

## User Manual

### **Portable Fault Locating System SMART THUMP ST16**

Read this entire manual before operating.

**Megger**®

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**Portable Fault Locating System  
SMART THUMP ST16  
User Manual**



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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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## 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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# 1

## SAFETY

### *Precautions*

This manual contains basic instructions on commissioning and operating the SMART THUMP 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 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.

### *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:



#### **WARNING!**

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



#### **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.

<p><i>NOTE:</i> The notes contain important information and useful tips for using the system. Failure to observe them can render the measuring results useless.</p>
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## ***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 instrument 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 authorized 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

## ***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

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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 may 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 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):
- De-energize
- Protect against re-energizing
- Confirm absence of voltage
- Ground and short-circuit
- 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<sub>2</sub>) 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 - Dangers when working with HV**

Special attention and safety awareness is 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 16 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 close proximity of the test equipment must be grounded in order to avoid the build-up of hazardous electric surface charges.

# 2

## TECHNICAL DESCRIPTION

### *System Description*

#### **Functional Description**

The SMART THUMP is a compact, battery or AC operated fault location system typically to be used for fault locating of solid dielectric low voltage and medium voltage cables.

It is ideally suited for use in URD systems and also feeder cables. The main advantages of the SMART-THUMP are its solid HV performance, simple operation, automated fault locating process, operation in rainy conditions, weight and economics.

Beside proven prelocation technique (inductive ARM, current decoupling (ICE)), the SMART THUMP provides sectionalizing capability (trouble shooting in URD loop systems, North America), acoustic pinpointing with the integrated 1500 J surge generator as well as DC for breakdown detection, insulation resistance estimation and sheath testing and sheath locating (sheath locating requires optional receiver ESG-NT).

#### **Product Models**

Typically, the SMART THUMP is mounted on a hand truck and equipped with a lead-acid battery/inverter system.

The hand truck mounted version is also available as an AC unit only (without battery/inverter system, but with an AC isolation transformer).

The SMART-THUMP can be also permanently installed in a vehicle and is powered by the power circuit of the vehicle (via inverter), a generator system or optionally by an external battery with internal inverter.

When installed into a vehicle, the SMART-THUMP also offers an optional remotely operated configuration, with a separation of up to 8 ft between the control and HV units.

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

## Features

The SMART THUMP system combines the following features and functions as a single device:

- Quick Steps and Expert Mode (full feature mode), Automatic detection and localization of transformers
- Automatic fault prelocation and localization with regard to the 2 closest transformers (optional Sectionalizing software)
- Automatic cable end and fault detection and localization
- DC test up to 16 kV with automatic breakdown detection and insulation resistance measurement
- Pinpointing of high resistance faults in surge mode
- Sheath test with automatic breakdown detection
- (Sheath) fault pinpointing (requires optional receiver ESG-NT)
- Integrated safety circuit for user's safety (F-OHM safe grounding)
- Optional external remotely operated safety device to shut off HV
- Operation from internal battery / inverter or from an external AC or DC source
- Sturdy and weatherproof enclosure for outdoor use

## Scope of Delivery

The scope of delivery of the SMART THUMP system comprises 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  (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

