Megger

TDM 45-P / TDM 4540-P

VLF Test System (with optional Boost module)

USER GUIDE

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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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Terms of Warranty

Megger accept responsibility for a claim under warranty brought forward by a customer for a product sold by Megger under the terms stated below.

Megger warrant that at the time of delivery Megger products are free from manufacturing or material defects which might considerably reduce their value or usability. This warranty does not apply to faults in the software supplied. During the period of warranty, Megger agree to repair faulty parts or replace them with new parts or parts as new (with the same usability and life as new parts) according to their choice.

This warranty does not cover wear parts, lamps, fuses, batteries and accumulators.

Megger reject all further claims under warranty, in particular those from consequential damage. Each component and product replaced in accordance with this warranty becomes the property of Megger.

All warranty claims versus Megger are hereby limited to a period of 12 months from the date of delivery. Each component supplied by Megger within the context of warranty will also be covered by this warranty for the remaining period of time but for 90 days at least.

Each measure to remedy a claim under warranty shall exclusively be carried out by Megger or an authorized service station.

This warranty does not apply to any fault or damage caused by exposing a product to conditions not in accordance with this specification, by storing, transporting, or using it improperly, or having it serviced or installed by a workshop not authorized by Megger. All responsibility is disclaimed for damage due to wear, will of God, or connection to foreign components.

For damage resulting from a violation of their duty to repair or re-supply items, Megger can be made liable only in case of severe negligence or intention. Any liability for slight negligence is disclaimed.

Since some states do not allow the exclusion or limitation of an implied warranty or of consequential damage, the limitations of liability described above perhaps may not apply to you.

Contents

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!

Declaration of Conformity (CE)

The product meets the following security requirements of the European Council Directives:

- EMC Directive (2004/108/EC)
- Low Voltage Directive (2006/95/EC)

Lifting and carrying

The device must only be lifted and carried using the handles provided on the side. Other parts of the device, such as the connecting cables, cannot withstand the forces caused by lifting the device and could break or tear off as a result.

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 10). 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.

Behaviour at malfunction of normal operation

The equipment may only be used when working properly. When irregularities or malfunctions appear that cannot be solved consulting this manual, the equipment must immediately be put out of operation and marked as not functional. In this case inform the person in charge who should inform the Megger service to resolve the problem. The instrument may only be operated when the malfunction is resolved.

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

Using cardiac pacemaker

Physical processes during operation of high voltage may endanger persons wearing a cardiac pacemaker when near these high voltage facilities.

Wear ear protection

Operation with VLF Cosine Rectangular voltage can cause high and sudden noise levels. It is strongly recommended to wear hearing protection during surge operation. Keep in mind that this will limit the operators awareness for ambient dangers.

Fire fighting in electrical installations

- According to regulations, carbon dioxide (CO_2) **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 CO_2 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.

WARNING

Dangers when working with high voltage

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.

- The TDM 45-P / TDM 4540-P test system generates a dangerous voltage of up to 45 kV_{PEAK}.
- 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.

2 Technical Description

2.1 System Description

Description

The TDM 45-P / TDM 4540-P test system enables the standard-compliant withstand testing of medium voltage cables and other equipment with a genuine 0.1 Hz sine wave test voltage of up to 45 kV_{PEAK} or 32 kV_{RMS}.

By means of this type of withstand test, operation-endangering faults, such as workmanship related problems, as well as insulation faults (e.g. water tree damage in PE/XLPE cables or local damage in PILC cables) can safely be brought to failure. The integrated breakdown detection shuts down the test voltage in the event of an excessive charge current and guarantees limited damage to the cable.

In addition, the system is also suitable for tests with…

- positive and negative DC voltages of up to 45 kV,
- 0.1 Hz VLF cosine rectangular voltage of up to 40 kV (Boost module required)
- trapezoidal AC voltage (rectangular voltage) of up to 45 kV_{PEAK} with a load-dependent slew rate

In addition, the optional internal TanDelta measurement allows the operator, during a step test with a sinusoidal test voltage, to determine the tanδ (TanDelta) dielectric loss factor and accordingly get an idea about the degree of ageing of the cable.

In combination with a suitable partial discharge (PD) coupler and a notebook with the required control software, the test system can also be used for standard-compliant partial discharge diagnosis.

Detailed information on the features of such a PD diagnosis system can be found in the operating manual of the used PD coupler.

Features

The TDM 45-P / TDM 4540-P test system combines the following features and functions in a single system:

- AC voltage test with up to three different voltage waveforms
- DC voltage test with positive and negative polarities
- Full-fledged TanDelta step test with automatic evaluation of the results
- Meaningful Voltage Withstand Diagnosis (VLF test and TanDelta diagnosis in one step)
- Leakage current measurement in DC voltage, rectangular voltage and cosine rectangular voltage test modes
- Sheath test and sheath fault pinpointing with up to 20 kV negative DC voltage
- Manual and automatic frequency adjustment
- Breakdown detection with automatic disconnection of test voltage and discharge of the test object if the charging current is too high
- Switchable burning function for fault conversion after a voltage breakdown (one minute maximum)
- Logging (Export in Easyprot logging software via USB interface)
- Firmware updates via USB interface
- Cable screen (earth loop) monitoring

2.2 Technical Data

The TDM 45-P / TDM 4540-P test system is defined by the following technical parameters:

Parameter	Value
Output voltage, sine wave	1.4 … 32 kV_{RMS} / 2 … 45 kV_{PEAK}
Output voltage, DC wave	2 … 45 kV
Output voltage, rectangular wave	±2 … ±45 kV
Sheath test and sheath fault pinpointing	0 … -20 kV
Source output current	12 mA_{RMS}
Leakage current measurement • Display area • Resolution	(VLF-CR, DC and rectangular voltage) 0 to 40 mA 10 µA
Frequency	0.01 Hz to 0.1 Hz
Testable load capacitance • Sine wave voltage • Rectangular voltage • DC 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 10 µF at reduced voltages and frequencies
Internal TanDelta (optional) • Load range • Measuring range • Precision (requires load capacitance to be >20 nF) • Resolution	 2 nF … 10 µF 10^{-3} … 10^{0} 1 x 10^{-3} or 1% resp. 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
Power supply	110 V to 230 V, 50/60 Hz
Power consumption	600 VA
Display	Transflective sunlight readable 5.7" colour display with a resolution of 640 x 480 pixels
Memory	At least 1000 records of test data
Interfaces	USB 2.0, Ethernet, external safety device
Weight	50 kg
Dimensions (W x D x H)	544 x 416 x 520 mm
Operating temperature	-20 °C to 55 °C
Storage temperature	-20 °C to 70 °C
Relative humidity	93% at 30 °C (non-condensing)

Parameter	Value
Protection class (in accordance with IEC 61140 (DIN VDE 0140-1))	I
Ingress protection rating (in accordance with IEC 60529 (DIN VDE 0470-1))	IP21

The optional Boost module is defined by the following technical parameters:

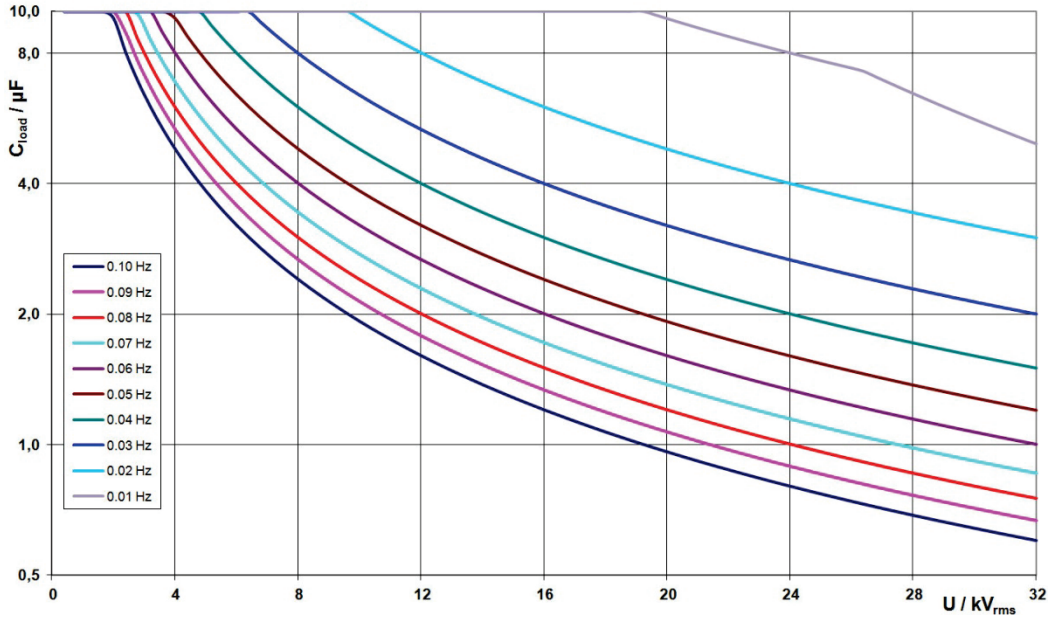
Parameter	Value
Output voltage, cosine rectangular wave	3 … 40 kV
Output voltage, damped AC (DAC) (only when used in combination with a PD coupler / notebook)	3 … 40 kV
Output current	12 mA_{RMS}
Frequency	0.1 Hz
Testable load capacitance	5 µF at 40 kV
Weight	42 kg
Dimensions (W x D x H)	544 x 416 x 400 mm
Operating temperature	-20 °C to 55 °C
Storage temperature	-40 °C to 70 °C
Relative humidity	93% at 30 °C (non-condensing)
Protection class (in accordance with IEC 61140 (DIN VDE 0140-1))	I
Ingress protection rating (in accordance with IEC 60529 (DIN VDE 0470-1))	IP21

The optional support capacitor is defined by the following technical parameters:

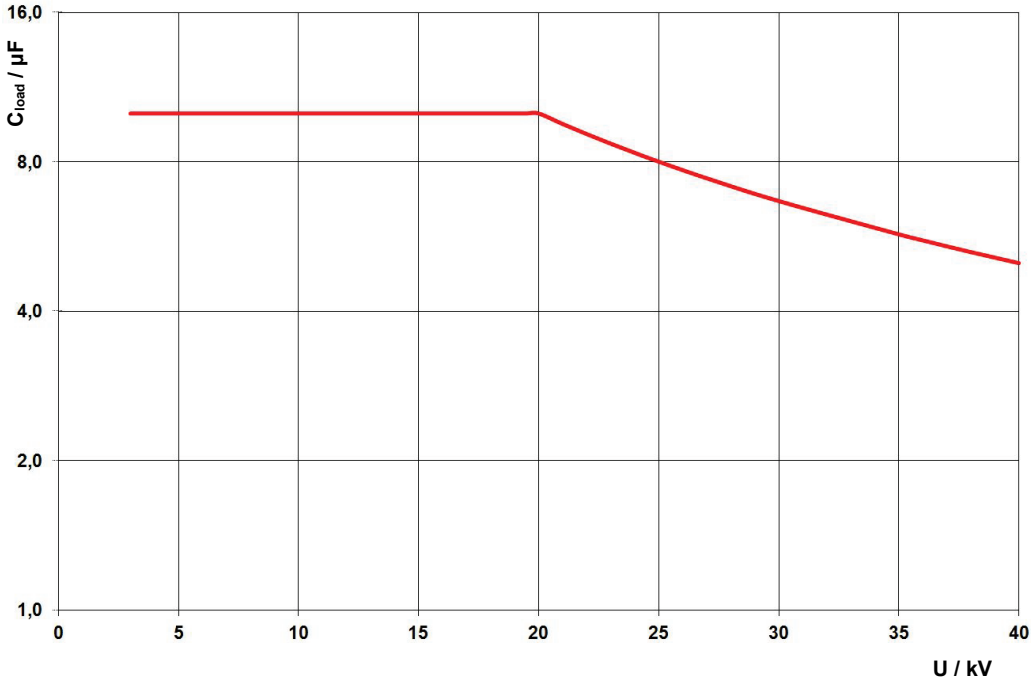
Parameter	Value
Capacity	150 nF
Voltage range	60 kV (peak value)
Dimensions (W x D x H)	400 x 400 x 850 mm
Weight	14 kg
Operating temperature	-25 °C … 55 °C
Storage temperature	-25 °C … 70°C

2.3 Load Diagram

The following diagram **applies to tests with sine wave voltage only** 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 limits of the test system's capacity, the frequency is automatically adapted and the user is informed of this.



For **tests with cosine rectangular and damped AC (DAC) voltage**, the following load diagram applies[1]:



[1] Applies only for temperatures between -25 and 45 °C. In the temperature range from 45 °C to 55 °C, the output power is reduced to 80%.

2.4 Scope of Delivery and Accessories

Scope of delivery

The scope of delivery of the system includes the following:

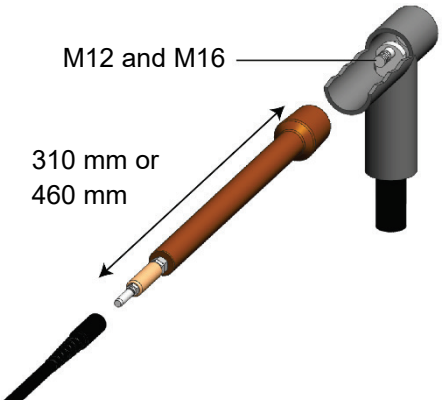
- Basic device
- Cover
- HV connection cable, 5 m
- Mains power cable, 3 m
- Earthing lead, 5 m
- USB flash drive
- Accessory bag
- Operating manual

Check contents

Check the contents of the package for completeness and visible damage right after receipt. In the case of visible damage, the device must under no circumstances be taken into operation. If something is missing or damaged, please contact your local sales representative.

Optional accessories

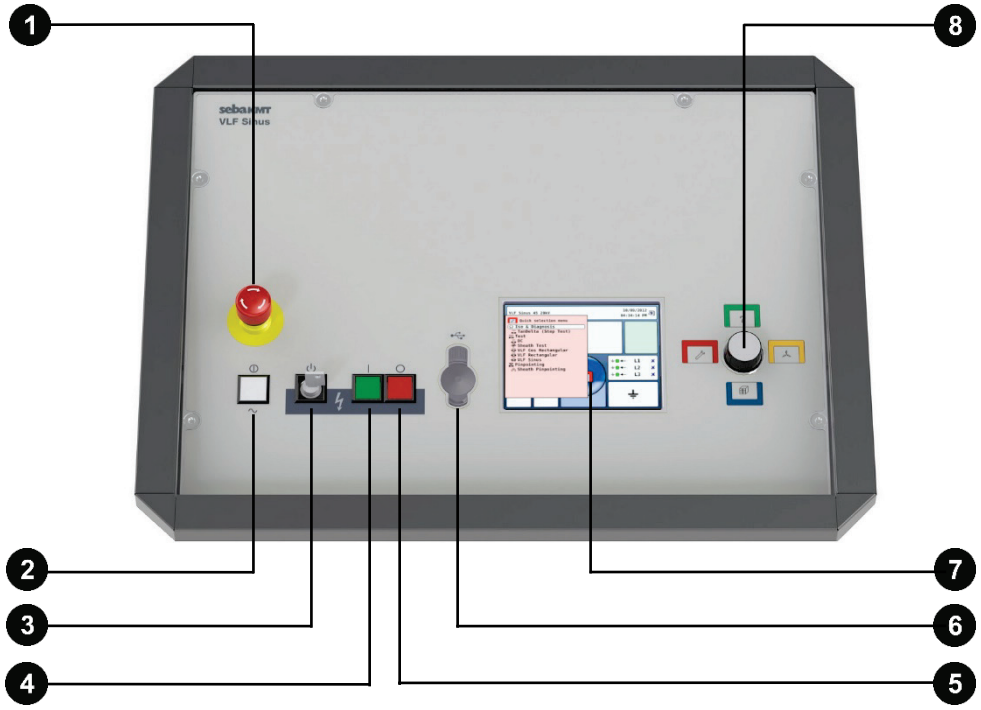
If the following optional accessories do not form part of the scope of delivery, these can be ordered from sales:

Accessory	Description	Item number
Boost module	Expands the system to enable testing with 0.1 Hz cosine rectangular voltage	128311042
Internal TanDelta measurement	Activation of optional internal TanDelta measurement	138316309
External safety device with HV controls	External box with signal lights, high voltage controls, EMERGENCY OFF switch and key switch	108300322
External safety device without HV controls	External box with signal lights, EMERGENCY OFF switch and key switch	2010001
Megger Book	Reporting software for Windows	2015875
TE PA-MC-UNI	PD-free connection adapter 	1013564 (460 mm) 1013563 (310 mm)
VLF CS-BB	Set of adapters for 3-phase cable testing; suitable for connection to busbar	128311801
External TanDelta cable diagnosis system	External TanDelta test attachment for very accurate TanDelta measurement (incl. notebook, software and accessories)	820020283

Accessory	Description	Item number
PD diagnosis module PDS 60	PD coupler for partial discharge diagnosis with sine wave, cosine rectangular and DAC voltage (incl. notebook, software, calibrator and accessories)	1014865
PD diagnosis module PDS 62-SIN	PD coupler for partial discharge diagnosis with sine wave voltage (incl. notebook, software, calibrator and accessories)	1014867
Support capacitor	Required to perform a PD diagnosis with VLF cosine rectangular and DAC voltage in case of very low load capacitance (<120 nF incl. connection lead)	2009309
Diagnostic connection set	Accessory set for a partial-discharge free connection to the test object	890017909

2.5 Display and Controls

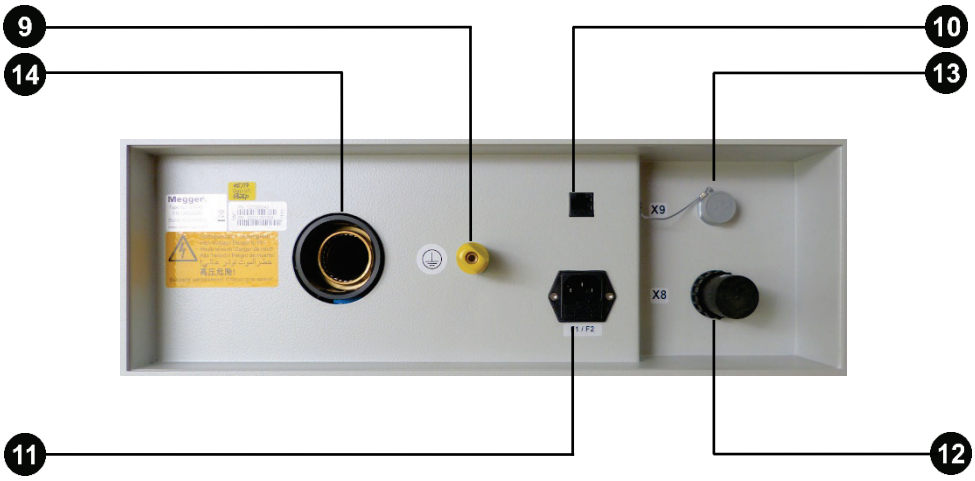
The following control and display elements are on the front panel of the TDM 45-P / TDM 4540-P test system:



Element	Description
1	EMERGENCY OFF switch
2	ON/OFF button
3	HV interlock key switch
4	“HV On” button
5	“HV Off” button
6	USB port
7	Display
8	Rotary encoder with function keys on the side

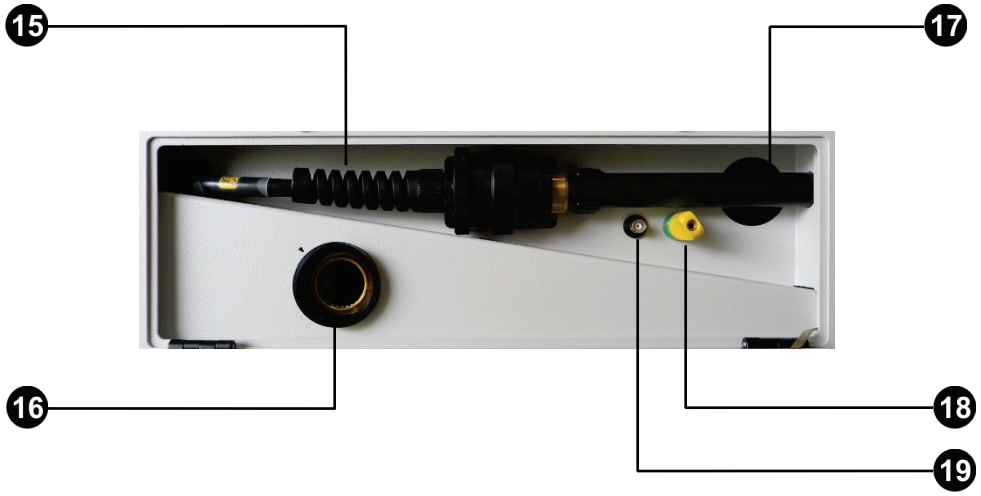
2.6 Connection Elements

The following connection components are located at the rear of the test system:



Element	Description
9	Protective earthing connection
10	Network port for communication with the control notebook (only required in combination with an external diagnosis module)
11	Power supply socket with fuses (2 x T6.3A)
12	Socket to connect the external safety device
13	Socket to connect the control cable to the Boost module
14	HV output

The following connection components are located at the rear of the optional Boost module:



Element	Description
15	HV connecting cable to connect to the test system
16	HV output
17	Control cable to connect to the test system
18	Protective earthing connection
19	Trigger output for triggering of a connected PD measuring system.

