance of the pulse source to the far end.

The second reflection (2nd) results from a reflection of the reference pulse at the near end and thereafter at the far end. The time difference between the first and second reflection (Δt_{12}) indicates the distance of the pulse source to the near end.

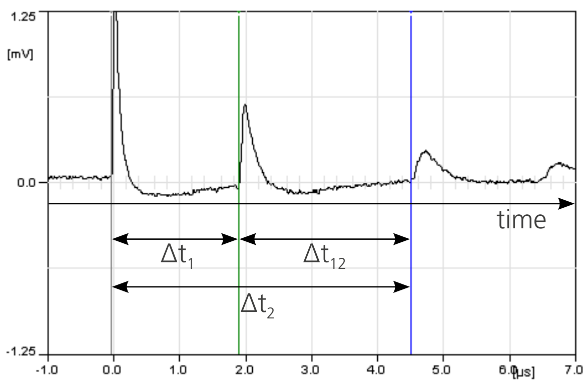


Figure 35: *Time diagram*

6.3.4.2 DSO – Software

The setup for the acquisition of PD pulses in TDR (single PD pulses are observed) has the same principle as for the PD pattern acquisition. A detailed description of this setup is already given with the VLF mode in section 6.3.3, except that the external synchronisation (SYNC) to the HV is not necessary.

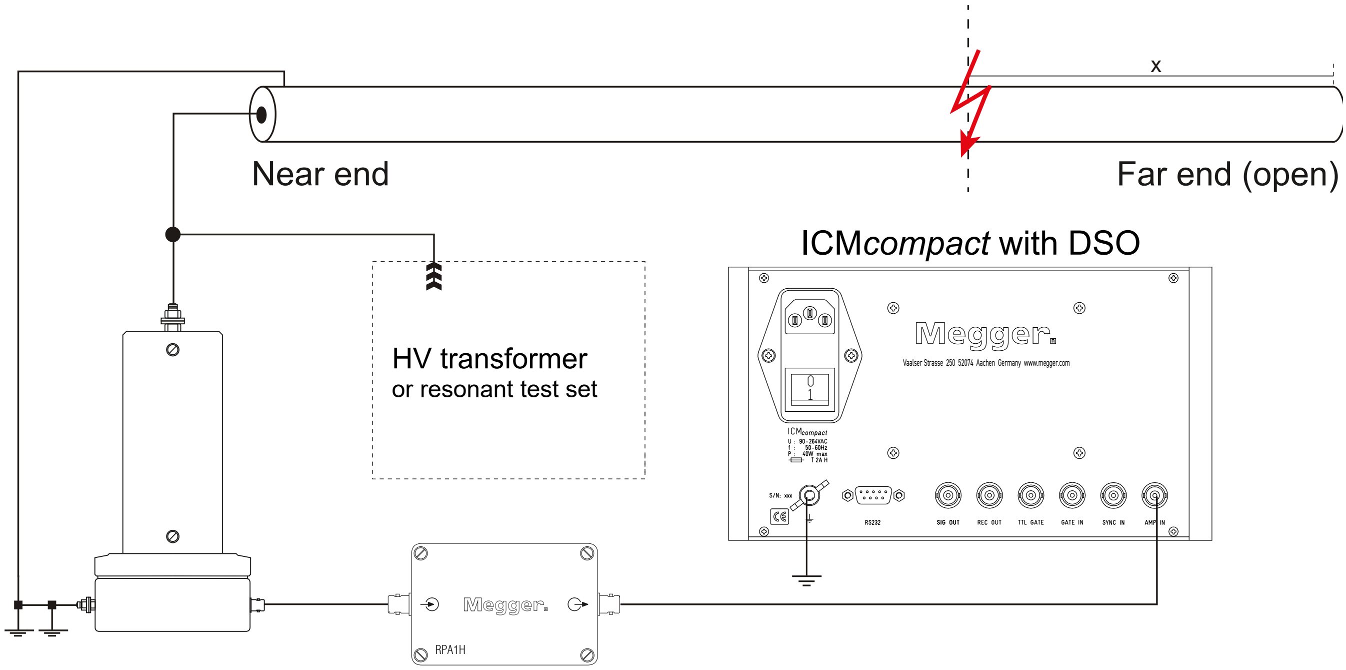
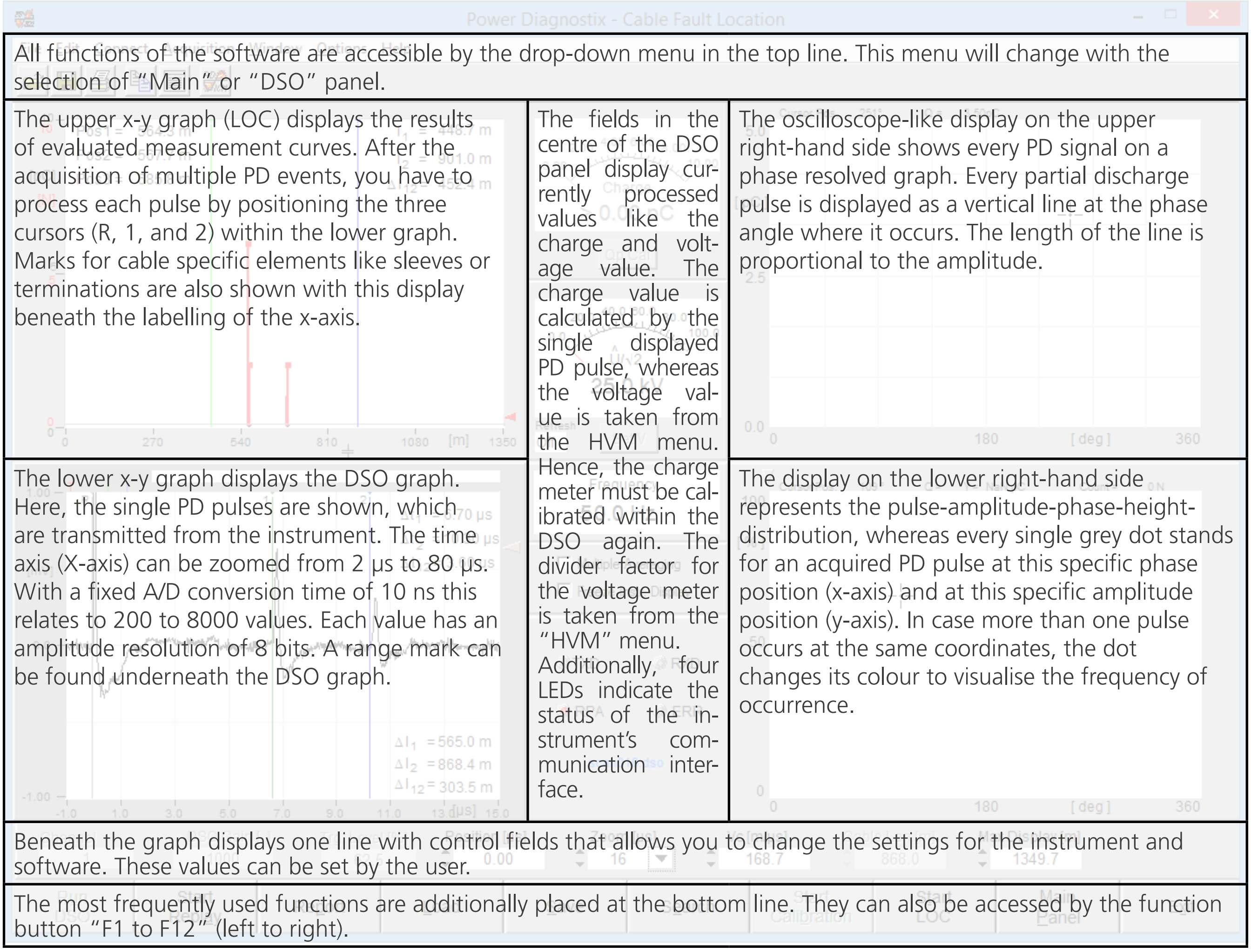


Figure 36: *Example test set up for PD location on an HV cable*

Although the ICM*compact* can be used as standalone instrument for cable fault location, the optional software extension greatly simplifies the acquisition and analysis with the DSO board. For this, each instrument has a USB connector, used to connect to a common PC. To protect the PC, a proper earthing of the instrument is necessary. Additionally, an insulating fibre optical link for the USB is available. There are USB/FOL converters available which can be connected to the COM TTL connector at the rear side. The connector for the COM TTL interface is on the instrument side a 9-pol SUB-D (or 'DE9') **male** plug. This is not to confuse with old serial interface (RS-232) which has had a 9-pol SUB-D **female** plug.

With the first on-line session, the device code of the instrument must be entered in the software. After a successful initialisation of the instrument, the setup values of the instrument are loaded e.g., range, gain, trigger level, cable length, pulse velocity.

The software that comes with the DSO extension has a function button ("F9") labelled "DSO Panel". Push this button to go to the panel for cable fault location. This panel has two x-y graphs.



All functions of the software are accessible by the drop-down menu in the top line. This menu will change with the selection of "Main" or "DSO" panel.

The upper x-y graph (LOC) displays the results of evaluated measurement curves. After the acquisition of multiple PD events, you have to process each pulse by positioning the three cursors (R, 1, and 2) within the lower graph. Marks for cable specific elements like sleeves or terminations are also shown with this display beneath the labelling of the x-axis.

The fields in the centre of the DSO panel display currently processed values like the charge and voltage value. The charge value is calculated by the single displayed PD pulse, whereas the voltage value is taken from the HVM menu. Hence, the charge meter must be calibrated within the DSO again. The divider factor for the voltage meter is taken from the "HVM" menu. Additionally, four LEDs indicate the status of the instrument's communication interface.

The oscilloscope-like display on the upper right-hand side shows every PD signal on a phase resolved graph. Every partial discharge pulse is displayed as a vertical line at the phase angle where it occurs. The length of the line is proportional to the amplitude.

The lower x-y graph displays the DSO graph. Here, the single PD pulses are shown, which are transmitted from the instrument. The time axis (X-axis) can be zoomed from 2 µs to 80 µs. With a fixed A/D conversion time of 10 ns this relates to 200 to 8000 values. Each value has an amplitude resolution of 8 bits. A range mark can be found underneath the DSO graph.

The display on the lower right-hand side represents the pulse-amplitude-phase-height-distribution, whereas every single grey dot stands for an acquired PD pulse at this specific phase position (x-axis) and at 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.

Beneath the graph displays one line with control fields that allows you to change the settings for the instrument and software. These values can be set by the user.

The most frequently used functions are additionally placed at the bottom line. They can also be accessed by the function button "F1 to F12" (left to right).

After launching the program, and at start of the DSO panel, there are two applications possible:

a) On-line measurement for cable testing
   Pushing the "Run DSO" button (or "F1") will start a continuous on-line acquisition. The software displays the acquired curves as quickest as possible. The refresh of the curves is dependent on the transmission rate and the set trigger mode.

b) Off-line use for data evaluation
   To evaluate recorded data, the software should be disconnected from the instrument by pushing the button "Offline". This will disable the "Run DSO" button and change the "Start Scan" button to "Start Replay". Pushing this button opens another window for selecting the stored measurement files. One file displays one fault within the cable. All relevant files should be added and will then be shown in an extra window. Here, two cursors can be set manually to determine the different fault locations. The result of this evaluation is shown in the LOC graph by red bars, relating to the distance and number of faults.

Position

The displayed range of the x-axis can be shifted by the value 'Position' or the scroll bar above the graph, whereas the trigger is always set as zero position of the x-axis and a pre-trigger time of -1 µs is fixed by the instrument. However, while in "RUN" mode, the 'Position' will change this pre-trigger time. In "HOLD" mode or when the instrument is off-line, the 'Position' will change the displayed range but not the acquired data. 'Position' and 'Zoom' will be adjusted in the "HOLD" mode automatically if one value is out of range.

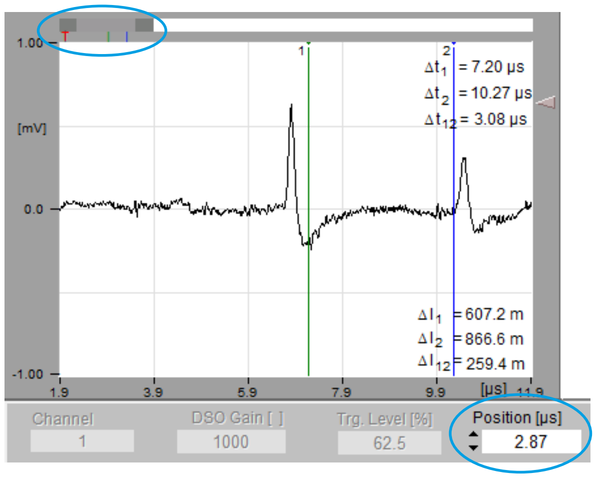


Figure 37: *Screenshot of the DSO graph*

Range/Zoom

While in "RUN" mode, this value defines the total range in µs. This time base should be kept short to avoid unnecessary data transmission between the instrument and the software.

Example: The ideal range for a cable of 1.4 km length and a known pulse velocity of 165 m/µs is between 18 and 20 µs (2 x 1400 m / 165 m/µs = 16.9 µs).

Due to the dispersion within the cable, the time range should be set 10 to 20 % higher than calculated. This will ensure to get the complete reflected signal. The value must be a multiple of 2 µs and cannot exceed 80 µs. The white bar underneath the DSO graph indicates the maximum possible range. The grey bar indicates the currently set range. Within the "HOLD" mode, a light grey bar indicates the displayed range of the measured data.

It is also possible to adjust the 'Position' and 'Zoom'/'Range' by the mouse cursor. The mouse arrow will change to a hand for shifting the position or to a double-headed arrow for changing the range/zoom. The coloured lines underneath the bar (grey, green, and blue) indicate the cursor positions within the DSO graph. The red 'T' stands for the trigger position and is fixed.

Figure 38: *Marking of the range within "RUN" mode and in "HOLD" mode*

The visible part within "HOLD" mode (zoom) can only be part of the acquired data (i.e., zoom ≤ range). Therefore, the range during the measurement should be large enough to be able to zoom during the analysis.

Gain, trigger level

The 'Gain' value defines the total amplification of the high frequent signal. The gain can be set between 1 and 80000 (0–98 dB) in different steps. The trigger level ('Trg.Level') can be set between 0 and 100 %. Both values are only accessible in "RUN" mode. Possible reasons for a lack of a repeating signal on the DSO graph are listed as followed:

- gain level too low: the trigger level is not reached
- trigger level too high: with weak signals, a lower trigger level might be necessary
- no partial discharge activity: even with very high gain only noise signals are triggered-on

A sensible combination of gain and trigger level can be achieved by using a calibrator signal (as described in section 6.5). The trigger level should be set between 50 % and 90 % of the calibration signal. The gain should be set, so that the reflection of the cable end is seen clearly, and the first pulse is not too much overranged. For a subsequent data analysis, it is mandatory to capture at least one reflection.

The arrow button next to the 'Trg. Level' ▼ selects the trigger mode. With the "Auto" mode, the DSO graph is updated continuously, independently of a trigger event. With the "Normal" mode, only triggered signals are

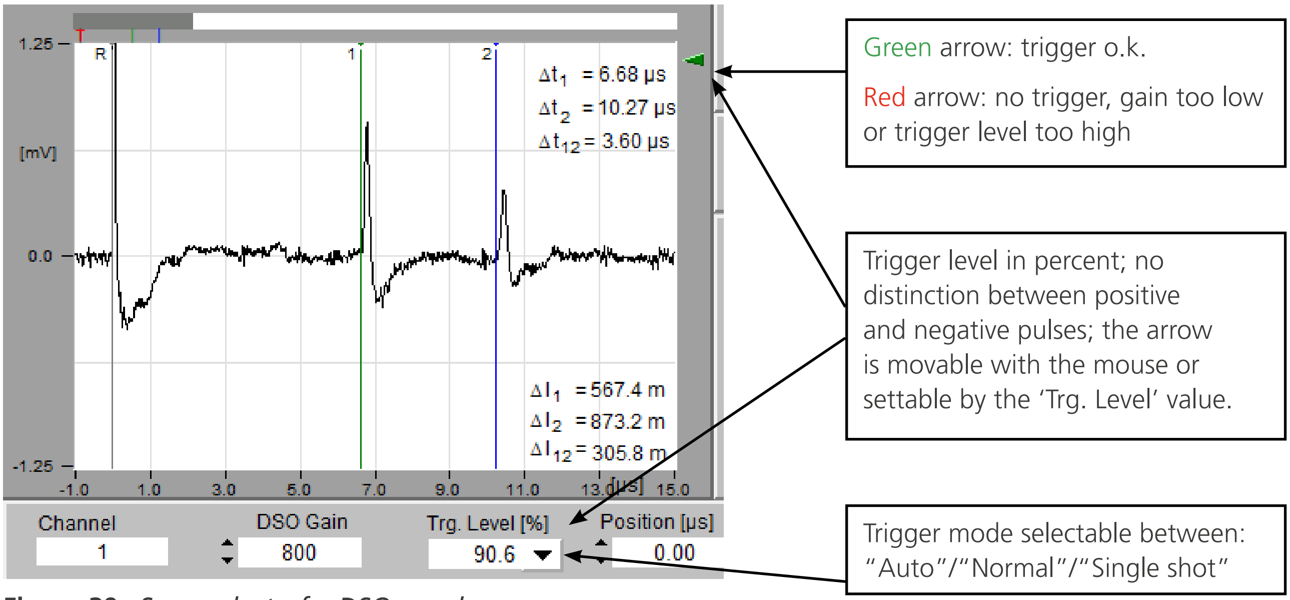


Figure 39: *Screenshot of a DSO graph*

displayed. With the "Single shot" mode, just one trigger event is shown (the first possible) then the software turns to the "HOLD" mode.

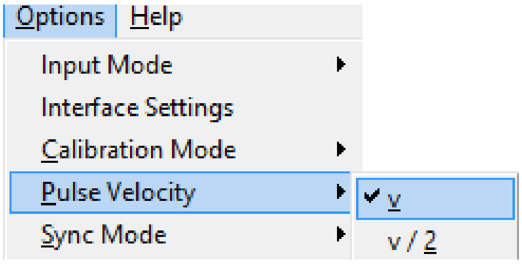
Max. display

This value limits the indicating range of the x-axis within the LOC graph. It is possible to choose a value greater than the cable length, however a sensible range is limited by the 'Range' and the pulse velocity. The maximum acquired length can be calculated by:

$$\text{Max. display} = \frac{v_c \cdot \text{Range}}{\text{max}^2}$$

Calibration of the cable length

The values for the cable length and the pulse velocity can be entered in the fields directly, if known. If only one value is known, the second value can be determined with a calibration measurement.



The selection of the calibrated value is done in the menu of the DSO panel: Options / Calibration Mode / Length.

If the pulse velocity of the cable type is known, it can be entered in the related field. The cable length can then be calibrated by injecting an impulse at preferably the near end of the cable.

For this an impulse generator (CAL1A, CAL1B, or equivalent) must be connected to the coupling unit. During the calibration the high voltage must be turned off, otherwise the impulse generator might be damaged. To get continuously new curves on the graph, the software must be connected ("Online") and set to the "RUN" mode. While injecting a pulse with the calibrator, the gain and the trigger level should be adjusted so that a triggered pulse is seen. The range should be adjusted in the way that the first reflection of the pulse at the cable head is seen clearly.

The grey cursor labelled "R" can now be placed at the beginning of the first pulse, which is around 0.0 µs (see Figure 40). The blue cursor labelled "2" should be placed at the beginning of the first pulse reflection from the cable head. The green cursor ("1") is not used during the calibration. Now the "Start Calibration" button (or "F7") should be pressed. After selecting a suitable folder and number of files to be recorded (usually one is sufficient), the record starts. Each triggered curve is saved in a separate *.dso file, and the position of the blue cursor ("2") within this graph is transferred to the LOC graph (right) and summed up in the red bars. Finally, the calibration files can be saved together with further information about the specimen ("Report") in a *.cfl file. After the acquisition has finished, the cable length is automatically calculated by the entered velocity ("Vc") and the tallest red bar.