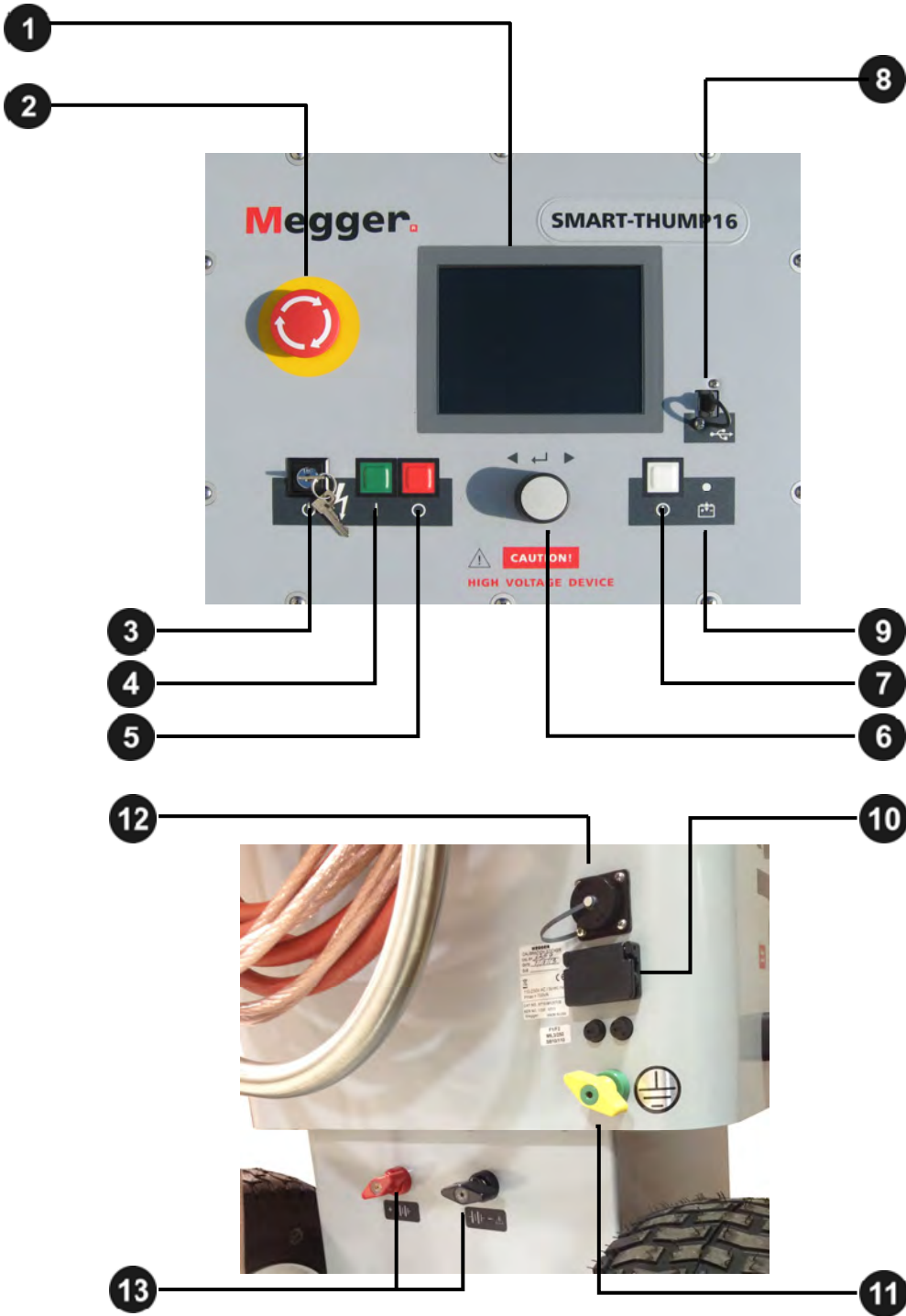
## Technical Data

Parameter	Value
DC Test voltage	0 to 16 kV
Surge voltage	0 to 8 / to16 kV,
Source current	0 to 60 mA (up to 8 kV) 0 to 30 mA (8 ... 16 kV)
Insulation measurement	20 kΩ ... 10 MΩ
Surge energy	1500 J at the maximum surge voltage of the respective surge levels (8 kV / 16 kV)
Power supply	110 V to 230 V ±15%, 50 / 60 Hz
Battery	Internal lead-acid gel type battery (12 V / 74 Ah)
Operating time battery	>90 min (pinpointing)
Power consumption	700 W
Display	640 x 480 pixel Transflective / high Brite TFT direct sunlight readable
Memory	>1000 traces
Interfaces	USB port
Measuring range (extended range)	8000 m , 25,000 ft, (32km, 100000ft)
Measuring resolution	0,8 m (2,5 ft) at 80 m/μs (250 ft/μs)
Max. sampling rate	100 MHz
Update rate	5 samples / second
Dynamic range	64 db
Output impedance	64 Ω
Operating temperature	20 °C to +50 °C

<b>Storage temperature</b>	25 °C to +70 °C
<b>Dimensions (W x H x D)</b>	690 x 1165 x 600 mm
<b>Weight</b>	145 kg, hand truck mounted incl. battery/ inverter and 50ft (17m) each of HV and Safety Ground cable
<b>Protection class (in accordance with IEC 61140)</b>	I
<b>Protection rating (in accordance with IEC 60529)</b>	IP53

### Control Elements, Indicators and Connectors

The SMART THUMP has the following control elements, indicators and connectors:



Element	Description
1	Display
2	Emergency stop button
3	HV “interlock” key switch
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 ( <i>See page 7 'Available Accessories'</i> ).
13	Terminals for external 12 V DC power supply

# Power Supply

## Battery Operation

### Introduction

The SMART THUMP can be equipped with an internal battery. In this case there is no requirement for an AC line supply to operate the unit in the field. For a good trade-off between weight and operation time, the battery is sized for up to more than 400 capacitor discharges at 90% of full voltage which equals approximately 1 hour of thumping (pinpointing).

### Battery Status and Automatic Shutoff

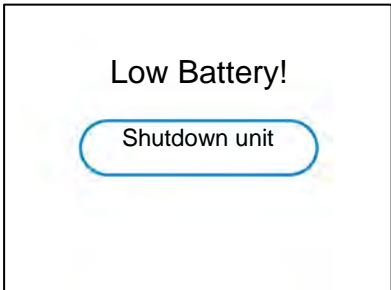
As long as more than 50% of the battery capacity is available, no battery icon is shown on the screen. As soon as the battery is discharged by more than 50%, the **battery icon** in the upper right corner of the screen starts flashing (*not* an active bar graph).



**Battery capacity >50%**

**Battery capacity <50%**

To protect the battery from a deep discharge, the unit turns automatically off, if the battery is discharged too low for safe operation.



*Note: To find out whether the battery charge is sufficient for further use of the unit in the field, just turn the unit on and check if the battery symbol is visible on the main screen. If the symbol is visible you should strongly consider recharging the battery before using the unit or plan to operate off AC line power.*

## **Backup Battery**

If the internal battery is becoming drained while fault locating, any 12 V battery providing more than 50 A (e.g. a car battery) can be connected to the 12 V terminals **13** in order to extend the operation time or the unit must be connected to an AC source (see below AC Line Operation).

## **Charging**

The battery automatically is being charged as soon as the SMART THUMP 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 **9**. During charging, the LED lights yellow. It turns to green, when the battery is full and charging is finished.

*NOTE: Always charge the battery immediately after use. Lead-acid batteries must always be kept in a charged condition. The battery life is longer with an almost fully charged battery rather than fully discharged one.*

*Store the unit always at a full charge by keeping the charger connected while the unit is not in use (trickle charge).*

## **AC Line Operation**

As soon as the AC power cord is connected to the receptacle **10** of the SMART THUMP and the AC line, ***the system is operating on AC power and being charged at the same time.***

# 3

## SETTING UP THE SYSTEM



### WARNING - Safety instructions for setting up

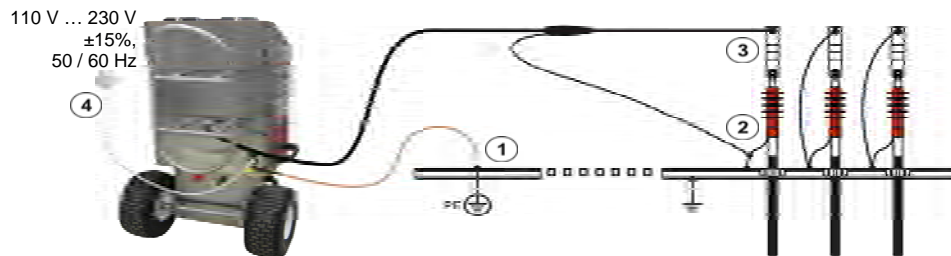
- The guidelines to maintain occupational safety when operating a non-stationary test system often differ between network operators and it is not uncommon to use National regulations (like, i.e. the German BGI 5191) to be used as well.

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*) - in particular the **five safety rules** - 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 grounded tested in compliance with all OSHA & company safety procedures.
- Select a setup location which is sufficient for the weight and size of the system and insure that it stands securely. Always locate the system off to the side of the cable path, never on top of the cable path.
- 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 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 is 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.



