User Manual

Portable / Vehicle Mounted
Fault Locating System
SMART THUMP ST25-30
covering units *with* and *without*
MULTI SHOT Capability

Read this entire manual before operating.

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Valley Forge Corporate Center
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U.S.A.

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www.megger.com

Portable / Vehicle Mounted Fault Locating System
SMART THUMP ST25-30

The information presented in this manual is believed to be adequate for the intended use of the product. If the product or its individual instruments are used for purposes other than those specified herein, confirmation of their validity and suitability must be obtained from Megger. Refer to the warranty information below. Specifications are subject to change without notice.

WARRANTY

Products supplied by Megger are warranted against defects in material and workmanship for a period of one year following shipment. Our liability is specifically limited to replacing or repairing, at our option, defective equipment. Equipment returned for repair must be shipped prepaid and insured. Contact your local MEGGER representative for instructions and a return authorization (RA) number. Please indicate all pertinent information, including problem symptoms. Also specify the serial number and the catalog number of the unit. This warranty does not include batteries, lamps or other expendable items, where the original manufacturer's warranty shall apply. We make no other warranty. The warranty is void in the event of abuse (failure to follow recommended operating procedures) or failure by the customer to perform specific maintenance as indicated in this manual.

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Table of Contents

Receiving Instructions

1. Check the equipment received against the packing list to ensure that all materials are present. Notify Megger of any shortage. Email your local Service Representative or send to *VFCustomerSupport@Megger.com*.

2. Examine the equipment for damage received in transit. If damage is discovered, file a claim with the carrier at once and notify Megger, giving a detailed description of the damage.

3. Prior to operation, check for loosened hardware or damage incurred during transit. If these conditions are found, a safety hazard is likely,
DO NOT attempt to operate equipment.

    Please contact Megger as soon as possible.

    Please check your delivery against:

    a) your order
    b) our advice note
    c) the item delivered, and
    d) the parts list

    any shortages must be reported immediately.

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, please contact:

VFCustomerSupport@Megger.com
or
phone: +1.610.676.8500 (USA)

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SAFETY

Precautions

This manual contains basic instructions on commissioning and operating the SMART THUMP ST25-30 system. 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 shall read and understand 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.

Applicable local regulations have to be observed.

Warning and Caution Notices

Warning and caution notices are used throughout this manual where applicable. These notices appear in the format shown below and are defined as follows:

F

WARNING!

Warning, as used in this manual, is defined as a condition or practice which could result in personal injury or loss of life.

G

CAUTION

Caution, as used in this manual, is defined as a condition or practice which could result in damage to or destruction of the equipment or apparatus under test. The user must consult the User Guide when this symbol marked on the instrument.

u

PROTECTIVE EARTH TERMINAL

NOTE:	*The notes contain important information and useful tips for using the system. Failure to observe them can render the measuring results useless.*

Working with the Product

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).

After working with the equipment, make sure to de-energise, protect against re-energising; discharge, earth and short-circuit the equipment and installations that have been worked on.

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

Operating Personnel

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 a trained or authorized electrician. In Germany 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 recognize potential hazards.

Repair and Maintenance

Repairs and service must only be done by Megger or Megger authorized service departments. 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

General Cautions and Warnings

Intended Application

Safe operation is only warranted if using the equipment for its intended purpose. Using the equipment for other purposes may result in bodily harm or death of the operator and damage the equipment itself and that of the involved test site.

The limits described under technical data may not be exceeded. Operating Megger products in environments, which feature high humidity in combination with condensation, may lead to flash-over, creepage, danger and damage. The instruments should only be operated under tempered conditions. It is not allowed to operate Megger products in direct contact with humidity, water or near aggressive chemicals nor explosive gases and fumes.

What to Do if Equipment Malfunctions

The equipment shall only be used when working properly. If irregularities or malfunctions appear which 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 equipment shall only be operated after the malfunction is resolved.

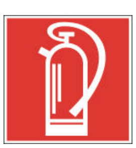
Five Safety Rules

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

1. De-energize
2. Protect against re-energizing
3. Confirm absence of voltage
4. Ground and short-circuit
5. Cover close by energized components

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 **Carbon Dioxide** 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 an ARC FLASH (voltage arc-over created by the powder dust cloud).

- It is essential to observe the safety instruction on the extinguishing agent.
- Applicable is DIN VDE 0132 in Germany

WARNING

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Dangers when working with HV

Special attention and safety awareness are needed when operating HV equipment and especially non-stationary equipment. The regulations VDE 0104 about setting up and operation of electric test equipment, i.e. the corresponding EN 50191 as well as country-specific regulations and standards must be observed.

- The system generates a dangerous voltage of up to 20 kV during operation. This is supplied via a HV cable to the test object.
- The system may not be operated without supervision.
- Safety installations may not be by-passed nor deactivated.
- All metallic parts in proximity of the test equipment must be grounded in order to avoid the build-up of hazardous electric surface charges.

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WARNING

Not paying attention or correcting unsafe conditions can lead to personal injury and potential death

IMPORTANT SAFETY ADVISORY NOTE -
WHEN WORKING WITH HV SURGE GENERATOR / THUMPER

REQUIREMENTS FOR SAFE WORK ENVIRONMENT WHEN PERFORMING MV or LV POWER CABLE FAULT LOCATING BY DISCHARGING A HIGH VOLTAGE CAPACITOR (Surge generator /Thumper)

Requirements for safe High Voltage work environment
(schematic on next page)

1. Safety Ground lead of unit is connected to system grounding point of power device, ①, e.g. transformer, switchgear etc., via proper clamp, *no alligator clips*.

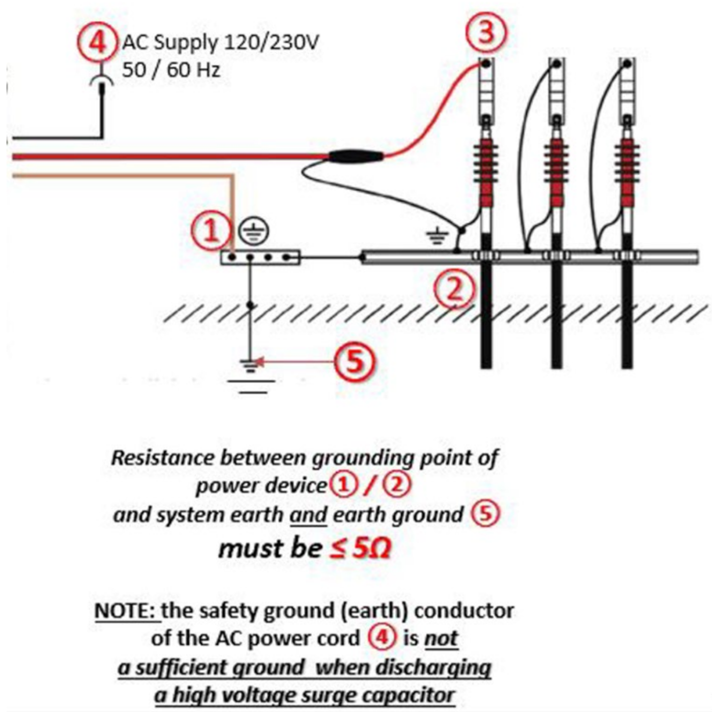
2. High Voltage Return (= shield of test lead) ② is connected via clamp to concentric neutral (shield) of power cable to be tested ***or*** to the grounded second faulty core in case of belted MV cables ***or*** to the second faulty core of a LV cable.

3. High Voltage lead ③ is connected via clamp or other proper means to the conductor of the power cable to be tested, *no alligator clips.*

4. The Concentric Neutral (shield of the cable to be tested) of the power cable, or the second faulty core of the cable to be tested must be bonded to the system grounding point of the power device (see also 1).

5. *The resistance of the* ***system grounding point*** *of the power device* ***to earth ground must be 5 Ohms or less*** when measured with an earth ground meter.

6. If a ***5 Ω or less condition cannot be attained***, the operator must follow the specific work procedures and instructions, applicable to a *"hot"/"energized"/"live"* work site; ***in Europe EN 50110-1 is mandatory***.



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TECHNICAL DESCRIPTION

System Description

Functional Description

The SMART THUMP ST25-30 is a compact fault location system typically to be used for fault locating of medium voltage power cables. It offers 2 or 3 power sources to be operated from, depending whether it is a vehicle mounted or portable version. The 3 power sources are AC line voltage, internal battery or external battery. When connected to the AC line, the portable ST25-30 will operate and if equipped with an internal battery, its 74 Ah internal battery gets simultaneously charged.

The ST25-30 is ideally suited for use in both URD systems as well as for fee- der cables and small and medium size network type systems. The 12/5/25kV surge and 30kV DC Hipot rating, in combination with the ARM Multishot fea- ture qualify the ST25-30 for all type of cable insulation materials, XLPE, EPR and also PILC. The main advantages of the ST25-30 are its solid HV perfor- mance, simple operation, automated fault locating process, capable of ope- ration in rainy conditions, weight, ergonomics and being self-contained.

Beside proven pre-location technique, like inductive ARM, current decoupling ICE, the SMART THUMP provides sectionalizing capability (trouble shooting in URD loop systems, North America), acoustic pinpointing with the integra- ted 1600 J surge generator as well as HV DC for insulation breakdown detec- tion, indication of insulation resistance and LV cable Ground fault locating/ sheath testing / sheath fault locating (sheath locating requires optional recei- ver ESG-NT).

Product Models

There are 7 configurations available for the ST25-30, 3 portable versions mounted on an integrated hand truck with large air tires and 4 vehicle mount versions with either an integrated or a remote control head.

The portable versions can be selected with **1** - (AC Only with internal Isolation Transformer), **2** - (AC with internal Isolation Transformer plus external DC/ Internal Inverter) or **3** power options (AC, External DC, Internal Battery /Inverter, no Internal isolation transformer).