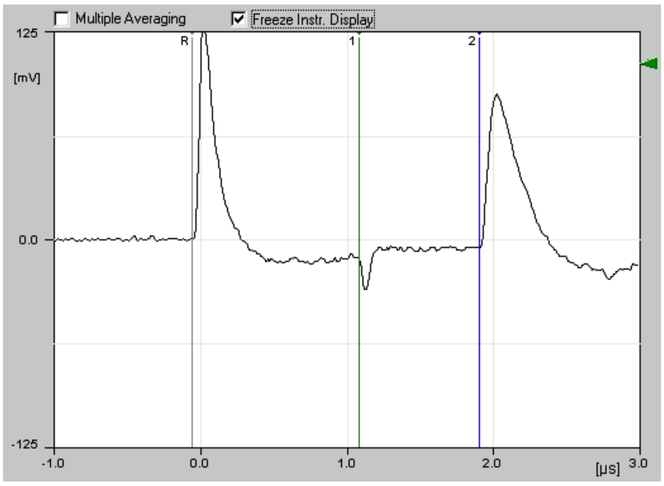


Figure 40: *Cursor positioning for length calibration*

Calibration of the pulse velocity (Vc)

If the cable length is known, the pulse velocity can be calibrated. This calibration should be done as described above. With a double click of the left mouse button at the position of the red bar, a new window pops up. By entering the precise cable length into this window, the pulse velocity will be calculated automatically.

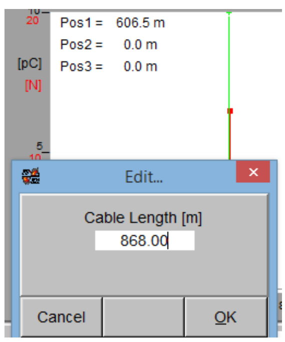


Figure 41: *Vc calibration*

Calibration of the charge value (Qp Cal)

The button “Qp Cal” within the charge meter allows calibrating the current DSO curve. The entered PD value will be assigned to the area underneath the triggered pulse. Thus, this charge value represents the single displayed curve, whereas the charge value shown in the “Main” panel represents the peak charge value since the last data refresh.

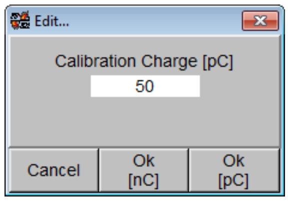


Figure 42: *Qp calibration*

Description of the functions

The function keys at the bottom of the window offer the major functions needed for a cable fault location. In the following, these are described in detail as well as the different conditions of the program. Active function keys are marked with dark grey. The keys are labelled with the function that will start when pressed. They are not showing the current state of the program. E.g., if the program is in the “HOLD” mode, the first key (“F1”) is labelled “RUN”. By pushing this button, the program will begin the “RUN” mode (start the acquisition), and the button is then labelled “HOLD”. Without a serial connection to an instrument, the program cannot perform the “RUN” mode.

Figure 43: *Off-line (instrument not connected)*

Figure 44: *Off-line, replay function started*

Figure 45: *On-line, in “RUN” mode*

Figure 46: *On-line, in “RUN” mode with scan and calibration function started*

Run/Hold DSO (F1, Ctrl+u, or Ctrl+o)

The program has two states for the DSO graph. With the first state “RUN”, the program takes continuous data from the instrument. Depending on the trigger mode, the DSO graph is updated continuously as well. Push the arrow ▼ next to the “Trig. Level” field to select one of the following trigger modes:

- With the “AUTO” mode selected, each transmitted curve is displayed.
- With the “NORM” mode selected, only triggered curves are displayed.
- With the “SINGLE” mode selected, only the first triggered curve is displayed, then the program turns into the “HOLD” mode.

The “HOLD” mode always displays the last triggered curve or the last file which was loaded. The program must be in “HOLD” mode to start replaying recorded data.

Start/Stop Replay, Start/Stop Scan (F2, Ctrl+A)

The second function key ("F2") changes its function depending on the program status. There, you find the most important functions for data acquisition ("SCAN") and evaluation ("REPLAY"). The "SCAN" function can only be used if the software has an on-line connection to the instrument. While off-line, the "REPLAY" function is available. Both functions are closely linked.

The SCAN function saves measurement data in different files. These files will have the extension '*.dso' and can be loaded and processed later while the software is off-line. The .dso files contain only raw data to minimise the memory requirements.

After the SCAN function is started, a window like the one shown in Figure 47 pops up. The entry "Data Directory" defines the destination folder where all recorded files are stored. It can either be entered manually or chosen from the existing folder structure by the button "Browse". The entry "File Prefix" defines the name of the data files. The later file name is put together from the entry in "File Prefix", the chosen 'phase' name, a consecutive number, and the extension '.dso'. The quantity of files recorded can be set in the "Max. File Number" field. A value between 1 and 1000 can be chosen. The option "Scan non triggered" allows you to save files that are not generated by a trigger event of the pulse. This option might be helpful, if heavily distorted signals are present and a firm triggering to dominant PD pulses is not possible. With this option, randomly taken data is recorded and analysed later. For this, the 'range' should be long enough to search for PD pulses and their reflections within the data stream. The acquisition is started by the "Ok" button and stopped by the "Cancel" button or if the number of files is complete.

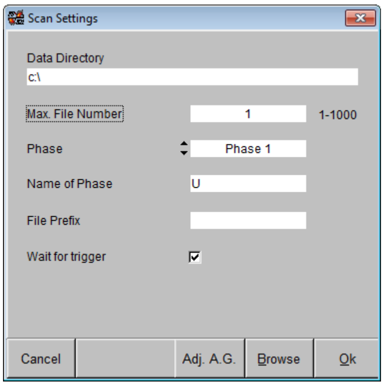


Figure 47: *Settings entry window*

The "Replay" function can only be started if the instrument is off-line. It will open a sub-window in which the scanned data files can be selected. It must be pointed out that only data with the same time-range should be selected at once.

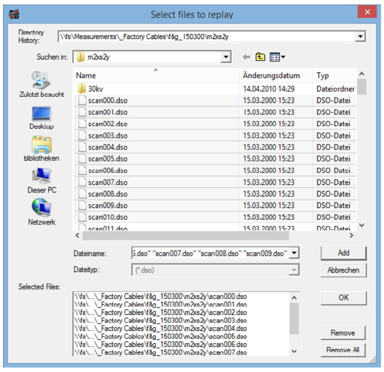


Figure 48: *File selection window*

After confirming the selection with the "OK" button, a new sub-window opens. Here the recorded graphs are shown one after the other together with two cursors. The path and filename of the current displayed graph is shown in the upper right-hand corner. Now you can place the grey cursor at the base of the trigger-pulse around 0 µs). The red cursor should be placed at the base of the first reflection of that pulse. "Select" will take this cursor interpretation, save the cursor positions, and put one red bar into the LOC graph of the main window. If there is already a red bar at that position, it will increase the length (number) of this bar. "Select All" will take the saved cursor positions of all selected files and add the results to the LOC graph in the main window. This should only be done if an interpretation of the graphs was already done and saved in the *.dso files. "Skip" will ignore the displayed graph and move to the next selected one without action. "Back" moves back one selected graph and deletes the last result in the LOC graph, e.g., to correct a misinterpretation. "Delete File" will remove the displayed file from the disc. With "Save File As", the current file can be copied and renamed. "Cancel" stops the whole replay function.

Each selected file is automatically counted in the LOC graph. The position of the red cursor determines the marking of a defect within the LOC graph.

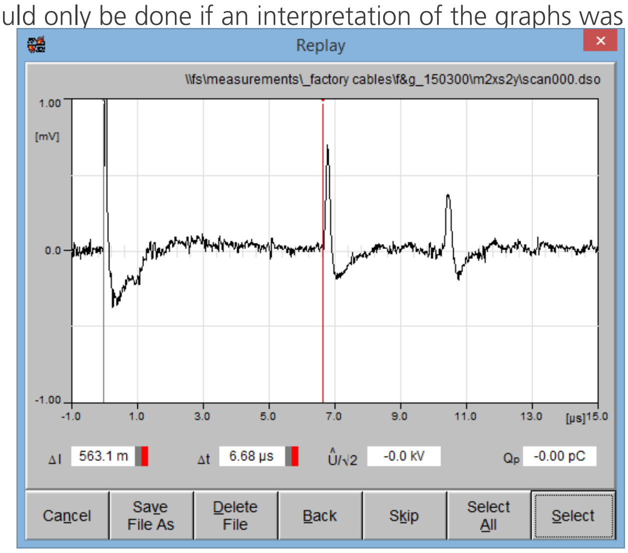


Figure 49: *Replay window for data analysis*

Report (F3, Ctrl+R)

This report is saved together with each cfl file created by the “Save” (“F5”) function. It allows you to add comments and further information to the measurement data. The report will be printed and exported to text-files. “Set Date & Time” places the current PC time into the related entries. “Load Report” allows you to change the *.dso graph which is saved together with the report data. “Edit Accs” (Edit Accessories) opens a further sub-window where the “List of Accessories” can be changed. They are also saved with the cfl file. With the “Browse Data Dir” the destination of the cfl file can be changed. “Export” will save the report data as a standard ASCII file (*.txt).

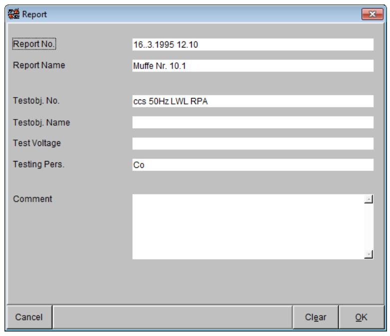


Figure 50: *Report entry window*

Load (F4, Ctrl+L)

In the off-line mode, saved files can be loaded and displayed. Both types can be loaded, the pure scanned graphs (*.dso) and the project files (*.cfl). The project files contain the last displayed DSO graph together with the setup information of the instrument, the report entries, as well as the fault location within the LOC graph.

Save (F5, Ctrl+S)

Saves the currently displayed data in a cfl file.

Search/Offline (F6, Ctrl+E)

This function connects or disconnects the link to an ICM*compact* instrument. During the connection all selected ports are scanned for possible instruments. This are by default the ports COM1 and COM2, however up to 16 COM ports as well as GPIB and virtual LAN ports can be selected. The selection can be changed in the MAIN Panel in the “Options/Interface Settings“ menu to RS232, GPIB, or LAN. During the program launch and when changing the panel, the search function is activated automatically.

Start Calibration (F7, Ctrl+B)

This function calibrates either the cable length or the pulse velocity. A detailed description is given on page 56. The calibration of the charge magnitude is done by the “Qp Cal” button within the “Charge” meter, whereas the voltage magnitude can be adjusted by the “Divider” button within the voltmeter.

Start LOC (F8, Ctrl+T)

This function starts the fault location (LOC/Location). To activate the automatic mode, the option “Options/LOC Graph/Calculations/Auto” must be selected. The processing of the measurements is based on the correlation frequency distribution and the results are shown in the right-hand graph (LOC graph). Each triggered curve which can be seen in the DSO graph is put into correlation with a reference pulse. This reference pulse was prior artificially ‘aged’ i.e., the dispersion of the cable was already taken into account. After the correlation, the maxima are put together in a three-dimensional field. With an increasing measuring time, the reflection position will show accumulation points. The sum of this accumulation points within on segment of the x-axis are pictured by red vertical bars, also called projections, within the LOC graph. But only points which exceed the set level are considered. This level can be seen as red arrow next to the LOC graph.

The most frequent maxima (also called peak distribution) are indicated as faulty positions underneath the LOC graph next to “Pos1”...3. Via the menu “Options/LOC Graph” different results can be shown or disabled. Two cursors can here be activated to “measure” distances. The results of the cursor distances are shown underneath the LOC graph. The sensitivity for the projections (red bars) can be adjusted as well.

The LOC function is automatically started with the replay of saved measurements. It must be pointed out, that the counting within the LOC graph starts from the far end. The display range for the x-axis (“Max. Display”) should always be larger than the cable length, otherwise faults can be overlooked.

NOTE : The automatic analysis of the curves (correlative peak distribution) should not be the only criterion for the fault location. To verify the results, the original DSO curves, the installation plan, and the impact of disturbances should be taken into account!

If the software is off-line, the “Start LOC” button will start the manual fault location as does the button “Start Replay“.

Main Panel (F9, Ctrl+P)

This button changes the instrument back to the PD mode, the software will also change its acquisition mode. One brief interruption during this switch is usual.

Exit (F10, Ctrl+X)

The program is terminated by the “EXIT” button.

Menu Options

Some additional functions are accessible via the menu block at the top of the program window. The following describes those functions of the menu block that are not accessible within the main user interface.

With the buttons “PgUp” and “PgDown”, the next respectively previous DSO file can be loaded from the current folder. The program has to be in the off-line mode. A brief message will give a warning if no DSO file can be found in the selected folder.

The function “Export Results” will put the calculated fault positions, shown in the LOC graph, into an ASCII text file. The “Report” data is also added.

With the function “Default Directory”, a folder can be selected which is automatically opened with the “Load” or “Save” function.

The menu “Edit” offers functions like “Copy DSO”, “Copy LOC”, and “Copy DSO+LOC” to put one or both graphs into the Windows clipboard. From here, they can easily be exported into other programs using the “Ctrl+V” buttons.

The basic settings for a scan can be changed without starting a scan, or even being on-line, using the “Scan Settings” menu.

The “List of Accessories” is a helpful tool to add information into the LOC graph. In here, cable accessories like sleeves, junctions, or terminations can be added and will be shown as small icons within the LOC graph.

The pull-down menu ‘ Acquisition’ repeats functions, which are already described on the previous pages.

The LOC graph on the right-hand side can be disabled to enlarge the DSO graph. This is helpful, especially with long cable specimen to get a better resolution for the positioning of the measurement cursor. By default, the ‘DSO+LOC’ is set to see both graphs.

The ‘Pulse Velocity’ (propagation speed of electrical signals within the cable) can be displayed as absolute value ‘v’ or as halved value ‘v/2’.

The units of length and speed values can be switched between the ‘SI-System’ (MKS = meter, kilo, second) and the ‘fps-System’ (= feet, pound, second).

If the “Sliding Average” is “on”, multiple acquisitions of the DSO graph are averaged before they are displayed. For this, it is necessary to always trigger the same fault signal.

The “Trigger Mode” allows selecting “Auto”, “Normal”, and “Single Shot”. This mode affects the repetition of the acquired graphs.

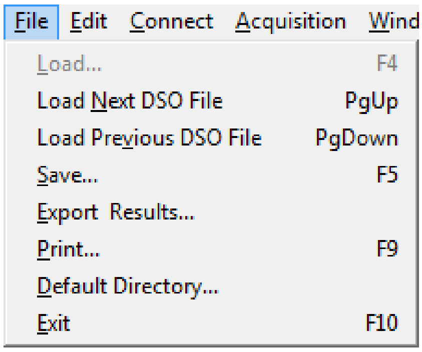


Figure 51: *Drop down menu “File”*

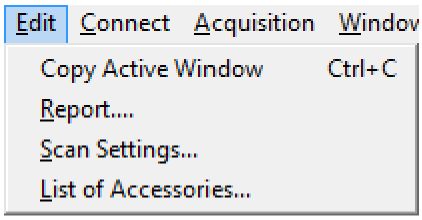


Figure 52: *Drop down menu “Edit”*

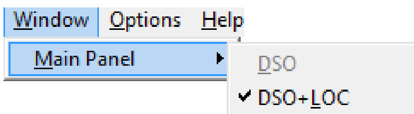


Figure 53: *Drop down menu “Window”*

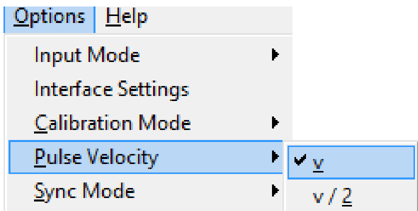


Figure 54: *“Options/Pulse Velocity”*

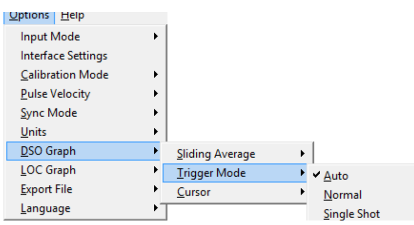


Figure 55: *“Options\DSO Graph”*

The cursor within the DSO graph can be hidden "off" or shown "on", so can the cursor within the LOC graph.

Most of the settings refer to the LOC graph.

The analysis of the LOC graphs (LOC Graph/Calculations) can be done automatically or manually. However, if the graph is more complex, it is recommended to do a manual analysis to avoid misinterpretations.

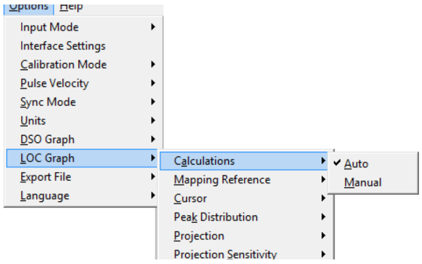


Figure 56: *"Options\LOC Graph"*

By the physical properties of TDR, the cable measurement always starts from the far end, i.e., the opposite end with no sensor. Therefore, the default display also measures and shows the results from the "Far End". However, the "Mapping Reference" can be changed to start with the "Near end". This will be indicated by a capacitor symbol as sensor at the zero position of the cable.

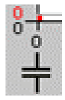
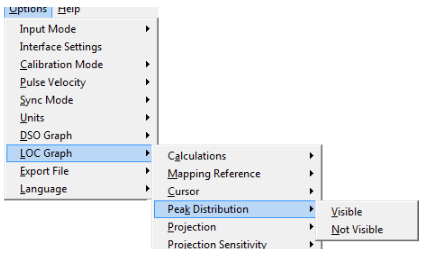


Figure 57: *Coupling capacitor symbol*

The "Peak Distribution" shows each measurement result by a small 'x'. This function can be enabled ("Visible") or disabled ("Not Visible").



The "Projection" (red bars) indicates the quantity of measured faults at one cable position. They also can be shown ("On") or hidden ("Off").

The "Projection Sensitivity" defines a kind of summation. Depending on the setting "High", "Medium", or "Low", the segments in which the peak distribution is summed up as one red bar can be changed. A "High" projection sensitivity results in small segments which will increase the total number of red bars and decrease the number of counts.

When exporting the data from the LOC graph and the report entries, the selection "Export File" allows you to suppress pulses from the cable ends ("Suppress End Reflections"). This is helpful if you are only interested in faults within the cable and you don't want to see pulses from the cable terminations.

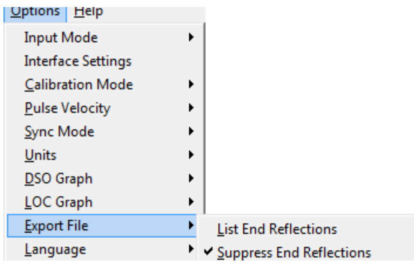


Figure 58: *"Options\Export File"*

With "Language", the inscription of the software, as well as in the report files, can be changed between English, German, and Spanish. Some shortcuts used with "ALT+..." will also change. Generally, the underlined letter on a function button can be used on a keyboard as a shortcut. Outside the drop down menu, the "ALT" button has to be pressed while also pressing the shortcut letter on the keyboard. Within the drop down menu, the underlined letter can be pressed directly to jump into the specific function.

6.3.4.3 Calibration for the TDR

Before raising the voltage on a cable for the location of PD, a TDR snapshot is done for calibrating the PD magnitude. This can also provide information on the length of the cable, locations of joints, condition of the neutral wire, and the level of sensitivity you can expect to obtain with PD measurements. For the calibration, following calibrators are recommended:

XLPE (polymeric cable)	⇒ **CAL1B** (0.1 to 10 nC)	or **CAL1D** (10 to 1000 pC)
Mass impregnated cable	⇒ **CAL1B** (0.1 to 10 nC)	or **CAL1E** (1 to 50 pC)
Laboratory measurements	⇒ **CAL1A** (1 to 100 pC)	

A list of all available calibrators can be found in section 6.5.1.