## Connection Sequence

Connect the unit in the following order:

Step	Description
①	<b>Connect the safety ground lead</b> to a reliable ground (e.g. station-ground, transformer ground rod. Do not drive a separate ground rod!).
②	<p><b>Connect the HV return lead</b> 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 <math>\Omega</math> (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.</p> <div style="border: 1px solid black; padding: 5px; margin-top: 10px;"> <p><i>NOTE: The closer and better the HV return is connected to the shield / concentric of the cable to be tested, the better the TDR trace readings will be.</i></p> </div>
③	<b>Connect the HV lead</b> to the phase conductor to be tested (optional elbow adapter or vice-grip). (See 'Available Accessories' in Section 2).
④	<p><b>Connect the supplied power cord</b> to the connector ⑩ on the back of the unit and connect the other end to a power outlet.</p> <div style="border: 1px solid black; padding: 5px; margin-top: 10px;"> <p><i>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 also provides 2 battery terminals that are accessible from the out-side, which can be connected to an external battery</i></p> </div>
⑤	Only after all necessary connections have been made, <b>the ground connection to the cable under test can be lifted.</b>

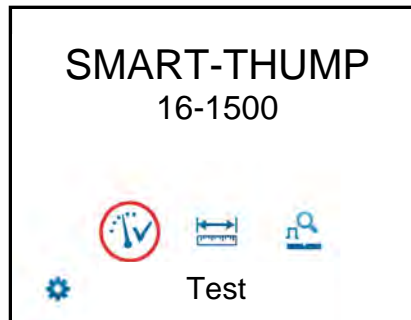


# 4

## OPERATING INSTRUCTIONS

### *Power on the System*

Once the “ON / OFF” button **7** is pressed, the system starts up. After start-up, the system is in the 'Ready for operation' state and the main menu is displayed:



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 **6** as follows:

**Turning**

**Selecting**

**Clicking**

**Confirming** (“ENTER” function)

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



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 the test, the user is prompted to enable high voltage. To do so, the green illuminated “HV ON” button **4** (green) must be pushed. This lifts the discharge resistor and enables the generation of high voltage. The red illuminated “HV OFF” button **5** 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 16 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” button **5**. The test is then immediately aborted and the system is placed in the 'Ready for operation' state. The high voltage power supply is turned off and the entire test circuit including the SMART-THUMP 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, 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 HV operation can be re-activated again.

## Conditions of the Safety Circuit

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

- The HV key switch **3** *must be* in the  position.
- The emergency off button **2** *must be* unlocked (up).
- The F-Ohm safety circuit must have a loop resistance below 6.5  $\Omega$  (if resistance is higher, warning on LCD will be provided).

<p><i>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.</i></p>
---

## User Modes

The E-TRAY system platform offers two operational modes, to the operator, which are fully customer configurable:

- **QUICK STEPS mode:**  
This mode is tailored for the “everyday jobs” where the basic settings may need no or just minor adjustments This is typically configured with a limited range of adjustment features and no access to the system settings.
- **EXPERT MODE:**  
This password-protected mode is recommended for experienced users. It offers the full range of adjustment features and access to the system settings, incl. the default settings.


For detailed information on how to switch modes, please refer to the next page

## System Settings (only accessible in Expert Mode)

In order to change the system settings, **EXPERT settings**  from the main menu must be accessed.

These settings are only available, if the system is operated in **Expert Mode**. If this is not the case, the rotary knob **6** must be pushed down and held down shortly on any of the main menu 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).

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

Menu item	Description	
<b>Leave EXPERT MODE</b>	By leaving the expert settings through this menu item the new settings are saved and the system is switched to <b>QUICK STEPS mode</b> . The  is no longer displayed in the main menu which prevents unauthorized persons from changing the system and default settings.	
<b>Date / Time</b>	Date and time settings	
<b>Language</b>	Language settings	
<b>Default Settings</b>		
>> <b>Measurement unit</b>	<b>Length</b>	Unit of the x-axis ( <b>Meter, Feet or Time</b> ). If set to <b>Time</b> , the actual runtime of the pulse is displayed and no conversion to length of cable is performed.
	<b>Rate</b>	<u>Only available, if Length is set to Meter or Feet</u> Rate refers to how the propagation velocity of the TDR pulse is specified. This can be done <i>either</i> relative to the speed of light ( <b>% of NVP</b> ) or in absolute units in $\mu\text{s}$ ( <b><math>\mu\text{sec} = \text{microseconds} = 10^{-6} \text{ sec}</math></b> ).
>> <b>V/2 or NVP</b>	<u>Only available, if Length is set to Meter or Feet</u> 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 $\text{m}/\mu\text{s}$	
>> <b>Trigger delay time</b>	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 its highest current). <b>If Delay time too short:</b> Flash-over is not fully developed and may cause poor or no reflections of the TDR pulse. <b>If Delay time too long:</b> 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 ST16 is 700 $\mu\text{ms}$ .	

Menu item	Description		
>> <b>Automatic HV release</b>	<p>The way a HV test is started, <b>automatic</b> or <b>manual</b>.</p> <p><b>Automatic</b> means that after initializing HV by pushing the HV ON button, HV will build up in the test mode or will charge the capacitor <b>and</b> fire as soon as voltage has been reached (typically preferred in North America).</p> <p><b>Manual</b> means that in both situations the HV has to be manually “released”, once the preset level has been reached (typically preferred in Europe).</p>		
<b>Voltage selection</b>	<p>When set to <b>Manual</b> the unit will always default to 2kV as a starting level in all HV modes. The operator must then select the actual HV level in any operating mode and operation menu (Quick-Steps and Expert mode).</p> <p>When set to <b>Automatic</b>, the unit, <b>when in Quick Steps mode only</b>, will always fire a shot in ARC reflection at the full voltage (max. energy) and when in thump mode will go to maximum voltage (operator can down adjust). If a HIPOT/Breakdown test was performed before hand, then the unit will match the thump voltage to the breakdown voltage during the HIPOT test <b>plus</b> 4kV, i.e. breakdown 4kV, thump voltage will be set to 8kV.</p>		
<b>Sheath Test Limit</b>	Units, which have the Sheath Test Option enabled, have a default test voltage that can be adjusted between 2 and 5kV.		
<b>Continuous Testing</b>	<ol style="list-style-type: none"> <li>1. When disabled, only DC HIPOT / breakdown tests can be performed.</li> <li>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.</li> <li>3. <b>Must</b> be enabled to perform Sheath Tests.</li> </ol>		
>> <b>Set-up Start Marker</b>	<p>Procedure to adjust the start marker position to the end of the actual length of the HV output cable (typically on SMART-THUMP at the end of the 50ft (17m) HV output cable).</p> <p>The procedure is fully automatic and the operator is prompted when necessary!</p> <p>First a measurement is taken with the ends of the connection cable open. Then the gain setting is adjusted if needed and confirmed and a copy of the trace is frozen.</p> <p>A second trace is recorded with the ends of the connection cable shorted to each other, which should show a significant change. The marker is automatically placed on the position where both traces start to split.</p> <p>If required, the marker can be manually adjusted. This setting of the start marker will be stored as the default, if operator acknowledges the prompt, <b>and should only be changed if the length of the connection cable is changed.</b></p>		
<b>Cable List</b>	<p>By means of the cable list the appropriate propagation velocity can be quickly adjusted / selected by identifying the type of cable to be tested</p> <p>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 43) and then share it among all units of a customer</p> <p>This submenu offers the following options:</p> <table border="1" style="width: 100%; border-collapse: collapse;"> <tr> <td style="width: 20%;"><b>Set default</b></td> <td>Menu item to select the default cable list out of all available cable lists. Only the cable types of the default cable list can be accessed during measurement.</td> </tr> </table>	<b>Set default</b>	Menu item to select the default cable list out of all available cable lists. Only the cable types of the default cable list can be accessed during measurement.
<b>Set default</b>	Menu item to select the default cable list out of all available cable lists. Only the cable types of the default cable list can be accessed during measurement.		