The vehicle mounted versions ST25-30 can be powered by AC (internal isolation transformer) from the vehicle (via customer provided inverter) or a generator system or by AC and external DC depending on the customer's specification

When installed into a vehicle, the ST25-30 also offers either an integrated or remotely operated control head with a separation of up to 12ft between the control head and the HV unit. The remote control head is installed in a Pelicase style instrument enclosure.

This manual covers all models of the SMART THUMP ST25-30. If necessary, any differences are noted in the text.

Features

The SMART THUMP ST25-30system combines the following features and functions as a fully integrated device:

- ***Quick Steps***, ***Expert Mode*** and ***Manual Mode***, allows to address 3 levels of user skill; the ***Manual Mode*** is available in all units that are equipped with the optional Multishot feature; if set to this mode ***all TDR features are always available*** on the user interface and ***must be selected / adjusted*** by the user; the ***automatic adjustments*** known from Quick-Steps and Expert mode ***are disabled*** in Manual Mode. This mode caters to the group of users who prefer to set the TDR up according to their own experience and expertise.
- ***Quick Steps*** and ***Expert Mode provide*** Automatic fault Prelocation and localization with regard to the 2 closest transformers (Sectionalizing software for MV circuits, optional)
- Quick Steps and Expert Mode provide Automatic cable end and fault detection and localization
- DC test up to 30kV with automatic breakdown detection and insulation resistance measurement
- Pinpointing of high resistance faults in surge mode (0-12.5 or 0-25kV)

- Ground Fault (Sheath) test with automatic breakdown detection (5kV max.)
- Ground Fault (Sheath Fault)) pinpointing (requires optional receiver ESG-NT) (5kV max.)
- Integrated safety circuit for user's safety (F-OHM for verification of correct connections of Safety Ground and HV Return)
- Optional external remotely operated safety device to shut off HV and ground system (remote Emergency Off function)
- Operation from internal battery / inverter or from an external AC or external DC source (e.g. external battery)
- Sturdy and dust /weatherproof enclosure for outdoor use, IP53

Scope of Delivery

The scope of delivery of the ST25-30 system comprises of the following components:

- HV output cable hard wired
- Safety Grounding cable
- AC Power cord
- Owner's manual

Available Accessories

The following accessories* can be ordered from Megger, if required:

Accessories	**Description**	**Item number**
Elbow adaptor with 14 mm female MC connector, fits T1 terminations (***NAFTA market***)	Used to connect HV output cable	865000100100000 (15 kV) 865000200100000 (25 kV) 865000300100000 (35 kV)
External safety device	Safety device with signal lamps, key switch and EMERGENCY OFF switch	893024147 and 890024896

*see also separate ***Data Sheet*** for optional accessories and cable reels ***CFL_ACCESS_DS_US_V04***

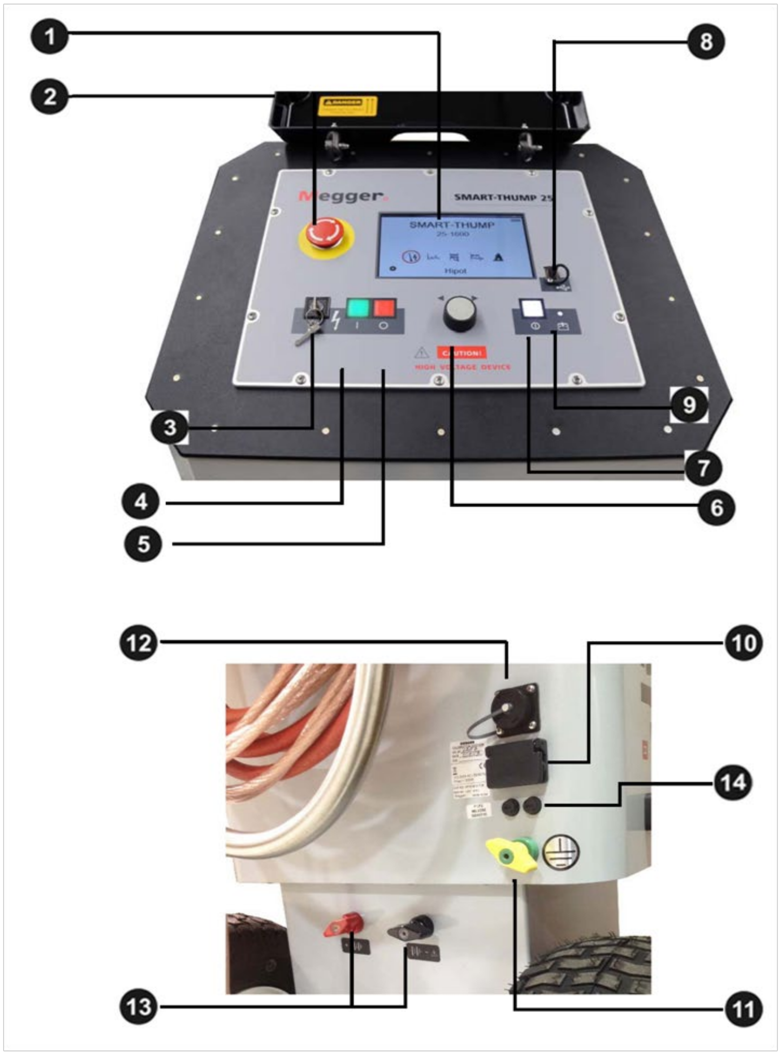
Technical Data

Parameter	**Value**
DC Test voltage	0 to 30 kV
Surge voltage	0 to 12.5/ to 25 kV
Source current	40 mA (up to 12.5kV) 20 mA (up to 25kV) 5 mA (between 25 and 30kV)
Insulation measurement	2 kΩ … 10 MΩ
Surge energy	1600J @ the maximum voltage in each of both surge levels (12.5kV / 25 kV)
AC Power Input	100-264V, 50-60 Hz 6.3A 230V fuses on line and neutral. IEC320-C14 Inlet.
Battery after 74 Ah	Internal, hermetically sealed lead-acid gel type battery (12 V / 74 Ah
External DC Connectors	10.0-14.4V, > 50A M8 Terminals w/ Wingnuts
Operating time battery	45 min (pinpointing) at full energy
Power consumption	700 W
Display	7”, 1280 x 800 pixel High Brite TFT direct sunlight readable
Memory	>1000 traces
Interfaces	USB port
ST25-30 units range with Multishot feature **ST25-30units with Single Shot Mode**	up to 180,000ft / 52km 25,000ft/8.5km and 100,000ft/32km
Measuring resolution	0.8 m (2.5 ft) at 80 m/μs (250 ft/μs)
Max. sampling rate TDR	100 MHz
Update rate	5 samples / second
Dynamic range	64 db
Output impedance	64 Ω
Operating temperature	-20 °C to +50 °C / -4°F to +122°F
Storage temperature	-25 °C to +70 °C / -13°F to +122°F
Intended Environment	Indoor and Outdoor
Relative Humidity	0-95% (non-condensing)
Operating Altitude	0 to 2000 meters / 6500 ft
Pollution Degree	II
Dimensions (W x H x D)	690 x 1165 x 600 mm

Weight	187lbs/85kg to 264lbs/120kg depending on selected model, incl. all items required to operate the specific model, e.g. HV cable and safety ground cable
Protection class (in accordance with IEC 61140)	I
Protection rating (in accordance with IEC 60529)	IP53 (open lid)

Control Elements, Indicators and Connectors

The ST25-30 has the following control elements, indictors and connectors:



External DC Terminals 13 *shown for portable version, similar for vehicle mounted*

Element	Description
1	Display 7 inch
2	Emergency stop button
3	HV key switch

Element	Description
4	“HV ON” button
5	“HV OFF” button
6	Rotary control knob
7	“ON / OFF” button
8	USB port
9	Charging status LED (yellow: charging | green: charging completed)
10	AC power connector
11	Safety ground connection
12	Jack for connecting external safety device *(See page 10 'Available Accessories').*
13	Terminals for external 12 V DC power supply
14	Fuse Holders for AC input power

Power Supply

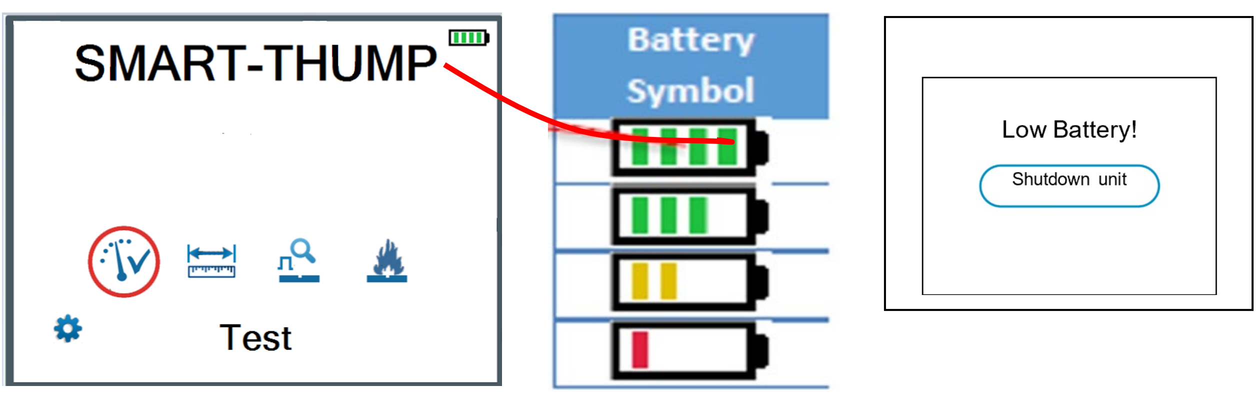
Battery Operation

Introduction

If the SMART THUMP ST25-30 is equipped with an internal battery and fully charged, the unit can deliver more than 400 HV discharges (thumps) at 90% of full voltage (in each range). This equals approxi- mately 1 hour of thumping (pinpointing) at almost full energy

Battery Status and Automatic Shutoff

A fully charged battery shows 4 green bars. After approximately 25 minutes of constant thumping at full voltage / energy 3 green bars will be visible. After an additional 10 minutes, 2 yellow bars will appear. After another additional 10 minutes the single red bar will be visible. The times given are approximate values. The best indication of the true capacity of the battery is when looking at the voltage recovery during the thump operation. The highest energy draw is experienced at the end of the full charging cycle of the capacitor when the largest charging energy is drawn. Initially, it is expected that the battery might lose the 4th bar at the end of the capacitor charging cycle, but when finished, it should always recover to the 4 bar state. The 25 minutes mentioned above means that after 25 minutes the voltage will not recover any more to the 4 bar status, but remains at 3 bars and will show the same behavior as described above for the 4 bar, and so on.