CAUTION : For the calibration, the system must be de-energised.

With the cable de-energised, the calibrator has to be connected to the conductor and neutral by two short leads at the near end of the cable (see Figure 59). After increasing the gain of the ICM*compact,* the magnitude of the calibration pulse should be increased until the pulse reflections are visible. Either the pulse velocity (v_c) of the cable or the cable length can be determined by the instrument or the software.

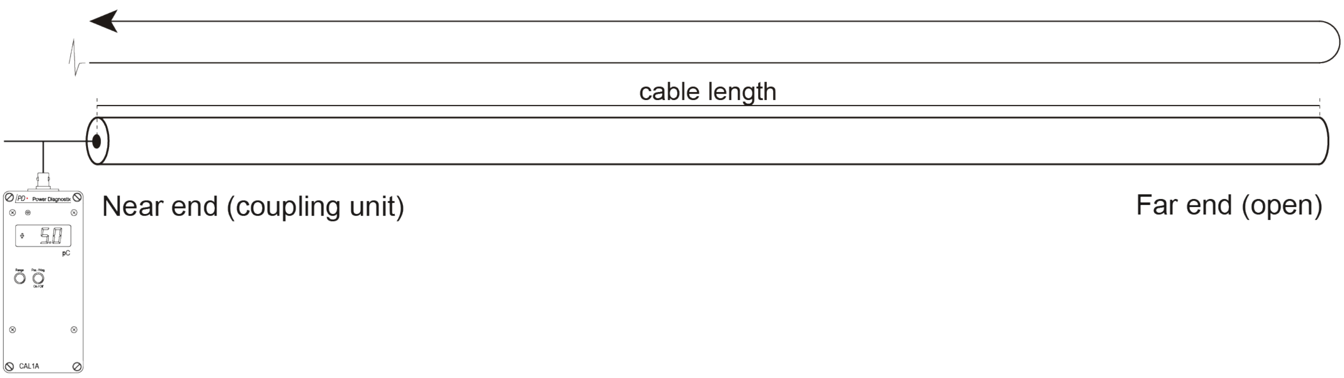


Figure 59: *Connection of the calibrator*

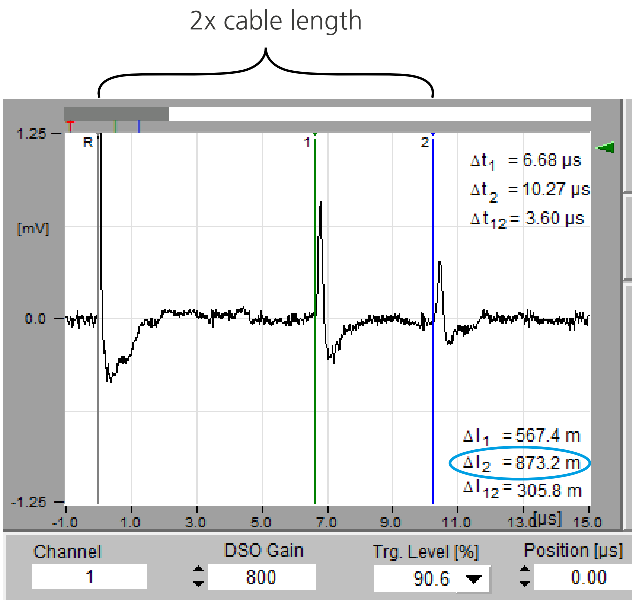


Figure 60: *Time diagram from the ICMcompact software*

In the example given in Figure 60, the pulse velocity (v_c = 170 m/ms) was inserted. After the two cursors were positioned, the cable length (Δl_2 = 873.2 m) was calculated (The factor of 2 is automatically computed and does not need to be considered).

It is also possible to calculate the pulse velocity if the cable length is known.

6.3.4.4 Measurement example with the TDR

The next figures show measurement examples of a cable having a cable joint. In Figure 63 on page 64 a joint was detected at 305.8 m, measured from the far end.

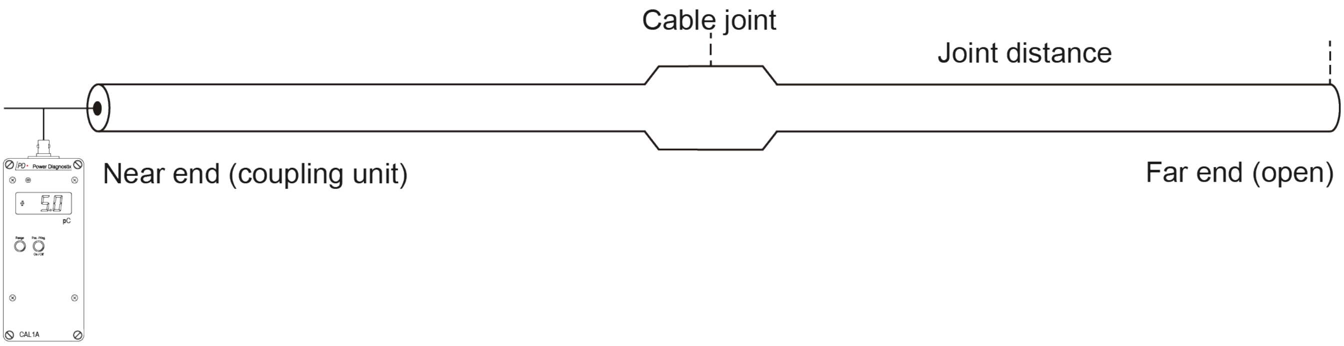


Figure 61: *Joint location*

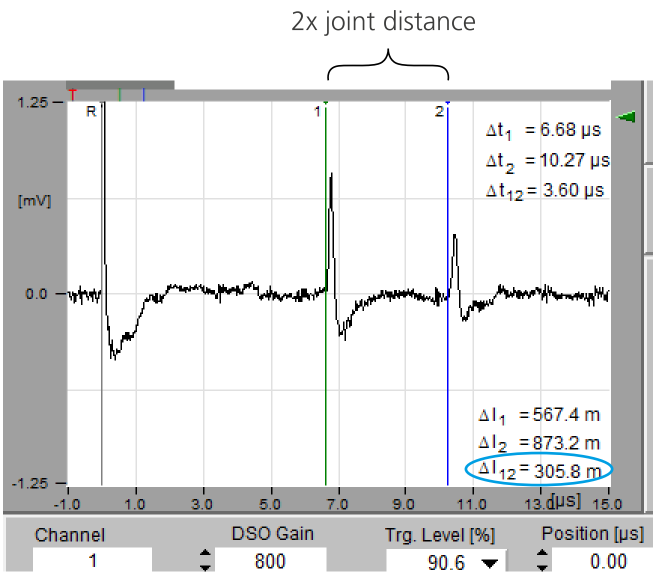


Figure 62: *Joint location on a cable*

Once the cable length has been specified and the joints are located, the cable can be energised. Figure 64 shows a measurement with one fault at 567.4 m taken from the far end. Consider that the distance is now taken between the first and second cursor (grey and green) but not between the first and third (grey and blue), as it was during calibration.

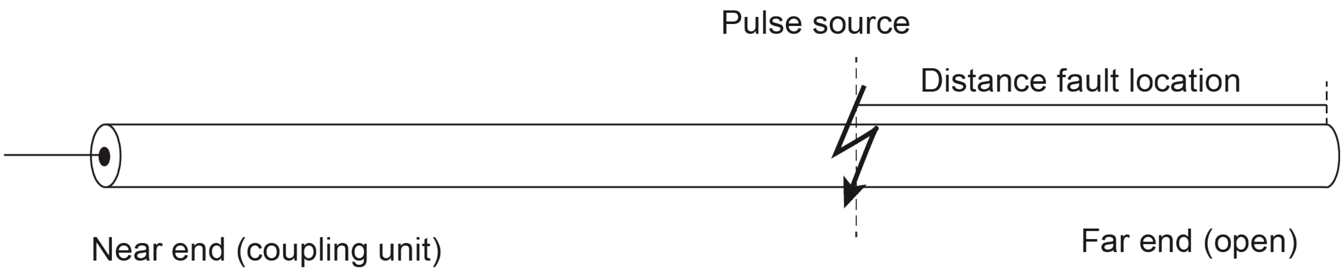


Figure 63: *PD location on a cable*

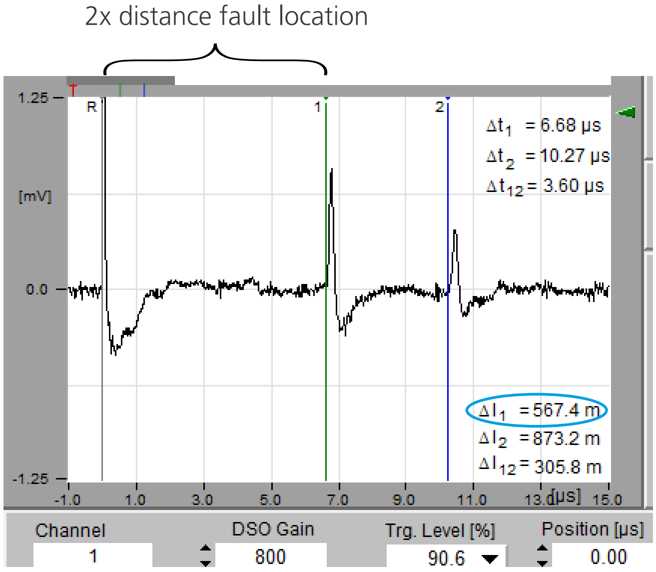


Figure 64: *Time diagram of a PD location*

6.3.4.5 Functions for the DSO

To get a proper PD pulse, the gain and trigger values must be set correctly. These factors are independent from the calibration factor described in section 6.5.3. Figure 65 shows an example of a triggered PD pulse with all its echoes taken from an HV test cable. Setting the trigger level and the amplification can be done in the submenus “GN/TRG” resp. “TRGLVL”, which can be found under the main menu “MAIN D”. The gain has to be increased until a trigger event occurs. Pushing one of the two gain buttons (GAIN+/GAIN-) will display the absolute gain value at the upper right border of the screen for a short moment (provided a pre-amplifier is connected). The gain can be set from 2 to 80000 in 17 steps. With a very high amplification, the trigger level reaches the range of the input noise. The trigger level should be set between 50 and 90 % of the y-axis range. Pushing the trigger buttons (TRG+/TRG-) in the “TRGLVL” submenu will display the trigger level as a horizontal line for about three seconds. The trigger makes no difference between positive or negative pulses, it is an absolute value. For better evaluation it is necessary to see the area in front of the trigger pulse. This pre-trigger is fixed to 1 µs (100 samples).

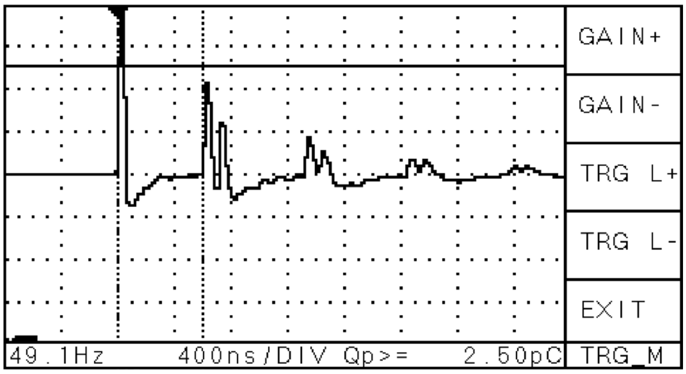


Figure 65: *Set trigger level*

For cable fault location, it is mandatory to use a pre-amplifier with a high bandwidth. Megger offers for this application the pre-amplifier RPA1L or RPA1H (40 kHz to 20 MHz). The higher bandwidth is necessary to measure the pulses and its reflections running over the HV cable without attenuation and distortion of the pre-amplifier. The time distance of the pulses is the decisive criteria for the location. Parameters like pulse velocity or cable length will be needed to precisely calculate the fault position within the cable. These settings can be changed with the menus “SPEED” or “LENGTH”. You can select between the measurement units ‘meter’ and ‘feet’ within the menu “UNIT”. This submenu can be entered via the menu “MODE D”.

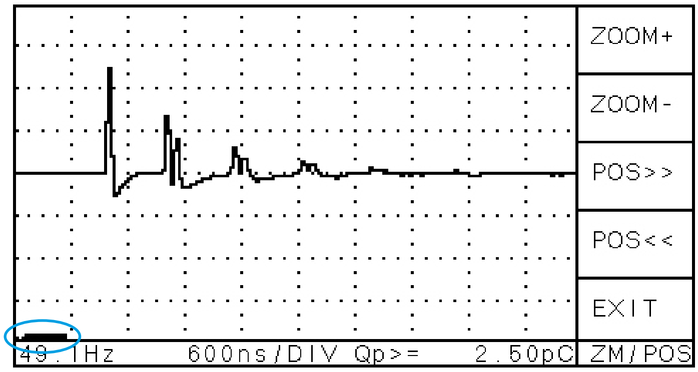


Figure 66: *Indicator for the displayed area*

After setting the correct trigger and gain, the PD pulse becomes visible. The triggered pulse and two reflections should be displayed before going on with further evaluations. Adjust the zoom if too few or too many reflections are visible.

After a single PD pulse has been captured and is held (menu “MAIN D”, “HOLD”), the current display can be zoomed. Each step of zooming (“ZOOM+”/“ZOOM-”) will increase or decrease the visible part by 2 µs (200 Samples). The black stripe at the lower side of the display illustrates the relation of visible time to the total acquired time of 80 µs (60 µs). Shifting the left position of the visible area by pushing the buttons “POS>>” or “POS<<” enables you to analyse the complete wave in a high resolution.

The easiest way to evaluate the pulses is using the cursor functionality for the display. Two cursors are supported. Each of them can be set individually to a time position by pushing the buttons "=POS>>" or "POS<<" within the menu "CURSOR". Push the upper button ("CURS1" or "CURS2") to select the respective cursor. The active cursor is always marked with a black filled triangle at the upper end of the vertical dotted line. It is best to first hold the running acquisition before setting the cursors. Moving the cursors will automatically calculate the new time distance and the result for the distance in meter (feet). These values can be read off from the upper border of the display. The distance on the HV cable is measured beginning from the far end of the measurement point (also see section 6.3.4.1). A sensible result can only be ensured if the pulse velocity is set correctly.

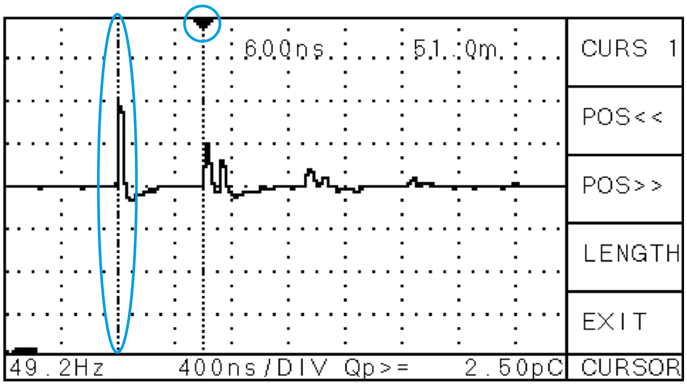


Figure 67: *Cursor measurement on a PD pulse*

The pulse velocity can be calculated if the cable length is known. For this, a calibration impulse has to be injected into the near end of the cable.

CAUTION : Caution: For calibration, the HV supply must be turned off!

Once the trigger is set to the first (largest) pulse, the echoes become visible. Setting one cursor to the first pulse and the other to the second pulse will read the calculated cable length. Within the menu "LENGTH" the precise cable length can be set. The pulse velocity is then calculated automatically using the settings of the cursors which are displayed at the upper right-hand side.

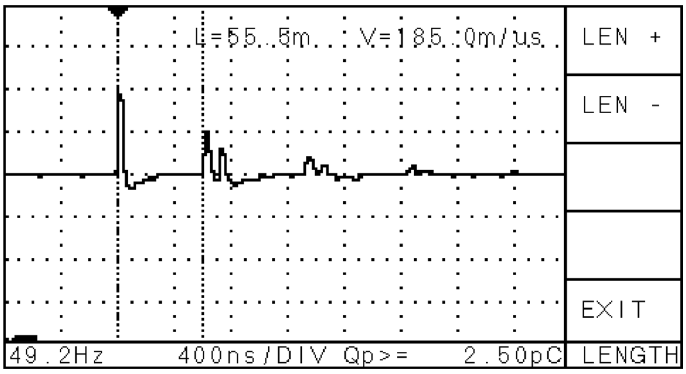


Figure 68: *Cursor settings: Length and velocity*

Another possibility to get the specimen settings is to modify the pulse velocity directly. This can be done in the menu "SPEED", which is accessible from the menu "MODE D". This function is useful if the cable length is not known, but the type of cable is. A calibration is not obligatory.

6.3.4.6 Key menus for the DSO

The following menus are accessible with an ICM*compact*, including the DSO for cable fault location:

GN/TRG
RUN/HD
MODE
SCOPE
SETUP
MAIN D

GN/TRG
Push this button to go to the submenu "GN/TRG". Within that menu you can set the gain, trigger level, and trigger mode for the PD display in time domain (DSO display).

RUN/HD
Push this button to go to the submenu "RUN/HD".

MODE
Push this button to go to the submenu "MD D1". This submenu gives access to several settings of the DSO display, such as zoom, position, and cursor settings.

SCOPE/METER
Depending on the switched-on displays (see menu "DISPL") this function switches to the next display type.

SETUP
Push this button to go to the "SETUP" menu. As there are several setup menus, this function enters ever in the last setup you've been once before.

GAIN+
GAIN-
TRGMOD
TRGLVL
EXIT
GN/TRG

GAIN+/GAIN-
Pushing this button increases or decreases the total gain (details see above). These settings are independent from the gain settings in the menus "SCOPE" and "METER".

TRGMOD
Push this button to go to the submenu "TRGMOD".

TRGLVL
Push this button to go to the submenu "TRGLVL".

EXIT
Push this button to go to the "MAIN D" menu.

SINGLE
>NORM
AUTO
EXIT
TRGMOD

SINGLE
Pushing this button sets the "SINGLE" trigger mode. In this mode, only the first triggered curve is displayed, then the instrument switches to the "HOLD" mode.

NORM
Pushing this button sets the "NORM" trigger mode. In this mode, only triggered curves are displayed.

AUTO
Pushing this button sets the "AUTO" trigger mode. In this mode, each measured curve is displayed.

EXIT
Push this button to go to the "GN/TRG" menu.

TRG L+
TRG L-
EXIT
TRGLVL

TRG L+/TRG L-
Pushing this button displays and changes the trigger level. More details are described above.

EXIT
Push this button to go to the "GN/TRG" menu.

RUN
>HOLD
MEM+
MEM-
EXIT
RUN/HD

RUN
Activates/deactivates the “RUN” mode for the DSO display.

HOLD
Activates/deactivates the “HOLD” mode for the DSO display.

MEM+/MEM-
Pushing this button toggles through the records of last 16 trigger events.

EXIT
Push this button to go to the setup menu “MAIN D”.

ZM/POS
CURSOR
SPEED
MORE..
EXIT
MD D1

ZM/POS
Push this button to go to the submenu “ZM/POS”. Within that menu you can set the zoom and the zero position for the DSO display.

CURSOR
Push this button to go to the submenu “CURSOR”.

SPEED
Push this button to go to the submenu “SPEED”.

MORE..
Push this button to go to the menu “MD D2”.

EXIT
Push this button to go to the setup menu “MAIN D”.

ZOOM+
ZOOM-
POS>>
POS<<
EXIT
ZM/POS

ZOOM+/ZOOM-
With these buttons the zoom can be adjusted.

POS>>/POS<<
With these buttons the displayed position can be adjusted. More details are described above.

EXIT
Pushing this button takes you to the setup menu “MODE D”.

CURS 1
POS>>
POS<<
LENGTH
EXIT
CURSOR

CURS 1, CURS 2
Pushing this button toggles between the two cursors. The selected cursor is indicated by a black filled triangle at the upper end of the dotted cursor line.

