

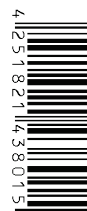
Megger[®]



Centrix 3 Centrally Controlled Test Van System

USER GUIDE

Issue: D (11/2021) - EN
Article number: 85689



Consultation with Megger

The present system manual has been designed as an operating guide and for reference. It is meant to answer your questions and solve your problems in as fast and easy a way as possible. Please start with referring to this manual should any trouble occur.

In doing so, make use of the table of contents and read the relevant paragraph with great attention. Furthermore, check all terminals and connections of the instruments involved.

Should any question remain unanswered or should you need the help of an authorized service station, please contact:

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
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














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1 Safety Instructions

1.1 General Notes

Safety precautions This manual contains basic instructions for the commissioning and operation of the device / system. For this reason, it is important to ensure that the manual is always available to the authorised and trained operator. He needs to read the manual thoroughly. The manufacturer is not liable for damage to material or humans due to non-observance of the instructions and safety advices provided by this manual.

Locally applying regulations have to be observed!

Labelling of safety instructions The following signal words and symbols are used in this manual and on the product itself:

Signal word / symbol	Description
DANGER	Indicates a potential hazard which will result in death or serious injury if not avoided.
WARNING	Indicates a potential hazard which may result in death or serious injury if not avoided.
CAUTION	Indicates a potential hazard which may result in moderate or minor injury if not avoided.
NOTICE	Indicates a potential hazard which may result in material damage if not avoided.
	Serves to highlight warnings and safety instructions. As a warning label on the product it is used to draw attention to potential hazards which have to be avoided by reading the manual.
	Serves to highlight warnings and safety instructions that explicitly indicate the risk of an electric shock.
	Serves to highlight important information and useful tips on the operation of the device/system. Failure to observe may lead to unusable measurement results.

Working with products from Megger It is important to observe the generally applicable electrical regulations of the country in which the device will be installed and operated, as well as the current national accident prevention regulations and internal company directives (work, operating and safety regulations).

After working on the system, it must be voltage-free and secured against reconnection as well as having been discharged, earthed and short-circuited.

Use genuine accessories to ensure system safety and reliable operation. The use of other parts is not permitted and invalidates the warranty.

Operating staff The system may only be installed and operated by an authorised electrician. DIN VDE 0104 (EN 50191), DIN VDE 0105 (EN 50110) and the German accident prevention regulations (UVV) define an electrician as someone whose knowledge, experience and familiarity with the applicable regulations enables him to recognise potential hazards.

Anyone else must be kept away!

Electromagnetic radiation This device is designed for industrial use. When used at home it could cause interference to other equipment, such as the radio or television.

The interference level from the line complies with the limit curve B (living area), the radiation level complies with the limit curve A (industrial area) according to EN 55011. Given that living areas are sufficiently far away from the planned area of operation (industrial area), equipment in living areas will not be impaired.

1.2 General Safety Instructions and Warnings

Intended application The operating safety is only guaranteed if the delivered system is used as intended (see page 11). Incorrect use may result in danger to the operator, to the system and the connected equipment.


The thresholds listed in the technical data may not be exceeded under any circumstances.


Operation in traffic environment To ensure safety for operators and traffic, the country-specific regulations must be observed.


Five safety rules
The five safety rules must always be followed when working with HV (High Voltage):


1. De-energise
2. Protect against re-energising
3. Confirm absence of voltage
4. Earth and short-circuit
5. Cover up or bar-off neighbouring energised parts

	<p>Using cardiac pacemaker Physical processes during operation of high voltage may endanger persons wearing a cardiac pacemaker when near these high voltage facilities.</p>
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	<p>Fire fighting in electrical installations</p> <ul style="list-style-type: none"> • According to regulations, carbon dioxide (CO₂) is required to be used as extinguishing agent for fighting fire in electrical installations. • Carbon dioxide is electrically non conductive and does not leave residues. It is safe to be used in energized facilities as long as the minimum distances are maintained. A CO₂ fire extinguisher must be always available within electrical installations. • If, contrary to the regulations, any other extinguishing agent is used for fire fighting, this may lead to damage at the electrical installation. Megger disclaims any liability for consequential damage. Furthermore, when using a powder extinguisher near high-voltage installations, there is a danger that the operator of the fire extinguisher will get an electrical shock from a voltage arc-over (due to the powder dust created). • It is essential to observe the safety instruction on the extinguishing agent. • Applicable is DIN VDE 0132.
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	<p>Objects should not be placed on or lent against the heater, nor pushed between the heater and wall.</p> <p>Do not cover the air exit or leave any combustible material in close vicinity to the heater.</p>
--	--

 <p>WARNING</p>	<p>Dangers when working with high voltage</p> <p>Working on high voltage systems and equipment – especially in non-stationary operation – requires particular care and safety-conscious action on the part of test personnel. VDE regulations 0104 on setting up and operating electrical test systems, as well as EN 50191 and national standards and regulations must be strictly adhered to.</p> <ul style="list-style-type: none"> • The Centrix 3 generates a dangerous voltage of up to 80 kV during measurement operation. This is supplied to the test object via a high-voltage cable. • The test system may not be operated without supervision. • Never fail to use safety equipment or put it out of operation. • Operation requires minimum two people whereas the second person must be able to activate the emergency switch in case of danger. • To prevent dangerous charge accumulation, earth all metal parts in the vicinity of the high voltage equipment.
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 <p>WARNING</p>	<p>Peripheral devices</p> <p>Please follow the safety instructions of the peripheral devices (e.g. heater) installed in the system environment. For all peripheral devices provided by Megger, the instructions manual is included in the scope of delivery. Megger is not liable for damage to material or humans due to misuse of these devices.</p>
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2 Technical description

2.1 Description

Concept The Centrix 3 is a modern, versatile and powerful test van system for fast, simple and non-destructive fault location of cables up to the 33 kV voltage range.

Optionally equipped with powerful VLF test technology and advanced diagnosis systems the Centrix 3 can also be used for standard-compliant testing and partial discharge diagnosis.
























Operation of the system is performed on a central, menu-driven operating unit, which is also responsible for the automatic storage and data recording of the test results. All system functions, measurement results, operating instructions and error messages are output on a single display.

The integrated safety system with its proven safety equipment ensures permanent for the safety of the operating personnel.

Features The system provides the following features:

- Powerful high voltage measuring methods for fault location
- High testable load capacitance for cable testing and diagnostics
- Intuitive operation using a touch display (optional)
- Automatic storage of measurement data and data recording
- The highest safety standards
- High system stability thanks to Linux® operating system
- Integrated database software MeggerBook Cable
- Internal power supply (optional)
- Remote control of important pinpointing and line location methods (optional)
- Wireless communication interfaces (4G, WiFi, GPS) (optional)

Equipment matrix The available operating modes vary depending on the equipment in the test van and can be found in the following overview:

		Minimum configuration	Optional
Testing			
Insulation testing		via HV cable	
			via LV cable
			With external insulation tester
Testing with DC voltage		up to 40 kV	up to 80 kV
			with TDM 45 (up to 40 kV)
VLF testing with cosine rectangular voltage			with 54 kV test attachment
			with TDM 4540 (up to 40 kV)
VLF testing with sine wave voltage			with TDM 45 (up to 45 kV)
Testing with trapezoidal AC voltage (square wave voltage)			with TDM 45 (up to 45 kV)
Sheath testing		up to 20 kV	
			with MFM 10 (up to 10 kV)
Fault location			
Pulse reflection measurement		via HV cable	
			via LV cable
Pulse reflection measurement for location of intermittent faults		via HV cable	
			via LV cable
ARM (Arc Reflection Measurement)		●	
ARM Conditioning			●
ARM Plus (double impulse)			●
DECAY method		up to 40 kV	up to 80 kV
DECAY Plus			● up to 40 or 80 kV
ICE current pulse method		●	

		Minimum configuration	Optional
ICE 3-phase			●
ARM burning			up to 8 kV (with internal cascades) or up to 20 kV (with power burning unit)
Sheath fault location			with MFM 10 (up to 10 kV)
Fault conversion			
Burning		up to 40 kV	up to 80 kV
Power burning			with power burning unit (up to 20 kV / 40 A)
AC burning			with power burning unit (up to 600 V / 70 A)
Fault pinpointing			
Surging		1280 J @ 4/8/16/32 kV	1750, 2000 or 2.560 J @ 4/8/16/32 kV
ICE surging			1200 J @ 2 kV
Audio frequency generator			50 W or 200 W
Sheath fault pinpointing		up to 20 kV	
			with MFM 10 (up to 10 kV)
Diagnosis			
Voltage withstand test with simultaneous Tan Delta measurement			TDM 45 + internal or external TanDelta sensor
Tan Delta step test			
PD diagnosis with sine wave voltage			TDM 45 + PDS 60(-HP)
PD diagnosis with cosine square voltage			TDM 4540 + PDS 60(-HP)
PD diagnosis with DAC voltage			TDM 4540 + PDS 60(-HP)

2.2 Technical data

Technical data of the test van The test van itself is defined by the following parameters:

Parameter	Value	
Mains voltage	230 V, 50 Hz or 120 V, 60 Hz Connection via isolating transformer (3.6 kVA)	
Connection power	3.6 kVA or 5.0 kV (depending on configuration)	
Connection equipment		
<ul style="list-style-type: none"> HV connection cable 	50 m (motorised or manual) Either one three-phase cable or three single phase cables	
<ul style="list-style-type: none"> Power cable 	50 m (incl. matching isolating transformer and mains connection system NAS 60-2)	
<ul style="list-style-type: none"> Earth cable 	50 m	
<ul style="list-style-type: none"> Auxiliary earth connection cable (FU) 	10 m	
<ul style="list-style-type: none"> External safety device connection cable (optional) 	15 or 50 m	
<ul style="list-style-type: none"> LV coaxial connection cable (optional) 	50 m	
Safety		
<ul style="list-style-type: none"> Electrical Safety 	According to DIN EN (IEC) 61010-1	
<ul style="list-style-type: none"> Safety and protection equipment 	The following criteria are monitored: <ul style="list-style-type: none"> Loop resistance: System earth to substation earth, auxiliary earth to substation earth Step voltage: Earth to the vehicle chassis Fast touch potential transients Rear door switch Safety key switch Internal/external emergency switch (EN 50191) 	
<ul style="list-style-type: none"> Discharging 	Forced discharge when an emergency stop is performed or a mains failure occurs thanks to SafeDischarge technology	
<ul style="list-style-type: none"> Supply voltage 	Overvoltage protection, undervoltage protection, residual current circuit breaker	
IPC	Basic configuration (PD diagnosis not possible)	Enhanced configuration
Processor	Intel Celeron J1900	Intel i5-4300U
RAM	4 GB	8 GB
Hard disk	32 GB	>320 GB
Display	21.5" TFT touchscreen (16:9), 1980 x 1080 pixels	

Parameter	Value
Interfaces	USB, Ethernet (for maintenance purposes only) With the optional 4G / GPS router: Mobile data (GPRS / EDGE / 3G / 4G), Wi-Fi, GPS
Operating temperature	-10 °C to +50 °C
Storage temperature	-20 °C to +70 °C
Operating humidity	93% at 30 °C (non-condensing)
Weight	>520 kg (HV module in basic configuration)

Technical data of the HV module Depending on the configuration, the HV module of test van is defined by the following parameters:

Parameter	Value
Insulation testing	
<ul style="list-style-type: none"> • Measuring voltage • Resistance measuring range • Capacity measuring range (only with 500 V or 1000 V) • Measurement over time (only with 500 V or 1000 V) 	<6 V, 500 V, 1000 V 1 Ω ... 2 kΩ (bei <6 V) 1 kΩ ... 2 GΩ (bei 500 V) or 1 kΩ ... 2 GΩ (bei 1000 V) 0 ... 20 μF (resolution 0.1 μF) up to 15 minutes
Pulse reflectometry (Teleflex)	
<ul style="list-style-type: none"> • Operating modes • Amplification • Measuring range (at v/2 = 80 m/μs) • Resolution • v/2 range • NVP range • Accuracy • Data rate • Measuring dynamic • Output impedance • Pulse width • Pulse amplitude 	Symmetric/asymmetric reflection measurement, differential and comparative measurement, IFL (for intermittent faults) Default: 1 ... 100%; ProRange: >22 dB 20 m ... 1,280 km (250 ns ... 16 ms) 0,1 m 10 ... 149.9 m/μs 0.067 ... 1 0.1% of measurement range >400 MHz >80 dB 50 Ω 20 ns ... 10 μs 150 V

Parameter	Value
Testing with DC voltage <ul style="list-style-type: none"> • Test voltage • Rated current • Short-circuit current 	0 ... 40 kV or 0 ... 80 kV (optional) 195 mA (at 0 ... 8 kV) 68 mA (at 8 ... 40 kV) 13,5 mA (at 8 ... 80 kV) 580 mA
Sheath testing / Sheath fault location <ul style="list-style-type: none"> • Test voltage • Maximum current • Duty cycle (pinpointing) 	0 ... 5 kV, 0 ... 10 kV, 0 ... 15 kV, 0 ... 20 kV ≤5 kV: 515 mA ±20 mA >5 kV: 155 mA ±20 mA (80 kV version) 260 mA ±10 mA (40 kV version) 0,5:1 / 1:3 / 1:6 / 1:12
ARM (Lichtbogenstoßen) <ul style="list-style-type: none"> • Surge voltage • Number of fault traces 	0 ... 32 kV 15
ARM Plus (double impulse) (optional) <ul style="list-style-type: none"> • Reference trace pulse • Fault ignition 	350 V or 1.5 kV (depending on the selected surge voltage) with a 0 ... 32 kV shock discharge (followed by a 4 kV pulse for arc stabilization)
DECAY voltage decoupling method <ul style="list-style-type: none"> • Voltage 	0 ... 40 kV or 0 ... 80 kV (optional)
DECAY Plus (double impulse) (optional) <ul style="list-style-type: none"> • Reference trace pulse • Fault ignition 	1.5 kV Test object is charged with 0 ... 40 kV / 80 kV (optional) up to the breakdown voltage (followed by a 4 kV pulse for arc stabilization)
ICE current decoupling method <ul style="list-style-type: none"> • Surge voltage 	0 ... 32 kV
ICE 3-phase (optional) <ul style="list-style-type: none"> • Surge voltage 	0 ... 32 kV
Burning <ul style="list-style-type: none"> • Output voltage • Max. burning current • Max. burning duration 	0 ... 40 kV or 0 ... 80 kV (optional) 260 mA (at 0 ... 40 kV) 155 mA (at 0 ... 80 kV) 60 minutes

Parameter	Value
ARM burning (optional)	
• Output voltage	0 ... 8 kV or 0 ... 20 kV (with optional 20 kV power burning unit)
• Max. burning current	515 mA or 530 mA (with optional 20 kV power burning unit)
• Max. burning duration	30 minutes
Surge pinpointing	
• Voltage levels	0 ... 2 kV (optional), 0 ... 4 kV, 0 ... 8 kV, 0 ... 16 kV, 0 ... 32 kV, >32 ... 60 kV (optional)
• Surge energy	1,200 J at 2 kV (optional) 1,280 J at 4, 8, 16 and 32 kV 1,750 J at 4, 8, 16 and 32 kV (optional) 2,000 J at 4, 8, 16 and 32 kV (optional) 2,560 J at 4, 8, 16 and 32 kV (optional) 1,800 J from 32 to 60 kV (optional)
• Surge rate	3 - 30 surges/min (adjustable) or single surge
Audio frequency generator (FLG) (optional)	
• Frequencies	0.491 kHz, 0.982 kHz, 8.440 kHz (customer-specific frequencies are possible)
• Output power	200 W (models 50 W or 10 W are available as external devices)

Technical data of the 20 kV power burning unit (optional) The optional 20 kV power burning unit is defined by the following parameters:

Parameter	Value
Output voltage	0 ... 20 kV (DC mode) 0 ... 440 V _{eff} (AC mode)
• Max. burning current	40 A (DC mode) 70 A _{eff} (AC mode)
• Max. burning duration	Continuous operation

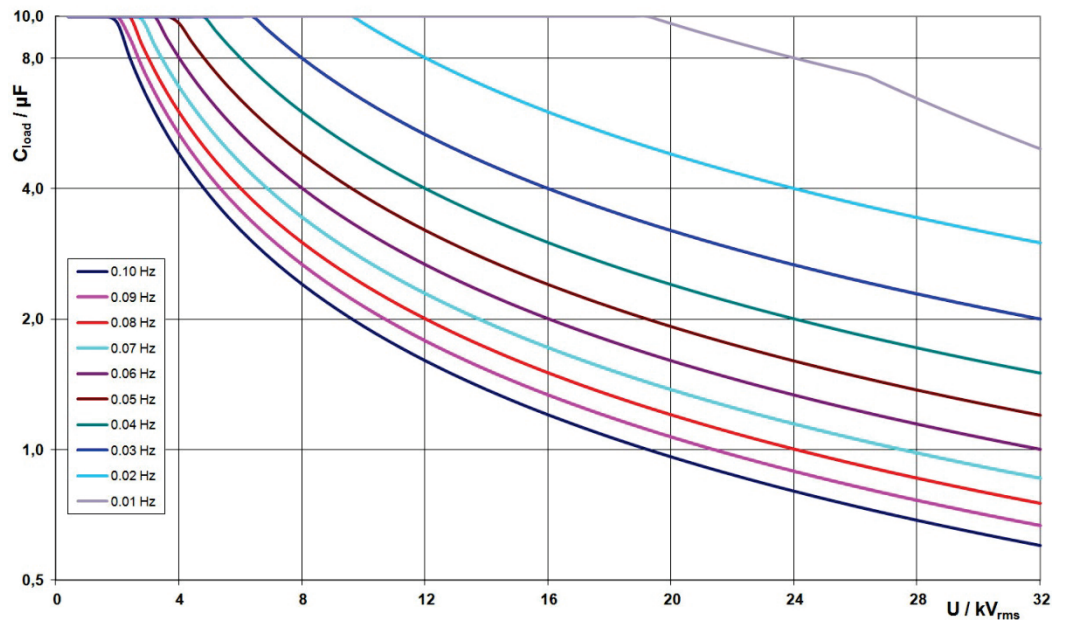
Technical data of the VLF CR 54 test attachment (optional) The optional VLF CR 54 test attachment is defined by the following parameters:

Parameter	Value
Test voltage	0 ... 54 kV (80 kV DC voltage source required)
Testable load capacitance	21 µF at 18 kV, 0,1 Hz 8 µF at 36 kV, 0,1 Hz 5 µF at 54 kV, 0,1 Hz

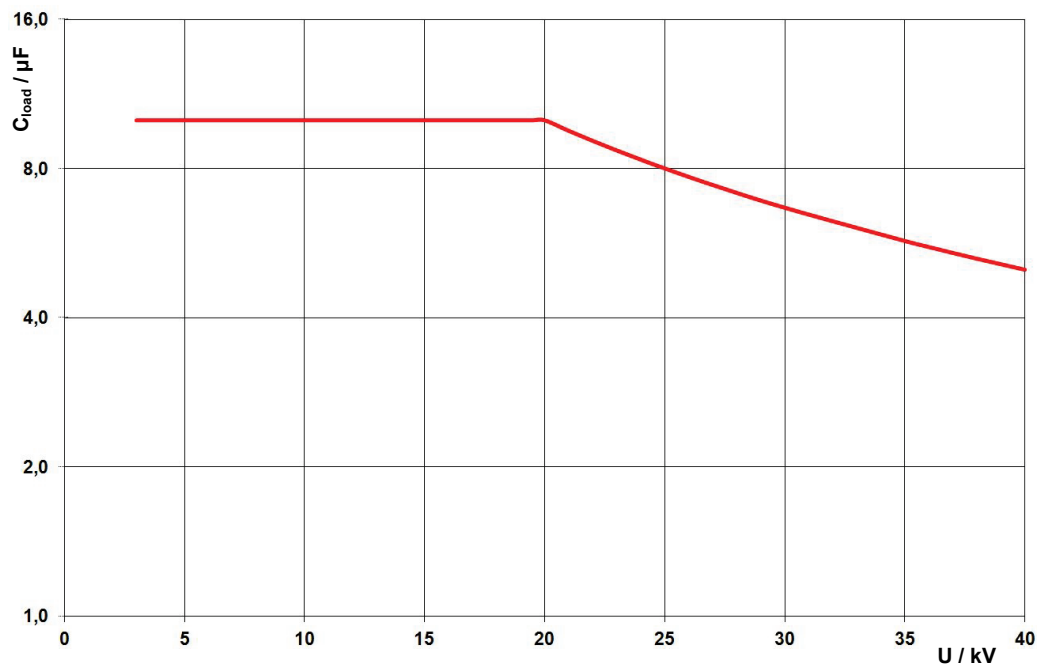
Technical data of the TDM 45 test attachment (optional) The optional TDM 45 test attachment is defined by the following parameters:

Parameter	Value
Output voltage	
<ul style="list-style-type: none"> Sine wave DC Square wave Cosine rectangular (optional) DAC (Damped AC) (optional) 	2 ... 32 kV _{RMS} / 45 kV _{PEAK} ±2 ... 45 kV ±2 ... ±45 kV ±3 ... 40 kV ±3 ... ±40 kV
Max. source output current	12 mA _{RMS} (at nominal voltage)
Leakage current measurement	(Rectangular, VLF-CR and DC operation)
<ul style="list-style-type: none"> Display area Resolution 	0 ... 20 mA 10 µA
Frequency	
<ul style="list-style-type: none"> Sine wave / square wave voltage Cosine rectangular voltage DAC voltage 	0.01 Hz to 0.1 Hz 0.1 Hz 20 Hz to 500 Hz
Testable load capacitance	(see also diagrams below)
<ul style="list-style-type: none"> Sine wave voltage Square wave voltage DC voltage Cosine rectangular voltage / DAC voltage Maximum load capacitance 	0.6 µF at 45 kV / 0.1 Hz 0.6 µF at 45 kV / 0.1 Hz 5 µF at 45 kV 4.8 µF at 40 kV 10 µF at reduced voltages and frequencies
Internal tan delta (optional)	
<ul style="list-style-type: none"> Measurement range Accuracy (at a load capacity >20 nF) Resolution 	10 ⁻³ to 10 ⁰ 1 x 10 ⁻³ or 1% 1 x 10 ⁻⁴
Pulse rate in sheath pinpointing mode (in seconds)	0.5:1 / 1:2 / 1:3 / 1:4 / 1.5:0.5

The following diagram **applies to tests with a sine wave voltage** and illustrates the dependency of the test frequency on the capacity of the load connected and the test voltage set. If a test frequency cannot be used due to the capacity limitations specified here, the frequency is automatically adapted and the user is informed of this.



In **cosine rectangular or DAC operation** (optional), the following load diagram applies analogously¹:

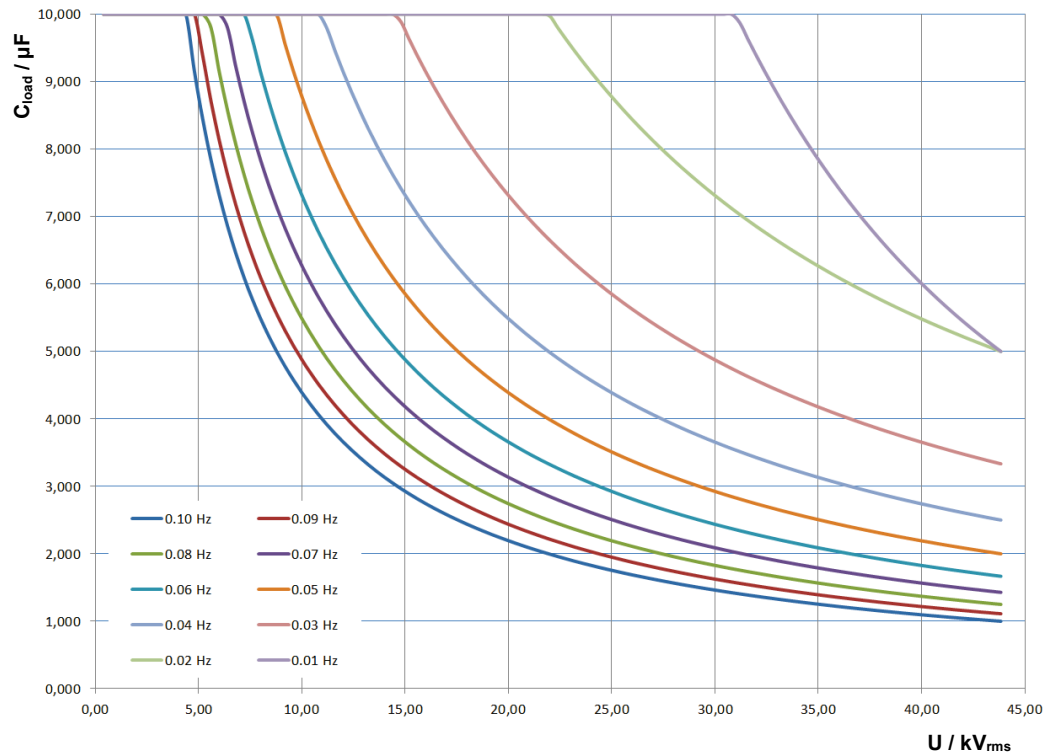


¹ Only applies between -25 and 45 °C. In the temperature range from 45 °C to 55 °C, at 40 kV the power is reduced to 80%.

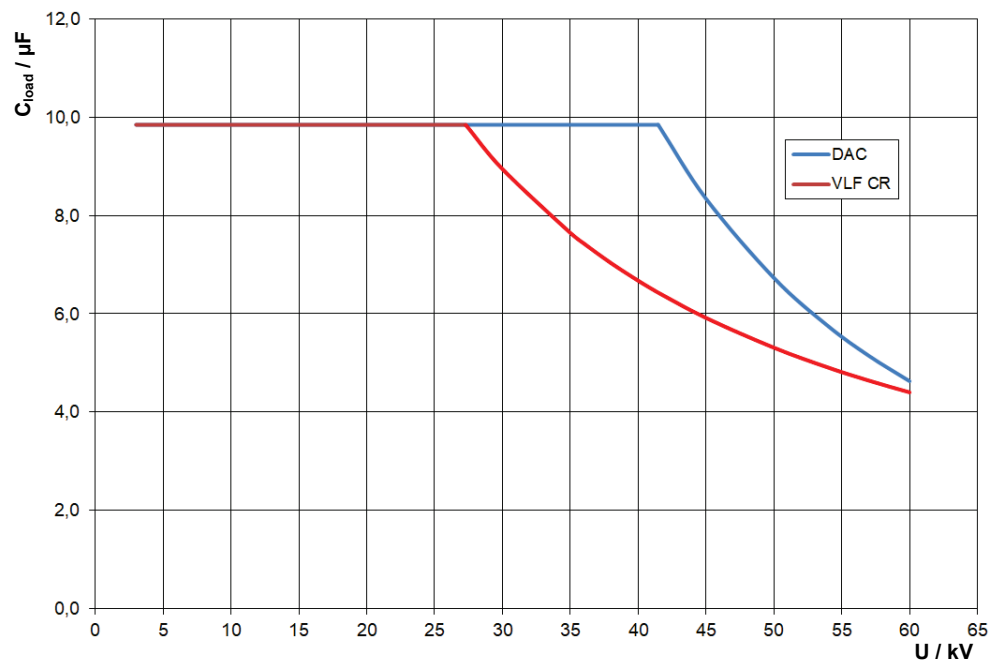
Technical data of the TDM 62 test attachment (optional) The optional TDM 62 test attachment is defined by the following parameters:

Parameter	Value
Output voltage	
<ul style="list-style-type: none"> • Sine wave • DC • Square wave • Cosine rectangular (optional) • DAC (Damped AC) (optional) 	2 ... 44 kV _{RMS} / 62 kV _{PEAK} ±2 ... 62 kV ±2 ... ±62 kV ±3 ... 60 kV ±3 ... ±60 kV
Max. source output current	23 mA _{RMS} (at nominal voltage)
Leakage current measurement	(Rectangular and DC operation)
<ul style="list-style-type: none"> • Display area • Resolution 	0 ... 20 mA 10 µA
Frequency	
<ul style="list-style-type: none"> • Sine wave / square wave voltage 	0.01 Hz to 0.1 Hz
Testable load capacitance	(see also diagram below)
<ul style="list-style-type: none"> • Sine wave voltage • Square wave voltage • DC voltage • Cosine rectangular voltage • DAC voltage • Maximum load capacitance 	1.0 µF at 62 kV / 0.1 Hz 1.0 µF at 62 kV / 0.1 Hz 5 µF at 62 kV 4,4 µF at 60 kV 4,6 µF at 60 kV 10 µF at reduced voltages and frequencies
Internal tan delta (optional)	
<ul style="list-style-type: none"> • Measurement range • Accuracy (at a load capacity >20 nF) • Resolution 	10 ⁻⁴ ... 10 ⁰ 1 x 10 ⁻⁴ 1 x 10 ⁻⁵
Pulse rate in sheath pinpointing mode (in seconds)	0.5:1 / 1:2 / 1:3 / 1:4 / 1.5:0.5

The following diagram **applies to tests with a sine wave voltage** and illustrates the dependency of the test frequency on the capacity of the load connected and the test voltage set. If a test frequency cannot be used due to the capacity limitations specified here, the frequency is automatically adapted and the user is informed of this.



In **cosine rectangular or DAC operation** (optional), the following load diagram applies analogously²:



² Only applies between -25 and 45 °C. In the temperature range from 45 °C to 55 °C, at 60 kV the power is reduced to 80%.

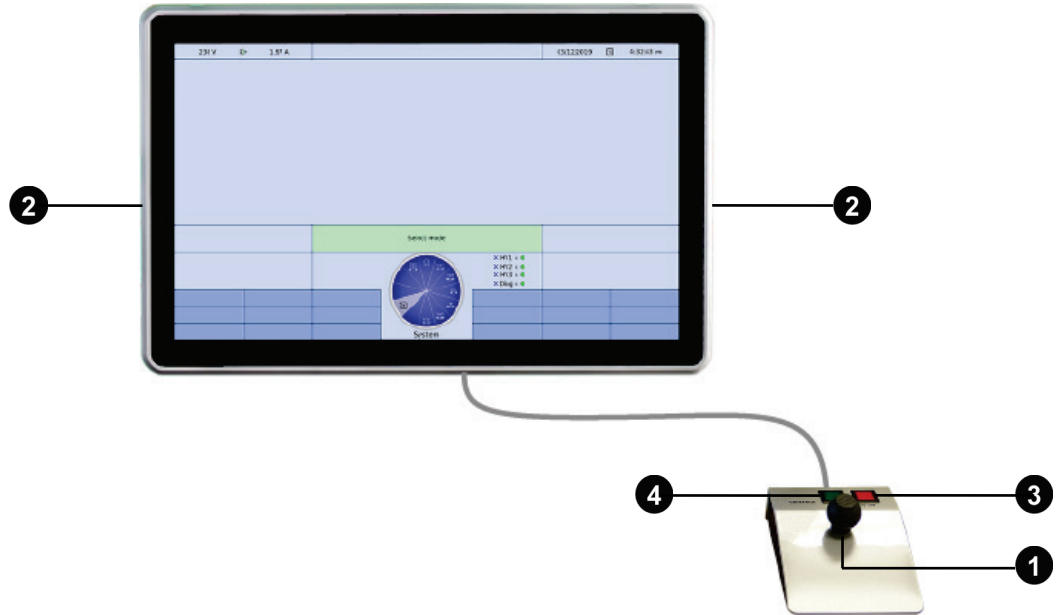
*Technical data of other
measurement
equipment / peripherals*



The technical data of additional measurement equipment (for example, digiPhone⁺, PDS 60, Tan Delta test attachment) and peripherals (for example, generator system) contained in the test van can be found in the respective operating instructions.