3 Commissioning

General safety instructions for set-up and commissioning

- The safety guidelines for the operation of mobile testing systems often differ from one network operator to another and are frequently subject to national regulations (such as the German BGI 5191). Before the measurement session, find out what the applicable guidelines are and follow the rules set out therein precisely, in respect of the organisation of work and the commissioning of the mobile test system.
- Select a location that is sufficient for the weight and size of the system and which ensures that it stands securely.
- When setting up or connecting the device, make sure that it does not impair the functional capability of any other systems or components. If other systems and components have to be modified, be sure to reverse these measures once the work has been completed. Always take the special requirements of these systems and components into account and only carry out work on them after consulting and obtaining approval from whoever is in charge of them.
- In the event of large differences in temperature between the storage and installation locations (cold to warm) condensation may form on components carrying high voltage (condensation effect). To avoid any risk of damage to people and devices caused by voltage flash-overs, the system must not be operated when in this condition. It should rather be left in the new environment to acclimatise for approximately one hour before putting it into operation.

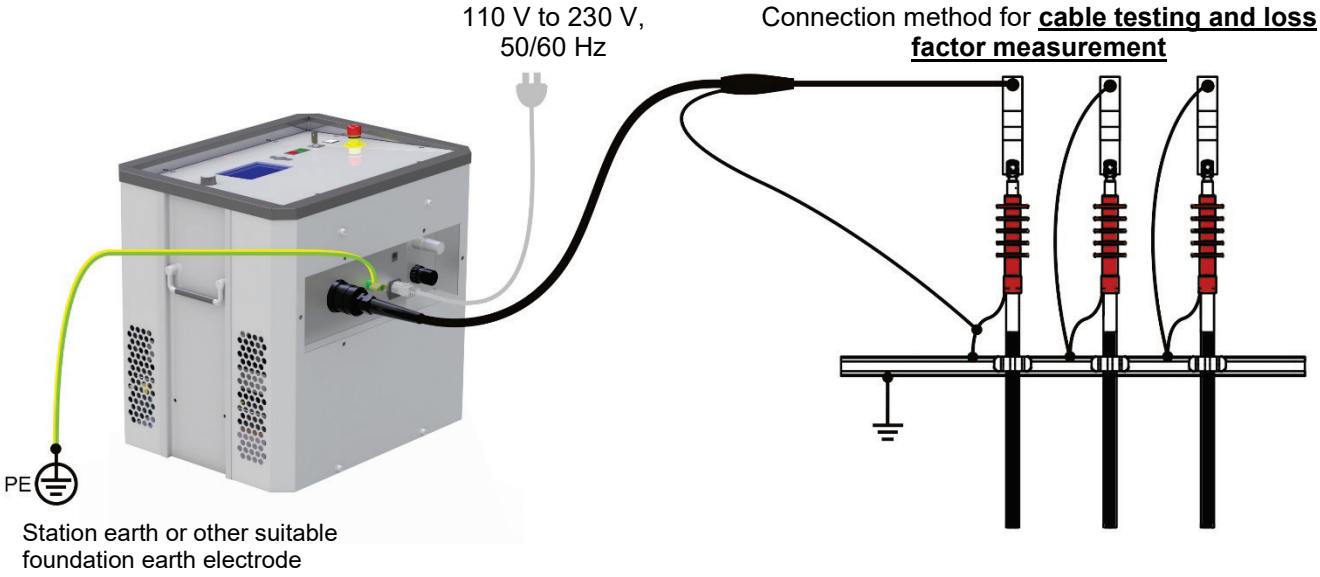
3.1 Electrical Connection

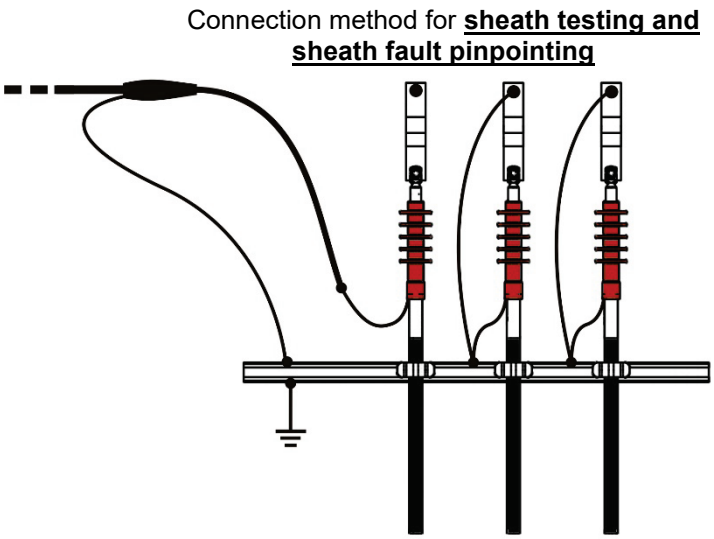
Safety instructions for the electrical connection

- The system may only be connected to **de-energized** equipment. The general safety instructions and, in particular, the five safety rules (see page 8) must always be followed prior to connection to the test object.
- Follow the specified connection sequence.
- All the cables at the measuring point that are out of operation and are not to be tested must be shorted and earthed.
- Because the amount of voltage applied to the test object poses a danger in the event of contact, the prohibition zone around live parts as defined in DIN EN 50191 (VDE 0104) must be protected in a way that it cannot be breached.
- The ends of the cables must be shielded to ensure that contact is not possible. When doing so, be sure to take all branches of the cables into account.

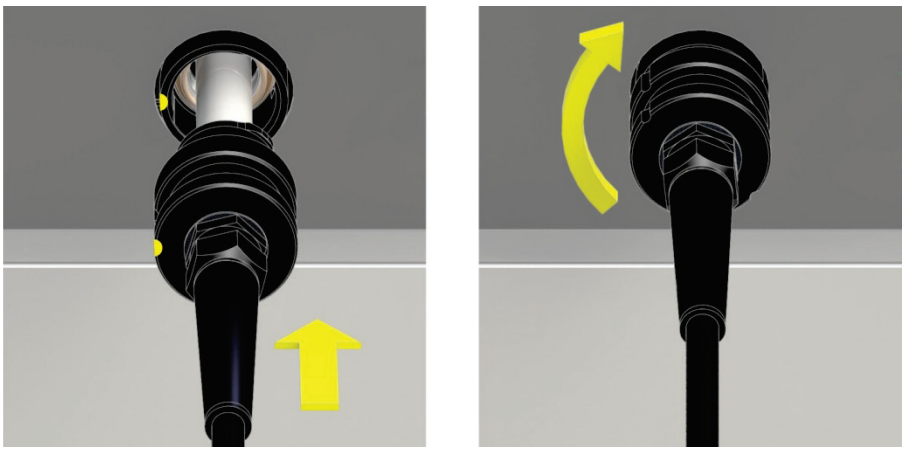
3.1.1 Normal Connection (Testing with Sine Wave Voltage)

Connection diagram The following figure shows a simplified connection diagram of the test system:





Procedure Proceed as follows, to connect the test system to the test object:

<table>
<tr><th>Step</th><th colspan="2">Action</th></tr>
<tr><td>1</td><td colspan="2">Using the green/yellow earth cable make a connection between the protective earth connection 9 of the device and a suitable point on the protective earth system (station earth).
Make sure that the connecting points of the earth cable are not polluted / corroded and that they provide good metallic contact.</td></tr>
<tr><td>2</td><td colspan="2">Insert the plug of the HV connecting cable, aligned as shown, into the HV output 14 of the system.
The connecting plug has a bayonet fitting. The plug must be pushed gently against the HV output with some force, and noticeably slot into place. Then tighten the plug by turning it in a clockwise direction.
  </td></tr>
<tr><td rowspan="2">3</td><td>If you want to carry out a <u>cable test</u> or a <u>loss factor measurement</u>:</td><td>If you want to carry out a <u>sheath test</u> or a <u>sheath fault location</u>:</td></tr>
<tr><td>Connect the screen of the HV connecting cable to the earthed screen of the test object (system earth).
Connect the internal conductor of the HV connecting cable to the phase conductor of the test object.</td><td>Connect the screen of the HV connecting cable to the earthing bar of the cable system (system earth).
Connect the internal conductor of the HV connecting cable to the earth screen of the test object.
The earth screens must be disconnected at both cable ends.</td></tr>
<tr><td>4</td><td colspan="2">Connect the power cord included in the scope of the delivery to the system’s power socket 11 and a power supply socket.</td></tr>
</table>