POS<</POS>>
Pushing these buttons will shift the selected cursor to the corresponding side. If the cursors are out of the display, push “POS<<”, “POS>>”, or increase the value of “ZOOM-”.

LENGTH
Push this button to go to the menu “LENGTH” for setting up the cable length.

EXIT
Push this button to go to the menu “MD D1”.

LEN+
LEN-
EXIT
LENGTH

LEN+/LEN-

Push this button to go the setting for the cable length. The calculated value for the distance between the two cursors can be set accordingly. This will also alter the pulse velocity. Refer to the calibration procedure described above.

EXIT

Push this button to go to the menu "CURSOR".

SPEED+
SPEED-
EXIT
SPEED

SPEED+/SPEED-

Push this button to go the setting for the pulse velocity. This value is used to calculate the distance of the cursors.

EXIT

Push this button to go to the setup menu "MD D1".

6.3.5 RIV - Radio interference voltage (RIV) measurement

The RIV mode is for the measurement of 'Radio Interference Voltage' according to NEMA 107-1987 and other relevant standards. In this mode, the bandwidth is fixed to 9 kHz. Technically, it is a selective µV-meter. However, the meter reading is weighted according to the CISPR weighting curve, whereas the repetition rate has a strong impact on the reading. The calibration of the RIV mode is done with the one of the calibrators from Megger's CAL3x series.

6.3.5.1 RIV calibrators

Megger offers three different models of calibration signal generators for RIV measurements: the CAL3A, CAL3B, and CAL3D. CAL3A and CAL3B have a 50 Ω output impedance, as needed for calibration according to NEMA 107-1987. In contrast, the CAL3D comes with an internal voltage source of 10 mV to 1 V and an output impedance of 30 kΩ, which causes a voltage drop of the indicated 10 µV to 10 mV across the 300 Ω impedance as required by IEC CISPR 18-2.

Figure 70: *Calibrator*

The calibrators are switched on with the button "On/Off". This button must be pressed for more than one second to switch the generator off, while automatic switch-off occurs after approximately eight minutes. The same button allows toggling between the continuous mode ("Cont.") and the burst mode ("Burst"). The burst mode is indicated by a blinking "+" sign. During the burst mode, the calibration signal is turned on for about 8 ms each cycle (20 ms for the 50 Hz version).

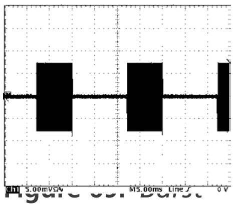


Figure 69: Burst *mode*

The "Range" button sets the amplitude in following steps: 10 µV, 20 µV, 50 µV, 100 µV, 200 µV, 500 µV, 1 mV, 2 mV, 5 mV, and 10 mV.

The rotary switch on the left side of the calibrator is used to select the signal frequency. The top position "0" selects 600 kHz for the CAL3A. It is increased in steps of 50 kHz up to 1350 kHz. The standard frequency of 1 MHz is selected at lowest position "8". The CAL3B and CAL3D offer a range of 400 kHz to 1900 kHz in steps of 100 kHz. The following table shows the position of the switch and the corresponding frequencies in kHz for all three calibrator types.

	0		2		4		6		8		A		C		E	
CAL3A	600	650	700	750	800	850	900	950	1000	1050	1100	1150	1200	1250	1300	1350
CAL3B	400	500	600	700	800	900	1000	1100	1200	1300	1400	1500	1600	1700	1800	1900
CAL3D	400	500	600	700	800	900	1000	1100	1200	1300	1400	1500	1600	1700	1800	1900

Table 4: *Calibrator output frequencies in kHz*

6.3.5.2 RIV adjustment

Before taking measurements with the ICM*compact*, the system setup should at least once be adjusted. This will correct any instrument drift and the impact of the signal path between the calibrator (CAL3x) and the acquisition unit. For the adjustment, the CAL3x is to be connected to the "REF" input of the ICM*compact* with the coax cable usually used with measurements. The lead between the specimen and the calibrator has to be disconnected. It should be ensured, that the same frequency is selected at the CAL3x and the ICM*compact*, which is typically 1 MHz. This can be set in the menu "SETUP1/CF" or "CURSOR/-> CF". Within the menu "ADJ", the buttons "ADJ+" and "ADJ-" allow you to set the induced voltage of the CAL3x. Pushing the "ADJ" button will correct the calculated value. This adjustment is permanently stored until a new adjustment is done or the adjustment is completely removed by the "RESET" button. However, it is recommended that you check the adjustment on a regular basis.

6.3.5.3 NEMA 107-1987 compliant RIV calibration

The ICM*compact* can automatically measure, calculate, and store the circuit RIV factor (k). This calibration should be done after the instrument is adjusted. However, if this factor is already known from a previous calibration, it can be entered in the "CAL" menu by "k+" and "k-". This "CAL" menu is only accessible while in the "RIV" mode and in the "METER" display. The current factor is displayed in the bottom right of the display ("k="). It should be between 0.25 and 1 for composite type bushings.

For calibration, the HV conductor has to be disconnected, and the calibrator (CAL3A or CAL3B) should be connected as close as possible to the RIV source. Figure 71 shows an example of a calibration on a transformer bushing. By using a BNC T-connector, the calibrator can also stay connected to the "REF" input of the ICM*compact* (as it was done during adjustment). Pushing the "CAL" button within the "RIV/CAL" menu will start one measurement on the "REF" input for about one second. Thereafter, one measurement is done on the selected input channel CHx. The calculated correction factor (k) can be seen in the bottom right-hand side of the display.

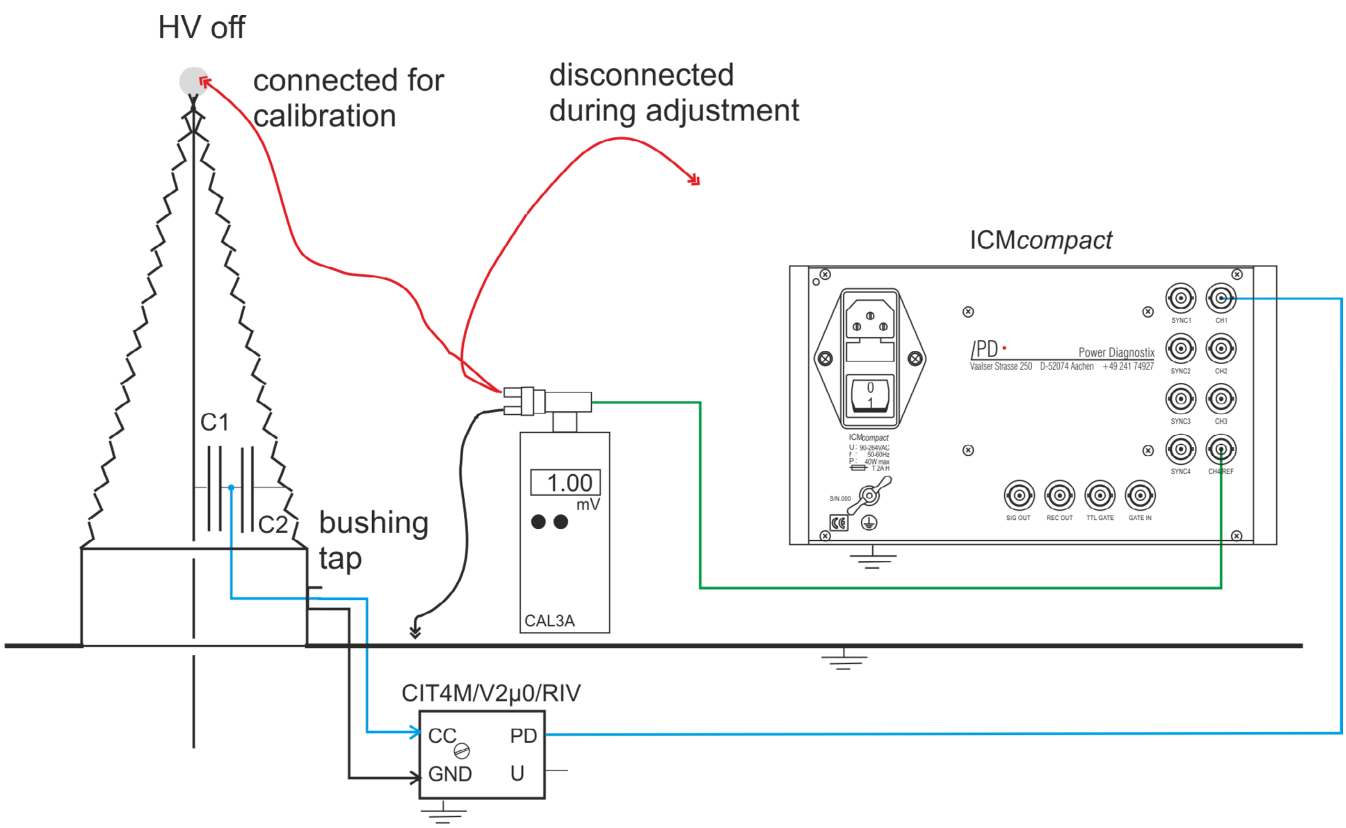


Figure 71: *Example test setup on a transformer bushing for the adjustment and calibration according to NEMA 107-1987*

6.3.5.4 CISPR 18-2 compliant RIV calibration

The CISPR 18-2 follows the idea of having a calibrator acting as current source, which causes a voltage drop of the desired calibration voltage across the specified resistor of 300 Ω. This requires that the source resistance of the calibrator is large against the measuring impedance. The standard specifies "at least 20 kΩ". Megger's CAL3D comes with an internal source resistance of 30 kΩ. Additionally, this calibration principle requires that the high voltage source is not acting as RF bypass. Hence, a filter has to be inserted into the HV lead between device under test and source. This filter is a parallel resonant circuit. Here as well, an impedance (at resonance) of >20 kΩ is specified.

If using off-shelf measurement receivers, the CISPR 18-2 standard specifies determining both the circuit attenuation and the network attenuation factor in dB. This result is then added to the receiver's reading taken in dBµV. However, the ICM*compact* as a dedicated instrument allows automatic calculation of the combined correction factor and displays the corrected reading after calibration.

With the CISPR selected in the “MODE” menu, the “CAL” menu allows you to choose the calibration magnitude (“CAL+/-”) and the calibration “CAL”, which calculates the overall attenuation and corrects the displayed magnitude. Figure 72 shows a typical setup.

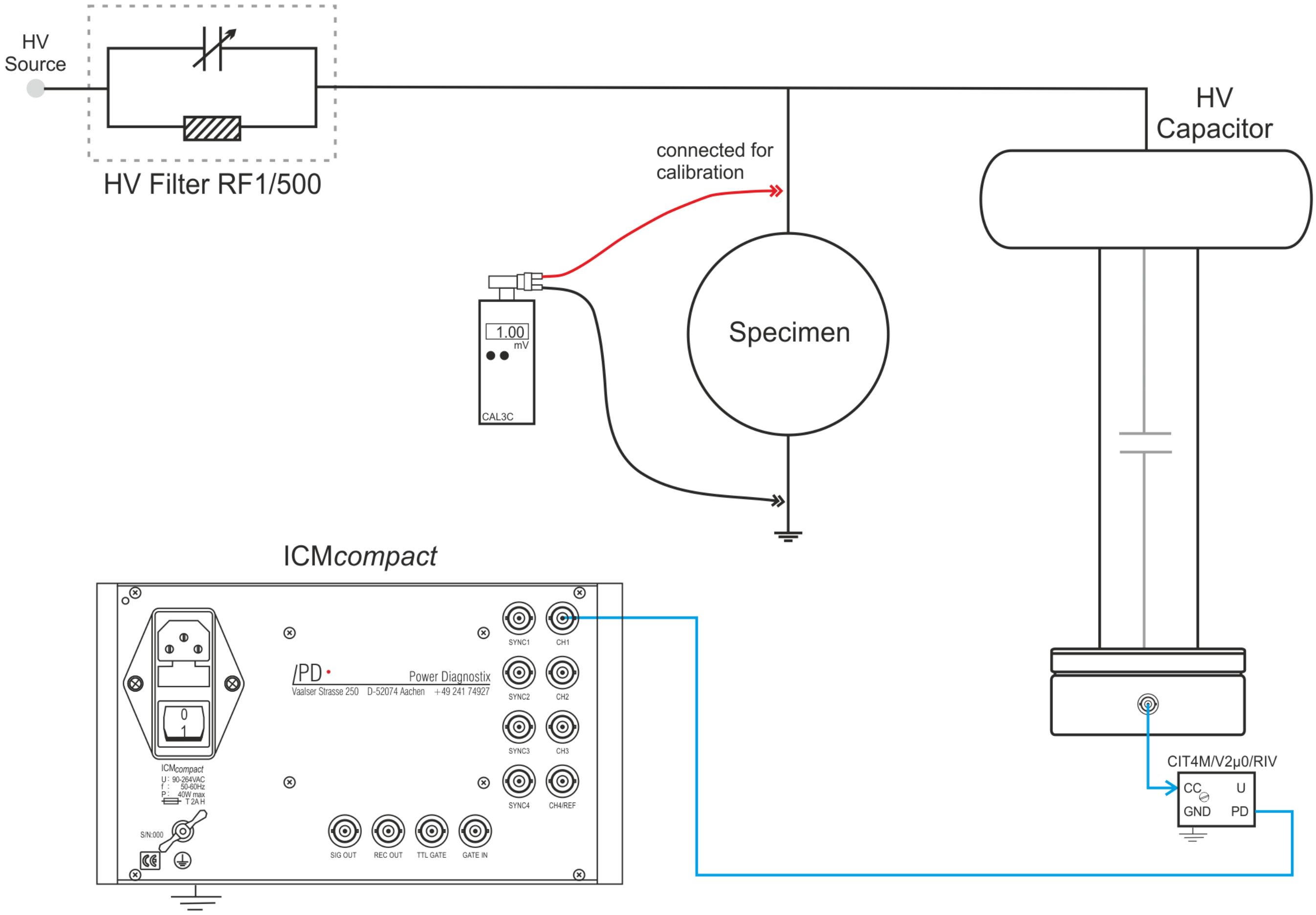


Figure 72: *Example of a test setup for calibration according to CISPR 18-2*

6.3.6 MUX – Channel multiplexer

Instruments with a built-in multiplexer (MUX) are able to switch between four or twelve different channels. The front panel of an instrument with this option includes five extra buttons labelled "∆ CH ∇", "∆ SYNC ∇", and "LOCK". These buttons enable to directly select one of the four or twelve signal sources. Hereby, the partial discharge signal ("CH") and the voltage signal ("SYNC") are split and can be selected separately. The gain setting, calibration factor, and divider factor (if HVM is installed) are stored separately for each channel.

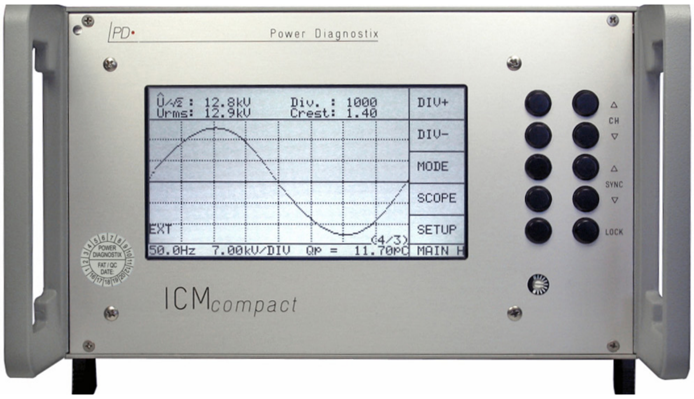


Figure 73: *ICMcompact with MUX (multiplexer) and HVM*

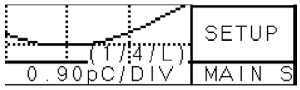


Figure 74: *Status display*

In the lower right-hand corner, the selected channel is displayed. The first number indicates the AMP channel for the PD signal. The next number shows which channel is taken for the synchronisation or voltage measurement. To avoid an unintended change of the channels, the five extra buttons can be locked and unlocked by the button "LOCK". This is indicated in the display by an "L". In the example in Figure 73, channel 1 is selected for the PD signal, channel 4 for voltage measurement and synchronisation. And the right keyboard is locked.

Two different multiplexer versions are available for the ICM*compact*:

1. 4x CH and 4x SYNC

Figure 75: *Back panel with MUX4 and RIV input*

2. 12x CH and 12x SYNC
   (with external remote-controlled box RB2/24)

Figure 76: *Back panel with MUX12 and TTL gating input*

Figure 77: *RB2/24*

6.3.7 AUX – Auxiliary inputs

Up to four auxiliary input channels (AUX) can be ordered for the ICM*compact*. These inputs can be used to record extra signals like power, temperature, pressure etc. Commonly used input levels of either 4 to 20 mA or 0 to 10 V DC are available.

NOTE : X9 to X12 are for future purposes and are currently without function.

CAUTION : Caution: The AUX inputs are only to be connected with their designed signal magnitude. Overvoltage (e.g., from the signal for the SYNC input) might harm your instrument.

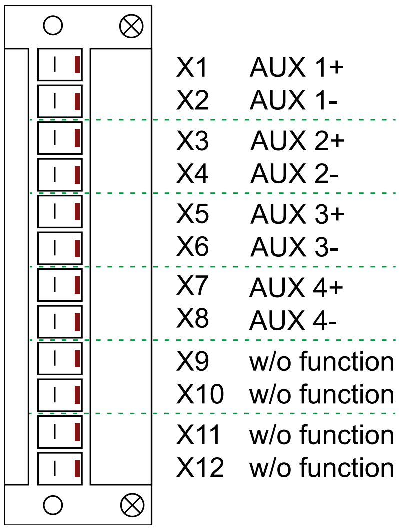


Figure 78: *AUXIN connector*

A USB interface is used to link the ICM*compact* instrument with the software, running on a standard PC. With the ICM*compact* software, it is possible to label and scale the AUX inputs. Figure 79 shows the setup window for a four-channel system. Within the main frame of the software, the processed AUX values are displayed together with the PD pattern and the voltage values (if the HVM is installed). Long term records of the PD, voltage, and AUX data are easily done and can be exported to standard data file formats. However, to access the AUX signal data, the ICM*compact* software is mandatory.

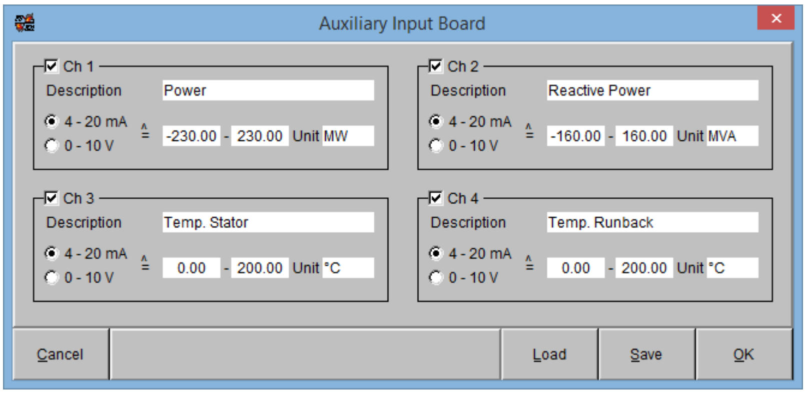


Figure 79: *Screenshot of the AUX input settings*

6.3.8 STP – Additional setups

If the ICM*compact* is frequently used at different places, the optional function STP can store up to twelve different setups. Three extra buttons are added to the front panel to swap between the different setups. The top buttons “D SETUP Ñ” will change the setup number, whereas the lower button will lock this function. The current setup number is shown in the lower right corner of the display.