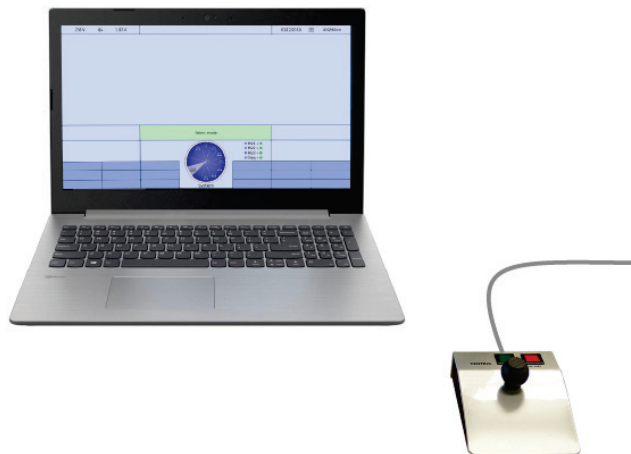
2.3 Operating unit

Standard operating unit By default, the central operating unit of the test van consists of an industrial PC and a control panel:

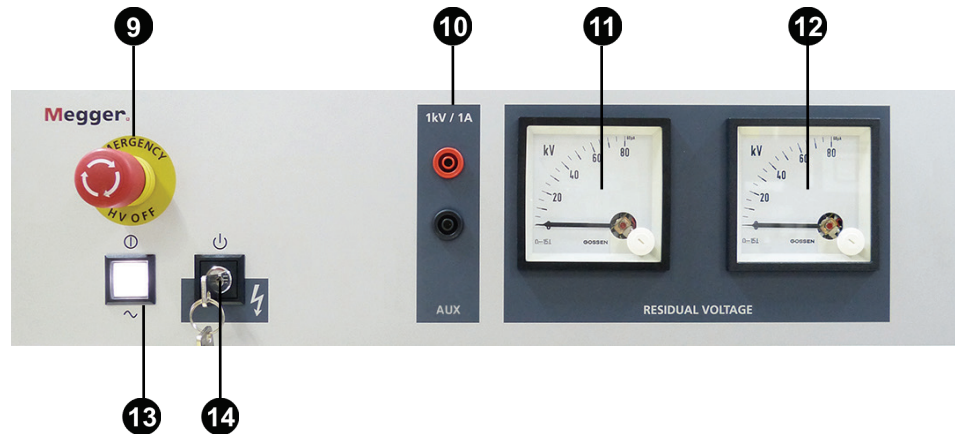




Element	Description
1	Selector knob with tilt function
2	USB slot for connecting a mouse, keyboard, storage media or printers (see page 40)
3	“HV Off” button
4	“HV On” button

Alternative: control via notebook The system may alternatively be controlled with a notebook (e.g. in the event of a failure of the industrial PC). Detailed information can be found in the appendix (see page 155).



Control panel The control panel of the test van has the following display and control elements:



Element	Description
9	EMERGENCY OFF switch Pressing the EMERGENCY OFF switch will shut off the high voltage immediately and discharge the test object.
10	External sockets (AUX) via which measurements of the connected test object phases can be taken (see page 93) using an external measuring device (e.g. an insulation tester).
11	Residual voltage indicator of fault location system (optional)
12	Residual voltage indicator of test and diagnosis module (TDM) (optional)
13	On/Off pushbutton
14	HV interlock key switch <div style="display: flex; align-items: center; margin-bottom: 5px;">  <div style="margin-left: 10px;">High voltage unlocked</div> </div> <div style="display: flex; align-items: center; margin-bottom: 5px;">  <div style="margin-left: 10px;">High voltage locked</div> </div> <p>In the locked state, the key can be removed and the system can thus be protected against unauthorised high-voltage operation.</p>

3 Putting the test van into operation

Applicable guidelines The guidelines for implementation of occupational safety when operating a test system / test van often differ between one network operator and another and it is not uncommon for national regulations (like, i.e. the German BGI 5191) to be used as well.

Inform yourself of the guidelines applicable in the area of operation beforehand, and comply with the specified rules for work organization and for implementing the test system / test van.

	<p>WARNING Risk of electric shock!</p> <p>In order to prevent the capacitor from becoming charged, when not in use, the PD coupling unit (optional) must be short-circuited using a short-circuit cable or the earthing sockets (if available).</p> <div style="display: flex; justify-content: space-around; align-items: center;"> </div>
--	--

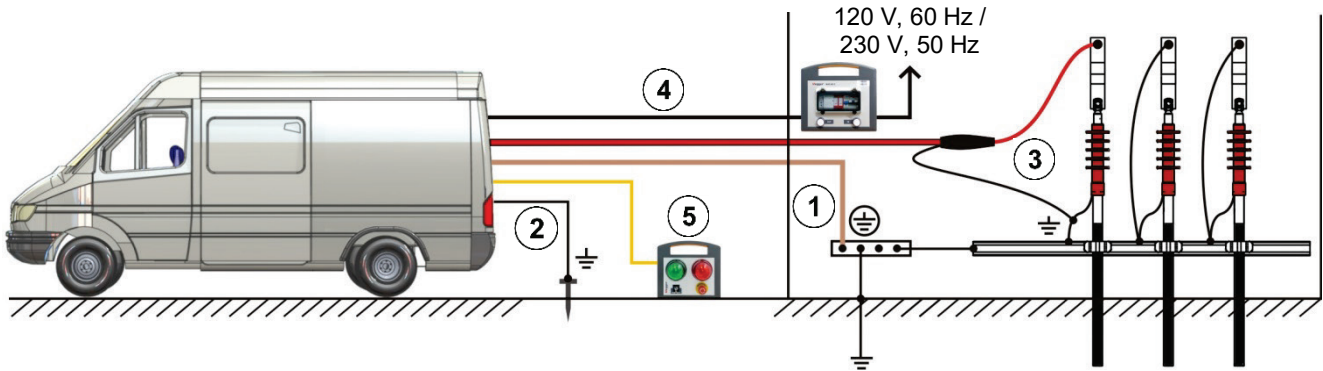
3.1 Securing the area


The following steps must be taken to adequately secure the area and the test van:

Step	Action		
1	Place the test van so that it is level (slope <math><10\%</math>) and near the access to the test object, taking into consideration its load and external dimensions. Verify that the test van is in a stable position. <div style="border: 1px solid black; padding: 5px; margin-top: 10px;"> <table border="1" style="width: 100%;"> <tr> <td style="text-align: center; vertical-align: middle;"> WARNING </td> <td>Never place the test van directly over the route of the cable to be tested!</td> </tr> </table> </div>	 WARNING	Never place the test van directly over the route of the cable to be tested!
 WARNING	Never place the test van directly over the route of the cable to be tested!		
2	Use the parking brake to secure the test van from rolling away and place stop blocks on the wheels if required.		
3	Secure the area according to regional regulations using barricades, warning signs and cable bridges.		

3.2 Electrical connection

The following figure shows the simplified connection diagram:



 WARNING	<p>Follow the specified connection sequence.</p> <p>The electrical connection must be carried out in the sequence shown in the figure. Connection to the mains occurs last.</p> <p>Taking down the setup is to proceed in reverse order.</p>
---	---

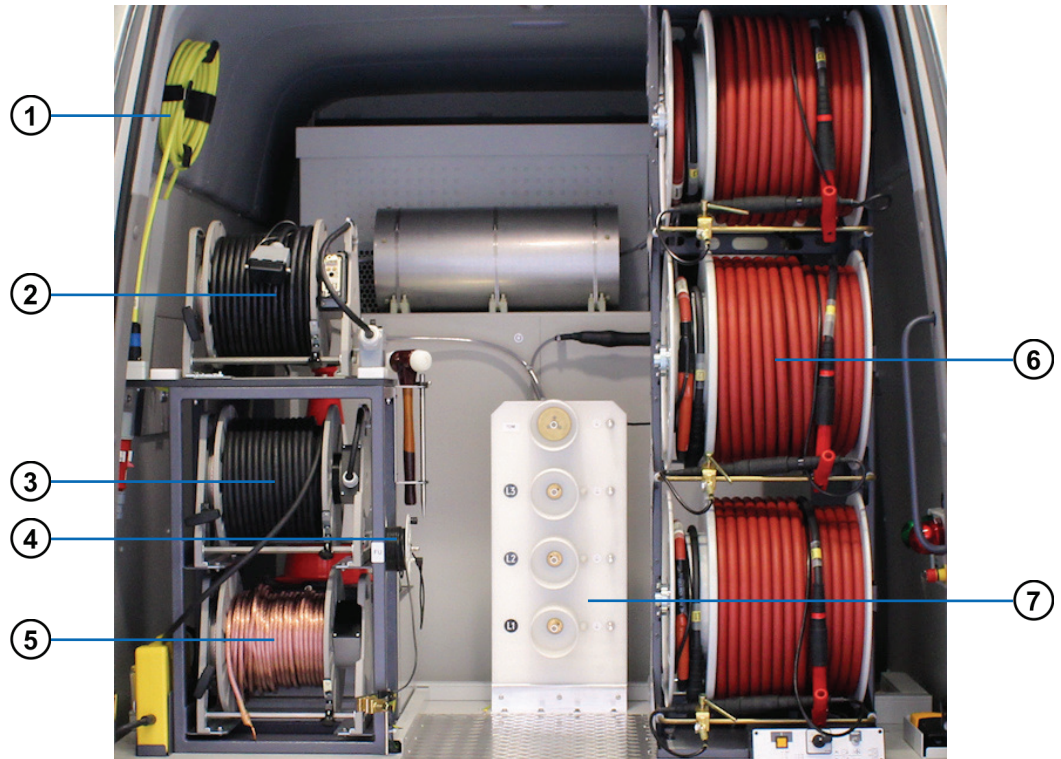
- ① Connection of the earthing cable (see page 28)
- ② Connection of the FU cable (auxiliary earth) (see page 29)
- ③ Connection to the test object (see page 30)
- ④ Connection to the mains (see page 37)
- ⑤ Connection of the external safety device (optional) (see page 38)

3.2.1 Connection technology



The arrangement and equipment of the connection technology may differ depending on the type of vehicle and equipment variant.

Typically, the test van in the HV room is equipped with the following components³:



Part	Description
①	Cable or cable drum for ext. safety device
②	Control line for connection of an external PD coupler (optional)
③	Power cable reel
④	Cable reel of FU cable
⑤	Cable reel of earth cable
⑥	Cable reels of high-voltage cables (optional: one reel with a three-phase cable)
⑦	HV connector panel

³ Not shown in the figure: LV cable reel (optional)

3.2.2 Connection of the earth cable



- The test van should never be operated without the earth cable being connected. The earth cable establishes the connection between the system and the protective earth and ensures that the entire system is touch-proof.
- The test van should be operated only on earthing systems or single earth electrodes with transition resistances $< 2 \Omega$.
- The protective earth (earth cable) and system earth (screen of the HV cable) must be connected so that no unacceptable voltage difference may arise between the protective earth (PE) and neutral conductor (N).
- For TT networks, there is no connection between the neutral conductor (N) and protective earth (PE) in the station. This connection must be created for the measurement with a suitable cable.

Proceed as follows to connect the earth cable:

Step	Action
1	Release the brake of the earth cable reel.
2	Unwind the cable and connect it to the station earth or other suitable foundation earth.
3	Clamp one of the contact sleeves attached to the cable at intervals of 5 m under the connecting clamp next to the cable reel.
4	Secure the cable reel brake again.

3.2.3 Connection of the FU cable (auxiliary earth)

Proceed as follows to connect the FU cable (auxiliary earth) to monitor the voltage-time integral and fault voltage:


Step	Action
1	Unwind the FU cable.
2	Place the earth spike into the ground in the immediate vicinity of the test van and attach the FU cable to it. <div data-bbox="842 571 1123 898" data-label="Image"> </div>
3	Connect the other end of the cable to the connector on the FU cable reel. <div data-bbox="847 1001 1118 1359" data-label="Image"> </div>



If after switching the test van on high voltage operation is blocked due to poor earthing conditions despite the connected auxiliary earth, the measures may correct the situation:

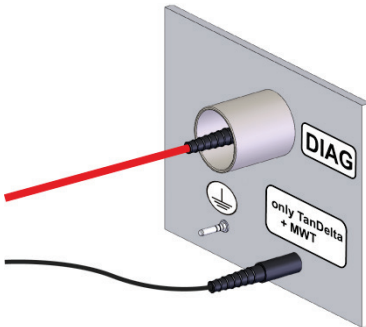
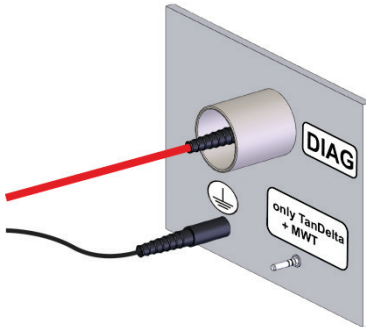
- Try inserting the earthing rod in other locations which may be more suitable. In heavily built-up areas, the gaps between the concrete slabs can be used, for example.
- Use water to moisten the location where the earthing rod has been inserted.
- Attach the auxiliary earth to a foundation earth (e.g. a lightning protection system). Do not use the same foundation earth to which you have already connected the main earthing cable.

3.2.4 Connection to the test object

 <p>WARNING</p>	<ul style="list-style-type: none"> • Before connecting to the test object, the five safety rules (see page 9) must be applied. • All test object phases which are not being tested must be short-circuited and earthed. • Install protective equipment (such as railings, chains or bars) to block access to the hazard zone and prevent the risk of touching live parts. • Since the voltage applied to the test object can assume values that pose a risk of incidental contact, all cable ends must be shielded in accordance with VDE 0104 to avoid this. Make sure that all cable branches are taken into account.
---	---

3.2.4.1 Using the HV connection cable

Basic procedure The electrical connection between the HV patch panel and the test object is to be performed as follows:

Step	Action
1	Make sure that the system-side end of the HV connection cable protruding from the side of the cable reel is not connected with the high-voltage connector panel.
2	Unwind the HV connection cable.
3	Connect the HV connection cable to the test object using suitable connection clamps. Follow the instructions and drawings on the following pages.
4	<p>Connect the system-side end of the HV connection cable to the HV connector panel. Follow the instructions and drawings on the following pages.</p> <p>Systems with a TDM 45 test and diagnosis module and internal tan delta measurement have two different earth connections at the diagnostic output (DIAG), one of which (only TanDelta + MWT) is intended exclusively for tan delta measurements:</p> <div style="display: flex; justify-content: space-around; align-items: flex-end;"> <div style="text-align: center;"> <p>Internal tan delta measurement</p>  </div> <div style="text-align: center;"> <p>All other operating modes via the DIAG output</p>  </div> </div>
5	If required, also connect phases L2 and L3 in the same way with the test object. Connection cables which are not required for the current measurement task, are to be short-circuited at the metal bar next to the cable reel.

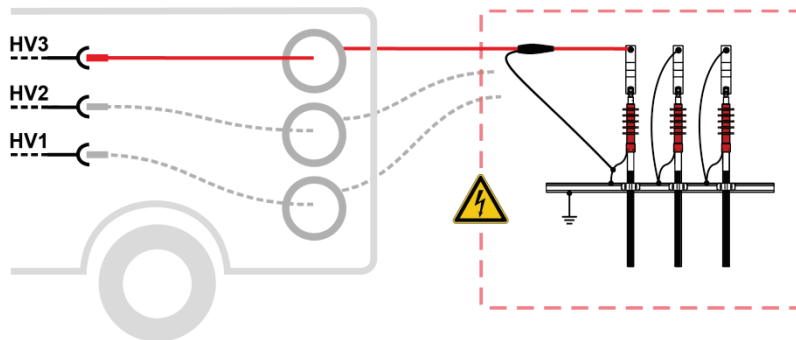
Connection diagrams Depending on the equipment of the test van and the desired operating mode, a few specifics should be taken into account when it comes to connecting the cable reel and the connector panel:



If your system is a custom solution with a custom-built connector panel and/or connection accessories that are different, please refer to the signs on the inside of the rear door for details on the electrical connection of the test object.

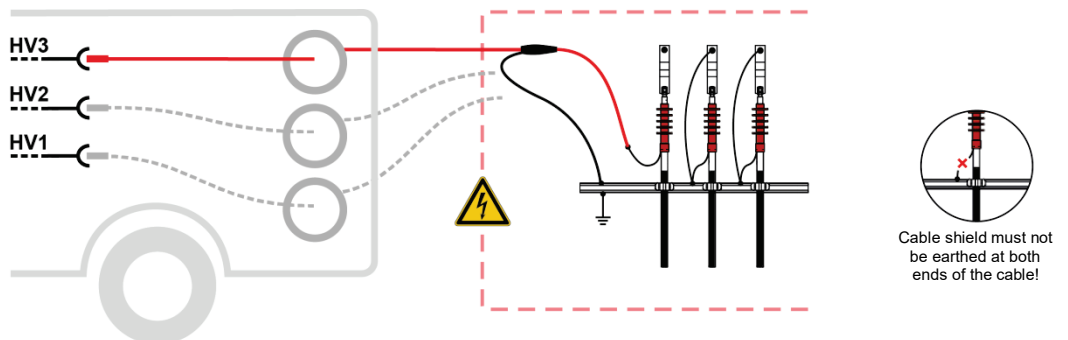
In a test van **without a test and diagnosis module** the connection should generally be carried out as demonstrated in the following image:

Default connection diagram



----- Should also be connected as required/depending on the operating mode

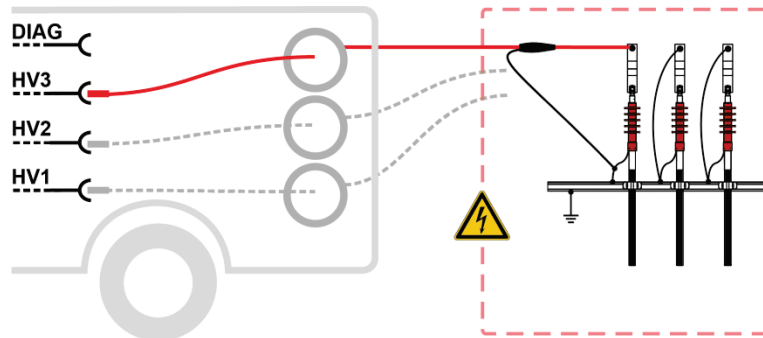
Sheath testing and sheath fault location



----- Should also be connected as required/depending on the operating mode

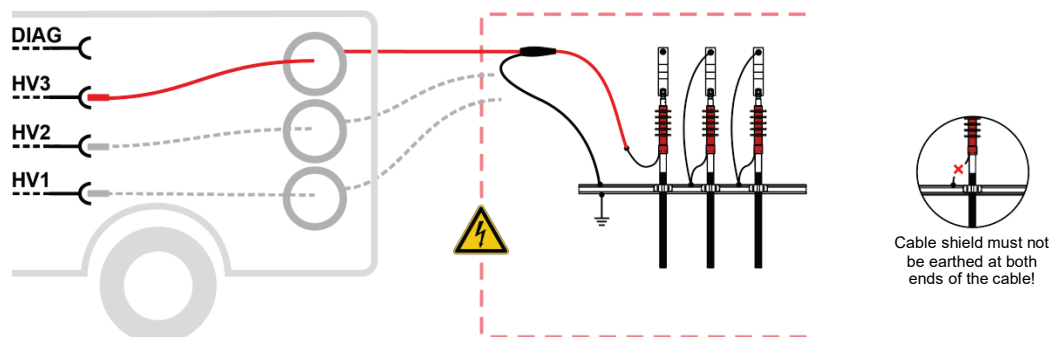
In a test van **with a test and diagnosis module and an additional diagnosis patch panel** connection must be carried out as follows depending on the operating mode:

Fault location and testing



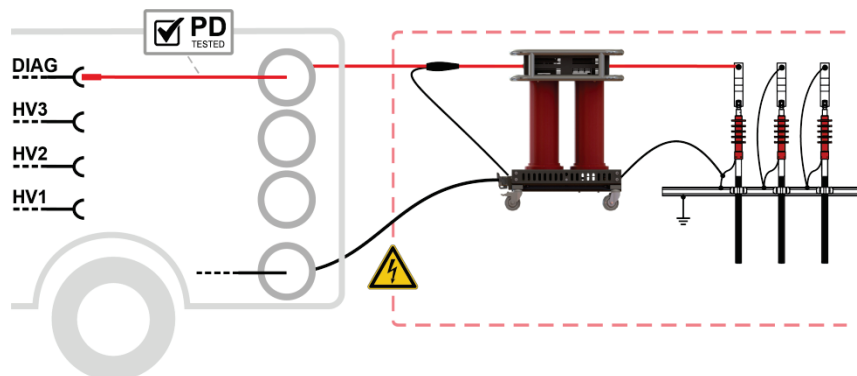
----- Should also be connected as required/depending on the operating mode

Sheath testing and sheath fault location

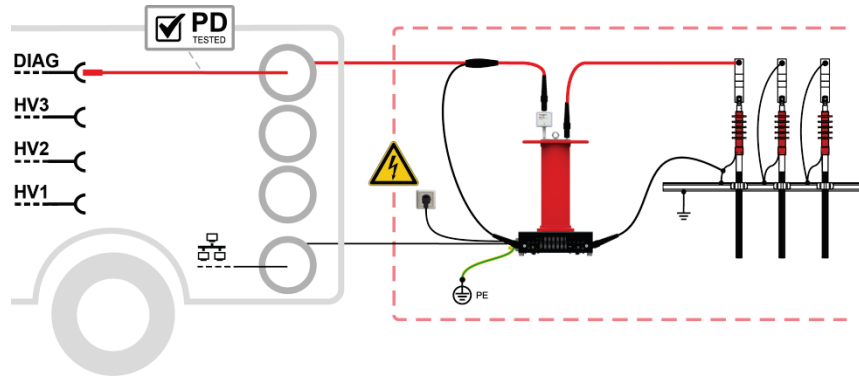


----- Should also be connected as required/depending on the operating mode

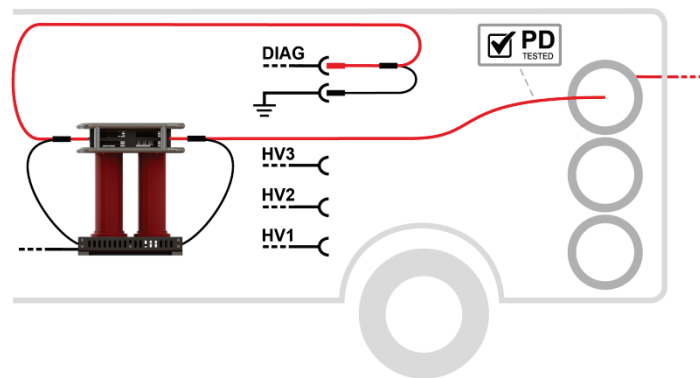
PD diagnosis with external coupler PDS 60(-HP)



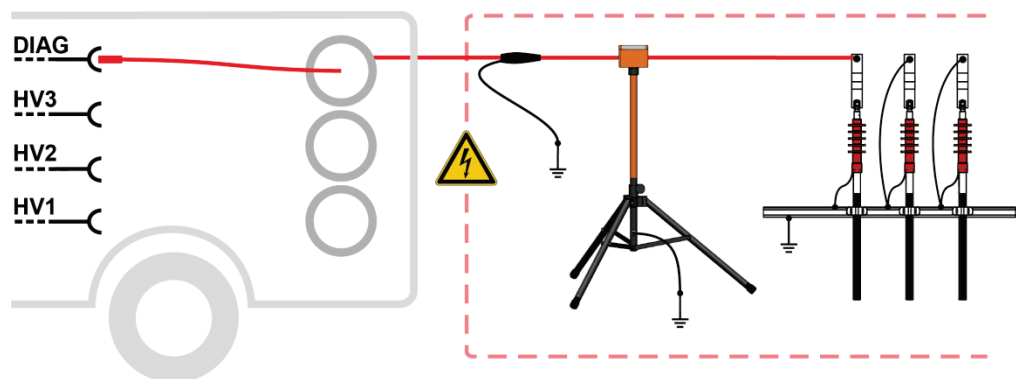
PD diagnosis with external coupler PDS 62-SIN



PD diagnosis with integrated coupler PDS 60(-HP)



Tan delta measurement with external sensor

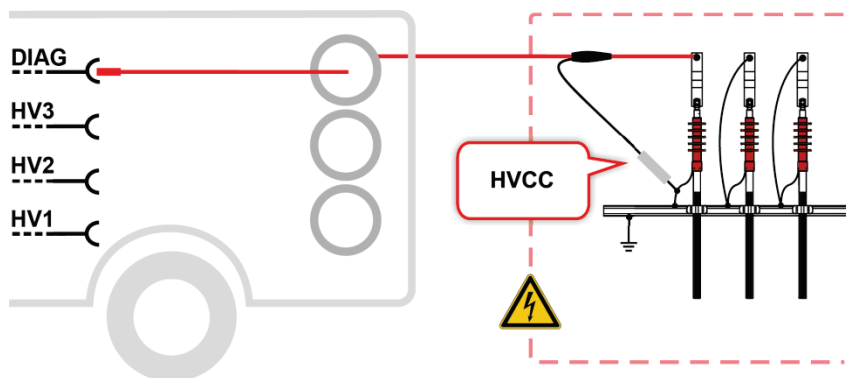


Tan Delta Messung mit TDM



When taking an internal tan delta measurement using a test and diagnosis module (TDM), observe the following with regard to the connection:

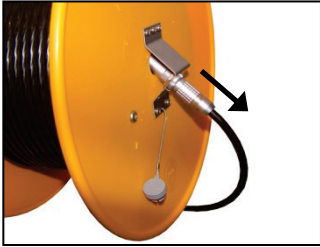
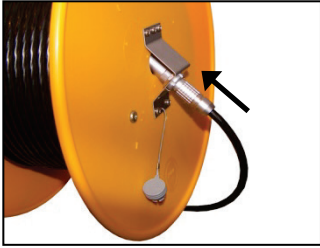
- The cable shield of the HV connection cable must be connected to the system earth of the test object using the HVCC adapter supplied.
- When using a TDM 45 test and diagnosis module, the system-side end of the HV connection cable must be earthed at the **only TanDelta + MWT** connection point.



3.2.4.2 Using the three-phase LV cable (optional)

Application If the three-phase LV connection cable is used to connect to the test object, only impulse reflection measurements and insulation tests with a measuring voltage up to 1,000 V can be conducted. In all other operating modes, the test object must be connected using the HV connection cable.

Procedure Perform the following steps to connect the LV cable to the test object:

Step	Action
1	<p>If the connection cable coming from the reflectometer is connected to the socket of the cable reel body, this connection must be disconnected before the cable can be unwound.</p> 
2	Unwind the LV cable.
3	Connect the unwound LV cable with the four-core adapter cable pre-assembled for the connection to the test object.
4	<p>Use appropriate connection accessories to connect the individual phases of the LV cable with the phases of the test object and connect the operational earth (red terminal) to the earthed screen of the test object.</p> <hr/> <div data-bbox="518 1238 582 1323" style="border: 1px solid black; padding: 2px; display: inline-block;">i</div> <p>When connecting, make sure that the four wires are run as uniformly as possible to each other (ideally twisted) and are not separated from each other until just before the actual connection point. This ensures that all three phases have similar impedance values.</p> <p>Labeling of the phases must be taken into account when making the connection in order for it to be possible to properly assign the measurement results to the respective phases.</p> <hr/>
5	<p>Reconnect the connection cable coming from the reflectometer with the socket on the cable reel.</p> 


3.2.4.3 Using the MFM/HVB connection cable (optional)


The special MFM/HVB connection cable is connected directly to the MFM 10-M sheath fault location system or the HVB 10-M high-voltage measuring bridge and is only used for their operating modes.



For detailed information about connecting to the test object, please refer to the operating instructions for the MFM 10-M or HVB 10-M.

3.2.5 Connecting the power cable

 WARNING	<p>If the measurement object and the supplied network are connected to different, unconnected earthing systems during operation of the test van, then establish potential equalisation using a connection cable with a cross section of at least 16 mm² Cu. Good earthing conditions are extremely important.</p>
---	--

 CAUTION	<p>When connecting to mains sockets which do not fit with the preassembled plugs, or when establishing a direct connection to the low voltage line, only approved (VDE/IEC or equivalent national regulations) interconnections are to be used.</p>
---	---

Procedure Proceed as follows to connect the test van to the mains power supply:

Step	Action
1	Release the brake of the mains cable reel.
2	Unroll the mains cable.
3	Connect the cable with a mains connection socket.
4	Secure the cable reel brake again.

Generator power (optional) If you have no way to tap mains power in the immediate vicinity of the deployment location and your system is equipped with a generator system such as the *Travel Power* used by Megger, the system can also be supplied on this generator.



For information on setting up and operating the generator, please see the associated operating manual.



When the generator is operating, the system automatically obtains its operating voltage from the generator. This is also the case if the mains power supply and generator are active at the same time.

3.2.6 Connection of the external safety device

Purpose Using the external safety device, the status of the system can be indicated outside the test van and the HV processing can be interrupted or blocked using the EMERGENCY OFF switch and key switch.

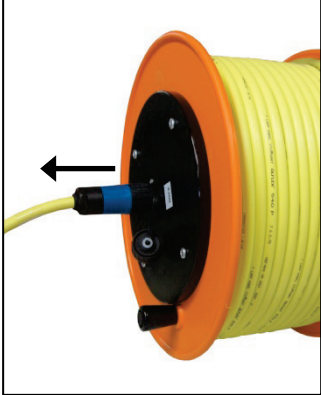
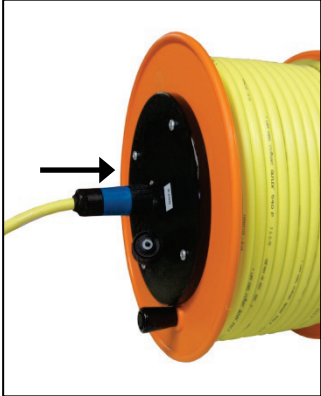
Description The following figure shows the external safety device:




Part	Description
①	Green signal light Lights up when the system is switched on but not in high-voltage operation.
②	Red signal light Lights up as soon as high voltage can be generated. All discharge and earthing devices are open and the test object must be treated as live.
③	HV interlock key switch <div style="display: flex; align-items: center; margin-bottom: 10px;">  <div style="margin-left: 10px;">High voltage unlocked</div> </div> <div style="display: flex; align-items: center;">  <div style="margin-left: 10px;">High voltage locked</div> </div> <p>In the locked state, the key can be removed and the system can thus be protected against unauthorised high-voltage operation.</p>
④	EMERGENCY OFF switch

Connection of the external safety device

Proceed as follows to connect the external safety device:


Step	Action
1	<p>If the connection cable (yellow) coming from the system control panel needs to be connected to the socket of the cable reel body, this connection must be disconnected before the cable can be unwound.</p> 
2	Unroll the connection cable.
3	Place the external safety device so that it is accessible and visible near the test van, and connect the connection cable to the appropriate socket.
4	<p>Reconnect the system control panel coming from the reflectometer with the socket on the cable reel.</p> 

3.3 Connect USB accessories

	<p>CAUTION! Risk of interference</p> <p>To prevent a malfunction or even damage to the IPC, the following precautions should be observed:</p> <ul style="list-style-type: none"> • When connecting USB accessories, no extension cords may be used. • In HV operation, there must not be any loose USB connection cables connected to the USB ports of the IPC.
---	--

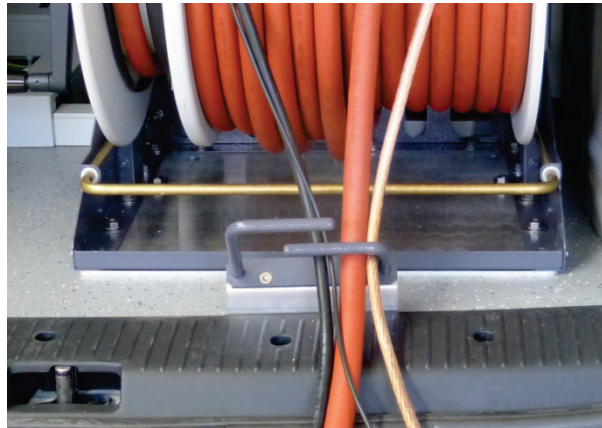
The IPC has several type A USB ports (see page 23), to which the following accessories can be connected:

Class	Description
Input devices	<p>For convenient data entry, both corded and cordless keyboards and mice can be connected.</p> <p>Depending on whether a hardware mouse and/or keyboard is connected, the on-screen keyboard and the mouse pointer can be activated / deactivated in the basic settings of the software (see page 58).</p>
USB mass storage	<p>For the import and export of measured data and reports, USB mass storage (for example USB sticks and external hard drives) can be connected.</p>
Printer	<p>For direct printing of measured data and reports, a printer can be connected. However, the selection of compatible printers is limited by the drivers installed on the system.</p> <p>Before buying a new printer, please contact your Megger sales partner for a list of supported devices.</p>

	<p>When importing or exporting a large amount of data, the USB 3.0 port on the control unit's stand should be used, which offers a significantly higher data transfer rate compared to the other USB ports.</p>
---	---

3.4 Setting up switch-on standby


After the test van has been connected or a change made to the test object activation, the connection cables must be led through the cable guide to the outside, as shown in the following figure:



After the rear doors of the test van have been closed, it is ready to be turned on. Assuming that the connection was established properly and good earthing conditions were ensured, the conditions of the safety circuit are thus also fulfilled.