3.1.2 Connection via Optional Test Module (Testing with Cosine Rectangular Voltage)

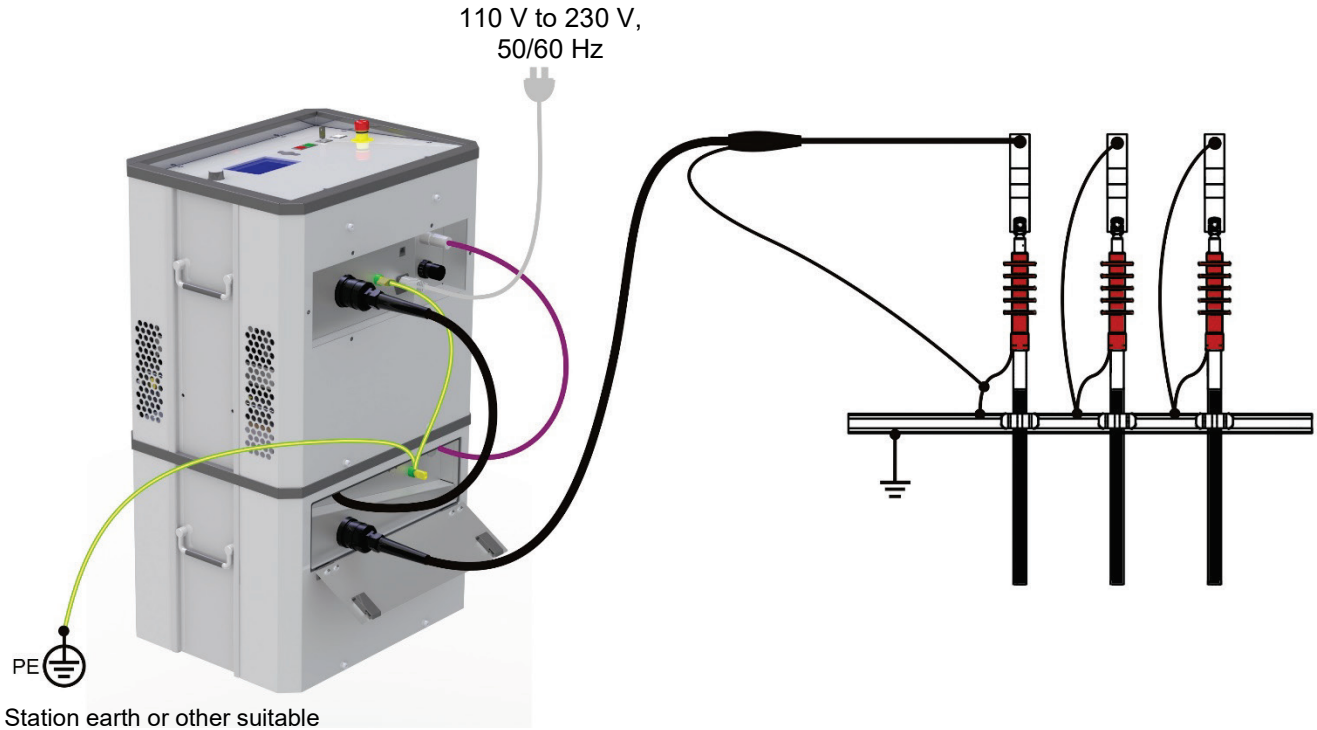
Purpose

If the test system is connected to the test object via the optional Boost module, **tests with cosine rectangular voltage can be carried out** (all other operating modes are disabled).

By means of the Boost module the maximum testable load capacitance at 40 kV and 0.1 Hz is increased to 5 µF. This way, standard-compliant tests of loads with higher capacitance and cables with a rated voltage >20 kV can be performed.

Connection diagram

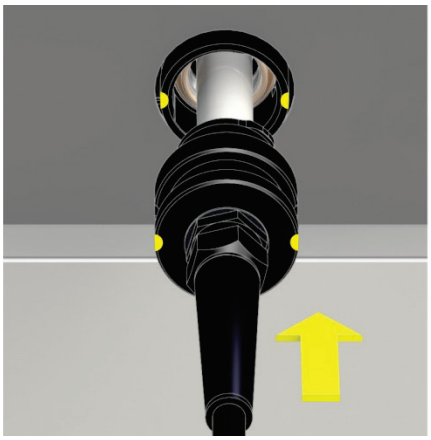
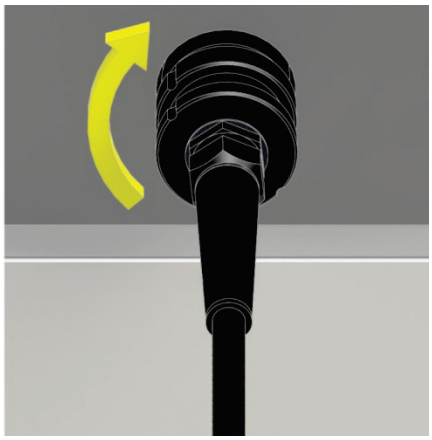
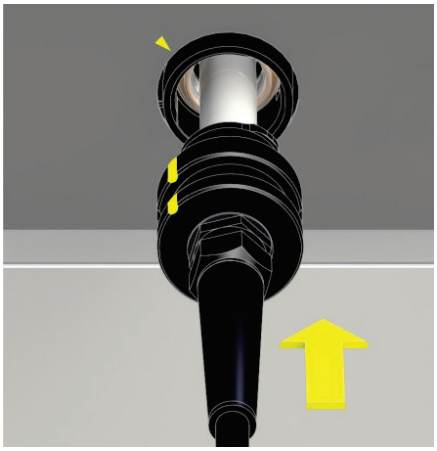
The following figure shows a simplified connection diagram of the test system with the Boost module:



Procedure

Proceed as follows to connect the test system to the test object:

Step	Action
1	Place the test system on top of the Boost module, as shown in the figure.
2	Using the green/yellow earth cable, make a connection between the protective earth connections (9 und 18) and a suitable point on the protective earth system (station earth). Make sure that the connecting points of the earth cable are not soiled and that they provide good metallic contact.
3	Connect the control cable 17 from the Boost module to the corresponding socket 13 of the test system.

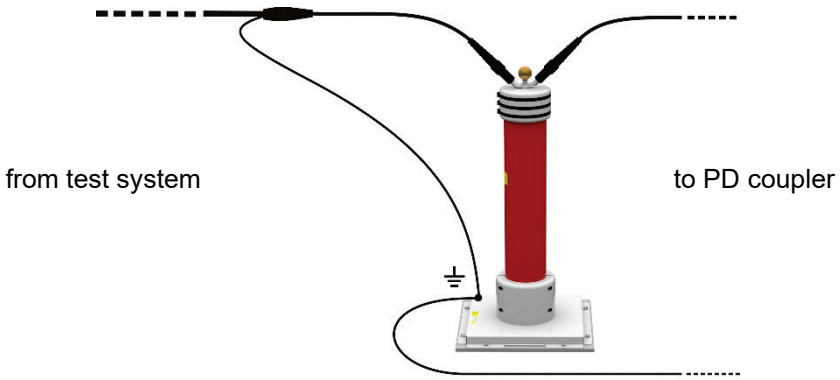
Step	Action
4	Connect the HV connection cable from the Boost module to the test system. To do so, insert the plug of the HV connecting cable (15), aligned as shown, into the HV output (14) of the system. The connecting plug has a bayonet fitting. The plug must be pushed flush against the HV output with some force, and noticeably slot into place. Then tighten the plug by turning it in a clockwise direction.  
5	Fasten the plug of the supplied HV connecting cable to the HV output (16) of the Boost module. Again, the correct alignment is important when inserting. 
6	Connect the screen of the HV connecting cable to the earthed screen of the test object (system earth).
7	Connect the internal conductor of the HV connecting cable to the phase conductor of the test object.
8	Connect the power cord included in the scope of the delivery to the system's power socket (11) and a power supply socket.

3.1.3 Connection to an External Diagnosis Module

In combination with a PD coupler (e.g. PDS 62-SIN) or the external TanDelta test attachment, the test system can be expanded to a full-featured diagnosis system. For this purpose, the test system must be connected not only to the diagnosis module itself, but also to a control notebook (either directly or via a separate connection box).

Detailed information on how to connect to such a diagnosis module can be found in the operating manual of the used module.

If during preparation of a diagnosis with VLF CR or DAC voltage the software reports that the load capacitance is too low (<120 nF), the support capacitor which is available as an accessory (see page 14) can be used to counteract this problem. To this end, the capacitor needs to be interconnected into the HV path between test system and PD coupler as follows:



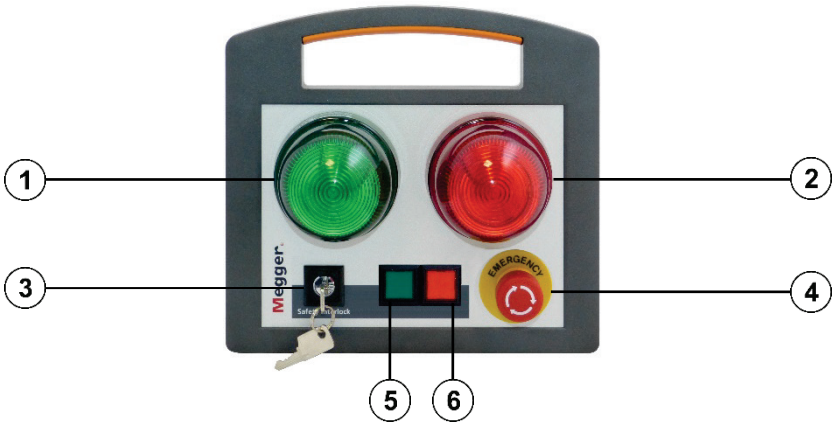
3.1.4 Use of an External Safety Device (Optional)

Purpose With the aid of an external safety device, the current status of the system can be made clearly visible with coloured signal lamps and the generation of HV can be interrupted or locked with an EMERGENCY OFF switch and key switch.

Connection The external safety device must be connected to the socket 12 that has been provided for this purpose.

In the event that no external safety device is used, the corresponding dummy plug must be screwed on to the socket.

