Megger

Operating Instructions

tan Delta Test Attachment

Mess- und Ortungstechnik
Measuring and Locating Technologies

Elektrizitätsnetze
Power Networks

Kommunikationsnetze
Communication Networks

Rohrleitungsnetze
Water Networks

Leitungsortung
Line Locating

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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:

Megger Limited

Archcliffe Road
Kent CT17 9EN

T: +44 1304 502100

F: +44 1304 207342

E: uksales@megger.com

Seba Dynatronic

Mess- und Ortungstechnik GmbH

Dr.-Herbert-Iann-Str. 6
D - 96148 Baunach

T: +49 9544 68 – 0

F: +49 9544 22 73

E: sales@sebakmt.com

Hagenuk KMT

Kabelmesstechnik GmbH

Röderaue 41
D - 01471 Radeburg / Dresden

T: +49 35208 84 – 0

F: +49 35208 84 249

E: sales@sebakmt.com

Megger USA

Valley Forge Corporate Centre
2621 Van Buren Avenue
Norristown, PA 19403 USA

T: +1 610 676 8500

F: +1 610 676 8610

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 Advices

1.1 General Notes

Safety precautions

This manual contains basic instructions on commissioning and operating the tan Delta test attachment. For this reason, it is important to ensure that the manual is available at all times to authorised and trained personnel. Any personnel who will be using the devices should read the manual thoroughly. The manufacturer will not be held liable for any injury or damage to personnel or property through failure to observe the safety precautions contained in this handbook.

Locally applying regulations have to be observed.

Labelling of safety instructions

Important instructions concerning personal, operational and technical safety are marked in the text as follows:

Symbol	Description
 WARNING	Indicates a potential danger that may lead to fatal or serious injury.
 CAUTION	Indicates a potentially hazardous situation which, if not avoided, may result in minor or moderate injury or material damage.
	The notes contain important information and useful tips for using the system. Failure to observe them can render the measuring results useless.

Working with products from Megger

It is important to observe the general 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 rules (work, operating and safety regulations).

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

Operating staff

This system and its peripheral equipment may only be operated by trained or instructed personnel. Anyone else must be kept away.

The system may only be installed 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.

Repair and maintenance

Repairs and service must only be done by Megger or authorised service departments of Megger. Megger recommends having the equipment serviced and checked once per year at a Megger service location.

Megger also offers direct on-site support. Please contact our service office for more information.

1.2 General Cautions and Warnings

Intended application

The tan Delta test attachment can be used to measure the loss factor tanδ of cables and transformers (see section 2.3).

Using the equipment for other purposes may lead to human danger and damage of equipment of involved installations.

The limits described under technical data may not be exceeded.

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. Ground 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.

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.

2 Technical Description

2.1 Technical Priciples

Requirement

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.

One measure for these dielectric losses is the loss factor tanδ.

To prevent cable faults or detect cables with critical ageing, the measurement of tanδ is a useful diagnostic method.

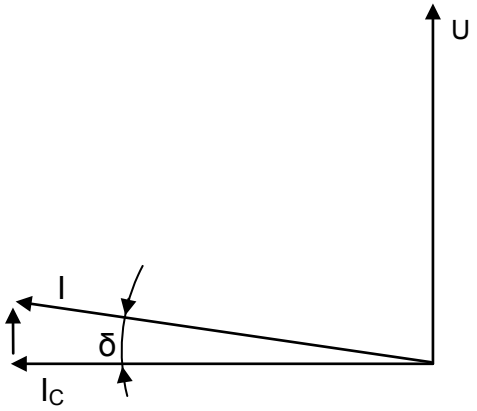
Physical background

The dielectric losses are primarily determined by the conductivity losses in the cable insulation. With mass-impregnated paper insulation cables, polarisation losses likewise influence the loss factor.

The dielectric losses (tanδ) can be calculated as follows:

$$\tan\delta = \frac{I_R}{I_C} = \frac{1}{\omega RC}$$

Shown as a vector diagram, this gives the following picture:



Put simply, the insulation resistance is inversely proportional to the tanδ. With a rising proportion of active current I_R an increase is consequently also seen in the tanδ.

Typical indicators of aged cables

The most important age indicator for **mass-impregnated paper insulation cables** is the decomposition of cellulose, which, in principle, acts to increase the moisture in the paper insulation (through thermal and chemical processes). The moisture decreases the insulation resistance and thus raises the cable insulation's loss factor tanδ.

Water that has penetrated the insulation from outside also has a considerable influence on the loss factor.

For **VPE cables**, the absolute value of the loss factor is less decisive than the change of the tanδ with increasing voltage (Δtanδ or “tip-up”). The dielectric properties of water in water trees do not behave in a linear manner with increasing voltage and are thus detectable using appropriate diagnostic methods.

Water trees are the most frequent age indicator for polymer cables and can definitely lead to abrupt cable failures.

2.2 Technical Data

The tan Delta test attachment is defined by the following parameters:

Parameter	Value
Measuring range, tanδ	1 x 10^{-4} ... 1 x 10^{0}
Measuring accuracy	1 x 10^{-4}
Resolution	1 x 10^{-5}
Frequency	0.01 Hz … 1 Hz (10 Hz with accuracy limitations)
Testable cable capacitance	2 nF ... 3 µF (10 m … 15 km VPE cable for example)
Maximum voltage	54 kV_{PEAK}
Measuring range, current	
Measurement Data Unit (MDU)	1 µA .. 25 mA
Termination Current Unit (TCU)	1 µA .. 1 mA
Measuring range, insulation resistance	1 MΩ … 10 TΩ
Power supply	
MDU / TCU	battery-operated
Charger	90 V ... 240 V, 50/60 Hz AC (via power cable) or 12 VDC (via optional vehicle charging cable)
Operating time	
Measurement Data Unit (MDU)	16 hours (for operation with TCU) 32 hours (for operation without TCU)
Termination Current Unit (TCU)	24 hours
Charging time	3.5 h
Interfaces	
Measurement Data Unit (MDU)	optical interface (TOSLINK), wireless connection (868/915 MHz)
Termination Current Unit (TCU)	optical interface (TOSLINK)
Data Reception Unit (DRU)	connection to PC via USB (DRU) or Ethernet (DRU-1) connection to MDU via radio link (868/915 MHz)
Operating temperature range	-25 °C...+55 °C
Operating humidity	+30 °C, 70 % relative humidity
Storage temperature range	-40 °C...+70 °C
Weight	
Measurement Data Unit (MDU)	2.6 kg
Termination Current Unit (TCU)	1.6 kg
System with case, tripod, accessories and cables	12.25 kg
Protection rating	(in accordance with IEC 60529)
MDU, TCU, tripod	IP52
case (closed)	IP62
case (open)	IP30