Menu item	Description	
	<b>Import from USB</b>	Imports a cable list from an inserted USB drive. The cable list must be located in the <i>CableLists</i> folder.
	<b>Export to USB</b>	Exports the selected cable list to the <i>CableLists</i> folder on the USB drive.
	<b>Remove cable list</b>	Removes the selected cable list from internal memory.
<b>User mode</b>	Menu item to select the <i>User Mode</i> which is the default after start-up. If set to <b>Last</b> , the unit starts up in last active mode, <b>recommended</b> is to set to <b>QUICK STEPS</b> .	
<b>Backlight settings</b>	Backlight timeout and contrast settings	
<b>Time Out Settings</b>	Minutes of inactivity after which the system is automatically shut down.	
<b>Stored Traces</b>	<p>Menu item to export or delete all traces which have been stored in the internal memory.</p> <p>Exporting traces requires a USB flash drive plugged into the USB port <b>8</b>. The traces are written into the <i>EtrayTraces</i> folder which is automatically created.</p> <p>The data can be viewed in any regular web browser by opening the <i>index.html</i> file which is also located in the <i>EtrayTaces</i> folder.</p>	
<b>System information</b>	Displays the detailed hardware and software configuration of the unit.	
<b>Change password</b>	Menu item to change the password required to enable the <b>EXPERT MODE</b> .	
<b>Customize TDR features</b>	Menu item to configure the options which are available during measurement, See <i>page 45</i> .	
<b>Return</b>	By leaving the <b>EXPERT MODE</b> 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 Section (Sectionalizing)**

##### **Introduction**

The sectionalizing technique is used to trouble shoot a distribution loop circuit in order to identify the faulted section, so it can be quickly switched out, and the rest of the circuit can be re-energized to provide service to all customers.

For this purpose, a LV reflection image is taken and scanned for impedance changes which are related to the cable end and transformers. A second reflection image of the TDR pulse is taken while an electrical arc is ignited by a sudden discharge of the charged capacitor at the fault location. This reflection is negative.

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 closing the normally open point within the distribution loop.

#### **2 Alternatives**

The procedure called “Sectionalizing” in the configuration set up will *work flow* perform the following steps:

##### **Pattern 1**

- low voltage TDR trace to identify cable end (blue trace)
- low voltage trace to identify all transformers in the faulted (half) loop (blue trace)
- high voltage trace to identify fault (negative reflection in red trace)




The procedure called "COMED" in the configuration set up will perform the following steps:

### Pattern 2






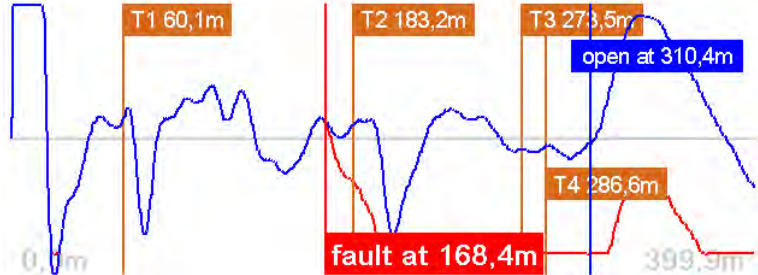


- low voltage trace to identify cable end (blue trace)
- high voltage trace to identify fault (negative reflection in red trace)
- low voltage trace to identify all transformers leading up to the fault plus one additional transformer past the fault (blue trace) if there is a transformer past the fault

### How to Determine the Faulty Section

Proceed as follows to perform sectionalizing according to *Pattern 1*:










Step	Description
1	<p>Select the  menu item from the main menu or from the  submenu (depends on the system configuration).</p> <p><b>Result:</b> 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 and, in addition, the approximate distance to each transformer is presented in the display.</p>  <p>This reference trace is also called "live" trace as it is permanently refreshed.</p>
2	<p>Compare the indicated transformers with the actual plans of the cable system.</p> <p>If necessary adjust the transformer search sensitivity and / or the propagation velocity in the options. See page <b>Error! Bookmark not defined..</b></p> <div style="border: 1px solid black; padding: 10px; margin-top: 10px;"> <p><i>NOTE: Sectionalizing is a transformer prediction algorithm based of impedance changes. If all transformers in a loop cause similar signatures the prediction works very well. If there are impedance changes for some other reasons (most likely joints) the software cannot tell them apart in every case. Please always check the distances to identify missing or "phantom" transformers.</i></p> </div>



Step	Description
3	Select  to start the fault location.
4	Adjust the surge voltage and select  to confirm the value (not required in automatic mode).
5	Press the green illuminated “HV ON” button  .
6	Select  to charge the surge capacitor (only if <b>measurement start</b> option is set to <b>manual</b> . See page 18).
<b>Result:</b> The capacitor is charged up to the selected voltage.	
7	Select  to discharge capacitor (only if <b>measurement start</b> option is set to <b>manual</b> (not required in automatic mode). See page 18).
<b>Result:</b> A capacitor discharge (shot) is initiated.	
<p>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.</p>	
	
<p><b>NOTE:</b> <i>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  menu item.</i></p>	
8	If necessary, adjust the display settings, TDR settings and marker position through the  menu in order to uniquely identify the affected section. See page 38).