Description The following figure shows the optional external safety device:

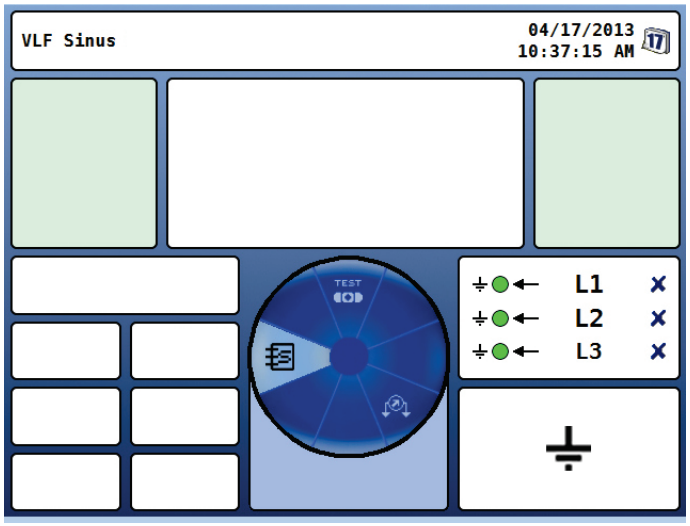


Part	Description
1	**Green signal light** Lights up when the system is switched on but is not in high voltage operation.
2	**Red signal light** Lights up as soon as high voltage can be generated. All discharge and earthing devices are open and the test object must be treated as live.
3	**“HV interlock” key switch**  High voltage unlocked  High voltage locked In the locked state, the key can be removed and the system can thus be protected against unauthorised high-voltage operation.
4	**EMERGENCY OFF switch**
5	**HV ON button** (only if the box is equipped with HV controls; equal to button 4 on the front panel)
6	**HV OFF button** (only if the box is equipped with HV controls; equal to button 5 on the front panel)

3.2 Switching On

	**WARNING** **Risk of electric shock!** Before switching on the test system, make sure that it has been properly earthed and connected to the test object via the HV connection cable in accordance with the instructions in section 3.1

The test system is switched on by pressing the ON/OFF button **2**. The software starts within a few seconds. If the test system was switched off whilst in an operating mode, this operating mode is called up again immediately after restarting. Elsewise, the software remains in the main menu shown below:



4 Operation

4.1 Safety Circuit

Signalling

Immediately after an operating mode has been selected, the TDM 45-P / TDM 4540-P test system continuously checks the requirements of the safety circuit. In the event that at least one requirement of the safety circuit is not fulfilled, the system disables HV operational readiness. The operator is informed in the header about the existing discrepancy:

To be able to generate high voltage, the cause of the fault must first be eliminated.

If the safety circuit trips during HV operation, the system will immediately interrupt the HV test. Subsequently the test object will automatically be discharged.

Possible error messages

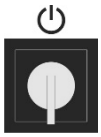
The following causes can interrupt the safety circuit:

Message	Cause
Cable shield not properly connected	Resistance between operating earth and protective earth too high (>9 ±3 Ω). Check whether the earth cable as well as the cable screen of the HV connection cable are correctly connected and that the respective connection points are making a good metallic contact.
HV cable not correctly connected	The HV connection cable has not been properly locked on to the HV output 14.
System disabled by EMERGENCY OFF	The EMERGENCY OFF switch 1 has been activated.
HV unit disabled by external EMERGENCY OFF	The EMERGENCY OFF switch on the external safety device has been activated.
HV Unit disabled by Interlock Key	High voltage has been locked by using the key switch 3 (see the next page).
Overtemperature in VLF Sinus	The internal temperature monitor reports a raised temperature of the HV components. The system can only be started up again after a sufficiently long cooling-down phase. Make sure that the air inlets and outlets on the sides of the housing are not covered.
VLF CR Test Boost is not ready.	The Boost module reports an error that is not defined with any greater precision or is not properly connected.

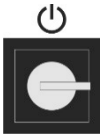
Message	Cause
VLF CR Test Boost is not ready. Cable shield not properly connected.	The Boost module reports that the resistance between operating earth and protective earth is too high (>9 ±3 Ω). Check whether the earth cable as well as the cable screen of the HV connection cable are correctly connected and that the respective connection points are able to make good metallic contact.
VLF CR Test Boost is not ready. HV cable not correctly connected.	The HV connection cable was not properly locked on to the HV output of the Boost module.

HV interlock

The TDM 45-P / TDM 4540-P test system has a key switch 3 that can prevent high voltage being switched on. The switch can be set to the following positions:



High voltage unlocked



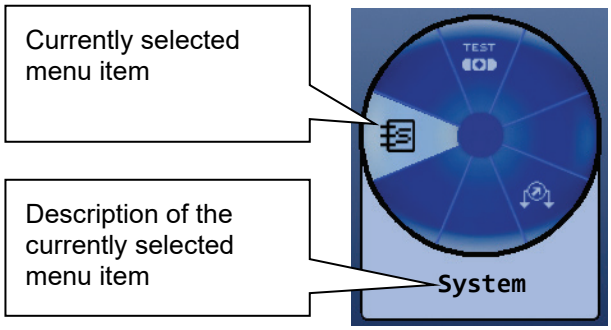
High voltage locked

In the locked state, the key can be removed and the system can thus be protected against unauthorised high-voltage operation.

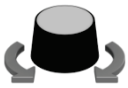
4.2 General Operation

Operating concept

Navigation within the menus is entirely controlled from the circular selection menu:



Operating the system with the rotary encoder 8 is as follows:



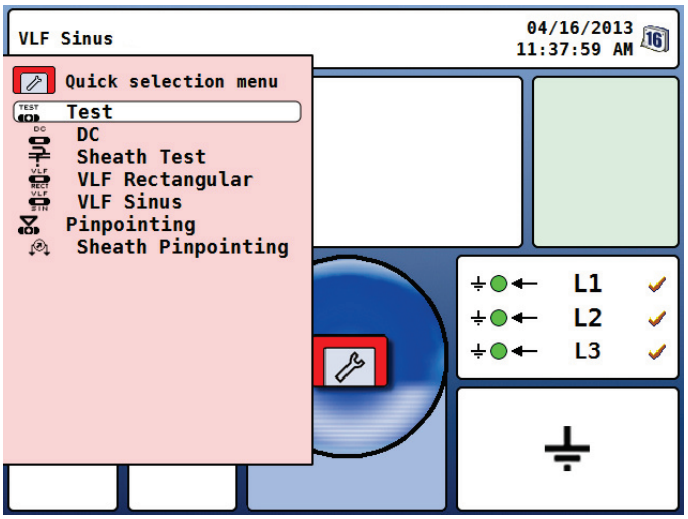
- Select the menu item
- Increase or decrease the value of a variable parameter
- Select an option from a selection list

- Call up the selected menu item
- Confirm the setting or the selection made

Each menu (with the exception of the main menu) has a menu item with which one can return to the next higher menu level.

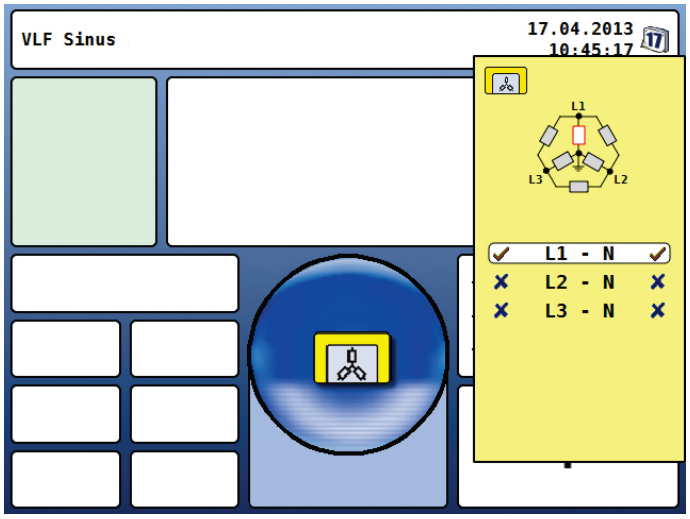
Quick selection

By pressing the function button located on the side next to the rotary encoder, the quick selection menu can be accessed (as well as closed) at any time irrespective of the position in the menu structure. The menu provides direct access to all the available operating modes.



Phase selection

Immediately after the activation of an operating mode (with the exception of the sheath pinpointing mode), the phase selection menu opens automatically:



Phase selection is used to select the phases of the test object on which the measurement is to be carried out. In this manner, the test logs and the records of the history database (see the next page) can also be easily assigned later.

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

✓ Phase is active

✗ Phase is not active

The phase selection menu can only be closed once a valid selection has been made. By closing the menu via the function button, the active selection is confirmed.

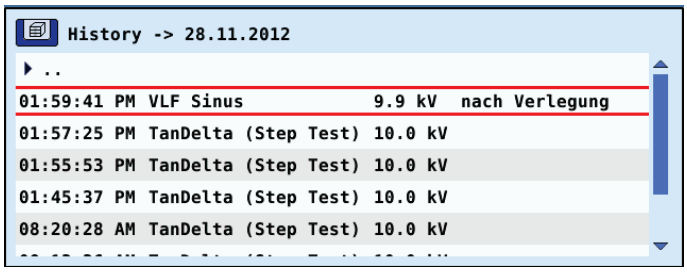
Until the actual start of the measurements, the selection menu can be called up again and adjusted by pressing the function button once again.

The last phase selection made is separately saved for each operating mode (even after a restart) and is preset when the operating mode is restarted.

History database

By pressing the function button  located below the rotary encoder, the history database can be called up at any time irrespective of the position in the menu structure.

The data in respect of all measurements and tests carried out with the system are contained in this database. The records are sorted by date and can furthermore also be distinguished according to operating mode, voltage or optional comments.



Once the desired record has been selected by turning the rotary encoder, the selection must be confirmed by pressing it briefly. Thereafter, the following functions are available:

- Export the selected record or all records to the inserted USB flash drive (for further processing in MeggerBook Cable)
- Delete the selected record or all records
- Add or edit a comment in respect of the selected record

Online help

By pressing the function button  located above the rotary encoder, a compact online help function with basic operating instructions can be called up at any time irrespective of the position in the menu structure.

4.3 System Menu

Selecting the menu item takes you directly to the system menu, where the following functions and submenus are available:

Menu item	Description
	Submenu with detailed system information Information on the current versions of the various software components Hardware information (e.g. MAC address and serial number of the system) The current system log file can be viewed ( ) and exported ( ) by selecting this submenu. When exporting the system log file, it is saved on the inserted USB flash drive (in the directory: *VLFSinus45/logfiles/*).
	System settings Setting the interface language. Select the desired language by turning the rotary encoder and activate by pressing it. The language selection is immediately active. In this submenu, the brightness and layout of the display can be adjusted and the background lighting can be switched on or off. Setting the date and time. The value of each segment that has been marked for selection can be adjusted by turning the rotary encoder. Pressing causes the mark to move the next segment. Once the input has been concluded, the changes can either be accepted with **OK** or rejected by selecting **Cancel**.
	Using this function resets all the saved test parameters (e.g. phase selection, voltage, test duration) to the default values preset in the factory.
	When this function is used, a search in respect of firmware and language files is conducted in the directory *VLF Sinus45/updates/* on the inserted USB flash drive. The files found are then listed and, using the rotary encoder, these can be selected and imported. A distinction is made between the following file types: *VLFSinus45-Software-x.xx.tar* — Updating all software components (including kernel, boot loader and database) to version x.xx *application-x.xx.img* — Updating solely the application to version x.xx *VLFSinus45-xxx.tar* — Importing the language xxx *VLFSinus45-Languages.tar* — Importing all the languages contained in the language file
	Access to the password-protected submenus that are reserved for service technicians and developers.