NOTE:	*To protect the battery from a deep discharge, the unit turns off automatically completely or provides an error message if the battery is discharged too low for safe operation, see above.*

NOTE:	*To find out whether the battery charge is sufficient for further use of the unit in the field, turn the unit on in battery mode check, the battery symbol should show 4 green bars.*

Backup Battery / DC Power Supply

If the internal battery is becoming drained while fault locating, any 12V battery or DC power source, provided it can source more than 50 A (e.g. a car battery) and is fully charged, can be connected to the 12 V terminals ⓭ in order to extend the operation time ***or*** the unit must be connected to a suitable AC source (see below AC Line Operation).

Charging

The battery is automatically being charged as soon as the ST25-30 has been connected to 120/230 AC line power. Charging time on a fully drained battery is about 10 to 12 hours. The progress of the charging process is indicated by the battery charging status LED ❾. During charging, the LED lights yellow. It turns to green, when the battery is full and charging is finished, but even when it turns green, leave unit plugged in to the AC line to maintain “trickle charging”

NOTE:	*Always charge the battery immediately after use. Lead-acid batteries should be kept in a charged condition. The battery life is longer with an almost fully charged battery rather than fully discharged one.* **This can be accomplished by keeping the unit connected to a working AC outlet at all times except when wanting to operate it from its internal battery or an alternate AC supply.**

120/230V AC Line Operation

As soon as the AC power cord is connected between the receptacle❿ of the SMART THUMP and the AC, ***the system is operating on AC power and, if an internal battery is installed, being charged at the same time.***

If using a power cord other than the one provided, ensure it is rated for at least 250VAC and is 18 AWG or larger. Do not use inadequately rated power cords.

3

SETTING UP THE SYSTEM

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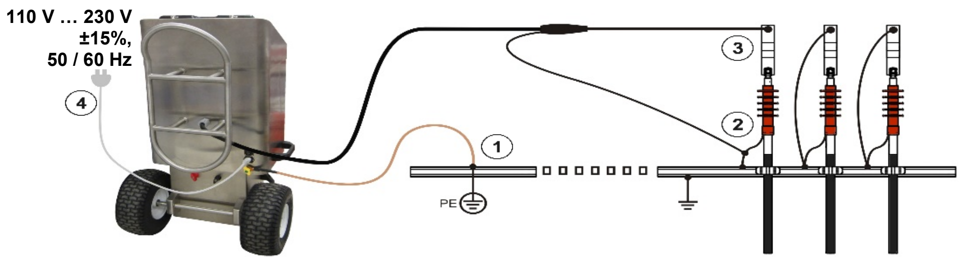
WARNING - Safety instructions for setting up

- The guidelines to maintain occupational safety when operating a non-stationary test system often differ between network operators and it is not uncommon to use National regulations (i.e. the German BGI 5191)

  Operator must inform him/her self about the guidelines applicable in the area of operation beforehand, and comply with specific work rules for non-stationary test systems.
- Always follow the safety instructions *(see Section 1 SAFETY)* - the **<u>five safety rules</u>** <u>(see page 3)</u> - before connecting to the cable to be tested.
- Before connecting the system to the cable to be tested, be sure that the cable has been tested for voltage, discharged / isolated and ground tested in compliance with all OSHA / National applicable & company safety procedures.
- Select a setup location which is sufficient for the weight and size of the system and ensure that it stands securely. Always locate the system off to the side of the cable path, never on top of the cable path of the faulted cable.
- When setting up the testing system, ensure that it does not impair the function of any other systems or components. If other systems and components have to be modified in order to set up and operate the test system, be sure to reverse these actions when the work is finished. 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.
- Install protective equipment (such as railings, chains or bars) around the test site to block access to the danger zone and prevent the risk of touching live parts.
- Always operate the SMART THUMP ST25-30 system in a vertical position. Grounding and HV contacts both require a vertical orientation to ensure proper functioning as well as a “Fail Safe Position” in case of an AC or DC power failure or if the unit needs to be shut off.
- After receiving clearance, make sure that NO dangerous voltages can reach unprotected places or technical equipment.
- As a matter of principle, all de-energized cables that are part of the test circuit shall be connected together and shorted to ground.

Connection Diagram

The following figure shows the simplified connection diagram
please review also important safety advisory on pages 4 and 5



Connection Sequence

Connect the unit in the following order:

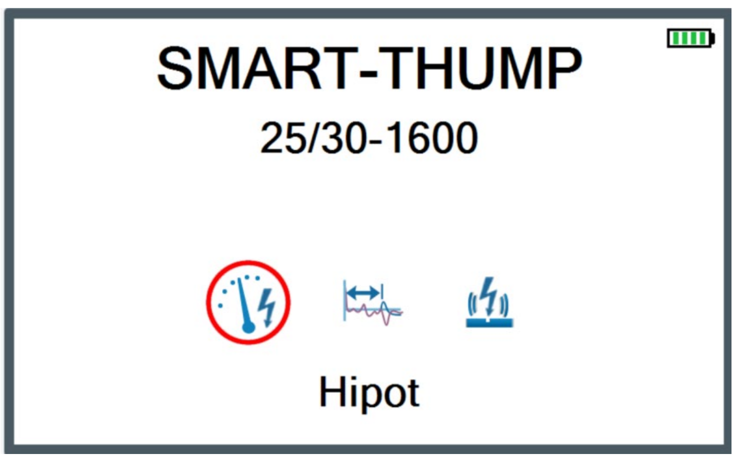
Step	Description
1	**Connect the safety ground lead** to a reliable ground (e.g. station-ground, transformer ground rod. ***Do not drive a separate*** ground rod!).
2	**Connect the HV return lead** to the cable shield or the concentric neutral of the specific cable to be tested. The resistance between the HV return (operational ground) and the safety ground should be less than 5 Ω (check with ohmmeter, if questionable), if not the F-OHM safety feature will be activated, disabling the HV ON function or activating the HV OFF function. *NOTE: It is important to connect the HV return to the shield / concentric of the cable to be tested as close as possible to the breakaway point, the TDR trace readings will be much better!*
3	**Connect the HV lead** to the phase conductor to be tested (optional elbow adapter or vice-grip. *(See 'Available Accessories' in Section 2).*
4	**Connect the supplied power cord** to the connector 10 on the back of the unit and connect the other end to a power outlet. *NOTE: If no power connection can be established, the unit can be operated from the internal battery, provided it is equipped with this feature and is properly charged. The unit provides also 2 external DC terminals that are accessible from the out-side, which can be connected to an external 12VDC supply like a battery*
5	Only after all necessary connections have been made, **the ground connection to the cable under test shall be lifted.**

4

OPERATING INSTRUCTIONS

Power on the System

Once the "ON / OFF" button ❼ is pressed, the system starts up. After start-up, the system is in the 'Ready for operation' state and the ***main screen*** is displayed:



The main screen image shows a typical set up with the 3 basic elements of fault locating, HIPOT, ARM PRELOCATION and PINPOINTING *(other elements or modes of operation can be set up; an additional icon for each selected mode will show on the main screen).*

In this state, the high voltage source is still switched off and the high voltage output is grounded via a discharge resistor.

Basics of Operation

Operation with Rotary Knob

Navigation within the menus is done using the rotary knob ❻ as follows:

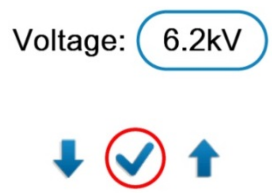
Turning ⇨ **Selecting**

Clicking ⇨ **Confirming** ("ENTER" function)

The currently selected menu item is identified by a red circle.

not selected **selected**

With the aid of the rotary knob, the individual menus can be accessed, and values can be entered. If a selected menu item requires a value to be adjusted, the following dialog is displayed:



The value for the parameter can then be adapted by turning the rotary knob and clicking it again to confirm.

High Voltage Control

Before the start of any HV test, the user is prompted to enable high voltage. To do so, the green illuminated “HV ON” button ❹ (green) must be pushed. This disconnects the discharge resistor and enables the generation of high voltage. The red illuminated “HV OFF” button ❺ signals that the HV output is now energized (hot) and the green button goes dark.

The activation of high voltage requires that all conditions of the safety circuit are met. See page 23 in Section *Safety Circuit.*

The high voltage can be switched off at any time during the course of the test by pushing the “HV OFF” button❺. The test is then immediately aborted and the high voltage power supply is turned off and the entire test circuit including the ST25-30 is discharged and grounded, which is indicated by the illumination of the light in the green push button.

Safety Circuit

Introduction

Once high voltage is turned on (Red HV OFF button is illuminated), the system's safety circuit continuously checks all safety-relevant parameters and switching operations of the system. Should the safety circuit detect a violation of the monitored thresholds / conditions while in high voltage mode, the system automatically switches the high voltage power supply off and discharges and grounds the HV output. A message will be displayed on the LCD display which ***must be acknowledged*** before any operation can be re-activated again.

Conditions of the Safety Circuit

The following safety conditions must be met in order to allow to perform tests under high voltage:

- The HV key switch ❸ *must be* in the ⏻ position (*some system might not have this feature because they were ordered without it*)
- The emergency off button ❷ *must* be unlocked (up).
- The F-Ohm safety circuit ***must*** have a loop resistance ***below 6.5 Ω*** (if resistance is higher, warning on LCD will be provided and system ***will lock*** out ***any HV application***).