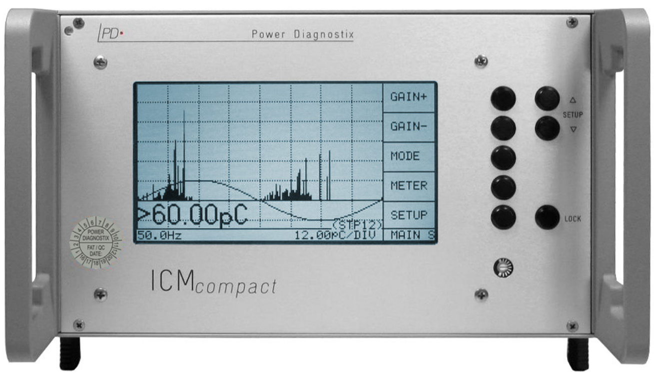


Figure 80: *ICMcompact with twelve selectable setups*

6.4 Noise reduction

6.4.1 LLD (Low level discriminator) noise ground

Depending on the environment and the test circuit, different levels of background noise are visible (see Figure 81). Since this noise level is usually stable for the whole phase (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 “NORM” and “SINUS” mode of the “SCOPE” display.

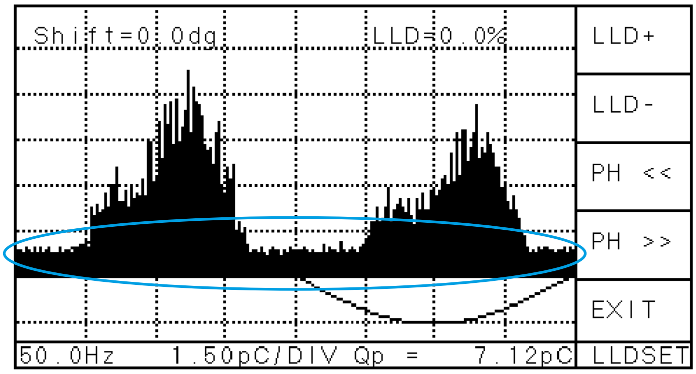


Figure 81: *PD pattern including noise level (LLD=0 %)*

The LLD can be set in the menu “SETUP2 \ LLD/P” by the buttons “LLD+” and “LLD-”. The standard setting is 10 %. The LLD function is not active in the “METER” display.

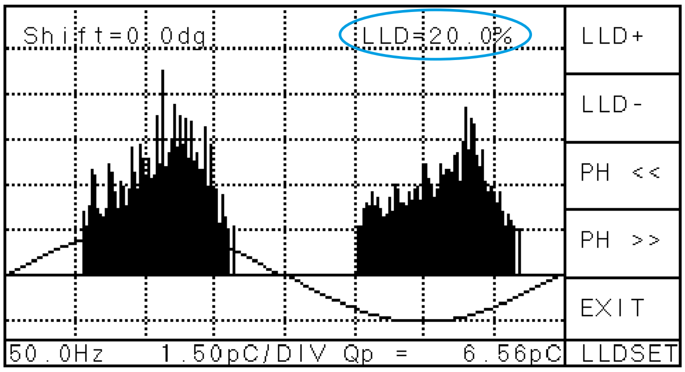


Figure 82: *PD pattern without noise level*

6.4.2 Window mask (software)

Some disturbances, like thyristor firing, are phase stable. They can be removed by the software function "WIN". This function selects up to three 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 reading of the meter.

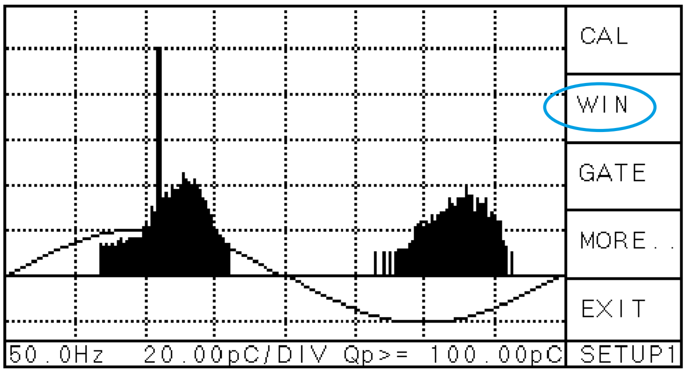


Figure 83: *PD pattern with one phase stable disturbance*

Figure 83 and Figure 84 show the same measurement, while in Figure 84, 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. The width of each window is identical and can be increased by pressing "<<>>" or decreased by pressing ">><<". The phase position is changed by "POS>>".

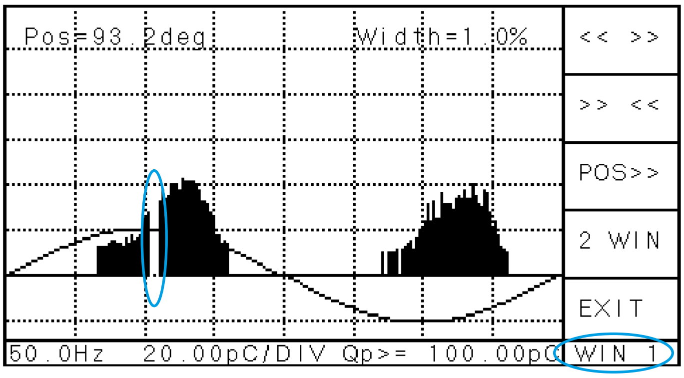


Figure 84: *PD pattern with one window at 93.2 °*

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

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

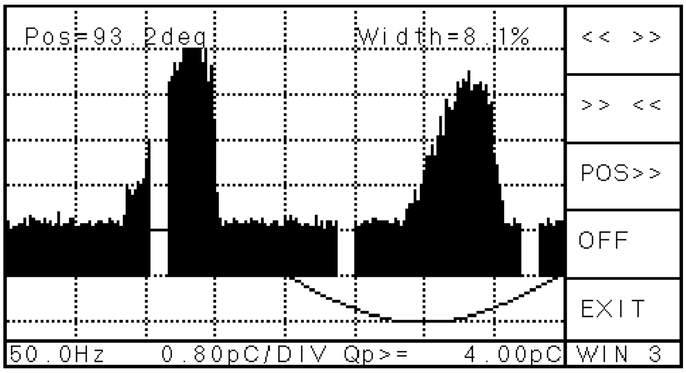


Figure 85: *PD pattern with three windows*

6.4.3 External signal sating (TTL gating)

If disturbances, like switching of a relay or thyristor firing, have a known source, it might be possible to create a TTL signal prior to the disturbance. This signal can be used to blind out the PD measurement path. ICM*compact*s with this function have a BNC connector on the back panel labelled "TTL GATE". If a signal source is connected to this input, the TTL signal is used at any time and can't be disabled. For the time this input is logically high (5 V DC; TTL standard) no signal is taken from the AMP IN terminal, i.e., no PD signal is recorded.

6.4.4 Gating with external sensor (analogue gating)

An effective noise reduction is required in case the ICM*compact* is used for partial discharge measurements in an environment with high frequency (HF) disturbance. HF disturbances, which hamper partial discharge 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. Continuous radio frequency signals from broadcasting, for example, cannot be removed by the gating function. Here, the active bridge adapter AB1 is used.

The analogue gating function is optional and has to be ordered separately. An ICM*compact* with a gating function comes with an onboard pre-amplifier (RPA6G) and a “GATE IN” terminal (BNC) on the rear panel. An antenna such as the DA1 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 86).

The gating function is activated in the menu “MAN G” or “AUTO G” (see section 6.2.2 “Optional key menus”). “>ON” indicates activated gating. In case the (disturbance) signal at the “GATE IN” terminal exceeds a threshold, the processing of the analogue signal is blocked for 10 µs (default) at 50 Hz. Thus, the signals falling in this period does not contribute to the instrument’s display and derived quantities.

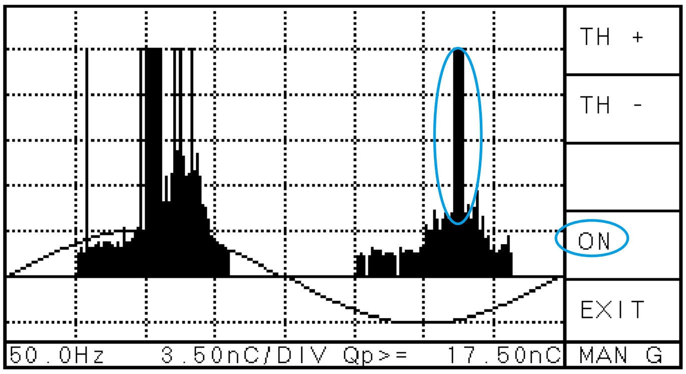


Figure 86: *PD pattern including disturbances*

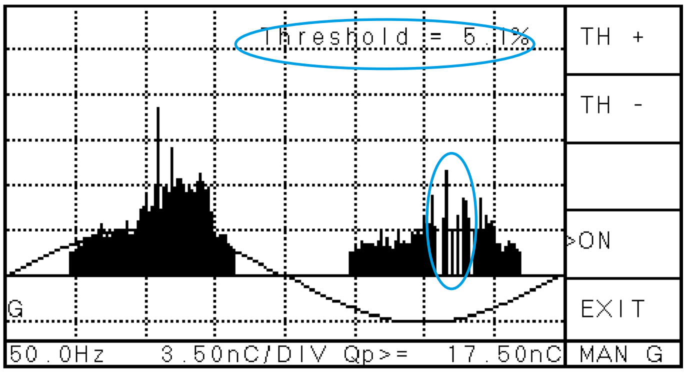


Figure 87: *PD pattern after manual gating*

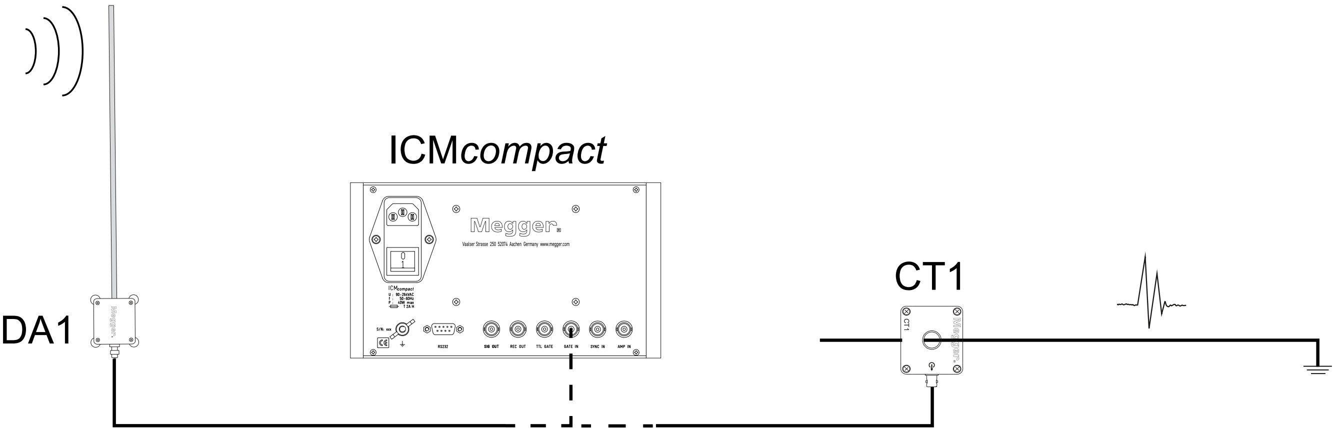


Figure 88: *Gating connections with DA1 or CT1*

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. To change the trigger level, press "TH+" and "TH-". 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 at 50 Hz. The trigger level will be set accordingly to this time. The total gating time, if activated, is displayed in the upper right corner of the menu "AUTO G". Pushing "GT+" and "GT-" allows you to change the gating from 1 to 50 %. This option is used when the noise situation is likely to change over time.

The onboard pre-amplifier (RPA6G) has a logarithmic amplification and is suitable for frequencies of 100 kHz to 10 MHz (1 kΩ input impedance).

An ICM*compact* equipped with the gating function offers the following additional menus. They can be accessed only in the "SCOPE" display "SETUP1/ GATE" menu:

MAN
AUTO
GT SET
EXIT
GATE

MAN
Push this button to go to the submenu for manual gating "MAN G".

AUTO
Push this button to go to the submenu for automatic gating "AUTO G".

GTSET
Push this button to go to the submenu "GT SET", where the frequency bands of the pre-amplifier (RPA6G) can be set.

EXIT
Push this button to go up one level to the menu "SETUP1".

TH+
TH-
GT IN
>ON
EXIT
MAN G

TH+/TH-
Pushing these buttons increases or decreases the gating threshold level. This value is displayed at the upper right side of the screen in percent. If the gating analogue signal exceeds this level, then the measurement PD signal is blocked for 100 µs at 50 Hz. The gating time per noise event T_g 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).

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 ("OFF"). The gating function remains off if no pre-amplifier is connected to the gating input. Usually, the pre-amplifier is built in.

EXIT
Push this button to go up one level to the menu "GATE".

GT+
GT-
GT IN
>ON
EXIT
AUTO G

GT+/GT-
Pushing these buttons increases or decreases the total gating time. This value is displayed at the upper right side of the screen in percent. The instrument automatically adjusts the threshold level. If the gating signal exceeds this automatically set level, then the PD signal ("AMP IN") is blocked for maximum 100 µs at 50 Hz.

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 ("OFF"). The gating function remains off if no pre-amplifier is connected to the gating input. Usually, the pre-amplifier is built in.

EXIT
Push this button to go up one level to the menu "GATE".

GL+/GL-

GL+
GL-
GT OUT
EXIT
GTSET

Pushing this button increases or decreases the period that 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.

GT OUT (>GT OUT)
This button activates (">GT OUT") or deactivates ("GT OUT") the TTL gating signal at the "SIG OUT" output. It should be deactivated if not needed.

EXIT
Push this button to go up one level to the menu "GATE".

For devices manufactured before 2016, see section 11.1.

6.5 Calibration

PD measurements refer to the apparent charge and are relative measurements. Therefore, each new installation or 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 (test object), measuring it without test equipment, and 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.

6.5.1 Calibration impulse generator

Megger offers a broad range of impulse generators for different purposes. Table 5 gives an overview of these calibrators. All calibrators allow the calibration of PD measurements according to IEC 60270:2000, except the CAL2B/C/D, since the CAL2B/C/D has left out the injection capacitor to enable calibration on GIS (gas insulated switchgear).

Calibrator	Range	Output	Frequency
CAL1A	1, 2, 5, 10, 20, 50, 100 pC	Injection capacitor <1 pF	50 Hz (60 Hz)
CAL1B	100, 200, 500 pC, 1, 2, 5, 10 nC	Injection capacitor <100 pF	50 Hz (60 Hz)
CAL1C	1, 2, 5, 10, 20, 50, 100 pC	Voltage output (50 Ω)	50 Hz (60 Hz)
CAL1D	10, 20, 50, 100, 200, 500, 1000 pC	Injection capacitor <10 pF	50 Hz (60 Hz)
CAL1E	0.5, 1, 5, 10, 20, 50 nC	Injection capacitor <500 pF	50 Hz (60 Hz)
CAL1F	0.2, 0.5, 1, 2, 5, 10, 20 nC	Injection capacitor <200 pF	50 Hz (60 Hz)
CAL1G	0.02, 0.05, 0.1, 0.2, 0.5, 1, 2 nC	Injection capacitor <20 pF	50 Hz (60 Hz)
CAL1H(/V+S)	0.5, 1, 2, 5, 10, 20, 50 pC	Live injection via stray capacitance*	50 Hz (60 Hz)
CAL1J	10, 20, 50, 100, 200, 500, 1000 pC 100, 200, 500, 1000, 2000, 5000, 10000 pC	100 pF 1 nF (external, switchable)	50 Hz (60 Hz)
CAL2B(/500)	2, 5, 10, 20, 30, 40, 50 V (into RL=50 Ω)	Voltage output (50 Ω)	50 Hz (60 Hz)
CAL2C(/500)	1, 2, 5, 7, 10, 12, 15, 17, 20 V (into RL=50 Ω)	Voltage output (50 Ω)	50 Hz (60 Hz)
CAL2D(/500)	5, 7.5, 10, 15, 20, 30, 40 V (into RL=50 Ω)	Voltage output (50 Ω)	50 Hz (60 Hz)

* pF value to be specified by the customer

Table 5: *Output and frequency ranges of PD calibrators*

All calibrators are switched on with the button "On/Off". Both amplitude ("Range") and polarity ("Pos/Neg") of the single charge pulse per cycle are displayed and can be adjusted by pushing the two buttons. 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 are available). The button "On/Off" must be pressed for more than one 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 on the LC display.

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

Megger delivers its standard calibrators with a fully traceable calibration. The corresponding calibration certificate documents the traceability according to national standards, which fulfil the units of measurement according to the International System of Units (SI). The DAkkS (Deutsche Akkreditierungsstelle) is signatory to the multilateral agreement of the European co-operation for Accreditation (EA) for the mutual recognition of calibration certificates.

Figure 89: *Calibrator*

6.5.2 Calibration test setup

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 PD source as close as possible. Figure 90 shows an example of a calibration circuit diagram.

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 PD pulse.

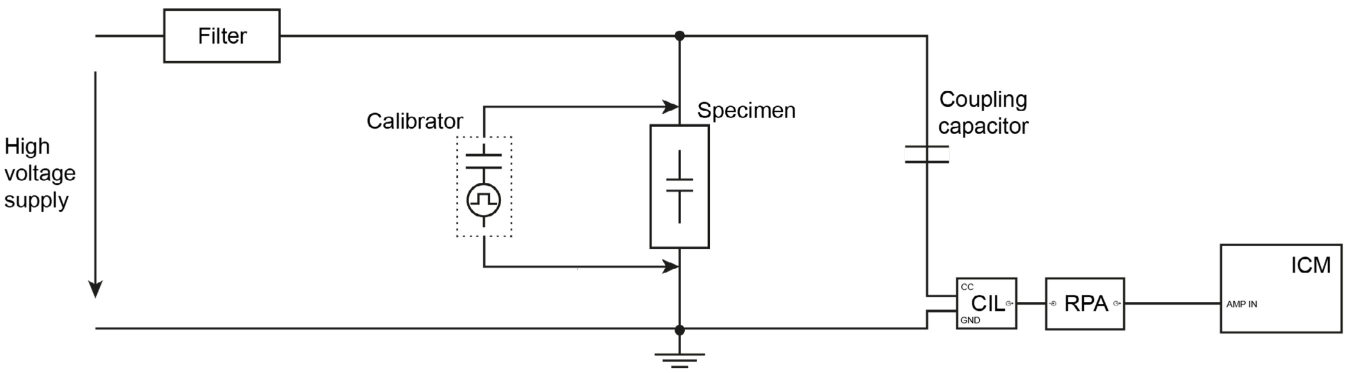


Figure 90: *Example of calibration setup*

6.5.3 Calibration menu

The ICM*compact* offers a calibration menu (“CAL”) which can be found as first item in the menu “SETUP1”. To have the complete information for doing the calibration, it is best to be in the “SCOPE” display. However, the menu “CAL” is not available when the optional displays “HVM” or “DSP” are visible. Figure 91 shows the calibration menu in the “SCOPE” mode.

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 has to be set equal to the one on calibration impulse generator. The calibration factor (CF) is calculated accordingly. There is no ability to undo this!

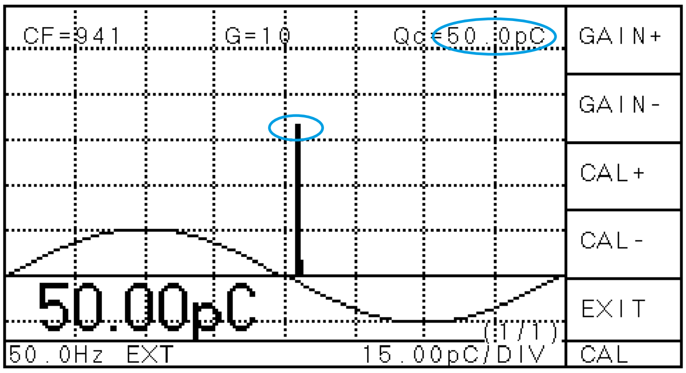


Figure 91: *Scope display during calibration*

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 test setup modifications to keep the integrity of the monitoring results.