5 Operating Modes

5.1 Cable Testing

Selecting the operating mode

If the TDM 45-P / TDM 4540-P is operated **without the optional Boost module**, the following cable test operating modes have been combined in their own submenu, which can be called up directly from the main menu by selecting the menu item TEST.

Menu item	Operating mode
VLF >> VLF SIN	Cable test with VLF sine wave voltage of up to 45 kV_{PEAK}
VLF >> VLF RECT	Cable test with trapezoidal AC voltage (rectangular voltage) of up to 45 kV
VWD	Cable test with VLF sine wave voltage and simultaneous tanDelta diagnosis (optional)
DC	Cable test with positive and negative DC voltages of up to 45 kV

With the optional Boost module connected, tests can only be performed with VLF cosine rectangular voltage of up to 40 kV. This operating mode can be access directly through the VLF CR menu item when in the main menu. Due to the high testable cable capacitance, this operating mode is also suitable for standard-compliant testing of very long cables.

Setting the test parameters

The phases and the test voltage 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 phase selection (see page 30) must be carried out in accordance with the actual type of connection. If to save time several phases are to be tested at the same time, the phase selection menu also makes it possible to select several phases. Thereafter, the phase selection menu must be closed using the function button .
U	Entering test voltage. The manner of the entry may also be specified (see the description in the bottom part of the table). If the voltage is shown as a multiple of the cable nominal voltage Uo, then Uo and the factor must be entered successively. Suitable voltage values for a meaningful cable test are set out in the table on the following page.
	The test time is shown in minutes. After expiry of the test time, the high voltage will be automatically switched off. Suitable test times for a meaningful cable test are set out in the table on the following page. The setting ∞ activates the continuous operation mode.

Button / Menu item	Description
f~	***Only adjustable for tests with sine wave or rectangular voltage*** 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 und 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 (see page 13), it may be necessary to adjust the test frequency set, whereof the user is informed at the start of the test. In the **Auto** setting, the system automatically selects the highest possible test frequency at the start of the test and starts the voltage conditioning without further inquiry.
+/-	***Only adjustable for DC voltage test*** This menu item is used to specify the polarity of the DC test voltage.
	In this submenu, the following additional parameters can be set: U↕ The manner of entering the voltage. Depending on the voltage form, the test voltage can be specified as peak value (**PEAK**), root mean square value (**RMS**), absolute value (**|U|**) or as a multiple of Uo (**x·Uo**). BURN Activates and deactivates the burning function. If the burn function is activated and a voltage breakdown occurs, the test continues for the purpose of fault conversion for a maximum one minute. These settings are stored separately for each of the test modes and are retained even if the unit is switched off.

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 (new cables)	3 Uo	15 to 60
VLF test (on aged cables)	1.7 to 3 Uo	60
DC test (on PILC cables)	4 to 8 Uo	15 to 30

Starting the test

Once all the relevant parameters for the test as well as the phase(s) have been set, the actual test can be started using the menu item . After which 10 seconds remain to enable high voltage with the “HV On” button 4.

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

For tests with sine wave or rectangular voltage, testing using a lower frequency is offered where required. The user can then either cancel the test or start it using a different frequency. In the **Auto** frequency setting, the adjustment, if necessary, is carried out without further inquiry.

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

During the test, the voltage curve (blue) and, if applicable, the leakage current (red) are logged in the display area in real time. The display area of the diagram can be increased or be reduced by means of the menu item .

In the VWD operating mode, the tanδ measured values (green dots) are shown in addition to the voltage curve (blue curve) and it is possible to switch to numerical representation of the measured values via the menu item.

Depending on the operating mode, a few relevant parameters and measured values are displayed next to the diagram:

Symbol	Description
/	Remaining test time / current test duration (in continuous operation mode)
LEAK	Leakage current (VLF-CR, DC and rectangular voltage)
f	Actual test frequency
	The load capacitance determined at the start of the test
	The insulation resistance determined at the start of the test
δ	Last measured tanδ value

Finishing the test

If a test time was defined, the high voltage is automatically switched off at the end of this time. In continuous operation mode, it must be switched off manually using the “HV Off” button 5 or the menu item HV Off.

If a voltage breakdown occurs in the test object during the test time, the test is also interrupted. In which event, the test does not qualify as having been passed.

Irrespective of whether the high voltage is switched off automatically or manually, 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 31) and, if necessary, on the inserted USB flash drive as well.

Evaluation of the test results

A dielectric strength test carried out to standard is generally deemed to have been successfully passed if there were no breakdowns 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 leakage current or the tanδ measured values.

E.g. a falling TanDelta can indicate wet cables / accessories, while a TanDelta increasing over time can be a definite indication of an emerging cable fault.

5.2 Sheath Test and Sheath Fault Pinpointing

Introduction

To detect sheath faults, the TDM 45-P / TDM 4540-P test system operates in test mode with a DC voltage of up to 20 kV (negative polarity), which also permits cables with a thicker outer sheath (such as cables rated 230 kV) to be tested.

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

During sheath fault pinpointing, DC pulses with an adjustable pulse rate are coupled into the screen of the faulty cable.

With each coupled pulse, the current flowing into the earth forms a voltage gradient around the point of escape (the fault position in the sheath), the centre of which can be located precisely by means of an earth fault locator and earth spikes (step voltage method).

Selecting the operating mode

To start a test, the submenu of the test operating modes must be opened using the menu item TEST and from this, the menu item must be called up.

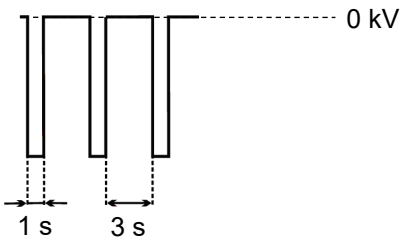
Sheath fault pinpointing can be started directly from the main menu using the menu item .

Setting the test parameters

The phases (sheath testing only) 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 or pinpointing.

The following test parameters can be set:

Button / Menu item	Description
	Only adjustable for sheath tests The phase selection (see page 30) must be carried out in accordance with the actual type of connection. If to save time several sheaths are to be tested at the same time, the phase selection menu also makes it possible to select more than one phase. Thereafter, the phase selection menu must be closed using the function button .
U	The set voltage range limits the maximum voltage that can be set during the test or pinpointing. 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: • PVC cable ≤3 kV • PE medium voltage cable ≤5 kV • PE high voltage cable ≤10 kV

Button / Menu item	Description
	Only adjustable for sheath fault pinpointing Menu item to select the rate of the DC pulses in seconds. **Example:** If a pulse rate of 1:3 produces is selected, every DC pulse with a duration of 1 second is followed by a 3 second voltage dropout. 
	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. The setting ∞ activates the continuous operation mode that should particularly be used for the sheath fault pinpointing.
	In this submenu, the following additional parameters can be set: RAMP Switching between manual and automatic ramp voltage. In automatic mode, as soon as high voltage is enabled, the test system begins voltage conditioning and charges the test object directly up to the upper limit that has been set. In the manual mode, the voltage must be ramped up by using the rotary encoder. This permits a gradual increase and therefore makes it easier to assess sudden fluctuations in current, for example.

Starting the test / pinpointing

Once all the settings have been made, the test or pinpointing can be started with the menu item ⏻. After which 10 seconds remain to enable high voltage with the “HV On” button **4**.

As soon as high voltage is enabled, the “HV Off” button **5** lights up red signalling high voltage at the HV output.

Depending on the setting (see above), the TDM 45-P / TDM 4540-P test system either immediately starts with voltage conditioning or waits for the manual adjustment of the voltage. During sheath testing or sheath fault pinpointing the applied voltage can be manually adjusted by means of the menu item U.

5.2.1 Sheath Test

Performing the test

During the test, the voltage curve (blue) and the current curve (red) are logged in the display area in real time. The display area of the diagram can be increased or be reduced by means of the menu item .

Depending on the operating mode, a few relevant parameters and measured values are displayed next to the diagram:

Symbol	Description
/	Remaining test time / current test duration (in continuous operation mode)
I_{LEAK}	Leakage current

Finishing the test

If a test time was defined, the high voltage is automatically switched off at the end of this time. In continuous operation mode, it must be switched off manually using the “HV Off” button 5 or the menu item **HV Off**.

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 31) and, if necessary, on the inserted USB flash drive as well.

Evaluating the test results

If the leakage current values measured during the test are above the limits specified by the cable owner, the tested cable should be examined in more detail soon or at least a shorter testing cycle should be introduced.

5.2.2 Sheath Fault Pinpointing

Pinpointing sheath faults

After high voltage has been enabled and, if necessary, the desired voltage has been set, the fault position can be accurately pinpointed by means of an earth fault locator (e.g. ESG NT).

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

Do not leave the system in operation unattended and accessible to the third parties. Cordon off the location in a secure manner or instruct an authorised person to monitor the system.

Completing the measurement

If a test time was defined, the high voltage is automatically switched off at the end of this time. In continuous operation mode, it must be switched off manually using the “HV Off” button 5 or the menu item **HV Off**.

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 31) and, if necessary, on the inserted USB flash drive as well.

5.3 VLF TanDelta Loss Factor Measurement (Optional)

5.3.1 Preparing for Measurement

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 leads to dielectric losses.

A measure of these dielectric losses is the so-called loss factor tanδ, which can be determined within the scope of a TanDelta 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.

Selecting the operating mode

To start a TanDelta step test, the submenu of the test operating modes must be opened using the menu item TEST and from this, the menu item TAN must be called up.

Upon entering the operating mode, some parameters (phases, test standard, insulation type and nominal voltage) are automatically queried, which however can still be adjusted until the actual start of the measurement (see the following table).