NOTE:	*If the HV application is disabled because of one or more of these conditions are not being met, they must be eliminated and the message must be acknowledged before HV ON can be enabled again.*

User Modes

The E-TRAY system platform offers two (2) operational modes respectively three (3) if the unit is equipped with the Multishot feature

- **QUICK STEPS Mode (*not* password protected):**
  This mode is tailored for the "everyday jobs" where the basic settings may need no or just minor adjustments. This mode is typically confi-gured with a limited range of adjustment features and no access to the system settings. It serves also very well the „casual" user of the unit
- **EXPERT MODE (password protected):**
  This mode is recommended for experienced users. It offers the full range of adjustment features (if selected and set-up by the user) and access to all customer accessible system settings, incl. the default settings.
- **MANUAL Mode (password protected, only available in units with *Multishot Feature*):**
  the Manual Mode is activated after accessing the DEFAULT *settings and selecting MANUAL MODE of OPERATION.*

This mode is only recommended to the group of users with *extensive experience and expertise in the set-up* and operation of the TDR. When selecting this mode, ***all automatic functions*** like **auto-ranging** and **auto-gaining**, and also the **automatic detection** of the **cable end** and the **distance to fault** *have been turned off* and ***must be adjusted manually.***

For detailed information on how to switch modes, please refer to the next paragraph below.

System Settings (*only accessible in Expert Mode, password protected*)

In order to change the system- and or default settings, **EXPERT settings** must be accessed from the main screen.

These settings are only available, if the system is operated in **Expert Mode**. If not in **Expert Mode**, the rotary knob ❻ must pushed down and held down shortly on any of the **main screen** icons until the system displays the prompt for the password, which is required to activate the **Expert Mode**. The default password is "0000" (can be changed – see below, *but is not recommended*).

After activation of the **EXPERT MODE**, you are automatically forwarded to the system settings:

Menu item	**Description**	
Leave EXPERT MODE	By leaving the expert settings through this menu item the new settings are saved and the system is switched to **QUICK STEPS mode**. The is no longer be displayed in the main menu which prevents unauthorized persons from changing the system and default settings.	
Date / Time	Date and time settings	
Language	Language settings	
Default Settings		
>> Measurement unit	**Length**	Unit of the x-axis (**Meter**, **Feet** or **Time**). If set to **Time**, the actual runtime of the pulse is displayed and no conversion to length of cable is performed.
	Rate	*Only available, if **Length** is set to **Meter** or **Feet*** Rate refers to how the propagation velocity of the TDR pulse is specified. This can be done *either* relative to the speed of light (**% of NVP**) *or* in absolute units in µs (**µsec = microseconds = 10^{-6} sec**).
>> V/2 or NVP	*Only available, if Length is set to **Meter** or **Feet*** Propagation velocity of the cable under test can be expressed as percentage of speed of light (NVP), e.g. 0.53 corresponds to 53% of speed of light V/2 (half of the actual velocity of propagation) in m/µs.	

Menu item	Description
>> **Trigger delay time*** ***Only available in units with SINGLE SHOT ARM MODE; not applicable in MULTI SHOT units****	Delay time between the time of flash-over at the fault and the time to trigger and capture the TDR trace. The delay time allows the flash-over to build up well before a measurement is done (ideally when the arc reaches it highest current). **If Delay time too short:** Flash-over is not fully developed and may cause poor or no reflections of the TDR pulse. **If Delay time too long:** Flash-over is extinguished already when TDR pulse arrives and reflection measurement is too late. Thus, the fault trace looks identical to reference trace. The default value for the ST25-30 is 700 µs.
>> **TDR - Mode Selection** ***only available in units with MULTI SHOT feature***	***AUTOMATIC TDR Operation*** means that the software utilizes algorithms to determine the end of the cable, the distance to fault, sets automatically the range, the gain and the pulse width, it also allows user to select which TDR features to make available in both the QUICK-STEPS and EXPERT Modes ***MANUAL TDR OPERATION*** means that all automatic functions listed above must be done manually by the user; it also means that ***all*** TDR features are available at ***all times*** on the screen
>> **Automatic HV release**	The way a HV test is started, **automatic** or **manual**. **Automatic** means that after initializing HV by pushing the HV ON button, HV will be building up in the test mode or will charge the capacitor ***and*** release as soon as pre-set voltage has been reached (*typically preferred* in North America). **Manual** means that in both situations the HV, after have been authorized, has to be manually "initiated", and once more after the preset level has been reached *and* the charge is to be released (*typically preferred in Europe*).

Menu item	Description
Voltage selection *manual* or *automatic*	When set to **Manual** the unit will always default to 0.1kV as a *starting level in all HV modes*. The operator must then adjust the HV level in any of the operating modes and operation menus involving HV to the desired level (Quick-Steps, Expert mode and Manual TDR mode). *NOTE: The factory DEFAULT for the ST25-30 Unit is set to Manual Voltage Selection in order to avoid an automatic 16 or 20kV HV build-up, which might be unexpected by the operator if not totally familiar with this feature.* *It is highly recommended* ***not to change this default.*** *If set to* ***Automatic****, the unit will always release a shot in ARC reflection at the full 16kV voltage; when in thump mode it raises the voltage to maximum 16kV (however operator can down adjust before starting to surge/thump); if preceding to the surge/thump, a HIPOT/ Breakdown test was performed, the unit will select a thump voltage based on the breakdown voltage during the HIPOT test and add 4kV, i.e. breakdown 4kV, thump voltage will be set to 8kV; even this selection is made automatically the user can override and set his/her own surge / thump voltage*
Sheath Test Limit	If the *Sheath Test Mode* is enabled, the test voltage that can be adjusted between 2 and a maximum voltage of 5kV
Continuous Testing	1. **When disabled**, only DC HIPOT / breakdown tests can be performed. 2. **When enabled**, DC HIPOT /Proof tests can be performed for up to 30 minutes and the data can be exported via USB stick and loaded on the EasyPROT software. 3. **Must be enabled** to perform Sheath Testing / Sheath Pinpointing.

<table>
<tr><th>Menu item</th><th colspan="2">Description</th></tr>
<tr><td>>> Set-up Start Marker</td><td colspan="2">Procedure to adjust the start marker "zero" position to the end of the actual length of the HV output cable, for portable ST25-30 at the end of the typical 50ft (15m) HV output cable; for vehicle mounted units typically optional cable reels are installed, and the Start Marker is set to the end of the output cable of the HV reel, could be 50ft (15m), 85ft (25m) or 130ft (40m).The procedure is fully automatic and the operator is prompted to perform the required steps:
1. a measurement is taken with the ends of the HV test lead open
2. the gain setting is adjusted if needed and confirmed and a copy of the trace is saved automatically (adjust gain of furthest peak on left till peak can be seen clearly, no clipped top)
3. a second trace is automatically saved when the 2 ends of the HV test lead are shorted to each other, should show a significant downward blip. The marker is automatically placed on the position where both traces start to split.
If required, the marker can be manually adjusted. This setting of the start marker will be stored as the default after operator acknowledges the prompt, <u>and should only be changed if the length of the connection cable is changed.</u></td></tr>
<tr><td rowspan="5">Cable List</td><td colspan="2">By means of the cable list the appropriate propagation velocity can be quickly adjusted / selected by identifying the type of cable to be tested.
Cable list can be exported and imported which allows for example to edit an exported list (XML file) according to the preferences of the customer (see page 51) and then share it among all units of a customer.
This submenu offers the following options:</td></tr>
<tr><td>Set default</td><td>Allows selection of one cable list amongst all available cable lists as default. Only the cable types of the default cable list can be accessed during measurement.</td></tr>
<tr><td>Import from USB</td><td>Imports a cable list from an inserted USB drive. The cable list must be located in the CableLists folder and be formatted correctly (see Chapter 7)</td></tr>
<tr><td>Export to USB</td><td>Exports the selected cable list to the CableLists folder on the USB drive.</td></tr>
<tr><td>Remove cable list</td><td>Removes the selected cable list from internal memory.</td></tr>
<tr><td>User mode</td><td colspan="2">Menu item to select the User Mode which is the default after start-up.
If set to Last, the unit starts up in last active mode, recommended is to set always to QUICK STEPS (no password required, access to any defaults or settings is disabled)</td></tr>
<tr><td>Backlight settings</td><td colspan="2">Backlight timeout and contrast settings.</td></tr>
<tr><td>Time Out Settings</td><td colspan="2">Minutes of inactivity after which system is automatically shut down (conserve battery).</td></tr>
</table>

Menu item	Description
Stored Traces	Menu item to export or delete all traces which have been stored in the internal memory. Exporting traces requires a USB flash drive plugged into the USB port 8. The traces are written into a *EtrayTraces* folder which is automatically created. The data can be viewed with any standard web browser by opening the *index.html* file which is also located in the *EtrayTaces* folder. *NOTE: when in the LOCATE Mode (ARC Reflection), the unit will save and store automatically both the blue (LV) and the red trace (HV) as long as both traces are shown together on the screen (complete measurement); if only the blue trace (LV) is shown, it will not automatically be saved ; it can be saved via the feature „SAVE CURRENT TRACE“, please see chapter 6, CUSTOMIZE TDR FEATURES*
System information	Displays the detailed hardware and software configuration of the unit.
Change password	To change the password (not recommended), **EXPERT MODE** must be enabled.
System Configuration ***(user configurable settings)***	**Aside from** to the <u>*factory preset unit configuration*</u> the user has the choice to select or de-select amongst 5 additional fault locating features. ***When selected***, a specific icon for each of the features will appear on the main screen (see page 19, *Power on the System)*
TDR Time Domaine Reflectometer	Selecting the *YES* key, allows the user to set up an operational mode to use the TDR by itself, *without any integration into one of the HV fault Prelocation modes* like ARM or ICE. In this mode the TDR is performing low voltage (<60V) time reflectometry and evaluating the impedance along a MV (shielded) cable or between 2 conductors of a multicore cable. This setting is also very helpful to fault locate multicore LV cables
Sheath-fault locating	By activating this mode of operation, the user can conduct *Sheath Fault Locating of MV* (shielded) cables or *Ground Fault testing on LV* (unshielded) cables. In this mode the unit will send out a pulsed DC signal with an adjustable voltage of max. 5 kV. Please see page 41 for application notes & additionally required equipment.
Burning	Burning is typically applied to a known failed cable in order to reduce its fault resistance. This is sometimes required to be able to surge / thump the cable, ***typically used with PILC cables, <u>but not</u> XLPE/EPR cables.***
Sheath Test	By activating this mode of operation, the user can conduct Sheath Testing of MV (shielded) cables according to the applicable standards or Hipot testing on LV cables with the test voltage limited to 5 kV max. *NOTE: when selecting this feature, the feature Continuous Testing (see page 25) must be also activated.*
ICE / Surge Pulse	ICE / Surge Pulse represents an alternate HV prelocation method, which is typically used when the HV ARM method experiences limitation, like very long and or PILC cables

Menu item	Description
Customize TDR features	Menu to configure the features which are available during measurement, for either QUICK-STEPS mode or EXPERT mode *See page 43;* ***not available in Manual Operation,*** *please see page 23*
Return	By leaving the **EXPERT MODE** through this menu item, the new settings are saved.