If the calibration factor is known from previous calibrations or from an identical test setup, it is also possible to directly enter this value in the menu “CALF”. For this change, it is not necessary to adjust the gain since there is no processing of the measurement value. The calibration factor (CF) is displayed in the top left corner and relates to a virtual gain of 1.

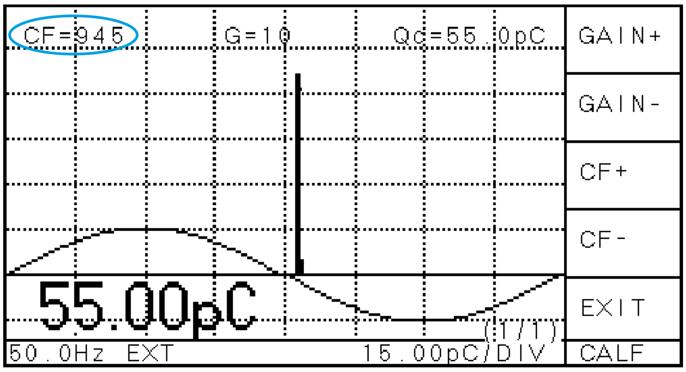


Figure 92: *Setting the calibration factor*

The software ICM*compact*, as well as HV*pilot*, offer to save all the instrument settings (as *.cmp rep. *.hvp) and, thus, enable you to repeat a test with the same settings and calibration. For using a stored calibration, you must ensure that the test circuit is the same. For saving and loading the instrument settings, see the respective software manual.

CAUTION : For the calibration, the system must be de-energised.

7. Software for the ICM*compact*

There are two software packages available to communicate with the ICM*compact* via serial link (USB drive or COM TTL).

- ICM*compact*: Standard software to record and save PD measurement data.
  Optional version for the cable fault location, only to use with the DSO extension.
- HV*pilot*: Used to take measurements over long periods. Useful only in combination with the STEP*compact*.

The software has to be ordered separately and is delivered on a USB drive. Software updates are available from Megger's support team. Please contact Megger via the contact form on the Megger web site www.megger.com.

After extraction of the files, the program 'setup.exe' will start the installation.

7.1 Standard software

The standard software shows an image of the LC display from the instrument. The acquired data, such as PD, voltage (if the optional HVM installed), and AUX (if installed) are constantly refreshed. The five menu buttons can be used in the same way as on the physical instrument, allowing you to remotely control the unit, even over long distances. For this, the serial link can be extended by a fibre optic cable or a LAN interface.

Install the ICM*compact* software before connecting the instrument to the PC!

NOTE : If the application window appears very small when started on a PC with Windows 10 or Windows 11, refer to section 9.1 "FAQ" on page 97.

The ICM*compact* software can be used on-line and off-line. In the first on-line session, the device code of the instrument must be entered to keep the serial connection. The PC will then actively communicate with the instrument and take the PD pattern and measurement values. This acquired data can be stored and exported in different ways, so that a repetition or later analysis of the measurement is feasible. The export functions allow an easy way to create reports with all necessary information like data, pattern, and graphs.

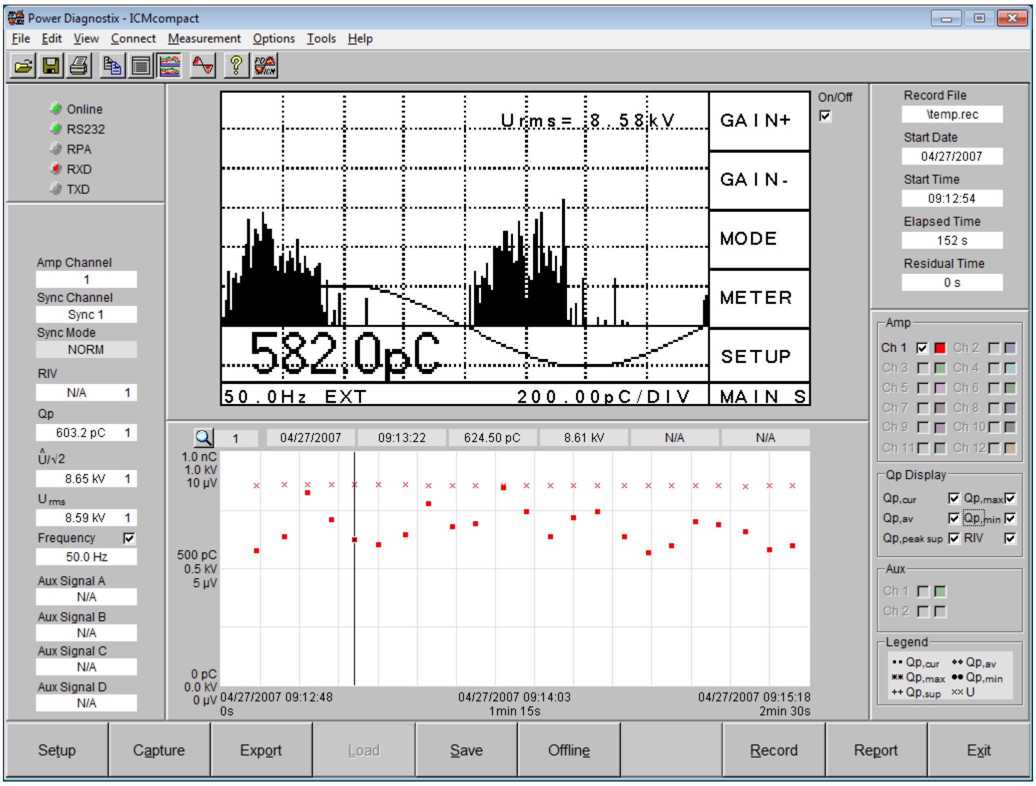


Figure 93: *Main control panel of the standard software ICMcompact*

7.1.1 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 94 shows an example of such a partial discharge pattern with the acquired shape of the high voltage super-imposed.

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 ("RXD"), while the lower red LED refers to a transmission of data (measurements) from the instrument ("TXD"). The "RS232" indicator shows that an ICM*compact* is connected to the software via USB drive or RS232, while the third indicator shows if a pre-amplifier unit is connected ("RPA"). The lower part of this display block shows up to five text displays.

If the ICM*compact* is equipped with a spectrum analysis board, it's possible to choose between the normal AMP path 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 300 kHz. "Mode" shows if the pattern is presented as a 2D or 3D view. The next text item shows the file name of the current data set. The date and time shown with the two remaining displays are referring to the moment when the acquisition of the current data set was started.

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 passed already. The following two entries are to display the number of

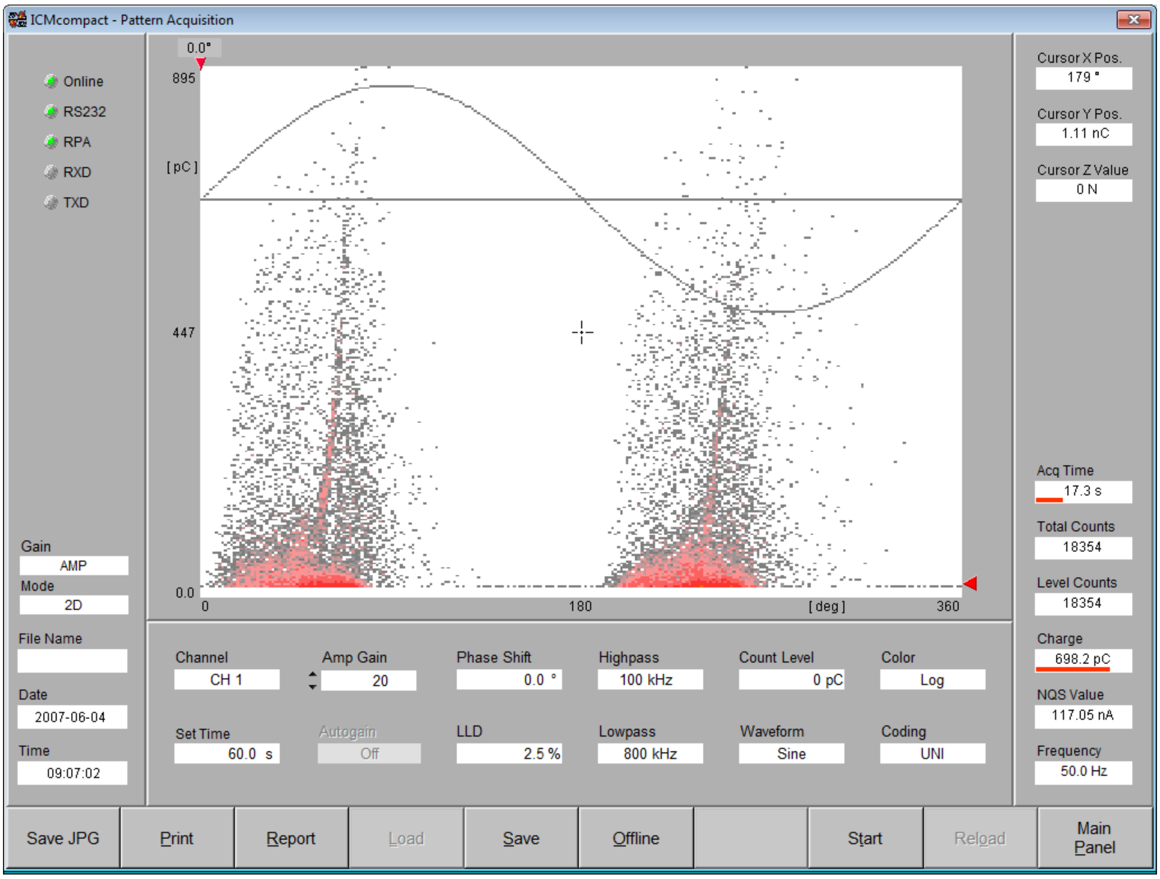


Figure 94: *Pattern acquisition panel*

counts of the current acquisition. "Level Counts" displays the counts raising the level set. The seventh item indicates the current peak charge measured. Again, the bar graph reads the utilisation. 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 is the frequency field that shows the automatically calculated frequency of the sync source (6 Hz to 505 Hz).

The ICM*compact* software offers a variety of setup parameters that can be modified in order to cope with different measurement environments. A subpanel underneath the main display area controls the ICM*compact*'s setup. Upon start-up the setup displayed will reflect the setup that was active when the software was shut down the previous time. With every file reloaded, the complete setup of that file is displayed and, in case of an instrument connected, sent to the acquisition unit as well. This makes sure that the instrument is reset completely to the state it had when the reloaded measurement was taken. On the other hand, take care to save your current setup to file before over-writing it by reloading a file. The subpanel contains the following entries:

Channel	Current measurement channel
Set Time	Entry to pre-set the acquisition time. Shortest time possible is 0.1 s. An acquisition may be stopped earlier by means of the "Stop" button.
Amp Gain	For setting, increasing, and decreasing gain, i.e., the amplification factor, respectively. If the acquisition mode is set to "AMP" or "SPEC" (only available with instruments that were manufactured 2015 or later), this entry is labelled "AMP Gain" or "SPEC Gain" respectively.
Autogain	The automatic gain adjustment can help to find the best gain setting for the PD measurement path. If the PD signal rises 95 % of the y-axis, the software automatically decreases the level, if the level drops down below 10 %, the gain level will be incremented. If the PD level is varies greatly, it may be sensible to disable the automatic mode.
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. Depending on the "Waveform" setting, the discharge pattern and/or the superimposed sine wave is being shifted. Double clicking onto this field offers the choice of 0 °, 60 °, 120 °, 180 °, 240 °, and 300 ° as values for phase shifting.
LLD	Entry to set the low level discriminator (LLD). The LLD acts symmetrically on positive or negative pulses. 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	Setting for the lower cut-off frequency of the PD bandpass filter.
Lowpass	Setting for the upper cut-off frequency of the PD bandpass filter.
Count Level	With some applications, you may want to know the number of pulses exceeding a certain level. This entry serves to enter such level. Further, this entry reads the level adjusted by means of the blue slider arrow at the right-hand edge of the main display. The level counts and the total counts are displayed in the right-hand display block.
Waveform	The shape of the acquired sine wave of the high voltage and a base line can be displayed along with the partial discharge pattern, not only to validate the phase relation between pattern and high voltage, but also to evaluate the influence of saturation effects or harmonics of the voltage on the pattern.
Color	The z-axis (i.e., the distribution of the colour) may be coded linear ("Norm") or logarithmic ("Log").
Coding	This entry is only available with newer instruments. PD pulses can be separated by its polarity. Bipolar ("BI") shows positive and negative pulses separated, whereas Unipolar ("UNI") does not consider the polarity.

There's a row of function keys at the lower end of the display as shortcuts for the main functions of the software.

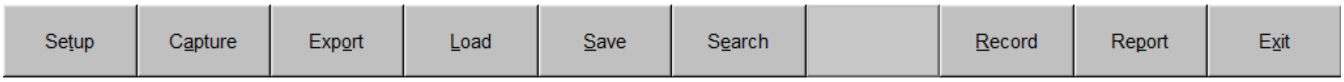


Figure 95: *Function keys of the panel for pattern acquisition*

7.1.2 Data record mode

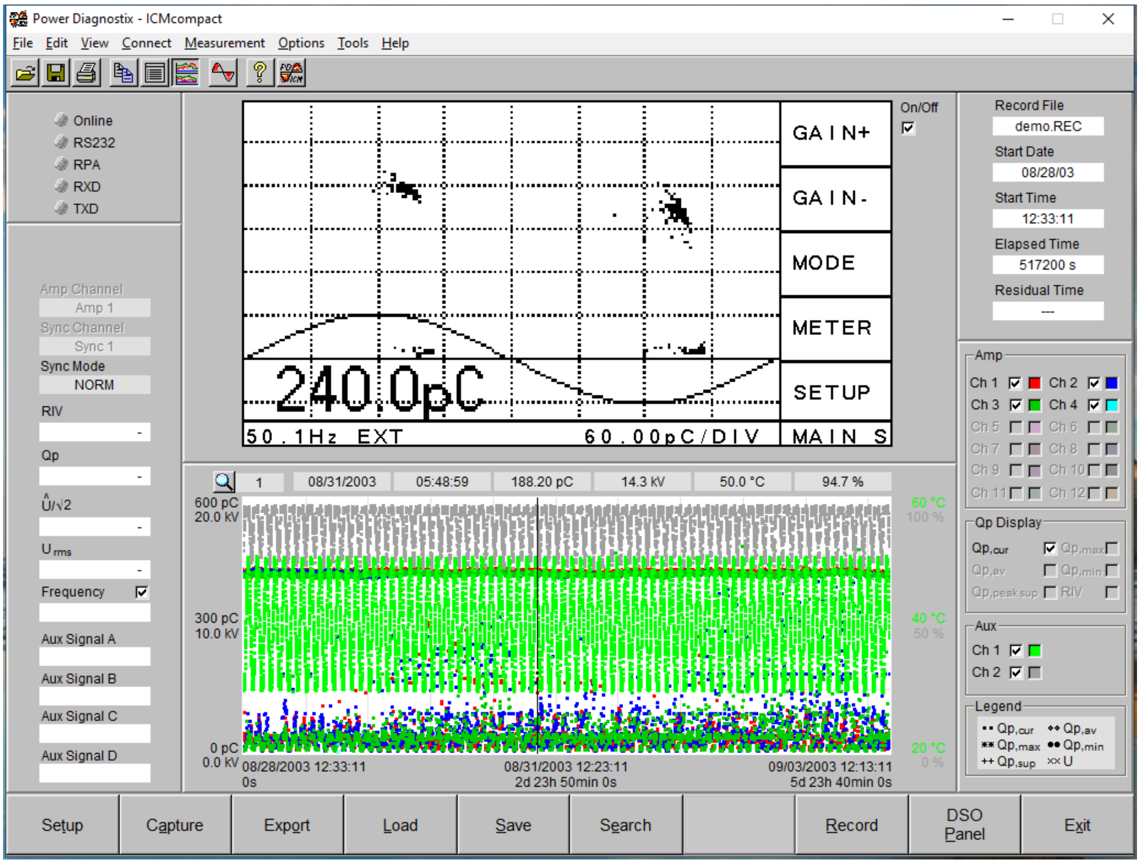


Figure 96: *Main panel with record view enabled*

The data record mode of the ICM*compact* allows you to log the Qp, voltage, and optional auxiliary values over time. The data is stored in a proprietary file format (.rec file) and can be exported to an Excel, HTML, or text file (menu: "File" - "Save Record"). The values are displayed on the strip chart in the lower part of the main panel if the "Record View" mode is enabled (menu: "View" - "Record Panel"). The row above the graph shows the values at the cursor position. The values shown here are: Multiplexer channel, date, time, Qp value, voltage value, auxiliary signal 1, and auxiliary signal 2. The chart graph can be copied to the clipboard and then pasted to any application that supports the import of bitmap files.

The record mode can be configured by the “Data Record Settings”. Select the “Edit - Data Record Settings” menu item to open the following window.

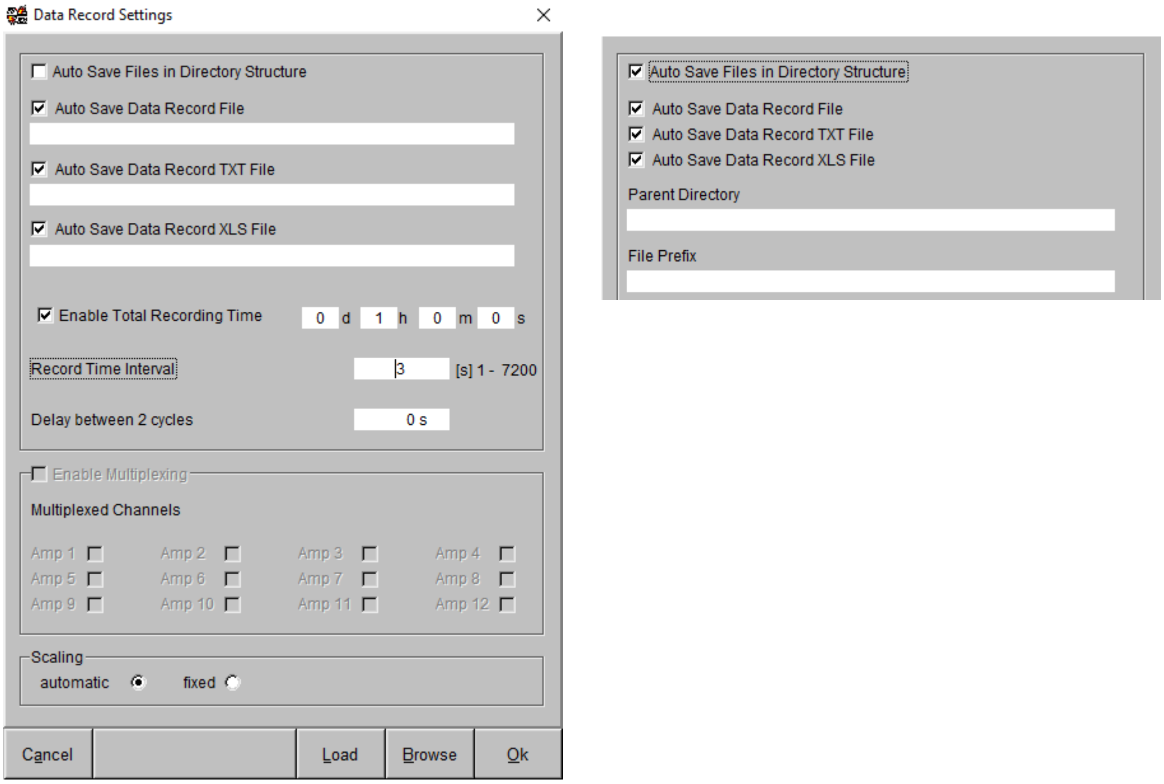


Figure 97: *Data record settings*

By selecting the “Auto Save Data Record File”, “Auto Save Data Record TXT File”, or “Auto Save Data Record XLS File”, the recorded values are stored in the selected file formats. The names of the files can be set by left clicking on the corresponding fields below the check marks and entering a name. These file names should be set for each new record, otherwise the files will be overwritten after a warning. By selecting the “Auto Save Files in Directory Structure” option, the selected files will be stored in a certain directory structure with an added increasing number. The directory structure is built as follows:

ParentDirectory\Year_Month_Day\FilePrefixXXXX
(with XXXX increasing number)

To set a time after which the record stops automatically, the “Enable Total Recording Time” option must be selected, and the time must be set. Otherwise, the record must be stopped manually. The “Record Time Interval” sets the time between two stored data sets. With “Delay between 2 cycles”, an additional delay between two stored data sets can be set. This option is mostly used in combination with the multiplexer option, to add a delay after changing the multiplexer channel. The “Enable Multiplexer” option is only active if an ICM*compact* with a multiplexer is connected. Then, the channels for the recording can be selected. After a data set is stored, the software will switch to the next selected channel.