Setting the test parameters

The following test parameters can be set (some of which are in the submenu):

Button / Menu item	Description
	During phase selection (see page 30), all the phases must be selected on which a TanDelta step test is to be performed. The test is carried out – starting with the lowest phase – successively on all the selected phases. The phase selection menu must be closed using the function button .
U_0	Nominal voltage Uo of the connected cable type as RMS value. Once the value is confirmed, a calculation of the respective voltage values of the individual levels is carried out and displayed on the screen. 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). 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.

Button / Menu item	Description
f	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. By measuring at different frequencies, a tanδ spectrum can furthermore be shown for the test object. This spectrum can provide further information on the condition of the test object. If the capacitance of the connected test object does not permit (see page 13) a measurement using 0.1 Hz and an automatic frequency adjustment is performed at the start of the measurement, the evaluation criteria that are independent of frequency should be looked more closely. These include, amongst others, the deviation of the absolute tanδ values between the phases of a cable system and the change of the tanδ with increasing voltage (Δtanδ).
NUM	Number of the voltage levels (1 to 6) that the test voltage runs through in the course of a test. The first voltage level is 0.5Uo. The voltage is increased by 0.5Uo with every additional voltage level. The sixth voltage level would accordingly be 3Uo. One requirement for the automatic evaluation (see page 45) of the test results is that the measurements were taken in respect of at least 3 voltage levels. Once the value is confirmed, a calculation of the respective voltage values of the individual levels is carried out while taking the nominal voltage into account and displayed on the screen. To avoid possible breakdowns, it is recommended that already heavily aged cables are not be measured at voltage levels greater than 2Uo (≤1.5Uo is even safer).
n	Number of tanδ measured values (5 to 20) per voltage level. At least 8 measured values per voltage level should be recorded in order to obtain a calculated tanδ mean value that is statistically meaningful. The higher the number of values, the more reliable the calculated mean value. 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 limited (recommended are 8 to 10 values).
TYPE	Insulation type of the cable under test. The chosen insulation type determines the criteria used for the automatic evaluation of the measurement results. In case of a mixed cable system (**Mixed** option), evaluation is performed according to the criteria defined for PILC cables.
	Standard according to which the recorded measurement results are to be automatically evaluated.

5.3.2 Course of the Measurement

Test start

Once all the settings have been made, the measurement can be started with the menu item . An instruction is then given in respect of the first phase to be connected (the smallest selected phase of the phase selection), which requires confirmation.

After which 10 seconds remain to enable high voltage with the “HV On” button 4. As soon as high voltage is enabled, the “HV Off” button 5 lights up red signalling high voltage at the HV output.

At the start of the measurement, load detection is performed. If the capacitance of the cable requires a reduction in the test frequency that has been set, this is indicated on the screen by a system message. The user can then either cancel the test or start it using a different frequency.

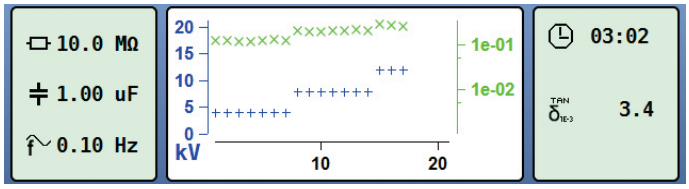
Alternatively, the number of voltage levels could be reduced, resulting in an automatic drop in the maximum necessary test voltage. However, care should be taken here to ensure that, if possible, the 3 voltage levels required for meaningful measurement results are retained.

Performing the measurement

The test voltage runs 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 system requires a certain number of periods (approximately three) at the start of each new voltage level in order to optimally adjust itself for the current and voltage values. During this phase, no tanδ measured values are displayed.

Selecting the menu item allows you to switch between two different views. In the curve representation, the measured individual tanδ values (green dots) together with the corresponding RMS voltage values (blue dots) are displayed in a diagram.



The display area of the diagram can be increased or be reduced by means of the menu item . In the tabular view, the last 4 individual tanδ values are numerically listed with the corresponding voltage level.

Changing phases during the course of the test

If more than one phase was selected before the start of the measurement, the test is interrupted after the measurement of a phase is completed and the user is prompted to connect the next phase.

The high voltage source is then automatically switched off and the HV output is discharged.

Follow the five safety rules

To establish and ensure a voltage-free state when changing phases, the five safety rules (see page 8) must be followed.

After changing the phase, the message needs to be confirmed and the high voltage must be enabled again with the “HV On” button **4**. After doing so, the system automatically continues with the measurement on the next phase.

If the test system is switched off (without leaving the operating mode) during the request to change phases, the software automatically returns to this system status after restarting. Due to this function, the phases can also be changed while the system is switched off.

Completing the test

After finishing a complete voltage run on all phases to be tested, the system automatically switches off the high voltage and discharges the test object.

In respect of each phase involved in the test, a separate log file is created and saved in the history database (see page 31).

In addition, an overall log is generated to facilitate a comparison of the individual phases. This log, which also contains information in respect of the evaluation of the individual phases (see page 45), is written to the history database as well as to the inserted USB flash drive, if necessary.

5.3.3 Evaluation of the Test Results

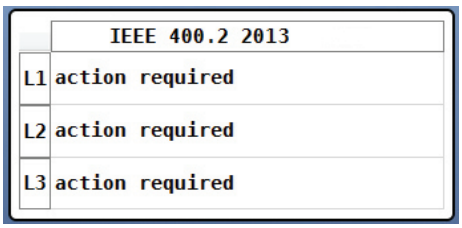
5.3.3.1 Automatic Evaluation

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.

The standard as well as the insulation type can be adjusted (see page 42) even after completion of the test.

If an automatic evaluation can be performed, the results are shown in the centre of the display:



5.3.3.2 Manual Evaluation

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 tanδ values can be called up by selecting the menu item Σ:

Criterion	Description
tanδ at **xUo**	The mean of the measured tanδ values is calculated separately for each voltage level. It is not recommended to perform the evaluation by means of the absolute values only, as they can be influenced by several factors: • Number of joints in the cable stretch • Type of joints • Temperature of the cable • Air humidity • Leakage current along the terminations / isolators 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 subjected to the same conditions. They have the same number of accessories 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 this case, further study (e.g. a PD measurement) is advised.
σ	The standard deviation σ is specified separately for each voltage level and is a measure of the distribution of the individual tanδ values around the mean value of the respective level.
1.5Uo – 0.5Uo (Δtanδ)	The most important criteria for a meaningful evaluation of the insulation condition is the Δtanδ, which reflects the voltage dependency of the tanδ. The Δtanδ is calculated from the difference between the tanδ mean value of voltage levels 0.5Uo and 1.5Uo. $\Delta\tan\delta = \tan\delta_{1.5Uo} - \tan\delta_{0.5Uo}$ The Δtanδ can only be calculated for measurements with at least 3 voltage levels.

Evaluation of XLPE cables

For XLPE cables, an insulation in good condition is indicated by a low Δtanδ, which corresponds to a nearly constant tanδ over increasing test voltages. For an aged insulation, the tanδ value increases slightly with increasing voltage. For a critically aged insulation, the tanδ value clearly increases with increasing voltage.

Using the relevant literature as an aid, the absolute tanδ 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 2Uo [10^{-3}]		**σ at Uo** [10^{-3}]		**Δtanδ (2Uo – Uo)** [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 Uo [10^{-3}]		**σ at Uo** [10^{-3}]		**Δtanδ (1,5Uo – 0,5Uo)** [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 tanδ 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 2Uo [10^{-3}]		**σ at Uo** [10^{-3}]		**Δtanδ (2Uo – Uo)** [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 Uo [10^{-3}]		**σ at Uo** [10^{-3}]		**Δtanδ (1,5Uo – 0,5Uo)** [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 Uo [10^{-3}]		**σ at Uo** [10^{-3}]		**Δtanδ (1,5Uo – 0,5Uo)** [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.

5.4 TanDelta Diagnosis in Combination with the External Test Attachment

The test system can be used together with the external TanDelta test attachment (see page 14) for a high-precision determination of a cable's condition.

The test system and the data exchange with the test attachment are controlled using a notebook on which the required software has been installed. Because this software also allows the native operating modes to be run, a notebook like this is also suitable for complete remote control of the test system.

Operation of the software is described in the "Notebook control of test and diagnosis systems" manual.

5.5 Partial Discharge Diagnosis in Combination with a PD Coupler

In combination with a suitable PD coupler (see page 14), the test system can be used for standard-compliant partial discharge diagnosis. A notebook with the required software is used to control the system and evaluate the test results.

Detailed information about carrying out the partial discharge diagnosis, can be found in the operating manual of the used PD coupler.

6 Completing the Work

Exporting the measured data

If there is a USB flash drive plugged in the USB port 6 on completion of the measurement / test, a log file (*.vlf*) as well as a print-ready report (*.pdf)* are automatically exported into the *VLFSinus45/measurements/* directory. If this was not the case, the data records can also be exported from the history database (see page 31) at a later stage.

Later in the office, the exported data can be compiled to a report and printed using the Megger Book Lite software supplied on the enclosed USB stick.

Shutting down the test system

After the measurements on a cable have been completed, the TDM 45-P / TDM 4540-P test system can be switched off by pressing the ON/OFF button 4.

When disconnecting the test system, proceed in reverse sequence to the manner in which the connection (see page 20) was made. The following safety instructions must be strictly adhered to.

 **WARNING**	• Follow the five safety rules (see page 8) • 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 shorted. • Only undo the earthing and short circuiting measures when the test object is to be operated again.

7 Maintenance and Repair

Repair and maintenance

Repair and maintenance work has to be carried out by Megger or authorised service partners using original spare parts only. Megger recommends having the system tested and maintained at a Megger service centre every two years.

Megger also offers its customers on-site service. Please contact your service centre if needed.

The connections and connection leads of the system must be regularly tested to ensure that they are free of defects and intact, in accordance with the applicable national and company-specific arrangements.

Storage

If the device is not used for a lengthy period, it should be stored in a dust-free and dry environment. Continuous moisture (humidity) especially when combined with dust can reduce critical insulating clearances that are essential for safe high-voltage operation.

Replacing fuses

If the device cannot be switched on, even though it is connected to the mains power supply, both fuses below the power supply socket (11) must be checked. The fuse holder must be pulled out to do so.