3.5 Switching on the test van


Proceed as follows to switch on the test van and to prepare for the measurements:

Step	Action
1	To switch on the test van and supply the control unit with voltage, press the lit on/off pushbutton 13 on the power module.
2	Before beginning the measurements, select the connected cable in the MeggerBook Cable log software (see page 72).
	 For information on operating the MeggerBook Cable log software, please read the corresponding online help.

3.6 High voltage control

Switching high voltage on Directly after a measurement is prepared and has been started by the operator, readiness for high voltage enable is signalled by the lit green “HV ON” button **4**. By pressing the button, earthing on the HV output is cancelled. This switching state means: **High voltage!**

If the button does not go on after start of the measurement, this is due to a problem in the safety circuit that must be corrected by the user. Depending on the displayed problem description, the following measures must be taken:

System reports...	Cause / remedy
<ul style="list-style-type: none"> Activated EMERGENCY OFF switch 	One of the EMERGENCY OFF switches (for example, on the operating unit or the external safety device) has been activated and needs to be reset again first.
<ul style="list-style-type: none"> Too high earthing resistance Not connected cable shield Potential increase Fault voltage Dangerous voltage-time surface 	<p>Non-permissible earthing resistances or voltage peaks were measured that indicate poor earthing conditions.</p> <p>It must be checked whether the following connections were established properly and provide good earth contact:</p> <ul style="list-style-type: none"> Earthing cable Auxiliary earth Cable shield of the HV connection cable <div style="border: 1px solid black; padding: 5px; margin-top: 10px;">  <p>Never fail to use safety equipment or put it out of operation.</p> </div>
<ul style="list-style-type: none"> Open rear door 	The rear door must be closed.
<ul style="list-style-type: none"> Locked high voltage 	The locked “HV Interlock” key switch on the operating unit or the external safety device must be unlocked.

Switching high voltage off When certain events occur (for example, voltage breakdown in the test object, expiration of the defined test duration), the high voltage is automatically deactivated by the system. This also happens when a problem has been identified in the safety circuit (see above).

HV operation can also be terminated manually at any time by pressing the red illuminated HV OFF button **3**.

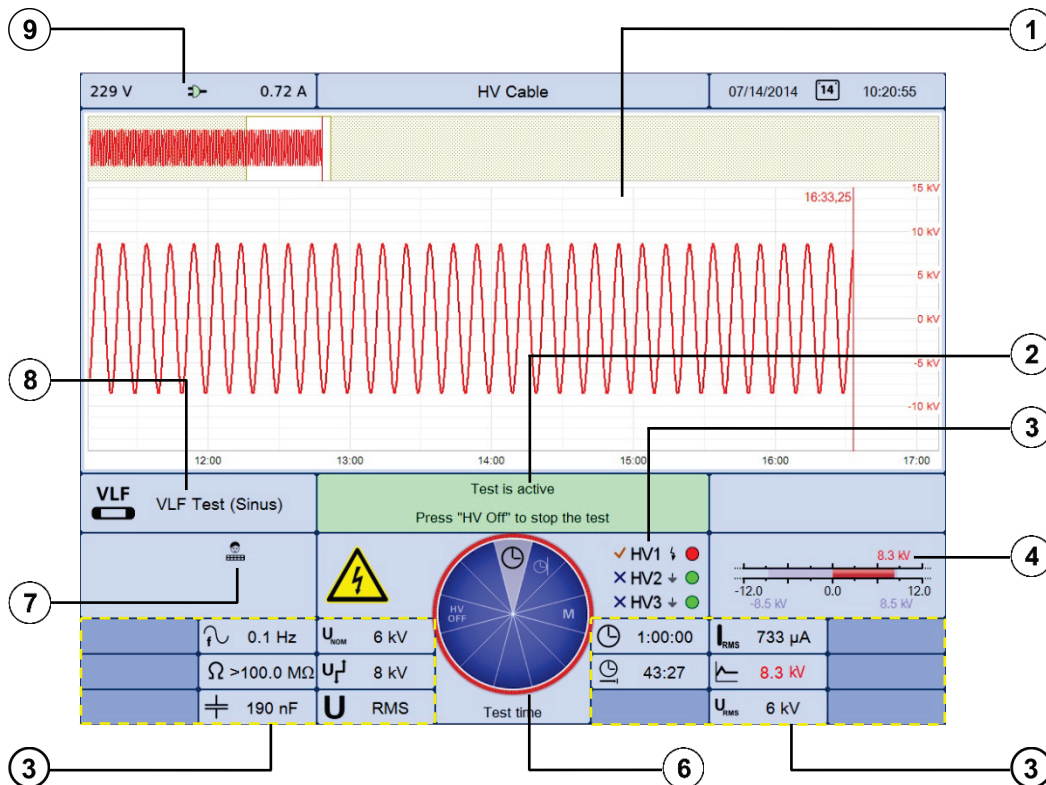
Irrespective of whether the high voltage is switched off automatically or manually, the test object is discharged by means of an internal discharge-resistor.

After the high-voltage shutdown, the de-energised status of the measuring circuit can be verified on the analogue residual voltage indicator **11**.












4 Basics of operation






4.1 Screen layout

The following figure shows the typical screen layout:



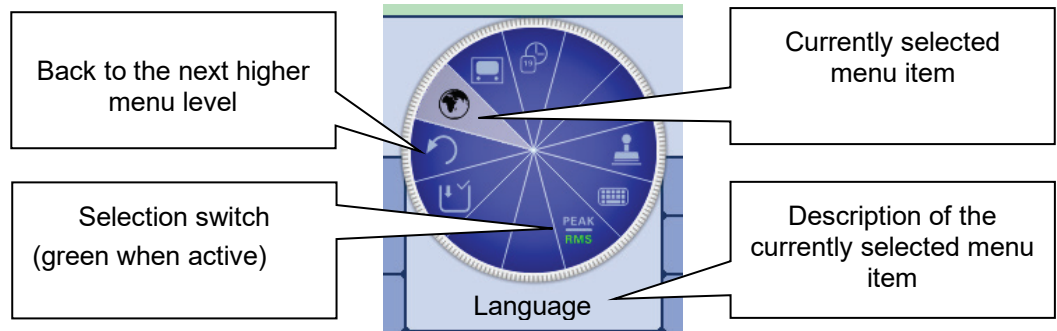
Segment	Description
①	Traces for current measurement or loaded measurements. The display is split up into a general overview (top) and in an enlarged section (bottom).
②	Current status messages and information on the next step required in the test sequence.
③	Information on the states of the high voltage outputs. The symbols indicate the following states: <ul style="list-style-type: none"> The HV output has not been selected for the upcoming / running measurement. The HV output has been selected for the upcoming / running measurement. High voltage generation is switched off and the HV output is discharged. The resistor discharge is cancelled here. High voltage is active!
④	Voltage display bar graph Blue bar: Set value Red bar: Actual value

Segment	Description
<p>⑤</p>	<p>The display elements arranged in the lower area of the screen may contain the following information:</p> <ul style="list-style-type: none"> • Set measurement parameters • Current measurement values, which are continuously updated as the measurement progresses • Legend of traces currently shown in display (see page 52). <p>Information (such as, e.g. measurement values) which apply for a particular trace only, is shown in the respective colour.</p>
<p>⑥</p>	<p>Selection menu (see page 46)</p>
<p>⑦</p>	<p>Current system state</p> <ul style="list-style-type: none">  The system is currently in standby.  Pulse reflection measurement currently under way.  The measurement was stopped and the traces frozen.  The device is in measurement operational readiness and waiting to be triggered.  A mobile data connection has been established via the optional 4G / GPS router.  A connection to a mobile radio network could be established via the optional 4G / GPS router, but no mobile data connection could be established. This may occur if the access point (APN) has not yet been configured, or has been configured incorrectly (see page 58).  No connection to a mobile radio network has been established via the optional 4G / GPS router yet. If this is still the case, even a few minutes after a system start, either the GSM field strength is insufficient to the current position, no valid SIM card has been installed in the router (see page 153), or the mobile data connection has been deactivated (see page 58).  The WiFi access point of the optional 4G / GPS router is active (see page 58).  The WiFi access point of the optional 4G / GPS router is not active (see page 58).  Remote control mode is active (see page 61).  The user operating the system has successfully logged into the administration menu (see page 67) and identified himself / herself as administrator.
<p>⑧</p>	<p>Current operating mode</p>

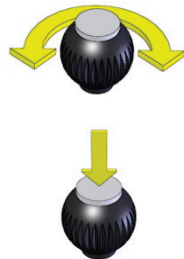
Segment	Description									
<p style="text-align: center;">9</p>	<p>Power source and parameters</p> <ul style="list-style-type: none">  Mains operation  Generator operation <p>Tapping / clicking on the screen segment shows / hides the power consumption values which are broken down into the power demand of the internal system components and the power demand of external loads (e.g. air conditioning, heaters, sockets):</p> <div style="border: 1px solid #ccc; background-color: #e6f2ff; padding: 5px; margin: 10px auto; width: fit-content;"> <table style="width: 100%; border-collapse: collapse;"> <tr> <td style="padding: 2px 10px;">238 V</td> <td style="padding: 2px 10px;"></td> <td style="padding: 2px 10px;">1,97 A</td> </tr> <tr> <td style="padding: 2px 10px;">System</td> <td style="padding: 2px 10px;"></td> <td style="padding: 2px 10px;">0,85 A</td> </tr> <tr> <td style="padding: 2px 10px;">External</td> <td style="padding: 2px 10px;"></td> <td style="padding: 2px 10px;">1,12 A</td> </tr> </table> </div> <p>In the event of overload, the display will open automatically and the current values will be displayed in red. In such a case, the external loads should be turned off first.</p>	238 V		1,97 A	System		0,85 A	External		1,12 A
238 V		1,97 A								
System		0,85 A								
External		1,12 A								

4.2 Basics of control system

Selection menu Navigation within the menus is effected almost entirely from the circular selection menu:

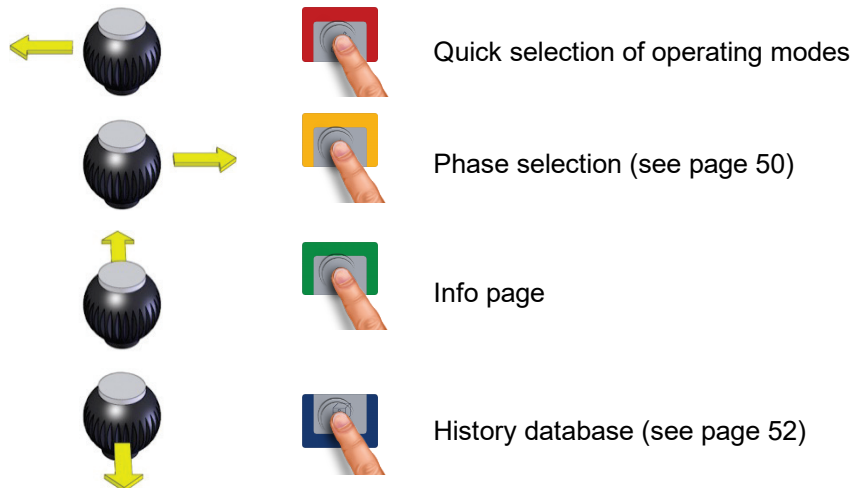


Operation with rotary encoder The system can be operated using the rotary encoder as follows:



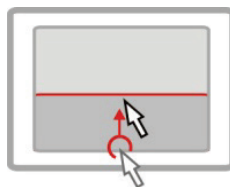
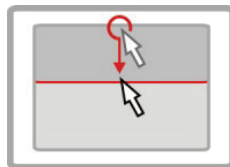
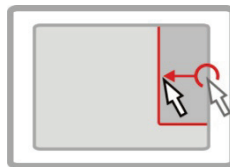
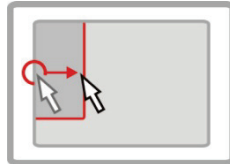
- Select the required menu item
- Increase or decrease the value of a variable parameter
- Select an option from a selection list
- Call up the selected menu item
- Confirm the setting or the selection made

The four side menus are retrieved either by tilting the rotary encoder or by pressing the corresponding function button (depending on the type of rotary encoder):



Operation with mouse and keyboard

The system can be operated using mouse and keyboard as follows:



- Select the required menu item
- Increase or decrease the value of a variable parameter
- Select an option from a selection list
- Call up the selected menu item
- Confirm the setting or the selection made

Quick selection of operating modes

Phase selection (see page 50)

Info page

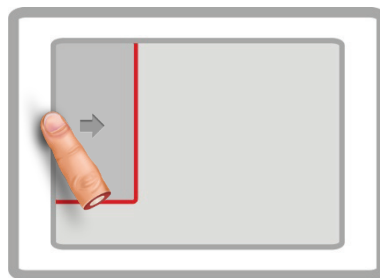
History database (see page 52)

Operation using the touchscreen If the device/system is equipped with a touch-sensitive display, then the software can also be operated just by using your fingers.

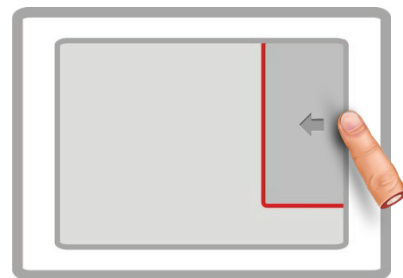
Briefly tapping on the buttons in the various menus, and tapping and holding the buttons in isolated cases, allows the respective functions to be activated in the same way as the rotary encoder control.



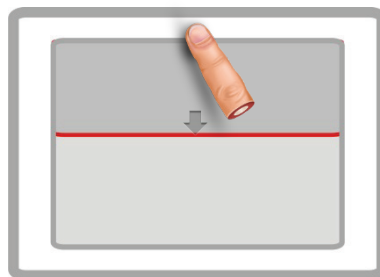
The four menus at the side can be opened by a swiping motion.



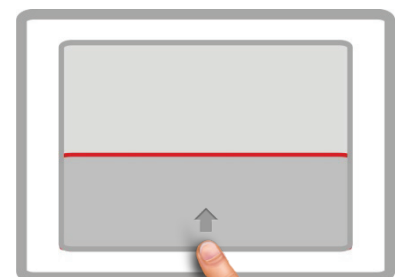
Quick selection of operating modes



Phase selection (see page 50)

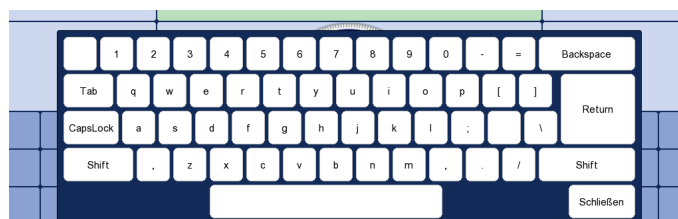


Info page



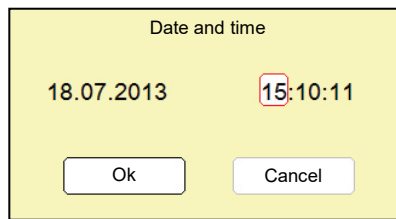
History database (see page 52)



Whenever character strings need to be entered or changed, an on-screen keyboard appears at the lower edge of the display:



If wanted, the touch functionality and the on-screen keyboard can be disabled in the basic settings (see page 58). The latter is particularly useful, if a hardware keyboard is connected.


Dialog boxes A few settings, which require values to be entered, are not made directly using the selection menu, but rather in a separate dialog box.




Using  and  the user can switch back and forth between the individual buttons in a dialog box. Each active button is then highlighted in white or it is surrounded by a red frame. Whenever the selected button requires letters or digits to be entered the screen keyboard automatically appears (touchscreen required), and it can then be used to make the entries.

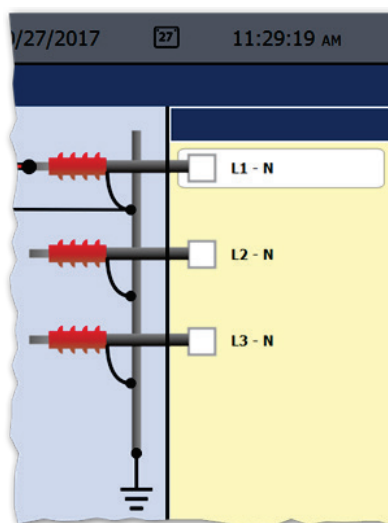
To close a dialog box, the corresponding button must be selected and then the rotary encoder pressed.

4.3 Quick selection of operating modes –



Using  the quick selection menu can be accessed (as well as closed) at any time. The menu provides direct access to all the available operating modes and the log function.

4.4 Phase selection -

Opening phase selection menu The selection menu for the phase(s) involved in the measurement opens automatically as soon as an operating mode is entered. It can also be opened manually at any time via .

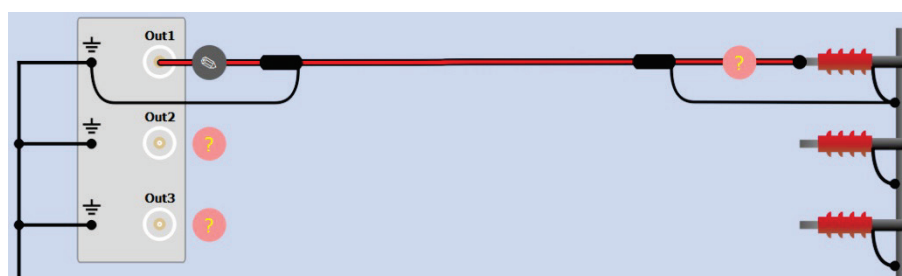


Selecting the phases The desired phase can be marked for selection by turning the rotary encoder and then selected or deselected by pressing it.



-  Option is active
-  Option is not active


The options that are displayed during phase selection and the number thereof that can be selected at the same time depends on both the operating mode and the number and type of cable reels.

Correcting the connection situation Immediately after at least one option has been selected, the recommended connection situation for the current phase selection is shown on the left next to the selection window, as shown in the example below.



It must be checked whether the connection to the test object that is shown corresponds with the actual connection situation. If this is not the case, the electrical connection must be adapted accordingly.

Depending on the operating mode and the available cable reels, changes can also be made to the connection schematic shown using the  and  buttons within the technical permitted scope. In this way, for example, test object phases can be individually connected / disconnected, the assignment between patch panel output and test object phase can be changed, or bridges installed at the test object (for simultaneous testing of multiple phases) can be added.


Confirming the phase selection The phase selection menu can only be closed once a valid selection has been made. By closing the menu via , the active selection is confirmed. Until the actual start of the measurement, the selection menu can be called up again and adjusted.



Make sure that the phase selection matches the actual connection situation! Otherwise, the measuring data will be stored with incorrect phase details whereupon the data will not be able to be correctly assigned afterwards.

4.5 History database -

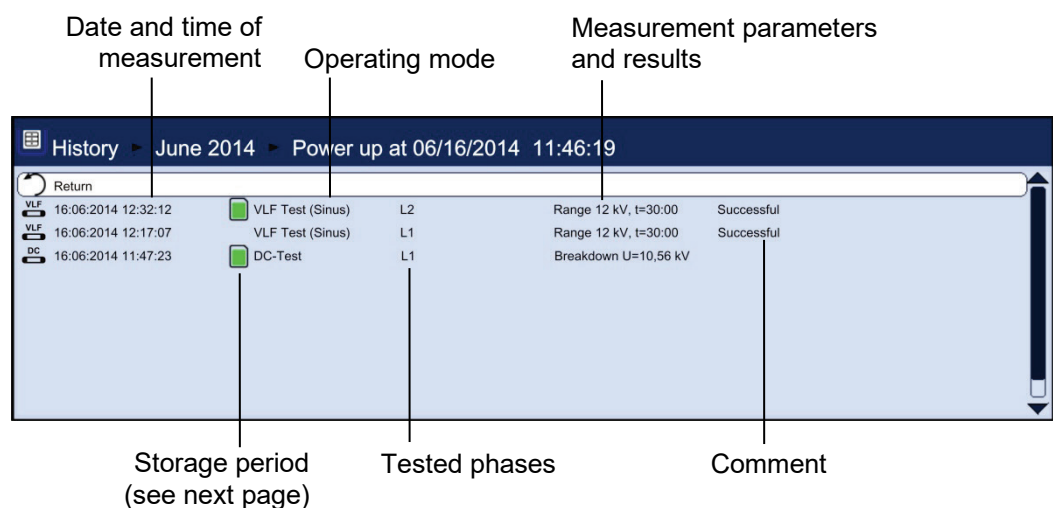
Purpose Each conducted measurement is temporarily stored in the History database and it can be retrieved from there again. This enables the user to access old traces and to compare them with the current traces. The parameters under which the measurement was conducted are also shown.


Browsing the history database Via  the history database can be called up at any time.

The measurement data records are organised by date in sub-directories.

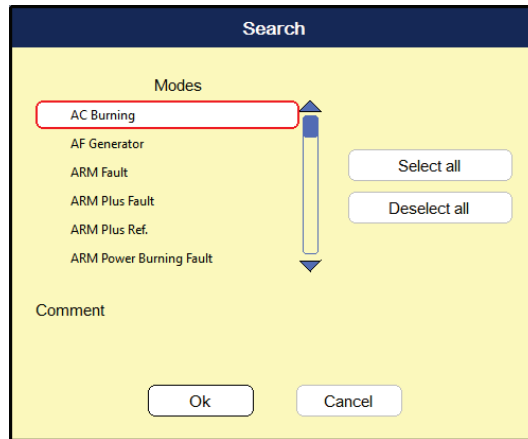


After the desired month and then the desired day have been selected, the measurement data records registered on this days can be searched through and retrieved.



Via the  list entry you can always return to the next directory level up.

Via the list entry you can reach the search mask using which you can search for particular operating modes and comment entries through the data records of the current directory and all sub-directories.



If you are searching for both an operating mode and comment entry at the same time, only those results which fulfil both criteria will be displayed.

Holding down the button will cause the search criteria to be discarded and all the data records to be displayed again.

Storage period The default setting stores the measurement data for 7 days in the history database. The following symbol indicates how long a measurement has already been stored:

Symbol	Description
No symbol	The data record has been conducted within the last four days. An automatic deletion is not imminent.
	The data record is either imported or permanently stored (see page 75).
	The data record is at least 4 days old and will be automatically deleted during the next few days.

Managing data records If a data record or an entire folder is to be exported or deleted, it has to be selected first using the rotary encoder and then has to be marked appropriately using

Symbol	Description
	The data record or the folder (incl. all data records in it) is marked for deletion.
	The data record or the folder (incl. all data records in it) is marked for export.
	Several data records within the folder have been marked for deletion.
	Several data records within the folder have been marked for export.
	The folder contains both data records marked for deletion and data records marked for export.

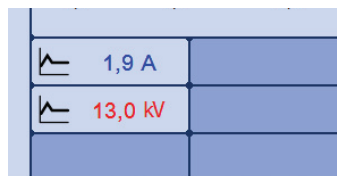
After selection of the measurements the data deletion or export process must be initiated in the data menu (see page 57). Otherwise the markings will expire the next time the software is started up.

Accessing measurement data from the history database To access curves and data from old measurements, first access the history database and then use the rotary encoder to select the respective measurement from the directory structure. **Briefly pressing** the rotary encoder enables all the curves and measured data for this measurement to be loaded. To this end, the software proceeds as follows:



- If the operating mode currently selected is the same operating mode in which the loaded measurement was recorded in, the accessed curves are shown together with the currently recorded curves. This enables the results of different measuring operations to be easily compared.
- If the current and the loaded measurement are not of the same operating mode, the current measurement is automatically ended and only the loaded measurement is displayed.
- If there are not enough free slots to display the loaded curves, the currently recorded curves are overwritten. To avoid this, it is advisable to select curves from the History database one by one (see below) so that you can assign them individually to slots that are free or no longer needed.

If you want to repeat a test, you can use this function to first of all access the measured dataset from the previous test from the history and then launch a new test with the same test parameters. Because the curves from the previous test also remain on the display after the new test has begun, you can conveniently compare these with those of the current test.

The colour-coded legend on the bottom right edge of the screen provides information relating to the measured values of the curves currently displayed.



Current and loaded curves can be differentiated between using the symbols in front of them.

Symbol	Description
	Curves which were recorded during the measurement in progress.
	Curves which have been accessed from the history database.














By **Holding down** the rotary encoder a context menu can be opened from which the following special functions can be accessed:

- Add / edit a comment for the measurement
- Access special measurement data or only individual traces of this measurement (possible in certain modes only)

4.6 System settings -





The System menu can be access directly through the menu item when in the main menu, and it contains the following menu items:

Menu item	Description
	Submenu for managing the measurement data (see page 57).
	Basic settings (see page 58)
	<p>Default values can be adapted for nearly all the system settings. If user management (see page 69) is active then each user can define and store his / her own default values. These defaults are then loaded each time the system starts or a user logs in.</p> <p>The submenu contains the following items:</p> <ul style="list-style-type: none"> This menu item enables the current settings to be stored as default values. These include all parameters that can be configured within the operating modes such as, e.g. voltage values, pulse width etc. (with exception of phase selection and propagation velocity). Naturally, only the changes made during this session are taken into consideration. <hr/> <p> When saving the default values, note that all values that have been changed since the last system start are saved, which means that you might inadvertently save some changes that you do not want. To be on the safe side, you can first reload the current defaults (see below), make the required settings and then save them.</p> <hr/> <ul style="list-style-type: none"> This menu item can be used by the current user to reload his / her stored default values. This menu item restores the factory settings. This menu item enables the default values for the current user to be exported as XML files to the <i>DefaultValues</i> directory of the inserted USB flash drive. This menu item can be used to import defaults values that are stored on an inserted USB flash drive into the system. The imported values then become immediately applicable. When user management (see page 69) is active, the imported default values are only applicable for the user currently logged on.
	Service menu which can only be accessed by a service technician.
	The administration menu (see page 67) enables a user with the appropriate permissions to access extended system functions.

Menu item	Description
	<p>This submenu enables various settings to be made for scale graduation on the X-axis and for entering the propagation velocity. It provides the following menu items:</p> <p> Depending on the setting of this switch, the X-axis is either scaled in seconds (runtime) or in length units (distance).</p> <p> <u>Only available when the X-axis is scaled in length units (see above)</u> This menu item can be used to switch the unit of the X-axis between meters and feet.</p> <p> <u>Only available when the X-axis is scaled in length units (see above)</u> To achieve reliable distance details, knowledge about the exact signal propagation velocity for the test object is absolutely essential. This can be specified in two different ways:</p> <ul style="list-style-type: none"> • NVP (Nominal Velocity of Propagation) - The signal propagation velocity is stated relative to the speed of light, e.g. NVP 0.53 = 0.53 x c. • SPEED - The signal propagation velocity is stated with half the actual propagation speed (the cable's so-called V/2). <p>Depending on the above settings, a default propagation velocity value can be defined using the menu items $\frac{V}{2}$ and NVP respectively. This value is then preset whenever a measurement is started.</p>
	<p>Submenu for displaying and exporting important system information.</p> <p> Information on software version</p> <p> Information on system hardware and the current IP address</p> <p> This menu item enables messages stored in the System log to be displayed, and exported to an inserted USB flash drive (<i>SystemLog</i> directory).</p> <p> This menu item enables all the system information to be exported to an inserted USB flash drive (<i>SystemLog</i>-directory).</p> <p> Option for checking key assignment for a connected USB keyboard.</p>
	<p>This menu item can be used to define whether measurement is to be printed through a connected printer or saved as a PDF file (into the <i>PdfFiles</i> directory of an inserted flash drive).</p>
	<p>To enable measurement to be printed out directly, the type of printer connected must be configured beforehand (see page 58).</p>
	<p>Activate / deactivate remote control mode (see page 61)</p>











4.6.1 Data menu -


















The Data menu enables stored measurement data to be imported, exported or deleted. It contains the following menu items:





Menu item	Description
DEL	Menu item to enable measurement data records to be deleted from the History database. The measurements to be deleted must be marked beforehand (see page 52).
	Menu item that enables measurement data records from the History database to be exported to the inserted USB flash drive (<i>Winkis</i> directory). The data records to be exported must be marked beforehand (see page 52).
	Menu item to enable measurement data records / logs to be imported. To do so, a window is opened in which the user can navigate through the directories on the plugged-in USB flash drive.
	This function can be used to compile a list of common cable types, whereby these can be accessed quickly through the log function and assigned to specific cable sections. Two filters (cable type and cable insulation) can be used to limit the number of cables displayed. Saved cable types can only be edited or deleted with administration rights (see page 67).
	Menu item to enable the cable list (see above) to be exported to a USB flash drive (<i>Cables</i> directory).

4.6.2 Basic settings -

The following menu items can be used to adapt the software's basic settings:


Menu item	Description
	Sets the language. Select the desired language by turning the rotary encoder and activate by pressing it. The language selection is immediately active.
	This submenu enables the following screen settings to be made: <ul style="list-style-type: none"> <li data-bbox="531 591 1463 658"> This menu item enables the user to select one of the available screen layouts. <li data-bbox="531 669 1463 736"> This menu item can be used to change the line thickness for the traces to meet one's own requirements. <li data-bbox="531 748 1463 815"> For systems with a touch sensitive display, this menu item can be used to enable / disable touch functionality. <li data-bbox="531 826 1463 893"> Menu item to show/hide the mouse cursor. In order to operate the software via a connected mouse, the mouse cursor must be enabled. <li data-bbox="531 904 1463 947"> Menu item to enable / disable the on-screen keyboard.
	Date and time.
	This menu item enables a connected printer to be selected from a variety of supported printers. <hr/> <hr/> <div data-bbox="520 1137 587 1216"></div> Before buying a new printer, please contact your Megger sales partner for a list of supported printers. <hr/> <hr/>

Menu item	Description
	<p>This menu item enables the following functions that influence the measurement sequence to be activated or deactivated:</p> <ul style="list-style-type: none"> <li data-bbox="533 394 1430 472">  If this option is activated, all three phases are automatically selected upon entering the Ω operating mode. <li data-bbox="533 483 1430 551">  If this option is activated, all three phases are automatically selected upon entering a TDR operating mode. <li data-bbox="533 562 1430 629">  If this option is activated, all three phases are automatically selected upon entering the TAN operating mode. <li data-bbox="533 640 1430 741">  If this option is activated, the phase selection is always reset upon exiting the operating mode and must be conducted again upon each return. <li data-bbox="533 752 1430 819">  If this option is activated, the selected voltage range is always reset upon exiting / changing the operating mode. <li data-bbox="533 831 1430 898">  If this option is activated, multiple phases can be selected in ARM operating mode. <li data-bbox="533 909 1430 976">  Activates / deactivates automatic scaling adjustment of the X axis as soon as a trace is recorded. <li data-bbox="533 987 1430 1055">  Activates / deactivates automatic gain adjustment of the Y axis as soon as a trace is recorded. <li data-bbox="533 1066 1430 1133">  Activates / deactivates the automatic positioning of the marker on the suspected fault location as soon as a trace is recorded. <li data-bbox="533 1144 1430 1211">  If this option is active, the WiFi access point is automatically activated with each system start (optional 4G / GPS router required). <li data-bbox="533 1223 1430 1290">  If this option is active, the mobile data connection is automatically activated with each system start (optional 4G / GPS router required).
	<p>Menu item to select suitable printing template for paper format being used.</p>
	<p>This menu item can be used to modify the logo which appears in the header when printing out the measured data.</p> <p>To import an additional logo in the PNG format, you need only insert a USB flash drive with this logo.</p> <p>The logo is then offered when calling up this menu item, and after selection it is then imported onto the system.</p>
	<p>Layout of the connected keyboard.</p>
	<p>This menu item enables the currently logged-on system user to be changed. Once a new user has been selected, the new user's default settings are then loaded. The menu item is only available if at least one user exists in the database. The administrator can manage user accounts in the administration menu (see page 67).</p>
	<p>Menu item for switching the voltage input / voltage display. Voltages are given as peak values or effective values depending on the setting.</p>

Menu item	Description
	<p data-bbox="598 320 1444 414">This input screen is used to configure the optional 4G/GPS router so that it can establish a mobile data connection. This kind of data connection is required for the following applications:</p> <ul data-bbox="619 421 1444 560" style="list-style-type: none"> • Access to online maps in the MeggerBook Cable protocol software • Remote control of the test van via app (see next page) • Remote access to the test van via TeamViewer software (see page 66) <p data-bbox="598 604 1444 667">This requires there to be at least one valid SIM card (SIM 1 or SIM 2) in the router (see page 153).</p> <p data-bbox="598 674 1455 824">If this is the case, the PIN of the SIM card and the login details for the network operator's access point (APN) must be entered via this input screen. If using a SIM card with PIN request disabled, enter 0000 as the PIN. If the Roaming parameter is enabled, the router will attempt to establish a data connection even when in an external network.</p>
	<p data-bbox="598 840 1396 907">The mobile data connection of the optional 4G / GPS router can be activated or deactivated using this menu item.</p>
	<p data-bbox="598 918 1444 985">The WiFi access point of the optional 4G / GPS router can be activated or deactivated using this menu item.</p>
	<p data-bbox="598 996 1444 1115">Suitable terminal devices (such as a provided notebook) can be logged in at this access point (SSID: Megger Centrix 2.0) and therefore use the mobile data connection of the test van. The key that is required for logging in can be requested from the Megger sales partner.</p> <p data-bbox="598 1131 1396 1193">Information about configuration and status of the optional 4G / GPS router</p>

4.7 Enabling remote control and remote access (optional) -

Requirement To access the test van from a PC, or to control the test van remotely via the app, the following conditions must be met:

- The test van must be equipped with the optional 4G / GPS router and a valid SIM card (see page 153).
- An existing data connection must be indicated by the  icon at the left-hand edge of the screen. A prerequisite for this is that a sufficiently strong GSM signal is present, the access point (APN) is configured and the mobile data connection has been activated (see page 58).