## 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 bad during the Sectionalizing procedure can be verified to be actually bad. Proceed as follows to perform a HIPOT test *after the identified cable section has been isolated at the 2 closest transformers:*











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	Select  to start the test (only if <b>measurement start</b> option is set to <b>manual</b> . See “System Settings” on page 17).								
	<p><b>Result:</b> The selected voltage is applied to the cable.</p> <p>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.</p> <p>Depending on whether or not a breakdown takes place during the test, one of the following results is presented in the display:</p> <table border="1"> <tbody> <tr> <td><b>Breakdown at...kV</b></td> <td>A voltage breakdown took place at the indicted test voltage.</td> </tr> <tr> <td><b>No Flash-over</b></td> <td>The cable has successfully withstood the applied DC test voltage. If possible, repeat () the test with higher voltage (do not exceed the maximum permissible voltage).</td> </tr> <tr> <td><b>Cable not chargeable</b></td> <td>The cable could not be charged by the test voltage. This is typically due to a short (fault) in the cable.</td> </tr> <tr> <td><b>Low resistance at ...kV</b></td> <td>The HV source cannot charge the cable beyond the indicated voltage value due to the very high leakage current level.</td> </tr> </tbody> </table>	<b>Breakdown at...kV</b>	A voltage breakdown took place at the indicted test voltage.	<b>No Flash-over</b>	The cable has successfully withstood the applied DC test voltage. If possible, repeat (  ) the test with higher voltage (do not exceed the maximum permissible voltage).	<b>Cable not chargeable</b>	The cable could not be charged by the test voltage. This is typically due to a short (fault) in the cable.	<b>Low resistance at ...kV</b>	The HV source cannot charge the cable beyond the indicated voltage value due to the very high leakage current level.
<b>Breakdown at...kV</b>	A voltage breakdown took place at the indicted test voltage.								
<b>No Flash-over</b>	The cable has successfully withstood the applied DC test voltage. If possible, repeat (  ) the test with higher voltage (do not exceed the maximum permissible voltage).								
<b>Cable not chargeable</b>	The cable could not be charged by the test voltage. This is typically due to a short (fault) in the cable.								
<b>Low resistance at ...kV</b>	The HV source cannot charge the cable beyond the indicated voltage value due to the very high 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 and, if the test fails, to determine the breakdown voltage. For this purpose, a test voltage of up to 16 kV is applied to the cable under test.

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.								
3	Press the green illuminated "HV ON" button  .								
4	<p>Select  to start the test (only if <b>Measurement Start</b> option is set to <b>Manual</b>. See section "System Settings" on page 17).</p> <p><b>Result:</b> The selected voltage is applied to the cable.</p> <p>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.</p> <p>Depending on whether a breakdown takes place during the test, one of the following results is presented in the display:</p> <table border="1"> <tbody> <tr> <td><b>Breakdown at...kV</b></td> <td>A voltage breakdown took place at the indicted test voltage.</td> </tr> <tr> <td><b>No Flash-over</b></td> <td>The cable has successfully withstood the applied DC test voltage. If required, repeat () the test with higher voltage (do not exceed the maximum permissible voltage).</td> </tr> <tr> <td><b>Cable not chargeable</b></td> <td>The cable could not be charged while the test voltage was applied. This may be due to a short on the cable.</td> </tr> <tr> <td><b>Low resistance at ...kV</b></td> <td>The HV source cannot charge the cable beyond the indicated voltage value due to a very high leakage current level.</td> </tr> </tbody> </table>	<b>Breakdown at...kV</b>	A voltage breakdown took place at the indicted test voltage.	<b>No Flash-over</b>	The cable has successfully withstood the applied DC test voltage. If required, repeat (  ) the test with higher voltage (do not exceed the maximum permissible voltage).	<b>Cable not chargeable</b>	The cable could not be charged while the test voltage was applied. This may be due to a short on the cable.	<b>Low resistance at ...kV</b>	The HV source cannot charge the cable beyond the indicated voltage value due to a very high leakage current level.
<b>Breakdown at...kV</b>	A voltage breakdown took place at the indicted test voltage.								
<b>No Flash-over</b>	The cable has successfully withstood the applied DC test voltage. If required, repeat (  ) the test with higher voltage (do not exceed the maximum permissible voltage).								
<b>Cable not chargeable</b>	The cable could not be charged while the test voltage was applied. This may be due to a short on the cable.								
<b>Low resistance at ...kV</b>	The HV source cannot charge the cable beyond the indicated voltage value due to a very high leakage current level.								
5	Select  to proceed with fault pre-location or  to return to the main menu.								





## How to Pre-Locate the Fault



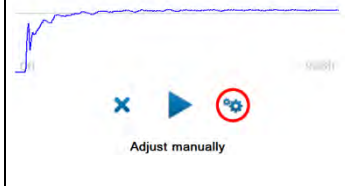
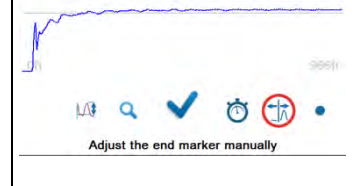





### Arc Reflection Method (ARM)


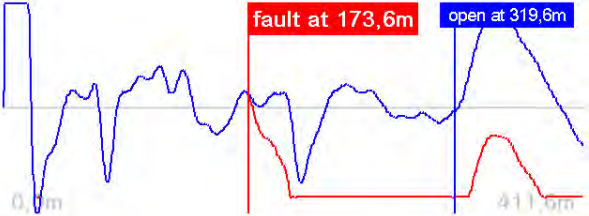





For pre-location of high resistance fault the SMART THUMP applies the widely approved and well-known ARM (Arc Reflection Method).

Locating the fault becomes possible by comparing a reflection image taken with a LV pulse (reference trace) to a reflection image taken while the 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 of the TDR pulse, indicating the fault location.