If the fuses are defective, they must be replaced with suitable microfuses (5 x 20 mm) of the type T6,3A.

If the fuses continue to trip, please get in touch with the Megger service department in order to have the problem resolved.

Tento symbol indikuje, že výrobek nesoucí takovéto označení nelze likvidovat společně s běžným domovním odpadem. Jelikož se jedná o produkt obchodovaný mezi podnikatelskými subjekty (B2B), nelze jej likvidovat ani ve veřejných sběrných dvorech. Pokud se potřebujete tohoto výrobku zbavit, obraťte se na organizaci specializující se na likvidaci starých elektrických spotřebičů v blízkosti svého působiště.

Dit symbool duidt aan dat het product met dit symbool niet verwijderd mag worden als gewoon huishoudelijk afval. Dit is een product voor industrieel gebruik, wat betekent dat het ook niet afgeleverd mag worden aan afvalcentra voor huishoudelijk afval. Als u dit product wilt verwijderen, gelieve dit op de juiste manier te doen en het naar een nabij gelegen organisatie te brengen gespecialiseerd in de verwijdering van oud elektrisch materiaal.

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

Този знак означава, че продуктът, обозначен по този начин, не трябва да се изхвърля като битов отпадък. Тъй като е B2B продукт, не бива да се изхърля и в градски пунктове за отпадъци. Ако желаете да извърлите продукта, го занесете в пункт, специализиран в изхвърлянето на старо електрическо оборудване.

Dette symbol viser, at det produkt, der er markeret på denne måde, ikke må kasseres som almindeligt husholdningsaffald. Eftersom det er et B2B produkt, må det heller ikke bortskaffes på offentlige genbrugsstationer. Skal dette produkt kasseres, skal det gøres ordentligt ved at bringe det til en nærliggende organisation, der er specialiseret i at bortskaffe gammelt el-udstyr.

Sellise sümboliga tähistatud toodet ei tohi käidelda tavalise olmejäätmena. Kuna tegemist on B2B-klassi kuuluva tootega, siis ei tohi seda viia kohalikku jäätmekäitluspunkti. Kui soovite selle toote ära visata, siis viige see lähimasse vanade elektriseadmete käitlemisele spetsialiseerunud ettevõttesse.

Tällä merkinnällä ilmoitetaan, että kyseisellä merkinnällä varustettua tuotetta ei saa hävittää tavallisen kotitalousjätteen seassa. Koska kyseessä on yritysten välisen kaupan tuote, sitä ei saa myöskään viedä kuluttajien käyttöön tarkoitettuihin keräyspisteisiin. Jos haluatte hävittää tämän tuotteen, ottakaa yhteys lähimpään vanhojen sähkölaitteiden hävittämiseen erikoistuneeseen organisaatioon.

Ce symbole indique que le produit sur lequel il figure ne peut pas être éliminé comme un déchet ménager ordinaire. Comme il s'agit d'un produit B2B, il ne peut pas non plus être déposé dans une déchetterie municipale. Pour éliminer ce produit, amenez-le à l'organisation spécialisée dans l'élimination d'anciens équipements électriques la plus proche de chez vous.

Cuireann an siombail seo in iúl nár cheart an táirgeadh atá marcáilte sa tslí seo a dhiúscairt sa chóras fuíoll teaghlaigh. Os rud é gur táirgeadh ghnó le gnó (B2B) é, ní féidir é a dhiúscairt ach oiread in ionaid dhiúscartha phobail. Más mian leat an táirgeadh seo a dhiúscairt, déan é a thógáil ag eagraíocht gar duit a sainfheidhmíonn i ndiúscairt sean-fhearas leictrigh.

Dieses Symbol zeigt an, dass das damit gekennzeichnete Produkt nicht als normaler Haushaltsabfall entsorgt werden soll. Da es sich um ein B2B-Gerät handelt, darf es auch nicht bei kommunalen Wertstoffhöfen abgegeben werden. Wenn Sie dieses Gerät entsorgen möchten, bringen Sie es bitte sachgemäß zu einem Entsorger für Elektroaltgeräte in Ihrer Nähe.

Αυτό το σύμβολο υποδεικνύει ότι το προϊόν που φέρει τη σήμανση αυτή δεν πρέπει να απορρίπτεται μαζί με τα οικιακά απορρίματα. Καθώς πρόκειται για προϊόν B2B, δεν πρέπει να απορρίπτεται σε δημοτικά σημεία απόρριψης. Εάν θέλετε να απορρίψετε το προϊόν αυτό, παρακαλούμε όπως να το παραδώσετε σε μία υπηρεσία συλλογής ηλεκτρικού εξοπλισμού της περιοχής σας.

Ez a jelzés azt jelenti, hogy az ilyen jelzéssel ellátott terméket tilos a háztartási hulladékokkal együtt kidobni. Mivel ez vállalati felhasználású termék, tilos a lakosság számára fenntartott hulladékgyűjtőkbe dobni. Ha a terméket ki szeretné dobni, akkor vigye azt el a lakóhelyéhez közel működő, elhasznált elektromos berendezések begyűjtésével foglalkozó hulladékkezelő központhoz.

Questo simbolo indica che il prodotto non deve essere smaltito come un normale rifiuto domestico. In quanto prodotto B2B, può anche non essere smaltito in centri di smaltimento cittadino. Se si desidera smaltire il prodotto, consegnarlo a un organismo specializzato in smaltimento di apparecchiature elettriche vecchie.

Šī zīme norāda, ka iztrādājumu, uz kura tā atrodas, nedrīkst izmest kopā ar parastiem mājsaimniecības atkritumiem. Tā kā tas ir izstrādājums, ko cits citam pārdod un lieto tikai uzņēmumi, tad to nedrīkst arī izmest atkritumos tādās izgāztuvēs un atkritumu savāktuvēs, kas paredzētas vietējiem iedzīvotājiem. Ja būs vajadzīgs šo izstrādājumu izmest atkritumos, tad rīkojieties pēc noteikumiem un nogādājiet to tuvākajā vietā, kur īpaši nodarbojas ar vecu elektrisku ierīču savākšanu.

Šis simbolis rodo, kad juo paženklinto gaminio negalima išmesti kaip paprastų buitinių atliekų. Kadangi tai B2B (verslas verslui) produktas, jo negalima atiduoti ir buitinių atliekų tvarkymo įmonėms. Jei norite išmesti šį gaminį, atlikite tai tinkamai, atiduodami jį arti jūsų esančiai specializuotai senos elektrinės įrangos utilizavimo organizacijai.

Dan is-simbolu jindika li l-prodott li huwa mmarkat b'dan il-mod m'għandux jintrema bħal skart normali tad-djar. Minħabba li huwa prodott B2B , ma jistax jintrema wkoll f'ċentri ċiviċi għar-rimi ta' l-iskart. Jekk tkun tixtieq tarmi dan il-prodott, jekk jogħġbok għamel dan kif suppost billi tieħdu għand organizzazzjoni fil-qrib li tispeċjalizza fir-rimi ta' tagħmir qadim ta' l-elettriku.

Dette symbolet indikerer at produktet som er merket på denne måten ikke skal kastes som vanlig husholdningsavfall. Siden dette er et bedriftsprodukt, kan det heller ikke kastes ved en vanlig miljøstasjon. Hvis du ønsker å kaste dette produktet, er den riktige måten å gi det til en organisasjon i nærheten som spesialiserer seg på kassering av gammelt elektrisk utstyr.

Ten symbol oznacza, że produktu nim opatrzonego nie należy usuwać z typowymi odpadami z gospodarstwa domowego. Jest to produkt typu B2B, nie należy go więc przekazywać na komunalne składowiska odpadów. Aby we właściwy sposób usunąć ten produkt, należy przekazać go do najbliższej placówki specjalizującej się w usuwaniu starych urządzeń elektrycznych.

Este símbolo indica que o produto com esta marcação não deve ser deitado fora juntamente com o lixo doméstico normal. Como se trata de um produto B2B, também não pode ser deitado fora em centros cívicos de recolha de lixo. Se quiser desfazer-se deste produto, faça-o correctamente entregando-o a uma organização especializada na eliminação de equipamento eléctrico antigo, próxima de si.

Acest simbol indică faptul că produsul marcat în acest fel nu trebuie aruncat ca și un gunoi menajer obișnuit. Deoarece acesta este un produs B2B, el nu trebuie aruncat nici la centrele de colectare urbane. Dacă vreți să aruncați acest produs, vă rugăm s-o faceți într-un mod adecvat, ducând-ul la cea mai apropiată firmă specializată în colectarea echipamentelor electrice uzate.

Tento symbol znamená, že takto označený výrobok sa nesmie likvidovať ako bežný komunálny odpad.Keďže sa jedná o výrobok triedy B2B, nesmie sa likvidovať ani na mestských skládkach odpadu. Ak chcete tento výrobok likvidovať, odneste ho do najbližšej organizácie, ktorá sa špecializuje na likvidáciu starých elektrických zariadení.

Ta simbol pomeni, da izdelka, ki je z njim označen, ne smete zavreči kot običajne gospodinjske odpadke. Ker je to izdelek, namenjen za druge proizvajalce, ga ni dovoljeno odlagati v centrih za civilno odlaganje odpadkov. Če želite izdelek zavreči, prosimo, da to storite v skladu s predpisi, tako da ga odpeljete v bližnjo organizacijo, ki je specializirana za odlaganje stare električne opreme.

Este símbolo indica que el producto así señalizado no debe desecharse como los residuos domésticos normales. Dado que es un producto de consumo profesional, tampoco debe llevarse a centros de recogida selectiva municipales. Si desea desechar este producto, hágalo debidamente acudiendo a una organización de su zona que esté especializada en el tratamiento de residuos de aparatos eléctricos usados.

Den här symbolen indikerar att produkten inte får blandas med normalt hushållsavfall då den är förbrukad. Eftersom produkten är en så kallad B2B-produkt är den inte avsedd för privata konsumenter, den får således inte avfallshanteras på allmänna miljö- eller återvinningsstationer då den är förbrukad. Om ni vill avfallshantera den här produkten på rätt sätt, ska ni lämna den till myndighet eller företag, specialiserad på avfallshantering av förbrukad elektrisk utrustning i ert närområde.