4.7.1 Remote control via app

Introduction The pinpointing and line tracing methods of the system can be remotely controlled via app when remote control mode is active. This has the advantage that adjustments can be made to the settings immediately and quickly during fault and route searches along the route of the cable, without first having to consult the colleague who has remained with the test van.

Requirements To activate remote control mode, the following conditions must be met:

- A mobile terminal device with the Android or iOS operating system must be available on which the **Centrix Remote Control** app.
- The app must be granted access to the camera of the terminal device.

Activating remote control mode Provided that all the above-mentioned conditions have been met, remote control mode can be activated as follows:

Step	Action
1	<p>Activate remote control mode via the  menu item (this menu item can also be called up directly from an operating mode that can be controlled remotely).</p> <p>Result: After a few seconds, a QR code appears on the screen.</p>
2	Start the app on your mobile device.
3	<p>Tap the  button at the bottom of the screen.</p> <p>Result: After the app has registered with the service, it automatically switches the camera on.</p>
4	<p>Point the camera at the displayed QR code in such a way that it fills as much of the screen as possible.</p> <div data-bbox="703 772 1177 1149" data-label="Image"> </div> <p>Result: As soon as the app detects the QR code, a connection between the mobile device and the test van is established via a server.</p> <p>As soon as this connection has been established, the  icon appears in the test van software at the left-hand edge of the screen. Remote control mode is now active.</p>

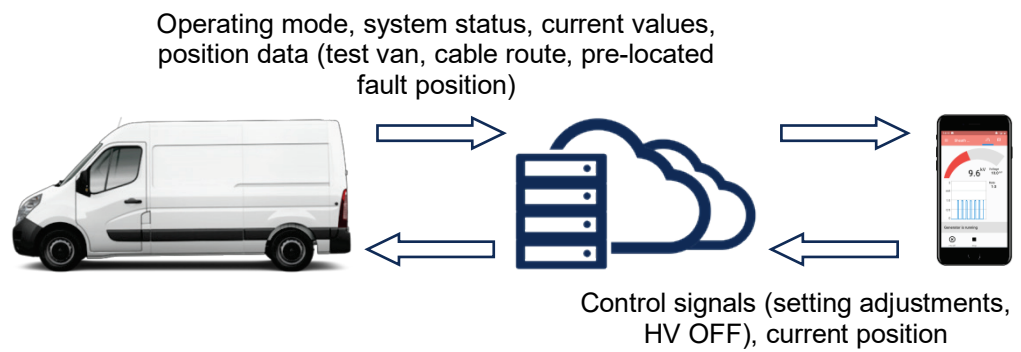
Preparing the operating mode for remote control

The following operating modes can be remotely controlled using the app:

- Surge pinpointing (see page 122)
- Sheath fault pinpointing (see page 91)
- Line and fault location with the audio frequency generator (see page 125)

As soon as one of these operating modes is called up with remote control mode activated, the buttons to adjusting the settings automatically appears in the app. In order to be able to use these, the operating mode must first be started at the operating unit of the test van, and high voltage must be enabled.

As soon as remote control mode is activated and the high voltage has been enabled, bi-directional communication takes place between the test van and the app via a web server, during which the following data is exchanged:




The measurement settings can now be adjusted using the app.

Operating the app In detail, the actual remote control screen differs depending on the active operating mode, but is basically arranged as follows:

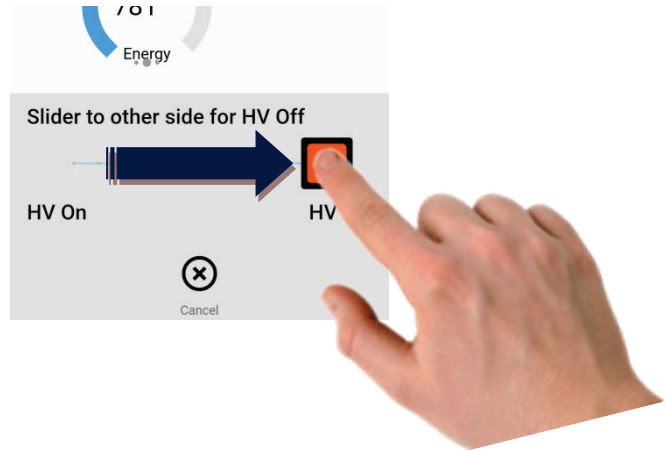
The screenshot shows the 'Surging' app interface. At the top, a red bar contains a menu icon, the word 'Surging', and a signal strength icon. Below this is a large semi-circular gauge showing '14.0 kV' in red and 'Voltage 20.0 kV' in grey. To the right of the gauge, it says 'Surge rate 7 /sec'. Below the gauge is a smaller circular gauge showing '382 J' in blue and 'Energy' in grey. At the bottom, a grey bar says 'Surge generator is running'. Below this are two buttons: 'HV Off' with a red 'X' icon and 'Stop' with a black square icon. Callout boxes point to various elements: 'Helpful diagrams, e.g. energy efficiency, measurement history (swipe to switch)' points to the left side; 'Voltage / energy bar graph' points to the top gauge; 'Current set values (tap to adjust)' points to the 'Surge rate' text; 'Status information and instructions' points to the 'Surge generator is running' bar and buttons; and 'Buttons for starting, stopping and pausing the operating mode' points to the 'HV Off' and 'Stop' buttons.

The bar graph in the upper area is subject to a certain latency for transmission reasons, for which reason it is not completely synchronous with the displays on the measuring device that is used.

In order to be able to approach the prelocated fault position or the cable section to be examined quickly, a map view with the following orientation aids can be displayed in the app by pressing the button :

The screenshot shows the 'Map' app interface. At the top, a red bar contains a menu icon, the word 'Map', and a signal strength icon. Below this is a map showing a red truck icon representing the 'test van' and a blue dot representing the 'Own position'. A red line on the map indicates the 'Cable route'. A yellow lightning bolt icon on the map indicates the 'Fault position'. At the bottom, a grey bar says '640 m to target'. Below this are two icons: 'Target area' and 'Hybrid'. Callout boxes point to: 'Position of the test van' (red truck icon), 'Own position' (blue dot), 'Cable route (if this has been specified in the MeggerBook Cable Software)' (red line), and 'Fault position (if this could be prelocated with the ARM method during the current measurement session)' (yellow lightning bolt icon).

Deactivating high voltage from remote In remote control mode, the high voltage can be disabled not only in the test van but also through the remote control app. To do this, first tap the (X) button at the bottom of the screen and then drag the slider all the way to the right.



However, for safety reasons the high voltage cannot be enabled again using the remote control app!



Deactivating remote control mode As soon as remote control mode has been activated, it remains active until it is deactivated using menu item or the test van is switched off. Remote control mode can also be deactivated at any time from the app using the buttons → .

A change of operating mode does not lead to deactivation of remote control mode.

4.7.2 Remote access via TeamViewer software

Introduction If the test van is equipped with the optional 4G/GPS router, a secure and encrypted remote connection to the test van's PC can be established from internet-enabled devices. This allows the metrologist in the test van to request assistance from a colleague in the office, for example, and quickly give them an overview of the measurements in progress and recorded measurement data. Furthermore, this functionality enables the test van's software to be presented on a larger display or projector, e.g. for training a group of employees on how to use the system.

Procedure To establish a remote connection, proceed as follows:




Step	Action								
1	<p>Open the TeamViewer client software via the menu item .</p> <p>Result: A dialog box appears on the screen showing the current connection status.</p> <div data-bbox="679 786 1318 1099" style="border: 1px solid black; padding: 10px; margin: 10px auto; width: fit-content;"> <div style="background-color: #002060; color: white; padding: 5px; text-align: center; font-weight: bold;">Remote control</div> <table style="width: 100%; border-collapse: collapse;"> <tr> <td style="padding: 2px;">TeamViewer version:</td> <td style="padding: 2px;">14.4.2669</td> </tr> <tr> <td style="padding: 2px;">TeamViewer ID:</td> <td style="padding: 2px;">1645792625</td> </tr> <tr> <td style="padding: 2px;">Password:</td> <td style="padding: 2px;">25193574</td> </tr> <tr> <td style="padding: 2px;">Status:</td> <td style="padding: 2px;">Connected to server, ready to connect with partner computer</td> </tr> </table> <div style="text-align: center; margin-top: 10px;"> <input type="button" value="Ok"/> </div> </div> <p>When the message Connected to server, ready to connect with partner computer appears in the status line, this means that the device is now connected to the TeamViewer server. A different status message indicates that the test van is not currently connected to the internet (see page 43).</p>	TeamViewer version:	14.4.2669	TeamViewer ID:	1645792625	Password:	25193574	Status:	Connected to server, ready to connect with partner computer
TeamViewer version:	14.4.2669								
TeamViewer ID:	1645792625								
Password:	25193574								
Status:	Connected to server, ready to connect with partner computer								
2	<p>Share the TeamViewer ID on the screen and the password with the user who wants to connect to the test van remotely.</p>								
3	<p>If they have not already done so, this user must install the TeamViewer software version for their device's operating system on their device. The version must also be compatible with the TeamViewer version shown in the dialog box.</p> <p>The user can then launch the software and, after entering the ID and password, connect to the test van.</p> <p>Result: Once connected, the user can use the mouse and keyboard or touch control (see page 46) to operate all the functions and features of the test van's software.</p> <p>Only on-site personnel in the test van can release the HV via the hardware buttons, however.</p>								
4	<p>Once the remote session is finished, press the menu item  to disconnect.</p>								

4.7.3 Administration menu - (administration password required)





Purpose The administration menu is password-protected and provides access to advanced system settings such as the user administration, as well as update and backup functions.

The software's menu structure has concealed menu items added to it when administration rights are issued. These enabled functions, which are only rarely used during day-to-day operation of the device, are described in greater detail throughout the course of the manual.

Access To open the administration menu, you must first enter the password. Proceed as follows:

Step	Action
1	Select menu item  , to access the Control Panel and then select menu item  .
2	Select menu item  Result: The password entry dialogue appears in the display.
3	Enter the password and confirm your entry with OK . Result: If you entered the password correctly, the menu items of the administration menu appear (see below). If your entry is incorrect, you must repeat the procedure from Step 2 .

Menu items The administration menu contains the following menu items:

Menu item	Description
	These menu items can be used to back up or update (see page 68) the individual modules of the software.
	Menu item used to manage the users accounts (see page 69) of the system.
	Menu item to activate/deactivate the connection lead calibration mode (see page 70).
	Menu item used to disable administrator rights and to protect the administration menu with a password again.

4.7.3.1 Backing up and updating data - $\frac{UP}{DATE}$ | $\frac{BACK}{UP}$

Data backup Menu item $\frac{BACK}{UP}$ can be used to back up all the files required to recover the system.

Depending on the type of system, the following files are exported to the inserted USB flash drive directory *Backup_<serial number>* during a backup:

File	Explanation
<i>application_<version>.tar</i>	The application file itself
<i>printforms.tar</i>	All print templates, log templates and logos
<i>Languages*.tar</i>	Language file that contains all the available menu languages in the system.
<i>SebaKMT.cfg.xml</i>	Configuration file
<i>backupDB.sql</i>	A backup of the database, containing the saved measurement data, cable database, user database and the default values.
<i>*.txt</i>	Log files of the system and the included test attachments.

Because the *backupDB.sql* file contains the complete database and therefore can only be loaded again in its entirety, the following data can also be exported separately using the menus so that they can be transferred separately (e.g. to another system):

- Measurement data (see page 57)
- User account data (see page 69)
- Default values (see page 55)
- Cable data (see page 57)

Loading software modules Menu item $\frac{UP}{DATE}$ can be used to install the individual software modules (see above) into the system. This way, you can restore or update modules, or transfer them to another system.

When you open the function, a file browser appears to help you navigate through the files on the plugged-in USB flash drive. Only the files which the system identifies as software modules and which the user is authorised to load are displayed.

This means that the application itself, the database and the configuration file can only be loaded by users with enhanced administrator rights. If you do not yet have the appropriate rights, please contact your local Megger sales partner.

4.7.3.2 User administration -

User administration allows you to set up various user accounts on the system, so that each user can adjust the default values and the way the system behaves according to his own preferences.




Menu item	Description
	<p>A new user can only be created if a user name is entered. You can also limit the maximum voltage that the user can adjust and protect the account with a password.</p> <p>If you do not specify a password, the user does not need to enter a password when logging in, which makes the procedure quicker.</p> <p>The default values for the new user are the same as the factory settings. If necessary, you can import (see page 55) the default values from another user account (or even another system).</p>
	<p>This menu item can be used to edit the name, voltage range and password of a user.</p>
	<p>This menu item can be used to delete individual users from the user database. If the last user has been deleted, the user management is deactivated and there is no longer a login procedure when the system is started.</p> <hr/> <div style="border: 1px solid black; padding: 5px; margin-bottom: 5px;"> You can only delete the last user by interrupting the login. </div> <p>When deleting a user, his default values are lost. Therefore – particularly for the last user – you should export the default values beforehand (see page 55) beforehand.</p> <hr/>
	<p>This menu item allows you to export a selection of user profiles from the system together with the respective standard values as an XML file to the inserted USB flash drive's <i>User</i> directory.</p>
	<p>This menu item can be used to import user profiles that are stored on an inserted USB flash drive into the system.</p> <p>This does not affect existing users. If two user names are the same, the system asks whether you want to overwrite or keep the existing user in the system.</p>

4.7.3.3 Connection Lead Calibration -

Necessity A properly calibrated connection lead (HV connection cable and LV connection cable) ensures the accuracy of all operating modes which function according to the TDR principle (Teleflex, IFL and all ARM modes). The length of the connection lead is not only automatically hidden from the visible diagram area, but also automatically subtracted from the calculated distance specifications.

As a principle, a calibration was already performed using the connection cables supplied during the final test. A repeat calibration should only be performed when one of the connection cables was replaced with a cable with a different length. In this case, an individual calibration must be performed for all respective operating modes and phases with a signal path which is affected by the cable replacement.

Procedure To calibrate a pre-measuring cable, proceed as follows:

Schritt	Aktion
1	Activate calibration mode using the menu item  in the administration menu.
2	Start the operating mode for which you wish to perform the calibration.
3	Select the phase for which you wish to perform the calibration.
4	Perform a measurement with the end of the connection cable open.
5	Exit the operating mode and then open it again immediately. Select the same phase as in Step 3 .
6	Open the trace recorded in the history database beforehand (see page 52).
7	Short circuit the connection cable at its end, and perform another measurement.
8	Select the menu item  and move the red cursor exactly to the point at which both traces diverge. Then press the rotary encoder and keep pressing it until the new zero position is applied.
9	Repeat the procedure, if necessary, for other phases and operating modes.
10	Deactivate calibration mode using the menu item  in the administration menu.

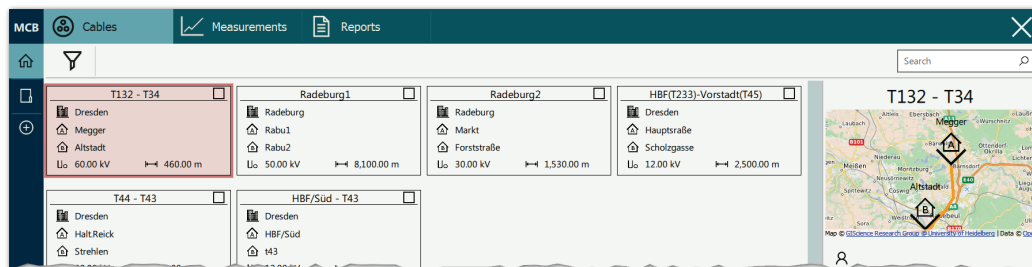
4.8 MeggerBook Cable protocol software -

Introduction The MeggerBook Cable log software is a database software which continuously logs the performed measurements in the background and serves in generating / managing cables and reports.

The saved data records (measurements, cables, reports) can be conveniently exchanged between various installations of the software, regardless of whether they are on another measuring system or a PC. This tremendously facilitates the use of shared cable lists and the central archiving of measurements and reports.

Opening and closing the MeggerBook Cable

The log software can be opened directly from the main menu using the menu item



To return to the measurement software, tap on the top right edge of the screen.

Operation




For instructions on operating the MeggerBook Cable protocol software, please refer to the help screens in the software.

5 Conducting measurements

5.1 Selecting the cable

Before beginning the measurements, the cable that is connected should, if possible, be selected from the MeggerBook Cable protocol software.

This has the advantage that each measurement sequentially performed and saved in the MeggerBook Cable is automatically assigned to the correct cable, enabling reports on the result of the measuring to be more quickly compiled.

In order to select the cable, the log software must be opened via the menu item  from the main menu. If the cable does not yet exist in the local cable list, it can be created or imported.

The measurements can, of course, also be performed without having selected a cable in advance. The assignment between measurements and cables can be done later by hand in the MeggerBook Cable without any problem.



For information on operating the MeggerBook Cable protocol software, please read the corresponding online help.

5.2 Good to know ...

5.2.1 Propagation velocity

Introduction To enable the exact distance between the start of the cable and the fault position to be calculated, the TDR must be aware of the propagation velocity in the cable. This velocity depends on several physical variables in the cable: insulation material and thickness, cable diameter, etc.

If the setting for the propagation velocity value is out by 2%, then the measurement result will also be out by 2%.

Determining unknown propagation velocity If the correct physical length of the cable under test is known, the propagation velocity can be measured. To do so, perform a pulse reflection measurement, and make sure that the end cursor is positioned exactly on the identified end of the cable. The propagation velocity is then continuously altered until the actual cable length is displayed. The propagation velocity should then be noted down for future measurements.

If the length of the cable under test is unknown because of elbows, reserves, etc., then a piece of the same cable can be measured in the workshop and the determined propagation velocity used for the cable out in the field. A reference cable such as this however, should be at least 50 metres in length.

5.2.2 Pulse width

Due to the attenuation and dispersion characteristics of a cable, signals get changed in amplitude and shape as runtime progresses. Naturally, this also applies to the measuring pulse and its reflections.

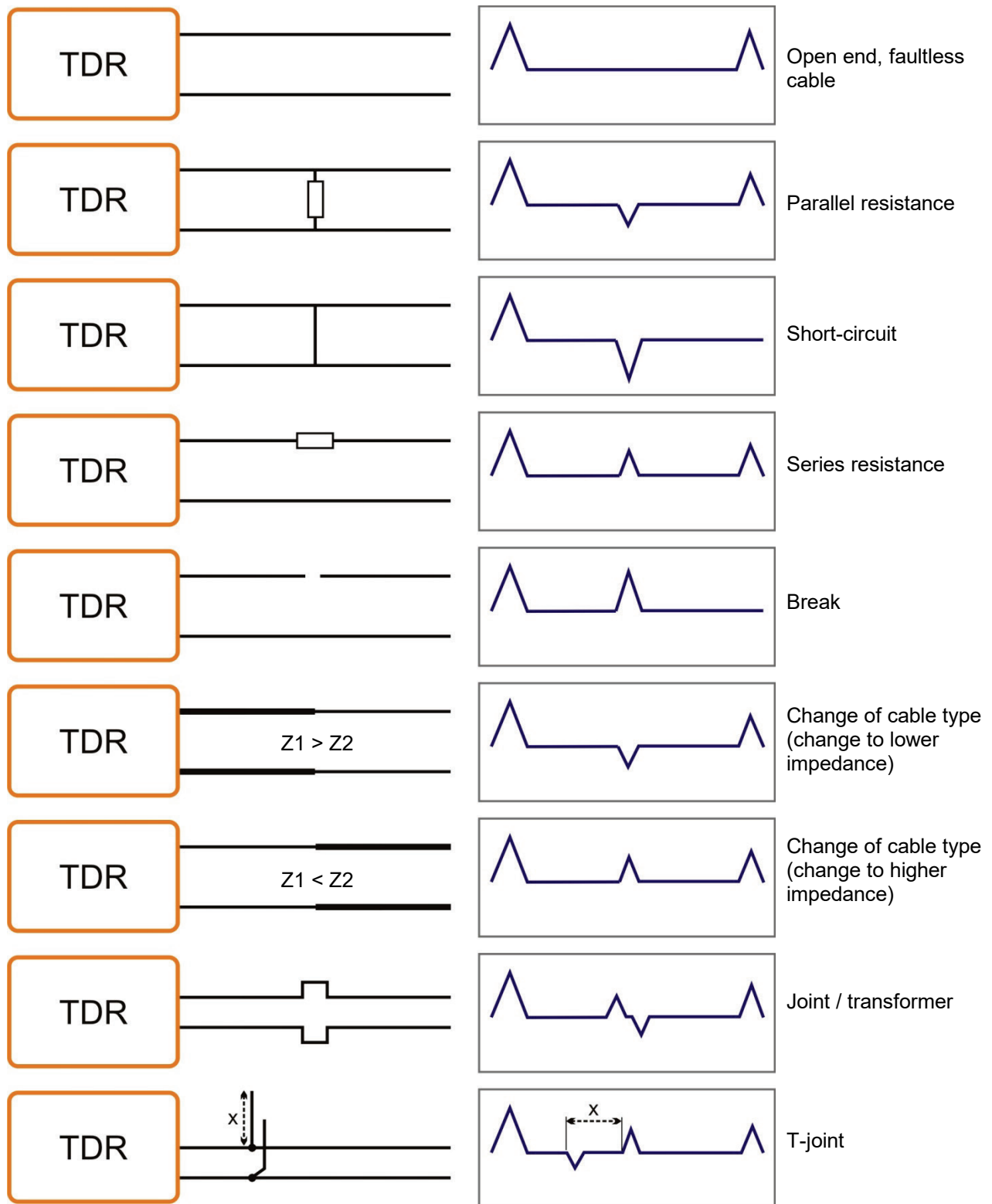
Narrow pulses, which contain a large portion of high frequencies, are subject to greater deformation than wide pulses. Consequently, narrow pulses are more suited for shorter ranges in which they can provide an image with higher resolution than wide pulses, whereas over larger distances they suffer from greater attenuation and dispersion. Here, wide pulses (up to 10 μs) must be used, as they are subject to significantly lower attenuation and therefore they supply a much clearer echo over longer distances.

The following table provides an overview of the pulse widths recommended for each required distance range:

Required distance range	Recommended pulse width
<100 m	20 ns
100 m ... 200 m	100 ns
200 m ... 1 km	200 ns
1 km ... 2.5 km	500 ns
2.5 km ... 10 km	1 μs
10 km ... 30 km	2 μs
30 km ... 80 km	5 μs
>80 km	10 μs

5.2.3 Typical TDR reflectograms

The following illustration shows several idealised examples for TDR reflectograms:



5.3 Standard functions











Generally available functions For all operating modes in which measured data are recorded and displayed, the following standard functions are available in the respective measurement menu:


Menu item	Description
	This menu item can be used to move the cursor along the X axis. The current, voltage, time or distance values of the currently marked position are displayed in the bottom part of the screen.
	This menu item can be used to increase or reduce the visual range on the X-axis. The section aligns itself with the current cursor position here.
	This menu item can be used to print out the currently displayed measuring data. Depending on the system settings (see page 55) the measuring data can either be printed out or saved as a PDF file.
M	This menu item can be used to access a list of all data records stored in the History database which match the currently active operating mode. Only the permanently stored data records are taken into account here. Using the rotary encoder enables a data record in the list to be selected and then accessed. This way, e.g. a reference trace previously recorded on the same cable can be quickly located and compared with the current trace. Furthermore, the menu item can be used to store the current measurement permanently in the History database.













Standard functions for pulse reflection measurements Due to the numerous functions, the measurement menus of all operating modes working according to the TDR principle (e.g. Teleflex operating modes, ARM operating modes, ICE and DECAY) feature two additional submenus.

In the actual measurement menu and in the Teleflex menu all measurement parameters relevant for recording and displaying the curves as well as several additional functions are consolidated. Depending on the operating mode, these menus include a selection of the following menu items:

Menu item	Description
	In all the operating modes in which the measurement has to be triggered (e.g. ARM), the respective trigger threshold can be manually adapted. Normally the trigger threshold is automatically pre-configured to a suitable value. If the measurement should however be interrupted by low voltage reflections which are clearly not induced by the transmitted pulses, then the trigger threshold should be manually increased. If, instead of this, no reflections are displayed at all, then it may be helpful to reduce the threshold.
	This menu item can be used to set the gain. For pulse reflection and ARM measurements, the gain can be set for the received signal. If the setting is good, the reflection for the open cable end can be clearly identified as a positive reflection. In the ICE and Decay operating modes, any change of the gain setting requires a new fault flash-over to be triggered for the effect to become visible.

Menu item	Description
	<p>This menu item can be used to set the measurement range (X-axis). For pulse reflection and ARM measurements, the end of the cable should be visible as a positive reflection at the right-hand edge of the screen.</p> <p>In the ICE and Decay operating modes, the measurement range should be set to five times - ten times the cable length.</p> <p>Whenever the measurement range is changed, the settings for filter, pulse width, pulse amplitude and de-attenuation are automatically adapted.</p>
	<p>This menu item can be used to move the red cursor along the X-axis.</p> <p>By pressing and holding the rotary encoder a blue mark can be set on the current position of the cursor whereupon the red cursor can then be moved further. In this way, e.g. the real distance between two noticeable positions along the trace can be measured. Depending on the operating mode, the distance (calculated from the runtime) between the two marks is shown in one of the following fields at the lower edge of the screen:</p> <p> The full distance between the blue mark and the red cursor</p> <p> Half the distance between the blue mark and the red cursor (in Decay operating mode only).</p>
	<p>This menu item can be used to set the bandpass filter, which limits the frequency range to be measured. Interference signals outside this frequency range are suppressed.</p> <p>The filter value is reset to its default value as soon as one of the following operations has been performed:</p> <ul style="list-style-type: none"> • change to the operating mode • change to the pulse width • change to the measurement range
	<p>Setting signal propagation velocity (see page 72).</p> <p>The type of entry depends on the system settings (see page 55).</p> <p>If the connected cable has been selected in the MeggerBook Cable software (see page 72) prior to the measurement, the signal propagation velocity of this cable type is automatically preset.</p>
	<p>This menu item can be used to delete individually no longer required traces from the current display, to make it easier to read the important traces.</p>
	<p>The de-attenuation function enables the attenuation of the electrical pulses in the cable to be counteracted. This is done through amplification of the input signal which increases as the runtime increases, i.e. as distance increases the reflections are further amplified. The amplification increases exponentially up to a fixed maximum amplification.</p> <p>The ideal de-attenuation setting depends on the length of the cable, so the de-attenuation setting is effectively adapted whenever the measuring range is changed.</p>
	<p>This menu item can be used for all types of pulse reflection measurement to set the pulse width (see page 73) for the measurement pulse.</p>
	<p>This menu item can be used to manually set the pulse amplitude if required. For fault positions in close range, it may be helpful to experiment with lower pulse amplitudes. Conversely, higher amplitudes are suited for particularly long cables.</p> <p>With each adaptation of the distance range (X-axis) the pulse amplitude is automatically adjusted by the system to a suitable value.</p>

The trace functions menu which can be activated during a pulse reflection measurement using the menu item  provides diverse options to adapt the arrangement of traces on the screen to meet individual requirements:

Menu item	Description
	This menu item can be used to move trace 1 along the Y-axis.
	This menu item can be used to move trace 2 along the Y-axis.
	This menu item can be used to move trace 3 along the Y-axis.
	This menu item can be used to move all visible traces along the Y-axis.
	<p>This menu item can be used to move the traces mapped on the display further apart from each other along the Y-axis and back in position.</p> <p> All traces are separated from each other by 50 pixels along the Y-axis.</p> <p> The traces are moved back into their original position and they are at the same level again.</p>
	This menu item can be used to move all visible traces along the X-axis.
	The difference between trace 1 and 2 is used to calculate and display a new trace. All other traces are hidden here.
	The difference between trace 2 and 3 is used to calculate and display a new trace. All other traces are hidden here.
	The difference between trace 3 and 1 is used to calculate and display a new trace. All other traces are hidden here.
	This menu item can be used to move one of two traces along the X-axis.



Functions which can only be applied to traces 1 to 3 are only available when the respective slots are actually occupied.
 Loading a trace from the History database into one of these slots has to be done by calling up the individual trace (see page 52) instead of the complete measurement data record.

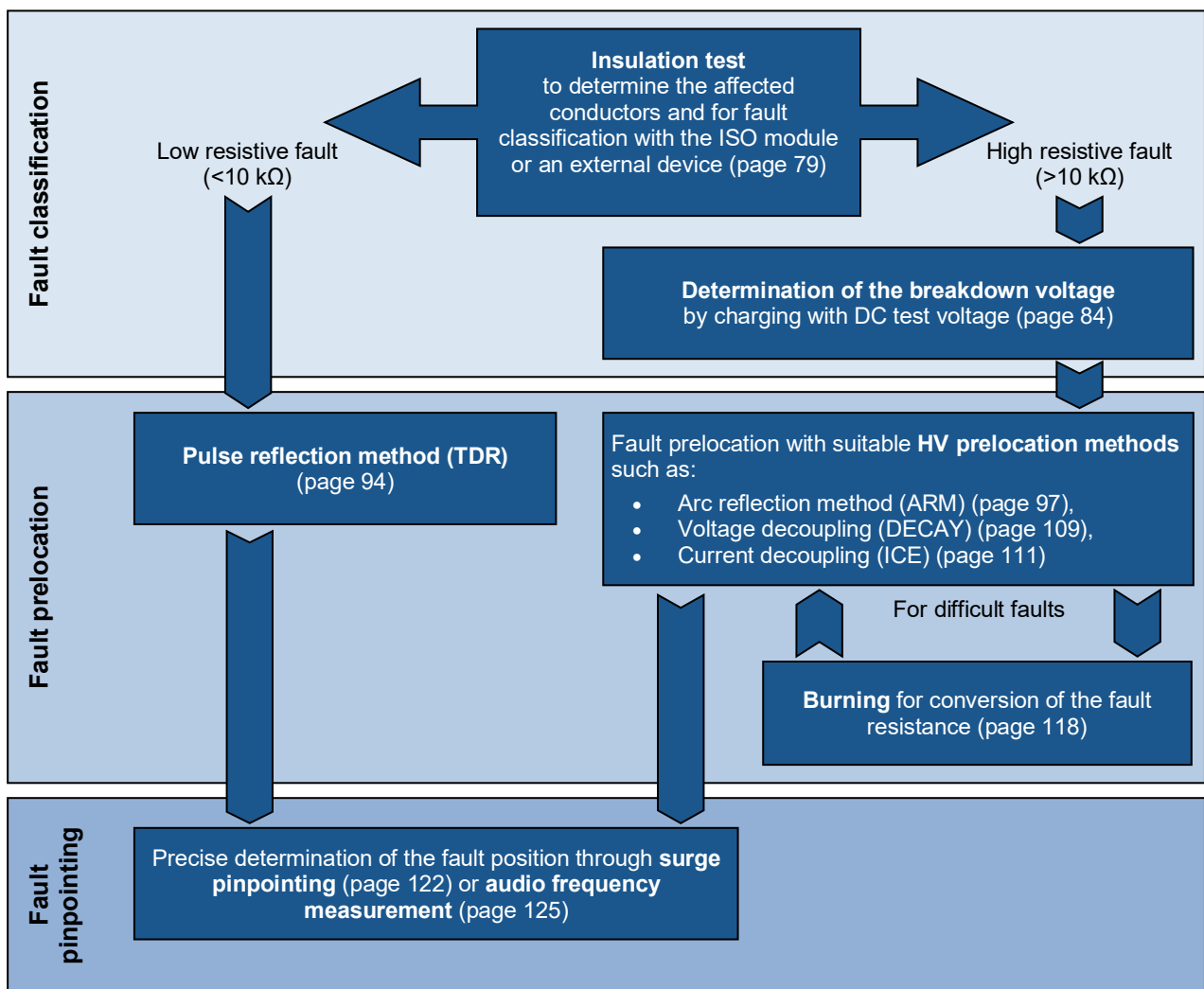
5.4 Systematics of cable fault location

Introduction Daily work with a cable test van is divided into the following two main areas:

- **Condition-oriented maintenance**
Testing, diagnosis and partial discharge measurement
- **Event-oriented maintenance**
Localisation of all types of cable faults

While there are many different concepts of and approaches to condition-based maintenance, the approach described below has established itself in event-oriented cable fault location.