2.3 System Description

Area of application

Dielectric losses can be measured on cables with XLPE (Cross Linked Polyethylene), PE (Polyethylene), PILC (Paper Insulated Lead Covered) and EPR (Ethylene-Propylene Rubber) insulation.

The measurement results for mixed sections can only be conditionally interpreted. It is possible, for example, to diagnose a PILC cable section with a small proportion of XLPE cable (e.g. about 10%) according to the criteria for a regular mass impregnated cable.

However, a XLPE/PE cable section with a certain proportion of PILC cable cannot be evaluated according to the known criteria for XLPE/PE insulation. This is due to the fact that measurements on even fault-free mass PILC cables show a considerably higher dielectric loss factor.

Prerequisites

In order to use the tan Delta test attachment to measure the loss factor, a VLF sine wave voltage source (VLF Sinus test system) is required for applying a sinusoidal voltage to the test object.

It does not matter if the VLF sine wave is used as a stand-alone system or as a component of a measurement or diagnostics device.

It is only important that the version of the software used by this system is able to analyse tanδ measured values. This is always evident in that a corresponding operating mode is provided in the software.

If this is not the case, please contact your Megger sales representative.

The tan Delta test attachment has been developed and designed exclusively for use with VLF sine wave systems of the Megger Group. If other test voltage sources are used, no guarantee can be made for trouble-free functioning and correct measurement results.

System components

The tan Delta test attachment consists of three main components, which are responsible for different tasks:

- **Measurement unit**
  The “Measurement Data Unit” (MDU) is directly integrated in the HV link between the sine wave source and test object and measures the object's current and voltage. The measured data are transmitted to the software per wireless signal via the E-Box.
- **Termination Current Unit**
  (only if your product configuration includes leakage current compensation)
  The task of the “Termination Current Unit” (TCU) is to record the leakage current over the terminations and to transfer this information to the measurement unit via the optical link.
- **Data Reception Unit**
  The “Data Reception Unit“ (DRU) enables the exchange of control and measurement data between the software and the measurement unit via wireless signal and USB interface.

2.3.1 Scope of Delivery and Accessories

Scope of delivery

In addition to the above described main components, the tan Delta test attachment's scope of delivery also includes the following components:

- Measurement unit (MDU)
- Data Reception Unit (DRU or DRU-1)
- Transport case / charging device
- Tripod
- 1 x custom HV connection cable with "guard" connections, 1 m
- 1 x power cable, 2 m
- 1 x USB or Ethernet cable, 1 m (for connecting the DRU)
- 1 x Ethernet cable, 1,5 m (for connecting the test voltage source)
- 1 x Ethernet cable, 30 m on cable drum (only for test van installations)
- 1 x earthing cables (green/yellow), 1.5 m
- 2 x measurement cables, 5 m
- 1 x operating manual
- Recovery CD

If the product configuration includes leakage current compensation, the package also contains the following components:

- Termination Current Unit (TCU)
- 2 x "guard" strips for leakage current measurement
- 2 x fibre-optic cables (TOSLINK), 3 m
- 1 x earthing cables (green/yellow), 1.5 m
- 1 x soft tie for fastening the TCU

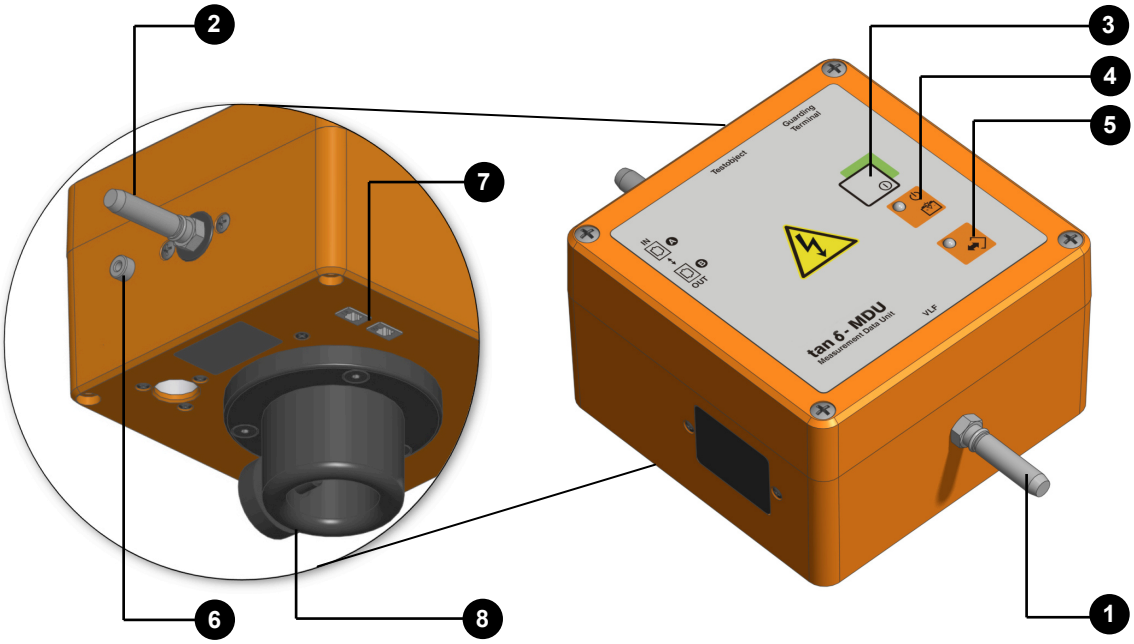
Optional accessories

The following optional accessories can be ordered::