Proceed as follows to pre-locate the cable fault:

Step	Description
1	<p>Select the  menu item from the main menu or from the  submenu (depends on the system configuration).</p> <p><b>Result:</b> A LV pulse is fed into the cable. The reflection image with the determined distance to the cable end is presented in the display.</p> <p><b>Cable end most likely at 950ft</b></p>  <p>This reference trace is also called “live” trace as it is permanently refreshed (blue color, a black color trace indicates a “frozen” or “saved” LV trace).</p> <div style="border: 1px solid black; padding: 10px; margin-top: 10px;"> <p><i>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.</i></p> <p><b><i>Either the suggested or the manually adjusted cable end must be confirmed, otherwise unit will not display any distances.</i></b></p> </div>

Step	Description
	<p>In case the software <b>cannot determine</b> the end of the cable, a message will be displayed stating “CABLE END NOT CLEARLY VISIBLE” and offering to proceed by “IGNORE” this fact.</p> <p>Do <b>NOT acknowledge</b> the IGNORE message, but turn to the  icon asking to perform a manual adjustment of the End Marker by activating the END MARKER icon in the feature menu. After adjustment to identify the cable end manually, click again and acknowledge the manually identified cable end.</p> <div style="display: flex; justify-content: space-around;"> <div data-bbox="410 581 753 879"> <p>Cable end not clearly visible</p>  </div> <div data-bbox="753 581 1096 879"> <p>Cable end not clearly visible</p>  </div> <div data-bbox="1096 581 1453 879"> <p>Cable end not clearly visible</p>  </div> </div>
2	<p>Select  to start the fault pre-location.</p> <div style="text-align: center;">  </div>
3	<p>If required, the surge voltage can be adjusted through the  menu item. Otherwise, the maximum surge voltage is automatically used, if default AUTOMATIC VOLTAGE CONTROL.</p>
4	<p>Press the green illuminated “HV ON” button .</p>
5	<p>Select  to charge the capacitor (only if <b>Measurement Start</b> option is set to <b>Manual</b>. See page 18).</p> <p><b>Result:</b> The surge capacitor is charged up to 16 kV.</p>

Step	Description
6	<p>Select  to discharge the capacitor (only if <b>Measurement Start</b> option is set to <b>Manual</b>. See page 18).</p> <p><b>Result:</b> A capacitor discharge (shot) is initiated.</p> <p>If a breakdown / flashover takes place, the red fault trace typically has a strong negative reflection. The red fault marker is automatically set to the position where both traces diverge from each other.</p>  <div data-bbox="446 884 1321 1171" style="border: 1px solid black; padding: 10px;"> <p><b>NOTE:</b> <i>If no trigger is received, no fault trace (red) is shown. Repeat the procedure with a higher surge voltage (if possible) by selecting the  menu item.</i></p> <p><i>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 or possibly good cable.</i></p> </div>
7	<p>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. See page 38.</p>
8	<p>Select  to proceed with pinpointing or  to return to the main menu.</p>

**Current Decoupling (ICE)**








As an alternative way for pre-location of high resistance faults, the SMART THUMP provides the current decoupling method (ICE, Surge Pulse).





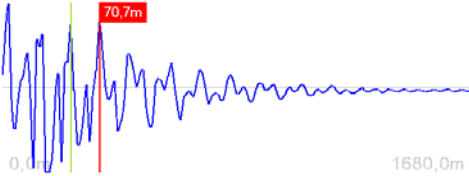

The capacitive discharge of the surge capacitor via the surge switch triggers and ignites the fault and causes it to a flash over. This flashover results in a travelling wave current on the HV return, which is inductively de-coupled and shown on the Reflectometer as a transient. Subsequently, an attenuated 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 period length corresponds directly to the fault distance.

*Note: Fault distance includes length of HV output cable: 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  menu item from the main menu 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  .
4	Select  to charge the capacitor (only if Automatic High Voltage Release is disabled). See page 20.
	<b>Result:</b> The capacitor is charged up to 16 kV.
5	Select  to discharge the capacitor (only if Automatic High Voltage Release is disabled). See page 20.
	<p><b>Result:</b> A sudden capacitor discharge (shot) is initiated.</p> <p>If a voltage breakdown takes place, a red oscillating curve is shown in the display.</p> <div style="border: 1px solid black; padding: 5px; margin-top: 10px;"> <p><i>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  menu item.</i></p> </div>

Step	Description
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. See page 38.
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 the Fault (*shielded MV power cable*)

The thumping mode can be used to pinpoint a fault between two phase conductors or between a phase conductor and the neutral conductor or on unshielded cables between the phase conductor and earth ground..

The SMART THUMP serves as surge pulse generator to continuously feed high voltage pulses into the defective cable, producing voltage flash-overs (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 flash-over noise 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 the 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 locating faults in conduit.**

Proceed as follows to pinpoint the fault:

Step	Description
1	Select the  menu item from the main menu 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  .
4	Select  to start the thumping mode (only if <b>Measurement Start</b> option is set to <b>Manual</b> . See page 18.  <b>Result:</b> 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, you can adjust the surge voltage by selecting the  menu item.
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 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 cables or ground faults in unshielded cables assumes that in both situations the cables are direct buried; cables in conduit, especially PVC conduit, will not respond to this method.*

### IMPORTANT

In contrast to the connection diagram on page 14 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  .







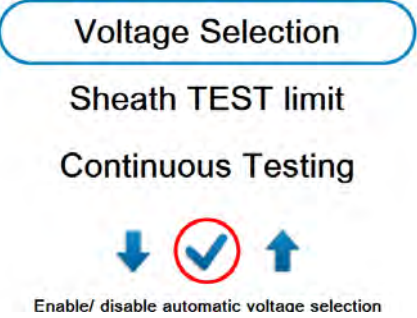



Step	Description								
3	Adjust the test voltage and select  to confirm the value.								
4	Press the green illuminated "HV ON" button  .								
5	<p>Select  to start the test (only if <b>Measurement Start</b> option is set to <b>Manual</b>. See "System Settings" on page 17).</p> <p><b>Result:</b> The selected voltage is applied to the cable shield.</p> <p>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.</p> <p>Depending on whether a breakdown takes place during the test, one of the following results is presented in the display:</p> <table border="1" style="width: 100%; border-collapse: collapse;"> <tbody> <tr> <td style="width: 20%;"><b>Breakdown at ... kV</b></td> <td>A voltage breakdown took place at the indicted test voltage.</td> </tr> <tr> <td><b>No Flash-over</b></td> <td>The cable jacket has successfully withstood the applied DC test voltage. You can repeat the test using the  menu item.</td> </tr> <tr> <td><b>Cable not chargeable</b></td> <td>The cable shield could not be charged with the test voltage. This may be due to a short on the circuit (fault in the jacket).</td> </tr> <tr> <td><b>Low resistance at ... kV</b></td> <td>The HV source failed to charge the cable shield beyond the indicated voltage value due to the very high leakage current level.</td> </tr> </tbody> </table>	<b>Breakdown at ... kV</b>	A voltage breakdown took place at the indicted test voltage.	<b>No Flash-over</b>	The cable jacket has successfully withstood the applied DC test voltage. You can repeat the test using the  menu item.	<b>Cable not chargeable</b>	The cable shield could not be charged with the test voltage. This may be due to a short on the circuit (fault in the jacket).	<b>Low resistance at ... kV</b>	The HV source failed to charge the cable shield beyond the indicated voltage value due to the very high leakage current level.
<b>Breakdown at ... kV</b>	A voltage breakdown took place at the indicted test voltage.								
<b>No Flash-over</b>	The cable jacket has successfully withstood the applied DC test voltage. You can repeat the test using the  menu item.								
<b>Cable not chargeable</b>	The cable shield could not be charged with the test voltage. This may be due to a short on the circuit (fault in the jacket).								
<b>Low resistance at ... kV</b>	The HV source failed to charge the cable shield beyond the indicated voltage value due to the very high leakage current level.								
6	Select  to proceed with sheath fault pinpointing or  to return to the main menu.								