Schema The following schema illustrates the typical approach for detection, classification and location of cable faults using the methods of measurement available in Centrix 3:



5.5 Insulation test - Ω


Selecting the operating mode and phases The operating mode can be accessed directly from the main menu using the menu item Ω .

If the equipment and configuration of the test van allow for insulation testing using the optional Teleflex cable, a submenu opens with the following menu items:

Menu item	Operating mode
 HVC	Insulation test via HV connection cable
 LVC	Insulation test via Teleflex cable

Directly upon entering the operating mode, the phases to be tested are queried. The phases must then be configured according to the actual connection situation.

It is also possible to activate multiple options. The measurement then takes place sequentially. If one of the "phase-to-phase" options (for example **L1-L2**) is selected, a floating measurement is taken between the two phases.

The phase selection menu must then be closed using . If necessary, the phase selection can be opened later and modified.

5.5.1 Measurement of insulation resistance and test object capacitance

Introduction Based on a measurement of the ohmic insulation resistance, a basic error classification can often be made in advance.

Thus, low- and medium-resistance cable faults can, for example, be directly detected and appropriate follow-up measurements (e.g. Teleflex measurements) can be undertaken.

The deviations in resistance within a cable system can also be used in the case of high-resistance cable faults to draw conclusions about the affected phases.

It can also be helpful to repeat resistance measurements after application of certain pre-location methods (e.g. ARM, ICE) or fault conversion methods (burning) and to compare the measurement results with those stored in the database.






With the Centrix 3-integrated test module, the complete measuring range from 1 Ω to 2 G Ω can, thanks to the selectable test voltages, be measured with high resolution.


The integrated resistance-dependent automatic switching of the test voltage can also be deactivated as needs require.

Test voltage	Measurement range
500 V / 1000 V	Insulation resistance: 1 k Ω ... 2 G Ω Cable capacitance: 0.1 μ F ... 19.9 μ F
Low voltage (<6 V)	Insulation resistance: 1 Ω ... 1 k Ω

Setting the measurement parameters

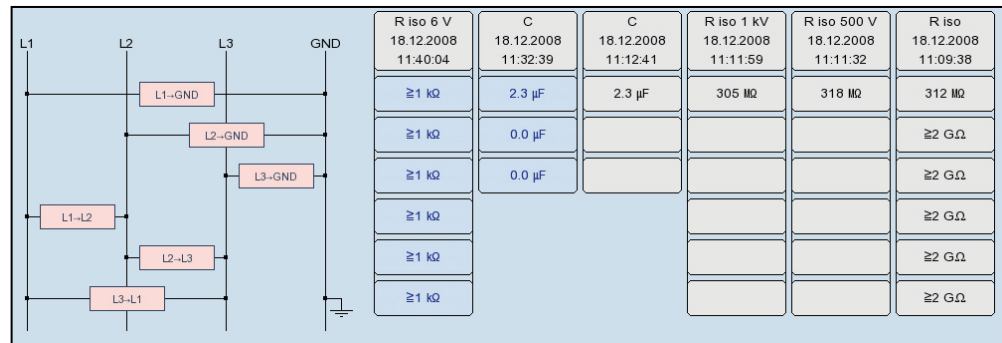
In preparation of the actual measurement, the following parameters can be set:

Menu item	Description
	<p>This menu item can be used to switch between automatic and manual mode.</p> <p>In automatic mode, the resistance and capacitance values are always measured. A selection must only be made between the upper test voltages of 500 V and 1000 V. The system automatically switches to low voltage when determining a low-ohm resistance, since the resistance values in this measuring range can only be measured with low voltage.</p> <p>In manual mode, you may only determine either the resistance or the capacitance during a test. The three test voltages of 500 V, 1000 V and low voltage (<6 V) are available for selection. No automatic switching between the voltages occurs during the measurement.</p>
	<p>This menu option is used to set a test voltage of 1000 V.</p>
	<p>This menu option is used to set a test voltage of 500 V.</p>
	<p><u>Only available in manual mode</u></p> <p>This menu option is used to set a low test voltage (<6 V).</p>
	<p><u>Only available in manual mode</u></p> <p>Switching between resistance and capacitance measurement.</p>

Measurement procedure After the measurement parameters have been set as described above, the measurement can be started via the menu item .

Depending on the set mode, the system measures the resistance and/or capacitance values for each selected phase combination.


The results are shown in a table:



R iso 6 V 18.12.2008 11:40:04	C 18.12.2008 11:32:39	C 18.12.2008 11:12:41	R iso 1 kV 18.12.2008 11:11:59	R iso 500 V 18.12.2008 11:11:32	R iso 18.12.2008 11:09:38
≥1 kΩ	2.3 μF	2.3 μF	305 MΩ	318 MΩ	312 MΩ
≥1 kΩ	0.0 μF				≥2 GΩ
≥1 kΩ	0.0 μF				≥2 GΩ
≥1 kΩ					≥2 GΩ
≥1 kΩ					≥2 GΩ
≥1 kΩ					≥2 GΩ

The measured parameter, date and time of measurement as well as the test voltage used can be read from the table header for each measurement (column).

A new column is created for every measurement begun. The columns start on the left with the most current measured values and end on the right with the oldest measured values. A maximum of six columns can be adjacently shown. For each additional measurement, the column with the oldest measurement results is deleted.

The user can also manually delete the column with the respectively oldest measurement results via the menu item .

5.5.2 Time-dependent measurement of resistance -


Introduction Through a time-dependent measurement of resistance, the chronological change of the absorption characteristics of the insulating material and thus the degree of moisture and dirt in an insulation can be tested.

A continual rise of the recorded resistance indicates an intact insulation. A flat or downward sloping curve can indicate a dirty, moist or damaged insulation, for example.


To obtain comparable measurement results, the chronological progress can be used to calculate the well-known coefficients PI (Polarisation Index) and DAR (Dielectric Absorption Ratio).

For the DAR coefficient, the value measured after one minute is divided by the measured value after 30 seconds. This coefficient should therefore be used primarily for evaluation of newer insulating materials, which exhibit a faster decline of dielectric absorption currents.






For other insulation materials, with absorption characteristics that normalise more slowly, the PI coefficients should be determined. For these, the value measured after 10 minutes is divided by the measured value after one minute.

Opening the operating mode and selecting the phases The time-dependent measurement of resistance is integrated into the insulation test operating mode and can be accessed using the submenu item .

Directly upon entering the operating mode, the phases to be tested are queried. The phases must then be configured according to the actual connection situation.

The phase selection menu must then be closed using . If necessary, the phase selection can be opened later and modified.

Setting the measurement parameters In preparation of the actual measurement, the following parameters can be set:

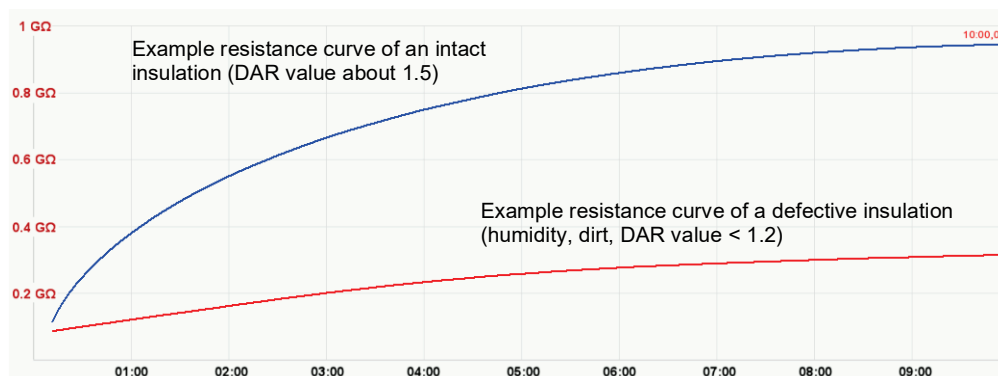
Menu item	Description
	Activates/deactivates the function for determining the DAR coefficients.
	Activates/deactivates the function for determining the PI coefficients.
	This menu option is used to set a test voltage of 1000 V (if possible, this voltage value should be set for the time-dependent measurement of resistance).
	This menu option is used to set a test voltage of 500 V.
	This menu option is used to specify a maximum test time of up to 15 minutes. The minimum test time is automatically set to 1 minute (when determining the DAR coefficients) or 10 minutes (when determining the PI coefficients).

Measurement procedure After the measurement parameters have been set as described above, the measurement can be started via the menu item **▶**.

The determined resistance values are shown on the screen during the course of the measurement as a curve over time.

With the completion of the measurement, any DAR and/or PI coefficients that are determined are shown in a dialog box.

Evaluation of the test results The course of the curve itself as well as the determined coefficients can provide information on the state of the insulation.




The following table provides generally accepted guidelines values that can be used to evaluate the measurement:





PI value	DAR value	Condition of insulation
<1	<1	poor
1 to 2	1 to 1.3	questionable
2 to 4	1.3 to 1.6	Good
>4	>1.6	excellent

A comparison with intact cables of identical construction or with previous measurements should also be taken into account.

To do so, previous measurements from “History” database (see page 52) can be accessed and the resistance curves compared. By selecting the menu option **⌘**, the determined DAR and/or PI coefficients can also be displayed for comparison.








5.6 Cable testing -




Selecting the operating mode The operating modes for cable testing are usually grouped not directly in the main menu but rather in the sub-menu .

Menu item	Operating mode
	Cable testing with VLF sine wave voltage or with trapezoidal AC voltage (square wave voltage)
	Cable testing with VLF cosine rectangular voltage (optional).
	Cable testing with positive and negative DC voltages (via the optional test attachment)
	Cable testing with negative DC voltage (via the internal voltage source)

Setting the measurement parameters The phases and the voltage range are automatically queried when entering the operating mode, however – like all other settings – they can be adjusted until the actual start of the test.

Depending how the test van is equipped and the selected operating mode, the following measurement parameters can be set:

Button / Menu item	Description
	The phase selection must be carried out in accordance with the actual type of connection. It is also possible to test several phases at once to save time. To this end, the phase selection menu permits the selection of more than one option. The phase selection menu must then be closed using  .
	The test duration is shown in minutes. On expiry of the test duration, the high voltage is switched off automatically.
	Voltage range for the upcoming test. After starting the test, the actual test voltage can only be set within this range.
	<u>Only adjustable for tests with sine wave or square wave voltage</u> This menu item is used to change the frequency of the VLF test voltage (0.01 Hz to 0.1 Hz). The HD 620 S1 and HD 621 S1 harmonisation documents recommend the 0.1-Hz frequency for VLF tests. As the maximum permitted test frequency depends on the determined cable capacitance and the test voltage being applied, it may be necessary to adjust the test frequency set and about which the user was informed at the start of the test.
	<u>Only adjustable for VLF tests with sine wave or square wave voltage</u> Switch between sine wave and square wave mode.
	<u>Can only be set for DC voltage testing with a bipolar test voltage source</u> This menu item is used to specify the polarity of the DC test voltage.


Button / Menu item	Description
	<p><u>Can only be set for testing with the internal test voltage source</u></p> <p>Setting of the slew rate in kV/s. After confirmation of the test voltage, the test object is charged continually at the set slew rate until it reaches the set value. The voltage increase can be paused and resumed.</p> <p>In the Manual setting, the increase of the test voltage is regulated manually with the rotary control and the test object is charged to the set value as quickly as possible without requiring confirmation. The test voltage then remains at this level until the set value is again manually increased or decreased.</p>
	<p><u>Only adjustable for VLF tests with sine wave or cosine rectangular voltage</u></p> <p>This menu item can be used to perform a partial discharge measurement in parallel with the standardised testing. A prerequisite for this is that the test van has a suitable partial discharge diagnostic system.</p> <p>Once the option has been activated, any further operator actions must be performed using the “PD Detector” software. After completion of the test, however, the test log can be printed and exported from the test-van software as usual.</p> <hr/> <p> Detailed information on the operation of the “PD Detector” software can be found in the operating manual for the partial discharge measurement system.</p> <hr/>

Notes on selecting the test voltage and test time

The requirements for a meaningful cable test are found in the harmonisation documents HD 620 S1:1996 and HD 621 S1:1996 and often in company-internal testing guidelines as well.

The following table provides a selection of proven test parameters for various applications:

Application	Test voltage	Test duration in minutes
VLF test (initial use)	3U _o	15 to 60
VLF test (on aged cables)	1.7 ... 3U _o	60
DC test (on PILC cables)	4 ... 8U _o	15 ... 30

Starting the test Once all the relevant parameters for the test as well as the phase(s) have been set, the test can be started using the  menu item. Following this the high voltage must be authorised using the “HV ON” button and the test voltage set.

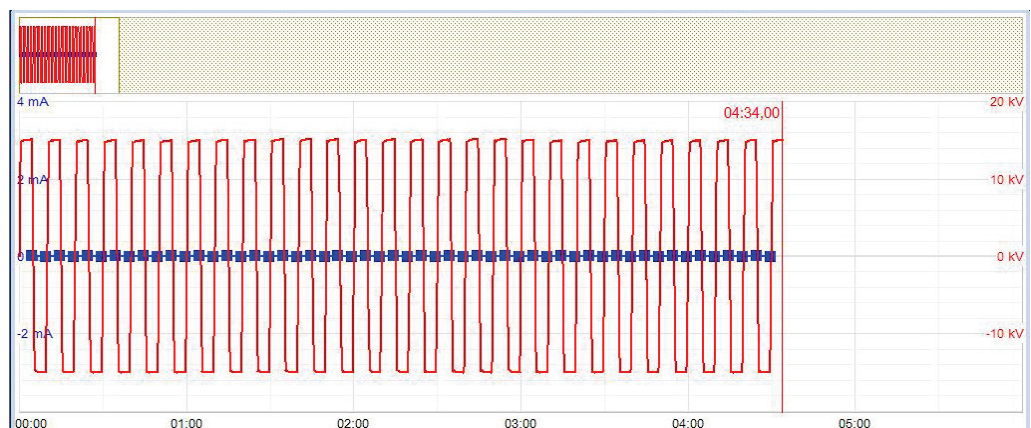
As soon as high voltage is enabled, the “HV OFF” button lights up red signalling “high voltage at the HV output”.


At the start of the test, load detection is performed. If the load characteristics (capacitance and insulation resistance) do not permit a test with the set test parameters, this is indicated on the screen by a system message.



Testing using a lower frequency is offered where required for tests with sine wave or square wave voltage. The user can then either cancel the test or start it using a different frequency.

Tests with DC voltage or cosine rectangular voltage must be stopped in any case and, if possible, restarted using a lower test voltage.






Performing the test The voltage curve can be followed on the screen during the test. In DC, square wave and cosine rectangular mode leakage current measurement is carried out too.



In the case of tests with DC, square wave or cosine rectangular voltage you can switch to expert view and display the periodic onset of charge current using the  menu item (only available for tests using the optional test accessories).

The test duration can be adjusted retrospectively even while the test is ongoing using the menu item  or reset using the  menu item.

Alongside the current and voltage values, some other relevant parameters and measurement values are shown at the bottom edge of the screen depending on the operating mode and the type of test voltage source.

Symbol	Description
	Remaining test duration
	Set test duration
	Actual test frequency
	The load capacitance determined at the start of the test
	The insulation resistance determined at the start of the test

Finishing the test If a test time was defined, the high voltage is automatically switched off at the end of this time. The measurement can be manually deactivated at any time via the “HV OFF” button or the **HV Off** menu item.

If a voltage breakdown occurs in the test object during the test duration, the test is also interrupted. In which event, the test does not qualify as having been passed. The user is informed about the breakdown voltage and – for multi-phase testing – the affected phase .

Irrespective of whether the high voltage is switched off automatically or manually, the HV output is discharged and earthed. The test data logged up to the switch-off are recorded in the history database (see page 52).



5.6.1 Sheath test and sheath fault pinpointing



Introduction The test for sheath fault can be performed with a negative DC voltage of up to 20 kV, which makes it possible to also test cables with thicker outer sheaths (for example, cables with a rated voltage of 230 kV).

If a voltage breakdown occurs during the course of a sheath test or the measured leakage current indicates that there is a sheath fault, pinpointing the sheath fault can be started immediately after the test.

During sheath fault pinpointing, DC pulses with an adjustable pulse rate are coupled with the shield affected by the earth fault.

With each coupled pulse, the current flowing into the ground forms a voltage gradient around the point of escape (the fault location in the sheath), the centre of which can be located precisely with the assistance of a earth leakage detector and its earth rods (step voltage method).

Selecting the operating mode At the start of sheath testing, the submenu of the test operating modes must be opened using the menu item  and from this, the menu item  must be called up.






Sheath fault pinpointing can be started directly from the main menu or from the submenu  using the menu item .


If the test van is equipped with a dedicated device for sheath testing and sheath fault location (for example, MFM 10) the measurements are instead performed directly on this device (see page 93).

5.6.1.1 Testing a cable sheath -



Setting the test parameters The phases and the voltage range are automatically queried when entering the operating mode, however – like all other settings – they can be adjusted until the actual start of the test.

The following test parameters can be set:



Button / Menu item	Description
	<p>The phase selection must be carried out in accordance with the actual type of connection.</p> <p>It is also possible to test several sheaths at once to save time. To this end, the phase selection menu permits the selection of more than one option.</p> <p>The phase selection menu must then be closed using .</p>
	<p>The set voltage range limits the maximum voltage that can be set during the test.</p> <p>In terms of the relevant standards (such as the VDE 0276), which may however differ from the local regulations or standards, the following guidelines are specified:</p> <ul style="list-style-type: none"> • PVC cable ≤3 kV • PE medium voltage cable ≤5 kV • PE high voltage cable ≤10 kV
	<p>The duration of the test can be specified within a range of 1 to 90 minutes. In the relevant standards (e.g. VDE 0276), the test duration of a sheath test is specified as being between 5 to 10 minutes depending on the cable type.</p>
	<p>Setting of the slew rate in kV/s. After confirmation of the test voltage, the test object is charged continually at the set slew rate until it reaches the set value. The voltage increase can be paused and resumed.</p> <p>In the Manual setting, the increase of the test voltage is regulated manually with the rotary control and the test object is charged to the set value as quickly as possible without requiring confirmation. The test voltage then remains at this level until the set value is again manually increased or decreased.</p>

Starting the test Once all the settings have been made, the test can be started with the  menu item. Following this the high voltage must be authorised using the “HV ON” button and the test voltage set.

As soon as high voltage is enabled, the “HV OFF” button lights up red signalling “high voltage at the HV output”. The test system starts with voltage conditioning. The voltage can be also adjusted during the further course of the test by means of the menu item U_{NOM}

Performing the test During the test the voltage curve and the measured leakage current are shown in the display area. The test duration can be adjusted retrospectively even while the test is ongoing using the menu item  or reset using the  menu item.

Alongside the current and voltage values, some other relevant parameters and measurement values are shown at the bottom edge of the screen:

Symbol	Description
	Remaining test duration
	Set test duration

Finishing the test If a test time was defined, the high voltage is automatically switched off at the end of this time. The measurement can be manually deactivated at any time via the "HV OFF" button or the **HV Off** menu item.

Irrespective of whether the high voltage is switched off automatically or manually, the high voltage output is earthed and the test object is discharged by means of an internal discharge-resistor. The test data logged up to the switch-off are recorded in the history database (see page 52).


Evaluation of the test results If the leakage current values that occur during testing are above the limit values defined by the cable owner, the tested cable should be examined in more detail soon or at minimum a shorter testing cycle should be introduced.

5.6.1.2 Pinpointing a sheath fault - ↻

Setting the measurement parameters The phases and the voltage range are automatically queried when entering the operating mode, however – like all other settings – they can be adjusted until the actual start of the pinpointing.

The following measurement parameters can be set:

Button / Menu item	Description
	<p>The phase selection must be carried out in accordance with the actual type of connection.</p> <p>The phase selection menu must then be closed using .</p>
	<p>The set voltage range limits the maximum voltage that can be set during the pinpointing.</p> <p>In terms of the relevant standards (such as the VDE 0276), which may however differ from the local regulations or standards, the following guidelines are specified:</p> <ul style="list-style-type: none"> • PVC cable ≤ 3 kV • PE medium voltage cable ≤ 5 kV • PE high voltage cable ≤ 10 kV
	<p>This menu item can be used to set the pulse rate of the direct current pulse in seconds.</p> <p>Example: For a pulse rate of 1:3, each direct current pulse with a duration of 1 second is followed by a pause of 3 seconds.</p>
	<p>This menu item can be used to enable/disable a pause of one pulse between two cycle sequences. For the example shown above, this would mean that an impulse is omitted after the first three direct current pulses.</p> <p>By means of this "dropout", the signal can be more clearly identified in areas with many interfering signals (e.g., stray currents caused by electric rail vehicles).</p>
	<p>This menu item can be used to enable / disable the voltage pulsing. If disabled, the cable shield is simply charged with constant DC voltage.</p>

Starting the pinpointing Once all the settings have been made, the pinpointing can be started with the  menu item. Following this the high voltage must be authorised using the “HV ON” button and the test voltage set.

As soon as high voltage is enabled, the “HV OFF” button lights up red signalling “high voltage at the HV output”. The test system starts with voltage conditioning. The voltage can be also adjusted during the further course of the pinpointing by means of the menu item **U_{NOM}**

Pinpointing sheath faults After high voltage has been enabled and the desired voltage has been set, the fault position can be accurately pinpointed with the assistance of an earth fault locator (e.g. ESG NT).



For more details about operating the earth fault locator, please read the accompanying instructions.



The safety of the test van that is in operation must be guaranteed at all times by the persons responsible for the test van in accordance with the applicable safety regulations and guidelines, also during line and fault location!

If the system is equipped with the optional remote control function, the measurement settings can also be adjusted remotely if required. In order to do this, the remote control app must be installed on a suitable device and remote control mode activated (see page 61).

Via the app the ongoing procedures in the test van can be followed and, if necessary, the following adjustments can be made during pinpointing:

The screenshot shows a mobile app interface for controlling the test van. At the top, there is a status bar with a menu icon, the text 'Sheath ...', and a power icon. Below this is a large gauge showing '9.6 kV' and 'Voltage 10.0 kV'. A red arc on the gauge indicates the current voltage level. Below the gauge is a graph showing a pulse sequence with a 'Rate 1:3' and a y-axis labeled 'mA' ranging from 0 to 2. At the bottom, there is a status indicator 'Generator is running' and two buttons: 'HV Off' (with a red 'X' icon) and 'Stop' (with a black square icon).

Adjust target voltage

- Adjust pulse rate
- Activate / deactivate a pause between two pulse sequences
- Switch between pulsed voltage and direct voltage




Pause / continue voltage conditioning

Completing the measurement After the fault location has been completed, the high voltage must be switched off manually using the “HV OFF” button or the menu item **HV Off**. The high voltage output is then earthed and the test object is discharged by means of an internal discharge-resistor.

5.6.2 Measuring with the MFM 10/HVB 10 or other supplied test equipment -

If a self-sufficient individual device, such as the MFM 10-M sheath testing device, is added to the system, this device must be activated manually before use.






Proceed as follows:

Step	Action
1	Select the menu item  and then  to access the operating mode.
2	Start the operating mode using the menu item  and then enable the high voltage using the "HV ON" button. Result: The individual device is supplied with mains voltage.
3	Perform further operating actions according to the associated instruction manual directly on the device.

5.6.3 Measuring at the external sockets —

Introduction The external sockets on the control panel can be used to take measurements of the connected test object phases using an external measuring device (such as an insulation tester). The measuring device's output voltage and current must not exceed 1 kV/1 A.

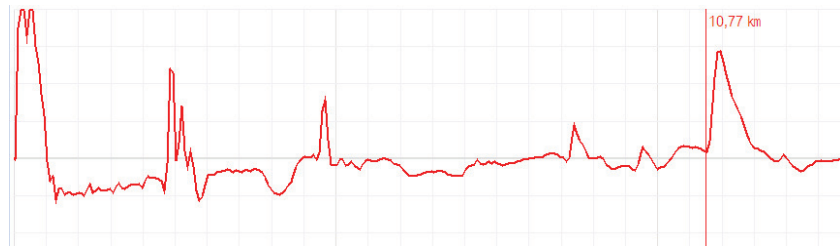
Procedure To take measurements at the external sockets, proceed as follows:

Step	Action
1	Connect the measuring device to the external sockets  on the control panel.
2	Select the menu item  and then  to call up the operating mode.
3	Select the test object phase that you want to measure from the phase selection menu, then close the phase selection menu using  .
4	Start the operating mode using the menu item  and then release the high voltage using the "HV ON" button.
5	Carry out further operations on the measuring device itself following the relevant operating instructions.

5.7 Pulse reflection measurement (TDR) -

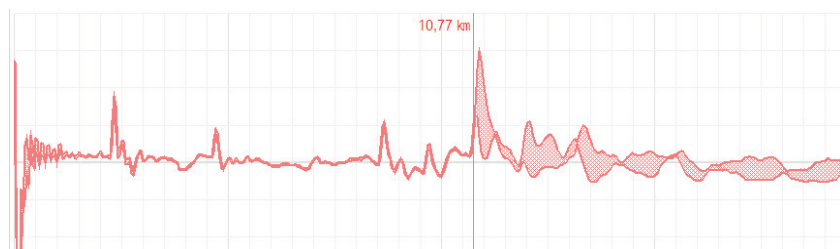
Introduction Low-resistance cable faults can be localised using the tried-and-tested and widely-used pulse reflection measurements. This method is based on the radar principle and makes use of the fact that any sudden deviations in the characteristic impedance of a cable reflect part of the energy transmitted into the cable. The degree of reflection is dependent on the magnitude of the deviation in the characteristic impedance, the number of reflections, the cable length and the distance to the fault position.

The recorded curve shows any deviation in the cable's characteristic impedance. Naturally, this means that not only fault positions, but also other changes in resistance such as, e.g. in joints are also recorded. These recordings can indeed also represent an additional orientation aid for accurate pinpointing of the fault position.




The special IFL operating mode (Intermittent Fault Locating) can be used to localise sporadically (time-variant) occurring low-resistance cable faults (caused, e.g. through traffic vibrations).

To this end, the individual curves in this operating mode are not continuously updated, but rather they form an enveloping curve from all the recorded measurements. In this way, any changes that occur (e.g. temporary fault triggering) during continuous measurements are rendered visible for the user.



Selecting the operating mode and phases


The menu with the TDR operating modes can be accessed directly from the main menu using the menu item  and, depending on the equipment in the test van, it can include the following menu items:


Menu item	Operating mode
$\frac{\overline{\Gamma}}{\text{HVC}}$	Normal pulse reflection measurement via the HV connection cable
$\frac{\overline{\Gamma}}{\text{LVC}}$	Normal pulse reflection measurement via the optional LV connection cable
$\frac{\text{IFL}}{\text{HVC}}$	IFL measurement via the HV connection cable
$\frac{\text{IFL}}{\text{LVC}}$	IFL measurement via the optional LV connection cable

Directly upon entering the operating mode, the phases to be tested are queried. The phases must then be configured according to the actual connection situation.

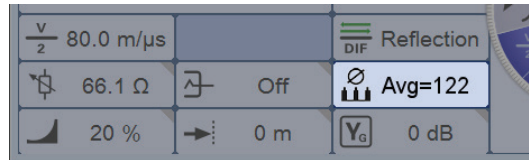
When you select a single phase (for example **L1 - N**), a reflection measurement is performed between the phase and the cable sheath. Here, not only the sought error is visible, the connection sleeve and tee joints are as well. They can often be used for orientation for fault location. For comparison purposes, additional individual phases can be activated for the measurement as desired.

Once one of the type “L - L” options (for example **L1 - L2**) has been selected, A differential measurement is performed between the two phases. In this mode the reflections of both inputs are combined to form a single curve. However, the reflections received at the second input have their polarity reversed through a differential transformed. Consequently, the differential curve generated here then shows genuine differences only. Faults of identical magnitude, all-core breaks or cable inhomogeneities (such as joints) will not be visible because a difference does not exist.




After selection of the desired options, the phase selection menu must be closed using . If necessary, the phase selection can be opened later and modified.

Averaging In the operating modes $\frac{F}{HVC}$ and $\frac{F}{LVC}$ the averaging function can be activated or deactivated using the menu item . When averaging is active, the curve shown on the display presents the average of all previously recorded measurements. A maximum of 256 measurements are taken into consideration here. After reaching this figure, the recording stops automatically.

The number of measurements taken into consideration for the averaging function is shown at the bottom area of the display and it is continuously updated.



Performing measurements After selecting the operating mode and the phases, proceed as follows to perform a pulse reflection measurement:


Step	Action
1	Use the Teleflex menu (see page 75) to make suitable settings for the diffusion speed, pulse width, pulse amplitude and filter and, if necessary activate the averaging function (see above).
2	Start the measurement using the menu item  .
3	Enable the voltage conditioning using the “HV ON” button. Result: Continuous measuring pulses are coupled into the phases involved in the measurement. Depending on the operating mode the recording curves are either continuously updated or combined to form an enveloping curve.
5	Examine the recorded reflectogram for deviations (see page 74) and, if necessary, use the available functions (see page 75) to improve the accuracy and display of the curve. In IFL mode, you may try to trigger an intermittent fault by appropriate means.
6	Stop the measurement using the menu item  .
	Result: The measurement is stopped and the current curve frozen. When necessary, the measurement can be continued using menu item  .

5.8 Pre-location of high-resistance cable faults -

In order to perform accurate pinpointing of the cable fault in as small a segment of the cable route as possible, a thorough prelocation procedure should be conducted beforehand. This achieves a significantly shorter total location time while also protecting the cables.

High-resistance cable faults reflect the low voltage pulses of a normal pulse reflection measurement either inadequately or not at all, so that the fault location cannot be identified using the recorded reflectogram. In this event, several other pre-location methods have established themselves, each of which combines a high-voltage process with the pulse reflection method. All these methods force arcing at the fault location through a “breakdown” caused by a sudden discharge of a charged capacitor or by charging the cable. Because the fault assumes the state of a low-resistance cable fault for a short time, its position can be measured beyond this period with a pulse reflection measurement.

The fault position can also be pre-located with sufficient accuracy using the oscillating travelling wave between the fault location and the measurement system that is triggered after the voltage breakdown.

In some pre-location modes, the  menu item can be used to specify the way the fault breakdown is caused. The following options can be selected:

- Surging** The breakdown is forced through abrupt capacitive discharge of the surge capacitor.
- Charging** With the surge switch closed, the surge capacitor and the connected cable itself are charged to the required breakdown voltage. The available surge capacity is thereby increased by the cable capacity, which can be very useful for particularly slow cables.


5.8.1 Arc reflection measurement (ARM) -

Introduction The ARM method is suited for the pre-location of high-resistance cable faults on power cables with a total length of up to 10 km. For faults with low ignition voltage (<32 kV), pre-location should be started with this method.

When locating the fault position a reflectogram is taken first under normal conditions (reference trace). The charged surge capacitor is then discharged suddenly into the cable and 15 reflection measurements are carried out in the static arc caused by faulty ignition. The user can then select the most suitable fault pattern from the 15 recorded patterns.

The direct comparison of reference and fault pattern usually makes possible immediate, clear identification of the fault location, because, due to the reflection at the burning arc, the fault pattern displays a significantly negative reflection at the fault location compared to the functional image.