The recording can be started by pressing the “Record” button or selecting the “Measurement/Start/Stop Data Record” menu item. One data set contains the following values: Date/time, measurement channel, synchronisation channel, current charge value, mean charge value, median charge value, maximum charge value, minimum charge value, accumulated charge value, RMS voltage value, square root of voltage value, frequency value, auxiliary value 1, auxiliary value 2, and RIV value. During the “Record Time Interval” several values are recorded, but only the latest values will be stored, except for the charge values. The charge values are calculated over the set “Record Time Interval”, and the current charge value is the latest value in the interval.

On the right-hand side of the main panel, the values, which should be displayed in the chart graph, can be selected. Only those values can be selected that are available with the instrument. If no multiplexer is available, only the values of one channel can be displayed, and the "Amp" area will be dimmed. The same applies if no auxiliary signals are available: the corresponding area will be dimmed.

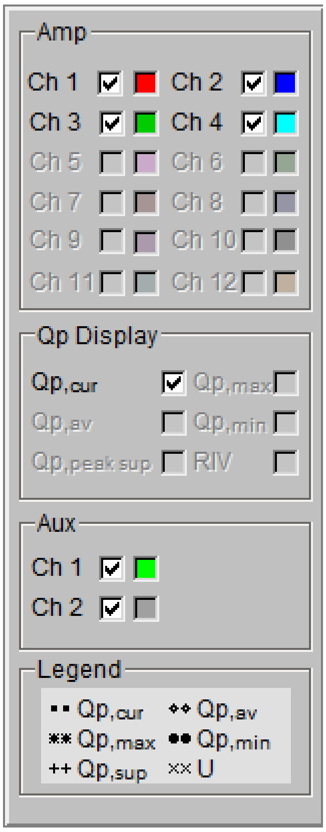


Figure 98: *Display option for data record mode*

7.2 Extended software with cable fault location

The optional software extension for cable fault location is specialised for high or medium voltage cable diagnostics. This requires an ICM*compact* instrument with the optional acquisition board ‘DSO’. For the general functionality of this board and a detailed description of this software extension, see also section 6.3.4 “DSO – Digital storage oscilloscope for time domain reflectometry (TDR) measurements”. Older instruments can be upgraded with the DSO board. Contact Megger for details.

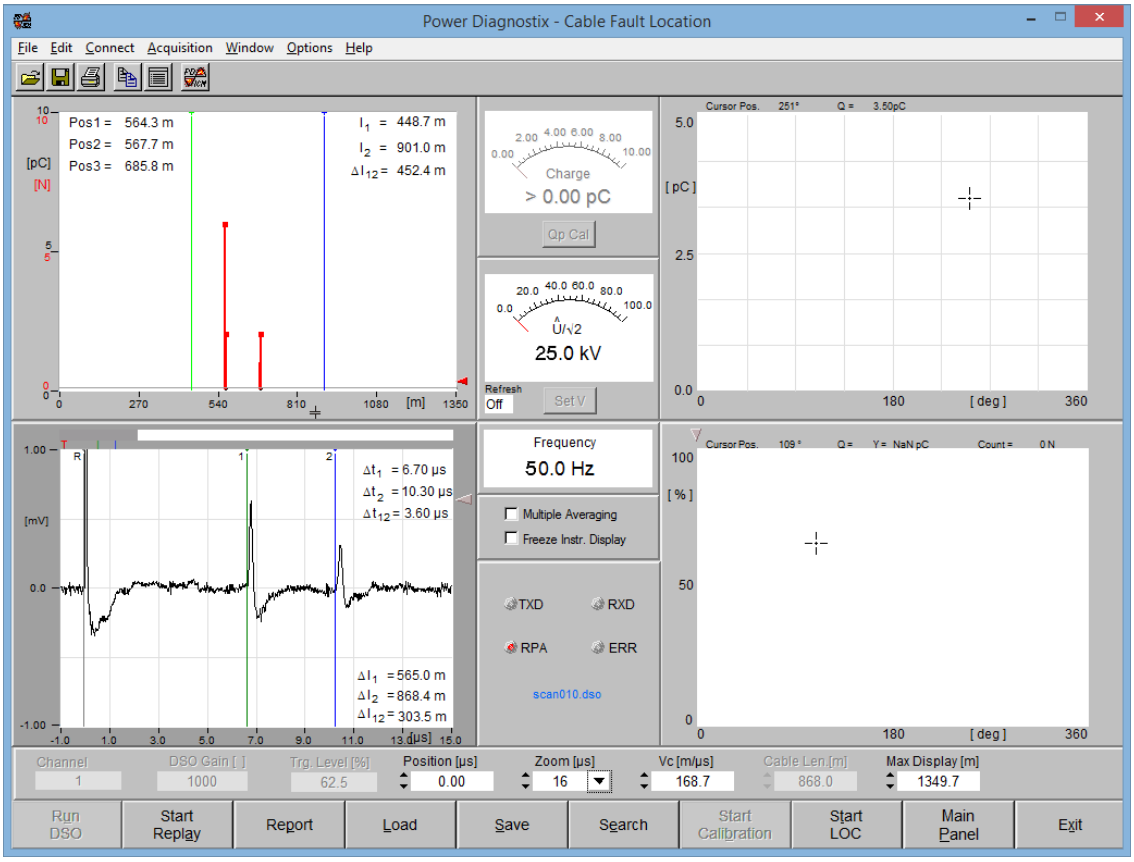


Figure 99: *Main panel of ICM*compact *with the LOC graph (upper left) and the DSO graph (lower left)*

The main panel shows at the left-hand side two graphs (LOC and DSO), as it is shown in Figure 99.

The DSO (digital storage oscilloscope) graph displays the current PD waveform including its reflection at the cable terminations. In principle, this is the same graph that is shown on the display of the instrument but with a higher resolution. The software offers three coloured cursors to evaluate the PD pulse. Since the time difference of the reflections refers to the fault position, the calculated values in time and meter/feet are listed at the right-hand side of the graph.

Usually, multiple PD pulses are recorded and evaluated. This ensures to capture further PD sources and to state more precisely the position of single defects. The graph on the upper left-hand side collects the results from the distance evaluation of the DSO graph. This localisation graph (LOC graph) is usually created off-line by a manual or automatic mode. It requires for the calculation either the total cable length or the pulse velocity. The number and charge of all captured PD pulses is then displayed as a function of the cable length. Finally, the fault positions can be measured by two cursors (blue and green) directly.

7.3 Specialised software HV*pilot* (optional)

The HV*pilot* software is designed to control the voltage for a test setup and to take measurements of voltage (high voltage site), partial discharge (PD), tan delta (dissipation factor), and Cx (ideal capacitance of the test object).

For this task, three further instruments beside a PC are necessary:

- The STEP*compact* to control the variac of a high voltage transformer, observing the voltage for a possible break down, and to supply the HV*pilot* with the current voltage value
- The ICM*compact* to take PD measurements of the test object
- The TDA*compact* (optional) to measure the tan delta and capacitance of the test object

The STEP*compact* and the HV*pilot* software are developed to automate high voltage test sequences. The three instruments are connected to a PC via serial link (RS-232) and exchange data with the HV*pilot* software. This software also provides the possibility to program a test sequence, analyse the measured data and generate a report automatically. Several different test sequences can be created to customise the program for special measurement tasks. The report files are created as doc or *.html and can also easily be customised.

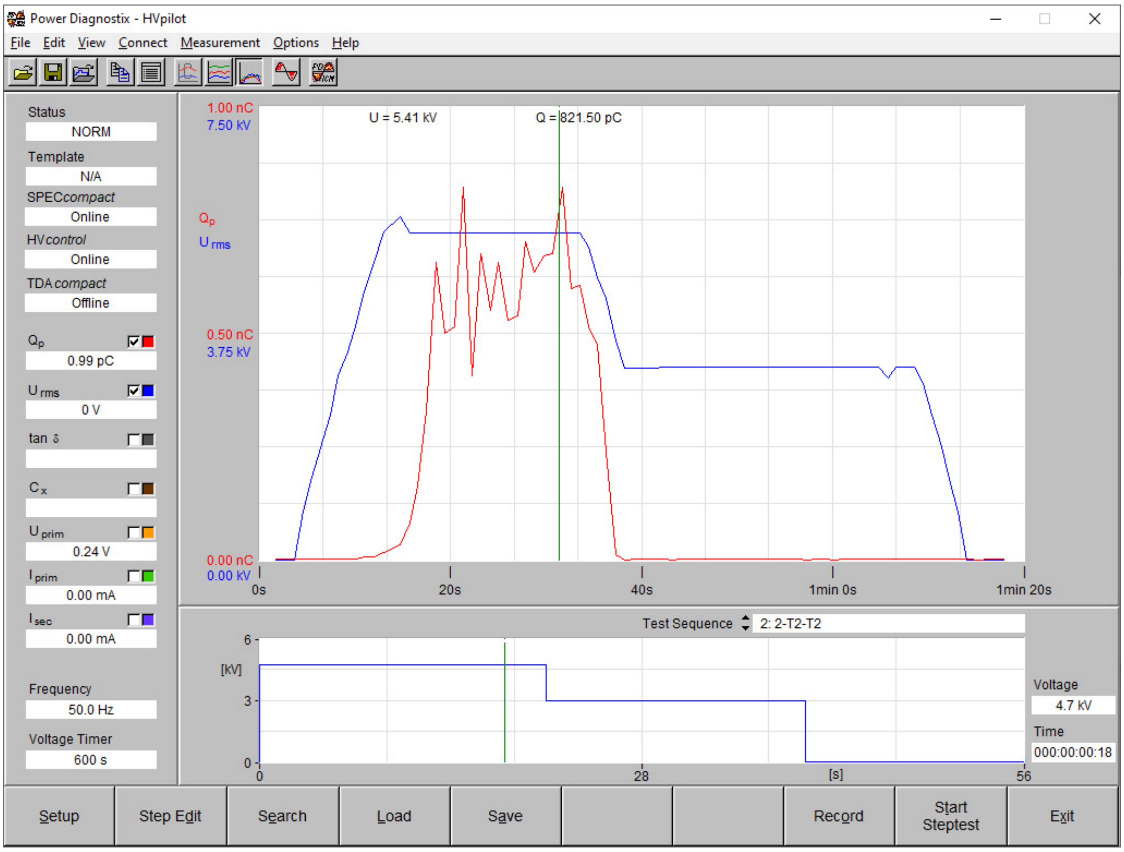


Figure 100: *Main panel of the HVpilot software for the automation of high voltage tests*

The main panel of the HV*pilot* software displays the four measurement values (Û/√2, PD, tan delta, C_x) continuously on a time axis. Below this, the programmed test voltage curve is displayed to follow a running test or to compare the measured data later on. Current measurement values from the cursor position are displayed on the left-hand side. The ten function buttons in the bottom row give you quick access to the main program functions.

The first step to create a test sequence is the step voltage curve. This can be done off-line (without the instruments) and downloaded later to the STEP*compact* (for the voltage control). Figure 101 shows the panel to create the step voltage curve.

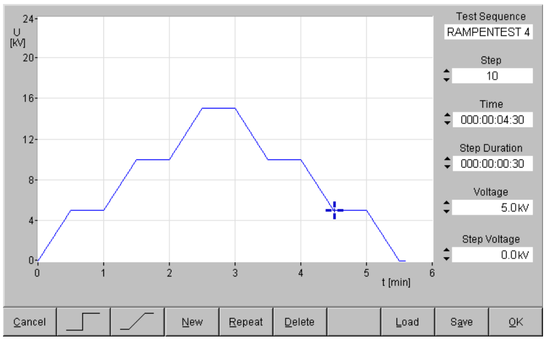


Figure 101: *Panel to create the step voltage curve*

The next step is to define the kind of test that has to be conducted. Three different kinds of test sequences are offered:

- The first is designed for tests which plainly acquire the PD activity and the tan delta/CX at predefined voltage levels.
- The second allows setting maximum PD levels at certain voltage values for, e.g., acceptance tests.
- The third is designed for breakdown tests. E.g., several test specimens have to withstand an over-voltage for a certain time. The voltage is increased stepwise, and the test procedure must be continued after a failed specimen is removed.

Once the test sequence is specified and saved, the automated test can be started by loading the required sequence. The specification data for the report must be entered, and the test can be started. The test report will then be saved as Figure 102 shows.

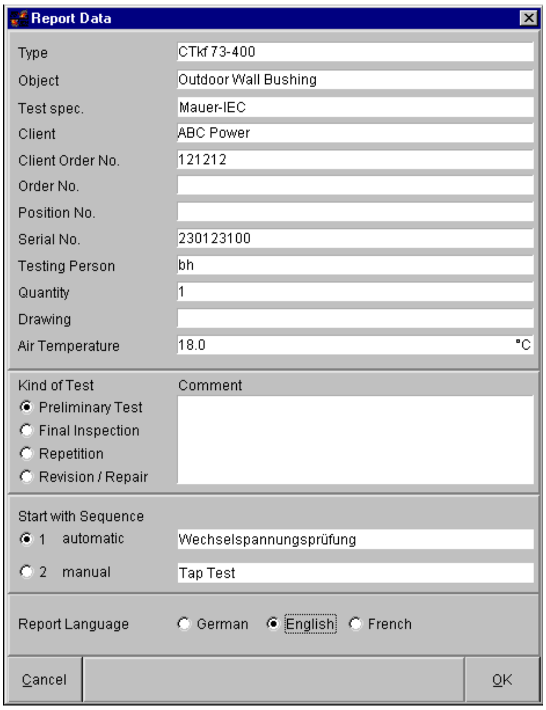


Figure 102: *Report specification fields*

Test Report

230123001
Reference No.

Object	: **Outdoor Wall Bushing**	Quantity	: 1
Type	: **CTkf 73-400**	Drawing	:
Client	: ABC Power	Preliminary test	
Client Order No.	: 121212	Test spec.	: IEC 137

Serial No. : 230123100

1. Tests carried out

1.0 Tightness test 1,5 bar rel., 1 hour
1.1 Measurement of dielectric dissipation factor and capacitance: see pos. 3.
1.2 Measurement of dielectric dissipation factor and capacitance: see pos. 3.
1.3 Check of dielectric dissipation factor and capacitance: no change
1.4 Measuring tap test 3 kV, 50 Hz, 1 min., carried out together with the measurement of capacitance: see pos. 3.

2. Test conditions

Test date :
1.1 to 1.4 : Bushing complete, lower part in oil / Ambient air temperature ≈ 18.0 °C
1.2 : Measuring circuit acc. IEC 270 / Measuring instrument: ICMcompact / Background noise: 2 pC

3. Individual results

	1.1		1.2		1.4	
U (kV)	tanδ (%)	C (pF)	PD (pC) ↓	PD (pC) ↑	C (pF)	tanδ (%)
3.0					9701	0.173
21.0	0.109	885				
44.0	0.110	902	128	136		
51.0			131	137		
63.0	0.110	915	↓	↑		

4. Assessment

The bushing corresponds to the test specification.

Edition A Issued by: bh Manager testing section:

5. Remark

PD •
Vaalser Strasse 250
52074 Aachen Tel. +49 241 74927
Germany Fax +49 241 79521
Power Diagnostix

Figure 103: *Example report*

7.4 Installation of software and drivers

The software comes with an installer and is suitable for Microsoft Windows 10 and 11. It is developed with National Instruments' LabWindows/CVI. Starting the program setup.exe, which is located on the provided USB pin, will install the software and the required CVI run time engine. The installer will guide you through the installation process.

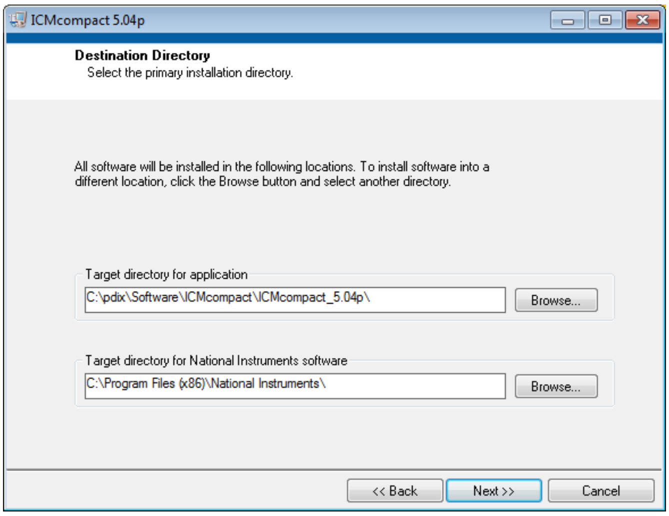


Figure 104: *Installation process*

The installation directory can be chosen individually, you may alter the location. In case you want to maintain access to different releases of the ICM*compact* software, you may place the software in a tree of subdirectories as C:\pdix\Software\ICM*compact*\ICM*compact*_5.04p\, for instance. By pressing the "Finish" button, the program files are extracted, and a program folder is created. It is recommended that you create a special data directory. Avoid placing the data directory as a subfolder into the program directory, as a de-installation of the program could lead to a loss of your data!

The installation package also comes with a driver for the standard USB interface for communication with the instrument. This driver has to be installed manually. The install file can be found in the installation directory of the software, e.g., C:\pdix\Software\ICM*compact*\Icmcompact_5.04p\USBDriver\FTDI.

Double clicking on "setup.exe" starts an installation wizard that will guide you through the installation process. It's necessary to confirm the license agreement for a successful installation of the USB driver.

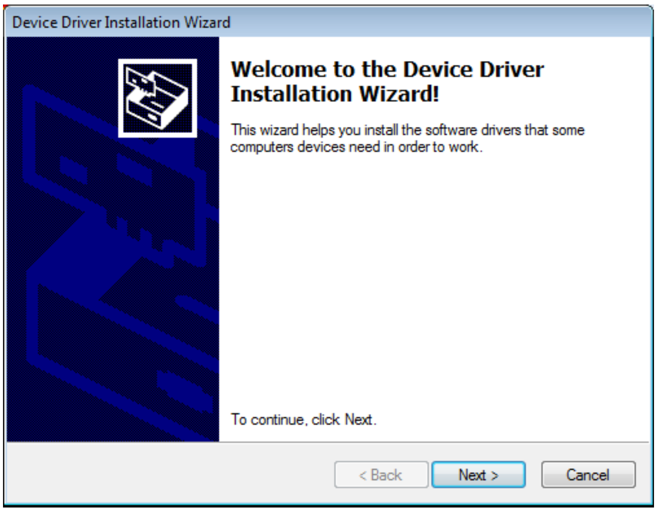


Figure 105: *First step of the USB driver installation process*

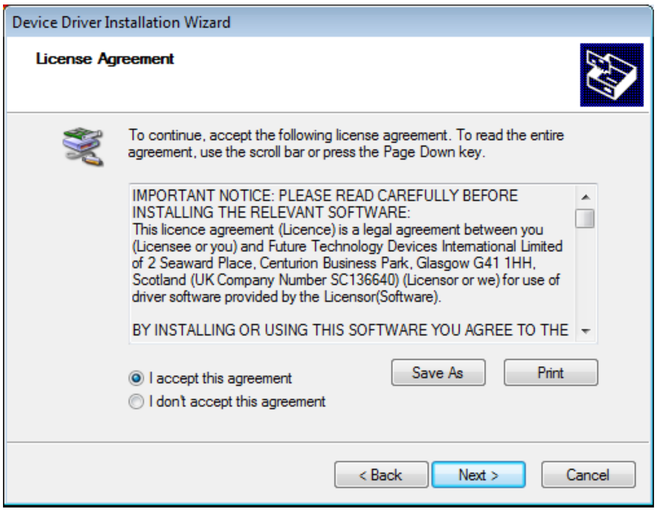


Figure 106: *License Agreement window*

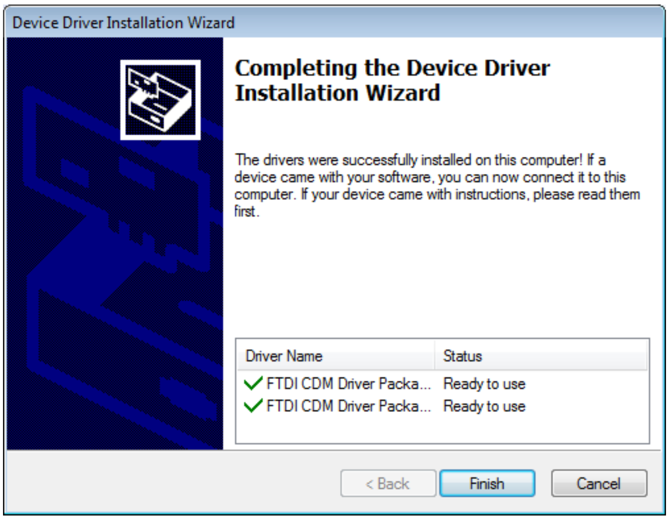


Figure 107: *By pressing the "Finish" button the installation is completed.*

If the software does not find the instrument at the correct COM port, it is possible to set the COM port manually. First open the Windows device manager with only the ICM*compact* connected to the computer to find the COM port of the instrument. The device should be listed as an item of 'Ports'.