## ***How to Pinpoint a Sheath Fault OR a Ground Fault in an Unshielded Low Voltage Cable (both must be directly buried)***

Following a failed sheath test (*see page* **Error! Bookmark not defined.**) fault location of the sheath fault in ***direct buried cables*** based on the step voltage method (earth gradient method) 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) 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.

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  .
5	Select  to start the sheath fault pinpointing mode. The <b>Voltage Selection, Automatic</b> should be disabled ( <i>see page 18</i> ) allowing you to select a voltage between 2 and 10 kV. If the <b>Voltage Selection , Automatic</b> is enabled, the maximum voltage is limited to 4 kV, <div style="text-align: center; margin-top: 20px;">  <p>Voltage Selection Sheath TEST limit Continuous Testing</p> <p>  </p> <p>Enable/ disable automatic voltage selection</p> </div>

Step	Description
	<p><b>Result:</b> The capacitor is charged up and a discharge takes place after 5 seconds injecting a pulsed voltage signal into the cable.</p> <p>This process is then repeated until the process is manually stopped.</p> <p>If required, you can adjust the pulse voltage by selecting the  menu item.</p>
6	<p>Pinpoint the sheath fault with an earth fault locator like the Megger ESG-NT.</p> <p>For detailed instructions, please refer to the user manual of the earth fault locator.</p>
7	<p>Select  to stop pulsing.</p>



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# 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 the TDR Features in order to adjust the display and TDR settings in order to optimize the trace.

Depending on the system configuration, the TDR Features may be divided into ***simple options*** (  menu item) and ***extended options*** (  menu item). *Simple options*, easily available as icons, are placed along the bottom of the screen. *Extended options* are available from a scroll down sub menu.






**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 45); 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 to the customer's needs (for both modes) see page 45).*


## Customized TDR Features

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

Menu item	Description
 <p><b>Adjust Gain</b></p>	<p>Adjusts the gain setting. By doing so, the amplification of the received signal and, thus, the amplitude of the Y-axis can be adjusted.</p> <p>With an adjustment of the gain setting, the fault trace, if present, is erased and a new “live” trace is immediately recorded.</p> <div style="border: 1px solid black; padding: 5px; margin: 10px 0;"> <p><i>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!</i></p> </div>
 <p><b>Change visible range</b></p>	<p>Changes the displayed range. By doing so, the trace can be zoomed in and out.</p>
 <p><b>Change value of Cable Velocity</b></p>	<p>Allows manual adjustment of the velocity of propagation. While changing the velocity, the distance values (X-axis scaling) are immediately refreshed and adapted.</p> <p>This menu option is only effective, if the <b>Rate</b> parameter is set to <b>Meter</b> or <b>Feet</b>. See page 18.</p> <p>You may either manually adjust the value or automatically adopt the value by identifying /selecting a cable from the cable list. See page 19.</p>
 <p><b>Set / Move Cursor</b></p>	<p>Changes the cursor position. By doing so, the distance value for any point on the trace (typically to the fault) can be obtained.</p> <p>You can also use the cursor to scroll along the X-axis in zoomed view.</p> <p>At first, a coarse adjustment is made and confirmed by pressing the rotary knob <b>6</b> once - subsequently, the position can be fine-tuned.</p>
 <p><b>Adjust the End Marker</b></p>	<p>Allows the manual adjustment of the blue end marker.</p> <p>At first, a coarse adjustment is made and confirmed by pressing the rotary knob <b>6</b> once - subsequently, the position can be fine-tuned.</p>



Menu item	Description				
 <b>Put Trace on Hold</b>	<p>Makes an exact copy (blue trace) of the “live” trace.</p> <div style="border: 1px solid black; padding: 10px; margin: 10px 0;"> <p><i>NOTE: This function is very helpful when making a phase comparison on a 3 phase circuit. It is also very helpful when just using the TDR function on low voltage cables with 2 or 3 phases and by comparing them. Typically this will show the location of the fault in one of the phases provided the fault is either an “OPEN” or a “SHORT” or shows enough of an impedance change compared to the impedance of the cable.</i></p> </div>				
 <b>Set Marker at Current Cursor Position</b>	<p>Places an additional marker (green) at the cursor position (red). <b>As only one additional marker can be placed, the very last marker is erased every time the marker is placed on a new position.</b></p>				
<b>Save Current Trace</b>	<p>Saves the current screen view to the internal memory.</p>				
<b>Export, Recall or Delete Stored Traces</b>	<p>Enables you to export, recall and delete stored data from internal memory.</p> <p>By selecting <b>All traces</b> you can delete or export all traces which are currently stored in the internal memory.</p> <p>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.</p> <p>After you selected the desired trace(s), you can choose from the following options:</p> <table border="1" data-bbox="511 1396 1437 1692"> <tbody> <tr> <td data-bbox="511 1396 678 1627"><b>Export</b></td> <td data-bbox="678 1396 1437 1627"> <p>Copies the selected trace(s) to the <i>EtrayTraces</i> folder on the USB flash drive which has been plugged into the USB slot <b>8</b>.</p> <p>The data can be viewed in any regular web browser by opening the <i>index.html</i> file which is also located in the <i>EtrayTaces</i> folder.</p> </td> </tr> <tr> <td data-bbox="511 1627 678 1692"><b>Remove</b></td> <td data-bbox="678 1627 1437 1692"> <p>Removes the selected trace(s) from internal memory.</p> </td> </tr> </tbody> </table>	<b>Export</b>	<p>Copies the selected trace(s) to the <i>EtrayTraces</i> folder on the USB flash drive which has been plugged into the USB slot <b>8</b>.</p> <p>The data can be viewed in any regular web browser by opening the <i>index.html</i> file which is also located in the <i>EtrayTaces</i> folder.</p>	<b>Remove</b>	<p>Removes the selected trace(s) from internal memory.</p>
<b>Export</b>	<p>Copies the selected trace(s) to the <i>EtrayTraces</i> folder on the USB flash drive which has been plugged into the USB slot <b>8</b>.</p> <p>The data can be viewed in any regular web browser by opening the <i>index.html</i> file which is also located in the <i>EtrayTaces</i> folder.</p>				
<b>Remove</b>	<p>Removes the selected trace(s) from internal memory.</p>				