Item	Description	Order number
Longer Ethernet cable	30 m on cable drum	820023868
Longer HV connection cable	3 m pre-assembled HV connection cable with "guard" connections	820020993
Connection set	Provides adequate adapters for typical connection conditions (see also chapter 6)	890017909

2.3.2 Measurement Data Unit (MDU)

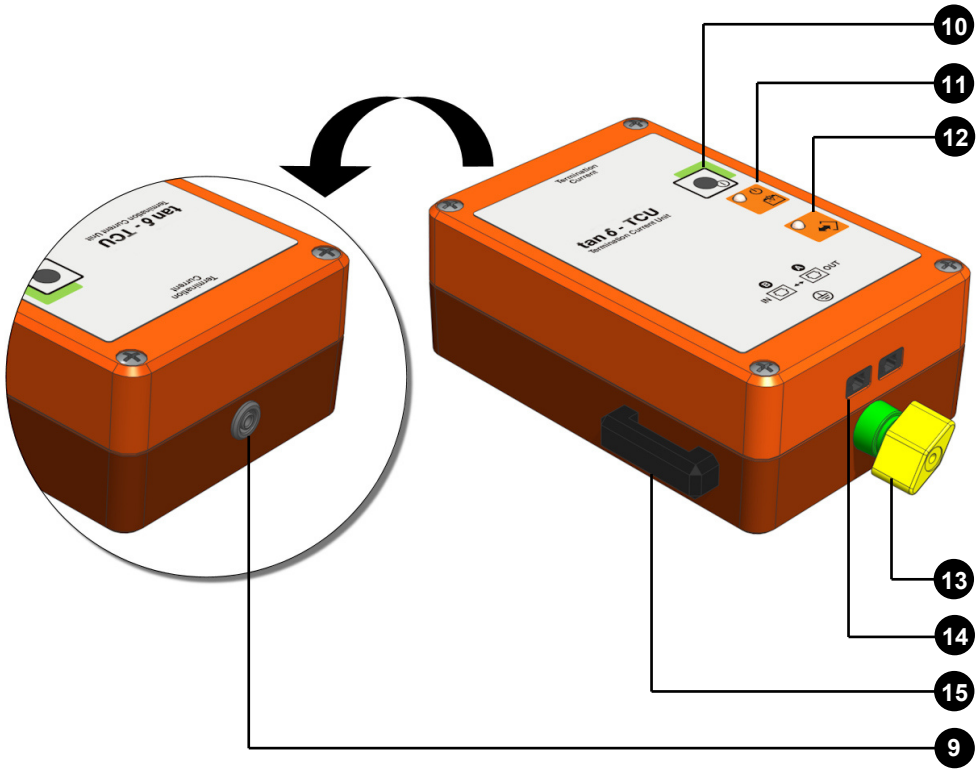
The following illustrations show the connection and operating elements of the MDU:



Element	Beschreibung
❶	**HV connection, VLF sine wave source, Ø 10 mm**
❷	**HV connection test object, Ø 10 mm**
❸	**On/off button**
❹	**Status LED** lit in green: operational lit in orange: charging
❺	**Communications LED** flashing green: Device is ready and awaiting activation (no high voltage is applied yet) flashing red: Processing of measurement data (high voltage on!) flashing blue: Communication with TCU
❻	**„Guarding“ terminal**
❼	**TOSLINK connection sockets (IN / OUT)**
❽	**Tripod attachment** with adjusting device and earth contacts

2.3.3 Termination Current Unit (TCU)

The following illustrations show the connection and operating elements of the TCU:



Element	Beschreibung
❾	**Leakage current connection** (guarding)
❿	**On/off button**
⓫	**Status LED** lit in green: operational lit in orange: charging
⓬	**Communications LED** flashing blue: Communication with MDU
⓭	**Earthing connection**
⓮	**TOSLINK connection sockets (IN / OUT)**
⓯	**Holder** (on both sides) for fastening the TCU with the enclosed soft ties

3 Setting Up the System

3.1 Connecting the DRU or DRU-1

Introduction

The Data Reception Unit is available in two different models, with the respective model which best suits the system features being used.

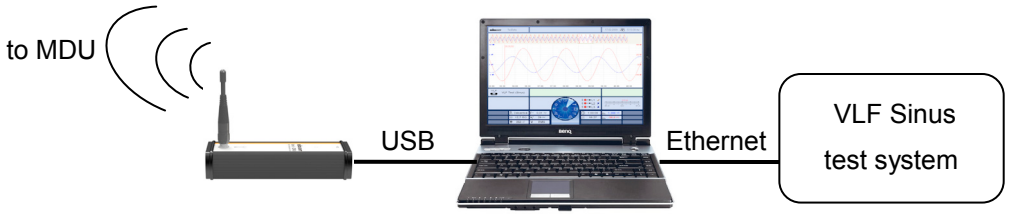
The DRU, which features a USB port, is generally used in systems which are operated using a laptop computer (e.g. diagnostic test vans, portable systems).

The DRU-1 model instead features a network connection, and is used in test van systems with a central control unit (e.g. Centrix).

Both models are powered via the respective connection cable, and are activated and deactivated by connecting the cable and disconnecting it.