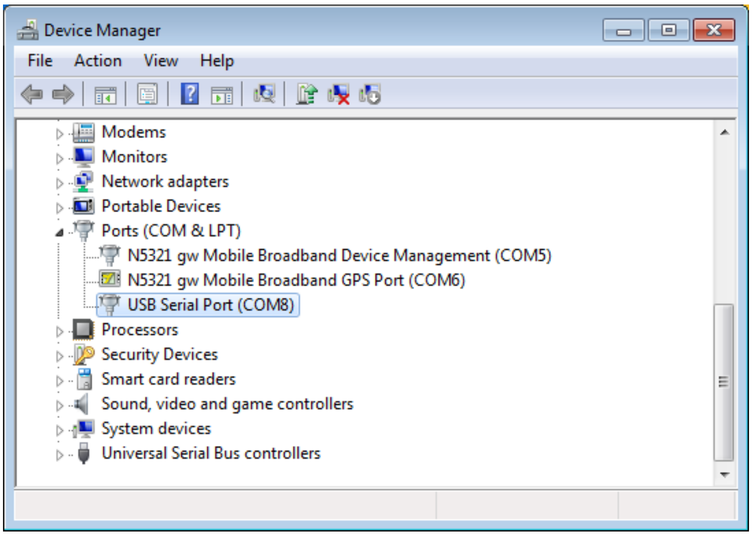


Figure 108: *Windows Device Manager*

Then open the "Interface Settings" of the software using the "Options" menu and activate the check box, which corresponds to the COM port in the device manager. Additionally, select the 921600 baud rate.

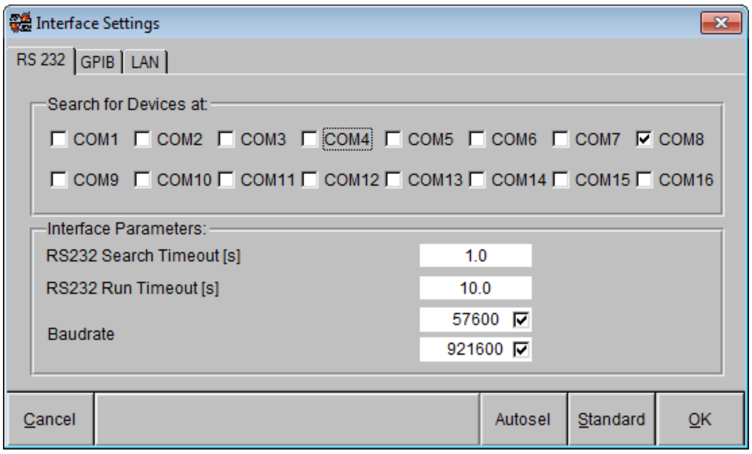


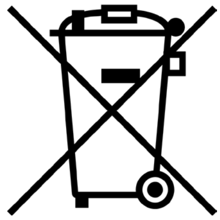
Figure 109: *Interface settings*

8. Miscellaneous

8.1 Maintenance

The ICM*compact* does not require any maintenance on a regular basis, neither is regular fine adjustment needed, as partial discharge measurement is a relative measurement that is calibrated with a reference source (charge calibrator, CAL series) prior to a measurement. It is recommended to calibrate this impulse generator annually to ensure that its output signal remains within the recommended limits.

8.2 Product marks



This symbol indicates that the marked product 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, do so properly by taking it to an organisation specialising in the disposal of old electrical equipment near you.

Any batteries installed must be disposed of separately from the unit.

As a responsible manufacturer, certified according to ISO 14001, Power Diagnostix offers to take back old instruments from its customers. Contact our support team via the Megger web site (www.megger.com) to discuss the procedure for this.

8.3 Transport and shipment instructions

8.3.1 Instrument

If 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 Megger for further details. Megger may provide you with a temporary replacement unit in urgent cases.

8.3.2 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.

8.4 Declaration of Conformity

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

declares that the product

ICM*compact*/ICM*compact* pro

Partial discharge detector

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 2014/30/EU
RoHS Directive 2011/65/EU

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

EN 61010-1:2020
EN 61326-1:2013
EN IEC 63000:2018

8.5 UK declaration of conformity

The UK government has laid legislation to continue recognition of current EU requirements, including the CE marking (Conformité Européene, or European Conformity marking). The legislation will apply indefinitely for a range of product regulations. This means businesses will have the flexibility to use either the UKCA (UK Conformity Assessed) or CE marking to sell products in Great Britain (GB). The message text can be found here: https://www.gov.uk/guidance/using-the-ukca-marking. Megger sells the ICM*observe*r in Great Britain using the CE marking.

9. Troubleshooting

9.1 FAQ

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

The ICM*compact* doesn't do anything when powered up.
The power fuse might be blown. Unplug the unit and check the power supply fuse. This fuse is located on the rear panel of the ICM*compact* (desktop and rack mountable version) or in the upper left corner (Explorer case version) above the on/off switch (see Figure 8 and Figure 9 in section 4.1).

The personal computer cannot find the ICM*compact*.
A communications error with the serial connection to the ICM*compact* might have occurred. Within the ICM*compact* PC software, check to be sure that the serial com port selected in the menu "Options>Interface settings" is the COM port to which the ICM*compact* is actually connected. Within the Windows Device Manager, check if the USB driver was properly installed (see section 7.4).

Try rebooting both the ICM*compact* and the PC.

The ICM*compact* application window appears very small on high resolution monitors and Windows 10 or Windows 11.
On PCs running Windows 10 with the Creator's Update of 2017 the ICM*compact* application window may appear very small on high resolution monitors. To increase the size of the window, take the following steps:

1. Right-click on the application shortcut on the desktop.
2. Choose "Properties" from the context menu, which will open the "Properties" window (Figure 110).
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".

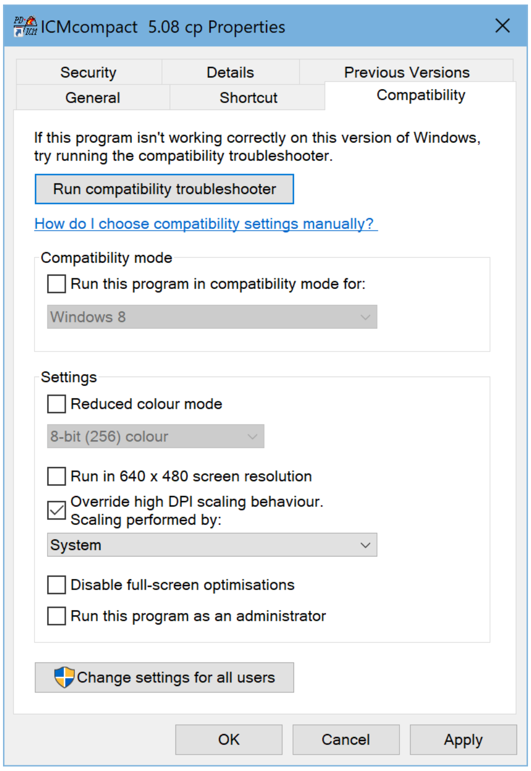


Figure 110: *Properties window*

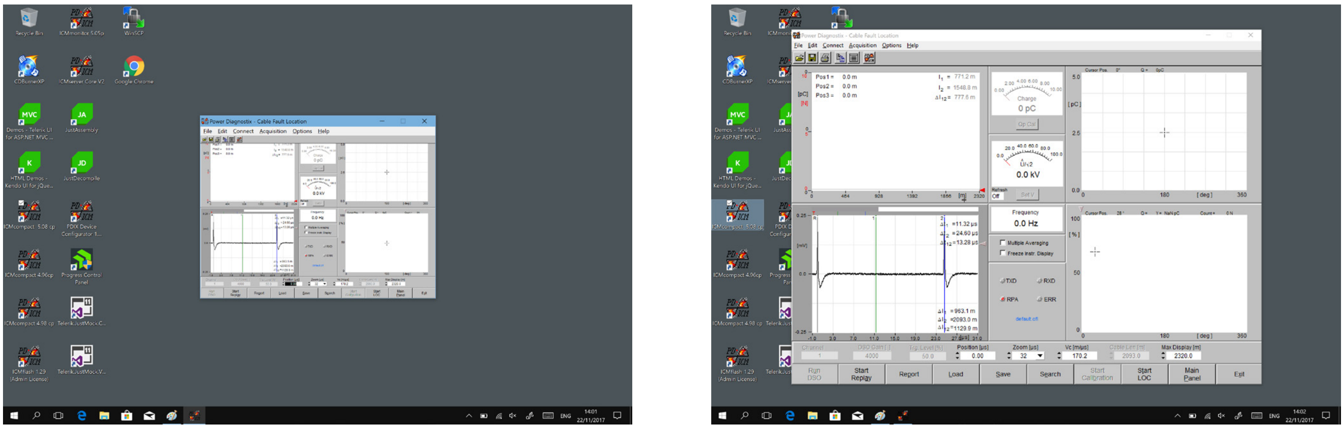


Figure 111: *Desktop before and after the change of the scaling behaviour*

The "RPA?" message appears in the lower left portion of the data display of the LCD panel, even though the RPA (pre-amplifier from Megger) is connected.

The RPA might be installed improperly (backwards). Check to be sure that the BNC connector marked with leads from the sensor (quadrupole, CT, or coupling capacitor), and that the BNC connector which is marked by the sign leads to the BNC connector labelled 'AMP IN' on the rear panel of the ICM*compact*.

The pre-amplifier must be enabled if an RPA is connected. Ensure the >RPA ON is marked (see section 6.2.3, on page 38). Try substituting the BNC cables to be sure that the problem is not in the cables themselves.

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 several 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 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*compact* into "SCOPE/Norm" mode. This will make the calibration pulse appear as a vertical bar, which makes it easier to see on the screen as 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. Try physically disconnecting the high voltage supply from the test setup during calibration. The calibrator will then be connected across only the test object quadrupole and the coupling capacitor (if present).

If the problem persists, contact Megger for technical support.

Other problems

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

10. Technical data

10.1 Standard ICM*compact*

Mains supply:	90–264 V AC, 47–440 Hz	(automatic)
Line fuse :	1.6 A	(time-lag)
Power requirements:	Approx. 40 W	
Display:	Backlit LCD	
Display resolution:	128 x 240 pixels b/w	
Operation:	5 menu supported buttons 5 fix function buttons with multi-channel version or remote controlled via software	
Recorder output:	0–10 V with R_o=100 W	(re-converted analogue value of the meter reading)
Operation temperature:	10–40 °C, non-condensing 0-45 °C, non-condensing (ICM*compact* pro)	(ICM*compact*)
Input impedance:	50 Ω II 50 pF (AMP IN)	
A/D converter:	8 bits (unipolar) / ±7 bits (bipolar)	
Size:	236 x 133 x 300 mm³	(desktop model, exclusive BNC connectors)
(W x H x D)	305 x 144 x 270 mm³ 305 x 360 x 270 mm³	(Explorer case version, closed) (Explorer case version, open)
Weight:	Approx. 4.0 kg Approx. 4.4 kg	(desktop model) (Explorer case version)

10.2 ICM*compact* pro

Mains supply:	100–240 V AC, 50/60 Hz	(automatic)
Line fuse :	2 A	(time-lag)
Power requirements:	Max. 40 W	
Display:	7” coloured touchscreen	
Display resolution:	800 x 480 pixels	
Operation:	Controlled via touchscreen or remote controlled via software	
Recorder output:	0–10 V with R_o=100 W	(re-converted analogue value of the meter reading)
Operation temperature:	0–45 °C	(non-condensing)
Input impedance:	50 Ω II 50 pF (AMP IN)	
A/D converter:	8 bits (unipolar) / ±7 bits (bipolar)	
Size:	236 x 133 x 300 mm³	(desktop model, exclusive BNC connectors)
(W x H x D)	305 x 144 x 270 mm³ 305 x 360 x 270 mm³	(Explorer case version, closed) (Explorer case version, open)
Weight:	Approx. 3.0 kg Approx. 3.5 kg	(desktop model) (Explorer case version)

10.3 All models

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/5 pC	(without pre-amplifier)
Gain range:	1, 2, 4, 8, 10, 20 …, 200, 400, 800	

Pre-amplifier

Input impedance:

RPA1/RPA1D/RPA1G/RPA4:	10 kΩ || 50 pF
RPA1L/RPA1H:	1 kΩ || 50 pF
RPA2:	50 Ω || 50 pF

Input sensitivity:

RPA1/RPA1D/RPA1G/RPA4:	< 50 µV RMS/0.03 pC
RPA1L:	< 15 µV RMS/0.02 pC
RPA1H:	< 40 µV RMS/0.05 pC
RPA2:	< 800 µV RMS/1 pC

Bandwidth:

RPA1/RPA1D/RPA1G/RPA4:	40–800 kHz
RPA1L/RPA1H:	40 kHz–20 MHz
RPA2:	2–20 MHz

Synchronisation/HVM

Synchronisation frequency:	5–505 Hz/VLF (0.02/0.05/0.1 Hz)
Maximum voltage:	200 V_{peak} (140 V RMS), 100 V RMS nom.
Input impedance:	10 MΩ
A/D converter:	±15 bits
Precision:	Typ. < 1.5 %

Spectrum function

Input sensitivity	< 5 µV RMS/ 0.5 pC	(270 kHz bandwidth)
	< 1 µV RMS/ 2 pC	(9 kHz bandwidth)
Max. input voltage	120 mV RMS	(270 kHz bandwidth)
	5 mV RMS	(9 kHz bandwidth)
	2.5 mV RMS	(RIV)
Frequency range	10 kHz–10 MHz	(in steps of 10 kHz)
Bandwidth	9vkHz or 270 kHz	
Precision:	Typ. < 5 %	

Cable fault location (CFL)

Trigger:	0 to 100 % of input signal	(step width of 3.125 %)
A/D Converter:	± 7 bits	
Samples:	100 MSamples/s	(Tsample = 10 ns)
Reduced sample rates:	50 MS, 25 MS	
Displayed time window:	200 ... 8000 Samples	(2 ... 80 µs at 100 MS/8 … 320 µs at 25 MS)
Specimen cable length:	10 to 5000 m (in theory), for 80 µs and v_c=140 m/µs (Note: CFL at cables > 3000 m is not possible because of pulse attenuation)	
Localisation precision:	1 m + 0.1 % of cable length	

11. Annex

11.1 Pre-amplifier for gating with older hardware versions

With older hardware versions (manufactured before 2016) instruments with gating function came with a built-in pre-amplifier RPA6. The pre-amplifier had a logarithmic amplification and could be set to three different frequency ranges, which were selected in the submenu "GT SET" with the entry "BANDW". The table at the right-hand side lists the frequency bands for the three available modes.

Bandwidth mode	Frequency range
MODE1	40 kHz to 800 kHz
MODE2	2 MHz to 20 MHz
MODE3	200 MHz to 600 MHz

Table 6: *Frequency ranges of the RPA6*

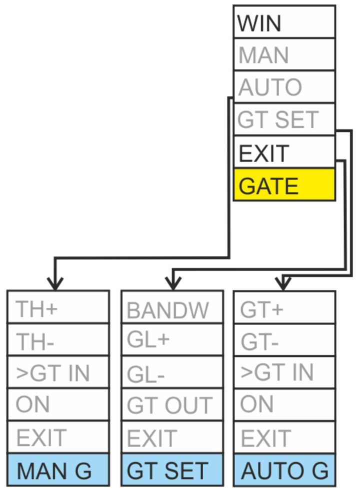


Figure 112: *Old optional key menu for gating*

Since the new gating pre-amplifier RPA6G has a fixed frequency range, the "BANDW" entry in the gating menu is no longer available.

11.2 National Instruments (NI) hardening guide

11.2.1 Introduction

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

This configuration guide will close three unnecessary National Instruments services. The local ports 3848 UDP and TCP opened by these services will also 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	*	*	

Figure 113: *List of installed National Instruments services*

11.2.2 Step-by-step guide

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

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

3.) Locate the following in the service list:

- NI Domain Service
- NI PSP Service Locator
- NI Time Synchronization

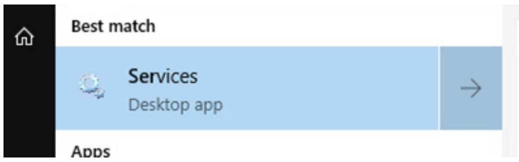


Figure 114: *Search result "Services"*

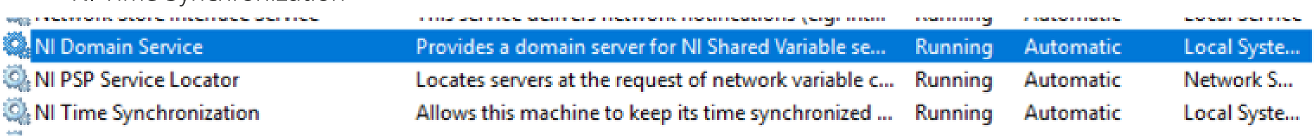


Figure 115: *National Instruments services in the "Service" window*

4.) Open the configuration pop-up by double clicking each service and changing the "Startup type" to "Disabled".

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

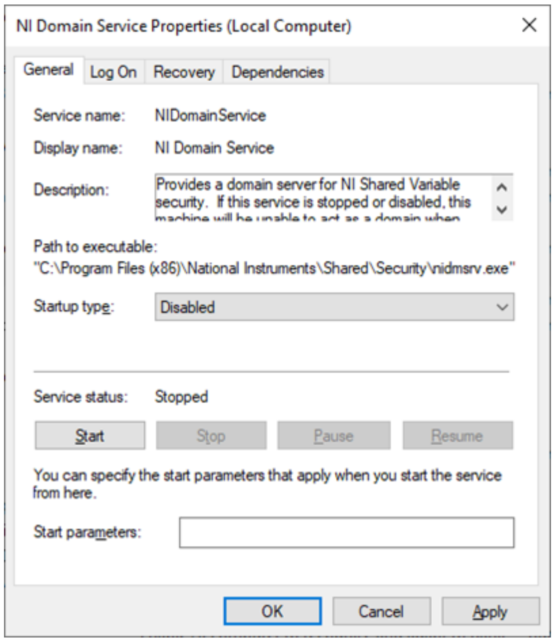


Figure 116: *Service properties window*

11.2.3 Service description

https://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.

12. Index

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Z

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ICMcompactM_UG_e1.03