5

HOW TO PERFORM A TEST

Detecting and Locating a Cable Fault in a Shielded Medium Voltage Power Cable

Locating a Faulty Cable Segment (Sectionalizing)

Introduction

The sectionalizing technique is used to trouble shoot single phase MV distribution loop circuits in order to identify the faulted section, so it can be quickly switched out, the rest of the circuit can be re-energized and the power outage kept to a minimum. The advantage is that the faulted section can be identified working from one set-up point without having to go from transformer to transformer to either remove the fuses or to stand the elbows off at each transformer.

For this purpose, a LV reflection image is taken and scanned for impe- dance changes that are related to the cable end and the transformers. The latter ones indicate the location of the transformers. A second re- flection image of a TDR pulse is taken while an electrical arc is ignited by a sudden discharge of the charged capacitor at the fault location.

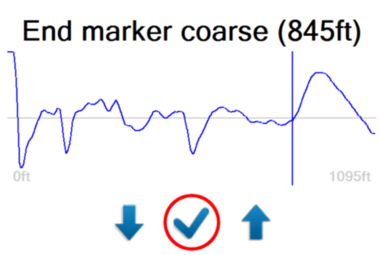
With both traces lying on top of each other, the fault location (position where the two traces diverge from each other) is identified and the transformers reflections provide the landmarks to identify the faulted cable segment. It will be switched out by pulling the elbows to the left and right side of the fault. Service to all customers is provided by clo- sing the normally open point within the distribution loop.

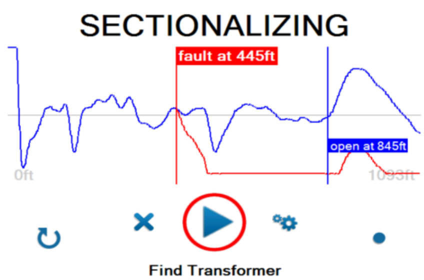
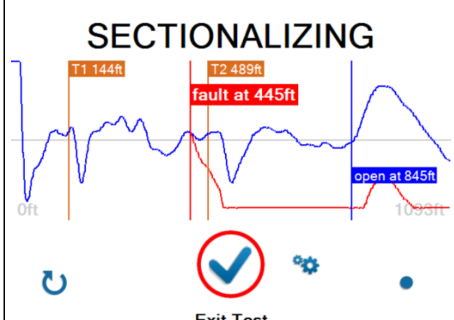
The software package to perform the fault locating method called “Sectionalizing”, if ordered by the customer, will perform automatically the following procedure:

- Determine the distance to the end of the cable or an open point in the circuit (blue trace, live trace)

- Determine the distance to the fault using the ARM method (red trace, frozen)
- Determine the number of transformers up to the fault & one beyond it
- Based on relative position of fault to the 2 closest transformers the faulted cable segment can be identified and easily isolated

<u>How to Determine the Faulty Section</u>

Step	Description
1	Select the menu item from the main menu or from the submenu (depends on the system configuration). **Result:** A LV pulse is fed into the cable. The reflection image is processed by the transformer identification software. After a few seconds, the reference trace which shows the distance to the cable end.  This reference trace is also called “live” trace because it is permanently refreshed and displayed
2	Select to start the fault location.
3	Adjust the surge voltage and select ✔ to confirm the value (not required in automatic mode).
4	Press the green illuminated “HV ON” button ❹.
5	Select to *charge* the surge capacitor (only if **measurement start** option is set to **manual.** *See page 25).* **Result:** The capacitor is charged up to the selected voltage.

Step	Description
6	Select to *discharge* capacitor (only if **measurement start** option is set to **manual** (not required in automatic mode). *See page 25.* **Result:** A capacitor discharge (shot) is initiated. If a voltage breakdown takes place, the red fault trace is shown in the display. The red fault marker is automatically set to the position where both traces diverge from each other. The fault is referenced to the 2 closest transformers, which identify the cable section containing the fault.  *NOTE: If no trigger is received and, thus, no fault trace is shown, you may try to repeat the procedure with a higher surge voltage (if possible) by selecting the repeat icon.*
7	Select to Identify Transformers The special software identifies the transformers in front of the fault and one transformer past the fault. This will clearly identify the bad section of cable. By pulling the 2 elbows on either side of the fault the bad segment is isolated. By closing in the NO (normal open point) all customers will have power.  If necessary, adjust the display settings, TDR settings and marker position through the menu in order to uniquely identify the affected section.

How to Verify Whether it is Actually a Bad Section

The HIPOT test within the context of Sectionalizing is done to confirm, that the section of cable identified as faulted during the Sectionalizing procedure can be verified to be actually faulted. Proceed as follows to perform a HIPOT test *after the identified cable section has been isolated at the 2 closest transformers* (DC HIPOT test *cannot* performed with the transformers still connected to the faulted cable section):

Step	Description	
1	Select the menu item from the main menu or from the submenu (depends on the system configuration).	
2	Adjust the test voltage and select to confirm the value.	
3	Press the green illuminated "HV ON" button 4.	
4	Select to start the test (only if AUTOMATIC VOLTAGE RELEASE option is set to **manual.** *See "System Settings" on page 24).*	
	Result: The selected voltage is applied to the cable. During the rise of the voltage the maximum charging current of the HVPS will be displayed till the cable has been fully charged, at which time the current will drop down to the actual leakage current level. The insulation resistance is displayed. This scenario is observed if the cable has *no insulation breakdown*, otherwise the high voltage will be shut off when the flashover/breakdown occurs. Depending on whether or not a breakdown takes place during the test, one of the following results is presented in the display:	
	Breakdown at…kV	A voltage breakdown took place at the indicated test voltage.
	No Flash-over	The cable has withstood the applied DC test voltage. If possible, repeat ( ) the test with higher voltage (do not exceed the maximum permissible voltage).
	Cable not chargeable	The cable could not be charged by the test voltage. This is typically due to a short (fault) in the cable, creating maximum current output.
	Low resistance at …kV	The HV source cannot charge the cable beyond the indicated voltage value due to the substantial leakage current level.
5	Select to return to the main menu.	

Locating a Cable Fault (shielded MV power cable)

How to Test the Dielectric Strength of the Cable

A HIPOT/breakdown test is used to test the dielectric strength of a cable under DC HV conditions, and in case the cable fails, provides the breakdown voltage. For this purpose, the unit will apply a test voltage of up to 30 kV to the cable under test (automatically 30kV if unit is set to AUTOMATIC VOLTAGE CONTROL; if set to MANUAL VOLTAGE CONTROL the user must adjust the voltage to the level he selects.

NOTE: *If selecting the DC HV test voltage, its minimum should equal the phase to ground voltage Vo (rms) multiplied by 1.41.*
Vo can be calculated by dividing the system voltage by $\sqrt[2]{3}$ *or 1.71. This value is equal to the peak value of the voltage under operating conditions!*

Example:
15kV cable, 8.7kV phase to ground AC rms, x 1.41=12.27kVDC

Proceed as follows to perform a HIPOT test:

Step	Description
1	Select the menu item from the main menu or from the submenu (depends on the system configuration).
2	Adjust the test voltage and select to confirm the value if on manual voltage control.
3	Press the green illuminated “HV ON" button 4.
4	Select to start the test (only if **AUTOMATIC VOLTAGE RELEASE** option is set to **Manual**. *See section “System Settings” on page 24).*
	Result: The selected voltage is applied to the cable. During the rise of the voltage the maximum current of the HVPS will be displayed till the cable has been fully charged, at which time the current will drop down to the actual leakage current level. The insulation resistance is displayed. This scenario is observed if the cable has no insulation breakdown, otherwise the high voltage will be shut off when the flashover / breakdown occurs. Depending on whether a breakdown takes place during the test, *one of the following* results is presented in the display:

Step	Description	
	Breakdown at…kV	A voltage breakdown took place at the indicted test voltage, meaning there was a flash-over at the fault
	No Flash-over	The cable has withstood the applied DC test voltage. In this case no current will be indicated. *If required*, repeat the test with higher voltage (do not exceed the maximum permissible voltage)
	Cable not chargeable	The cable could not be charged while the test voltage was applied. This is typically caused by a short circuit condition in the cable (zero voltage and max current),
	Low resistance at …kV	The HV source cannot charge the cable beyond the indicated voltage value due to a substantial leakage current level; this indicates a very low resistance fault (some voltage and high current) The voltage indication *must not* be interpreted as a flash-over voltage, it is merely the voltage that the HVPS can build given the high leakage current.
5	Select to proceed with fault pre-location or to return to the main menu.	