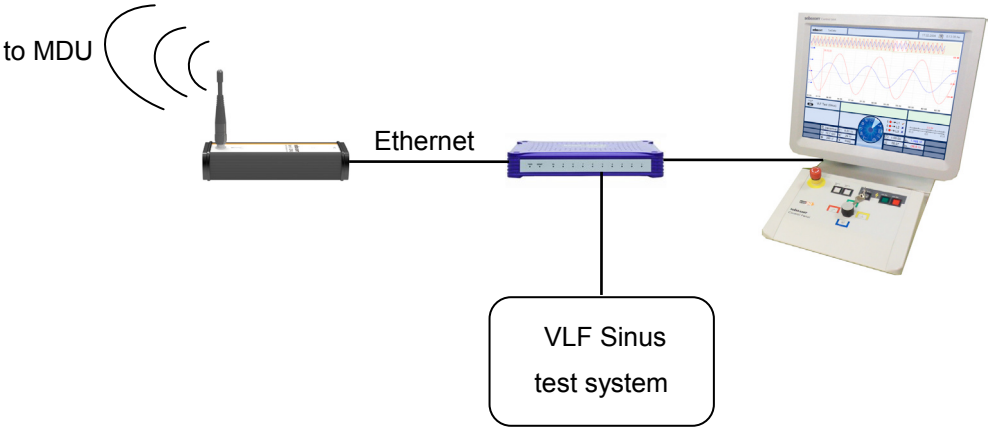
Connecting the DRU

For portable systems, the operator must connect the DRU manually prior to each measuring assignment. This step is usually not required for built-in test van systems.



Connecting the DRU-1

In test vans which are operated via one central control unit, the Data Reception Unit usually has a standing connection with the IPC and the test voltage source via a PoE-capable (Power over Ethernet) network switch.



If the test van is located at a remote distance from the test object, e.g. in front of a larger substation, problems could arise in the wireless connection between the DRU-1 and the MDU. This would be signalled by a fault message output to the screen.

In this case, a longer Ethernet cable (see section 2.3.1) should be used to connect the DRU-1 to the switch. In this way, the DRU-1 can be brought closer to the MDU and a continuous wireless connection can be ensured.

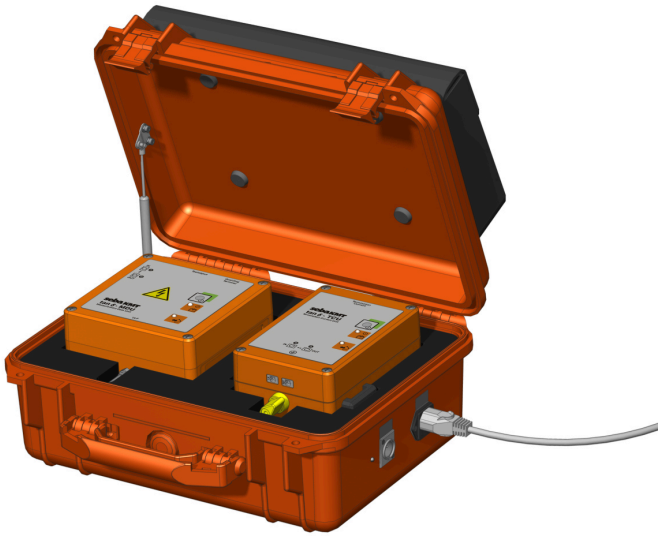
3.2 Power Supply

Both the MDU and the TCU have an internal, maintenance-free nickel metal hydride battery. When the batteries are fully charged, both devices can be operated together during measurements for up to 16 hours.

When the capacity is low, the respective status LED (4 or 11) begins to flash orange. The affected device also emits a signal tone at regular intervals. During measurement, the remaining capacity can also be seen in the software.

It is recommended to check both devices for sufficient capacitance before connecting them.

To charge the devices, they need merely be placed in the position provided in the transport case and then connected to the mains with the supplied power cable (90 V ... 240 V, 50/60 Hz AC).



Alternatively, an optional vehicle charging cable for connection to 12 VDC can be used.

The charging procedure takes about 3.5 hours. The status LED is lit in orange during the charging. When the battery is fully charged, the LED lights up green.

3.3 Electrical Connection

 WARNING	When performing the following listed work steps, the applicable safety regulations as specified by VDE 0104 and the “five safety rules” must be followed when setting up and operating high voltage testing systems (see section 1.2). The test site and the forbidden area must be made safe, fenced off and equipped with indicator lamps and warning signs according to the regulations.

 WARNING	Before performing the actual electrical connection of the tan Delta test attachment, the VLF sine wave test system must be brought into position, secured and earthed according to the work steps described in the manual. Connection of the VLF sine wave test system to the mains may only be done after the installation of the tan Delta test attachment.

 CAUTION	The measuring sensors were functionally tested for alternating currents of up to 40 kV_{RMS}. To avoid damage, tests with higher alternating current or any other operating mode (e.g. interval operation, DC tests) may not be performed with the test attachment installed!

	As a rule, the connection on the test object should be made free of partial discharge. Partial discharges at the connection point could falsify the measurment results.

Versions of measurement set-up

For a measurement of the loss factor, only the measurement unit MDU needs to be installed - as described in the following section - in the HV path between test voltage source and test object.

If, during the measurement, the leakage current over the terminations is additionally to be recorded and considered in the measurement result, the TCU box must also be installed in the immediate vicinity of the test object. Electrical connections must also be made on the remote end (see section 3.3.2).

A measurement with leakage current compensation is always recommended, if small tanδ values are to be expected. For example, this can be expected when measuring on homopolymeric and copolymeric XLPE cables. In these cases, the leakage current caused by dirty or moist cable terminations should not be neglected. If this is not recorded and compensated for, the measurement results can be falsified which would make the analysis more complicated.

If the terminations are obviously clean or if the measurement is performed on aged paper-insulated lead covered (PILC) cables, leakage current compensation is not a mandatory requirement.


To obtain comparable measurement results, repeat measurements must always be undertaken with the identical measurement set-up.