Delay between TDR measuring pulses

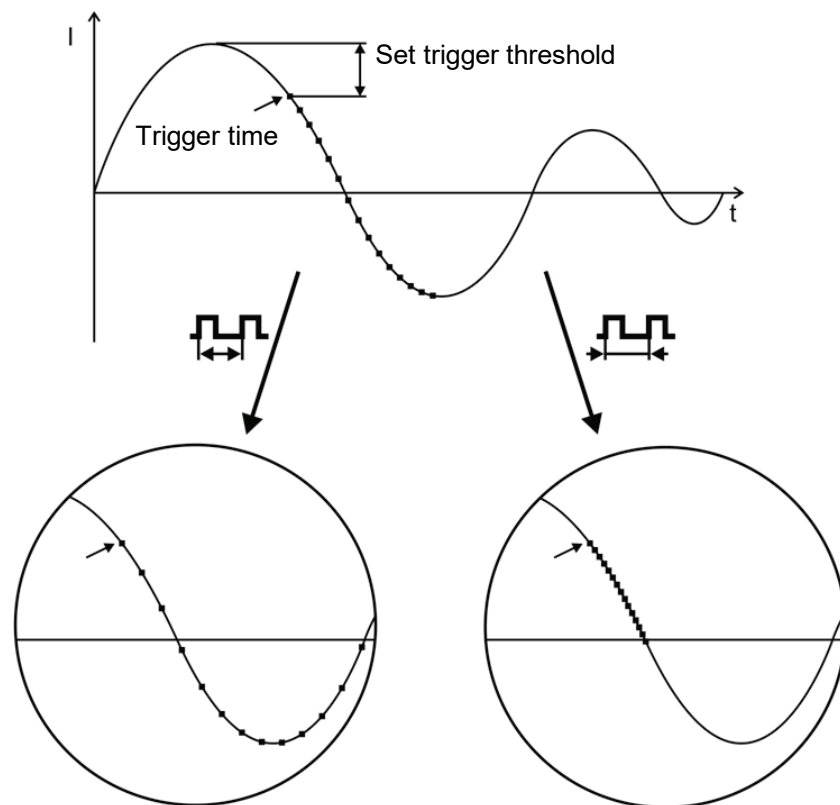
Before recording a fault trace, the user can manually configure the delay between two successive pulses using the menu item . This type of delay however, should not be confused with the trigger delay time (see next page), which only delays the first pulse.

In principle it is advisable to record the first series of fault traces with a default delay of 256 μs .

If required the delay can be varied to suit between 0 μs and 3.84 ms and a renewed faulty ignition undertaken.


For a setting of 0 μs the pulses are triggered as quickly as possible one after the other.

The effect of a delay adjustment is best illustrated in the current curve following a voltage flash-over:



■ Triggering a measuring pulse

As can be clearly seen in the figure, an increase in the delay enables a “wider” period to be mapped, in which the arc - under certain circumstances - is extinguished before igniting again.

Adjusting trigger delay time A user issued with Administration rights (see page 67) can use the menu item  to adjust the delay time between the received trigger signal (configured trigger threshold exceeded) and the actual start of the TDR measurement.









This is intended to give the ignition process at the fault position sufficient time to form a stable arc.


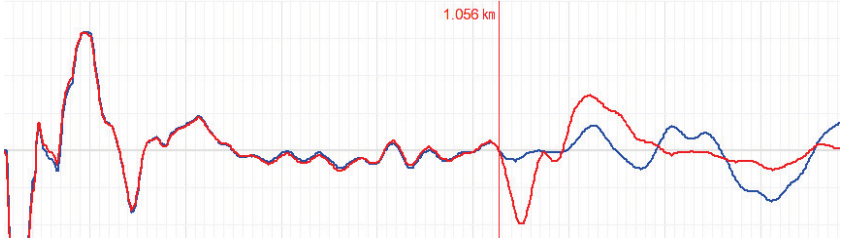
Basically, the delay time is set to an ideal setting at the factory for the system configuration and it should only be adjusted in exceptional cases (in very special measurement layouts) and this should be conducted by experienced users only.

Any improper adjustment to the delay time poses the following risks:

- **Delay time too short:** The arc is unstable and the reflectogram is not representative or it is faulty.
- **Delay time too long:** As the delay time increases the risk of conducting a measurement in the decay curve's zero crossing increases. The ignition procedures repeated at this point in time can falsify the reflectogram. If the delay time is excessively high there is also a risk that the arc may already be completely extinguished.

Procedure Proceed as follows to pre-locate a cable fault using the ARM method:

Step	Action
1	Connect the HV cable to the defective phase.
2	If it is a chargeable cable, perform a brief DC voltage test to determine the fault ignition voltage.
3	When in the submenu  activate the menu item  .
4	Select the defective phase in the phase selection menu and close the menu using  .
5	Set the voltage range to a few kV above the identified fault ignition voltage, to preset a low voltage level and to thus ensure a high surge energy. For non-chargeable cable faults, you should increase up to the fault ignition voltage in multiple iterations.
6	Use the Teleflex menu (see page 75) to make suitable settings for the propagation velocity, pulse width, pulse amplitude and filter. Use the menu item  to select whether the fault breakdown should be forced by charging the cable or by triggering a surge discharge (see page 97).
7	Start recording the reference trace using the menu item  .
8	Enable the high voltage using the "HV ON" button. Result: Following a brief calibration procedure the reference trace is shown on the display.
9	Check whether the recorded curve and, in particular, the marked end of the cable match the expected result. If necessary, use the available functions (see page 75) to improve the accuracy and the display of the reference trace then repeat the recording using the menu item  .
10	Prepare the system for fault trace recording using the menu item  .
11	Taking the required fault ignition voltage into consideration, set the surge voltage and then trigger the surge discharge using the menu item  .









Step	Action
	<p>Result: If a voltage flash-over occurs at the fault position, a red (fault) curve is shown on the display.</p> <p>If triggering failed to occur, and therefore a fault trace could not be made, it may then be necessary to adjust the trigger threshold or the surge voltage before triggering a further surge.</p>
12	<p>Turn the rotary encoder to select one of the 15 recorded curves and confirm your selection by pressing it briefly. The selected curve can be changed using the menu item  up until the next measurement is started or the operating mode is changed.</p>
	<p>Result: The red marking is automatically positioned at the location identified as the fault position (at which the two curves diverge).</p> 
13	<p>If necessary, use the available functions (see page 75) to optimise the curve display (filter, amplification) and re-adjust the marked fault position. Then read off the fault distance.</p>
14	<p>Switch off the high voltage using the menu item HV OFF.</p>

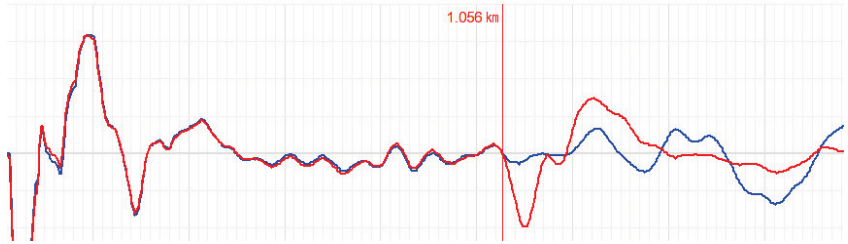
5.8.2 ARM Conditioning -

Introduction In ARM Conditioning mode, the fault is first subjected to an individually adjustable number of surge discharges, causing it to heat up. This supply of heat causes the fault to be conditioned, especially in the case of difficult-to-locate faults involving moisture ingress. An ARM fault trace is recorded immediately afterwards. As the conditioning process and the ARM measurement are combined in one operating mode, there is no need for manual mode switching. This shortens the time in which the fault can cool down and return to its original characteristics.

The general instructions for carrying out an ARM measurement also apply in the same form to the ARM Conditioning mode.

Procedure Proceed as follows to pre-locate a cable fault using the ARM Conditioning method:

Step	Action
1	Connect the HV cable to the defective phase.
2	If it is a chargeable cable, perform a brief DC voltage test to determine the fault ignition voltage.
3	When in the submenu  activate the menu item  .
4	Select the defective phase in the phase selection menu and close the menu using  .
5	Set the voltage range to a few kV above the identified fault ignition voltage, to preset a low voltage level and to thus ensure a high surge energy. For non-chargeable cable faults, you should increase up to the fault ignition voltage in multiple iterations.
6	Use the Teleflex menu (see page 75) to make suitable settings for the propagation velocity, pulse width, pulse amplitude and filter.
7	Use the menu item  to select whether the fault breakdown should be forced by charging the cable or by triggering a surge discharge (see page 97). The selection made here does not affect the conditioning phase prior to the actual ARM measurement. During the conditioning phase, the voltage breakdown at the fault position is generally caused by an abrupt capacitive discharge of the surge capacitor.
8	Start recording the reference trace using the menu item  .
9	Enable the high voltage using the "HV ON" button. Result: Following a brief calibration procedure the reference trace is shown on the display.
10	Check whether the recorded curve and, in particular, the marked end of the cable match the expected result. If necessary, use the available functions (see page 75) to improve the accuracy and the display of the reference trace then repeat the recording using the menu item  .
11	Prepare the system for fault trace recording using the menu item  .
12	Taking the required fault ignition voltage into consideration, set the surge voltage.
13	Use the menu item  to set the number of surge discharges to which the fault location is to be subjected before the actual ARM measurement.







Step	Action
14	<p>Start the conditioning and measuring process using the menu item ▶▶.</p> <p>Result: The system starts conditioning the fault by carrying out the set number of surge discharges. If required, this conditioning phase can also be ended prematurely using the menu item ▶▶▶.</p> <p>The conditioning phase is followed directly by the ARM measurement, after which one of the recorded fault traces is displayed.</p> <p>If triggering failed to occur, and therefore a fault trace could not be made, it may then be necessary to adjust the trigger threshold or the surge voltage before restarting the whole conditioning process.</p>
15	<p>Turn the rotary encoder to select one of the 15 recorded curves and confirm your selection by pressing it briefly. The selected curve can be changed using the menu item ↶ up until the next measurement is started or the operating mode is changed.</p> <p>Ergebnis: Die rote Markierung wird automatisch auf der als Fehlerstelle identifizierten Position platziert (an welcher beide Kurven auseinanderlaufen).</p> 
16	<p>Nutzen Sie bei Bedarf die zur Verfügung stehenden Funktionen (see page 75), um die Kurvendarstellung zu optimieren (Filter, Verstärkung) und die markierte Fehlerposition nachzuzustieren. Lesen Sie anschließend die Fehlerentfernung ab.</p>
17	<p>Schalten sie die Hochspannung über den Menüpunkt HV OFF aus.</p>

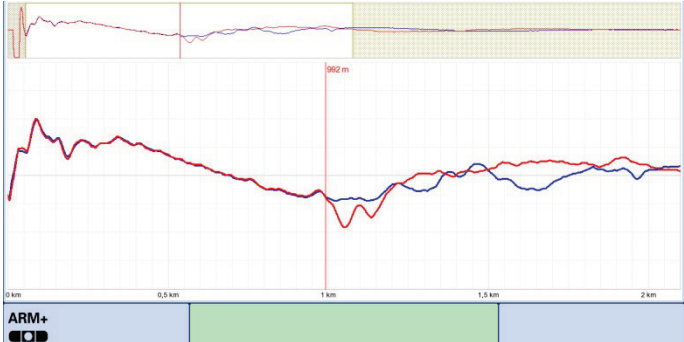
5.8.3 ARM Plus - (optional)

Introduction The ARM Plus method is a process with active arc stabilisation for locating high-resistance cable faults in long cables (up to 10 km long) or under difficult conditions (oil-filled sleeves, moist sleeves).

The arc in the fault location, generated with a surge voltage of up to 32 kV, is stabilised and extended by a second discharge from the 4 kV surge module. Into this arc, a reflection measurement is performed with a high-energy measurement pulse (up to 1500 V) at the momentarily low-resistance fault location.

Procedure Proceed as follows to pre-locate a cable fault using the ARM Plus method:

Step	Action
1	Connect the HV cable to the defective phase.
2	If it is a chargeable cable, perform a brief DC voltage test to determine the fault ignition voltage.
3	When in the submenu  activate the menu item  .
4	Select the defective phase in the phase selection menu and close the menu using  .
5	Set the voltage range to a few kV above the identified fault ignition voltage, to preset a low voltage level and to thus ensure a high surge energy. For non-chargeable cable faults, you should increase up to the fault ignition voltage in multiple iterations.
6	Use the Teleflex menu (see page 75) to make suitable settings for the propagation velocity, pulse width, pulse amplitude and filter.
7	Start recording the reference trace using the menu item  .
8	Enable the high voltage using the "HV ON" button. Result: Following a brief calibration procedure the reference trace is shown on the display.
9	Check whether the recorded curve and, in particular, the marked end of the cable match the expected result. If necessary, use the available functions (see page 75) to improve the accuracy and the display of the reference trace then repeat the recording using the menu item  .
10	Prepare the system for fault trace recording using the menu item  .







Step	Action
11	Taking the required fault ignition voltage into consideration , set the surge voltage and then trigger the surge discharge using the menu item $_/_$.
	<p data-bbox="512 360 1461 461">Result: If a voltage flash-over occurs at the fault position, a red (fault) curve is shown on the display. The marking is automatically positioned at the location identified as the fault position (at which the two curves diverge).</p>  <p data-bbox="512 864 1461 958">If triggering failed to occur, and therefore a fault trace could not be made, it may then be necessary to adjust the trigger threshold or the surge voltage before triggering a further surge.</p>
12	If necessary, use the available functions (see page 75) to optimise the curve display (filter, amplification) and re-adjust the marked fault position. Then read off the fault distance.
13	Switch off the high voltage using the menu item HV OFF .

5.8.4 DECAF Plus - (optional)

Introduction In this method, similar to the ARM Plus method, the fault is caused to breakdown by charging the cable, also making it possible to pre-locate faults with ignition voltages of up to 40 or 80 kV according to the highly accurate ARM principle. Accordingly, the method can only be applied to chargeable cables.

Just like with the ARM Plus method, after the fault ignition the arc is stabilised by a discharge of the 4 kV surge module and a reflection measurement is performed into the arc with high-energy measurement pulses (up to 1500 V).

Procedure Proceed as follows to pre-locate a cable fault using the DECAF Plus method:

Step	Action
1	Connect the HV cable to the defective phase.
2	When in the submenu  activate the menu item  .
3	Select the defective phase in the phase selection menu and close the menu using  .
4	Set the voltage range, taking the required fault ignition voltage into consideration.
5	Use the Teleflex menu (see page 75) to make suitable settings for the propagation velocity, pulse width, pulse amplitude and filter.
6	Start recording the reference trace using the menu item  .
7	Enable the high voltage using the "HV ON" button. Result: Following a brief calibration procedure the reference trace is shown on the display.
8	Check whether the recorded curve and, in particular, the marked end of the cable match the expected result. If necessary, use the available functions (see page 75) to improve the accuracy and the display of the reference trace then repeat the recording using the menu item  .
9	Prepare the system for fault trace recording using the menu item  .

Step	Action
10	<p>Increase the voltage to the desired test voltage using the rotary encoder and confirm the value by pushing in the rotary encoder.</p> <p>The dialogue for setting the voltage closes automatically after a few seconds for safety reasons but it can be accessed again using the menu item U_{NOM}.</p>
	<p>Result: After the voltage flash-over at the fault position, a red (fault) curve is shown on the display. The marking is automatically positioned at the location identified as the fault position (at which the two curves diverge).</p> <div data-bbox="646 562 1332 853" data-label="Figure"> </div> <p>If triggering failed to occur, and therefore a fault trace could not be made, it may then be necessary to adjust the trigger threshold or the surge voltage before triggering a further surge.</p>
11	<p>If necessary, use the available functions (see page 75) to optimise the curve display (filter, amplification) and re-adjust the marked fault position. Then read off the fault distance.</p>
12	<p>Switch off the high voltage using the menu item HV OFF.</p>

5.8.5 ARM burning - $\text{ARM}^- / \text{ARM}^+$ (optional)




Introduction In ARM burning a continuous arc reflection measurement takes place during the burning procedure that occurs after the fault breakdown. This enables any changes in the fault caused by the burning procedure to be monitored on the screen. If required, the system automatically stops the measurement as soon as a stable low resistance state of the fault is achieved.

As with the ARM method, the reference trace and the fault trace are compared with each other and the fault distance can be read off directly.

The advantage of this method compared with conventional burning is the controlled procedure which restricts the actual burning to the shortest necessary time and by doing so preserves the cable's service life.

Depending on the equipment in the test van, the application of the method is limited to faults with an ignition voltage <8 kV or <20 kV (for systems with power burning unit).

Procedure Proceed as follows to pre-locate a cable fault using the ARM burning method:

Step	Action
1	Connect the HV cable to the defective phase.
2	When in the submenu PRE activate the menu item $\text{ARM}^- / \text{ARM}^+$
3	Select the defective phase in the phase selection menu and close the menu using  .
4	Use the Teleflex menu (see page 75) to make suitable settings for the propagation velocity, pulse width, pulse amplitude and filter.
5	Start recording the reference trace using the menu item  .
	Result: Following a brief calibration procedure the reference trace is shown on the display.
6	Check whether the recorded curve and, in particular, the marked end of the cable match the expected result. If necessary, use the available functions (see page 75) to improve the accuracy and the display of the reference trace then repeat the recording using the menu item  .
7	The menu item $\frac{\text{F}}{\text{TRI}}$ can be used to activate or deactivate an automatic switch-off. If automatic switch-off is activated, the measurement is automatically stopped as soon as the fault position becomes clearly apparent during the burning procedure when comparing reference and fault traces. Otherwise the measurement has to be manually stopped.
8	Prepare the system for fault trace recording using the menu item $\frac{\text{REF}}{\text{FAU}}$.

Step	Action
9	<p>Increase the voltage to the desired test voltage using the rotary encoder and confirm the value by pushing in the rotary encoder.</p> <p>The dialogue for setting the voltage closes automatically after a few seconds for safety reasons but it can be accessed again using the menu item U_{NOM}.</p> <hr/> <p>Result: The test object is charged to the set voltage. After the voltage arc-over at the fault location, the burning process begins and measurement pulses are continuously coupled into the burning arc. With each of these pulses, the red (fault) curve is updated.</p>
10	<p>As the burning procedure continues, monitor the accompanying fault conversion on the screen and stop the measurement using the menu item <input type="checkbox"/>, as soon as the fault position becomes clearly apparent through the comparison of reference and fault traces.</p> <p>In this case, when the automatic switch-off is activated, the measurement is automatically stopped.</p>
11	<p>If necessary, use the available functions (see page 75) to optimise the curve display (filter, amplification) and re-adjust the marked fault position. Then read off the fault distance.</p>
12	<p>Switch off the high voltage using the menu item HV OFF.</p>






5.8.6 Voltage decoupling (DECAY) -


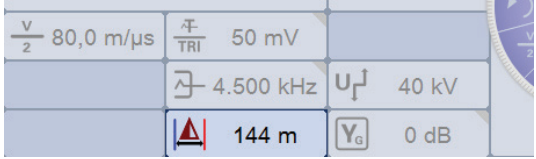
Introduction The decay method is used to pre-locate high-resistance cable faults using a high fault ignition voltage in rechargeable cables.

To this end, the cable is charged with a DC voltage until the voltage exceeds the fault's breakdown voltage. The energy stored in the cable capacitance discharges through the fault and generates a travelling wave, which is recorded and displayed by the system as an attenuated oscillation. The period of this oscillation can be used along with the following formula to determine the actual fault distance:

$$\text{Fault distance} = \frac{\text{Full period distance}}{2} - \text{Length of HV connection cable}$$

Procedure Proceed as follows to pre-locate a cable fault using the DECAY method:

Step	Action
1	Connect the HV cable to the defective phase.
2	When in the submenu  activate the menu item  .
3	Select the defective phase in the phase selection menu and close the menu using  .
4	Set the voltage range, taking the required fault ignition voltage into consideration.
5	Use menu item $\frac{V}{2}$ or NVP to set the propagation velocity and then use menu item  to set the measuring range to roughly five to ten times the complete length of the cable.
6	Start the measurement using the menu item  .
7	Enable the high voltage using the "HV ON" button.





Step	Action
8	<p>Increase the voltage to the desired test voltage using the rotary encoder and confirm the value by pushing in the rotary encoder.</p> <p>The dialogue for setting the voltage closes automatically after a few seconds for safety reasons but it can be accessed again using the menu item U_{NOM}.</p> <p>Result: The test object is charged to the set voltage. Once the fault breaks down, an attenuated and oscillating voltage curve is shown in the display and the voltage conditioning is interrupted.</p>  <p>The software automatically attempts to calibrate a period of the oscillation and to set corresponding markings.</p>
9	<p>Switch off the high voltage using the menu item HV OFF.</p>
10	<p>If the recorded decay curve is superimposed to an excessive degree by interference signals, it uses the available filter settings (see page 75) to smooth the characteristic of the curve. Amplitudes that are too high can be counteracted by reducing the amplification (see page 75).</p> <p>Each time an adjustment is made, you must repeat the procedure from Step 6.</p>
11	<p>If the automatically set markings do not enclose a period exactly, you can use the function → to correct their positions.</p> <p>Half the distance of one period is shown directly next to the cursor and in the bottom left corner of the display.</p> 
12	<p>Subtract the length of the connection cable from this value and the internal wiring of the test van. This equates to a total of approx. 65 metres in the case of a standard 50-metre cable drum.</p> <p>The calculated value roughly corresponds to the distance between the connection point and the fault. For technical reasons, this method has a slightly higher tolerance than, for example, pre-location using the ARM method.</p>

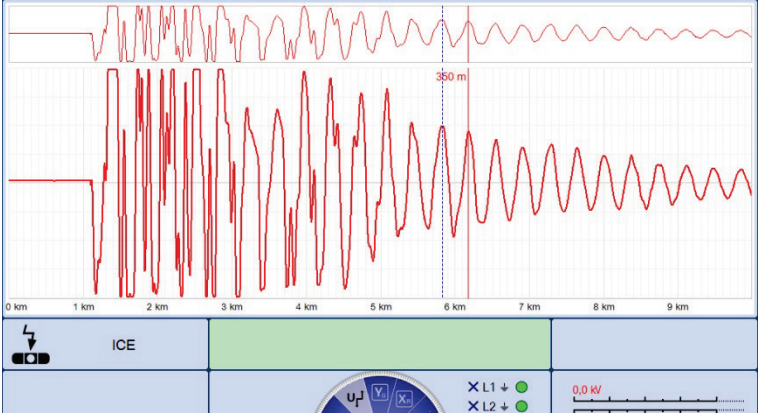
5.8.7 Current decoupling (ICE) -

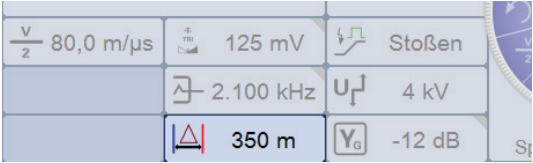
Introduction Prelocation using current decoupling has established itself, particularly with regard to faults in the lower kOhm range and for extremely large fault distances, in which the ARM- method often fails to achieve any results.

As with the ARM method, an abrupt discharge of the surge capacitor triggers a breakdown in the fault. Consequently, an attenuated transient wave moves back and forth between the fault location and the measurement system. Inductively decoupling the current causes the display of an oscillation, which has a period equivalent to a single fault distance. However, the length of the pre-measuring cable still needs to be deducted from this distance.

Procedure Proceed as follows to pre-locate a cable fault using the ICE method:

Step	Action
1	Connect the HV cable to the defective phase.
2	If it is a chargeable cable, perform a brief DC voltage test to determine the fault ignition voltage.
3	When in the submenu PRE activate the menu item  .
4	Select the defective phase in the phase selection menu and close the menu using  .
5	Set the voltage range to a few kV above the identified fault ignition voltage, to preset a low voltage level and to thus ensure a high surge energy. For non-chargeable cable faults, you should increase up to the fault ignition voltage in multiple iterations.
6	Use menu item $\frac{V}{2}$ or NVP to set the propagation velocity and then use menu item X_R to set the measuring range to roughly five to ten times the complete length of the cable.
7	Use the menu item  to select whether the fault breakdown should be forced by charging the cable or by triggering a surge discharge (see page 97).
8	Start the measurement using the menu item  .
9	Enable the high voltage using the "HV ON" button.

Step	Action
10	<p>Set the voltage, taking the required fault ignition voltage into consideration. If the fault will be caused by surge discharge to breakdown, this needs to be initiated using the menu item _/_ once the surge capacitor has been charged to the set voltage.</p> <p>If instead the cable should be charged to the fault breakdown, the system starts immediately with voltage conditioning.</p>
	<p>Result: If a voltage flash-over occurs at the fault position, the display shows an attenuated and oscillating current curve.</p>  <p>The software automatically attempts to calibrate a period of the oscillation and to set corresponding markings.</p> <p>If triggering failed to occur, and therefore a fault trace was not made, it may then be necessary to adjust the trigger threshold or the surge voltage before triggering a further surge.</p>
11	Switch off the high voltage using the menu item HV OFF .
12	<p>If the recorded decay curve is superimposed to an excessive degree by interference signals, it uses the available filter settings (see page 75) to smooth the characteristic of the curve.</p> <p>Amplitudes that are too high can be counteracted by reducing the amplification (see page 75).</p> <p>Each time an adjustment is made, you must repeat the procedure from Step 7.</p>

Step	Action
13	<p>If the automatically set markings do not enclose a period exactly, you can use the function \rightarrow to correct their positions.</p> <p>The distance of one period is shown directly next to the cursor and in the bottom left corner of the display.</p> 
14	<p>Subtract the length of the connection cable from this value and the internal wiring of the test van. This equates to a total of approx. 65 metres in the case of a standard 50-metre cable drum.</p> <p>The calculated value roughly corresponds to the distance between the connection point and the fault.</p> <p>For technical reasons, this method has a slightly higher tolerance than, for example, pre-location using the ARM method. With the ICE methods, often 5 ... 10% larger distances are measured, which is why measurement technicians should first walk toward the test van when pinpointing the pre-located fault position.</p>

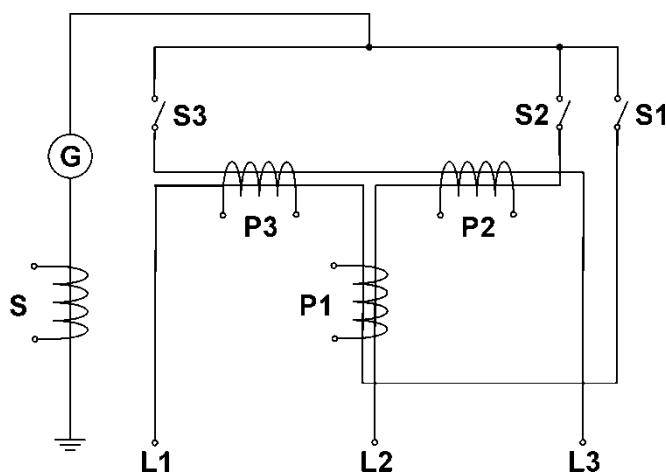
5.8.8 Three-phase current decoupling (optional) -

Introduction Three-phase current decoupling is used to locate high-resistance and sporadic cable faults in **branched cables networks**. The ignition voltage of the fault may not exceed 32 kV.

From the different known methods, the differential comparison method has proven itself in particular for pre-location of faults in the branched low voltage network, which is why the description in this section is based mainly on this method.

With the differential comparison method, in addition to the defective phase, an intact phase must also be connected and activated. For comparison purposes, after a measurement with open ends, additional measurements need to be performed in which the cable ends (and later also the ends of the branches, if necessary) must be bridged.

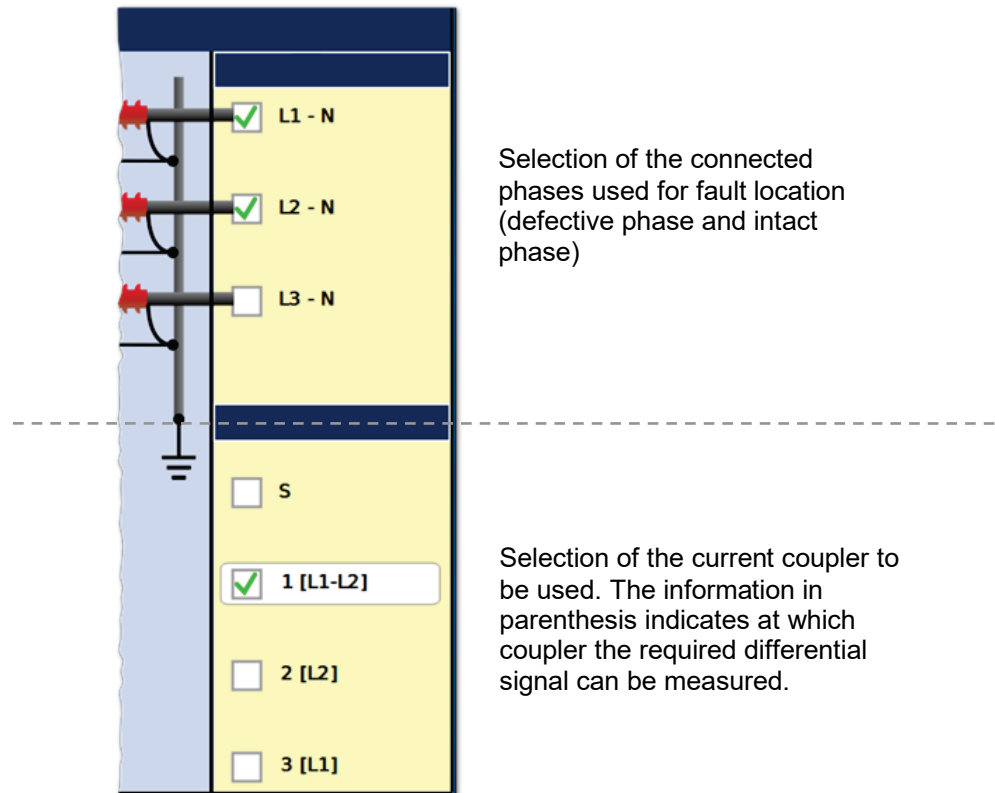
Special features for the phase selection The system is equipped with various current couplers, which can catch the current from one or more phases, depending on the connection configuration.



Accordingly, depending on the connected phases, the following signals are caught at the various couplers:

Connected phases	Additive coupler S	Differential coupler		
		P1	P2	P3
L1	L1	L1	-	L1
L2	L2	L2	L2	-
L3	L3	-	L3	L3
L1, L2	L1+L2	L1-L2	L2	-L1
L1, L3	L1+L3	L1	-L3	L3-L1
L2, L3	L2+L3	-L2	L2-L3	L3

In the phase selection menu, in addition to the connected phase, the current coupler to be used must also be selected. This ensures that the desired sum or differential signal is displayed as reflectogram.








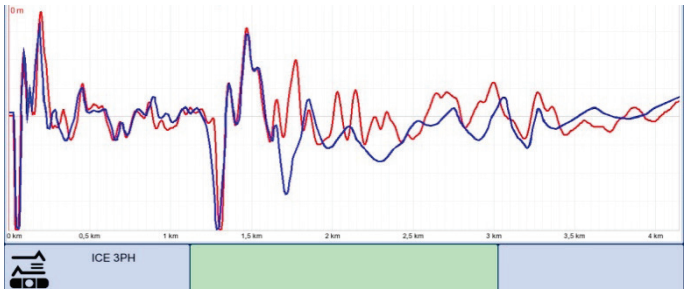
Selection of the connected phases used for fault location (defective phase and intact phase)

Selection of the current coupler to be used. The information in parenthesis indicates at which coupler the required differential signal can be measured.

For example, if a fault in phase L1 needs to be localised using the differential comparison method and L2 will serve as the intact phase, the options **L1** and **L2** must first be activated. The differential coupler P1 (option **1 [L1-L2]**) must then be activated, over which the differential signal between L1-L2 is decoupled.

Procedure Proceed as follows to pre-locate a cable fault using the differential comparison method:

Step	Action
1	Connect the test van to the defective phase and to an intact phase of the cable system.
2	If it is a chargeable cable, perform a brief DC voltage test on the defective phase to determine the fault ignition voltage.
3	When in the submenu PRE activate the menu item  .
4	In the phase selection menu, select the two phases involved in the measurement and the current coupler over which the differential signal of these two phases can be decoupled. Please observe the instructions on previous pages. Then close the menu using  .
5	Set the voltage range to a few kV above the identified fault ignition voltage, to preset a low voltage level and to thus ensure a high surge energy. For non-chargeable cable faults, you should increase up to the fault ignition voltage in multiple iterations.
6	Use menu item $\frac{V}{2}$ or NVP to set the propagation velocity and then use menu item X_R to set the measuring range to roughly five to ten times the complete length of the cable.
7	Use the menu item  to select whether the fault breakdown should be forced by charging the cable or by triggering a surge discharge (see page 97).
8	Start the measurement using the menu item  .
9	Enable the high voltage using the “HV ON” button.