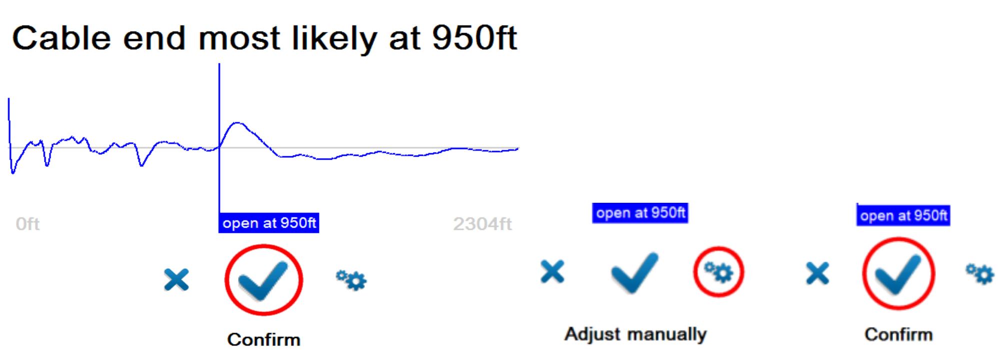
How to Pre-Locate the Fault

Arc Reflection Method (ARM)

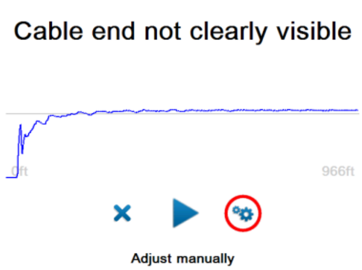
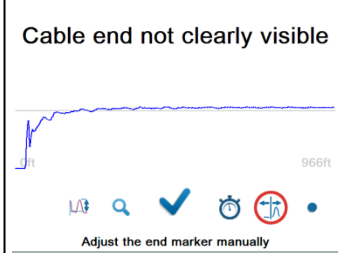
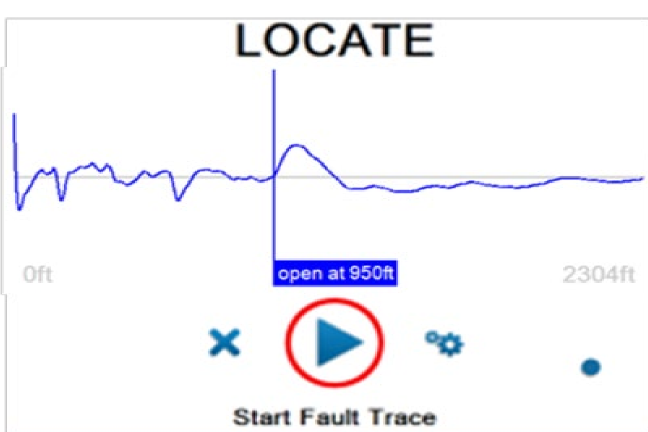
For pre-location of a high resistance MVcable fault the SMART THUMP applies the widely approved and well-known ARM (Arc Reflection Method).

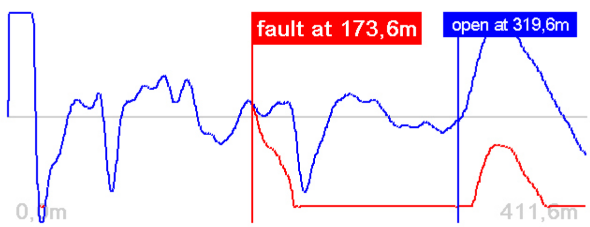
Locating the fault is accomplished by comparing a reflection image (impedance) taken with a LV pulse (reference trace) to a reflection image (impedance) taken while an arc, ignited by sudden discharge of the charged capacitor, was present at the fault location (fault trace). With this method, the two measured traces diverge at the position, where the arc caused a negative reflection (impedance change) of the TDR pulse, indicating the fault location.

Proceed as follows to pre-locate the cable fault:

<table>
<tr><th>Step</th><th>Description</th></tr>
<tr><td rowspan="2">1</td><td>Select the LOCATE menu item from the main screen or from the submenu screen (depends on the system configuration).</td></tr>
<tr><td>Result: A LV pulse is applied to the cable. The reflection image with the determined distance to the cable end is presented in the display.


This reference trace is also called the “live” trace as it is permanently refreshed (blue color vs a black color trace indicating a “frozen” or “saved” LV trace).</td></tr>
</table>

Step	Description
	NOTE: The software provides its best estimate for the cable end. If the trace beyond the flag "open at 950 ft" does not show any significant upwards or downwards reflection, then click to confirm. If there is a substantial reflection beyond this point, turn the rotary to the , click and adjust the end marker manually to where the end of the cable is visible, then click to save and confirm. ***Either the suggested or the manually adjusted cable end must be confirmed, otherwise unit cannot display any distances because it misses a reference point.***
	In case the software ***cannot determine*** the end of the cable, a message will be displayed stating "CABLE END NOT CLEARLY VISIBLE" and will automatically suggest a "manual adjustment". The manual adjustment of the End Marker is performed by activating the END MARKER icon in the feature menu. After adjusting the end marker to identify the cable end manually, click again and acknowledge the manually identified cable end. ***The SW requires a defined cable end as a reference, otherwise no distances can be shown***
	 
2	Select to start fault trace (fault pre-location. 

Step	Description
3	If required, the surge voltage *can be adjusted* via the icon, otherwise, the maximum surge voltage is automatically used, <u>*if*</u> AUTOMATIC VOLTAGE CONTROL has been selected as default.
4	Press the green illuminated "HV ON" button ❹.
5	Select to charge the capacitor (only if AUTOMATIC HIGH VOLTAGE RELEASE option is set to **Manual.** See page 24).
	Result: The surge capacitor is charged up to 25 kV when set-up for AUTOMATIC VOLTAGE CONTROL *and* no adjustment per step 3 has been made
6	Select to discharge the capacitor (only if AUTOMATIC HIGH VOLTAGE RELEASE option is set to **Manual**. See page 24.
	Result: A capacitor discharge (shot) is initiated. If a breakdown / flashover takes place, the red fault trace typically has a strong negative reflection. The *red fault marker flag* is automatically set to the position where both traces diverge from each other (largest difference in impedance).  *NOTE: If no trigger is received, no fault trace (red) will be shown. Repeat the procedure with a higher surge voltage (if possible) by selecting the menu item.* *If the blue trace (TDR trace) and the red trace are either 100% matching or following each other very closely, the trigger has been activated, however no breakdown/flashover was detected - increase ( ) voltage <u>or</u> possibly good cable.*
7	If necessary, adjust the display settings, TDR settings and marker position through the menu in order to identify the fault distance as precisely as possible.
8	Select to proceed with pinpointing or to return to the main screen.

Current Decoupling (ICE)

The ST25-30 SMART THUMP features the current decoupling method (ICE, Surge Pulse) as an *alternative method* to pre-locate high resis- tance (flash over) faults. It has proven very useful on very long (>5 mi/ 8km) and or PILC cable fault situations, where the standard ARM pre-locating method has failed to provide a concise and unambiguous *di- stance to fault* reading.

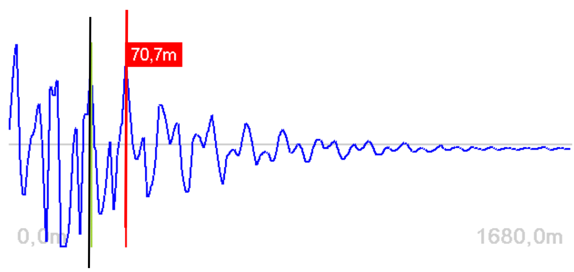
The capacitive discharge of the surge capacitor via the surge switch triggers & ignites the fault and causes it to flash over. This flashover results in a travelling current wave along the HV return, which is induc- tively de- coupled and shown on the Reflectometer as a transient wave shape. Subsequently, an attenuated transient wave travels back and forth between fault and surge generator (standing wave).

By decoupling the current signal from the HV return, an oscillation is obtained where the distance between 2 adjacent *and* similar peaks corresponds directly to the fault distance.

NOTE:	*Fault distance includes length of HV output cable: must deduct this length to get the distance to the fault going forward from the connection point, e.g. transformer, switchgear etc.*

Proceed as follows to pre-locate the cable fault:

Step	Description
1	Select the ICE icon from the main screen or from the submenu (depends on the system configuration).
2	Adjust the surge voltage and select ✓ to confirm the value.
3	Press the green illuminated “HV ON” button ❹.
4	Select ▶ to charge the capacitor (only if AUTOMATIC VOLTAGE RELEASE is disabled). See page 24.
	Result: The capacitor is charged up to 8 or 16kV.
5	Select ▶ to discharge the capacitor (only if AUTOMATIC VOLTAGE RELEASE is disabled). See page 24.

Step	Description
	Result: A sudden capacitor discharge (shot) is initiated. If a breakdown takes place, a red oscillating curve is shown on the display screen. *NOTE: If no trigger is received and, thus, no fault trace is shown, you may try to repeat the procedure with a higher surge voltage (if possible) by selecting the icon.*
6	If necessary, adjust the display settings, TDR settings and marker position through the menu in order to identify the fault distance as precisely as possible.
7	Go into the simple options menu in order to measure out the distance. Use the cursor to select one peak first. Drop a marker at the cursor position and move the cursor to the next peak. The distance between the cursor and the marker is given on the screen. 
8	Select to return to the main menu.

How to Pinpoint a High Resistance (Flash-over) Fault

The thumping mode can be used to pinpoint a high resistance fault between a phase conductor and the neutral conductor of a MV cable. between two phase conductors of a „belted“ MV cable, between 2 phase conductors of a LV cable or between the phase conductor and earth ground of a LV cable.

The SMART THUMP serves as surge pulse generator to continuously feed high voltage pulses into the defective cable, producing a flashover (arcing) at the fault position. The fault can either be pinpointed using a magnetic / acoustic coincidence detector for best results or a simple acoustic detector with distinct and well understood limitations. The criterion for pinpointing with a simple acoustic detector is the greatest loudness of the flashover noi- se at the fault location, or, in the case of a magnetic / acoustic coincidence measurement, the smallest propagation time difference between speed of light and speed of sound, where it is not the loudest sound, but the first after receiving magnetic signal.