Measures for improving the measuring accuracy

The following factors can have unwanted influence on the measurement results and at worst lead to false interpretations:

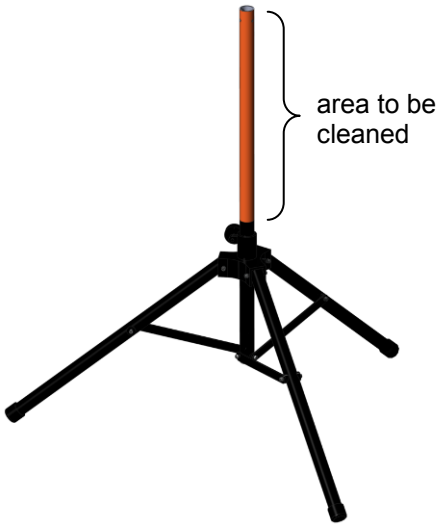
- **Dirt** on the test attachment, especially in the upper area of the stand. Soiling due to grease, dirt and scratches are the main causes of falsified measurement results.
- **Condensation** can appear if the tan Delta test attachment was stored in a cold place (e.g. overnight in the test van) and the system is afterward set up in a warm station. The condensation due to air humidity can be clearly seen and felt.
- **High air humidity** (>70%), which can occur in certain regions.

Falsified measurement results carry more weight the more limited the measured tanδ values. The measures described in the following should particularly be performed for measurements of relatively new homopolymeric and coploymeric XLPE cables.

For measurements of aged XLPE cables, new and old PILC cables, as well as EPR cables, the falsifications that appear can generally be ignored.

It is recommended, however, to adhere to the following rules for everyday handling of the tan Delta test attachment:

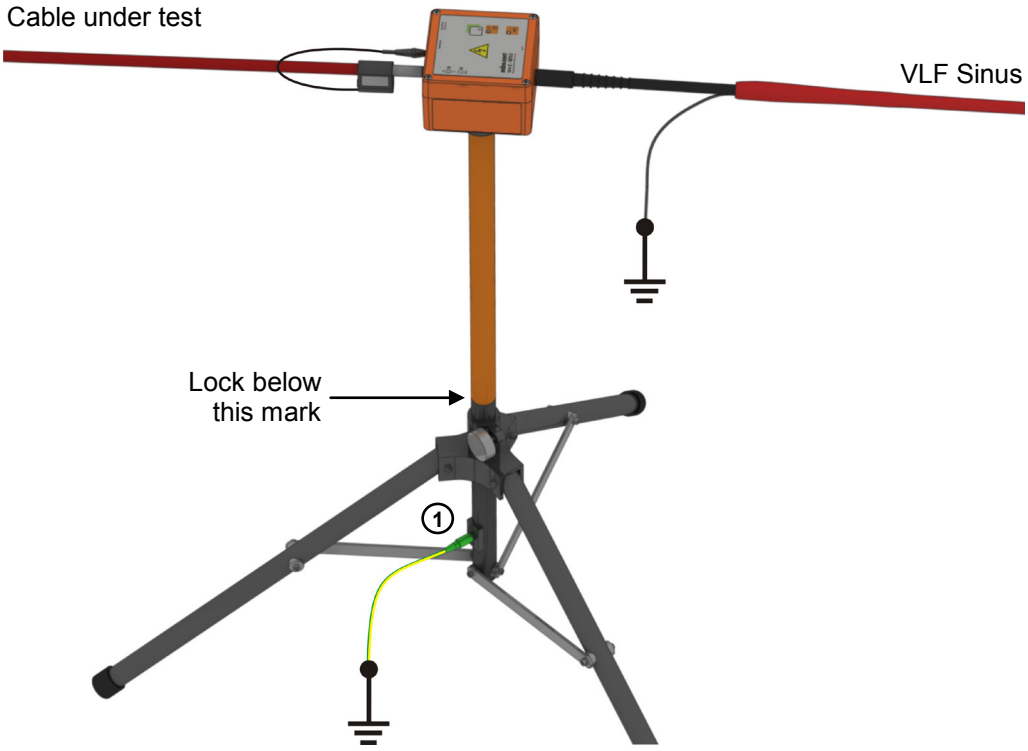
- Try to avoid condensation in the system due to air humidity. Do not store the test attachment in a cold place if the measurement will later be performed in a warm station. If this is not possible, the devices (MDU on stand) should be set up about 1-2 hours prior to the measurement in order to acclimatise them. It is recommended to perform such an acclimatisation before every measurement.
- Try to avoid performing measurements with the test attachment on days with clearly higher air humidity. High humidity affects not only the test attachment, but also the test object and its terminations in particular. Increased humidity typically results in lower than usual tanδ absolute values.
- Clean the upper part of the stand with a dry cloth before beginning a measurement. This will remove deposited dirt as well as any condensation due to humidity.



3.3.1 Electrical Connection for Measurements without Leakage Current Compensation

Connection of the MDU

The following is an idealised illustration depicting the electrical connection of the MDU for measurements without leakage current compensation:



When connecting the MDU, proceed as follows:

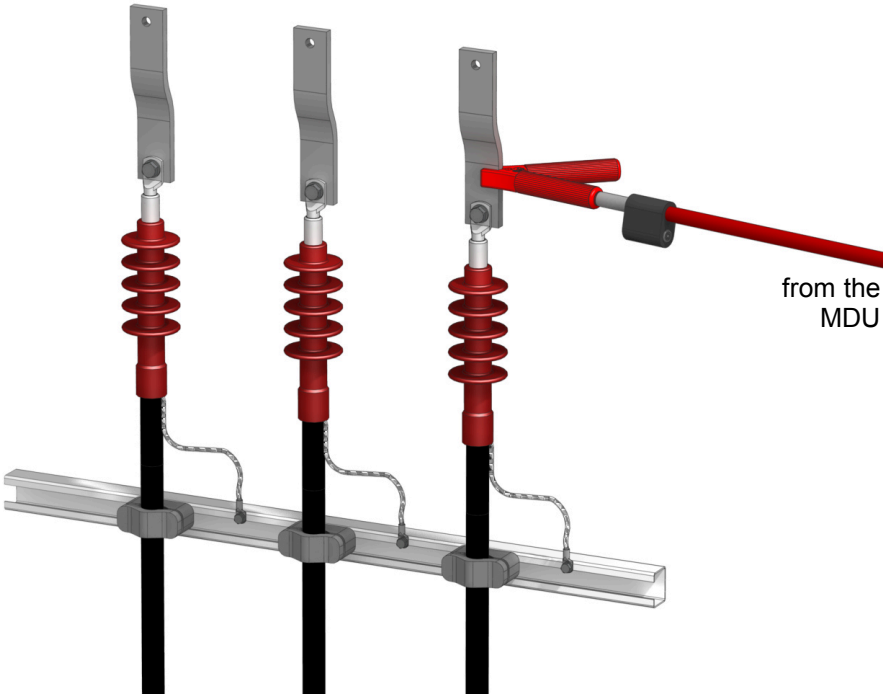
Step	Description
1	Place the tripod between the test voltage source and the test object. Ensure that the tripod has solid and secure footing. Set the height of the stand so that the orange portion of pipe rises completely out of the tripod (see figure).
2	Connect the earthing point ① with the station earth. Use the supplied earth cable and the measuring cable with banana plugs.
3	Connect the phase of the HV cable coming from the test voltage source with the HV plug ❶ of the MDU (VLF) and the shield of the cable with the laid earth line (station earth) from **Step 2**. Details of the procedure can also be found in the operating manual for the test voltage source.
4	Connect the phase of the supplied HV connection cable (the end with the fixed “guarding” lead) with the remaining HV plug ❷ of the MDU (test object) and plug the “guarding” lead into the “guarding” terminal ❻.

Connection to the test object

Connect the other end of the HV cable coming from the MDU to the phase of the test object which is to be tested, as described in the operating manual of the test voltage source. If measurements of multiple phases are planned, the numerically lowest phase should always be connected first.

To ensure a connection free of partial discharges, the appropriate connection accessories from the kit should be used according to the connection requirements.

The shield of the HV connection cable, as indicated in the following example illustration, is to be fastened in the upper area of the termination using the copper band. The copper band should lie taut on the termination. It should lie as fully against it as possible (without air gaps) so that it can compensate for all leakage currents.

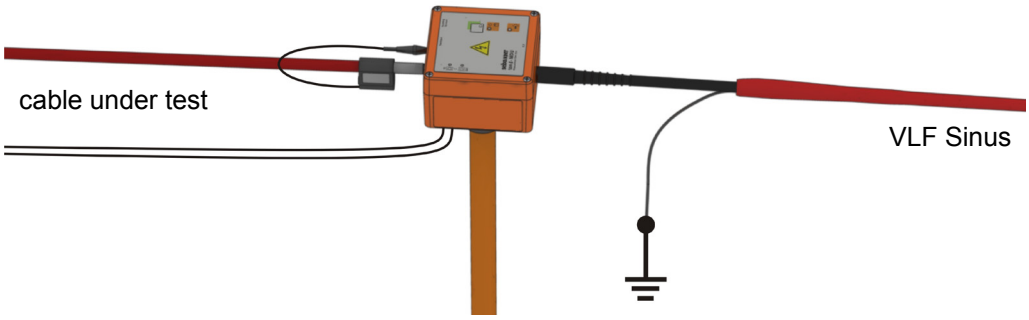


A selection of other possible connection conditions, see chapter 6.

3.3.2 Electrical Connection for Measurements with Leakage Current Compensation

Connection of the MDU

The following illustration depicts **in a simplified manner** the electrical connection of the MDU for measurements with leakage current compensation:



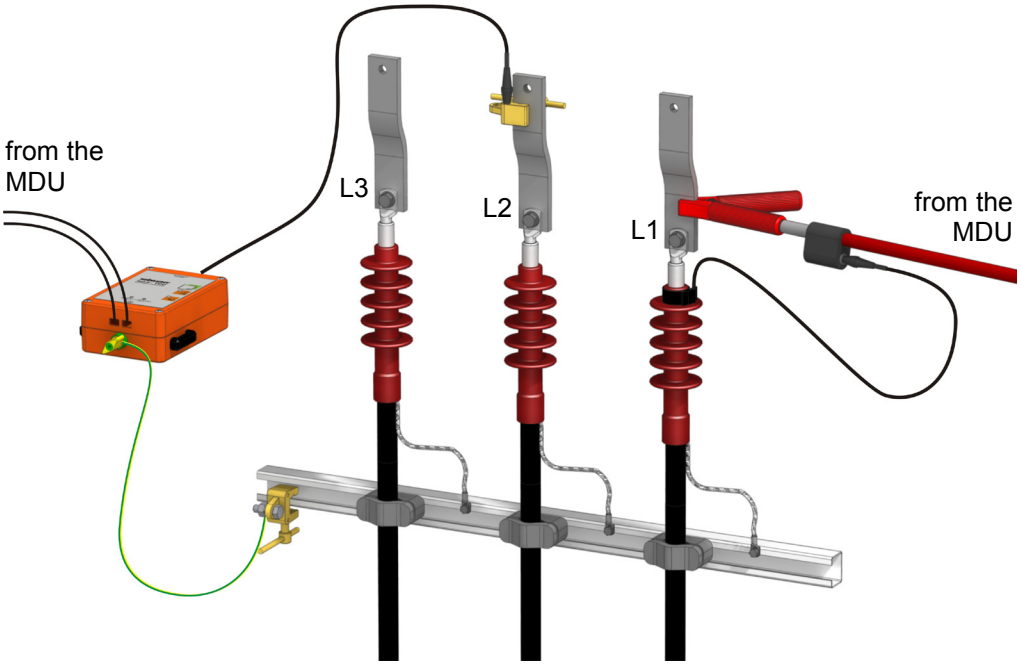
For measurements with leakage current compensation, the MDU is connected the same way as described in the previous section.

Additionally, the two fibre-optic cables supplied in the delivery must be inserted in the TOSLINK connection sockets ❼ on the underside of the MDU and later connected with the TCU (see next page).

When laying the cables, avoid kinks, twists, bending radiuses that are too tight and mechanical deformations. The cables should not be subject to any chafing or winding.