Step	Action
10	<p>Set the voltage, taking the required fault ignition voltage into consideration. If the fault will be caused by surge discharge to breakdown, this needs to be initiated using the menu item $_/_$ once the surge capacitor has been charged to the set voltage. If instead the cable should be charged to the fault breakdown, the system starts immediately with voltage conditioning.</p> <p>Result: If a voltage arc-over takes place at the fault location, a reflectogram is shown in the display, the curve of which is affected both by the reflections at the fault location and by the reflections in the individual branches.</p>  <p>If triggering failed to occur, and therefore a fault trace was not made, it may then be necessary to adjust the trigger threshold or the surge voltage before triggering a further surge.</p>
11	Bridge the defective line and the intact line at the far end of the cable.
12	Prepare the software for recording a second reflectogram using the menu item $\frac{TR1}{TR2}$.
13	<p>Provoke a breakdown of the fault again through a surge discharge or charging.</p> <p>Result: A second reflectogram is shown that differs from the first diagram in that the reflection directed from the fault location to the end of the cable now runs back to the start of the cable via the bridge and the intact line, and when it passes through the current coupler, an additional reflection is caused.</p> 
14	Based on the differential comparison method, determine the fault distance. If the calculation indicates that the fault location is in a branch, another measurement must be performed with the ends of the corresponding branch bridged.



5.9 Fault conversion -

5.9.1 Burning - /

Introduction What is known as “burning” enables ongoing conversion of high-impedance faults into low-impedance shunts right up to saturated short-circuits. To this end, the fault is first caused to breakdown by charging the test object and then continuously fed a high current, which keeps the arc burning. Ideally, this causes the burned insulating material to form a conductive carbon bridge, thus reducing the resistance of the fault (the fault then becomes locatable) or the moisture that penetrated into the cable evaporates.






Thanks to steady improvement in pre-location methods, this material-stressing method must be used only very rarely with difficult faults, such as moist sleeves.



Selecting the operating mode The burning operating modes are usually grouped not directly in the main menu but rather in the sub-menu .

Menu item	Operating mode
	Burning faults with an ignition voltage of up to 80 kV via the internal cascades
	Power burning of faults with an ignition voltage of up to 20 kV via the optional power burning unit (40 A maximum burning current)


Setting the measurement parameters The phase and the voltage range are automatically queried when entering the operating mode, however – like all other settings – they can be adjusted until the actual start of the test.

Depending how the test van is equipped and the selected operating mode, the following measurement parameters can be set:

Button / Menu item	Description
	The defective phase must be selected in accordance with the actual type of connection. The phase selection menu must then be closed using  .
	A burn time can be specified in minutes. On expiry of the burn time, the high voltage is switched off automatically.
	Voltage range for the upcoming measurement. The actual voltage can only be set within this range.
	Setting the current range. In the Auto setting, the range is always automatically adjusted to the currently measured currents.

Button / Menu item	Description
	<p><u>Only configurable in the normal burn operating mode</u></p> <p>Switch between intermittent and continuous burn operation.</p> <p>In intermittent operation, the burn operation is always stopped after 3 seconds and the test object only charged again to the set voltage after a pause of 3 seconds. Because the pause also starts even if target voltage was not reached within the 3 seconds of operation, intermittent operation is not suitable for faults with high ignition voltages.</p>
	<p><u>Only configurable in power burning mode</u></p> <p>Limit of the maximum burning current.</p>

Starting and stopping the burning process

Once all the relevant parameters and the defective phase have been set, the measurement can be started using the menu item . Following this the high voltage must be authorised using the “HV ON” button and the target voltage set.

As soon as high voltage is enabled, the “HV OFF” button lights up red signalling “high voltage at the HV output”. The voltage will be ramped up to the set target value immediately without prior confirmation.

The dialogue for setting the voltage closes automatically after a few seconds for safety reasons but it can be accessed again using the U_{NOM} menu item.

The voltage and current curves are shown on the display. When the fault location is ignited, the voltage drops abruptly while the burning current rises sharply.

A few minutes are usually enough to convert the fault resistance so that it may be localised using an HV pre-location method.







Using the menu item  and , the voltage conditioning can be interrupted and resumed as necessary.

5.9.2 AC burning - (optional)

Introduction This method, which requires the optional power burning unit, is not primarily used to convert a fault, but rather to pre-locate a low-resistance fault in a highly branched low voltage network (house connection network, lighting network) using the voltage drop method.

For this purpose, an adjustable AC voltage is applied to the low voltage cable, which results in high current over the fault resistance. For measurements on individual service boxes, a significant voltage or current drop can be measured after the fault, thus narrowing the fault position, ideally down to a specific section/house connection.

Procedure Proceed as follows to pre-locate a fault using the voltage drop method:

Step	Action										
1	Connect the HV cable to the defective phase.										
2	When in the submenu  activate the menu item  .										
3	Select the defective phase in the phase selection menu and close the menu using  .										
4	Use the menu item  to set the desired burning stage. The power burning unit supports the following burning stages: <table border="1" data-bbox="702 963 1300 1198"> <thead> <tr> <th>Burning stage</th> <th>Maximum burning current</th> </tr> </thead> <tbody> <tr> <td>30 V</td> <td>70 A</td> </tr> <tr> <td>75 V</td> <td>40 A</td> </tr> <tr> <td>180 V</td> <td>16 A</td> </tr> <tr> <td>440 V</td> <td>8 A</td> </tr> </tbody> </table>	Burning stage	Maximum burning current	30 V	70 A	75 V	40 A	180 V	16 A	440 V	8 A
Burning stage	Maximum burning current										
30 V	70 A										
75 V	40 A										
180 V	16 A										
440 V	8 A										
5	If necessary, also limit the maximum burning current using menu item  _{MAX} . In the Off setting, no limit is active and the maximum burning current is based on the limit that applies for the corresponding burning stage (see above). If the user-defined maximum burning current or the maximum burning current for the active burning stage is exceeded during a burning process, the system automatically selects a burning stage in which neither of the two limits is exceeded.										
6	Start the measurement using the menu item  .										
7	Enable the high voltage using the “HV ON” button.										

Step	Action
8	Start voltage conditioning use the menu item ▷. Result: The graph of the current fed to the cable is shown in the display as a curve.
9	By measuring the voltage or current drop, determine the branch of the network affected by the fault. Using the menu items □ and ▷, the voltage conditioning can be interrupted and resumed as necessary.
10	After completing the measurements, switch off the high voltage using the menu item HV OFF .


5.10 Fault pinpointing -


The aim of every cable fault pinpointing is the precise location of the fault position to avoid unnecessary excavation works. Precise pre-location helps to narrow down the search area as much as possible.


5.10.1 Surge pinpointing - /



Introduction Surge pinpointing is the preferred method for precise location. It can be used for about 90% of all cable faults.

Using an abrupt discharge of the surge capacitor, surge voltage pulses are continuously fed into the defective cable, causing voltage arc-overs at the fault location. The resulting flashover noise propagates in the ground and can be recorded with a ground noise sensor on the surface (acoustic location). The distance to the fault can be calculated using either the volume of the flashover noise or the time difference between the arrival of the magnetic pulse and the flashover noise.

Selecting the operating mode The two surge operating modes are usually grouped not directly in the main menu but rather in the sub-menu .

Using the menu item , pure surge mode can be started, in which no curves are recorded or displayed.





For paper-insulated cables in particular, however, it can be helpful to be able to directly track any changes in the ignition behaviour of the fault during surging. In this case, the operating mode  should be selected, which combines traditional surging with a pre-location method (current decoupling). Here, the oscillating curve of the inductively decoupled current is shown in the display during surge operation and refreshed with each surge. If a change occurs, the refresh can be stopped manually at any time and the current curve examined more closely. Surge mode continues unchanged.

In systems with the “Surging 60 kV” option, the maximum surge voltage is only available in actual surge mode ()! In operating mode , surges can only take place with a maximum of 32 kV.


Setting the measurement parameters

The phase and the voltage range are automatically queried when entering the operating mode, however – like all other settings – they can be adjusted until the actual start of the test.


The following test parameters can be set:

Button / Menu item	Description
	The defective phase must be selected in accordance with the actual type of connection. The phase selection menu must then be closed using  .
U_{r}	Voltage range for the upcoming surge pinpointing. The actual surge voltage can only be set within this range. Set the voltage range to a few kV above the identified fault ignition voltage, to preset a low voltage level and to thus ensure a high surge energy. The maximum available surge energy, based on the currently selected setting, is shown permanently next to the symbol E_{MAX} at the bottom of the screen.
 AUTO	Switch between automatic and manual surge decoupling. With automatic surge decoupling, the desired distance between two surges (surge rate) can be set down to the second using the menu item  .


Carrying out fault locating

 WARNING	The safety of the test van that is in operation must be guaranteed at all times by the persons responsible for the test van in accordance with the applicable safety regulations and guidelines, also during line and fault location!
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In order to avoid subjecting the cable to unnecessary stress, surge mode should not be activated until the measuring technician has reached the prelocated fault position.

Once the operating mode has then been started via menu item , the high voltage must be enabled via the “HV ON” push-button and the target voltage set. The dialogue for setting the voltage closes automatically after a few seconds for safety reasons but it can be accessed again using the menu item U_{NOM} .

As soon as high voltage is enabled, the “HV OFF” button lights up red signalling “high voltage at the HV output”. The surge capacitor is directly charged to the set surge voltage.

Using the menu item , the automatic surge mode is started and a voltage breakdown is caused at the fault location in the set surge interval. In manual surge mode, each surge discharge must be initiated manually using the menu item $_/_$.

During surge operation, the fault position can now be pinpointed in the pre-located area using a suitable surge wave receiver.



For more details about operating the surge wave receiver, please read the accompanying instructions.

The measurement technician who remains in the test van should maintain telephone contact with their colleagues at the fault location and if necessary modify the settings (surge voltage, surge mode, surge interval), initiate individual surges or pause/continue surge operation.

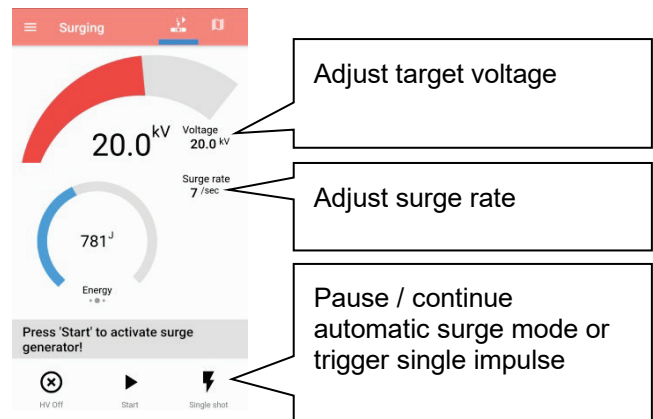
In ICE surge mode, they can also observe the recorded curves and if necessary interrupt recording using the menu item $\text{T}_{\text{ON/OFF}}$ for an in-depth analysis of the curve (see page 111).

Use of the remote control app (optional)

The optional remote control app makes it easier to find the prelocated fault position thanks to its map view (see page 64), and allows the measuring technician to make all of the relevant settings remotely. In order to do this, the app must be installed on a suitable device and remote control mode activated (see page 61).

Using the remote control app has the advantage that the measuring technician can enable the high voltage before leaving the test van without having to set a target voltage (no voltage conditioning takes place yet).

Once the measuring technician has reached the assumed fault position, he can then independently adjust the target voltage and make all other necessary settings using the app in order to start the actual surge mode:



If adjustments need to be made to the settings during pinpointing, he can also make these quickly without having to consult the colleagues in the test van first.

5.10.2 Line and fault location with the audio frequency generator

Introduction The audio frequency generator, in combination with an appropriate audio frequency receiver, is suitable for pinpointing of low resistance cable faults (field of twist method, minimum turbidity method), for locating cables and metallic conductors (for example, pipes) and for cable identification.

With automatic impedance matching, multi-frequency operation and SignalSelect operating mode for showing the direction of flow, the generator provides a number of features that facilitate location/identification and ensure reliable results.



Coupling to the cable or metallic conductor When locating/routing metallic lines (e.g. cables, pipes), a signal return current must be ensured through contact with the ground or, if necessary, through connection to an alternative conductor. One possible option is a direct connection to the cable shield. This method eliminates the need for further switching operations at the other end of the cable.




If the shield cannot be isolated from earth at the connection point, the signal can also be directly coupled to the inner conductor. In this case, however, it is recommended that the inner conductor is grounded at the other end of the cable — especially at low frequencies.






Specific connection methods for locating sleeves and faults in twisted multi-core cables are provided in the operating instructions for the audio frequency receiver.

Selecting the operating mode and phases At the start of an audio frequency measurement, the submenu of the pinpointing operating modes must be opened using the menu item  and from this, the menu item  accessed.



Directly upon entering the operating mode, the connected phase to be tested is queried. The phase must then be configured according to the actual connection situation.


The phase selection menu must then be closed using . If necessary, the phase selection can be opened later and modified.

Setting the operating mode and the measurement parameters In preparation of the actual measurement, the desired operating mode should be set first:

Operating mode	Description
	Sine wave mode In this default mode, the currently set frequency is normally emitted as a pure sine wave.
	“SignalSelect” mode In “SignalSelect” mode, a specially coded audio frequency signal is emitted that identifies the direction of the signal flow, thus increasing the accuracy and reliability of route tracing. The mode is thus perfectly suited for routing of conductors in areas with lines that run close together. Reliable identification of the coded signal can only be ensured when no customer-specific frequencies are preconfigured on the audio frequency generator, instead only the standard frequencies (see following table).
	Multi-frequency mode In multi-frequency mode, the frequencies f_1 , f_2 and f_3 are emitted parallel and superimposed.

Depending on the set operating mode, the following parameters can be set:

Menu item	Description
	Setting of the output frequency with which the metallic conductor should transmit. By default, the frequencies 0.488 kHz (f_1), 0.956 kHz (f_2) and 8.867 kHz (f_3) are offered. Upon request, other/additional ones can be activated (in total up to 5 frequencies between 0.400 and 9.999 kHz are possible).
	Switch between continuous and pulse mode In pulse mode, after 700 ms, the output signal is interrupted for 300 ms. This timing can be useful for disturbed and superimposed signals in order to be able to clearly identify your own signals. Due to special coding of the output signal, in “SignalSelect” mode, no pulsed signal can be emitted.

Starting audio frequency transmission Once all relevant parameters have been set, transmission along the metallic conductor can be started using the menu item . Following this the high voltage must be authorised using the “HV ON” button and the transmission power set. The dialogue for setting the power level closes automatically after a few seconds for safety reasons but it can be accessed again using the menu item P_{NOM} .

As soon as high voltage is enabled, the “HV OFF” button lights up red signalling “high voltage at the HV output”. The audio frequency signal is transmitted on the connected conductor.

Line and fault location During line and fault location, the test van must not be left unattended and accessible to third parties.

The measurement technician who remains in the test van can maintain telephone contact with their colleagues and if necessary modify the operating mode or frequency.

For line and fault location, any audio frequency receiver whose reception frequencies match the frequencies of the generator is in principle suitable. For clear identification of the specially coded "SignalSelect" signal (and thus the signal direction of flow), however, an audio frequency receiver from the product assortment of Megger is necessary.



For detailed information on using the audio frequency receiver and the various location methods, please read the accompanying instructions.



WARNING

The safety of the test van that is in operation must be guaranteed at all times by the persons responsible for the test van in accordance with the applicable safety regulations and guidelines, also during line and fault location!

If the system is equipped with the optional remote control function, the measurement settings can also be adjusted remotely if required. In order to do this, the remote control app must be installed on a suitable terminal device and remote control mode activated (see page 61).

The current procedures can be tracked in the test van via the app during fault location / routing and the following adjustments made:

The screenshot shows the 'Audio' app interface with the following data points and callouts:

- Power:** 78.5 W (Target: 80 W) - Callout: Adjust transmission power
- Mode:** Signal Select - Callout: Change operating mode, Switching between continuous and pulse mode
- Frequency:** 0.491 kHz - Callout: Adjust frequency
- Voltage:** 13.4 V
- Current:** 0.2 A
- Impedance:** 2.3 Ω
- Status:** Audio generator is running
- Warning:** HV OFF (High Voltage Off)

5.11 Dielectric diagnosis (optional)

Introduction Underground medium and high voltage cables are continuously subject to thermal, electrical and mechanical stresses over the course of their use.

This fact inevitably leads – despite the use of durable materials – to increasing damage or ageing of the cable, which in turn can lead to a measurable increase in dielectric losses.

A measure of these dielectric losses is the so-called loss factor $\tan\delta$, which can be determined within the scope of a tan delta step test.

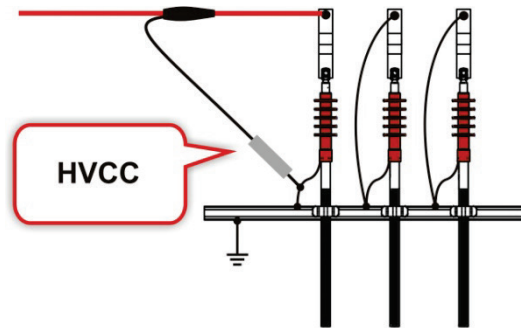
On the basis of the measurement results, integral ageing effects, such as the degree of humidity, can be diagnosed and cables with critical ageing identified.

Requirements A tan delta test unit is essential for carrying out a dielectric state analysis. Both the optional internal measurement sensor and the external tan delta test attachment are best suited to this.

Both solutions can be ordered from your Megger distribution partner if need be.



Before tan delta measurements using the internal measurement sensor, the cable shield of the HV connection cable must be connected to the system earth via the HVCC adapter.

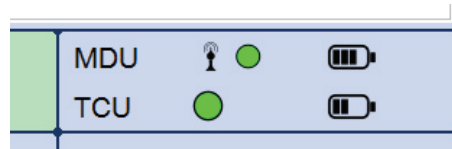


Selecting the operating mode The operating modes for dielectric cable diagnosis can be accessed either directly from the main menu or grouped in the sub-menu **DIAG**.

Menu item	Operating mode
MWT	Monitored withstand test (sine wave voltage) with accompanying tan delta measurement
TAN	Tan delta step test with automatic standard-compliant evaluation of measured data

Selection and status of measuring sensor If the measuring sensor to be used (internal or external) has not already been explicitly pre-configured in the software by the factory, this selection must be made before starting each measurement using the $\frac{\text{INT}}{\text{EXT}}$ menu item.

If using the external tan delta test attachment, the current status of the devices is displayed permanently at the right edge of the screen throughout the measurement.



The measurement can generally only be started when there is an adequate wireless connection to the MDU (green circle). If the TCU is also being used for the measuring and is connected to the MDU via a fibre optic cable, its status should also be displayed.

If the status display indicates problems connecting to the MDU (red circle) or to the TCU (not displayed despite being connected), the electrical connection of the respective individual device must be checked.

If an empty, red battery symbol is shown for one of the devices, it is recommended that you charge up the device before beginning the measurement.








For detailed instructions on connecting and charging the devices please read the operating instructions for the tan delta test attachment.

5.11.1 Withstand voltage diagnosis

Setting the measurement parameters The phases and the voltage range are automatically queried when entering the operating mode, however – like all other settings – they can be adjusted until the actual start of the test.


The following test parameters can be set:

Button / Menu item	Description
	<p>The first phase to be tested must be selected.</p> <p>As soon as the testing of a phase has been completed, the phase selection opens again automatically and testing can be continued directly at the next phase with the same settings.</p> <p>The phase selection menu must be closed after selecting the phase using .</p>
	The test duration is shown in minutes. On expiry of the test duration, the high voltage is switched off automatically.
	Voltage range for the upcoming test. After starting the test, the actual test voltage can only be set within this range.
	<p>This menu item is used to change the frequency of the VLF test voltage (0.01 Hz to 0.1 Hz). The HD 620 S1 and HD 621 S1 harmonisation documents recommend the 0.1-Hz frequency for VLF tests.</p> <p>As the maximum permitted test frequency depends on the determined cable capacitance and the test voltage being applied, it may be necessary to adjust the test frequency set and about which the user was informed at the start of the test.</p>

Notes on selecting the test voltage and test time The requirements for a meaningful cable test are found in the harmonisation documents HD 620 S1:1996 and HD 621 S1:1996 and often in company-internal testing guidelines as well.

The following table provides a selection of proven test parameters for various applications:

Application	Test voltage	Test duration in minutes
VLF test (initial use)	3U ₀	15 to 60
VLF test (on aged cables)	1.7 ... 3U ₀	60

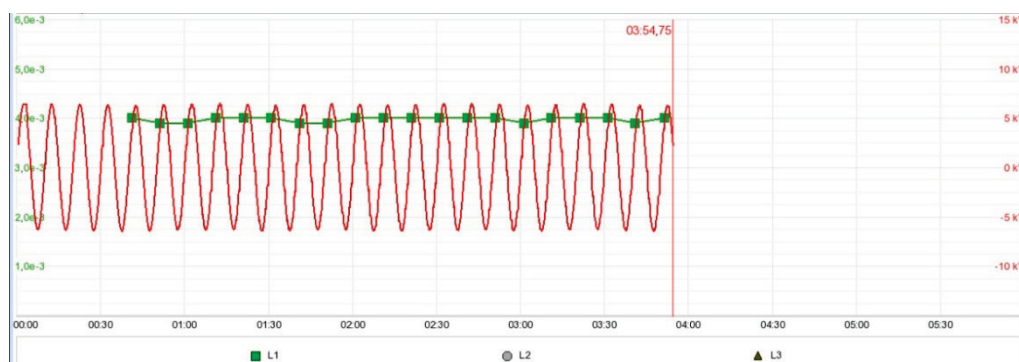
Starting the test Once all the relevant parameters for the test as well as the phase(s) have been set, the test can be started using the  menu item. Following this the high voltage must be authorised using the “HV ON” button and the test voltage set.


As soon as high voltage is enabled, the “HV OFF” button lights up red signalling “high voltage at the HV output”.


At the start of the test, load detection is performed. If the load characteristics (capacitance and insulation resistance) do not permit a test with the set test parameters, this is indicated on the screen by a system message.

Testing using a lower frequency is offered where required. The user can then either cancel the test or start it using a different frequency.








Performing the test The voltage curve can be followed on the screen during the test. After the test has started, the measuring sensor generally needs about 3 cycles to adapt optimally to the current and voltage level. Not until after this start-up phase will the tanδ values measured be displayed as coloured symbols (as per the legend below the diagram) on the curve line.



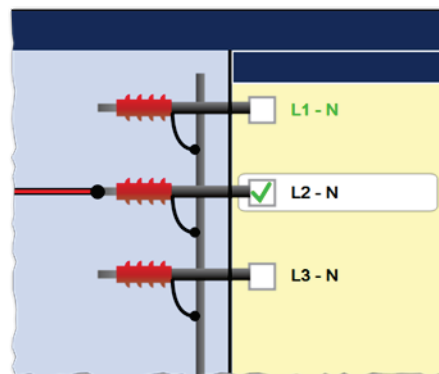
You can use the  menu item any time to display a table with the last 10 measured values.

The test duration can be adjusted retrospectively even while the test is ongoing using the  menu item.


Alongside the voltage and $\tan\delta$ values, some other relevant parameters and measurement values are shown at the bottom edge of the screen.

Symbol	Description
	Remaining test duration
	Set test duration
	Actual test frequency
	Measured load capacitance Either the measured value is calculated just once at the start of the test (internal measuring sensor) or continually updated throughout the course of the measurement (external test attachment)
	Measured insulation resistance Either the measured value is calculated just once at the start of the test (internal measuring sensor) or continually updated throughout the course of the measurement (external test attachment)
	Average of the individual measurement values so far
	Standard deviation of the individual measurement values so far

Changing phases during the course of the test As soon as the testing of a phase has been completed, the phase selection opens again automatically and another phase can be selected (if not all phases have been tested yet). The phases which have already been tested are marked in green.




If wanted, the next phase to be tested can be selected and the electrical connection adjusted accordingly. The high voltage source is automatically switched off and the HV output is discharged.

 WARNING	<p>Follow the five safety rules</p> <p>To establish and ensure a voltage-free state when changing phases, the five safety rules (see page 9) must be followed.</p>
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After changing the phase, the phase selection menu must be closed and the high voltage must be enabled again with the “HV On” button. After doing so, the system automatically continues with the measurement on the next phase.

Finishing the test If a test time was defined, the high voltage is automatically switched off at the end of this time.

The measurement can be manually deactivated at any time via the “HV OFF” button or the **HV Off** menu item. A measurement which has been suspended this way can be resumed as long as the operating mode has not been exited in the meantime. The query as to whether the measurement should be continued or restarted will appear immediately after selecting the  menu item.

When resuming a measurement, the voltage run of the last phase measured begins from the start. This way, any confusion about phase changes can be corrected without having to start the complete measurement from the start all over again.

If a voltage breakdown occurs in the test object during the test duration, the measurement is also interrupted.

Irrespective of whether the high voltage is switched off automatically or manually, the HV output is discharged and earthed. The test data logged up to the switch-off are recorded in the history database (see page 52).


Evaluation of the test results A dielectric strength test carried out to standard is generally deemed to have been successfully passed if there are no break-downs in the test object throughout the duration of the test. In addition to this clear statement, further conclusions can be drawn on the state of the test object using the trend over time of the measured $\tan\delta$ values.



E.g. a falling measured $\tan\delta$ value can indicate damp cables / fittings, while a $\tan\delta$ increasing over time can be a definite indication of an emerging cable fault.

In the event of such a change in the measured values during the test it is strongly recommended that you carry out a tan delta step test following the test (see next section). The measurement results from this can be assessed using the relevant standards and will provide an even more accurate conclusion as to the ageing of the cable insulation.


5.11.2 Tan delta step test

5.11.2.1 Preparing the step test


Automatic query of information As soon as the operating mode has been selected using the  menu item, the information relevant for the measurement is queried in the following order:

Information	Description
Phases	<p>The first phase to be tested must be selected.</p> <p>As soon as the testing of a phase has been completed, the phase selection opens again automatically and testing can be continued directly at the next phase with the same settings.</p> <p>The phase selection menu must be closed after selecting the phase using .</p>
Nominal voltage	<p>U₀ nominal voltage of the connected test object as an effective value.</p> <p>Once the value is confirmed, a calculation of the respective voltage values of the individual steps is carried out and displayed on the screen.</p> <p>You can use the U₀ menu item to amend the selection made right up until the actual start of the measurement.</p> <hr/> <p> The maximum nominal voltage that can be set depends on the maximum output voltage of the test system as well as on the set voltage levels (see the next page).</p> <p>If the nominal voltage of the cable is above the maximum value that can be set, the number of the voltage levels would have to be reduced accordingly first.</p> <hr/>
Insulation type	<p>The insulation type of the connected cable is required for the automatic evaluation of the measurement results.</p> <p>The insulation type will only be queried directly upon entering the operating mode, if currently a standard is preselected (setting of previous measurement used), according to which the automatic evaluation needs to be performed.</p> <p>If this is not the case, standard and insulation type can also be selected/modified later (even after the measurement) and thus an automatic evaluation made possible (see page 141).</p>




Setting the measurement parameters






Once you have entered the operating mode you can use the  menu item to access a sub-menu where you can adjust advanced measurement settings.




Changing these parameters can have a considerable effect on the total test duration! It is therefore recommended to check the estimated total test duration after performing any changes. This is displayed in the lower portion of the screen next to the icon  and is updated with every change.


The following parameters can be modified:

Menu item	Description
 NUM	<p>Number of the voltage levels (1 to 6) that the test voltage runs through in the course of a step test.</p> <p>The first voltage level is $0.5U_0$. The voltage is increased by $0.5U_0$ with every additional voltage level. The sixth voltage level would accordingly be $3U_0$.</p> <p>A requirement for the automatic evaluation of the test results is that the measurements were taken in respect of at least 3 voltage levels.</p> <p>Once the value is confirmed, a calculation of the respective voltage values of the individual steps is carried out while taking the nominal voltage into account and displayed on the screen.</p> <hr/> <p> In practice, 4 levels with voltages of $0.5U_0$, $1U_0$, $1.5U_0$ and $2U_0$ have proven useful.</p> <p>To avoid possible breakdowns, it is recommended that already heavily aged cables not be measured at voltage levels greater than $2U_0$ ($\leq 1.5U_0$ is even safer).</p>
	<p>Number of $\tan\delta$ measured values (5 to 20) per voltage level.</p> <p>At least 8 measured values per voltage level should be recorded in order to obtain a calculated $\tan\delta$ mean value that is statistically meaningful. The more measured values that are utilised, the more reliable the calculated mean. However, the stress placed on the test object also increases accordingly. As the goal is a non-destructive diagnosis, the number of measured values, especially in the case of high test voltages, should be kept to as small a number as possible (recommended: 8 to 10 values).</p>

Menu item	Description
	<p>Frequency of the VLF test voltage (0.01 Hz to 0.1 Hz). A setting of 0.1 Hz is definitely recommended, since all the experience documented in the relevant technical literature or in the corresponding standards refer to this frequency as the diagnostic frequency.</p> <p>By measuring at different frequencies, a $\tan \delta$ spectrum can furthermore be shown for the test object. This spectrum can provide further information on the condition of the test object.</p> <hr/> <div style="border: 1px solid black; padding: 5px;">  <p>If the capacitance of the connected test object does not permit a measurement using 0.1 Hz and an automatic frequency adjustment is performed, the evaluation criteria that are independent of frequency should be looked more closely. These include, amongst others, the deviation of the absolute $\tan \delta$ values between the phases of a cable system and the change of the $\tan \delta$ with increasing voltage ($\Delta \tan \delta$).</p> </div> <hr/>
	<p><u>Only visible after obtaining administration rights (see page 67)</u></p> <p>You can use this menu item to activate or disable averaging for smoothing the measurement curve. Doing so will result in the display of the average value of the last 3 values measured in the diagram rather than the $\tan \delta$ value actually measured.</p> <p>Averaging does not take place beyond two voltage levels. Accordingly the first two measured values of each voltage level are not shown when averaging is activated.</p> <hr/> <div style="border: 1px solid black; padding: 5px;">  <p>If averaging is activated then automatic analysis of the measurement results is not possible. Furthermore, the duration of the voltage strain is increased. As such it is generally recommended that you only activate this function in the event of a significant fluctuation in measurement values.</p> </div> <hr/>
	<p><u>Only visible after obtaining administration rights (see page 67)</u></p> <p>This menu item can be used to adapt the voltage levels (as multiples of U_0) for the individual voltage stages to your individual needs.</p> <p>In practice, a voltage increase of $0.5U_0$ between two stages as proven itself useful.</p> <p>In addition, the two voltage stages, from which the $\Delta \tan \delta$ (see page 144) is calculated, can be modified.</p>

Menu item	Description
 SEC	<p data-bbox="571 286 1311 318"><u>Only visible after obtaining administration rights (see page 67)</u></p> <p data-bbox="571 327 1458 479">This menu item can be used to activate or disable a safety function which monitors the progression of the measured $\tan\delta$ values during the measurement process and highlights any dubious variations. The measurement can then be suspended or continued. If the measurement is continued, a non-destructive diagnosis can no longer be guaranteed.</p> <p data-bbox="571 488 1417 640">Primarily, the safety function is used to catch “water trees” before they turn into “electrical tress” and thus avoid a breakdown of the insulation. This effect, intentionally provoked by a VLF test, should of course be avoided in order to obtain a diagnosis that is as non-destructive as possible.</p> <p data-bbox="571 649 1442 801">If necessary, the dialogue window can be used to adapt the various triggering thresholds of the safety function. Here a differentiation is made between deviations from the moving average (average out of the last three measured values) and from the statistical average (average out of all measured values of the voltage level).</p>

5.11.2.2 Performing the step test

Test start Once all the relevant parameters for the measurement as well as the phase(s) have been set, the test can be started using the menu item . Following this the high voltage must be authorised using the “HV ON” button and the test voltage set.

As soon as high voltage is enabled, the “HV OFF” button lights up red signalling “high voltage at the HV output”.