Menu item	Description
	<p><b>Recall</b></p> <p>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.</p> <p>By selecting , the loaded trace is closed and the last recorded trace is displayed again.</p>
<p><b>Adjust Trigger Delay Time</b></p>	<p>Allows manual adjustment of the trigger delay time (see page 18). 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.</p> <p>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 ST16 is 700µs.</p>
<p><b>Adjust Pulse Width</b></p>	<p>Allows manual adjustment of the pulse width.</p> <p>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 have to be used when measuring on long cables.</p> <p>With an adjustment of the pulse width, the fault trace, if present, is erased and a new “live” trace is immediately recorded.</p>
<p><b>Change transformer sensitivity</b></p>	<p>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, <b>but will not change the position of the transformers</b> relative to each other and the 2 cable ends.</p> <div data-bbox="545 1304 1308 1381" style="border: 1px solid black; padding: 5px; margin: 10px auto; width: fit-content;"> <p><i>Note: The sectionalizing method is typically only used in North American URD loop type circuits!</i></p> </div>
<p><b>Find Transformers in Actually Trace</b></p>	<p>Allows manual start of the transformer search.</p>
<p><b>Disable live trace/ Enable live trace</b></p>	<p>Disables / enables continuous “live” trace recording.</p> <p>For most operators it is beneficial to “disable live trace”, which means the trace is always live and any adjustment becomes immediately visible.</p>

## ***Completing the Operation***

After the fault location procedure has been finished switch off the system by pressing the “ON / OFF” button **7**.

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 3.

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.

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# 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 19*). 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 <sup>2</sup> ) (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 ( <b>mandatory</b> )
<unit>	Unit of the propagation velocity in <b>feet/μs</b> or <b>m/μs</b> ( <b>mandatory</b> )
</velocity>	

## How to Edit the Cable List

<p><i>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.</i></p>
---




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 19).
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 <i>CableLists</i> folder of the USB drive.
5	Import the new cable list into the unit. See page 19.
6	Set the new cable list as default cable list. See page 19.

## 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 17) are customer configurable.

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

Step	Action	
1	Enable the EXPERT MODE. See page 18.	
2	Access the expert settings via the  menu item.	
3	Select the <b>Customize TDR Features</b> menu item.	
4	Select the <b>Setup options</b> menu item.	
5	<i>If you want to change the options of the <b>QUICK STEPS mode</b>...</i>	<i>If you want to change the options of the <b>EXPERT MODE</b>...</i>
	... select the <b>QUICK STEPS</b> menu item.	... select the <b>Expert</b> menu item.
6	Select the option you want to activate / deactivate. An overview table of all options can be found in appendix 1.	
7	Select one of the available options by rotating the rotary knob  .	
	<b>Disabled</b>	The option is not available in the selected user mode.
	<b>Simple</b>	The option is available in the <i>Standard Options</i> menu of the selected user mode.
	<b>Extended</b>	The option is available in the <i>Extended Options</i> menu of the selected user mode.
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 <b>Export</b> and <b>Import</b> functions of the <b>Menu Locate Options</b> menu.	





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

The SMART-THUMP allows 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.

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# 8

## CARE and MAINTENANCE

### ***Maintenance***

For installation and operation of the instrument it is not necessary to open the housing of the instrument. Opening the housing 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.

### ***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.

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# 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.
<b>Cable Velocity</b> (option to adjust the cable velocity)	QUICK STEPS: <b>simple</b> Expert: <b>simple</b>						
<b>Xfmr sensitifty</b> (option to adjust the transformer sensitivity)	QUICK STEPS: <b>disabled</b> Expert: <b>simple</b>						
<b>Delay time</b> (option to adjust the trigger delay time)	QUICK STEPS: <b>disabled</b> Expert: <b>extended</b>						
<b>Disable live Trace</b> (option to disable live trace recording)	QUICK STEPS: <b>disabled</b> Expert: <b>extended</b>						
<b>Graphic View</b> (option to enable the graphical view)	QUICK STEPS: <b>disabled</b> Expert: <b>disabled</b>						
<b>Enable live Trace</b> (option to enable live trace recording)	QUICK STEPS: <b>disabled</b> Expert: <b>extended</b>						
<b>Alphanumeric View</b> (option to enable the alphanumeric view)	QUICK STEPS: <b>disabled</b> Expert: <b>disabled</b>						
<b>Opt Gain</b> (for service purposes only)	---	---	---	---	---	---	---
<b>Search for Xfmr</b> (option to start a transformer search)	QUICK STEPS: <b>disabled</b> Expert: <b>simple</b>						
<b>Gain</b> (option to adjust the gain setting)	QUICK STEPS: <b>disabled</b> Expert: <b>simple</b>						
<b>Put Trace on hold</b> (option to put live trace on hold)	QUICK STEPS: <b>disabled</b> Expert: <b>simple</b>						
<b>Adjust End Marker</b> (option to adjust the end marker)	QUICK STEPS: <b>disabled</b> Expert: <b>simple</b>						
<b>Adjust Start Marker</b> (option to adjust the start marker)	QUICK STEPS: <b>disabled</b> Expert: <b>extended</b>						
<b>Recall stored Traces</b> (option to export, delete and recall traces)	QUICK STEPS: <b>disabled</b> Expert: <b>simple</b>						
<b>Cursor</b> (option to move the cursor)	QUICK STEPS: <b>simple</b> Expert: <b>simple</b>						
<b>Additional Marker</b> (option to place an additional marker)	QUICK STEPS: <b>disabled</b> Expert: <b>simple</b>						
<b>Pulse width</b> (option to adjust the pulse width)	QUICK STEPS: <b>disabled</b> Expert: <b>simple</b>						
<b>Save trace</b> (option to save the current trace)	QUICK STEPS: <b>disabled</b> Expert: <b>simple</b>						
<b>Save Fulltrace to USB</b> (for service purposes only)	---	---	---	---	---	---	---
<b>Zoom In/Out</b> (option to zoom the trace in and out)	QUICK STEPS: <b>disabled</b> Expert: <b>simple</b>						