Connection of the TCU

The following illustration depicts **in a simplified manner** the electrical connection of the TCU for measurements with leakage current compensation. In the example shown, phase L1 is tested and the leakage current is transported from the remote termination to the test point via phase L2. No diagnosis is made for phase L2; it is merely used as a transport medium.



When connecting the TCU, proceed as follows:

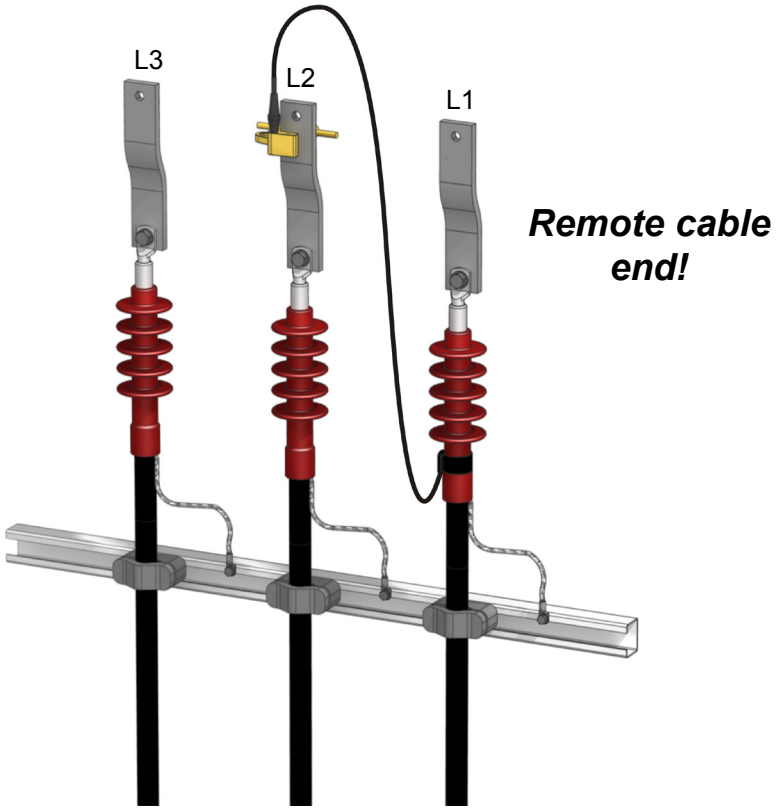
Step	Description
1	Fasten the TCU with the enclosed soft ties and holders ⑮ so that it is as close as possible to the cable to be tested.
2	Connect the two fibre-optic cables coming from the MDU with the TOSLINK connection sockets ⑭ of the TCU. In doing so, ensure that each of the sockets **IN** and **OUT** are connected with each other (Ⓐ ↔ Ⓐ and Ⓑ ↔ Ⓑ).
3	Connect the earthing connection ⑬ of the TCU with the station earth.
4	Connect the leakage current connection ⑨ of the TCU with one of the two unused phases of the test object (L2 in the example).
5	Connect the phase of the HV connection cable coming from the MDU with the phase to be tested.
6	Using the copper tie, fasten the shield of the HV connection cable in the upper area of the termination as shown in the figure. The copper band should lie taut on the termination. It should lie as fully against it as possible (without air gaps) so that it can compensate for all the leakage currents.

Electrical connection on remote cable end

In order for the leakage current of the remote termination to likewise be compensated, an additional copper band (shielding) must be installed on the remote cable end as well, as shown in the following illustration.

To do so, use the supplied cable to connect the termination of the phase to be tested (L1 in the example) and the phase on which the TCU will measure the leakage current (L2 in the example; see also previous page).

This time, fasten the copper band in the lower area of the termination.



3.4 Starting Up the Test Attachment and the Test Voltage Source

After the electrical / optical connections of the MDU and, if required, the TCU have been made according to the previous sections, the modules must then be switched on.

To do so, press the respective On / Off button (3 or 10) for about two seconds, after which an acoustic signal will sound and the status LED (4 or 11) should be continuously lit in green. For measurements with the TCU, turn on the TCU first, followed by the MDU.

After the tan Delta test attachment has thus been made ready, the VLF Sinus test system can be connected with the mains supply and put into operation as described in the accompanying manual.

4 Performing Measurements

The actual measurement and the evaluation of the measured data are carried out either on a notebook connected to the test voltage source or on the control unit of the test van and are not covered in these instructions.

For detailed information on how to perform a Tan Delta measurement, please read the operating manual of the test and diagnosis module in use or the guide “Software for remote control of a VLF Sinus test system”.

5 Concluding the Measurement

After the measurements have been completed and the measurement data evaluated, logged and if necessary saved, the test system can be switched off.

The system should then be disconnected from the mains power supply.

 **WARNING**	**Follow the five safety rules** To establish and ensure the voltage-free state before disassembling the test attachment, the five safety rules described in section 1.2 must be followed.

 **CAUTION**	After disassembly of the tan Delta test attachment, the optical TOSLINK- connection sockets on the MDU and TCU are to be immediately safeguarded with the supplied cover caps to protect them from dust and dirt.

6 Connection examples

Introduction

In this chapter, selected examples are used to point out possible problem areas to be considered when connecting the tan Delta test attachment.

In principle, it can be said that the effects of unfavourable connection conditions are clearly less critical if higher tanδ absolute values are expected (e.g. for PILC cables).