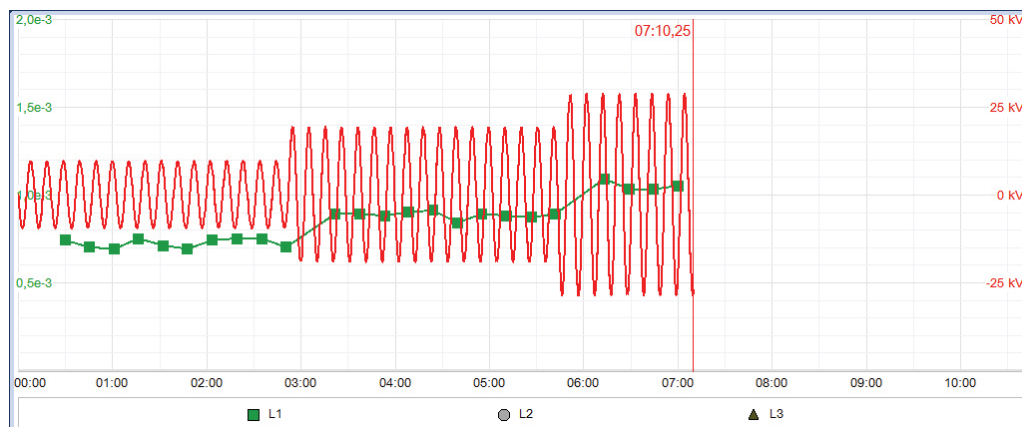
At the start of the measurement, load detection is performed. If the load characteristics (capacitance and insulation resistance) do not permit a measurement with the set test parameters, this is indicated on the screen by a system message.


Measurement using a lower frequency is offered where required. The user can then either cancel the measurement or start it using a different frequency. However, the latter would result in the measurement being non-compliant and would prevent any automatic evaluation of the measurement results from being carried out.

Alternatively, the number of voltage levels could be reduced, resulting in an automatic drop in the maximum necessary test voltage. However, care should be taken here to ensure that, if possible, the 3 voltage levels required for meaningful measurement results are retained.








Performing the measurement The test voltage flows through the selected number of voltage levels during the course of the measurement and remains at a voltage level for the selected number of measured values.

The measuring sensor generally needs about 3 cycles to adapt optimally to the current and voltage level after the measurement has started. Not until after this start-up phase will the $\tan\delta$ values measured be displayed as coloured symbols (as per the legend below the diagram) on the curve line.

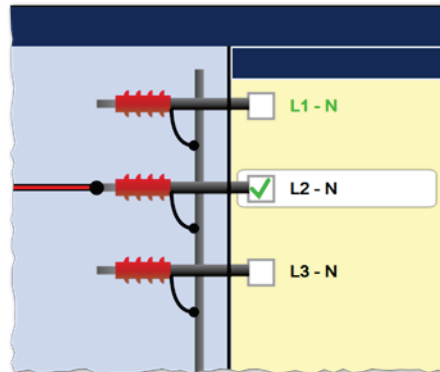


You can use the  menu item any time to display a table with the last 10 measured values.


Alongside the voltage and $\tan\delta$ values, some other relevant parameters and measurement values are shown at the bottom edge of the screen.

Symbol	Description
	Estimated total test time
	Actual test frequency
	Measured load capacitance Either the measured value is calculated just once at the start of the measurement (internal measuring sensor) or continually updated throughout the course of the measurement (external test attachment)
	Measured insulation resistance Either the measured value is calculated just once at the start of the measurement (internal measuring sensor) or continually updated throughout the course of the measurement (external test attachment)
	Difference of the $\tan\delta$ mean values for two specified voltage levels (default: Level 3 – Level 1)
	Standard deviation of the individual measurement values so far
	Status of the safety function (see page 134)

Changing phases during the course of the test As soon as the testing of a phase has been completed, the phase selection opens again automatically and another phase can be selected (if not all phases have been tested yet). The phases which have already been tested are marked in green.




If wanted, the next phase to be tested can be selected and the electrical connection adjusted accordingly. The high voltage source is automatically switched off and the HV output is discharged.

	<p>Follow the five safety rules</p> <p>To establish and ensure a voltage-free state when changing phases, the five safety rules (see page 9) must be followed.</p>
--	---

For measurements with leakage current compensation (only available for external test attachment), it should be noted that a different phase might need to be used for the transport of the leakage current if the previously used phase will be measured next. In this case, the electrical connection must be adjusted at the near and far cable ends.

After changing the phase, the phase selection menu must be closed and the high voltage must be enabled again with the “HV On” button. After doing so, the system automatically continues with the measurement on the next phase.

Completing the test After all the set phases have run through the voltage levels, the measurement process ends automatically and high voltage is switched off.

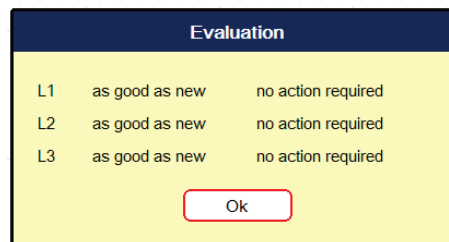
The measurement can be manually deactivated at any time via the “HV OFF” button or the **HV Off** menu item. A measurement which has been suspended this way can be resumed as long as the operating mode has not been exited in the meantime. The query as to whether the measurement should be continued or restarted will appear immediately after selecting the  menu item.

When resuming a measurement, the voltage run of the last phase measured begins from the start. This way, any confusion about phase changes can be corrected without having to start the complete measurement from the start all over again.

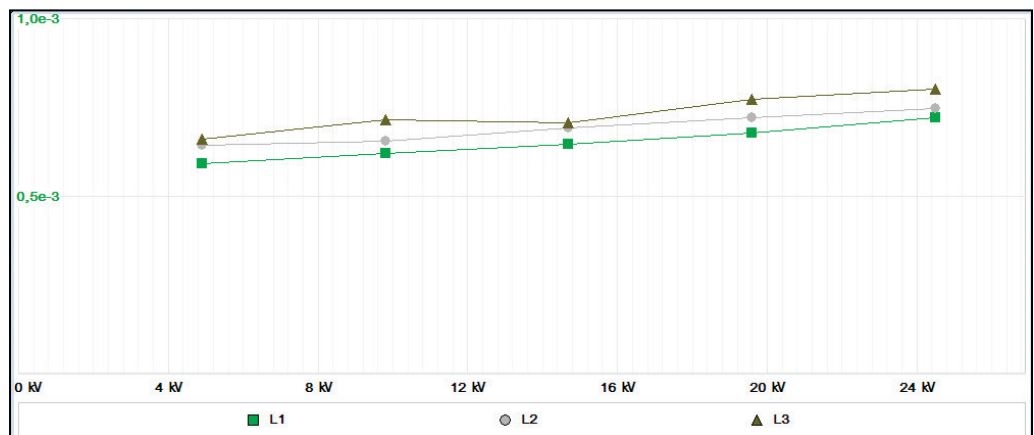
If a voltage breakdown occurs in the test object during the test duration, the measurement is also interrupted.

Irrespective of whether the high voltage is switched off automatically or manually, the HV output is discharged and earthed. The test data logged up to the switch-off are recorded in the history database (see page 52).

If all the conditions for an automatic evaluation of measurement results (see page 141) are met, this is shown straight away upon completion of the measurement:



Instead of the voltage curve, the diagram area now shows the tan delta trend view across all voltage levels and phases. The values form the mean value of the tanδ values measured at the respective voltage level. The following illustration shows, by way of example, a trend view over five voltage levels for all three phases:




You can use the **STD**/**TRD** menu item to switch back from this trend view to the standard diagrams.




5.11.2.3 Automatic evaluation of the test results

Requirements An automatic evaluation of the test results is only carried out if the following requirements have been fulfilled:


- A standard for the evaluation of the test results has been selected.
- The selected standard contains criteria for the evaluation of the insulation type of the connected cable.
- The test was conducted in respect of at least 3 voltage levels.
- The test was carried out on a test voltage with a frequency of 0.1 Hz.

Displaying the evaluation If the software was able to carry out an automatic evaluation, this will be shown together with the resulting recommendations for action straight away following completion of the measurement.

Using the following menu items shown in the  sub-menu you can adjust the evaluation criteria even after the measurement and display the evaluation again.

Symbol	Description
	Standard according to which the recorded measurement results should be evaluated. In the manual setting there is no automatic evaluation.
 TYPE	Insulation type of the connected cable. Automatic evaluation is not possible in the mixed setting.
	Menu item for displaying the automatic evaluation and recommendations for action. If automatic evaluation is not possible, the non-fulfilled requirements are indicated instead.

If the measurement has been performed at a varying frequency or with too few voltage levels, it must either be repeated or the measurement results must be evaluated manually (see page 144).

 The evaluation criteria may be adapted as many times as required and the log with the updated evaluation printed out again.
If, for example, the criteria of a stored standard have been adapted on account of new findings (see next section), even past measurement results can be re-evaluated thanks to the History database (see page 52).





5.11.2.4 Setting your own evaluation criteria

Introduction With IEEE 400.2 - 2013 a key standard for evaluating measurement results is already implemented in the software.



Furthermore, the software features an assistant which allows customised evaluation criteria to be specified and to be stored as an 'in-house' standard.

You may only create, edit and delete your own standards upon acquiring the administration rights (see page 67).



Creating a custom standard Proceed as follows to create a custom standard:

Step	Action
1	In the submenu  , select menu item  .
2	Select Create standard .
3	Enter a descriptive name for the new standard and then select the Next button.
4	Mark all the types of insulation for which you wish to store evaluation criteria in this standard.
5	Mark all the evaluation criteria (see page 144), which should be included in the evaluation of the condition and then select the Next button.
	<div style="border: 1px solid black; padding: 5px; margin: 10px 0;">  Select the evaluation criteria with care. As soon as just one of the criteria has exceeded the specified threshold, the condition of the cable insulation will be given a poorer evaluation. An evaluation based on several criteria can therefore be more severely affected by measurement inaccuracies. </div>
6	For every combination of insulation type and evaluation criterion, enter the lower and upper threshold for the condition description aged and then select the Next button.
7	After entering all thresholds, save the new standard using the menu item Finish . The new standard can now be selected as the basis for evaluation for each measurement using the menu item  .

Editing a custom standard Proceed as follows to edit a custom standard:

Step	Action
1	In the submenu  , select menu item  .
2	Mark the standard you wish to edit.
3	Select the Edit standard button.
4	Proceed the same way as under steps 3–7 describing the procedure for creating a new standard (see above).


Deleting a custom standard Proceed as follows to edit a custom standard:

Step	Action
1	In the submenu  , select menu item  .
2	Mark the standard you wish to delete.
3	Select the Delete standard button.
4	Confirm the prompt with Yes .

5.11.2.5 Manual evaluation of the test results

Introduction An automatic evaluation of the measurement results made by the software should be understood as a valuable tool, however by no means should it be used as a sole decision-making criterion.

Criteria such as deviating measurement results within a cable system, the influence of leakage currents as well as outside influencing parameters can only be analysed to a limited extent by software. The technician performing the test is therefore urged to scrutinize the evaluation critically and, if necessary, to conduct own analyses to avoid incorrect conclusions.

Evaluation criteria After completing a test, an overview of the following evaluation criteria derived from the individual $\tan \delta$ values can be called up by selecting the menu item  :

Criterion	Description
$\tan \delta$ at xU_0	<p>The mean value of the measured absolute $\tan \delta$ values is specified separately for each voltage level.</p> <p>The condition should not however be evaluated solely on the basis of these absolute values since these may be influenced by the following factors:</p> <ul style="list-style-type: none"> • Number of sleeves in the cable stretch • Type of sleeves • Temperature of the cable • Air humidity • Leakage current over the terminators <p>Nevertheless, important information can be derived from the mean value. For example, a comparison can be made of the values for all three phases of a cable system under identical conditions. As a rule, all three phases of a cable stretch are subject to the same conditions. They have the same number of mountings and are subject to the same environmental influences. By taking the measurements within a short time frame, an almost uniform cable temperature can also be ensured. Consequently, the mean values of the three phases should be almost identical. Substantial deviations upwards indicate that the condition of the affected phase is poor. In such a case further investigations should be made (e.g. a TE measurement).</p>
σ	<p>The standard deviation σ is specified separately for each voltage level and is a measure of the distribution of the individual $\tan \delta$ values around the mean value of the respective level.</p>
$1.5U_0-0.5U_0$ ($\Delta \tan \delta$)	<p>The most important criteria for a meaningful evaluation of the insulation condition is the $\Delta \tan \delta$, which reflects the voltage dependency of the $\tan \delta$.</p> <p>The $\Delta \tan \delta$ is calculated from the difference between the $\tan \delta$ mean value of the voltage levels $0.5U_0$ and $1.5U_0$.</p> $\Delta \tan \delta = \tan \delta_{1.5U_0} - \tan \delta_{0.5U_0}$ <p>The $\Delta \tan \delta$ can only be furnished in respect of measurements taken in respect of at least 3 voltage levels.</p>

Evaluation of XLPE cables For XLPE cables, an insulation in good condition is indicated by a low $\Delta \tan \delta$, which corresponds to a nearly constant $\tan \delta$ over increasing test voltages. For an aged insulation, the $\tan \delta$ value increases slightly with increasing voltage. For a critically aged insulation, the $\tan \delta$ value clearly increases with increasing voltage.

Using the relevant literature as an aid, the absolute $\tan \delta$ values measured on a XLPE cable (homopolymeric) can also be used to derive conclusions about the condition (with the restrictions presented on the previous page). The IEEE 400.2 - 2013 differentiates between different regions of the world. For countries **outside of North America**, the following limit values apply:

Mean value at $2U_0$ [10^{-3}]		σ at U_0 [10^{-3}]		$\Delta \tan \delta$ ($2U_0 - U_0$) [10^{-3}]	Condition assessment
<1.2	and	<0.1	and	<0.6	No action required
1.2 bis 2	or	0.1 bis 0.5	or	0.6 bis 1	Further study advised
>2	or	>0.5	or	>1	Action required

For the **North American area**, however, significantly higher limit values are defined due to differences in the design of the cables:

Mean value at U_0 [10^{-3}]		σ at U_0 [10^{-3}]		$\Delta \tan \delta$ ($1,5U_0 - 0,5U_0$) [10^{-3}]	Condition assessment
<4	and	<0.1	and	<5	No action required
4 to 50	or	0.1 to 0.5	or	5 to 80	Further study advised
>50	or	>0.5	or	>80	Action required

Evaluation of PILC cables The interpretation of the dielectric loss factor in evaluating the condition of PILC cables has not yet been thoroughly investigated. An exact, qualitative evaluation can therefore only be derived to a limited extent from the measurement results received, as compared to XLPE cables.

In principle, it can be said that the dielectric loss factor of a PILC cable is always considerably higher than that of a XLPE cable. Even a vulnerable XLPE cable will show lower $\tan \delta$ absolute values measured as compared to a healthy PILC cable.

The IEEE 400.2 - 2013 differentiates between different regions of the world. For countries **outside of North America**, the following limit values apply:

Mean value at $2U_0$ [10^{-3}]		σ at U_0 [10^{-3}]		$\Delta \tan \delta$ ($2U_0 - U_0$) [10^{-3}]	Condition assessment
<50	and	<-0.5	and	-20 to 20	No action required
50 to 100	or	0.5 to 1	or	-20 to -50 or 20 to 50	Further study advised
>100	or	>1	or	<-50 or >50	Action required

For the **North American area**, however, significantly higher limit values are defined due to differences in the design of the cables:

Mean value at U_0 [10 ⁻³]		σ at U_0 [10 ⁻³]		$\Delta \tan \delta$ (1,5 U_0 – 0,5 U_0) [10 ⁻³]	Condition assessment
<85	and	<0.1	and	-35 to 10	No action required
85 to 200	or	0.1 to 0.4	or	-35 to -50 or 10 to 100	Further study advised
>200	or	>0.4	or	<-50 or >100	Action required


Evaluation of EPR cables EPR cables by their nature exhibit a higher dielectrical loss factor as compared to XLPE cables. However, this still lies below the level of PILC cables.



The threshold values given in the following table are to be regarded merely as guiding values:



Mean value at U_0 [10 ⁻³]		σ at U_0 [10 ⁻³]		$\Delta \tan \delta$ (1,5 U_0 – 0,5 U_0) [10 ⁻³]	Condition assessment
<35	and	<0.1	and	<5	No action required
35 to 120	or	0.1 to 1.3	or	5 to 100	Further study advised
>120	or	>1.3	or	>100	Action required

You can find a detailed breakdown of EPR insulations by material composition in the IEEE standard IEEE 400.2 - 2013.

5.11.2.6 Processing the measured data

Printing the log The log with the measured data can be printed out immediately after completing the measurement and selecting the evaluation criteria using the  menu item (or saved as a PDF file).

The  menu item in the  sub-menu offers even more options for adapting the scope of the report. While only the trend diagram is embedded in the standard report, the more detailed report includes a complete measured value and voltage diagram for each phase measured.

Exporting the measured data The  menu item in the  sub-menu can be used to export the measured values of the last performed measurement in CSV (Comma Separated Values) format. These data can later be conveniently displayed on the PC with any CSV-compatible application (e.g. Excel).

The table basically contains the information as it is shown in the measured value table. In addition, the standard deviation and the mean are displayed for each voltage level.

The file is exported to the inserted USB stick's *TanDelta* directory.

5.12 Partial discharge diagnosis (optional)

The test accessory can also be used for partial discharge diagnostics. A prerequisite for this is that the test van has a suitable partial discharge diagnostic system.

To perform a partial discharge diagnosis, menu item **PD** must either be opened directly from the main menu or from submenu **DIAG**. Any further operating actions must be performed using the “PD Detector” software (on provided notebook).



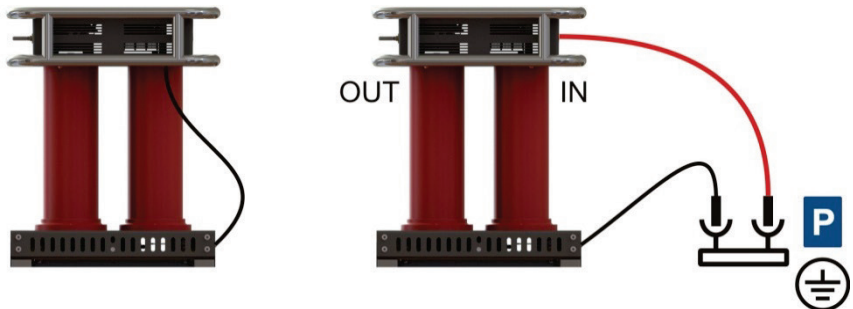
Detailed information on the operation of the “PD Detector” software can be found in the operating manual for the partial discharge measurement system.



WARNING

Risk of electric shock

Directly after completion of a partial discharge measurement, the PD coupling unit must be short circuited using the short-circuit line or any available earthing jacks, to prevent charging of the capacitor!



The short circuit may only be removed just before the start of the next measurement.

6 Completing the work

Preparing a report After completion of the measurements, if necessary, a report on the measurement work can be prepared using the MeggerBook Cable protocol software (see page 71).

If the connected cable was already selected in MeggerBook Cable before the start of the measurements, all measurements taken will be automatically assigned to this cable, making it possible to compile the report almost automatically in just a few steps. The assignment between measurements and cable can also be defined later.

Alternatively, the measurements can be exported from the local MeggerBook Cable database and the report prepared in the office with the PC version of MeggerBook Cable.



For instructions on operating the MeggerBook Cable protocol software, please refer to the help screens in the software.

Switching off the test van and disconnecting from the test object After the measurement has been completed on a cable system and the high voltage has been switched off (see page 42), the test van can be turned off using the main switch on the power module.

When disconnecting the test system, proceed in reverse sequence to the manner in which the connection (see page 26) was made. The following safety instructions must be strictly adhered to.

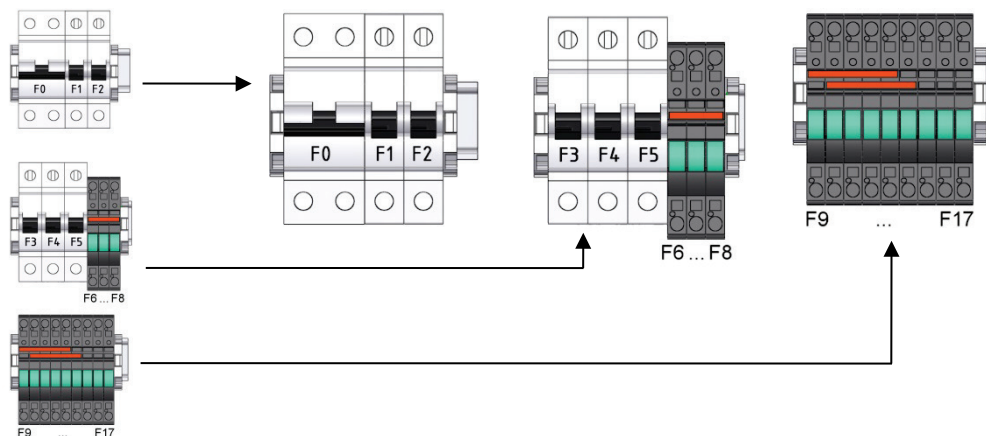


- Follow the five safety rules (see page 9).
- Even if switched off properly and discharged using the discharge device, the system components that were under voltage should only be touched once they have been discharged using a suitable discharge rod as well as having been earthed and short-circuited.
- Only undo the earthing and short-circuiting measures when the test object is to be operated again.

7 Care, Maintenance and Troubleshooting

7.1 Behaviour at Malfunction of Normal Operation

Checking the fuses If a failure occurs, the positions of the circuit breakers and the fuses should first be checked. These are in the leg area below the desk and arranged as follows:



No.	Value	Function
F0	RCD C16/0,03A	Residual-current device providing protection to circuits F4, F5, F9, F12 and F13
F1	K16A	Main fuse mains
F2	K16A	Main fuse generator
F3	K16A	Switching power supply and options
F4	C10A	Air-conditioning system
F5	B6A	Mains fuse reserve
F6	2A	Mains fuse A3/24 V (illuminated on/off pushbutton)
F7	4A	Mains fuse A1/24V
F8	4A	Mains fuse A2/24V
F9	10A	Sockets (external)
F10	1A	PCB FU/EP
F11	2A	Operating hours counter of the generator
F12	10A	Sockets (external)
F13	4A	Charger
F14	2A	PCB current measurement
F15	4A	Output A1: 24V stabilised, control unit
F16	4A	Output A1: 24V stabilised, electronic circuits
F17	8A	Output A2: 24V stabilised, motors

Several other relevant 12 V or 24 V circuits (e.g. the interior lighting of the van, the cable reel motor) are protected by the fuses of the vehicle.



If a circuit breaker or fuse is tripped repeatedly, it must be assumed that there is a permanent fault in the affected circuit. To prevent additional damage, further operation of the test van is not allowed.

Behaviour at continuing malfunction In case of damage, irregularities or faults that are not solved by following the instructions in the manual proceed as follows:

Step	Action
1	Turn off the system.
2	Plug a USB flash drive into one of the IPCs USB ports.
3	Turn on the system. Result: The system log file is written to the USB flash drive (<i>SystemLog</i> folder) during system start-up.
4	Put the test van out of operation and mark it as not functional.
5	Contact a service workshop authorised by Megger about the fault and provide the service staff with the exported log file.

7.2 Maintenance work you can carry out yourself

To identify possible problems at an early stage and keep the system in good condition, you must carry out the following tasks yourself at appropriate intervals depending on use:

- Remove dust and dirt
- Check the function of door and EMERGENCY OFF switches
- Unwind the cables and inspect for cracks and damage
- Check connecting cables and HV components for secure hold



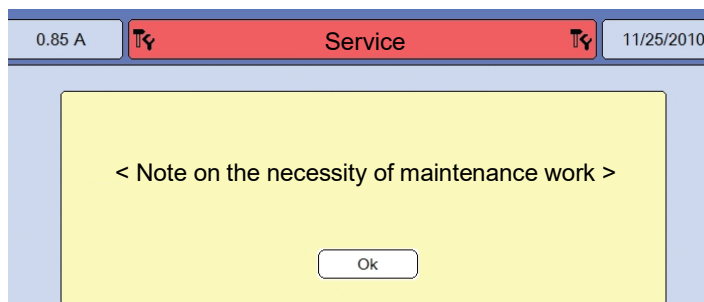
For information on do-it-yourself maintenance and care of peripheral devices, read the corresponding sections in the relevant operating manuals. This especially applies to battery-powered devices.



If you find any defects during the test, promptly inform a service centre authorised by Megger.

7.3 Required maintenance by a service centre

Maintenance cycles A measurement system of the technical complexity of the Centrix 3 needs regular maintenance to maintain its functionality. Predictable activities such as the periodic inspection of the test van and the use-dependent maintenance of the surge switch are announced by system messages of the following type:



Upon occurrence of such a message, promptly contact the responsible service centre to make an appointment for maintenance. The following causes are possible:

Message text	Cause
„Your system is due for service in xx day(s). Please contact your Megger service centre.“	The internally stored date of the next periodic inspection (check of the HV components, the safety devices, the insulating oil and the individual devices / accessory parts) is approaching.
„The cycle counter of the surge switch reached %1 cycles. At %2 cycles the Surge-Pinpointing rate will be automatically limited.“	The surge switch has reached or already exceeded the maximum permitted number of cycles (48,000 to 90,000 surge discharges; depending on surge energy). Maintenance of the surge switch is required to eliminate residue of combustion on the contacts and deposits on the insulating components.
„The cycle counter of the surge switch has exceeded %1 cycles. The Surge-Pinpointing rate is now limited to 30 s.“	The surge switch has greatly exceeded the maximum permitted number of cycles (63,000 to 110,000 surge discharges; depending on surge energy). To protect the system from damage, the surge rate is set to 30 seconds (non-adjustable)! This limitation is only to be lifted after the affected surge switch has been serviced.



If the maintenance requirements described above are not fulfilled, the manufacturer releases itself from the warranty on defects shown to be due to inadequate maintenance.

7.4 SIM card replacement and troubleshooting at the 4G / GPS router (optional)

Introduction The optional 4G /GPS router is easy to access – in the majority of cases – can be found behind the IPC attached to the partition walls or side walls of the vehicle. With the exception of software-side configuration (see page 58) of the router and the replacement of the SIM card, unauthorized changes to the router and its cabling are not permitted under any circumstances.

Inserting / replacing the SIM card To establish a mobile data connection, there must be at least one SIM card in the router. There is also a second slot for inserting a second SIM card available. The SIM cards must meet the following requirements:

- Format: Mini SIM
- Enabled for data connection via GPRS, EDGE, 3G or 4G (a pure data plan is sufficient)
- Provider with good network coverage



It is advisable to take out contracts with a fixed upper cost limit in order to keep the costs that are incurred under control in the event of high data consumption!

To replace the current SIM card or insert a SIM card for the first time, proceed as shown below:





After the new SIM card has been inserted in the direction shown, the tray must be pushed back into the slot until it noticeably engages. After installing a new SIM card, if necessary the PIN for the SIM card must be entered and the configuration of the access point (APN) must be adjusted (see page 58).

If there is a SIM card in both slots **SIM1** and **SIM2**, the data connection of the SIM card in slot **SIM1** is used until one of the following conditions occurs:

- The data volume of the SIM card in slot **SIM1** is used up.
- A data connection via the network provider of the SIM card in slot **SIM1** cannot be established.

Checking status LEDs If connection problems occur during test van operation, the LEDs on the 4G / GPS router may provide an indication of the cause of the problems. The following statuses are signalled:

LED	Status	Description
PWR	Off	No mains voltage available
	On	Mains voltage available
	Off	No GSM signal
	Flashing red and green alternately	No SIM card found or there are problems with the SIM cards. This may be due to the access point (APN) or SIM PIN not having been configured yet or not having been configured correctly (see page 58).
	Permanently lit or flashing a single colour	Connected. When there is data traffic, the LED flashes very quickly.
		Signal strength

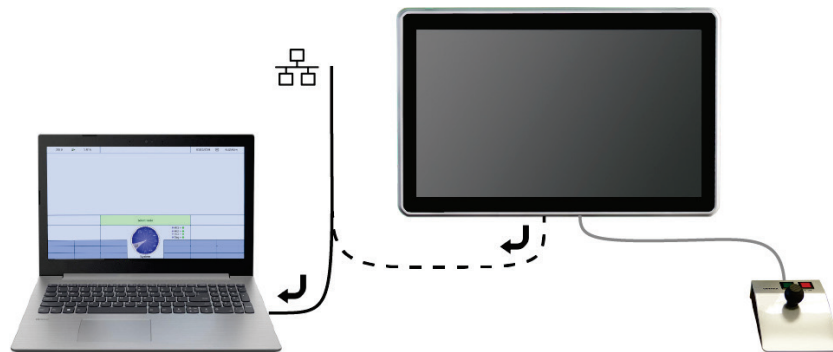
8 Appendix 1: Control via notebook

General If the industrial PC is defective or there is very limited space available in the test van, the system can also be controlled via a Windows notebook.

If a suitable notebook with the system-specific configuration already applied was not provided directly with the order of the test van, it can be reordered at any time.


Connecting the notebook If the test van is controlled exclusively by the notebook from the outset, the notebook is already correctly connected to the system.


If the notebook is only to be used temporarily for control purposes (e.g. if the industrial PC is defective), the network cable at the bottom of the industrial PC must be disconnected and instead connected to the notebook's network adapter.



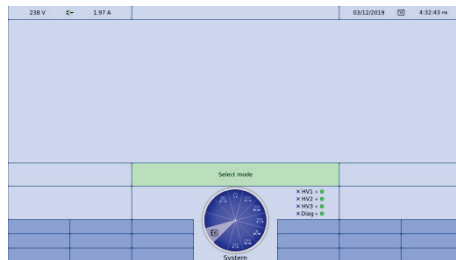
For systems with partial discharge measurement technology, the licence dongle for the PD detector software must also be removed from the industrial PC and inserted into a USB port in the notebook.

Operation

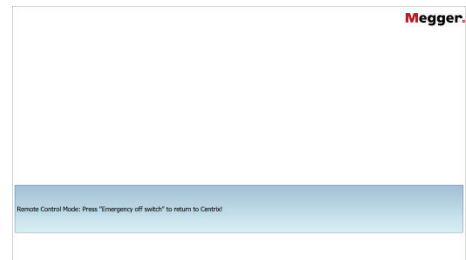
	<p>WARNING!</p> <p>Risk of electric shock!</p> <p>When operating the test van using a notebook, the following information must be observed to avoid dangerous increases in voltage:</p> <ul style="list-style-type: none"> • A notebook used to control the test van must never be operated outside of the test van itself! • The notebook power supply must be connected to one of the mains sockets within the test van! • Peripheral devices that are located outside the test van must not be connected to the notebook via cable.
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The operating software is launched on the notebook via the icon . The following two applications start in parallel:

Centrix operating software for fault location and test operations




PD detector software for partial discharge diagnostics

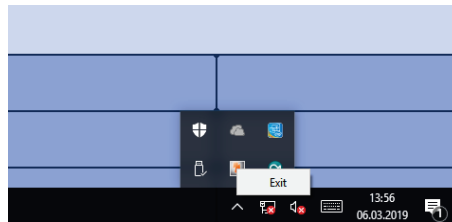


Depending on the measurement task, it is possible to switch between the two open applications using the key combination ALT + TAB. Both applications are controlled using mouse and keyboard (see page 46).

Compared to operation via the designated industrial PC, the following restrictions and features arise when controlling via notebook:

- It is not possible to configure the internet router (if present) via the notebook. Accordingly, remotely controlling the system via the app is not possible.
- The file export from the system is not carried out directly on an inserted USB stick, but rather in the Windows user directory. When importing files, the storage location can be freely selected via the file explorer.

Before the software can be shut down, the automatic restart must be deactivated, otherwise the software will restart immediately after being shut down. To deactivate automatic restart, right-click the  icon in the taskbar, then left-click **Exit**.



Following this, the software can be exited as standard by pressing ALT + F4.

Troubleshooting If problems occur, they may be diagnosed and corrected using the following table:

Problem	Possible cause/remedy
The message "Startup of HV Unit failed" appears after starting the software	Communication with the system is disrupted. <ul style="list-style-type: none"> • Check the Ethernet connection to the system • Check the network adapter configuration (IP address: 192.168.150.1/ subnet mask: 255.255.0.0)
Message regarding missing licence for PD detector software appears when software starts	Check that the licence dongle is plugged into the notebook.
Software does not start	Check whether an instance of the application is already running. Only one instance can run at a time.