The latter one is more accurate and can be used in all high resistance fault situations (e.g. Megger Digiphone Plus) and **even for pinpointing faults in conduit**.

Proceed as follows to pinpoint the fault:

Step	Description
1	Select the icon item from the main screen or from the submenu (depends on the system configuration).
2	Adjust the surge voltage and select ✔ to confirm the value.
3	Press the green illuminated “HV ON” button ❹.
4	Select ▶ to start the thumping mode (only if AUTOMATIC VOLTAGE RELEASE option is set to **Manual,** *See page 23)*
	Result: The capacitor is charged up and a discharge takes place after 5 seconds or, if the charging takes longer, right after the selected surge voltage has been reached. This process is then repeated until thumping is manually stopped. If required, the surge voltage can be adjusted by selecting the icon.
5	Pinpoint the fault within the pre-located area with a surge wave receiver like the Megger Digiphone Plus. For detailed instructions, please refer to the user manual of the surge wave receiver.
6	Select ✖ to stop thumping.

Detecting a Sheath Fault in a shielded Medium Voltage Cable *or* a Ground Fault in an Unshielded, Low Voltage Cable (both must be directly buried)

NOTE: The methods described to detect and pinpoint sheath faults in shielded power cables or ground faults in un-shielded cables requires that in both situations the ca- bles are direct buried and not installed in any type of conduit, either PVC conduit or metal type conduit.

IMPORTANT

In contrast to the connection diagram on page 20 the HV Output lead has to be connected to the cable shield (concentric neutral) ***which in turn has to be disconnected from the common bonding point on both ends*** of the specific cable to be tested. Consequently, the HV return lead has to be connected directly to the system ground or a separately driven ground rod.

Fault locating on ***unshielded, direct buried low voltage cables*** must be carried out in the sheath fault locating mode in order to ensure that the maximum voltage is limited to 5kV; in this case the HV out put cable is connected to the center conductor and the HV return to a driven ground rod.

The insulation of any high or medium voltage shielded power cable is protected from water ingress by a jacket made from XLPE or PVC. The Sheath test checks ***if*** the integrity of the jacket has been compromised, typically during installation.

With a sheath test the dielectric strength of the cable jacket can be tested by applying a DC voltage of up to 5 kV between the cable shield (concentric neutral) and ground. Any leakage indicates a fault in the jacket.

Proceed as follows to perform a sheath test:

Step	Description	
1	Select the menu item from the submenu.	
2	Confirm the following two notices with ✓.	
3	Adjust the test voltage and select ✓ to confirm the value.	
4	Press the green illuminated "HV ON" button 4.	
5	Select ▶ to start the test (only if **AUTOMATIC VOLTAGE RELEASE** option is set to **Manual**. *See "System Settings* on page 24).	
	Result: The selected voltage is applied to the cable shield. During the rise of the voltage the maximum current of the HVPS will be displayed till the cable has been fully charged, at which time the current will drop down to the actual leakage current level. The insulation resistance is displayed. This scenario is observed if the cable has no insulation breakdown, otherwise the high voltage will be shut off when the flashover / breakdown occurs. Depending on whether a breakdown takes place during the test, one of the following results is presented in the display:	
	Breakdown at … kV	A voltage breakdown took place at the indicted test voltage.

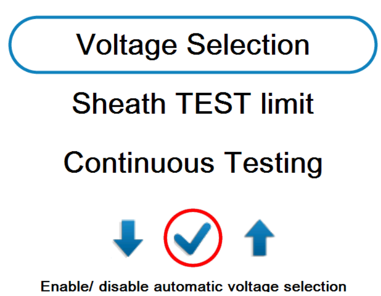
Step	Description	
	No Flash-over	The cable jacket has successfully withstood the applied DC test voltage. The test can be repeated using the menu item.
	Cable not chargeable	The cable shield could not be charged with the test voltage. This is caused by a short in the circuit (fault in the jacket).
	Low resistance at … kV	The HV source cannot charge the cable beyond the indicated voltage value due to a substantial leakage current level; this indicates a very low resistance fault (some voltage and high current) The voltage indication *must not* be interpreted as a flash-over voltage, it is merely the voltage that the HVPS can build given the high leakage current.
6	Select to proceed with sheath fault pinpointing or to return to the main menu.	

How to Pinpoint a Sheath Fault in a Shielded Medium Voltage cable *or* a Ground Fault in an Unshielded Low Voltage Cable (both must be directly buried)

A failed sheath test (see page 39) is followed by fault locating the sheath fault (in direct buried cables). The test method is based on the step voltage method (earth gradient method) and can be performed with the SMART THUMP serving as HV pulse generator (limited to a voltage of 5 kV, see below). An additional receiver is required to read the strength and polarity of the earth gradient voltage (e.g. Megger ESG-NT or Digiphone+2) in order to pinpoint the sheath fault.

When approaching the fault position, the step voltage increases quickly and decreases to a zero reading directly over the fault and then will swing to a strong voltage of the opposite polarity when going past the fault.

Proceed as follows to pinpoint the sheath fault:

Step	Description
1	Select the menu item from the submenu.
2	Confirm the following two notices with ✓.
3	Adjust the surge voltage and select ✓ to confirm the value.
4	Press the green illuminated “HV ON” button ❹.
5	Select ▶ to start the sheath fault pinpointing mode. The **Voltage Selection, Automatic** *should* **be disabled** *(see page 5* allowing to select a voltage between 0.1 and 5kV. 
	Result: The capacitor is charged up and a discharge takes place after 4 seconds injecting a pulsed voltage signal into the cable. This process is then repeated until the process is manually stopped. If required, you can adjust the pulse voltage by selecting the menu item.
6	Pinpoint the sheath fault with an earth fault locator like the Megger ESG-NT. For detailed instructions, please refer to the user manual of the earth fault locator.
7	Select ✕ to stop pulsing.

6

CUSTOMIZE TDR FEATURES
(applicable to TDR and ARM Mode)

Introduction

As soon as a trace has been recorded and is shown on the display, the operator can access up to 20 TDR Features in order to optimize the trace and display settings. The system configuration allows the user to display each of the 20 features as one of 3 categories, which can be individually selected by user for both modes of operation, QUICK STEPS and EXPERT MODE:

DISABLED (not available to user)
ENABLED, which can be activated by pushing the icon
*EXTENDED OPTION*S , which are activated by clicking on the icon

Enabled options, easily available as icons, are placed along the bottom of the screen.

Extended options are available from a scroll down sub menu (typically not used very often).

NOTE:	*The selection of available features depends on the system configuration and the active user mode. All TDR features are configurable by the customer to best fit his requirements in both Quick Steps mode and Expert Mode.* *In general, the majority of features listed will be made available when working in* ***EXPERT MODE*** *(see page 53); while in* ***QUICK STEPS MODE*** *typically only a selection of the most basic features is offered.* *For detailed information on how to adjust the selection of available features according to the customer's needs (for both modes, see page 53).*

Customized TDR Features

The following table lists and describes all TDR features included in the system

Menu item	Description
Adjust Gain	Adjusts the gain setting. By doing so, the amplification of the received signal and, thus, the amplitude of the Y-axis can be adjusted. With an adjustment of the gain setting, the fault trace, if present, is erased and a new "live" trace is immediately recorded. *NOTE: The unit adjusts the gain automatically; however the operator can set his own gain. Too much or too little gain makes the interpretation of the trace impossible!*
Change visible range	Changes the displayed range. By doing so, the trace can be zoomed in and out.
Change value of Cable Velocity	Allows manual adjustment of the velocity of propagation. While changing the velocity, the distance values (X-axis scaling) are immediately refreshed and adapted. This menu option is only effective, if the **Rate** parameter is set to **Meter** or **Feet**. *See page 25*. You may either manually adjust the value or automatically adopt the value by identifying /selecting a cable from the cable list. *See page 28.*
Set / Move Cursor	Changes the cursor position. By doing so, the distance value for any point on the trace (typically to the fault) can be obtained. You can also use the cursor to scroll along the X-axis in zoomed view. At first, a coarse adjustment is made and confirmed by pressing the rotary knob ❻ once - subsequently, the position can be fine-tuned.
Adjust the End Marker	Allows the manual adjustment of the blue end marker. At first, a coarse adjustment is made and confirmed by pressing the rotary knob ❻ once - subsequently, the position can be fine-tuned.

<table>
<tr><th>Menu item</th><th colspan="2">Description</th></tr>
<tr><td>Copy trace, makes copy of live trace when superimposing several traces</td><td colspan="2">Makes an exact copy (blue trace) of the “live” trace.
NOTE: This function is very helpful when making a phase comparison on 3 phase MV circuits.