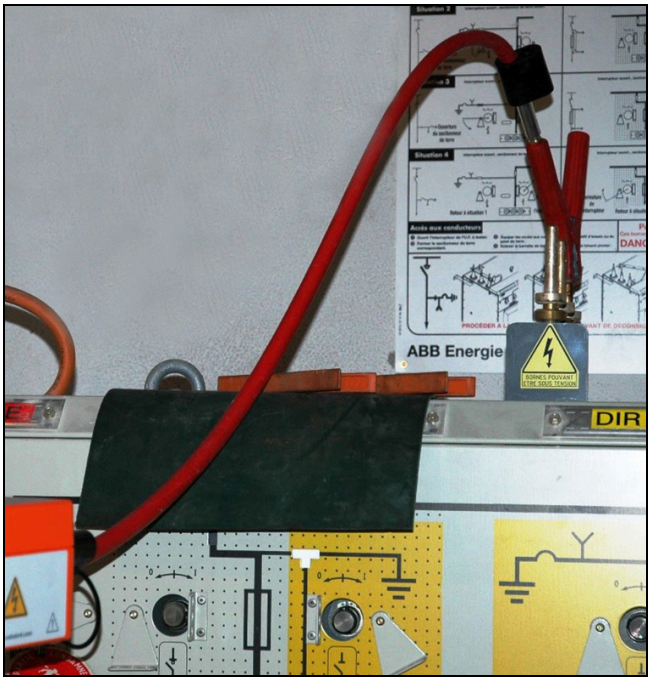
Partial discharge-free connection

A PD-free connection is an important point not only when performing a partial discharge measurement. The dielectric loss factor can also be falsified by strong partial discharges at the connection points. It is therefore very important to ensure a PD-free connection.

For this, adequate clearance must be maintained between the earthed components and the voltage-conducting cable. Since the danger posed by PD depends heavily on the selected test voltage, the required safety clearance can vary and should amount to about 1 cm per kV. In most cases, an air gap of about 30 cm to the metallic edges and objects is sufficient to avoid partial discharges.

Below is an example in which the HV connection cable is laid too close to a different phase:

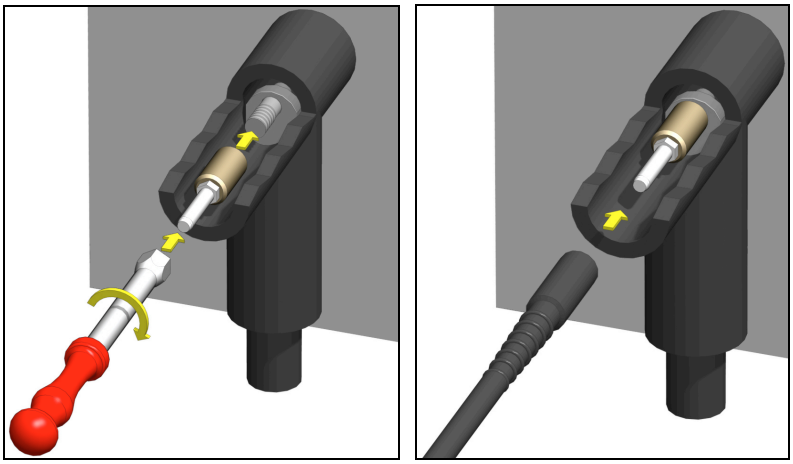
In particularly tight situations (such as in the following shown substation), one can undertake suitable protective measures to avoid a flashover. In this case, a semiconducting rubber mat was laid between the connection cable and the metal edge. Another point to be aware of is the connection to the phase. Special care should be taken here to ensure a PD-free connection.



Connection to right-angle plug

Switch gear with elbow connectors are generally difficult to connect with the connector pliers. A cable connected thusly can furthermore only be subjected to limited strain, which makes it considerably more difficult to increase the clearances to the metallic (earthed) edges of the switchgear.

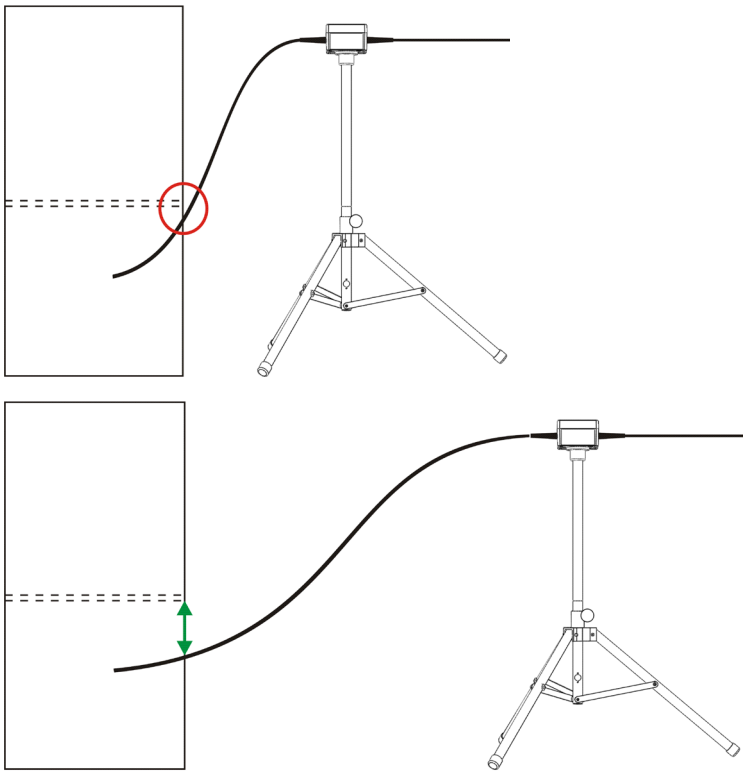
For this connection situation, the optionally available connection set (see section 2.3.1) provides a suitable adapter used to directly plug the connection cable on the MC connector:



Since this adapter ensures a secure fit, the cable can be aligned better and guided past the metallic components as shown below.

Using a longer connection cable

Because of the height of the stand, it may be helpful in certain circumstances to use the optionally available 3 m long HV connection cable (see section 2.3.1) to ensure the necessary safety clearance to the metallic components.



As a rule however, it is recommended to keep the connection length of the line as short as possible!

Connection to bus bars

The HV conection cable can also be connected to bus bars. The test object does not have to be disconnected from the switchgear.

The following is an example for a connection to a bus bar:

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 şi un gunoi menajer obişnuit. Deoarece acesta este un produs B2B, el nu trebuie aruncat nici la centrele de colectare urbane. Dacă vreţi să aruncaţi acest produs, vă rugăm s-o faceţi 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.