It is also very helpful when just using the TDR function on low voltage cables with 3 or 4 conductor cables and by comparing them. Typically this will show the location of the fault in one of the conductors, provided the fault is either an “OPEN” or a “SHORT” or shows an impedance change when compared to another impedance of the cable.</td></tr>
<tr><td>Set Marker at Current Cursor Position</td><td colspan="2">Places an additional marker (green) at the cursor position (red). As only one additional marker can be placed, the very last marker is erased every time the marker is placed on a new position.</td></tr>
<tr><td>Save Current Trace</td><td colspan="2">Saves the current screen view to the internal memory.</td></tr>
<tr><td rowspan="4">Export, Recall or Delete Stored Traces</td><td colspan="2">Enables you to export, recall and delete stored data from internal memory.
By selecting All traces you can delete or export all traces which are currently stored in the internal memory.
In case you want to select a specific trace, you need to select the recording date first. You are then allowed to scroll through preview pictures of all traces stored on this day.
After you selected the desired trace(s), you can choose from the following options:</td></tr>
<tr><td>Export</td><td>Copies the selected trace(s) to the EtrayTraces folder on the USB flash drive which has been plugged into the USB slot 8.
The data can be viewed in any regular web browser by opening the index.html file which is also located in the EtrayTaces folder.</td></tr>
<tr><td>Remove</td><td>Removes the selected trace(s) from internal memory.</td></tr>
<tr><td>Recall</td><td>Displays the selected trace on the screen. The screen view can then be adjusted using any function which does not require the trace to be updated.
By selecting ✕, the loaded trace is closed and the last recorded trace is displayed again.</td></tr>
</table>

Menu item	Description
Adjust Trigger Delay Time (***<u>only for you units with single shot</u>***)	Allows manual adjustment of the trigger delay time (see page 24). It synchronizes the HV pulse with the LV TDR pulse to a reflection measurement at the highest or closest to highest current of the arc occurring at the fault location. With an adjustment of the trigger delay time, the fault trace, if present, is erased and a new “live” trace is immediately recorded. Typical value for the ST25-30 is 700µs.
Adjust Pulse Width	Allows manual adjustment of the pulse width. Pulse width is automatically selected as a function of cable length Narrow pulses lead to short ranges but at very high resolution. Wide pulses which provide lower resolution must be used when measuring long cables. With an adjustment of the pulse width, the fault trace, if present, is erased and a new “live” trace is immediately recorded.
Change transformer sensitivity	Only applicable in combination with the sectionalizing software. Allows manual adjustment of the transformer search sensitivity. Decreasing or increasing the sensitivity has an effect on the number of transformers identified by the software, ***but will not change the position of the transformers*** relative to each other and the 2 cable ends. *NOTE: The sectionalizing method is typically only used in North American URD loop type circuits!*
Find Transformers in Actual Trace	Allows manual start of the transformer search.
Disable live trace/ Enable live trace	Disables / enables continuous “live” trace recording. For most operators it is beneficial to “disable live trace”, which means the trace is always live and any adjustment becomes immediately visible.

Completing the Operation

After the fault location procedure has been finished switch off the system by pressing the "ON / OFF" button ❼.

The test object is to be grounded and shorted. Afterwards, the unit can be disconnected from the test object in accordance with the safety instructions below:

WARNING

Follow the five safety rules described on page 4.

Even if proper disconnection and discharging has taken place, system components which have been under voltage must only be touched, if they have been visibly shorted and grounded before hand.

Do not undo and or remove grounding and shorting measures until the time when the test object is put into operation again.

7

ADVANCED SYSTEM SETTINGS

How to Edit the Cable List

Introduction

Cable lists are XML files which are stored in the internal memory and can be imported and exported *(see page 28)*. By default, one cable list with a selection of prevalent cable types is pre-installed on the unit.

XML Structure of a Cable List File

The following example shows the XML structure of a cable list:

```
<?xml version="1.0" encoding="utf-8"?>
<cablelist name="Default" version="1">
      <tabledef>
            <column attrName="TYPE">TYPE</column>
            <column attrName="MILS">MILS</column>
            <column attrName="KV">KV</column>
            <column attrName="GAUGE">GAUGE</column>
      </tabledef>
      <cable>
            <attr name="TYPE">EPR</attr>
            <attr name="MILS">220</attr>
            <attr name="KV">15</attr>
            <attr name="GAUGE">4/0</attr>
            <velocity>
                  <value>286</value>
                  <unit>feet/µs</unit>
            </velocity>
      </cable>
      ...
</cablelist>
```

While the **bolded parts must not be changed,** there can be an arbitrary number of <cable> elements placed one after another each presenting a cable type.

The <cable> element consists of the following mandatory and optional child elements:

`<attr name="TYPE">`	Cable type (mandatory / unique)
`<attr name="MILS">`	Area of the cable type (e.g. in kcmil or mm^2) (optional)
`<attr name="KV">`	Rated voltage of the cable (optional)
`<attr name="GAUGE">`	Diameter of the cable type (e.g. American wire gauge value) (optional)
`<velocity>`	
`<value>`	Value of the propagation velocity (**mandatory**)
`<unit>`	Unit of the propagation velocity in **feet/µs** or **m/µs** (**mandatory**)
`</velocity>`	

How to Edit the Cable List

> *NOTE: Editing cable lists requires basic knowledge of the Extensible Markup Language (XML) standards. By altering the structure of the XML file during edit, the cable list would be rendered unreadable and useless.*

Proceed as follows to adapt the list to your needs:

Step	Action
1	Export the standard cable list to a USB flash drive (see page 28).
2	Open the XML document using a text editor with XML syntax highlighting (e.g. Notepad++).
3	You can now add new cable types by adding new <cable> elements to the file (see previous page). You may also change or remove existing <cable> elements.
4	Save the new cable list in the *CableLists* folder of the USB drive.

Step	Action
5	Import the new cable list into the unit. See page 28.
6	Set the new cable list as default cable list. See page 28.

How to Setup Customer-Specific TDR Features

Thanks to the high level of configurability of the SMART THUMP, the TDR features for both, "EXPERT MODE" and "QUICK STEPS MODE", (see page 24) are customer configurable.

In order to create your own customer-specific settings, proceed as follows:

<table>
<tr><th>Step</th><th colspan="2">Action</th></tr>
<tr><td>1</td><td colspan="2">Enable the EXPERT MODE. See page 25.</td></tr>
<tr><td>2</td><td colspan="2">Access the expert settings via the  menu item.</td></tr>
<tr><td>3</td><td colspan="2">Select the Customize TDR Features menu item.</td></tr>
<tr><td>4</td><td colspan="2">Select the Setup options menu item.</td></tr>
<tr><td rowspan="2">5</td><td>If you want to change the options of the <u>QUICK STEPS mode</u>…</td><td>If you want to change the options of the <u>EXPERT MODE</u>…</td></tr>
<tr><td>… select the QUICK STEPS menu item.</td><td>… select the Expert menu item.</td></tr>
<tr><td>6</td><td colspan="2">Select the option you want to activate / deactivate. An overview table of all options can be found in appendix 1.</td></tr>
<tr><td rowspan="4">7</td><td colspan="2">Select one of the available options by rotating the rotary knob 6:</td></tr>
<tr><td>Disabled</td><td>The option is not available in the selected user mode.</td></tr>
<tr><td>Simple</td><td>The option is available in the Standard Options menu of the selected user mode.</td></tr>
<tr><td>Extended</td><td>The option is available in the Extended Options menu of the selected user mode.</td></tr>
</table>

Step	Action
8	Confirm the selection with .
9	If required, perform steps **6** to **8** for further options.
10	The adjusted configuration can be shared among your units using the **Export** and **Import** functions of the **Menu Locate Options** menu.

How to Use EasyPROT Software to Plot DC HIPOT/Sheath Test Data

The ST25-30allows recording and graphing of DC test data, either DC HIPOT test data or Sheath test data. Before switching the ST16 on, insert USB drive into front panel. Then start the unit and conduct the particular test. After the test is finished, operator will be asked if he or she wants to export data. By clicking yes a *.csv* data set is written to the USB drive. It can be downloaded on to a laptop, which has the EasyPROT software installed. The EasyPROT software is available as an option for all E-TRAY products.

8

CARE and MAINTENANCE

Maintenance

For installation and operation of the equipment it is not necessary to open the enclosure of the instrument. Opening the enclosure will void the warranty and liability of the manufacturer.

Connections and connectors must be tested according to all applying standards (international, national and company own). Keep connectors and connections clean.

Line and neutral on the AC power input are fused. The fuse form factor is 5x20mm and are each rated for 6.3A 250VAC slow.

Storage

If not in use, the system should be stored in a dust free and dry environment. Humidity (condensation) by itself or in combination with dust can reduce critical distances within the equipment, which are necessary to maintain safe high voltage performance.

Always store the unit at a full state-of-charge. Apply topping charge every six months.

Appendix 1

Overview of TDR Features

See next page for complete chart.

Option	Recommended settings	Your settings (mark with x)					
		QUICK STEPS mode			EXPERT MODE		
		Disa.	Simp.	Ext.	Disa.	Simp.	Ext.
Cable Velocity (option to adjust the cable velocity)	QUICK STEPS: **simple** Expert: **simple**						
Xfmr sensitifity (option to adjust the transformer sensitivity)	QUICK STEPS: **disabled** Expert: **simple**						
Delay time (option to adjust the trigger delay time, Single Shot units only	QUICK STEPS: **disabled** Expert: **extended**						
Disable live Trace (option to disable live trace recording, not recommended)	QUICK STEPS: **disabled** Expert: **extended**						
Graphic View (option to enable the graphical view)	QUICK STEPS: **disabled** Expert: **disabled**						
Enable live Trace (option to enable live trace recording)	QUICK STEPS: **disabled** Expert: **extended**						
Alphanumeric View (option to enable the alphanumeric view, not recommended))	QUICK STEPS: **disabled** Expert: **disabled**						
Opt Gain (for service purposes only)	---	---	---	---	---	---	---
Search for Xfmr (option to start a transformer search)	QUICK STEPS: **disabled** Expert: **simple**						
Gain (option to adjust the gain setting)	QUICK STEPS: **simple** Expert: **simple**						
Put Trace on hold (option to put live trace on hold)	QUICK STEPS: **simple** Expert: **simple**						
Adjust End Marker (option to adjust the end marker)	QUICK STEPS: **simple** Expert: **simple**						
Adjust Start Marker (option to adjust the start marker)	QUICK STEPS: **disabled** Expert: **extended**						
Recall stored Traces (option to export, delete and recall traces)	QUICK STEPS: **disabled** Expert: **simple**						
Cursor (option to move the cursor)	QUICK STEPS: **simple** Expert: **simple**						
Additional Marker (option to place an additional marker)	QUICK STEPS: **disabled** Expert: **simple**						
Pulse width (option to adjust the pulse width)	QUICK STEPS: **disabled** Expert: **simple**						
Save trace (option to save the current trace)	QUICK STEPS: **simple** Expert: **simple**						
Save Fulltrace to USB (for service purposes only)	---	---	---	---	---	---	---
Zoom In/Out (option to zoom the trace in and out)	QUICK STEPS: **simple** Expert: **simple**						